Volume II – Technical Appendices to the Planning Report and Draft Environmental Impact Statement

Navajo-Gallup Water Supply Project

New Mexico – Arizona

Navajo Nation | **City of Gallup** | **Jicarilla Apache Nation**

U.S. Department of the Interior
Bureau of Reclamation

March 2007

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 a environmentally and economically sound manner in the interest of the American public.

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Technical Memorandum
(Final Draft – March 16, 2001)

FINAL DRAFT

TECHNICAL MEMORANDUM

THE NAVAJO-GALLUP WATER SUPPLY PROJECT

The Navajo Nation Department of Water Resources

The City of Gallup

The Northwest New Mexico Council of Governments

The U.S. Bureau of Reclamation

March 16, 2001

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Navajo-Gallup Water Supply Project

EXECUTIVE SUMMARY

The Project has evolved over four decades as a major infrastructure initiative to identify and secure a long-term water supply for the parched lands of the eastern portions of the Navajo Reservation and the City of Gallup. Planning has progressed under guidance of a local steering committee, and in collaboration with Reclamation and the BIA. Project participants anticipate agreement between local, tribal and federal agencies on the technical, biological, financial and other parameters of the Project. This agreement will clear the way for Congress to authorize the construction the Project. This technical memorandum is focused on the region's municipal water needs. It is not intended to quantify the water claims of any of the parties.

I. Objectives

The objective of this technical memorandum is to consolidate the information needed by the Navajo Nation and the City of Gallup to formalize their commitments to the Project, and to present this Project in the context of regional water development. Based on these objectives:

- The participants will finalize the project definition for a project that will provide a long-term water supply to the service area and will adequately define the options for the key project features and the operation of those features, to comply with the Endangered Species Act and the National Environmental Protection Act.

- A "Final Plan Report" will be developed by Reclamation during Fiscal Years 2000 and 2001 that will adequately describe the Project as part of the submission to Congress for authorization in Fiscal Year 2002.

- This technical memorandum will become the primary reference document for the Environmental Impact Statement which was initiated in March 2000.

- This technical memorandum will also be the foundation for agreements between the participants, as requested by the New Mexico Congressional Delegation, regarding various aspects of the Project.

II. Service Area

This Project is designed to provide a forty-year water supply to the Navajo Nation and the City of Gallup. The Project will deliver water to more than 20 Navajo public water supply systems in New Mexico and Arizona, and the Navajo Agricultural Products Industry (NAPI). For planning purposes, the study area is the New Mexico portion of the Navajo Nation, the Window Rock area within Arizona, and the City of Gallup, New Mexico. Within the State of New Mexico, the study area is encompassed by the State's Water Planning Regions 2 and 6 (Table 5.1 includes a complete list of the Chapters within the Project service area). Along with greater economic opportunity in the Gallup area, the Project will improve the municipal water supply to Navajo economic development growth centers in Window Rock, Tohatchi, Crownpoint and Shiprock.

Navajo-Gallup Water Supply Project

By the year 2040 the projected municipal demand in the service area (including NAPI) is approximately 52,000 acre-feet per year. This projection does not include any major industrial uses. The Project's annual diversion from the San Juan River will be approximately 36,600 acre-feet and its annual depletion will be 34,700 acre-feet. In addition to the San Juan River depletion, the Navajo Nation will supply an additional 3,200 acre-feet of groundwater annually and the City of Gallup will supply an additional 1,400 acre-feet of groundwater. The Animas La Plata Project will divert an additional 4,680 acre-feet to the Shiprock area. The San Juan River depletions for each basin are shown in Table E.S. 1.

III. Project Configurations

Because the location of the proposed points of diversion have critical hydrologic implications for the endangered species in the San Juan River (which have yet to be fully evaluated), this technical memorandum presents two distinct alternatives. The first alternative diverts water directly out of the San Juan River below the confluence of the La Plata and San Juan Rivers. This configuration is referred to as the San Juan River Diversion Alternative. For the San Juan River Alternative, the pipeline begins either the Hogback Diversion or PNM Diversion which are downstream of the La Plata River confluence and it proceeds along Highway N36 to Highway 666, and south to Yah-ta-hey, Window Rock and the Gallup Area. This configuration is very similar to the "San Juan Alignment" described in the 1984 Environmental Statement.

The second alternative utilizes the Navajo Indian Irrigation Project (NIIP) Main Canal to divert water from Navajo Reservoir. This configuration is referred to as the NIIP Alternative. For the NIIP Alternative, the pipeline begins at the proposed Moncisco Reservoir at NIIP and proceeds south to the existing El Paso Natural Gas pipeline corridor. The pipeline route follows the gas line corridor to the vicinity of Twin Lakes. The pipeline then turns south to Yah-ta-hey, Window Roc, and the Gallup Area. It is similar to the "Cottonwood Alignment" described in the 1984 Environmental Statement. Analyses of the no-action and non-structural alternatives are beyond the scope of this document.

From Yah-ta-hey both alternatives connect to a lateral to Window Rock and to the water distribution system for the Gallup Area. Spurs from the Window Rock Lateral will serve communities along Highway 264. Navajo residents in the Gallup area and the surrounding Chapters will receive Project water conveyed through the City of Gallup's distribution system. Four spurs will connect to the main pipeline to service the Chapters between NIIP and Gallup. Storage tanks and water treatment are included in the Project.

Table E.S. 1
Projected Navajo Gallup Water Supply Project San Juan River Depletions (including NAPI) in the Project Service Area by Basin
(Acre-feet)

Decade	New Mexico Upper Colorado Basin	New Mexico Lower Colorado Basin	New Mexico Rio Grande Basin	Arizona Lower Colorado Basin	Project Total
2000	5,242	2,352	336	1,652	9,582
2010	5,202	10,503	470	2,469	18,644
2020	6,996	11,360	638	3,493	22,487
2030	9,722	12,479	850	4,783	27,834
2040	13,229	13,934	1,119	6,411	34,693
2050	17,820	15,907	1,451	8,404	43,583
2060	23,686	18,429	1,875	10,950	54,939

IV. Project Cost

Cost summaries were prepared for the NIIP and the San Juan River Alternatives. As presented in this technical memorandum, both alternatives serve the same area. The total Project cost for the San Juan River Alternative is $368 million and the total Project cost for the NIIP Alternative is $390 million. These estimates include the Gallup Regional System and delivery to the Shiprock Subarea. The cost of power transmission lines is assumed to be incorporated in the unit price of the power. The separate allocated costs for the Navajo Nation and City of Gallup are based on each ones share of the annual capacity of each component or pipe segment. The total project and programmatic costs, and the allocated costs, are shown in Tables E.S. 2 and E.S. 3.

The NDWR investigated the mutual benefits due to the shared economy of scale of a joint Navajo /City of Gallup Project. The NDWR estimates that a stand-alone Gallup only system would cost approximately $107 million. A stand-alone Navajo project using the San Juan River Alternative would cost $324 million and a stand-alone NIIP Alternative would cost $354 million. By partnering with the Navajo Nation, the City's share of the resulting project is approximately $60 million. By partnering with the City, the Navajo Nation's share of the resulting project is $310 million for the San Juan Alternative and $326 for the NIIP Alternative. The operation and maintenance costs presented in Tables 8.16 and 8.17 show similar benefits with partnering.

Navajo-Gallup Water Supply Project

The water delivery costs have been divided between programmatic and Project costs. A number of federal and state programs may be able to assist with water development in the region. For instance, the IHS has P.L. 86-121 authorization to construct domestic water systems on the Navajo Nation. The IHS annual budget is approximately $25 million per year. The EPA, USDA, HUD and other federal agencies also assist with water development. The Project will provide a core system around which programmatic funding can build on.

Table E.S. 2
Navajo-Gallup Water Supply Project Capital Costs
(Millions of Dollars)

Component	Project Cost	Programmatic Cost	Total Cost
1A. 36,700 af NIIP Alternative			
8,800 af Moncisco Reservoir	$59.72	$0.00	$59.72
65 CFS Treatment Plant	$78.21	$0.00	$78.21
Conveyance to Yah-ta-hey	$129.58	$0.00	$129.58
Project Laterals	$122.60	$27.30	$149.90
Power Lines, SCADA etc.	$5.10	$0.00	$5.10
1B. 36,700 af San Juan River Alternative			
Diversion Structure	$3.14	$0.00	$3.14
Water Treatment Plant	$70.81	$0.00	$70.81
Regulating Reservoir	$15.07	$0.00	$15.07
Conveyance to Yah-ta-hey	$161.47	$0.00	$161.47
Project Laterals	$117.44	$30.30	$147.74
Power lines, SCADA, etc.	$5.10	$0.00	$5.10
2. Groundwater Component	$0.00	$73.00	$73.00
3. Wastewater treatment	$0.00	$113.00	$113.00
4. Value of Water Rights	$0.00	$90.00	$90.00
5. Value of Rights-of-way	$0.00	$24.80	$24.80
Total NIIP Alternative	$395.21	$328.10	$723.31
Total SJR Alternative	$373.03	$331.10	$704.13

Table E.S. 3
Navajo-Gallup Water Supply Project Summary of Allocated Capital Costs

Scenario	Water Supply (Acre Feet)		Capital Cost (Millions of Dollars)		
	Navajo Nation	City of Gallup	Navajo Nation	City of Gallup	Total
SJR Alternative					
	29,067	0	$324	$0	$324
	29,067	7,500	$310	$58	$368
NIIP Alternative					
	29,067	0	$354	$0	$354
	29,067	7,500	$326	$64	$390

Note: Tabulated costs exclude transmission lines and groundwater components.

V. Unit Cost of Project Water

The unit costs of the Project water including several important noncapital costs are presented in Table 9.3. Based on the data presented in Table 9.3 the total unit cost of the Project water is approximately $4.81 per thousand gallons. Included in this estimated rate is the full cost of amortizing the capital investment and the value of the water rights. This estimate also includes the cost of using the NIIP, improving the local systems and the retail expense of the water utilities. The estimated rate is approximately $2 per thousand gallons more than NTUA and the City of Gallup are currently charging for water. For a family of four, using 160 gallons per capita per day, the monthly water bill would be $94 per month.

Table E.S. 4
Estimated Average Unit Cost of Navajo-Gallup Water Supply Project Water Based on 36,700 acre-feet of Diversion

Cost Component	Estimated 2000 Cost (Dollars/AF)	Estimated Cost (Dollars/1000 gal)
1.Amortized $370 Million Capital Cost (7% and 40 Years)	$756	$2.34
2. CRSP fee	$60	$0.18
3. Amortized Water Rights ($3,000/af, 7% and 40 years)	$191	$0.59
4. NIIP Cost of Services ($50 to $300 per acre-foot)	$50	$0.16
5. City of Gallup improvements	$36	$0.11
6. City of Gallup retail cost	$195	$0.60
7. Project Operation and Maintenance	$272	$0.83
Total Unit Cost	$1,560	$4.81

Note:
During the first decade of operation the Project operation and maintenance expense will be approximately $1.30 per thousand gallons for the Navajo Nation and $1.02 dollars per thousand gallons for the City of Gallup.

VII. Action Plan

To expedite the Project, the Navajo Nation, the City of Gallup and Reclamation have developed a plan of approach. This approach includes a time line for NEPA Compliance, preparing the Planning Report/EIS, Construction Authorization, and Starting Construction. In addition, the planning report and the Environmental Impact Statement will be compiled into a single document. This schedule anticipates Congressional authorization for design and construction by October 2002 and a Record of Decision on the EIS by February 2003.

Navajo-Gallup Water Supply Project

1.0 OBJECTIVES

Recognizing their severe water supply problems the Navajo Nation and the City of Gallup signed a Memorandum of Agreement (see Appendix B) on April 17, 1998 to proceed with the planning and development of the Navajo-Gallup Water Supply Project (Project). The Navajo Nation and the City of Gallup are working as partners, with the Bureau of Reclamation (Reclamation) and the Bureau of Indian Affairs (BIA) to plan, implement environmental compliance, secure water supplies, obtain Congressional authorization, and construct a domestic water supply system. This Project will serve the residents of the Navajo Nation and the City of Gallup.

The objective of this technical memorandum is to consolidate the information needed by the Navajo Nation and the City of Gallup to formalize their commitments to the Project, and to present this Project in the context of regional water development. Based on these objectives:

- The participants will finalize the project definition for a project that will provide a long-term water supply to the service area and will adequately define the options for the key project features and the operation of those features, to comply with the Endangered Species Act and the National Environmental Protection Act.

- A "Final Plan Report" will be developed by Reclamation during Fiscal Years 2000 and 2001 that will adequately describe the Project as part of the submission to Congress for authorization in Fiscal Year 2002.

- This technical memorandum will become the primary reference document for the Environmental Impact Statement which was initiated in March 2000.

- This technical memorandum will also be the foundation for agreements between the participants, as requested by the New Mexico Congressional Delegation, regarding various aspects of the Project.

This technical memorandum draws on Reclamation studies of the Project conducted from the 1970's through the 1990's, primarily the Draft Environmental Statement prepared by Reclamation in January 1984. It also draws on additional work by the Navajo Nation Department of Water Resources (NDWR), the Northwest New Mexico Council of Governments, and the City of Gallup. The participation of the NDWR was funded in part by Reclamation through the Navajo Nation/Reclamation Cooperative Agreement No. 5-FC-40-17490.

2.0 INTRODUCTION

The Project has evolved over four decades as a major infrastructure initiative to identify and secure a long-term water supply for the parched lands of the eastern portions of the Navajo Reservation and the City of Gallup. Planning has progressed under guidance of a local steering committee, and in collaboration with Reclamation and the BIA. Project participants anticipate agreement between local, tribal and federal agencies on the technical, biological, financial and other parameters of the Project. This agreement will clear the way for Congress to authorize the construction the Project. This technical memorandum is focused on the region's municipal water needs. It is not intended to quantify the water claims of any of the parties.

To improve the health and standard of living of those residing in Navajo Nation communities and to serve the future demographic and economic growth of both the City of Gallup and the Navajo Nation, a long-term, high quality, domestic water supply is needed. This technical memorandum presents Project alternatives to move the Navajo-Gallup Water Supply Project from open-ended planning to construction authorization.

This Project is designed to provide a forty-year water supply to the Navajo Nation and the City of Gallup. The Project will deliver water to more than 20 Navajo public water supply systems in New Mexico and Arizona, and the Navajo Agricultural Products Industry (NAPI). For planning purposes, the study area is the New Mexico portion of the Navajo Nation, the Window Rock area within Arizona, and the City of Gallup, New Mexico. Within the State of New Mexico, the study area is encompassed by the State's Water Planning Regions 2 and 6 (Table 5.1 includes a complete list of the Chapters within the Project service area). Along with greater economic opportunity in the Gallup area, the Project will improve the municipal water supply to Navajo economic development growth centers in Window Rock, Tohatchi, Crownpoint and Shiprock.

By the year 2040 the projected municipal demand in the service area (including NAPI) is approximately 52,000 acre-feet per year. This projection does not include any major industrial uses. The Project's annual diversion from the San Juan River will be approximately 36,600 acre-feet and its annual depletion will be 34,700 acre-feet. In addition to the San Juan River depletion, the Navajo Nation will supply an additional 3,200 acre-feet of groundwater annually and the City of Gallup will supply an additional 1,400 acre-feet of groundwater. The Animas La Plata Project will divert an additional 4,680 acre-feet to the Shiprock area.

Because the location of the proposed points of diversion have critical hydrologic implications for the endangered species in the San Juan River (which have yet to be fully evaluated), this technical memorandum presents two distinct alternatives. The first alternative, which is shown in Figure 2.1, diverts water directly out of the San Juan River below the confluence of the La Plata and San Juan Rivers. This configuration is referred to as the San Juan River Diversion Alternative. This configuration is very similar to the "San Juan Alignment" described in the 1984 Environmental Statement. The second alternative, which is shown in Figure 2.2, utilizes the Navajo Indian Irrigation Project (NIIP) Main Canal to divert water from Navajo Reservoir. This configuration is referred to as the NIIP Alternative. It is similar to the "Cottonwood Alignment" described in the

1984 Environmental Statement. Analyses of the no-action and non-structural alternatives are beyond the scope of this document.

Section 3 of this technical memorandum presents a comprehensive Project history. The history includes a literature review and descriptions of the Project alternatives that have been previously evaluated. Section 4 presents the projected water demand and Section5 presents the current water production in the region. Current water sources will be unable to meet the future demand. Section6 presents water conservation options and Section 7 presents potential surface water supply options for the Project. Section 8 presents two Project alternatives (the San Juan River Diversion Alternative and the NIIP Alternative). Section 9 presents the unit cost of the Project water. And, Section 10 presents a plan of approach and time-line.

2.1 The Navajo Nation Background

The Navajo Reservation was established in 1868, and expanded through a series of executive orders, public land orders, and congressional statutes, to become the largest Indian reservation in the United States. Larger than the State of West Virginia, the Navajo Nation coves an area of approximately 27,000 square miles including portions of Arizona, New Mexico and Utah. The Navajo Nation is divided into 110 chapters, which are areas of local government. According to the 1990 Census the on-reservation Navajo population was 155,876 (Rodgers 1993).

Even after more than 100 years of federal trusteeship, the Navajo Nation faces serious economic and social challenges. In 1997 the Navajo Division of Economic Development observed that the Navajo median family income was only $11,885 while the U.S. median family income was more than $30,000. The average per capita income for the Navajo Nation was less than $5,600 while the average per capita income for the State of Arizona was approximately $22,000. More than 50 percent of the Navajo families on the Reservation lived below the federal poverty levels, compared with less than 13 percent of the general U.S. population. This poverty rate is one of the worst in the United States, even among American Indians. The Navajo unemployment rate on the Reservation is 58 percent, while the unemployment rate for the U.S. is approximately 5 percent. These disparities show no sign of narrowing. Even while the regional economy has boomed, these gaps in income, unemployment, and poverty have widened.

The Navajo Nation also faces serious water resource problems. Many homes lack indoor plumbing. More than 50 percent of Navajo homes lack complete kitchens and more than 40 percent of Navajo households rely solely on water hauling to meet daily water needs. Data from the Navajo Tribal Utility Authority (NTUA) and others demonstrate that Navajo's use far less water per capita yet pay among the highest water rates in the region. The low per capita water use is part of a larger pattern of a low economic standard of living.

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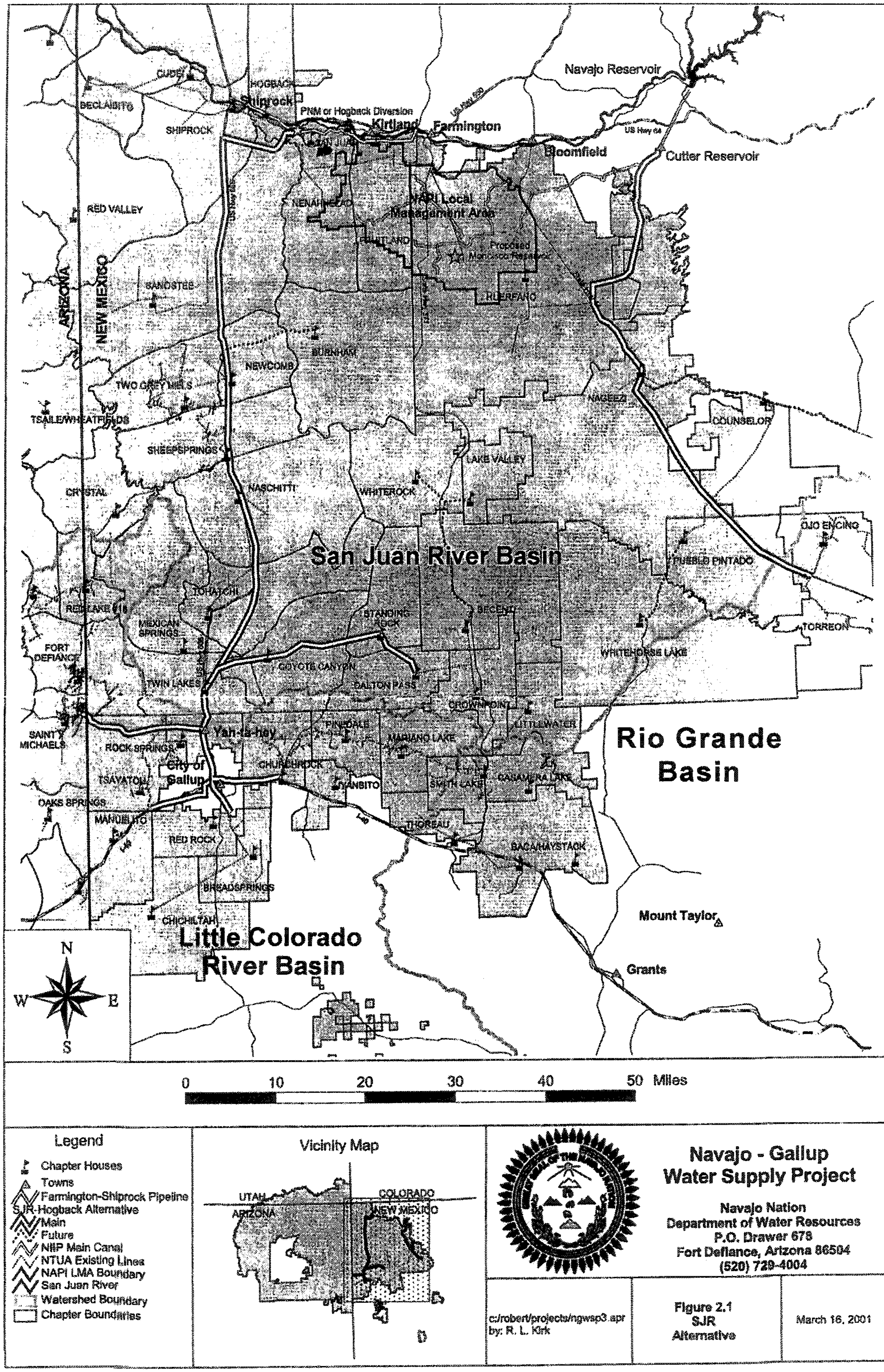

Figure 2.1
SJR
Alternative

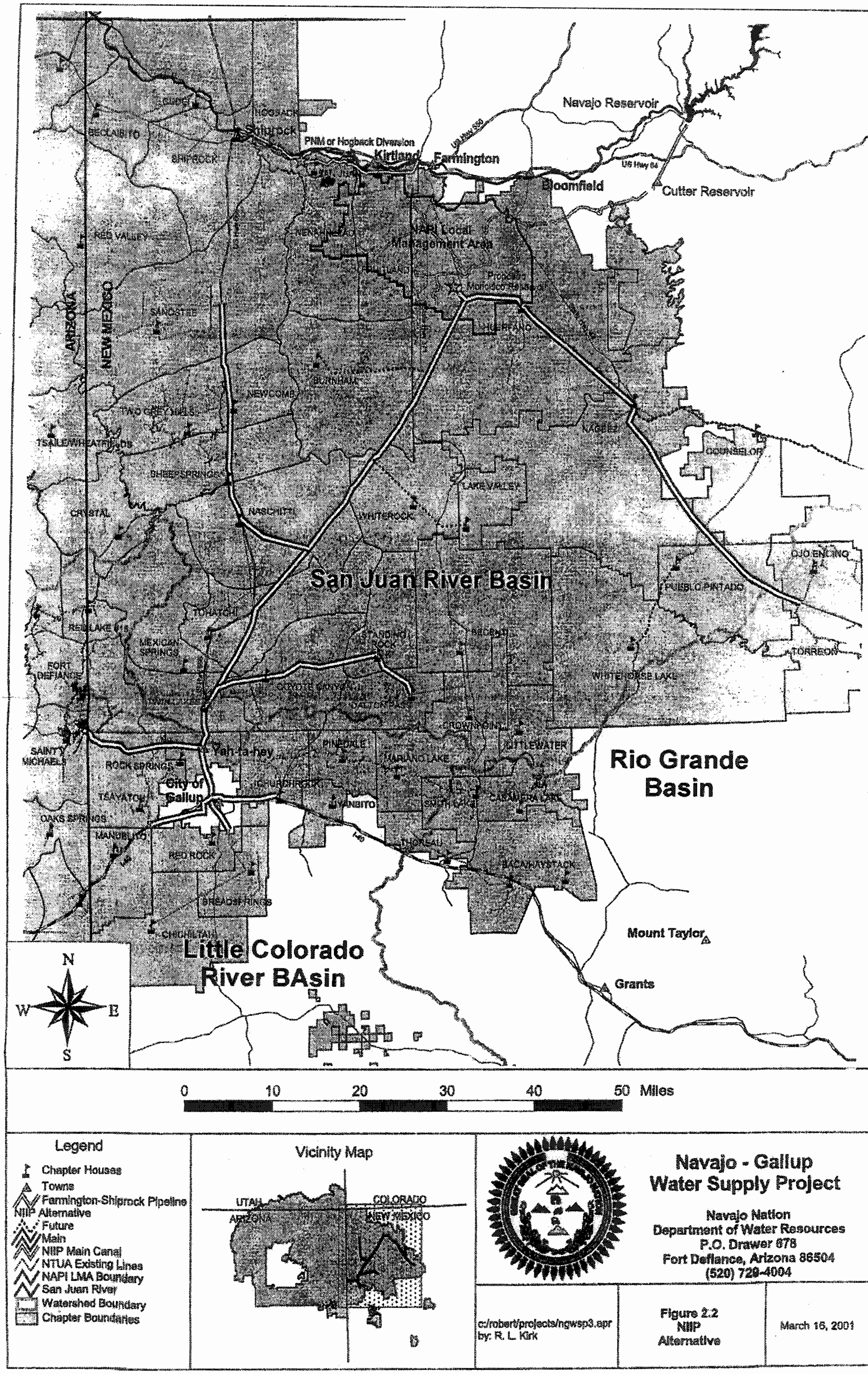

Figure 2.2
NIIP
Alternative

Navajo-Gallup Water Supply Project

Safe drinking water is a precondition for health promotion and disease prevention. The lack of clean safe water results in a higher incidence of disease, poor health, and inadequate fire protection. In 1996, President Clinton noted that "the number one health problem in the developing world is the absence of clean, safe water." Children living in homes without access to safe, affordable, and dependable drinking water are especially vulnerable. Without access to safe drinking water, people are forced through a revolving door of expensive medical treatment and unhealthy conditions. In a report to Congress by the Comptroller General, it was noted that families living in homes with satisfactory environmental conditions placed one fourth of the demands on Indian Health Service (IHS) primary health care delivery systems than families living in homes with unsatisfactory conditions. Biological contaminants such as coli form bacteria, giardia, and *crypto-sporidium* can only be controlled by proper water source protection, treatment, and distribution systems.

These grim statistics adversely impact the survival of the Navajo Nation. According to the Division of Community Development, due to the stagnation of development in Navajo country, the Navajo Nation is losing population to off-reservation communities, the Four Corners Area, and the remaining 46 states. Between 1980 and 1990, the Navajo off-reservation population in New Mexico, Arizona, and Utah grew by 125 percent, the Navajo population in the other 47 states grew by 71 percent, while the on-reservation population grew by only 22 percent. Without reducing the out-migration, by 2012 more than half of the Navajo people may be living off of the Navajo Reservation (Rodgers, 1993).

The lack of infrastructure, the lack of economic development and the sustained poverty are closely connected. Throughout the arid southwest, and especially on the Navajo Nation, a reliable water supply is essential for stimulating and sustaining economic development. The Navajo Nation has identified economic development growth centers throughout the Reservation. These economic development centers represent large population bases that have the potential to benefit from an economy of scale in infrastructure development. Accordingly the Navajo Nation will focus resources in these locations to stimulate economic growth.

Creating an adequate water infrastructure does not guarantee sustained economic growth, nor a narrowing of the disparities between the Navajo people and the rest of the United States. It is however, a necessary prerequisite. If an improved water infrastructure could create even modest improvements, the benefits will be compounded. For instance, the Navajo Nation captures less than 8 percent of the $660 million annual tourism revenue in the Four Corners Area. If an enhanced tourist infrastructure increased that percentage to 12 percent, the Navajo Nation's economy would benefit from an additional $26 million annually. If an improved water infrastructure can close the income gap between the Navajo and the U.S. average by just one percent, the direct benefits will be worth tens of millions of dollars annually. Without this Project the Navajo economy will continue to stagnate.

2.2 The City of Gallup Background

The City of Gallup was established in the 1880's as a small company headquarters for the Atchison, Topeka and Santa Fe Railroad. Initially the town's economy was supported by coal mining in the region. The City of Gallup became a regional trade center for the surrounding area, including the Navajo Nation which borders most of the City's geographic boundary. Today, the City's population exceeds 23,000 and it continues to serve as an economic center for more than 100,000 people. The City relies solely on a groundwater supply that is being progressively mined with little recharge into the source aquifers. Current hydrologic projections by the City predict severe shortages in the groundwater supply within 10 years. This projected shortfall will have severe economic and social impacts on the City of Gallup and the surrounding Navajo Chapters.

The Navajo land near the City of Gallup has been explicitly included in this Project service area.. This area includes the Chapters of Bread Springs, Chichiltah, Church Rock, Iyanbito, Manuelito, Pinedale, Red Rock, Rock Springs, and Tsayatoh. Project water will be conveyed through the municipal system of the City of Gallup to the surrounding NTUA systems and, under some circumstances, to individual water users.

2.3 The Navajo Agricultural Products Industry

The Navajo Agricultural Products Industry (NAPI) is a tribal enterprise, which was created in 1970 to develop, farm, and operate the Navajo Indian Irrigation Project (NIIP) lands, and operate and maintain the NIIP water delivery system. NAPI currently produces a variety of crops including corn, potatoes, alfalfa, pinto beans, and others. Its crops are marketed throughout the United States, Mexico, and other international markets under the "Navajo Pride" trademark. NAPI provides approximately 250 permanent jobs and up to 800 seasonal jobs during peak seasons. Subcontractors, joint venture partners, and independent truckers employ additional workers. In 1999, NAPI farmed 64,000 of the 110,630 acres to be developed. NAPI channels $55 million annually into the Navajo Nation's economy.

Both Project alternatives will provide additional industrial water for the NAPI. The Project alternative that utilizes the NIIP Canals would be closely integrated with NIIP canal operation. The conveyance of municipal water may provide significant benefits to both NIIP and the Project. The thoughtful sequencing of construction, operation and maintenance, and financing could benefit NAPI and the Project. However, hydrologic constraints created by the Endangered Species Act may preclude the use of the NIIP canals for the Project.

3.0 PROJECT HISTORY

Regional water plans over the past 40 years have repeatedly identified the need for additional rural, municipal, and industrial water supplies for the eastern portion of the Navajo Nation and the City of Gallup. The history of the Project is presented in the following sections.

1958 - Congressional hearings on the Navajo Indian Irrigation Project

In 1958 the New Mexico State Engineer testified during Congressional hearings for the proposed Navajo Indian Irrigation Project that NIIP would be part of the regional water infrastructure intended to provide water from Navajo Reservoir to Navajo communities in northwest New Mexico and to the City of Gallup (Hearings before the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs, S.3648, July 9 and 10, 1958). This position was reaffirmed in House Report #685, July 10, 1961 which stated that NIIP is adapted to serve municipal and industrial water users as well as its primary purpose of irrigation.

1960 - Preliminary Report on the Domestic Water Supplies for the Navajo Tribe

In 1960 Banner and Associates prepared a report entitled *Preliminary Report n Domestic Water Supplies for the Navajo Tribe, Newcomb-Window Rock Area, Supplement to Proposed Water Supply to the Town of Gallup, New Mexico.* Banner and Associates proposed a 20-inch diameter pipeline to deliver five million gallons a day to the City of Gallup, and 1.5 million gallons a day to the BIA schools along the pipeline route and the Navajo population in the Window Rock area. The proposed configuration would convey water from the NIIP canals, to an 8,800 acre-foot storage reservoir located in Newcomb, and then follow Highway 666 to the City of Gallup with a spur to the Window Rock area.

1962 - Authorization of the Navajo Indian Irrigation Project

The Navajo Indian Irrigation Project was authorized by Public Law 87-483 (June 13, 1962), amended by Public Law 91-416 (September 23, 1970). These laws authorized the Secretary of the Interior to construct, operate, and maintain NIIP for the principal purpose of furnishing irrigation water to approximately 110,630 acres of land. In developing NIIP, the Secretary of the Interior is authorized to "provide capacity for municipal and industrial supplies or miscellaneous purposes over and above the diversion requirements for irrigation." Public Law 87-483 also authorized the construction of the San Juan-Chama Diversion Project. The San Juan-Chama Project was complet̀ed during the 1960's and it is supplying water for municipal, recreation and irrigation uses for a population of 500,000 in the Rio Grande Corridor. Public Law 87-483 also stipulated that no long-term contracts for San Juan River water, other than the Navajo Indian Irrigation Project and the San Juan-Chama

Project, will be granted until a Hydrologic Determination by the Secretary of the Interior shows that there is sufficient water to fulfill the contract.

1967 - Temporary water allocation from Navajo Reservoir

In June 1967, the City of Gallup through Resolution 24-51 formally requested that the New Mexico Interstate Stream Commission (ISC) support the 15,000 acre-feet per year allocation of Upper Colorado River water for Gallup. Upon review, the ISC recommended temporarily reserving 7,500 acre-feet of water from Navajo Reservoir for the City of Gallup. Based on the 1967 Hydrologic Determination, the Secretary of the Interior approved a temporary allocation for the State of New Mexico for 100,000 acre-feet from Navajo Reservoir through the year 2005 (Assistant Secretary of the Interior, Report No. 1106, 90^{th} Congress, 2d Session, February 27, 1968 - S.J. Res. 123). This reservation was made for planning purposes and was not a Secretarial contract for water delivery.

Because the 7,500 acre-feet temporary reservation for the City of Gallup is part of the 100,000 acre-foot allocation for New Mexico, any water use contract beyond the year 2005 must be supported by a hydrologic determination by the Secretary of the Interior and approved by Congress. However, in a letter dated December 13, 1973 from the State Engineer of New Mexico to Reclamation's Regional Director of the Southwest Region, he states that "It is New Mexico's position that under the correct interpretation of the compact's provisions, the full 100,000 acre-feet of consumptive use from Navajo Reservoir contracts would be available in perpetuity."

1971 - Congressional authorization for feasibility studies

Congress specifically authorized Reclamation to complete feasibility studies for the "Gallup Project" (now called the Navajo-Gallup Water Supply Project) to transport San Juan River water to the City of Gallup (PL. 92-199, December 15, 1971). In 1972 the reconnaissance report concluded that: (1) water to meet the City's needs was available from Navajo Reservoir, (2) there was a potential to develop groundwater supplies within import distance of Gallup, and (3) feasibility investigations should be undertaken to develop plans for providing water to the City of Gallup and that those studies should consider providing water to Navajo communities along the supply routes.

1976 - The Turney Report assessing the Navajo Nation's water needs

In 1975 the Navajo Tribal Utility Authority (NTUA) requested that the investigation be expanded to include municipal/domestic water supplies for various Navajo communities in the eastern part of the Navajo Reservation. A memorandum of understanding between the Bureau of Reclamation and NTUA to include Navajo Nation communities was executed August 12, 1975. As part of the agreement, NTUA retained the engineering firm of William F. Turney & Associates to prepare the report *U.S. Bureau of Reclamation - Navajo Tribal Utility Authority Water Study P.L. 92-1999*

Navajo-Gallup Water Supply Project

(Turney,1976). Turney and Associates assessed the Navajo Nation water needs that could by addressed by the Project. Turney and Associates projected the population and water demand through the year 2025 and evaluated 25 community water systems. Many of those systems had water quality and water supply problems. Turney and Associates identified the Dakota-Morrison-Cow Springs aquifer as having the best potential in the southwest portion of the study area. These formations, however would only be able to supply one third to one half of the water demand in the Tohatchi-Gallup Area by the year 2025. The Navajo Nation fully supported the findings of Turney's report and Reclamation adopted the findings as a basis for the 1984 project plan formulation.

1984 - Compliance with the National Environmental Protection Act

During the late 1970's and early 1980's investigations were conducted to develop and evaluate alternatives to meet the Project's purposes. To comply with the National Environmental Protection Act (NEPA) the fish, wildlife, and habitat resources of the Project area were assessed and the impacts of the alternatives were analyzed. Alternatives were evaluated which would divert 25,800 to 48,500 acre-feet of water per year. Meeting the Project's purposes through increased groundwater withdrawals, surface water from the Chaco Wash and the Rio Puerco, and weather modification were determined to be infeasible. These investigations culminated with the *Gallup-Navajo Indian Water Supply Project, New Mexico-Arizona-Utah, Part I, Planning Report, Part II, Draft Environmental Statement* (Reclamation, 1984). This report confirmed the City of Gallup and the Navajo Nation's need for a water supply, and it determined that the San Juan River was the only source of water capable of meeting the Project demand. The following alternatives were evaluated in that report:

- No-Action Plan - This plan was based on the premise that there would be no federal action taken to meet current and future water needs of the Project area. This plan did not satisfy the purpose and need of the Project.

- Non-structural Plan (Water Conservation) - It was determined that water conservation could not meet the needs of the Navajo communities. While conservation measures may help the City of Gallup meet short term needs, it was not a viable solution to meet long-term needs and did not address deteriorating water quality.

- Shiprock Diversion Plan - The features of this plan included a diversion structure on the San Juan River near Shiprock, pipelines, pumping plants, and related facilities necessary for water delivery, and specific environmental features pertinent to reaches of the river influenced by the plan. This plan was not viable due to the poorer quality of the San Juan River at this diversion point and the additional 350-foot lift. No cost estimates were prepared for this alternative.

- San Juan Alignment Plan - The features of this plan included a diversion structure on the San Juan River upstream from the Animas River in Farmington, 180.5 miles of pipeline, 14 pumping plants and related facilities. A treatment plant near the diversion would be constructed separately. The route of the pipeline was along Highway 666 from Shiprock to Gallup and to Window Rock. This configuration would serve Burnham, Coyote Canyon, Standing Rock, Crownpoint, St. Michaels, Fort Defiance, Sanostee, Two Grey Hills, Toadlena, Mexican Springs, and 23 other Navajo communities.

This plan was evaluated for demands from 25,200 to 45,600 acre-feet per year. The estimated capital cost, excluding water treatment, was between $199 and $263 million in 1980 dollars. Using Reclamation's steel price index, the cost in 2000 dollars would be between $330 and $437 million. The estimated annual operation and maintenance was between $2.6 and $3.7 million in 1980 dollars. Using Reclamation's composite index, the cost in 2000 dollars would be between $4.1 and $5.8 million. The unit cost of the water including repayment of the capital, and operation and maintenance cost was between $1.87 and $2.59 per thousand gallons in 1980 dollars. Using Reclamation's steel price index, the unit cost in 2000 dollars would be between $3.06 and $4.28 per thousand gallons.

- Cottonwood Alignment Plan - This plan proposed to use the existing NIIP facilities to divert water from Navajo Reservoir and deliver it to a reservoir constructed in Cottonwood Canyon. Other features included a treatment plant (constructed by others) located near the dam, 180.6 miles of pipeline, 13 pumping plants and related facilities. The route of the pipeline went through Burnham along Highway 5 and then south along Highway 666 to Gallup.

  The plan was evaluated for demands from 25,200 to 45,600 acre-feet per year to serve 23 Navajo communities. The estimated capital cost, excluding water treatment, was between $210 and $266 million in 1980 dollars (or between $348 and $442 million in 2000 dollars). The estimated annual operation and maintenance cost was between $2.2 and $3.1 million in 1980 dollars (or between $3.5 and $4.9 million in 2000 dollars). The unit cost of the water including repayment of the capital, and operation and maintenance was between $1.83 and $2.68 per thousand gallons in 1980 dollars (or between $3.06 and $4.49 per thousand gallons in 2000 dollars).

- Four Corners Plan - This plan was considered the preferred alternative. It was essentially the same as the 1984 San Juan Alignment Plan except that it included construction of a water treatment plant for $23 million (or $37 million in 2000 dollars) and provided service to nine additional Navajo communities in Arizona and Utah. Features included 254.7 miles of pipeline and nine pumping plants.

  The plan provided a total water supply of 42,270 acre-feet per year with 29,300 acre-feet of delivery in New Mexico, 6,990 acre-feet in Arizona and 1,180 acre-feet in Utah. The proposed configuration would serve Upper Fruitland, Nenahnezad, Shiprock, Sanostee, Tocito, Burnham, Newcomb, Two Grew Hills, Toadlena, Sheep Springs, Naschitte, Tohatchi, Mexican springs, Twin Lakes, Yah-ta-hey, Gamerco, Gallup, Rattlesnake, Beclabito, Teec Nos Pos, White Mesa, Navajo, St. Michaels, Fort Defiance, Sawmill, Crystal, Coyote Canyon, Standing Rock and Crownpoint.

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The estimated cost in 1981 was $303 million (or $605 in 2000 dollars). The estimated annual operation and maintenance cost was $5.7 million in 1980 dollars (or $8.9 million in 2000 dollars). The unit cost of the water including repayment of the capital, and operation and maintenance was $3.24 per thousand gallons in 1980 dollars (or $5.41 per thousand gallons in 2000 dollars).

This 1984 planning report recommended the Four Corners Plan as the best alternative to meet the area's needs. It was noted that some of the proposed service area overlapped with that of the Animas-La Plata Project. And, if the Animas-La Plata Project was funded for construction, those communities could be dropped from the Navajo-Gallup Project. The report concluded that the Secretary of the Interior should seek congressional authorization to construct, operate, and maintain the Four Corners Plan.

During April of 1984, public meetings on the draft environmental statement were held in Gallup, Crownpoint, Shiprock, Farmington, and Window Rock. The City of Gallup indicated continued support for the recommended plan. However, the Navajo Nation, under new administration, indicated that prior to any further commitment to the Four Corners Plan, other alternatives serving water short communities along New Mexico Highway 371 needed to be evaluated. Reclamation discontinued work on the Planning Report and Draft Environmental Statement and published a notice of withdrawal of the Draft Environmental Statement in the Federal Register.

1986 - Reclamation's Gallup-Navajo Technical Report

Funding was written into the Energy and Water Development Appropriations Act for Fiscal Year 1986 to evaluate additional alternatives. Reclamation coordinated the definition of the Project's purpose with the Navajo Nation and the City of Gallup. The proposed concept would provide 7,500 acre-feet to the City of Gallup, 12,245 acre-feet to the Navajo Communities and 37,000 acre-feet for a proposed generating plant near Burnham, New Mexico. These alternatives were described by Reclamation in the *Gallup-Navajo Indian Water Supply Project, New Mexico-Arizona, Technical Report* (Reclamation,1986). The following alternatives were evaluated in that report:

- Direct San Juan River Pipeline - Two plans were evaluated (Alternatives A and C) which would divert water directly from the San Juan River. These plans were essentially the same as the San Juan Alignment Plan proposed in the 1984 Draft Environmental Statement. The nominal capacity of the pipeline would have been 7,500 acre-feet for the City of Gallup and 5,280 acre-feet for Window Rock, Fort Defiance and St. Michaels. Alternative A would divert water from the Fruitland Canal. Alternative C would require a new diversion dam on the San Juan River upstream of the Animas River confluence. Using an 8-year construction period and a 50-year repayment obligation at 8.5 percent, the total 1986 estimated costs, including indirect costs, was approximately $364 million for Alternative A and $363 million for Alternative C. These costs would be $512 and $511 million in 2000 dollars.

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- A pipeline from the Navajo Indian Irrigation Project - Three alternatives were put forth in the 1986 document which include a feeder canal to divert water from the NIIP main canal to the proposed Gallegos Reservoir. Alternatives B and E would convey water from Gallegos Reservoir water through the Burnham Lateral and then south along Highway 371 to Thoreau and along Interstate 40 to Gallup. Alternative D was similar to Alternative B, but would not require the use of the Burnham Lateral canal. Alternative E included the staged development of the pumping plants required for irrigation. The nominal capacity for all three alternatives would have been 7,500 acre-feet for the City of Gallup and 5,280 acre-feet for the Navajo communities from White Horse to Crownpoint to Church Rock. Based on an 8-year construction period and a 50-year repayment obligation at 8.5 percent, the 1986 estimated costs, including indirect costs, of Alternatives B, D, and E were $456 million, $381 million, and $369 million respectively. These costs would be $642, $537 and $519 million in 2000 dollars.

In the late 1980's the Project stalled in part due to the Navajo Nation's concerns over the failure to complete the Navajo Indian Irrigation Project, and the inadequacy of the Project's proposed service area. It also stalled due in part to Reclamation's concern over the long-term availability of water, lack of quantified water rights for the Project, difficulty in complying with the Endangered Species Act, and difficulty in financing the Project. Reclamation funding was suspended at that time.

1991 - The City of Gallup's Forty Year Water Supply Master Plan

In January of 1991 the City of Gallup prepared a forty-year water supply master plan (Shomaker 1991). The master plan projected that by the year 2030 the annual water demand in the Gallup area will be 7,632 acre-feet and that by the year 2010 the City will face peak water shortages of one million gallons per day. The City has already implemented periodic water rationing. As part of the master plan, the City evaluated additional water sources including "Alternative E" which is the alignment from NIIP to the City proposed in the 1986 Technical Report (Reclamation, 1986). The City also evaluated groundwater in the Bluewater area, the Ciniza Well Field, the Church Rock Mine area, the Yah-ta-hey Well Field, the Ramah Area Well Field, and the Danoff Well Field. The City also evaluated tertiary treatment and wastewater reuse, providing additional City storage and developing the surface water from the South Fork of the Rio Puerco. The City concluded that the Gallup-Navajo Project was the only project that offers a permanent supply and it should be pursued. This conclusion is supported by subsequent regional water plans prepared for the New Mexico Interstate Stream Commission. The short term alternatives identified by the Master Plan were to expand the Yah-ta-hey well field and to investigate groundwater in the Ciniza and Church Rock areas.

In December of 1991 the City investigated a stand alone water transmission line from NAPI to the City. The proposed project would convey 7,500 acre-feet of water. The proposed pipeline began at the southwest corner of NAPI, followed BIA Route 5 through Burnham, and south along Highway

666. The estimated cost in 1991 for the stand-alone pipeline was $61 million (or $74 million in 2000 dollars). This cost estimate did not include many of the indirect costs that would be incurred.

1993 - Reclamation appraisal level evaluation and cost estimate

Funding was written into the Energy and Water Development Appropriations Act for Fiscal Year 1993 for the Reclamation to evaluate the Project and provide cost estimates. The study culminated in the *San Juan River Gallup/Navajo Water Supply Project Engineering and Cost Estimates Technical Appraisal Report*, (Reclamation, 1993), which evaluated the following three alternatives:

- Alternative "A" - This plan was for a pipeline capable of conveying 10,860 acre-feet per year. The pipeline alignment would begin at the proposed Gallegos Reservoir, proceed south along Highway 371, west along Navajo Route 9 and South to Yah-ta-hey along Highway 666. This pipeline would deliver water to the City of Gallup at Yah-ta-hey and to unidentified Navajo communities along the route. The estimated 1993 construction cost was $67 million, the indirect cost was $20 million, and the operation and maintenance cost was $2.7 million (or $84 million, $24 million, and $3.3 million in 2000 dollars, respectively).

- Alternative "B" - This plan utilized the same pipeline route as Alternative A. This plan included 1,085 acre-feet for NAPI, 7,960 acre-feet for the City of Gallup, 9,412 acre-feet for Window Rock and 7,783 acre-feet for thirteen Navajo chapters. The estimated 1993 construction cost was $140 million, the indirect cost was $40 million, and the operation and maintenance cost (excluding the laterals) was $5.2 million (or $175 million, $50 million, and $6.3 million in 2000 dollars, respectively).

- Alternative "C" - This plan was developed in an effort to find a more cost effective alternative. The pipeline alignment would begin at the proposed Gallegos Reservoir and convey water to a point near Twin Lakes, and south along Highway 666 to Yah-ta-hey. This plan included 7,820 acre-feet for NAPI, 5,940 acre-feet for the City of Gallup, 8,600 acre-feet for Window Rock and 8,655 acre-feet for thirteen Navajo chapters. With this plan the main line is shorter than the other two alternatives. It requires fewer pumping stations and it eliminates the need to lift the large quantities of water needed to serve Window Rock and Gallup up to the Crownpoint elevation via the Highway 371 alignment. The estimated 1993 construction cost was $115 million, the indirect cost was $34 million and the operation and maintenance cost (including the laterals) was $4.7 million (or $143 million, $42 million, and $5.7 million in 2000 dollars, respectively). This alternative serves the same water-short communities that were to have been served by Alternative E described in the 1986 report. This analysis did not include the full costs of the proposed Gallegos Reservoir, water treatment, an adequate peaking capacity, or pipe installation.

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1996 - Reclamation evaluates the water supply and storage options

In the 1996 report *Water Supply and Storage Options Gallup Navajo Pipeline Project*, the Reclamation's Farmington Construction Office reviewed three water supply and storage options. This Reclamation investigation did not evaluate the conveyance system that would bring the water south to the Navajo Nation communities and the City of Gallup. This investigation included:

- Direct diversions from Navajo Reservoir - This option would deliver water from Navajo Reservoir through a pipeline to the proposed Gallegos Reservoir at NIIP. The total estimated cost of the pipeline, pumping plants, Gallegos Dam, power lines, utilities and mitigation was $107 million (or $118 million in 2000 dollars). This option minimizes the use of NIIP facilities.

- Direct diversions from the San Juan River - This option would divert 42 cubic feet per second (approximately 30,400 acre-feet per year) from the San Juan River near Farmington to the proposed Gallegos Reservoir. This option would require the construction of a diversion structure within the designated critical habitat of endangered fish species. The estimated cost of the pipeline and pumping plant was $34 million. The estimated cost of Gallegos Dam with 1,800 acre-feet of storage was $18 million. The total estimated cost including power lines, utilities and mitigation was $58 million (or $64 million in 2000 dollars). Energy for pumping water from the San Juan River to Gallegos Reservoir would cost $414,000 (or $459,000 in 2000 dollars) per year. This option also minimizes the use of NIIP facilities.

- Diversions from the NIIP Canal System - This option included several scenarios for conveying water through the NIIP canals. Reclamation investigated three sites for a proposed water storage reservoir: (1) Lower Cottonwood, (2) Upper Cottonwood, and (3) Moncisco Wash. Reclamation assessed three reservoir capacities (1,850, 8,800, and 11,000 acre-feet) at each site. Based on this analysis, the Moncisco site became the preferred alternative for the dam. Moncisco Reservoir is a modification of the previously proposed Gallegos Reservoir. With 8,800 acre-feet of storage, stabilized channels, utilities and mitigation, the field cost was $32.5 million (or $36.1 in 2000 dollars). Energy for pumping water from the NIIP canal to the reservoir would cost $160,000 (or $176,000 in 2000 dollars) per year.

Although the Reclamation analysis did not explicitly include the full cost of using the NIIP facilities, Reclamation concluded that conveying water through the NIIP facilities was slightly more economical than the San Juan Diversion option and far more economical than the Navajo Reservoir Diversion option. Furthermore, the collaboration between NIIP and the Project may increase the overall benefits of the already constructed NIIP facilities.

1998 - The Memorandum of Understanding between the City and the Navajo Nation

In April 1998 George Galanis, the Mayor of the City of Gallup and Thomas Atcitty, President of the Navajo Nation signed an agreement to cooperate on the planning for the Navajo-Gallup Water Supply Project. That document commits the City and the Navajo Nation to:

- A cooperative effort to proceed with planning and development;
- A project that works conjunctively with the Navajo Indian Irrigation Project;
- A project that will result in a fair and equitable distribution of project water between the City of Gallup and the Navajo communities;
- Cooperatively investigate all viable alternative project configurations;
- Support the commitment of the Bureau of Indian Affairs to engage in consultation with the USFWS as quickly as possible; and
- Work together to resolve issues affecting the implementation of the Project.

The Memorandum of Understanding continues to serve as the basis for the collaborative efforts of the Navajo Nation and the City of Gallup to develop the Project (See Appendix B).

1999 - Resolutions of the Upper Colorado River Commission

Recognizing the need to develop depletion schedules for long-range planing, the Upper Colorado River Commission periodically assesses the depletion projections for the Upper Colorado Basin states. Projections made in July 1994 had shown that New Mexico would exceed 669,000 acre-feet as soon as the year 2020. In December of 1999 the Upper Colorado River Commission passed a resolution not objecting to the use of the State's updated depletion schedules. According to the updated January 2000 depletion schedules, the State of New Mexico will not exceed 669,000 acre-feet of Upper Basin depletion until sometime between the years 2030 and 2040. Based on the January 2000 schedule, even though water allocated under the Upper Basin Compact to the State of New Mexico may not be available after the year 2040, it would be possible for the Project to develop a new water contract based on unused Upper Basin allocations at least through the year 2060.

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1990 to 1999 - Interdisciplinary technical reports

In a letter dated March 5, 1992 from Marshal Plummer, Vice President of the Navajo Nation to George Galanis, Mayor of the City of Gallup, Mr. Plummer indicated the Navajo Nation's support for a cooperative effort on this Project. As a result, a steering committee was created in June 1992 to oversee Project activities funded through annual congressional write-in funding and matching funds from the Project sponsors. The steering committee includes representatives from IHS, BIA, Reclamation, the City of Gallup, and the Navajo Nation. Additional technical investigations produced the following findings:

- Engineering - Reclamation provided additional review and constructablity surveys of the Project's regulating storage facilities. Technical analysis also refined estimates of Project demands, diversions and depletions. Based on this information, in 1998 a draft Project description was developed with adequate detail for engaging the USFWS in consultation pursuant to Section 7 of the Endangered Species Act.

- Cultural Resources - Extensive cultural resource studies were conducted for the El Paso Natural Gas and Transwestern Pipeline corridors which overlap some of the proposed Navajo-Gallup alignments. These reports include Winter (1991a), Winter (1991b), Kearns (1990), ENSR 1990, and FERC (1991). In 1993 staff from Reclamation, the Navajo Nation Archaeology Department and the Navajo Nation Historic Preservation Department provided information on cultural resources within the potential impact area. Based on these studies sites that are potentially within the area of direct impact of the Navajo-Gallup Project were identified. The scope of work and budget for a Phase II cultural resource survey was prepared.

- Biological Resources - Extensive biological resource studies were conducted for the El Paso Natural Gas and Transwestern Pipeline corridors which overlap some of the proposed Navajo-Gallup alignments. These reports include Cedar (1990), Mariah (1991), Ecosphere (1990), and ENSR (1990), and FERC (1991). In 1993 Reclamation and the Navajo Department of Fish and Wildlife identified the terrestrial biological issues and concerns associated with construction of the Navajo-Gallup Project. A comprehensive bibliography of biological resource information for the Project area was completed, and the scope of work for further investigations was prepared. In 1998 a field trip was made to the proposed reservoir sites to assess the presence of Willow Flycatcher habitats. A biological assessment for the threatened and endangered aquatic species in the San Juan River is underway.

- Ability to Pay - In 1993 Reclamation estimated the annualized construction costs over a forty-year life cycle for Alternative C as described in the 1993 *San Juan River Gallup/Navajo Water Supply Project Engineering and Cost Estimates Technical Appraisal Report*. These costs were calculated for a range of interest rates from 3 to 9.5 percent and a range of an outside subsidy from 10 to 75 percent. Based on that analysis, the annualized construction cost ranged from$1.6 million to $15.8 million. For an interest rate of 6.5 percent and a 10 percent subsidy the annualized construction cost was $10.1 million per year. The Reclamation analysis did not discount the interest rate due to inflation.

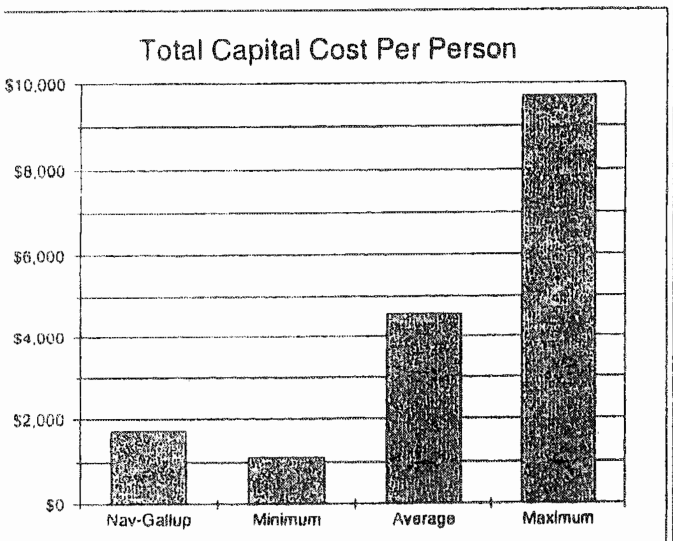
Based on average and maximum water bills, household incomes and tax burdens of 110 communities in New Mexico, Reclamation estimated the ability to pay for Gallup and the Reservation communities. The total annual ability to pay was estimated to be a little less than $2.2 million for the City of Gallup and approximately $1.0 million for the Reservation communities. This total amount was about one third of Reclamation's midrange estimate of the annualized construction cost. However, the Reclamation analysis did not fully take into account future population growth nor inflation.

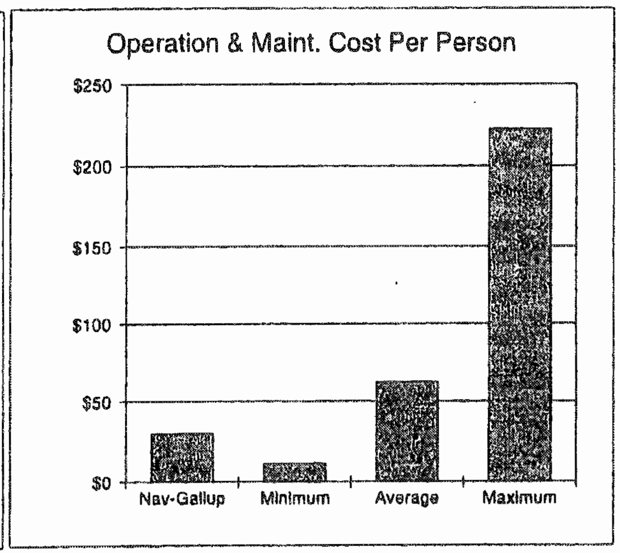
To determine if the communities had the willingness to pay for the construction and operation of the proposed facilities, in 1995 willingness to pay surveys were conducted for the Navajo communities and the City of Gallup. The communities in the service area share a widespread appreciation of the value and scarcity of water in the region. The surveys indicated that the water users were willing and able to pay a portion of the operating cost for the Project. According to the survey, in 1994 approximately 44 percent of the Navajo homes in the service area were without direct access to a public water supply system.

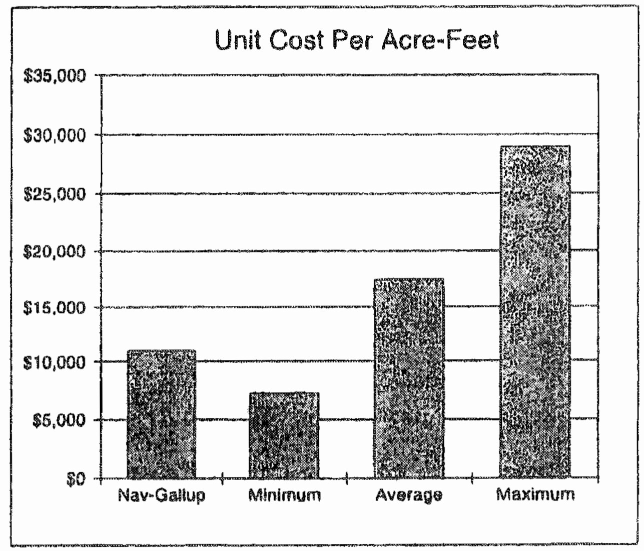
- Comparative Analysis - In 1999 the NDWR compared the Navajo-Gallup Water Supply Project with comparable municipal pipeline projects in the Western United States. This selection was originally compiled by MSE-HKM & Associates. The results of this comparison are shown in Figure 3.1. This list includes projects funded by the Garrison Reformulation Act including projects at Fort Berthold, Standing Rock and Fort Tolten, and the Southwestern Pipeline. It also includes the WEB Rural Water Development Project, the Lewis and Clark Rural Water System, the Mid-Dakota Rural Water System, the Mni Wiconi Project and the north-central Montana Project. The unit cost of the Navajo-Gallup Water Supply Project is approximately $11,000 per acre-foot of water (based on a Project cost of $350 million). This unit cost is less than 65 percent of the overall average unit cost of all of the projects evaluated. The unit cost of the Navajo-Gallup Water Supply Project is only $3,700 greater than the least expensive unit cost of the other nine projects reviewed. Additionally, the estimated operation and maintenance cost per acre-foot for the Navajo-Gallup Water Supply Project is only 78 percent of the overall average. These figures demonstrate that this Project compares very favorably with the other similar water supply projects.

Figure 3.1 : Comparsions of Muncipal Water Projects

Projects	Total Capital $ Cost	Annual O&M	Annual Pumping Cost	G.P.D.	TCC/ Person	O&M/ Person	O&M/ 1000 Gal.	Pumping/ 1000GAL	TCC/ G.P.D.	Unit Cost/ Acre-Feet
ort Berthold	$95,746,810	$2,197,296	$409,965	299	$9,705	$223	$2.04	$0.38	$789	$28,970
tanding Rock-Phase I	$11,069,217			391	$4,290					$8,386
ort Totten-Phase I	$6,226,625			141	$1,159					$7,334
outhwest Pipeline	$200,220,240	$1,752,700	$1,489,300	302	$3,626	$32	$0.29	$0.24	$173	$10,712
VEB Rural Pipeline	$176,416,000	$938,000	$227,000	309	$7,787	$41	$0.37	$0.09	$149	$22,499
ewis & Clark	$330,993,000	$3,451,623	$1,816,409	56	$1,114	$12	$0.57	$0.30	$285	$17,897
lid-Dakota	$157,787,010	$1,803,176	$359,781	84	$3,094	$35	$0.55	$0.11	$215	$15,652
lni Wiconi	$318,521,610	$4,018,000	$1,707,000	215	$6,169	$78	$0.99	$0.42	$459	$25,535
lorth Central Montana	$207,883,520	$1,428,565	$349,047	230	$6,944	$48	$0.57	$0.14	$230	$26,945
lav-Gallup	$350,372,000	$5,038,489	$3,568,969	160	$1,735	$30	$0.59	$0.50	$356	$11,061
Minimum	$6,226,625	$938,000	$227,000	56	$1,114	$12	$0.29	$0.09	$149	$7,334
Average	$185,526,603	$2,578,481	$1,240,934	219	$4,562	$62	$0.75	$0.27	$332	$17,499
Maximum	$350,372,000	$5,038,489	$3,568,969	391	$9,705	$223	$2.04	$0.50	$789	$28,970







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- Collection of NIIP Return Flows - An alternative water supply is to collect subsurface drainage water from NIIP irrigated lands. The potential advantage of sub-surface return flow is that it would be available all year reducing the need for Project storage at NIIP. Relief and interceptor drains would intercept groundwater helping to maintain the agricultural productivity at NIIP. Collector drains would collect the water from the relief and interceptor drains. Outlet drains would carry the collector drain water to a central location(s) for pumping into a forebay reservoir. A portion of the cost of the proposed collection systems may be incurred by NIIP to maintain commercial farming.

  A study is being conducted on NIIP to predict the groundwater buildup under current and future irrigation practices. The groundwater model is being updated as additional input data is available and as assumptions are refined. Using return flows would not reduce the overall combined depletions associated with NIIP and the Project. However, it could reduce NIIP discharges into the San Juan River that may affect native species.

  Recent studies of selenium levels in the San Juan River demonstrated that the environmental benefits of preventing these return flows from entering the San Juan River may be minimal. The relatively small volume of return flows, the high cost of the collection system, concerns regarding the expense of water treatment and the minimal environmental benefit have eliminated this option from further consideration as a water supply alternative.

- Groundwater Alternatives - In 1998 the NDWR prepared a summary of the current groundwater production for public water systems within the Navajo-Gallup Water Supply Project area. In some respects this report updates the 1976 report prepared by Turney & Associates. The NDWR identified and evaluated potential groundwater supply alternatives for each community within the Project area. The level of analysis is appropriate for planning purposes of the Navajo Chapters in the Project service area. For most of the communities evaluated, additional groundwater development is hindered by low yields, poor water quality, large depths to water and very low recharge rates. These conditions make the cost of drilling and pumping prohibitively expensive. Limited supplemental groundwater supplies were considered for several of the communities in the service area and they are included in the Project for development.

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1999 - San Juan River Recovery Implementation Program Flow Recommendations

In 1991 the USFWS designated much of the San Juan River as critical habitat for the Colorado pikeminnow (formerly known as the Colorado squawfish) and razorback sucker. This designation dramatically impacted the ability of water users to deplete additional water from the San Juan River.

In the early 1990's the USFWS issued a biological opinion that concluded that an additional depletion of 57,100 acre-feet of water out of the San Juan River for the Animas-La Plata Project and 120,000 acre-feet for NIIP would jeopardize the continuing existence of the endangered Colorado pikeminnow and razorback sucker. The USFWS reasonable and prudent alternative for the Animas-La Plata Project included a recovery program that was initiated in 1992. The program included a research period of approximately seven years and a recovery period of an additional seven years. The goals of the recovery program are to:

- Conserve populations of Colorado pikeminnow and razorback sucker in the basin consistent with the recovery goals established under the Endangered Species Act.

- Proceed with water development in the basin in compliance with federal and state laws, interstate compacts, supreme court decrees, and federal trust responsibilities to the Tribes.

In 1992 the recovery program established the total San Juan River baseline depletions for New Mexico at approximately 440,000 acre-feet.

One component of the USFWS's 1992 reasonable and prudent alternative for NIIP included participation in the recovery program. This decision by the USFWS enabled NIIP to initiate construction of Blocks 7 and 8. Additional features of the alternative included incorporating "conservation acreage" into NIIP's crop rotation, allocating NIIP project-wide water shortages, and transferring 16,400 acre-feet of baseline depletions from other Navajo irrigation projects in the Shiprock area. With these constraints the overall Navajo depletions from the San Juan River, and in the environmental baseline, did not increase.

Due to the recovery program the San Juan River and the operation of Navajo Dam have been the subject of intensive research. Between 1992 and 2000, NIIP invested approximately $14 million supporting the recovery effort. Based on that research, the flow requirements necessary to protect the endangered fish were assessed. The first phase of the flow recommendations were approved by the recovery program in May 1999 (Holden 1999). These recommendations have been provided to the USFWS for use in future Section 7 Consultations. The initial flow recommendations indicate that an additional 122,000 acre-foot annual withdrawal may be possible without jeopardizing the endangered fish. Through NIIP's 1999 consultation with the USFWS, this volume of depletion was added to the San Juan River environmental baseline. This additional depletion is barely sufficient to complete the construction of NIIP, and it does not enable NIIP to restore the 16,400 acre-foot baseline depletion to the Navajo irrigation projects in the Shiprock area. Additional features of the reasonable and prudent alternative include:

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- Re-operation of Navajo Dam to mimic a natural hydrograph and meet the flow recommendations for the San Juan River

- Construction of three rearing ponds to assist the augmentation program for razorback suckers and potentially Colorado pikeminnows

- Removal of the Cudei Diversion Dam to provide fish access to designated critical habitat

- Construction of fish passage at the Hogback Diversion Dam to provide fish access to designated critical habitat

- Improve irrigation efficiency to reduce irrigation return flows, improve water quality, and reduce impacts to river flows

- Continued funding of, and participation in, the San Juan River Recovery Implementation Program

Pending future research and recovery, the outcome of future Section 7 Consultations with the USFWS may enable additional depletions. Work is continuing to refine and optimize the required flow conditions for the fish while allowing water depletions for future development. Because the point of diversion for this Project has critical hydrologic implications, its location may be largely determined by the requirements of the endangered species in the San Juan River.

2000 - Investigation of the City of Gallup Transmission and Storage Facilities

The *City of Gallup Transmission and Storage Facilities* (December 2000) by DePauli Engineering and Surveying Company presented a preliminary design and cost estimate for distributing the Project water from the Yah-ta-hey Junction through the City of Gallup to the NTUA systems in Churchrock on the east, Manuelito and Spencer Valley on the west, and Redrock on the south. DePauli also investigated the required peaking factor for the City of Gallup. The total estimated cost for construction, engineering and contingencies for this regional project is $23.5 million (excluding costs associated with addressing NEPA, cultural resources and right-of-way).

2001 - A technical summary and plan of approach for the Project

This document is the *Navajo-Gallup Water Supply Project Technical Memorandum*. It presents a summary and analysis of the Navajo-Gallup Water Supply Project with reconnaissance level cost estimates. It includes Project alternatives which can meet the Project's purpose and need. And, it forms the basis of understanding between the Navajo Nation and the City of Gallup for establishing a partnership to construct the water system.

Navajo-Gallup Water Supply Project

More than twenty-five years of studies have reached essentially the same conclusions. The range of alternatives is very limited because the San Juan River is the only viable, long-term, source of water. Configurations have been developed which, at an appraisal level, appear to meet the Project's purpose in an economic manner. Further refinements and analysis to the Project plan such as the selection of reservoir sites, pipeline alignments, and other project facilities will require the collection and analysis of on-the-ground design data and information which will be generated through the NEPA compliance activities that started in March 2000. The draft planning report which is being prepared by Reclamation will be completed by December 2001. The Final Planning Report and EIS will be completed by January 2003.

4.0 WATER DEMAND IN THE PROJECT SERVICE AREA

The Project service area includes two Navajo Chapters in Arizona and 41 in New Mexico. It also includes NAPI, the City of Gallup, and Navajo land adjacent to the City of Gallup. To better characterize the water supply and demand of the region and the Project's service area, the communities have been grouped into twelve municipal subareas as shown in Figure 4.1. The subareas include: (1) City of Gallup, (2) Central Project Chapters, (3) Crownpoint, (4) Gallup Area (Navajo land adjacent to the City of Gallup), (5) Huerfano, (6) Rock Springs, (7) Route 666 Chapters, (8) San Juan River Chapters, (9) Torreon, (10) NAPI, (11) Window Rock, and (12) Thoreau-Smith Lake. A list of the municipal subareas and the communities within those areas served is shown in Table 4.1.

The water demand in the Project service area is based on three distinct components: (1) current population, (2) per capita water use, and (3) projected growth rates. The assumptions underlying those components are presented in this section.

4.1 Current population

The Navajo population statistics for this analysis are based on 1990 census data as reported in the *1990 Census - Population and Housing Characteristics of the Navajo Nation* (Rodgers 1993). The Project service area includes more than 66,000 people in New Mexico (including the City of Gallup) and more than 11,000 in Arizona. The population totals for each municipal subarea and basin are shown in Table 4.1. Population totals for the specific chapters in the Project service area are shown in Tables 4.2. Population totals for the Thoreau-Smith Lake Subarea, which is outside of the Project service area but within the study area, are shown in Table 4.3. The projected populations within the Upper Colorado River, Lower Colorado River, and Rio Grande Basins at ten year intervals are shown in Table 4.4. The population statistics presented in this technical memorandum do not take into account that the U.S. Census Bureau believes that the actual population of Navajos in 1990 was approximately 13.9 percent greater than the official count. After reviewing housing statistics, the McKinley County staff believe that the undercount in the study area may be even greater, but the County has not definitively quantified the undercount.

The current population of the City of Gallup is approximately 23,000. Statistics from the Northwestern New Mexico Council of Governments show that 30 percent of the City of Gallup population is Navajo. Growth trends indicate that Navajos may comprise approximately 50 percent of the Gallup population by the year 2040.

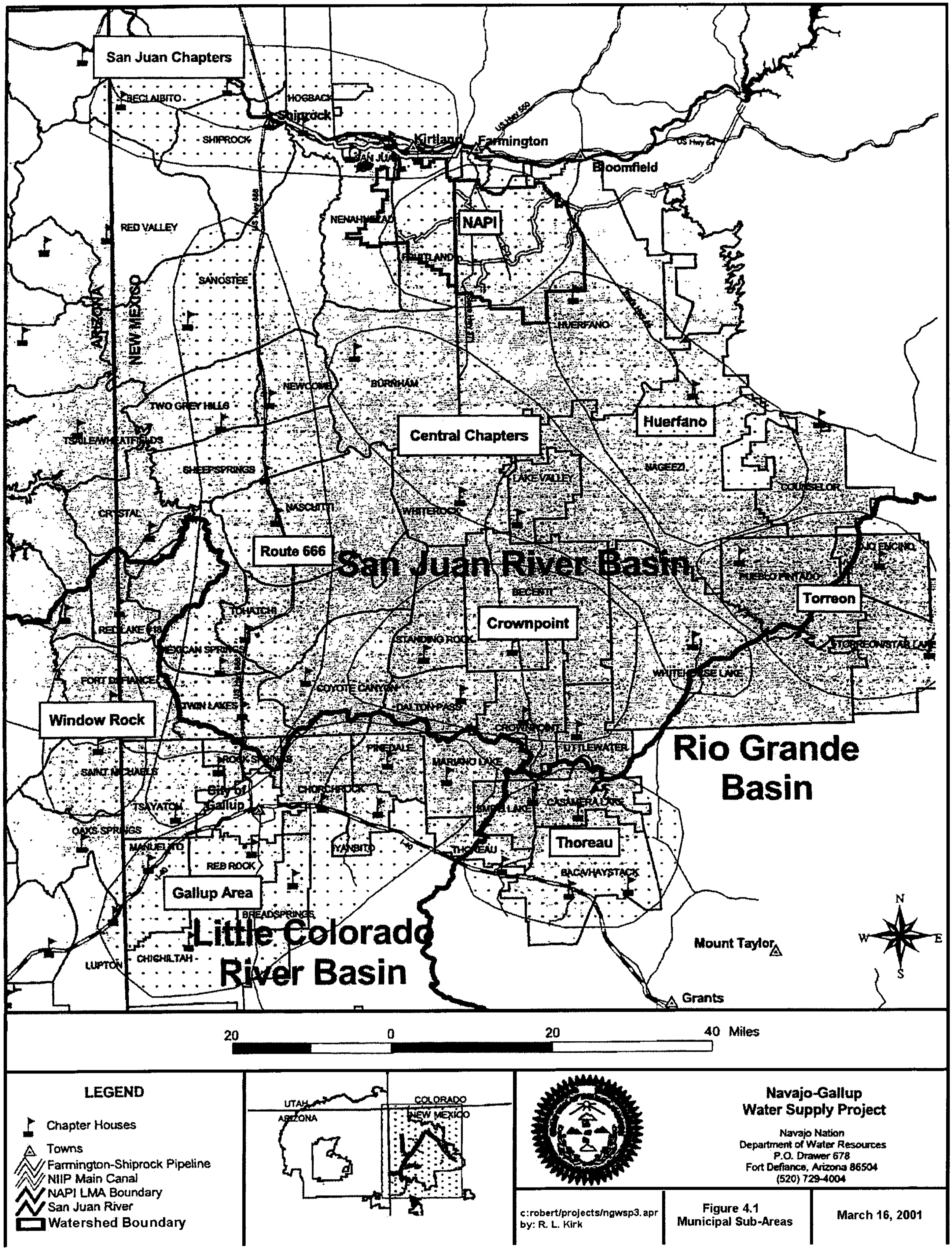


Figure 4.1
Municipal Sub-Areas

Table 4.1
Municipal Water Demand by Basin for the Navajo-Gallup Water Supply Project

Municipal Sub-Area	Basin of Use [2]	1990 Census Pop	2040 Pop [3]	2040 Demand [4] (Ac-ft/yr)	2040 G.W. Production & ALP [5] (Ac-ft/yr)	2040 SJR Diversion [6] (Ac-ft/yr)	2040 SJR Depletion [7] (Ac-ft/yr)
Central Area, NM	U.C.	1,493	5,082	911	77	834	834
City of Gallup, NM [8]	L.C.	19,154	47,197	8,459	1,439	7,500	7,500
Crownpoint, NM	U.C.	5,287	17,996	3,225	752	2,473	2,473
Gallup Area, NM	L.C.	7,904	26,903	4,822	506	4,316	4,316
Huerfano, NM	U.C.	1,492	5,078	910	46	864	864
NAPI Industrial, NM [9]	U.C.	n/a	n/a	7,274	0	700	700
Rock Springs, NM	L.C.	3,749	12,761	2,287	169	2,118	2,118
Route 666, NM	U.C.	10,099	34,374	6,161	795	5,366	5,366
San Juan River, NM [10]	U.C.	13,804	46,985	8,421	4,680	3,741	1,871
Torreon, NM [11]	U.C./ R.G.	3,797	12,924	2,316	77	2,240	2,240
NEW MEXICO UPPER COLORADO BASIN	U.C.	34,012	115,767	28,023	7,050	15,100	13,229
NEW MEXICO RIO GRANDE BASIN	R.G.	1,960	6,672	1,196	77	1,119	1,119
NEW MEXICO LOWER COLORADO BASIN	L.C.	30,807	86,861	15,568	2,114	13,934	13,934
TOTAL NEW MEXICO		66,779	209,300	44,788	9,241	30,153	28,282
TOTAL ARIZONA [11]	L.C.	11,767	40,052	7,179	767	6,411	6,411
PROJECT TOTAL		78,546	249,352	51,967	10,008	36,564	34,693

Notes:

1. Rounding error may cause subtotals to be off by 1
2. U.C.= Upper Colorado Basin, L.C.=Lower Colorado Basin, AND R.G.=Rio Grande Basin.
3. Annual growth for the City of Gallup is 1.82% and for Navajo Nation is 2.48%.
4. Per capita water demand is 160 gallons per person per day.
5. Estimated sustainable groundwater production.
6. Diversions = demand - groundwater use.
7. Depletions are based on zero return flow and use of sustainable groundwater.
8. The City of Gallup plans to recharge its aquifer and use groundwater for summer seasonal peaking.
9. NAPI depletions are 700 ac-ft/year including 400 ac-ft/year for the proposed french fry factory.
10. Approximately 4,680 acre-feet/yr of diversion and 2,340 acre-feet per year of depletion from the San Juan River Subarea's demand is met by the ALP Project and 1,871 acre-feet of depletion is met by the Navajo Gallup Water Supply Project. Assume 50 percent of the San Juan River municipal diversions return to the River.
11. Torreon includes use in the Rio Grande Basin. These depletions are counted toward New Mexico Upper Colorado River allocation.
12. Window Rock Subarea includes depletions which are counted toward the Arizona Lower Colorado allocation.

Table 4.2
Chapter Water Demand for the Navajo-Gallup Water Supply Project

Service Area	Chapter	1990 Population	2040 Population	2040 Demand (Ac-ft/yr)	2040 G.W. Production and ALP (Ac-ft/yr)	2040 SJR Depletion[1] (Ac-ft/yr)
City of Gallup, NM	City of Gallup	19,154	47,179	8,459	1,439	7,500
Central Area, NM	Burnham	246	837	150	0	150
	Lake Valley	436	1,484	266	46	220
	White Rock	201	684	123	See Lake Valley	123
	Whitehorse Lake	610	2,076	372	31	341
	SUBTOTAL	*1,493*	*5,082*	*911*	*77*	*834*
Crownpoint, NM	Becenti	193	657	118	See Crownpoint	118
	Coyote Canyon	1,234	4,200	753	61	692
	Crownpoint	2,658	9,047	1,622	614	1,008
	Dalton Pass	313	1,065	191	0	191
	Little Water	638	2,172	389	See Crownpoint	389
	Standing Rock	251	854	153	77	76
	SUBTOTAL	*5,287*	*17,996*	*3,225*	*752*	*2,473*
Gallup Area, NM	Bread Springs	1,219	4,149	744	77	667
	Chichiltah	1,555	5,293	949	See Bread Spr	949
	Church Rock	1,780	6,059	1,086	123	963
	Iyanbito	974	3,315	594	153	441
	Mariano Lake	726	2,471	443	92	351
	Pinedale	609	2,073	372	See Mariona Lk	372
	Red Rock	1,041	3,543	635	61	574
	SUBTOTAL	*7,904*	*26,903*	*4,822*	*506*	*4,316*
Huerfano, NM	Huerfano	511	1,739	312	31	281
	Nageezi	981	3,339	598	15	583
	SUBTOTAL	*1,492*	*5,078*	*910*	*46*	*864*
Rock Springs, NM	Manuelito	631	2,148	385	46	339
	Rock Springs	1,685	5,735	1,028	77	951
	Tsayatoh	1,433	4,878	874	46	828
	SUBTOTAL	*3,749*	*12,761*	*2,287*	*169*	*2,118*
Route 666, NM	Mexican Springs	711	2,420	434	See Tohatchi	434
	Naschitti	1,539	5,238	939	77	862
	Newcomb	651	2,216	397	12	385
	Sanostee	2,081	7,083	1,270	153	1,117
	Sheep Springs	660	2,246	403	15	388
	Tohatchi	1,607	5,470	980	307	673
	Twin Lakes	1,967	6,695	1,200	153	1,047
	Two Grey Hills	883	3,005	539	77	462
	SUBTOTAL	*10,099*	*34,374*	*6,161*	794	*5,367*
Torreon	Counselor	1,365	4,646	833	0	833
	Ojo Encino	596	2,029	364	15	349
	Pueblo Pintado	472	1,607	288	0	288
	Torreon	1,364	4,643	832	61	771
	SUBTOTAL	*3,797*	*12,924*	*2,316*	*76*	*2,240*
San Juan River[2]		13,804	46,985	8,421	2,340	1,871
NAPI Industrial[3]		n/a	n/a	7,274	0	700
TOTAL NEW MEXICO		*66,779*	*209,282*	*44,788*	*6,199*	*28,284*
Window Rock, AZ	Fort Defiance	6,187	21,059	3,774	767	3,007
	St. Michaels	5,580	18,993	3,404	See Fort Def	3,404
TOTAL ARIZONA		*11,767*	*40,052*	*7,179*	*767*	*6,412*
PROJECT TOTAL		***78,546***	***248,889***	***51,967***	***7,668***	***34,693***

Table 4.3
Water Demand for the remaining Chapters in the Study Area

Municipal Subarea	Chapters	1990 Population	2040 Population	2040 Demand (Ac-ft/yr)	2040 SJR Depletion (Ac-ft/yr)
Thoreau-Smith Lake[1]	Baca/Haystack	731	2,488	446	0
	Casamera Lake	568	1,933	347	0
	Smith Lake	515	1,753	314	0
	Thoreau	1,786	6,079	1,090	0
TOTAL		*3,600*	*12,253*	*2,196*	*0*

Note:
1. The Thoreau-Smith Lake Subarea is outside of the Project service area, but is within the Study Area. These Chapters do not receive San Juan River water.

Table 4.4
Projected Population in the Project Service Area by Basin

Decade	New Mexico Upper Colorado Basin	New Mexico Lower Colorado Basin	New Mexico Rio Grande Basin	Arizona Lower Colorado Basin	Project Total
2000	43,453	37,828	2,504	15,033	98,818
2010	55,516	46,494	3,199	19,206	124,416
2020	70,926	57,205	4,087	24,538	156,756
2030	90,614	70,454	5,222	31,349	197,639
2040	115,767	86,861	6,672	40,052	249,352
2050	147,904	107,200	8,523	51,170	314,796
2060	188,960	132,439	10,889	65,374	397,662

Note:
1. Annual growth for the City of Gallup is 1.82 percent and for Navajo Nation is 2.48 percent.

4.2 Projected growth rates

The City of Gallup has estimated that its annual growth rate over the next five decades will be between 1.32 and 2.36 percent per year. The City of Gallup's 1991 *Water-Supply Study and the Forty-year Water Supply Master Plan* (Shomaker 1991) utilized a 1.82 percent growth rate for projecting the City's water demand. This rate is based on a stable population base and assumes that the economy does not encourage people to move into, or out of, Gallup.

Due to the difficulty in conducting an accurate census, determining the growth rate of the Navajo Nation is difficult. The Navajo Nation's reported annual increase in population changes dramatically from one census to the next. For instance, during the 1950's the reported annual growth rate of the Navajo Nation's population was 3.57 percent, during the 1960's it was 1.45 percent, during the 1970's it was 1.76 percent and during the 1980's it was 4.48 percent. In 1990 the Navajo Division of Community Development determined that the average annual growth of the Navajo Nation is about 2.48 percent per year and the average Navajo family has 4.52 people (*1990 Census - Population and Housing Characteristics of the Navajo Nation,* Rodgers,1993).

Several other analyses of the population growth rate have been conducted. In a 1996 population study for the New Mexico Interstate Stream Commission, the University of New Mexico Bureau of Business and Economic Research (BBER) estimated that the 1990 growth rate for Native Americans in McKinley and Cibola Counties was 1.86 percent. The BBER study included members of the Navajo Nation, and the Pueblos of Acoma, Laguna and Zuni. This BBER study did not adequately address how the current lack of critical infrastructure, including water facilities, is one of the greatest factors leading to stagnant economic growth and increased out-migration.

In 1984 Reclamation used a projected Project population growth rate of 2.5 percent (*1984 Plan Formulation and Environmental Statement*, Reclamation, 1984). The Institute of Distribution and Development Studies at Colorado State University (CSU) evaluated the changes in annual growth rates of the Navajo Nation. CSU concluded that a reasonable annual growth rate for planning purposes is 2.48 percent (*Employment and Incomes in the Navajo Nation: 1987 - 1988 Estimates and Historical Trends* Eckert et. al, 1989). In 1993 Northwest Economic Associates reached the same conclusion (*Support Documentation for Current and Projected Population of the Little Colorado River and N-Aquifer Basins*, NEA, 1993b). The CSU and NEA estimates take into consideration in-migration, out-migration, fertility, and survival rates of the Navajo population. This growth rate has also been accepted by the multi-agency federal team involved in the Little Colorado River settlement negotiations. The NDWR recommends using a 2.48 percent annual growth rate for projecting Navajo water demand through the year 2040. Based on a 2.48 percent annual growth rate for the Navajo Nation and 1.82 percent growth rate for the City of Gallup, by 2040 the service area will include more than 200,000 people in New Mexico and more than 40,000 in Arizona. By the year 2060, the service area will include more than 300,000 in New Mexico and 60,000 in Arizona. The projected populations for specific communities and basins are shown in Tables 4.1, 4.2, 4.3 and 4.4.

4.3 Average daily per capita water use

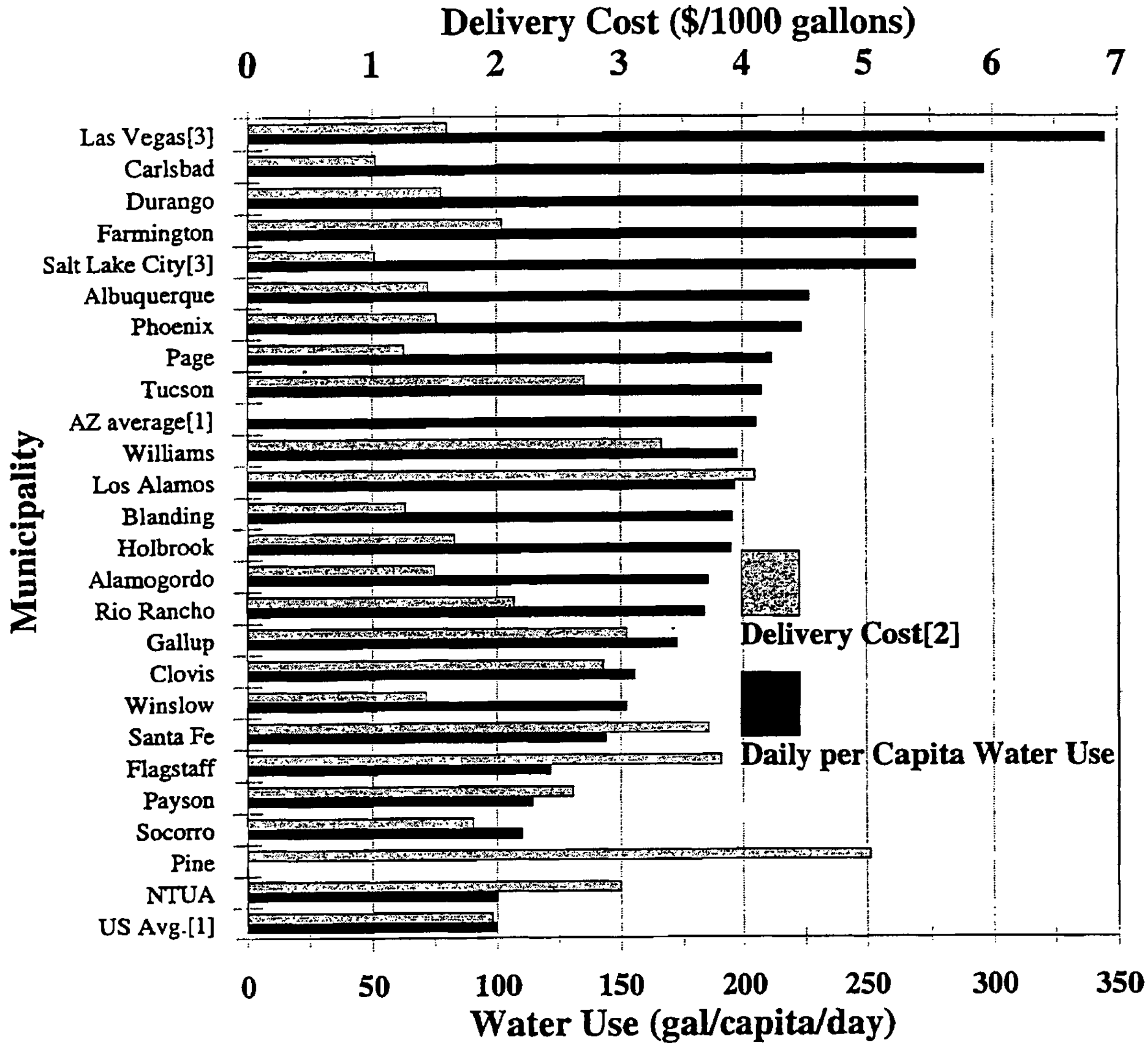
For the purposes of this technical memorandum, the per capita water use is the total community water use divided by the total population. Consequently, this definition includes some water use associated with commercial activity, schools, hospitals and other civic uses. These uses rarely exceed 500 acre-feet per individual user. This definition of per capita water use does not include specific large industrial allocations that may be needed for power plants or large factories.

According to the City of Gallup's 1991 Water Supply Master Plan, the City's average water consumption was 57 gallons per capita per day (gpcd) in 1950, 118 gpcd in 1970, and 160 gpcd in the late 1980's (Shomaker,1991). This 1991 water supply plan states that "since the historical trend of increasing consumption seems to have been arrested, since the future of mining and defense industries is uncertain, and since water conservation measures are expected to maintain or decrease current consumption, no increase in the gpcd was assumed." Consequently the City of Gallup uses 160 gpcd for current and future demand projections. The regional per capita water use comparisons shown in Figure 4.2 illustrate that the City's per capita water use is in the lower third and its water rates are in the top twenty percent.

Per capita water use on the Navajo Reservation varies depending on the accessibility of the water supply. The willingness to pay surveys conducted in 1994 report that 44 percent of the Navajo households in the service area are without direct access to a public water supply system and use very little water. In a 1982 water resource report *Navajo Water Resources Evaluation Volumes 1 - 8*, (Morrison Maierle Inc., 1982), the per capita water use for homes without running water is estimated to be 10 gallons per day. This same rate of water use is cited in *Estimated Use of Water in the United States* (Murray, Richard C., 1965). In 1993, NEA estimated that families which haul water for domestic purposes spend the equivalent of $22,000 per acre-foot compared with $600 per acre-foot for a typical suburban water user in the region (*Cost of Water Hauling, Relocation, and Water Mining and the Value of Family Garden Plots in the N-Aquifer Basin*, NEA, 1993a).

Billing data from NTUA indicates that the average water use on the NTUA systems is approximately 100 gallons per capita per day. According to data from other metered systems, water use on the non-NTUA systems ranges from 20 to 100 gallons per person per day. These low usage rates are often limited by system and supply constraints, not demand. Historic data for non-reservation communities in the region show that water use has increased over time and is currently approximately 160 gallons per capita per day. The increase in per capita water use is correlated with community growth, development and an improved standard of living. Therefore, a per capita water use of 160 gallons per capita per day is recommended for water resource planning on the Navajo Nation.

Figure 4.2
Southwestern Water Use and Water Rate Comparison



Notes:

1 U.S. average per capita use from APWA, Arizona average per capita use from USGS Circular 1200, U.S. average water use rate from Western States Water Circular #1283.

2 Average delivery cost is based on 18,700 gallons per month (25 cubic feet) for residential use. Seasonally variable rates were averaged over the entire year.

3 Salt Lake City and Las Vegas service areas extend beyond their city limits. Per capita water use is the reported value, and not a value calculated by NDWR.

Navajo-Gallup Water Supply Project

As shown in Figure 4.2, the recommended water use rate is well within the rates of other municipalities in the Southwest. This rate allows for increasing water use as the Navajo water systems are developed, and as the Navajo water users achieve parity with non-Indian water users in Arizona and New Mexico. The 160 gallon per capita per day rate has also been accepted by the multi-agency federal team overseeing the Little Colorado River settlement negotiations and it has been used for regional water plans in Arizona. This per capita water use is also cited in the City of Albuquerque's long-term water strategy (Brown, 1996).

The water demand projections using this rate per capita water use rate are shown in Tables 4.1, 4.2, and 4.3. The projected municipal demands (excluding NAPI) in the service area within the Upper Colorado River, Lower Colorado River, and Rio Grande Basins at ten year intervals are shown in Table 4.5. By the year 2040, the overall municipal water demand in the service area, excluding NAPI, is 44,700 acre-feet per year.

Table 4.5
Projected Municipal Demand (excluding NAPI) in the Project Service Area by Basin
(Acre-feet)

Decade	New Mexico Upper Colorado Basin	New Mexico Lower Colorado Basin	New Mexico Rio Grande Basin	Arizona Lower Colorado Basin	Project Total
2000	7,789	6,780	448	2,695	17,712
2010	9,951	8,333	573	3,442	22,299
2020	12,672	10,253	773	4,398	28,096
2030	16,241	12,628	936	5,619	35,424
2040	20,749	15,568	1,196	7,179	44,692
2050	26,509	19,214	1,528	9,171	56,422
2060	33,869	23,738	1,951	11,717	71,275

The 1998 groundwater production in the service area was approximately 6,800 acre-feet per year. Of that amount approximately 2,500 acre-feet was for the Navajo public water systems. These estimates are presented in greater detail in Chapter 5. In *Navajo Gallup Water Supply Evaluation of Groundwater and Conjunctive Use Alternatives* (NDWR, February 1998), the NDWR estimated the sustainable groundwater yield that might be available in 2040 for each municipal subarea. For instance, the Window Rock Subarea relies on the alluvial system for approximately 70 percent of its current water supply. NTUA should be able to maintain 760 acre-feet of water production during most years. The groundwater production in the Crownpoint Subarea is projected to double to approximately 750 acre-feet per year.

By the year 2040 groundwater production in the service area is estimated to be 4,600 acre-feet per year. Of that amount, 3,200 acre-feet per year will be for the Navajo Nation public water systems and 1,440 acre-feet will be for the City of Gallup for summer peaking demands. These estimates are presented in greater detail in Chapter 5. These assumptions are very similar to the conclusions reached by Turney and Associates in that water needs assessment (Turney, 1976). Without the Project severe municipal water shortages will ensue. Figure 4.3 shows the depletion schedule for the Project including groundwater withdrawals. Table 4.6 presents the projected San Juan River Project depletions by Basin. Detailed information on the Project depletions is shown in Appendix ___.

Figure 4.3
Projected Annual Depletions in the Navajo-Gallup Project Service Area

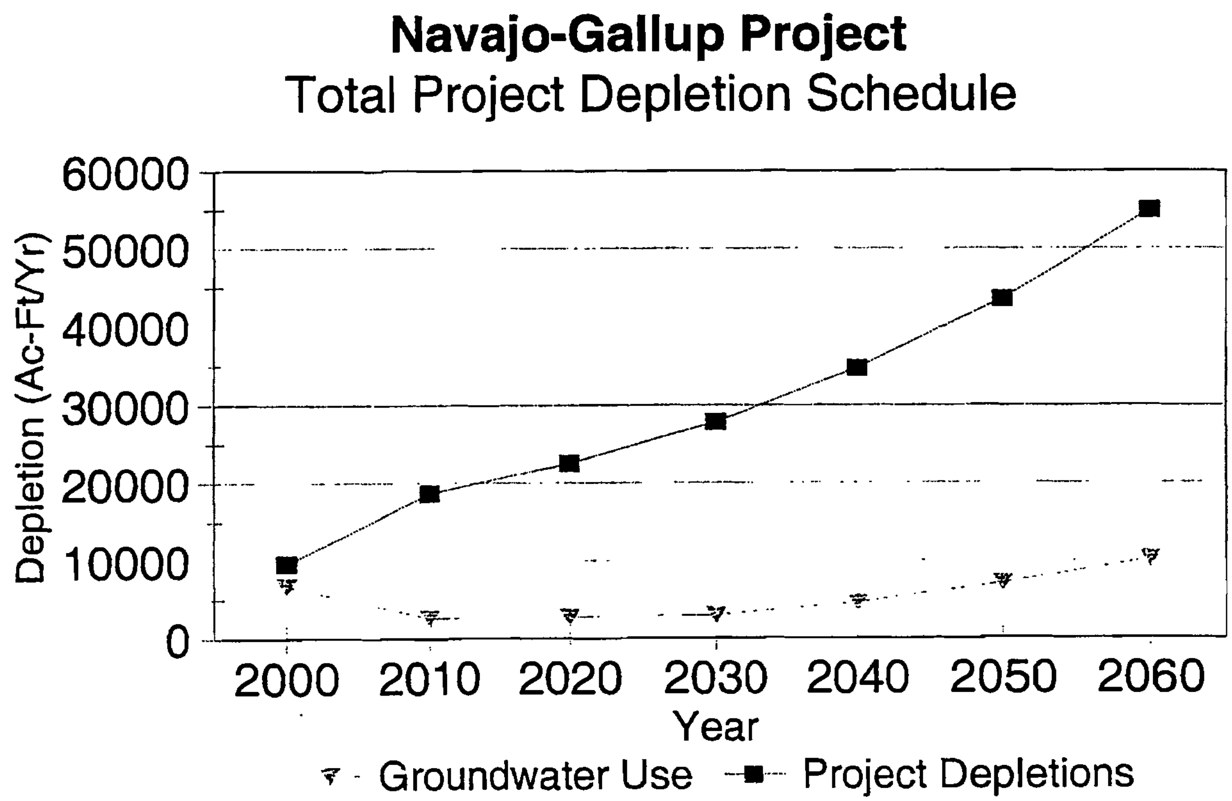


Table 4.6
Projected Navajo Gallup Water Supply Project San Juan River Depletions (including NAPI) in the Project Service Area by Basin
(Acre-feet)

Decade	New Mexico Upper Colorado Basin	New Mexico Lower Colorado Basin	New Mexico Rio Grande Basin	Arizona Lower Colorado Basin	Project Total
2000	5,242	2,352	336	1,652	9,582
2010	5,202	10,503	470	2,469	18,644
2020	6,996	11,360	638	3,493	22,487
2030	9,722	12,479	850	4,783	27,834
2040	13,229	13,934	1,119	6,411	34,693
2050	17,820	15,907	1,451	8,404	43,583
2060	23,686	18,429	1,875	10,950	54,939

4.4 Seasonal and daily peak per capita water use

Over the course of a day, week, month and year significant fluctuations occur in a municipal water system's demand. .To avoid rationing and customer disruptions, and to assist with fire protection, municipal water systems should have adequate production capacity to meet the estimated requirements during peak demand days. The NDWR reviewed several water use studies to determine the appropriate peaking factors for this Project.

The daily peaking factor is the peak daily water use divided by the average daily water use. Daily municipal peaking factors from comparable municipalities and projects are shown in Table 4.7. These daily peaking factors range from 1.70 to 2.50.

However, it may not be economical to design the main conveyance system of this project large enough to meet the daily peak demands. It may be more economical to design the main conveyance system to meet the seasonal demands, and to meet the daily peak water demands with local storage tanks. The daily average water demand for a municipal system during the maximum month is typically 1.2 times the daily average demand during the entire year. The daily average demand during the maximum week is typically 1.4 times the average daily demand during the year (Davis et.al., 1985).

Table 4.7
Daily Municipal Peaking Factors from Comparable Municipalities and Projects

Community	Daily Peaking Factor
Bloomfield	1.70
Shiprock (NTUA)	1.70
Gallup	1.80
Standing Rock and Fort Tolten	1.80
Mid-Dakota Rural System	2.10
Mni Wiconi and Fort Berthold	2.22
Farmington	2.40
Aztec	2.50

In 1993 Molzen-Corbin and Associates (MCA) prepared a report entitled *Navajo Tribal Utility Authority Shiprock Water Supply Study*. According to that study "At minimum, water systems should have enough capacity to meet sustained production needs during the peak 7-day period demand which is the greatest volume of water required over any seven-day period." MCA reviewed daily water production data between 1988 and 1992 for the NTUA's Shiprock system. The ratio between the peak seven day demand and the average daily demand is 1.28 which MCA rounded to 1.3. The greatest demand period for the City of Gallup occurs during the first half of July. The summer peaking factor for the City is 1.35 (DePauli, 2000). These peaking factor values are within the range of values cited by Davis.

At a minimum the Project should have enough capacity to meet sustained production for a seven-day period. In a letter dated August 28, 2000, from David Ruiz (City Manager) and Arvin Trujillo (Executive Director, Division of Natural Resources) to Rege Leach (Project Manager, Reclamation), the participants recommend that the Project be sized to handle a seasonal peaking factor of at least 1.3. Daily peak water demands of approximately 1.8 will be handled by local storage tanks. The peaking factor used in this technical memorandum is 1.3.

4.5 NAPI's water demand for future projects

In a June 30, 1993 letter from Tsosie Lewis, General Manager of NAPI, to Peterson Zah, President of the Navajo Nation, the General Manager described the positive benefits of the Project for NIIP including: (1) additional support for the construction of additional water storage, (2) a much needed supply of treated water that would be required for future agricultural processing projects, and (3) additional opportunity for NAPI to diversify its business activities which will increase profits and employment. In that letter, NAPI describes a variety of future projects that will be possible when NIIP is completed. These projects, listed in Table 4.8, may require a total of 7,274 acre-feet of treated water and 3,420 acre-feet of untreated water. The untreated water demands for NAPI have not been included in the demand tabulations.

All of these projects have been further evaluated. The project that has reached the most advanced state of planning is the potato chip and frozen french-fry factory. As recently proposed, this project will be a joint venture partnership with R.D. Offutt and Son, Incorporated. The proposed factory venture would create 500 jobs and the growing venture would create 100 jobs. The factory will process 600 million pounds of potatoes into 300 million pounds of frozen potato product with annual sales of $100 million and $15 million in pretax profits. The factory venture will use between 2,000 and 4,000 acre-feet of water per year. Most of the effluent from the factory will be used to irrigate fields. Approximately 400 acre-feet of the factory's water supply will be depleted. The BIA successfully consulted with the USFWS on this depletion as required under Section 7 of the Endangered Species Act. In addition to this 400 acre-feet of depletion, an additional 300 acre-feet of depletion, for a total of 700 acre-feet, have been included in the Navajo-Gallup Project for NAPI to pursue additional industrial diversification.

Table 4.8
Future NAPI Processing Water Demand

Future Project	Treated Water (Acre-feet)	Untreated Water (Acre-feet)
1. Dairy Farm Operation	112	
2. Hog Farm Operation	10	
3. Poultry Operation	336	
4. Vegetable Canning Plant	1,120	
5. Milk Packaging	1,120	
6. Ethanol-Gasohol		1,120
7. Animal Slaughter Plant	1,120	
8. Meat Packaging	1,120	
9. Potato Chip & French Fry Plant	1,120	
10. Frozen Vegetable Plant	1,120	
11. Dehydrated Onions	20	
12. Compressed Hay Bales		
13. Nursery Stock and Products		1,200
14. Christmas Trees		1,000
15. Aquiculture		100
16. Carrot Fresh Pack	22	
17. Truck Stop	22	
18. Farmer Market	5	
TOTAL	7,274	3,420

Source: Letter dated June 30, 1993 from Tsosie Lewis, General Manager of NAPI to Peterson Zah, President of the Navajo Nation.

5.0 WATER PRODUCTION IN THE SERVICE AREA

The objective of this section is to quantify the existing water production in the region. Outside of the San Juan River Chapters, the Navajo communities in the region and the City of Gallup rely almost entirely on groundwater for their water supply. The public water systems in the Project service area derive water from a variety of groundwater sources ranging from shallow, unconfined aquifers to deep, confined aquifers. The major aquifers are: (1) Permian and Triassic formations of the Coconino Aquifer system which include the De Chelly Sandstone and Shinarump Member of the Chinle Formation on the Defiance Plateau in Arizona, (2) Permian Glorietta and San Andreas Limestone in New Mexico, (3) Mesozoic sandstone formations which include the Morrison Formation and the Dakota Sandstone, (4) Cretaceous Gallup Sandstone, (5) the Tertiary Ojo Alamo Sandstone, and (6) alluvial deposits in the major drainages.

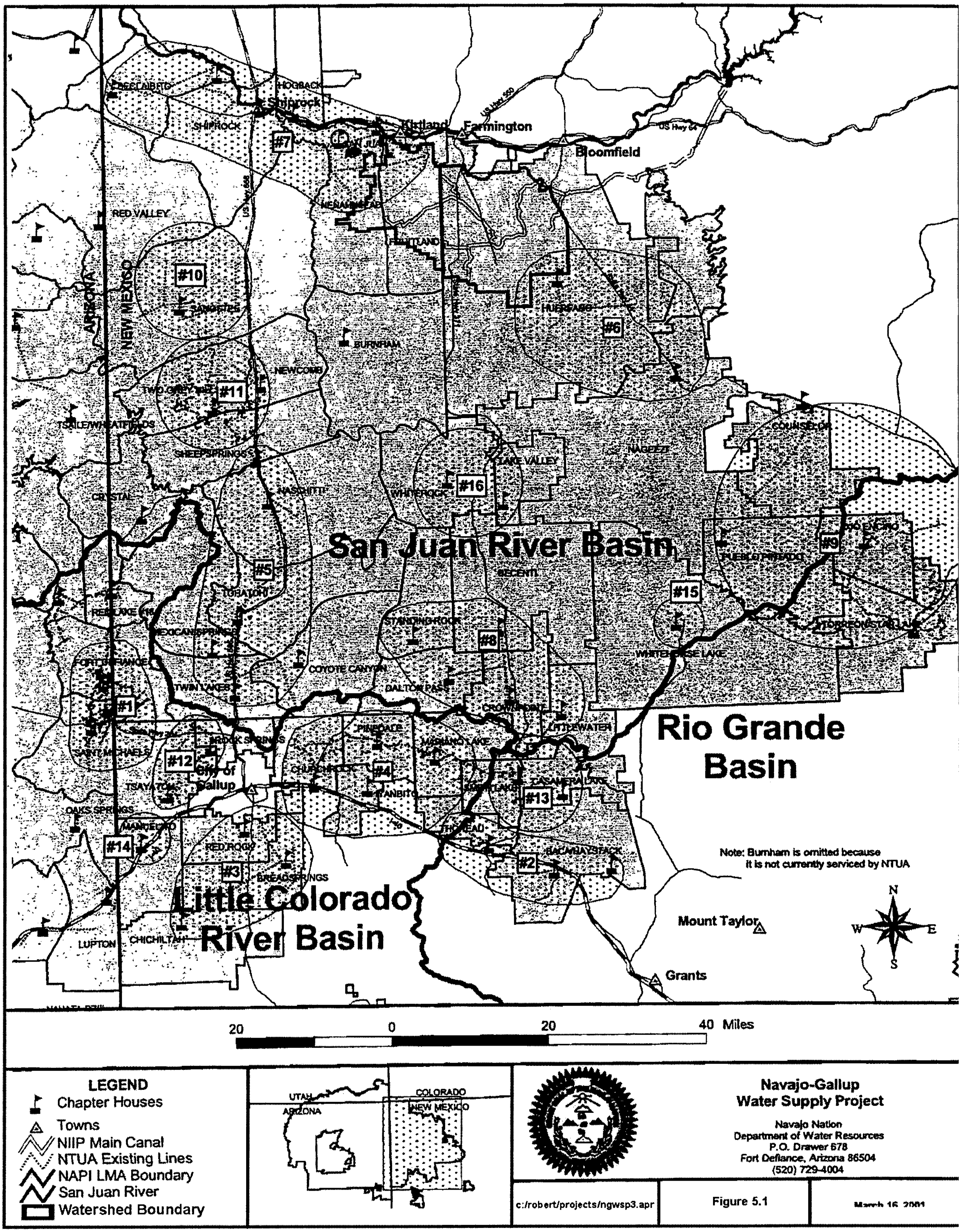
Alternatives to the proposed Project may include upgrading and extending existing water systems, and increasing groundwater withdrawals to meet part of the future demand. These alternatives have been investigated for each municipal subarea and they are described in Section 8.3. Most of the aquifers investigated are undesirable for additional long-term municipal development because of the harmful impacts of continued over-drafting on the groundwater. Continued over-drafting of the groundwater may:

- lower the water levels in wells and increase the pumping depths
- reduce the yield of the well fields
- reduce the quality of the water supply
- increase the capital and operating costs
- deplete the groundwater available for a drought reserve
- lower the water table in riparian areas
- cause land subsidence

The water production in the region and the Project's service area, is grouped into twelve municipal subareas as shown in Figures 4.1 and 5.1. The subareas include: (1) City of Gallup, (2) Central Project Chapters, (3) Crownpoint, (4) Gallup Area (Navajo land adjacent to the City of Gallup), (5)Huerfano, (6) Rock Springs, (7) Route 666 Chapters, (8) San Juan River Chapters, (9) Torreon, (10) NAPI, (11) Window Rock, and (12) Thoreau-Smith Lake. The estimated water production in each subarea is presented in Table 5.1. The NTUA water supply priority of each subarea is shown in Figure 5.1. The Thoreau-Smith Lake Subarea is within the planning region, but it is not within the Project's proposed service area. Detailed well production information for each subarea is given in Appendix C. The estimated populations and water demands are shown in Table 4.1.

TABLE 5.1
Regional Municipal Water Production during 1998

MUNICIPAL SUBAREA	PRODUCTION (Acre-feet)	SOURCE AQUIFER
1. City of Gallup	4,335	Gallup Sandstone Dakota-Westwater
1. Central	27	Alluvium Picture Cliffs Menefee
2. Crownpoint	330	Westwater Morrison Menefee Gallup Sandstone Point Lookout
3. Gallup Area (Navajo land adjacent to Gallup)	258	Gallup Sandstone Dakota-Westwater
4. Huerfano	90	Alluvium Ojo Alamo
5. Rock Springs	58	Gallup Sandstone
6. Route 666	518	Alluvium Morrison Menefee Point Lookout Gallup Sandstone Mesa Verde Dakota
7. San Juan River	2,256	Surface Water
8. Torreon	113	Ojo Alamo
9. NAPI	N/A	Surface Water
10. Window Rock	1,043	Alluvium De Chelly Gallup Sandstone Shinarump
NAVAJO SUB-TOTAL	4,693	
1. Thoreau-Smith Lake	193	Glorieta
REGIONAL TOTAL	9,221	



San Juan River Basin
Rio Grande Basin
Little Colorado River Basin
Shiprock
Kirtland
Farmington
Bloomfield
City of Gallup
Mount Taylor
Grants
HOGBACK
SHIPROCK
RED VALLEY
SANOSTEE
BURNHAM
NEWCOMB
TWO GREY HILLS
TSAILE/WHEATFIELDS
SHEEPSPRINGS
CRYSTAL
NASCHITTI
WHITEROCK
LAKE VALLEY
NAGEEZI
COUNSELOR
HUERFANO
FRUITLAND
NENAHNEZAD
TOHATCHI
MEXICAN SPRINGS
RED LAKE
FORT DEFIANCE
TWIN LAKES
COYOTE CANYON
STANDING ROCK
DALTON PASS
CROWNPOINT
LITTLEWATER
BECENTI
PUEBLO PINTADO
TORREON/STAR LAKE
WHITEHORSE LAKE
ROCK SPRINGS
PINEDALE
MARIANO LAKE
CHURCHROCK
IYANBITO
CASAMERO LAKE
THOREAU
BACA/HAYSTACK
SAINT MICHAELS
TSAYATOH
OAKS SPRINGS
MANUELITO
RED ROCK
BREAD SPRINGS
LUPTON
CHICHILTAH
ARIZONA
NEW MEXICO
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
US Hwy 550
US Hwy 64
Note: Burnham is omitted because it is not currently serviced by NTUA
N
E
S
W
20
0
20
40 Miles
LEGEND
Chapter Houses
Towns
NIIP Main Canal
NTUA Existing Lines
NAPI LMA Boundary
San Juan River
Watershed Boundary
UTAH
COLORADO
ARIZONA
NEW MEXICO
Navajo-Gallup Water Supply Project
Navajo Nation
Department of Water Resources
P.O. Drawer 678
Fort Defiance, Arizona 86504
(520) 729-4004
c:/robert/projects/ngwsp3.apr
Figure 5.1
March 16, 2001

Navajo-Gallup Water Supply Project

5.1 Groundwater production for the City of Gallup

City of Gallup records for 1997 report an average daily water production of 3.87 million gallons per day or 4,335 acre-feet for the year. The maximum daily use was 5.50 million gallons per day. According to the City of Gallup's *Well Production Planning Report* (Sterling & Mataya, and John W. Shomaker and Associates, Inc.,1998) the City derives its groundwater from two confined aquifers, the Gallup Sandstone and the Dakota-Westwater Canyon. The water table in the Gallup Sandstone Aquifer is between 900 and 2,000 feet deep and the aquifer is between 400 and 500 feet thick. The water table in the Dakota-Westwater Aquifer is between 1,900 and 3,000 feet deep and the aquifer is between 300 and 400 feet thick.

The City of Gallup operates two well fields: the Santa Fe Well Field and the Yah-ta-hey Well Field. Historic water table data provided by the City indicate that, from the early 1960's until the late 1990's, the static water level of the Santa Fe Well Field has declined between 340 and 350 feet. And, from the early 1970's until the late 1990's, the static water level of the Yah-ta-hey Well Field has declined between 700 and 835 feet. The City is anticipating a one million gallon per day shortage during peak periods as early as 2010. In 1991, the City's forty-year master water supply plan (Shomaker 1991) identified two short term alternatives including the expansion of the Yah-ta-hey Well Field to the north and developing water in the Ciniza area to the east. Neither alternative is sustainable. The City is also investigating the transfer of water rights from the Plains Escalante Generating Station.

In 1976 the U.S. Geological Survey completed groundwater investigations of the nearby Zuni Mountain and Malpais Region, and the Westwater Canyon Aquifer in the vicinity of Church Rock. The results indicated that the groundwater resources of those areas are inadequate to meet the municipal and industrial needs for the City of Gallup. These findings have been reiterated in numerous studies conducted since that time.

In 1998 the City collaborated with Reclamation and the Pueblos of Acoma and Laguna on an investigation of utilizing existing de-watering wells at the inactive Mount Taylor Mine located near San Mateo, New Mexico. In the March 1999 Technical Appraisal Reclamation estimates that a 4,000 acre-feet yield is possible for a 40-year period. The water source is approximately 70 miles from the City of Gallup and 43 miles from the Pueblo of Laguna. Based on delivering 2,000 acre-feet to the City of Gallup and 2,000 acre-feet to the Pueblos, the total project cost was estimated as $36 million and the annual operation as $2.2 million. This estimate was based on a peaking factor of 1.0 and no storage. Neither the allocation of the costs among the parties, nor the concerns of other interests in the region were addressed by that study. The Mount Taylor Project is not sustainable and does not meet the purpose and needs of the Navajo-Gallup Water Supply Project (Reclamation, 1999).

5.2 Groundwater production for the Navajo Nation

According to the Navajo Environmental Protection Agency, in 1996 there were more than 50 public water supply systems in the Project service area. The largest supplier of domestic and municipal water is NTUA which operates more than 30 water systems in the area. The NTUA systems in the service area are shown in Figures 2.1 and 2.2. The NDWR operates nine systems in the service area. According to data supplied by NTUA and estimates made by the NDWR, in 1998 the Navajo public water systems delivered 5,062 acre-feet in the region. This volume includes approximately 2,200 acre-feet of surface water delivered by the Shiprock NTUA system and 193 acre-feet (or 266?) delivered in the Thoreau-Smith Lake Subarea which is in the planning region, but outside the Project service area. This total also includes 1,043 acre-feet per year delivered by the NTUA system in Window Rock, Arizona.

Descriptions of the groundwater conditions in the municipal subareas are presented in the following section. The population data was provided by Navajo Division of Community Development in *1990 Census - Population and Housing Characteristics of the Navajo Nation* (Rodgers, 1993). Data on the number of service connections for the drinking water systems comes from *Navajo Nation Public Water Systems Inventory Listing May 6 1996* (Navajo EPA, 1996).

5.2.1 Central Project Chapters Subarea

The Central Subarea includes the Chapters of Burnham, Lake Valley, White Rock and Whitehorse Lake. Capacity is included in the main line for these Chapters. However, they may be served by groundwater until additional programmatic resources are available to connect them to the main line. The 1990 population of this subarea was 1,493 and the projected population by the year 2040 is 5,082. The annual water production in 1998 was 8,912,000 gallons (27 acre-feet). Essentially all of the municipal water is from two sources. One source is the Menefee Aquifer near White Horse with a maximum well yield of 16 gpm and well depths of approximately 1,400 feet. The other source is the alluvium aquifer near Lake Valley which has a maximum yield of 24 gpm and well depths of approximately 80 feet. NTUA staff report that a well near Whiterock with a depth of 4,620 feet was abandoned in part due to low yields. The low yields combined with the great depths make groundwater development in this subarea very difficult.

5.2.2 Crownpoint Subarea

The Crownpoint Subarea includes the Chapters of Becenti, Coyote Canyon, Crownpoint, Dalton Pass, Little Water, and Standing Rock. Crownpoint has been designated a primary growth center by the Navajo Division of Economic Development (NDED). The 1990 population of this area was 5,287 and the projected population by the year 2040 is 17,996. Its annual water production in 1998 was 107,416,000 gallons (330 acre-feet). Most of the groundwater in this area is from the Westwater and Morrison Aquifers. The maximum well yield in the area is 248 gpm. near Crownpoint from the Westwater Aquifer. Well depths in the area range from 2,400 to 2,700 feet deep.

Three water systems serve the Coyote Canyon Chapter. One is operated by NTUA and consists of two wells, a 64,000-gallon storage tank, and 114 service connections. The NDWR operates the Bass Lake system, which consists of a well, no storage tanks, and 11 service connections. The Coyote Canyon Chapter operates the Chapter House system, which has a well, an 8,000-gallon storage tank, and 20 service connections. One of the NTUA wells pumps from the Menefee Formation with a yield of about 30 gpm. The NDWR well is artesian and flows at about 60 gpm from the Dalton Sandstone. The Chapter well is completed in sandstones of the Mesa Verde Group and yields about 15 gpm.

5.2.3 Gallup Area

Navajo land adjacent to the City of Gallup has been explicitly included in this plan formulation. This area includes the Chapters of Bread Springs, Chichilta, Church Rock, Iyanbito, Mariano Lake, Pinedale, and Red Rock. The 1990 population of this area was 7,904 and the projected population by the year 2040 is 26,903. The annual water production was 84,078,900 gallons (258 acre-feet). The municipal water is from the Gallup Standstone, Glorietta, Dakota, Chinlee and Morrison Aquifers. Well logs for this subarea indicate that the maximum well yield is 180 gpm near Iyanbito and its depth is approximately 300 feet deep in the Glorietta Aquifer. The producing NTUA wells have depths that range from 1,100 to 1,800 feet. These are some of the same formations that the City of Gallup is withdrawing water from.

5.2.4 Huerfano Subarea

The Huerfano Subarea includes the Chapters of Huerfano and Nageezi. This subarea lies immediately south of the NIIP boundary. The 1990 population of this subarea was 1,492 and the projected population in the year 2040 is 5,078. Its annual water production in 1998 was 29,427,000 gallons (90 acre-feet). Essentially all of the municipal water is from the Ojo Alamo Aquifer. Well logs for this area indicate that the maximum well yield is 81 gpm near Huerfano and its depth is approximately 1,100 feet deep.

5.2.5 Rock Springs Subarea

The Rock Springs Subarea includes the Chapters of Manuelito, Rock Springs, and Tsayatoh. This subarea lies immediately south of the Highway 602 west of the City of Gallup. The 1990 population of this area was 3,749 and the projected population in the year 2040 is 12,761. Its annual water production in 1998 was 18,767,000 gallons (58 acre-feet). Essentially all of the municipal water is from the Gallup and Dakota Aquifers. These are some of the same formations that the City of Gallup is withdrawing water from. Well logs for this area indicate that the maximum well yield is 44 gpm near Tsayatoh and it is approximately 1,300 feet deep.

Rock Springs is served by the NTUA Rock Springs community system, which consists of one well which pumps water from the Gallup Sandstone aquifer with a yield of 20 gpm, a 107,000-gallon storage tank, and 43 service connections. This well is 1,760 feet deep.

Two water systems serve the Tsayatoh Chapter. The Spencer Valley/Defiance system is operated by NDWR and consists of a well which pumps from the Dakota Sandstone aquifer with a yield of about 27 gpm, a 27,000-gallon storage tank, and 21 service connections. The Tsayatoh community system is operated by NTUA and consists of one well which pumps from the Gallup Sandstone aquifer with a yield of about 44 gpm, a 150,000-gallon storage tank, and 67 service connections. Manuelito is served by an NDWR water system.

5.2.6 Route 666 Chapters

The Route 666 Chapters lie along Highway 666 between Shiprock and Yah-ta-hey. With either alignment alternative, these chapters and their public water systems are well positioned to take advantage of the Project water supply as soon as it is available. In addition, some of these chapters are able to take advantage of groundwater. The Route 666 Chapters include Mexican Springs, Naschitti, Newcomb, Sanostee, Sheep Springs, Tohatchi, Twin Lakes, and Two Grey Hills. Tohatchi has been designated by the NDED as a primary growth center. The 1990 population of this area was 10,099 and the projected population by the year 2040 is 34,374. In 1998 the annual water production was 168,723,000 gallons (518 acre-feet).

The communities along Highway 666 produce water from several of aquifers including alluvial sources, the Morrison, Menefee, Gallup Sandstone, and Dakota among others. The maximum well yield in this subarea area is 180 gpm from a well located near Twin Lakes which penetrates the Morrison Formation. This well is approximately 3,200 feet deep.

The Mexican Springs Chapter is served by three water systems, all operated by NTUA. The Tohatchi/Mexican Springs regional system consists of three wells, three storage tanks with a combined capacity of 1,400,000 gallons, and 472 service connections. Two wells pump from the Point Lookout Sandstone with yields ranging from about 30 to 150 gpm. These wells range from 345 feet to 800 feet in depth. The third well produces water from the Gallup Sandstone, Dakota Sandstone, and Morrison Aquifers. The Morrison Aquifer is the primary aquifer with a yield of more than 180 gpm. This well is 1,760 feet deep.

The Black Springs Wash/Deer Springs system consists of a well which pumps from the Crevasse Canyon Formation with a yield of about 15 gpm, an 11,500-gallon storage tank, 39 service connections, and is interconnected with the regional system. The Mexican Springs West Rural system consists of two wells, an 80,000-gallon storage tank, and 47 service connections. The wells pump from the Point Lookout Sandstone with yields of about 10 to 20 gpm.

Navajo-Gallup Water Supply Project

The Naschitti Chapter is served by two interconnected NTUA water systems. The Buffalo Springs system consists of one well which pumps water from the Gallup Sandstone aquifer with a yield of about 55 gpm, a 40,000-gallon storage tank, and 329 service connections. The Naschitti/Bisola system has two wells, three storage tanks with a combined capacity of 230,000 gallons, and 164 service connections. These wells pump from the Menefee and Point Lookout Sandstone aquifers with yields ranging from 70 to 115 gpm. These wells are approximately 1,400 feet deep.

Tohatchi Chapter is served by the Tohatchi/Mexican Springs regional system which also serves Mexican Springs. The Ramona Smith system consists of a single well which flows from a depth of 2,000 feet with a yield of 200 gpm, one storage tank, and 28 service connections.

Two water systems serve the Twin Lakes Chapter. One is the Tohatchi/Mexican Springs regional system. The other is operated by the NDWR, and consists of a single well which flows from the Gallup Sandstone aquifer at about two gpm, a 1,000-gallon storage tank, and has one service connection at the Chapter House.

NTUA operates five wells in the Sanostee Chapter which range in depth from 800 to 2,150 feet. Several of the wells were originally for oil exploration and converted for domestic water supply by NTUA. These wells withdraw water from the Dakota and Morrison Formations, and flowing artesian wells. Nominal well yields range from 30 to 60 gpm. All wells are equipped with submersible pumps. Recharge to the Dakota and Morrison Formations in the Sanostee Area is very limited.

5.2.7 San Juan River Subarea

NTUA's Shiprock District includes the Chapters of Beclaibito, Cudei, Hogback, Nenahnezad, San Juan, Sanostee, Shiprock, and Upper Fruitland. In 1990 the District's population was 15,581. NTUA provides water service to more than 10,000 people living in the Shiprock area and to commercial, industrial and institutional customers. According to NTUA records between 1988 and 1992 NTUA's average annual Shiprock water production was approximately 735,000,000 gallons (2,260 acre-feet). NTUA production records report that in 1997 Shiprock's annual water production was 535,976,000 gallons (1,645 acre-feet). The peak daily production in 1997 was 2,075,000 gallons. NTUA's entire Shiprock District supply is from the San Juan River.

For this analysis, the San Juan River municipal subarea includes the same chapters as NTUA's Shiprock District with one exception. Sanostee has been shifted to the Route 666 Subarea to better reflect the proposed pipeline configurations. The 1990 population of this subarea is 13,804 and the projected population by the year 2040 is 46,985. The NDWR projects the water demand of the Shiprock Subarea will be 8,421 acre-feet per year by 2040.

Navajo-Gallup Water Supply Project

NTUA diverts San Juan River water for the Shiprock area from three sources: (1) the Hogback Irrigation Project Canal, (2) water pumped directly from the San Juan River at the Highway 666 bridge in Shiprock, and (3) water purchased from the City of Farmington. In 1997 the City of Farmington provided 1,168 acre-feet or approximately 70 percent of the overall water supply. NTUA frequently shuts down its San Juan River diversion at Shiprock because poor water quality and high sediment loads create operation and maintenance problems, and significantly increase the cost of treatment. The proposed Animas-La Plata Project may enable NTUA to divert up to 4,600 acre-feet, and deplete 2,340 acre-feet, of Animas - La Plata Project water.

5.2.8 Torreon Subarea

The Torreon Subarea includes the Chapters of Counselor, Ojo Encino, Torreon, and Pueblo Pintado. The 1990 population of this area was 3,797 and the projected population by the year 2040 is 12,924. Its annual water production in 1998 was 36,783,000 gallons (113 acre-feet). Essentially all of the municipal water is from the Ojo Alamo Aquifer. Based on well logs for this area the maximum well yield is 70 gpm and it is approximately 1,100 feet deep.

5.2.9 NAPI

NAPI does not withdraw any groundwater for municipal or industrial purposes. However, NAPI currently receives approximately a small volume of per year of water for municipal and industrial purposes from NTUA. According to the information provide to the Navajo Nation Water Code in 1996 NAPI diverts 2,240 acre-feet for food processing and 55 acre-feet for local construction contractors (Department of Water Resources Management, *Water Use Fee Policy*, June 18, 1996).

5.2.10 Window Rock Subarea

The Window Rock Subarea includes the Fort Defiance and St. Michaels Chapters. Both of these communities have been designated by the NDED as economic development areas. Window Rock, Arizona is also the capital of the Navajo Nation. The NTUA system in Window Rock is the largest NTUA system on the Reservation. It has more than 2,800 connections. The 1990 census population of this subarea was 11,767 and the projected population by the year 2040 is 40,052. The annual water production in 1998 was 339,767,000 gallons (1,043 acre-feet).

Approximately 70 percent of the Window Rock water supply comes from the Black Creek Alluvium. These wells have yields up to 270 gpm and their depths range from 30 to 140 feet. However, this alluvial system is fully developed and very susceptible to droughts. To increase storage and recharge to the alluvial system during droughts, in 1984 the Indian Health Service built Blue Canyon Dam near Fort Defiance. Due to the limited surface water supply and seepage into the faults underlying the reservoir, this 1,900 acre-foot reservoir has only filled once since it was constructed. Although a portion of the seepage loss recharges the Black Creek Alluvium, Blue Canyon Dam provides little recharge during droughts.

The remaining 30 percent of the Window Rock water supply is derived from the Slick Rock Well field east of Window Rock and from wells in the De Chelly Sandstone in the St. Michael's area. These wells all exceed 800 feet in depth. The Slick Rock well field, which has a static water level 700 feet deep, derives its water from the Gallup Sandstone. NTUA reports that the static water level in the Slick Rock area has declined 250 feet.

5.2.11 Thoreau - Smith Lake Subarea

The Thoreau - Smith Lake Subarea includes the Chapters of Baca/Haystack, Casamera Lake, Smith Lake and Thoreau. This subarea is not part of the Project's service area. This subarea has been included in this analysis because it currently exports groundwater to Chapters that are part of the service area. After the Project is completed, these exports will be reduced or eliminated. These Chapters are primarily located in the Rio San Jose watershed which is tributary to the Rio Grande. The 1990 population of this area was 3,600 and the projected population by the year 2040 is 12,253. Its annual water production in 1998 was 86,193,000 gallons (193 acre-feet). Much of this water is conveyed to the Church Rock Area from the Glorietta, Dakota and Morrison formations. Based on well logs for Thoreau the maximum well yield is 30 gpm and it is approximately 1,700 feet deep. For Smith Lake the maximum well yield is 110 gpm and it is approximately 2,000 feet deep. Modeling of the Plains Electric Generating Station indicated that 8,000 acre-feet per year withdrawals would result in a water level decline of 40 feet in the Thoreau area.

6.0 NON-STRUCTURAL ALTERNATIVES

The Rock Mountain Institute has defined water conservation as increasing the efficiency of water use without diminishing the quality of services. In some cases conservation may allow communities to downsize, defer, or avoid new water infrastructure. Water conservation may represent a non-structural alternative for meeting the Project's purpose and need. At the very least water conservation can reduce water consumption and the Project's operation costs. Due to the Project's expense and environmental considerations, the communities in the service area will need to make every reasonable effort to maximize the current water supplies. The objective of this section is to evaluate the potential application of a water conservation program.

6.1 Water Conservation

Like any water supply alternative, water conservation needs to be evaluated based on its potential yield and its potential costs. These issues were addressed in water conservation plans prepared for the City of Albuquerque (Brown et. al 1996), the Santa Ynez Water Conservation District (Stetson Engineers, 1992) and the City of Gallup Forty Year Water Plan (Shomaker 1991). For the Santa Ynez Water Conservation District, Stetson Engineers evaluated the reported costs of reducing water use with three approaches to water conservation: (1) public education, (2) incentive programs, and (3) regulations.

6.1.1 Public education programs

The goal of public education programs is to increase water user awareness of habits that waste water and to promote understanding in the community on water conservation topics. Public information programs are relatively inexpensive. The California Department of Water Resources (CDWR) estimated that a community will typically reduce water use by 4 to 5 percent if public information is the only conservation program offered by a water agency. However, those savings largely depend on the number of water users already practicing water conservation measures. The CDWR estimated that additional reductions in water use in a community that already has a high level of community awareness, like the City of Gallup, are closer to one percent at a unit cost of approximately $300 per acre-foot. In the *1984 Plan Formulation and Environmental Statement*, Reclamation expressed concerns over the long-term effectiveness of voluntary programs.

6.1.2 Incentive programs

A more aggressive approach to water conservation is to financially reward water conservation and penalize wastefulness. These incentives may include increasing the unit cost of the water or implementing a seasonal fee structure to further encourage conservation during peak demands periods. For residential users the response to conservation incentives tends to vary with household income. For commercial users the response to water conservation incentives depends on the relative cost of water compared to the total operating costs. Stetson Engineers estimated that the cost of an education program combined with an incentive program targeting a 15 percent reduction has a unit cost of $990 per acre-foot. However, in a community like Gallup that has already adopted above average water rates and a seasonal rate structure, the resulting unit costs needed to reduce water use an additional 15 percent will be higher. The City's water plan cites the following studies:

- A study by the Colorado Water Resources Research Institute indicates that increasing water rates from $0.43 to $0.86 per thousand gallons (a 100 percent increase) reduced consumption by 25 percent.
- A study of water rates in the City of Santa Fe demonstrates that increasing water rates from $1.60 to $4.06 per thousand gallons (a 151 percent increase) reduced consumption by 39 percent.
- A study by the Texas Department of Water Resources indicates that a 10 percent increase in water rates results in a 3 percent reduction in municipal water use.
- A study by the California Department of Water Resources indicates that a 10 percent increase in water prices, reduces inside residential use by 2.6 percent and outside residential use by about 4 percent.

Most water utilities generate much of their revenue through the per-unit charge for water. Consequently, increasing the unit costs may encourage water conservation and, at the same time, increase the revenue needed to repay construction obligations and to pay for system operation, maintenance and repair. If the water rate accurately reflects the cost of the service and the value of water, then economically reasonable conservation incentives benefit both the utility and its customers. However, if the unit cost of the water becomes too high, and if the water use declines too much, the utility's revenue declines. The water rate structure must provide a stable income for the utility while conveying an accurate value for delivery of the water. A well designed conservation program will achieve this balance over time and will still provide enough price elasticity so that short term use reduction is still possible to address emergencies and droughts (Brown, et al, 1996).

As shown in Figure 4.2, the overall per capita water use rates in the service area are already among the lowest in the region. Per capita water use in Farmington and Albuquerque is 250 gallons per capita per day. By comparison, the per capita water use rate in Gallup is less than 170 gallons per capita per day. Navajo water users use far less. Significant, cost-effective, water conservation opportunities may not be available due to the relatively high water rates and low use.

The operation and maintenance expensive of the Project water may be greater than the current water rates. This higher rate may result in water users utilizing the over drafted groundwater before turning to the more costly pipeline supplies. Some type of pumping restrictions in the Gallup area may be required.

6.1.3 Regulatory programs

The CDWR suggested that the only way to achieve a 30 percent reduction in water use is through a program combining public education, incentives and regulations. Based on the Stetson study the unit cost for this type of program is $1,600 per acre-foot. Once again, for a community with very little outdoor water use, the unit costs will be much higher. And, according to Reclamation mandatory programs are less acceptable to the public.

The City of Gallup has recently raised water rates which should encourage water conservation. According to the City of Gallup's Forty Year Water-Supply Master Water Plan the City has instituted water conservation regulations which:

- Prohibit any person from allowing potable water to flow from his property onto any street.
- Prohibit the watering of streets with potable water.
- Restrict potable water usage by any person to 500 gallons per capita per day for soil compaction, street and driveway construction, or any other construction except where special permission has been granted.
- Prohibit the use of City fire hydrants or connections except by members of the City Water or Fire Departments.
- Prohibit leaky pipes, taps and appliances.
- Set minimum water-use standards for new plumbing.

The City is also pursuing:

- A public information program to promote water conservation.
- Xeriscaping of City parks and facilities.
- Restricting turf areas in new landscaping.
- Tiered water charges.
- Restricting lawn watering.

Due to the low per capita water use rates, in the *1984 Plan Formulation and Environmental Statement,* Reclamation concluded that a water conservation plan would not work for the Navajo communities in the study area. While conservation measures may help the City of Gallup meet short-term needs, it was not a viable solution to meet long-term needs, and water conservation will not address the problem of declining water quality. As a non-structural alternative, water conservation did not meet the Project's purpose and need.

6.2 Water Reuse

Although current safe drinking act regulations limit water reuse applications, water reuse can significantly increase a community's usable water supply. Under certain circumstances reclaimed water can be used on outdoor landscaping and athletic facilities. The City of Gallup has implemented several innovative water reuse projects to irrigate its golf course and athletic fields.

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On the Navajo Nation, irrigated landscaping is very limited and most wastewater ends up in sewage lagoons or evaporation ponds. The Navajo Nation and Reclamation have contracted with Westlands Resources to investigate water reuse opportunities. Appraisal level studies have been conducted in Tuba City and Ganado. The Nation Park Service has received a grant from the Arizona Water Protection Fund to use NTUA effluent in Ganado for a riparian restoration project.

Out of necessity within the next couple of decades "toilet to tap" water reuse systems will become commonplace across the West. At the current time there are no direct effluent-to-drinking water systems in use in Arizona or New Mexico. To make the concept socially acceptable some type of disconnect between the effluent and drinking water may be needed. For instance, if the treated effluent can be recharged in the ground, treatment costs may be reduced and the concept becomes more acceptable to the water users. Treated effluent may be more accepted for industrial uses than residential uses. The reuse system may include normal oxidation, micro filtration, activated carbon and disinfection.

Cost estimates by Westland Resources Inc. indicate that the capital cost of a toilet-to-tap system for a community like Gallup is $16 per gallon. Meeting the current peak demand of 5.5 million gallons per day will require a system with a capital cost of approximately $90 million. If the wastewater is available, the cost of a system designed to meet the average 2040 demand will cost $165 million. The estimated operation and maintenance cost is between $600 and $1,000 per acre-foot. Additional distribution systems will also be required. Even if this approach could assure a water supply, these unit costs far exceed the estimated cost of meeting the City of Gallup's demand with the Project.

6.3 Conjunctive use of groundwater and aquifer storage

Groundwater may be used conjunctively with the surface water supply to enhance the overall water supply available for the Project. Three approaches for conjunctive use have been considered: (1) utilizing wells during the summer when the water demand is at its peak, (2) supplementing the Project's surface water supply with groundwater during critical years on the San Juan River, and (3) aquifer storage and recovery. These approaches are described in greater detail in the following sections.

6.3.1 Utilize wells for peak summer demand

During the first few years of Project operation, the Project will have adequate capacity to greatly reduce groundwater withdrawals. Eventually, however, the City of Gallup and NTUA will need to utilize their wells for short periods during the summer when the water demand is at its peak. By the year 2040 the City's system will need to produce approximately 1,400 are-feet of groundwater, primarily during the summer months. The aquifers will be able to recharge during the remainder of the year. Although the City of Gallup's well fields may be able to supplement the total projected peak demands for a short period of time, it is unlikely that they will be able to replace the total projected summer demand.

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The estimated recharge to the source aquifers is very low, far less than current withdrawals. As the water demand increases over the next 20 years, without the Project, the demand to recharge ratios will become far less favorable. In conclusion, during the early life of the Project, the 1.3 peaking capacity in the system will greatly reduce, or eliminate, the City's dependence on groundwater. By the year 2040, groundwater will be needed to help meet the summer peak demands.

6.3.2 Supplemental groundwater during critical years

Theoretically, groundwater could supplement or replace the Project's surface water supply during critical years on the San Juan River. These critical years would depend on the flow recommendations adopted by the San Juan River Recovery Implementation Program to assist the recovery of the endangered species in the San Juan River (Holden 1999). These flow recommendations are intended to mimic the natural hydrograph of the San Juan River. These recommended flows require releases from Navajo Reservoir with the appropriate duration and frequency. However, based on the historic flow data, the critical period during which the recommended flows would have been most difficult to achieve lasted for seven years. Consequently, the USFWS may expect a commitment of seven acre-feet of groundwater to off set an acre-foot of proposed surface water depletion. This option is not practical for these groundwater aquifers.

6.3.3 Aquifer storage and recovery

In a January 26, 2000 letter to the City, John Shomaker and Associates, Inc., presented a technical review of aquifer storage. Based on that review, it may be possible to store and recover Project water. Eventually, it may also be economically possible to store and recover treated wastewater. Conceptually, production wells in the Yah-ta-hey and Santa Fe well fields would be used as injection wells during periods when water is available in excess of the City's demand. This water would then be available during periods when surface water is not available in adequate amounts. During the first years of the Project the City may only be able to utilize approximately 4,500 acre-feet per year out of the total Project allocation of 7,500 acre-feet. The difference may be available for recharge. This approach has been successful in other communities. The City of Santa Fe is recharging water and is proposing to expand its program with Title XVI funds. Typically the storage and recovery cycle is seasonal. With a seasonal cycle the stored water does not have enough time to move far from the recovery well, and the groundwater head does not have enough time to dissipate to pre-storage levels before the water is recovered.

Shomaker notes that the source aquifers for the City of Gallup are confined, and that they have very low hydraulic conductivities and storage coefficients. Because of the low conductivity, groundwater movement is relatively slow. For these reasons, the injected water would stay within reach of a recovery well for a longer than typical period, and the rise in water levels would take a long time to dissipate. Therefore, a longer recovery period might be feasible. Injecting Project water may restore part of the large decline in water levels in the wells and extend the life of the fields beyond the limits predicted by the City. The cost of storing this water would be partly offset by a reduction in the pumping lifts. Shomaker speculates that the water levels are so deep that water may be injected successfully by gravity flow, requiring no pumping. Aquifer storage is especially sensitive to the quality and chemical characteristics of the water. Shomaker concludes that the concept is worth considering. But, a complex analysis is needed before the feasibility of the concept can be determined.

7.0 SURFACE WATER SUPPLY OPTIONS

With more than 40 percent of the Navajo population lacking domestic water, and static water levels in the City of Gallup's well fields declining by hundreds of feet, the need for the Navajo-Gallup Water Supply Project is clear. Numerous investigations have found that additional groundwater sources are inadequate, and that they can only temporarily delay water supply shortfalls. This conclusion was presented in the 1976 Turney report which was the basis for the 1984 Plan Formulation and Environmental Statement. The objective of this section is to present the advantages and disadvantages of various surface water sources for the Project. While the following discussion adheres to the context of the 1922 Colorado River Compact and the 1948 Upper Colorado River Basin Compact, it should be noted that the Navajo Nation firmly believes the allocations in these compacts do not limit the Navajo Nation's claim to water within the Colorado River system.

Sources of surface water that were considered for the Project demand within New Mexico include: (1) acquisition of private water rights or options, (2) a San Juan River contract for water with the Department of the Interior, (3) a San Juan River contract for water from the Jicarilla Apache Nation (Apache Nation), (4) Navajo Indian Irrigation Project water, and (5) Navajo Nation non-NIIP water. Approximately 25 percent of the Project's water demand is in the Lower Colorado River Basin within the State of Arizona. For addressing the Arizona demands the Navajo Nation is investigating Central Arizona Project water and other main-stem Colorado River water. These water supply options are discussed in greater detail below, followed by a conclusion.

7.1 Acquisition of private water rights or water options

One option for providing a permanent water supply for the Project is to purchase private water rights or water options from water users within the San Juan River Basin. One advantage of acquiring private water rights is that these existing depletions have been included in past Section 7 Consultations with the USFWS and will most likely be included in future consultations. Through these consultations the USFWS determines which additional depletions can occur in the San Juan River basin without causing jeopardy to the endangered fish. Identifying water within the baseline reduces, but does not necessarily eliminate, the complications associated with compliance with the Endangered Species Act. Another advantage of acquiring private water rights is that these water rights are within the State of New Mexico's Upper Colorado River Basin compact allocation.

Although private water rights may have a senior priority date, they may not have a full water supply every year. Furthermore, these water rights do not come with a storage right behind Navajo Dam. They would not be subject to the Colorado River Storage Project Act (CRSPA) fee which is approximately $60 per acre-foot. However, if this water is conveyed through the NIIP facilities it would be subject to an administration fee for the use of Navajo Reservoir as a point of the diversion. The administration fee is less than the CRSPA fee.

The primary disadvantage to purchasing private water rights is that they are not cheap. Long-term water contracts in the Colorado River Basin frequently cost $2,000 to $5,000 per acre-foot. Recent small transactions in the Farmington area have been for approximately $1,500 per acre-foot. At that price, water for the City of Gallup's demand could cost between $11 and $20 million and water for the Navajo demands could cost in excess of $40 and $70 million.

Another disadvantage of purchasing water rights is that the depletions associated with these water rights will need to be transferred to the Project. It is very likely that these transfers will be protested by numerous parties within the Basin. The effect of the depletions that may be transferred will be closely scrutinized. If downstream depletions are to be transferred upstream to the Navajo Reservoir, a large number of water users may claim to be impacted. The Office of the State Engineer has a process for administrating transfers. However, these hearing processes may become complicated, protracted and expensive. A final disadvantage is that private water rights within the San Juan River Basin, even those purchased by the City of Gallup, may not necessarily be exempt from any ultimate federally reserved water rights claim exerted by the Navajo Nation.

Acquiring water options for San Juan River water would most likely be less expensive than purchasing water rights. These water options may take the form of forbearance agreements. Under these forbearance agreements current water users would agree that if there is a call on the river to meet either the flow recommendations or the compact requirements, then those water users would agree to discontinue their uses. These water options would not necessarily be exercised every year. Presumably the need to exercise an option would be based on the water supply forecast for the San Juan River and the flow recommendations in effect at that time. As a practical matter, it is unlikely that these options would be exercised at least until NIIP and the ALP projects begin to fully utilize their allocations.

7.2 A San Juan River water contract with the Department of the Interior

The City of Gallup has no water rights for San Juan River water, nor does it have any San Juan River water under contract. During the 1950's and 1960's the City of Gallup filed three notices of intent to divert water from the San Juan River. After the construction of Navajo Reservoir, the State Engineer indicated that the City would need a contract with the Secretary of the Interior for water. In 1966 a contract for 7,500 acre-feet of water was drafted and several meetings were held between Reclamation and the City of Gallup to work out the details. That contract was never finalized. In 1967 the ISC recommended, and the Secretary of the Interior granted, a temporary allocation for the City of Gallup of 7,500 acre-feet per year through the year 2005. In the 1988 Hydrologic Determination Reclamation identified 24,000 acre-feet of water in New Mexico and 7,000 acre-feet of water in Arizona that was temporarily available from the San Juan River for the Navajo-Gallup Water Supply Project through the year 2039. In a letter dated November 22, 2000 from Kelsey A. Begaye, President of the Navajo Nation and John Pena, Mayor of the City of Gallup to Eluid Martinez, Commissioner of Reclamation, the Project participants request separate water contracts from the Navajo Reservoir Water Supply. The Navajo contract would be for 29,300 acre-feet per year and the City of Gallup contract would be for 7,500 acre-feet per year.

Several important issues need to be addressed by the authorizing legislation before this water could be contracted by the Secretary. These issues are summarized in a letter dated June 30, 1994 from Rob Luethhouser, Reclamation to the Project participants and include:

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- The Navajo-Gallup Water Supply Project was never specifically authorized by Congress as part of the Colorado River Storage Project Act (CRSP). Consequently, the Project is limited to temporary water contracts from Navajo Reservoir.

- CRSP temporary water service contracts for municipal and industrial uses are authorized by Section 9(c)(2) of Reclamation Project Act of 1939. However, they are limited to a maximum term of 40 years. Contract renewal may be subject to the extent of other water developments in the San Juan River Basin. The long-term dependability of contract water needs to be evaluated.

- Before any temporary contract from Navajo Reservoir can be allowed to extend past the year 2039, the 1988 Hydrologic Determination must be officially updated and approved by the Secretary of the Interior, and transmitted to Congress.

- Due to specific language in the authorizing legislation of NIIP (Public Law 87-483), any additional 40-year contracts from Navajo Reservoir must be authorized by Congress. Congressional approval may take several years.

Other issues that need to be addressed before contracting new water from the San Juan River include:

- A new contract will require an examination of future depletions in the Upper Basin. The determination of when, and if, the Upper Basin exceeds its allocation depends in part on various interpretations of the river compacts. Based on Reclamation's 1967 Hydrologic Determination, an additional 100,000 acre-feet of water was temporarily allocated to the State of New Mexico through the year 2005. This 100,000 acre-foot block of temporarily allocated water includes 7,500 acre-feet for the City of Gallup. Based on the Department of the Interior's interpretation, 5.8 million acre-feet per year of Upper Basin depletion was set as an upper limit for planning purposes. According to Reclamation's 1988 Hydrologic Determination, New Mexico's Upper Basin water allocation of 669,000 acre-feet per year will be exceeded by 74,000 acre-feet by the year 2039. Consequently, Reclamation limits new contracts. The current Reclamation administrative policy limits new contracts to 25 years.

  The Upper Basin States do not agree with the Department of the Interior's interpretation that they are limited to 5.8 million acre-feet per year. Under the State's interpretation, the State of New Mexico is entitled to 727,000 acre-feet of depletion per year. In a letter dated December 13, 1973 from Steve Reynolds, the New Mexico State Engineer, to James A. Bradley, Regional Director, Southwest Region, Reclamation the State Engineer writes "It is New Mexico's position that under a correct interpretation of the compact's provisions, the full 100,000 acre-feet of consumptive use from Navajo Reservoir contracts would be available in perpetuity," and "New Mexico's view is that there is sufficient water available from the San Juan River Basin to Supply Gallup 7,500 acre-feet annually for at least 50 years."

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In December1999 the Upper Colorado River Commission updated the depletions presented in the previous determinations. Based on the updated tables, the State of New Mexico will not exceed 669,000 acre-feet of depletion until sometime between 2030 and 2040. And, it may be possible for the Project participants to develop new water contracts based in part on the Upper Basin's unused allocation through the year 2060.

- Even if a new contract is granted, these depletions have not been included in previous Section 7 Consultations with the USFWS. The San Juan River may not be able to accommodate additional depletions without jeopardizing the endangered fish.

- The overall impact of a new contract on Indian Trust Assets within the San Juan River Basin will need to be evaluated by the Department of the Interior. Four Indian tribes including the Southern Ute Indian Tribe, the Ute Mountain Ute Tribe, the Jicarilla Apache Nation, and the Navajo Nation, may have concerns regarding the potential impacts.

- The City of Gallup in New Mexico and Window Rock in Arizona are geographically located in the Little Colorado River Basin which is tributary to the Lower Colorado River Basin. The provisions of the 1948 Upper Colorado River Basin Compact need to be addressed to utilize an Upper Basin allocation of water in either the Gallup or Window Rock subareas.

7.3 Contract water from the Jicarilla Apache Nation

The recent Jicarilla Apache Nation settlement includes 25,500 acre-feet of depletion per year of the Navajo Reservoir supply that may be available for marketing within the State of New Mexico. The Apache Nation is pursuing a variety of development options for using its San Juan River Basin depletions including potential third party contracts and on-reservation water projects. Consequently, under certain circumstances, the Apache Nation may be amenable to providing some water for this Project.

The Apache Nation water has a quantified water right and shares priority with other Navajo Reservoir users. Unlike other Navajo Reservoir contracts with the Secretary, the Secretary has already determined that sufficient water is available to fulfill the Apache Nation's settlement. While third party contracts for Apache Nation water must be approved by the Secretary (through his designee with Reclamation), no further Congressional action is necessary for the use of Apache Nation water. In addition, these depletions will be recognized in future hydrologic determinations, while the Navajo-Gallup Project water may not.

If Apache Nation water was made available for this Project under terms favorable to the Apache Nation, they would have incentive to support the Project during Section 7 Consultation with the USFWS and during NEPA compliance. In addition, because the Apache Nation already has a contract with the Secretary, a subcontract with the Apache Nation eliminates the need for a new Secretarial water use contract out of Navajo Reservoir. This subcontract may require an annual construction payment currently set at $2.60 per acre-foot, and a payment for the proportionate share of the operation and maintenance of Navajo Dam.

However, a long-term Apache Nation water lease may not be cheap, and it may not be less expensive than leasing private water rights. In addition, the Apache Nation water has not been included in recent environmental baselines for previous consultations under Section 7 of the Endangered Species Act in the San Juan River Basin. Consequently, even with an Apache Nation subcontract, it may not be possible to meet the new San Juan River flow recommendations for the additional depletions needed for this Project.

The City of Gallup, as well as the Navajo Nation, need long-term, essentially permanent municipal water supplies. However, the Apache Nation may be more inclined to support a short-term contract. Any arrangement with the Apache Nation will need to consider an equitable renewal clause. Such a clause may be able to reference future water prices against some mutually agreed upon benchmarks. Even with these limitations, the Apache Nation water may provide a short-term "bridge," allowing the Project to proceed until broader water rights settlement issues for the Navajo Nation can be resolved, or additional depletions are made available through the Recovery Program.

7.4 Navajo Indian Irrigation Project water

The Navajo Indian Irrigation Project was authorized in 1962 by Public Law 87-483. This public law authorized the Secretary of the Interior to construct, operate, and maintain NIIP for the principal purpose of furnishing irrigation water to approximately 110,630 acres of land. NIIP consists of the initial land development, water distribution system, water delivery, roads, and other infrastructure. In 1970 the Navajo Nation created the Navajo Agricultural Products Industry (NAPI) to run the agricultural business venture and take responsibility for operating the NIIP facilities. The boundaries of NIIP are shown in Figure 2.1.

NIIP is approximately 60 percent complete with 64,000 acres developed. In 1999, NIIP diverted 193,100 acre-feet of water from Navajo Reservoir and depleted 129,571 acre-feet of San Juan River water. Based on an average unit depletion of 2.44 acre-feet per acre, at full build-out, with all of the Project acreage irrigated, NIIP will deplete approximately 270,000 acre-feet per year of San Juan River water. Based on the current overall Project irrigation efficiency, NIIP would divert approximately 337,500 acre-feet of water (*Navajo Indian Irrigation Project Biological Assessment*, June 11, 1999, Keller Bliesner Engineering and Ecosystems Research Institute Inc.).

NIIP has successfully consulted with the USFWS on approximately 270,000 acre-feet of depletion which according to the USFWS can be depleted without jeopardizing the endangered fish. However, NIIP was only able to acquire the water it needs to complete Blocks 9, 10, and 11 by shifting more than 16,000 acre-feet of baseline depletions away from the Hogback and Fruitland irrigation projects. Even so, NIIP's depletions may include two types of water that may under certain circumstances be available for municipal use: unused NIIP water and forbearing the use of NIIP irrigation water. These options, which will need to overcome considerable legal and political hurdles, are described in the following sections.

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- Municipal use of unused NIIP Water

At current funding levels, it will take more than 18 years to complete NIIP. This completion date delays the time when NIIP can provide all of the benefits that are envisioned. A revised completion schedule to complete NIIP by the year 2009 has been proposed by Reclamation, NAPI and the BIA. The revised schedule assumes that the financial and environmental challenges can be addressed, enabling all 110,630 acres of land to be developed as soon as the year 2006. The drains, the system control and data acquisition facilities, and Gallegos Dam would be completed by the year 2009.

Consequently, there is a six to 18 year period during which unused NIIP water, which has undergone Section 7 Consultation, may be available. Sequencing the construction of NIIP with this Project may enable NIIP to realize some benefits from this water resource until it can be used for irrigation. However, several issues need to be addressed before this water can be used for municipal purposes.

The authorized purposes of the NIIP facilities include conveying water for municipal, domestic, and industrial uses, and for other beneficial purposes. The Secretary is authorized to provide capacity for municipal and industrial water supplies or miscellaneous purposes over and above the diversion requirements for irrigation of NIIP, but such additional capacity will not be constructed and no appropriation of funds for such construction will be made until contracts have been executed which provide satisfactory assurance of repayment of all costs properly allocated.

Even if the Navajo Nation is willing to convert unused NIIP water from irrigation uses to municipal uses, under the present contract the Secretary of the Interior is not authorized to deliver water for uses other than irrigation. NIIP's statutory authorization, and the Navajo Nation's contract with the Secretary of the Interior, allocate to NIIP an average annual diversion of 508,000 acre-feet of water per year from the San Juan River for the principal purpose of furnishing irrigation water to approximately 110,630 acres of land. It is presently unresolved whether (and how) NIIP irrigation water can be used for municipal and industrial purposes. Furthermore, the Secretary has no authority to contract for the delivery of any water from Navajo Reservoir which would impair the availability of water for the irrigation of 110,630 acres of Navajo Indian land.

In addition, if irrigation water is transferred away from any of the 110,630 acres, Navajo Dam and Reservoir may have separable costs allocated to NIIP which could become a repayment obligation. And, a portion of the NIIP capital costs associated with the idled acreage could also become a repayment obligation. Presumably these issues can be addressed through the Project's enabling legislation.

A more critical issue is that unused NIIP water is only temporarily available, perhaps for a six to 18 year period. The municipal demand, however, requires a nearly permanent supply. Committing this water temporarily to non-NIIP municipal water demand creates significant disincentives for the completion of NIIP, and it may eventually result in conflict between the irrigation and municipal uses. Even with these concerns, the unused NIIP water may be able to provide a short-term "bridge," allowing the Project to proceed until biological and water rights settlement issues can be resolved.

- A forbearance agreement for NIIP water

Another water supply option is for the Navajo Nation to enter into a forbearance agreement to provide water for municipal needs. Unlike the "unused" water described in the previous section, under a forbearance agreement NIIP would forbear the use of a specific volume of water that it could otherwise make use of for a designated period of time. This foregone use may come at the expense of not irrigating a specific number of acres. Based on an average depletion of 2.44 acre-feet per acre, the Gallup water supply would require idling or fallowing, approximately 3,000 acres and the Navajo demand would require approximately 10,000 acres.

Instead of idling acreage, it may be possible to change the proposed crop mix to include crops that require less water, or to under irrigate some of the irrigated crops in the current mix. However, these approaches have agronomic impacts on NIIP including lower revenue, fewer jobs, and greater risk of crop failure.

Another approach is to improve the overall irrigation efficiency at NIIP. Most, but not all, of the water diverted by NIIP is depleted directly by the crops. However, much of the reported irrigation inefficiency returns to the San Juan River (Keller-Bliesner, 1999). This portion of NIIP's diversion is not credited against NIIP's San Juan River depletions. However, some portion of the water diverted by NIIP is depleted by a variety of causes including evaporation in the canals and from the sprinklers. The State of New Mexico refers to these losses as incidental depletions. If improved irrigation technology can be deployed at NIIP, these incidental depletions may be reduced. Theoretically, reducing NIIP's overall depletions from 2.44 to 2.1 acre-feet per acre, or 11 percent, would result in a depletion saving that could provide water for the Navajo Gallup Project's entire municipal demand.

Some of this technology, such as improved sprinklers, is relatively straightforward. Other techniques, such as improving the match between water application and climate conditions, require extremely vigilant management. Still other techniques, such as adding amendments to the soil to reduce infiltration losses, are still experimental. All of these techniques hold promise for reducing NIIP's depletions. Due to the expense of moving water from Navajo Reservoir to the NIIP fields, reducing these depletions offers some economic benefit to NIIP. However, none of these methods are inexpensive, and they all have agronomic impact. And, under its current Biological Opinion, NIIP is already committed to improving its overall efficiency by 10 percent, from 55 percent to 65 percent. Even so, eventually, this approach may result in water that can be utilized for a long-term municipal water supply. However, the potential promise must be weighed against the unknown agronomic costs. The trade offs between increasing efficiency and impacting NIIP should be investigated by the Project participants.

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If NIIP water is converted from an irrigation to a municipal use, a repayment obligation may exist for costs against the Indian owned land that is idled. In addition there may be conflicts between state and federal law. From the State of New Mexico's perspective, agricultural water rights can only be transferred from irrigated land if the irrigated land is fallowed or dry farmed. These water rights only include the consumptive use of the crop, not the incidental losses. Since there is no inherent right to the incidental losses, reducing them does not "free up" water that can be transferred between water users. From the irrigators' perspective, the main incentives for conserving water in this manner are to lower pumping costs and to make more water available to the crops during times of shortage.

In conclusion, although NIIP has a relatively large amount of water that has undergone Section 7 Consultation and other environmental compliance, forbearance agreements for NIIP water will not be simple or inexpensive. These agreements would need to be developed around the current contractual constraints and without creating disincentives to the completion of NIIP. However, this option may provide a bridge until broader water issues are resolved.

7.5 Navajo non-NIIP water

One option to provide a water supply for the Navajo-Gallup Water Supply Project is for the Navajo Nation to assume the responsibility for guaranteeing depletions out of water supplies allocated to the Navajo Nation, either through existing statutes or an eventual settlement of the Navajo Nation's federally reserved water claims. Such an approach saves the City of Gallup from having to deal directly with the San Juan Basin interests, and provides the Navajo Nation the opportunity to redistribute its water resources consistent with its internal policies.

The primary disadvantage with this approach is that the Navajo Nation has very limited non-NIIP water in the San Juan River Basin that has a quantified water right and that could be leased to Gallup. For instance, as a result of its Section 7 Consultation with the USFWS, unused water from the Shiprock irrigation projects has already been temporarily utilized by NIIP to ensure that NIIP's construction can continue. When this depletion is restored to the Shiprock irrigation projects, it may under certain circumstances in the future, be available for the Navajo-Gallup Project. However, utilizing Navajo Nation water to meet non-Navajo municipal demands raises issues that will need to be addressed.

The Navajo Nation is concerned that using the non-NIIP water for the Navajo-Gallup Project may hinder other future Navajo water development. Even if Navajo non-NIIP water becomes available under favorable terms, it will not necessarily be less expensive than acquiring private water rights. Consequently, in the short-term, this non-NIIP water option may not meet the City of Gallup's need to secure a long-term water supply.

7.6 Central Arizona Project or other Main-stem Colorado River water

The 1988 Hydrologic Determination identified 7,000 acre-feet of water in the Upper Basin of Arizona for the Arizona portion of this Project. However, the most recent Reclamation Consumptive Use and Loss Report for that area does not identify depletions for this Project. Water allocated to the Lower Colorado River Basin may fit most readily into existing Compact allocations for use in Lower Basin areas like Window Rock, Arizona. For instance, the Navajo Nation is in the process of adjudicating its Little Colorado River water rights. Through that adjudication a modest amount of Central Arizona Project water may be available to address on-reservation needs in the Window Rock Subarea. However, many of the Central Arizona Water Conservancy District constituents are opposed to water leaving that district's service area. Other scenarios are to acquire non Central Arizona Project main-stem water or lower priority non-municipal water.

Procuring Central Arizona Project water or other main-stem Colorado River water may be expensive. It will also require an adequate accounting system to ensure that system gains and losses are accurately calculated, and that other issues such as lost power revenues and increased salinity are addressed. Reclamation has initiated work on an *Environmental Impact Statement on the Allocation of Water Supply and Expected Long-term Contract Execution for the CAP*. The results of that study may have a direct impact on this water supply option.

7.7 Conclusions

All of the water supply options pose difficult challenges. One option for a water supply is the outright acquisition of water rights within the environmental baseline from a willing seller. Unfortunately, this option is, in the short-term, the most expensive. Depending on the specific conditions, acquiring water options may be less expensive. The City of Gallup can approach either the Navajo Nation or the Jicarilla Apache Nation for a lease. However, the longer the lease, the more expensive the terms will become.

Even though the Navajo Nation has the paramount water right in the San Juan River Basin, that right has not been fully quantified. Consequently, the Navajo Nation shares some of the same water supply obstacles as the City of Gallup in meeting its long-term water supply needs. Until there is a fully quantified water right, the Navajo Nation can convert NIIP irrigation water to municipal use, acquire water from willing sellers or willing leasers, or join the City in pursuing a new Secretarial water contract. Such a contract could secure the Project water until the interpretation of the compacts and the Navajo Nation's water rights are resolved. With respect to compliance with the Endangered Species Act, it may be possible to work with various entities that have water in the currently described environmental baseline to ensure that specific depletions will be scheduled in a manner that provides an opportunity for this Project to deplete water during an interim period.

The City and the Navajo Nation have approached the Commissioner of Reclamation for two new water contracts. These Secretarial contracts will require the tacit support of the Indian tribes in the basin. For instance, the water that may be available for the City through their proposed contract may be water that would otherwise be included in a Navajo water rights settlement. Or, it may affect existing Navajo or Apache Secretarial contracts. Although a Secretarial contract does not provide a permanent guarantee of water, even under the most restrictive interpretation of the compacts, the full water supply should be available at least through the year 2060. According to the interpretation by the State of New Mexico, the supply should be available for a much longer period. A contract with the Secretary may also result in the smallest short-term financial burden to the City and the Navajo Nation.

8.0 NAVAJO-GALLUP PROJECT STRUCTURAL ALTERNATIVES

The principal objective of this technical memorandum is to describe Project configurations that may meet the Project's purpose and need, and that are acceptable to the participants. The configurations presented in this technical memorandum are the product of more than 40 years of progressively refined analysis. The location of the point of diversion has critical hydrologic implications for the endangered species in the San Juan River which have yet to be fully evaluated. Therefore, this technical memorandum presents two distinct configurations:

- The first alternative is the San Juan River Alternative. This alternative would divert water directly out of the San Juan River below the confluence of the La Plata and San Juan Rivers and then south along Highway 666 to Yah-ta-hey.

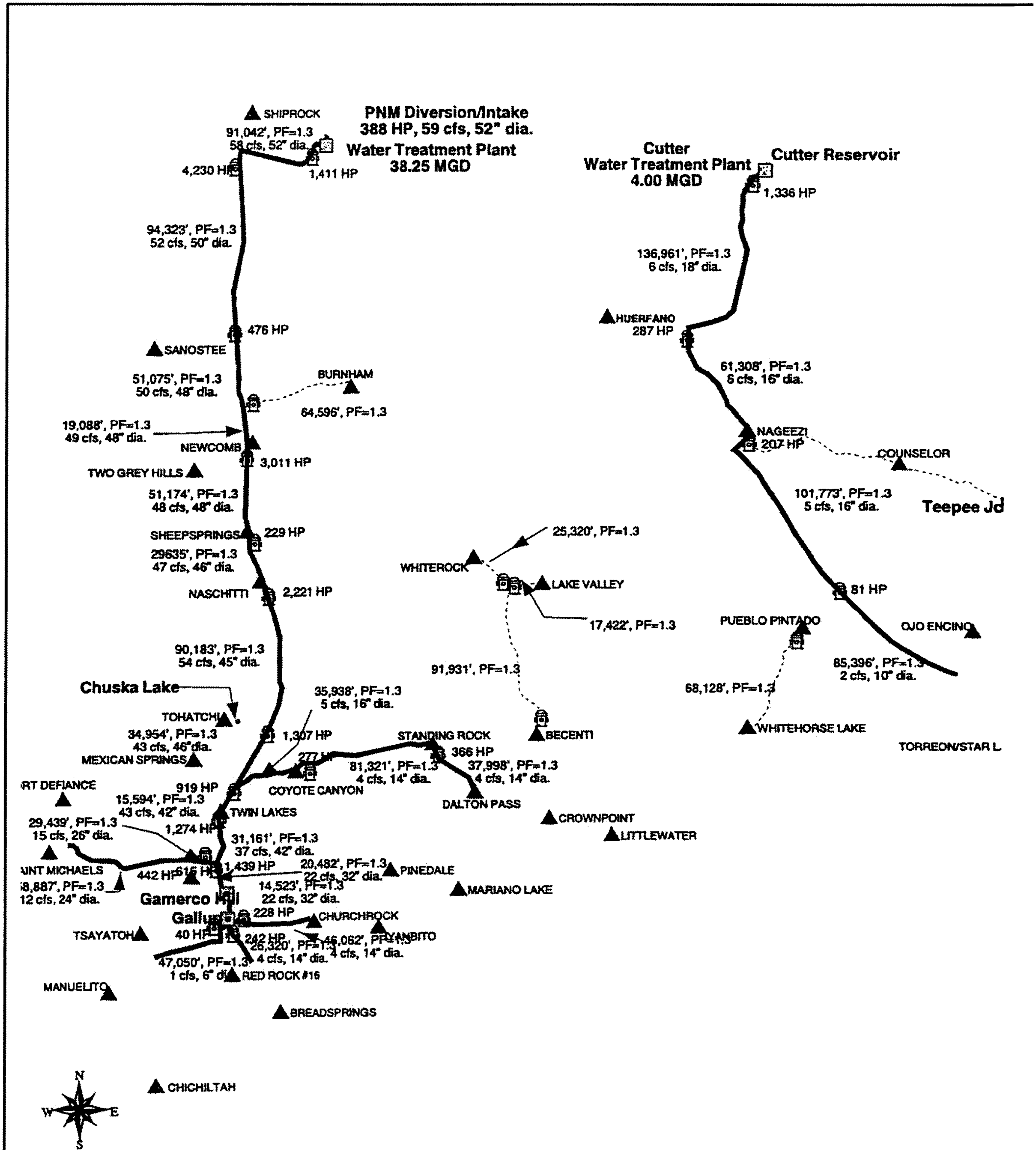
- The second alternative is the NIIP Alternative. This alternative would route water through the Navajo Indian Irrigation Project (NIIP) Main Gravity Canal to Moncisco Reservoir and then south along the Transwestern Pipeline corridor to Yah-ta-hey.

As proposed, both alternatives provide water to the same service area. These alternatives are shown in Figures 2.1, 2.2, 8.1 and 8.2. By the year 2040 the Project will divert 36,600 acre-feet and deplete 34,700 acre-feet from the San Juan River. The remaining municipal demand will be met with 4,680 acre-feet from the Animas La Plata Project, 3,200 acre-feet of groundwater production by the Navajo public water systems, and 1,400 acre-feet of groundwater production by the City of Gallup.

The NDWR investigated additional groundwater development for the Navajo communities in the Project area. One scenario is to provide the entire municipal demand with groundwater. In most cases this scenario is not viable at any cost because groundwater supplies are inadequate to provide a reliable, long-term water supply. The other preferred scenario is to develop a conjunctive water supply based on the sustainable yield of the groundwater. The conjunctive groundwater component reduces the cost of the surface water system and the required depletions from the San Juan River.

The major system elements are:

- The diversion from the San Juan River and conveyance along Highway 666 (The San Juan River Diversion Alternative)
- Routing water through the NIIP facilities and conveyance along the Transwestern Pipeline Corridor (The NIIP Alternative)
- Service to the municipal subareas
- Water treatment
- Wastewater treatment
- Terminus storage
- Project rights-of-way
- Other direct and indirect costs
- Operation and Maintenance



LEGEND

Required Pumping HP

Served Chapters

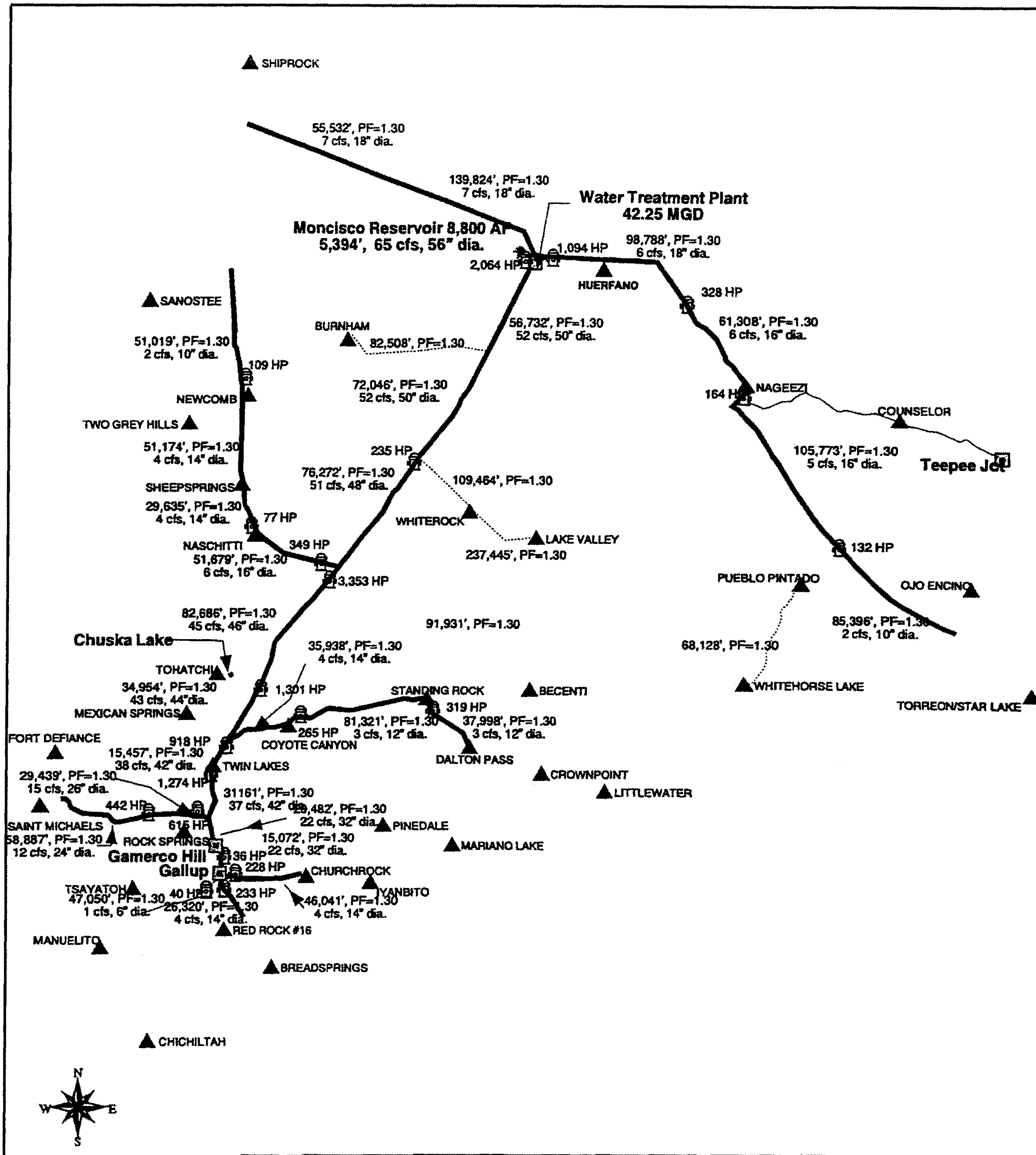
SJR Alternative

Figure 8.1
Navajo-Gallup Water Supply Project
Project Configuration Map

Navajo Department of Water Resources

proj1.apr

March 15, 2001
by: Robert L. Kirk



LEGEND

Required Pumping HP
Moncisco.shp
Served Chapters
Programmatic Lines
NIIP Alternative

Figure 8.2
Navajo-Gallup Water Supply Project
Project Configuration Map

Navajo Department of Water Resources

nilpalt1_30.apr

March 16, 2001

Navajo-Gallup Water Supply Project

8.1 The San Juan River Diversion Alternative

The San Juan Diversion would divert approximately 33,000 acre-feet per year directly from the San Juan River. The average diversion is 46 cubic feet per second and the peak diversion is 60 cubic feet per second. A treatment plant, settling basin, and regulating reservoir would be constructed near the point of diversion. Compared to the water in the NIIP canals, the water quality of the San Juan River is lower and it may require additional treatment. From the treatment plant, the pipeline alignment proceeds south along Highway 666 to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. Another lateral from Twin Lakes goes east along Indian Route 9 to Dalton Pass. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.1 and 8.1.

To service the eastern portion of the Navajo Reservation, a separate pipeline, referred to as the Cutter Lateral, will be constructed. This diversion would divert approximately 3,500 acre-feet per year with an average diversion of 4.6 cubic feet per second and a peak diversion of six cubic feet per second. This pipeline will originate at a treatment plant to be constructed at Cutter Reservoir. The Cutter Lateral will convey water from the treatment plant south to Huerfano, follow Highway 44 to Nageezi and then south to Torreon. Cutter Reservoir is a part of the NIIP canal system and it receives water from Navajo Reservoir. The Cutter Lateral may also be able to convey water to the Jicarilla Apache Nation. This lateral is shown in Figures 2.1 and 8.1.

There may be greater hydrologic flexibility if the main point of diversion is located on the San Juan River below the confluence of the La Plata and San Juan Rivers than if it is located upstream at Navajo Reservoir. This flexibility may make it easier for the Project to be operated in a manner that will satisfy the San Juan River Recovery Implementation Program's flow recommendations.

For the cost estimates presented in this technical memorandum, it has been assumed that the San Juan River Diversion Alternative would use the existing San Juan Generating Station Diversion Structure. This structure is located on the San Juan River at river mile 166, downstream of the La Plata River confluence and upstream from the Chaco Wash. However, other diversion points such as at the Hogback Diversion Structure and a Ranney infiltration gallery will also be considered.

8.1.1 Potential San Juan River Points of Diversion

During the 1980's and 1990's several points of diversion were evaluated including: (1) direct diversions out of the San Juan River, (2) collection of NIIP subsurface drainage return flows, (3) a direct pipeline from Navajo Reservoir, (4) developing groundwater and (5) routing water through the NIIP Main Canal to Moncisco Reservoir. Diverting water directly from the San Juan River is evaluated in this section.

Reclamation investigated two new sites for the diversion structure: (1) upstream from the Fruitland Diversion Structure, and (2) a Ranney infiltration gallery. The impacts of the new diversion on the endangered fish species may be minimized if the Project utilizes an existing diversion structure. Five sites at existing diversions were also evaluated: (1) the diversion for the Fruitland Irrigation Project, (2) the NTUA intake in Shiprock, (3) the BHP diversion to Morgan Lake which provides cooling water to the Four Corners Power Plant, (4) the APS diversion to the San Juan Generating Station, and (5) the diversion for the Hogback Irrigation Project. The potential points of diversion are described in the following sections.

The locations of these diversions are shown in Figure 8.3 and they are described in greater detail in the following section. Other small diversions used by the Lower Valley Water Users Association and the Lee Acres Hammond Irrigation Project diversion may also need to be evaluated. All of the proposed diversion sites could be connected to the existing and proposed Farmington to Shiprock pipelines.

- Potential Diversion Site #1: Upstream from the Fruitland Diversion Structure

  Reclamation assessed direct diversions out of the San Juan River for the 1984 Environmental Statement, and again in 1996 (*Water Supply and Storage Options, Gallup Navajo Pipeline Project, Engineering and Cost Estimates, Appraisal Level Report*, 1996, Reclamation). Reclamation evaluated a pipeline, pumping plant, pipeline outlet structure, 1,800 acre-foot storage facility and appurtenant structures. The total estimated cost for construction including the pipeline and pumping plants, dam, power lines, and relocation of utilities and archeological mitigation is $58 million in 1996 dollars ($64 million in 2000 dollars). This estimate includes five percent for unlisted items and 20 percent for contingency. This configuration would require an 800-foot lift from the intake pipeline. With a power demand rate of $3.54/kw/month and an energy rate of $0.008 kWh, the annual power cost at full build out would be $414,000 or approximately $13.80 per acre-foot. The estimated field cost of the diversion structure is $2 million.

  In addition to the diversion facilities, a lined regulating pond with a capacity of approximately seven percent of the annual demand, or 1,500 acre-feet of the total annual diversion, may be required to provide water when the water quality of the river is low and the pumps must be shut down. This pond has an estimated field cost of $9.6 million.

  The point of diversion has critical hydrologic implications for the endangered species in the San Juan River. A diversion on the San Juan River upstream from the confluence of the La Plata and San Juan Rivers may be unable to accommodate with the current flow recommendations. For this reason, this site was not considered further.

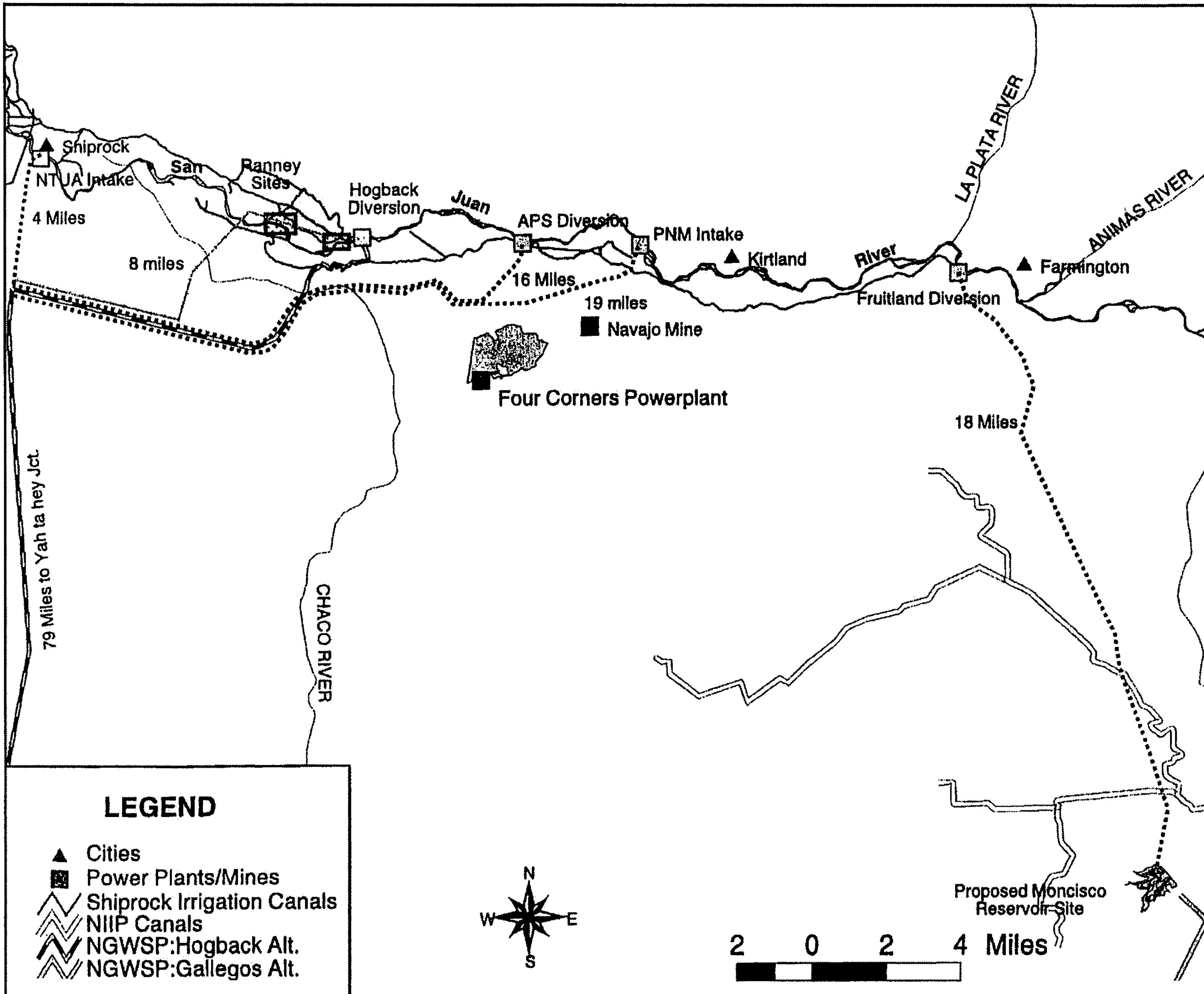


Figure 8.3
Direct Diversions Options

nilpproj.apr
By: R.L. Kirk
March 15, 2001
Department of Water Resources

Navajo-Gallup Water Supply Project

- Potential Diversion Site #2: The Fruitland Diversion Structure

The Fruitland Irrigation Project includes approximately 350 farming plots totaling 3,830 assessed acres (*BIA 1993 Crop Utilization Survey*, BIA, 1993). The Fruitland Diversion Structure is located two miles west of Farmington, San Juan County, New Mexico, on the southern bank of the San Juan River at river mile 178.5 about 0.4 miles upstream from the confluence of the La Plata River. The diversion structure is located on land which was previously owned by the Navajo Mission and is now owned by the City of Farmington.

The Fruitland Diversion Structure is a quarry rock structure that is maintained on an as-needed basis. A sluiceway to the river adjacent to the canal can sluice up to 1,000 cfs back to the river through two 10 foot wide gates. During midsummer these gates are operated to allow a flow of 100 to 200 cfs through the sluiceway. The gates are opened wider during periods of higher flows and are left open during the winter. The capacity of the canal is approximately 165 cfs although 120 cfs is considered the likely maximum. This diversion does not operate during the winter months (BIO/WEST, 1996).

The Fruitland Diversion is very close to the upstream diversion site evaluated in the 1984 Environmental Statement, and it is very close to the site evaluated by Reclamation in 1996. Of the diversion sites considered, the Fruitland Diversion is the furthest upstream and it has the best water quality. Utilizing the existing Fruitland Diversion would require significant upgrades including fish screens and passages, better sediment control, and a more permanent weir. A nearby rock quarry has several excavated pits that have filled with water from the San Juan River. These ponds might provide regulating storage for the Project. However, they would need to be protected from potential flood damage during high flows.

The Fruitland Diversion is upstream from the confluence of the La Plata and San Juan Rivers. Consequently, its location does not have the hydrologic flexibility needed to accommodate the San Juan River Recovery Program Flow Recommendations. For this reason, it was not further evaluated.

- Potential Diversion Site #3: The Shiprock NTUA Diversion Structure

NTUA has an octagonal intake tower set in the river channel on the north side of the San Juan River near river mile 145. It is adjacent to the Highway 666 bridge. The NTUA facilities include a gravity line leading to a settling basin, pumps and a pipeline to the water treatment plant. The diversion diverts approximately 600 acre-feet per year. The original facilities have been modified twice to reduce the intake of river sand. These modifications include an infiltration gallery beneath the river bed and a venturi type sand separator. The sand separator is not able to extract sand fast enough which creates major problems. The operators have indicated that suspended solids originating largely from the Chaco Wash also create water treatment problems (Molzin-Corbin, 1993).

Reclamation ruled out a diversion structure for the Project at Shiprock because the extra 300 foot pumping lifts were excessive and the water quality was low. The Recovery Program reports that during 1999 turbidity of the San Juan River at Shiprock exceeded 4,000 NTU's for three six-day periods. Reclamation reports that the total dissolved solids (TDS) at Shiprock ranged from 149 mg/l to more than 2,000 mg/l during low flows. The median concentration was 488 mg/l which barely meets secondary safe drinking water standards. Projected flow reductions in the San Juan River by the year 2030 will cause those concentrations to increase. Reclamation recommended a more favorable site up stream closer to Farmington (Reclamation, 1984). The NTUA diversion is downstream from the Uranium Mine Tailing Reclamation Act site in Shiprock. A diversion downstream from this site may raise health and safety concerns in the future. For these reasons, this site was not further evaluated.

- Potential Diversion Site #4: The Four Corners Generation Station Diversion Structure

The Arizona Public Service Company (APS), which operates the Four Corners Power Plant, diverts water from the San Juan River near river mile 160. The intake structure is at the base of a cliff on the south side of the river. It was constructed during the late 1960's. Since then silt and landslides have shifted the river channel away from the intake making it more difficult to maintain an adequate water supply to the power plant. From the intake structure, two sets of two pumps convey 32,000 gpm approximately 2.5 miles from the river to Morgan Lake. Morgan Lake is used as a cooling pond for the power plant. Depending on the weather and power demands, during a typical year the pumps operate between 60 and 70 percent of the time.

Morgan Lake impounds 39,000 acre-feet. The water is used for condenser cooling, domestic use at the plant, boiler feed makeup, ash sluicing and scrubbers. Approximately 10,000 acre-feet of the Morgan Lake water returns to the San Juan River each year via the Chaco River.

One of the concerns with incorporating Morgan Lake into the Project is the poor quality of the water in the lake. The cooling process results in a build up of solids. While relatively low TDS water (415 ppm) is diverted from the river, the operation of the lake results in TDS concentrations between 900 and 1000 ppm. APS tries to keep the TDS between 700 and 800 ppm. The TDS of the water discharged to the Chaco Wash has been measured at 3,300 ppm. Data from 1975 indicate that the water in Morgan Lake is, on average, twice as hard as the water in the San Juan River near Shiprock (230 verses 452 ppm) and that it fails to meet a large number of secondary water treatment standards (*Four Corners Power Generating Plant and Coal Mine, Environmental Report*, March 1975, Westinghouse Environmental Systems Department).

Although these water quality issues are not necessarily fatal flaws, they would result in much more complex water treatment requirements. Theoretically, the Lake could be managed to maintain higher water quality. However, occasional contamination due to small amounts of turbine lubricating oil has occurred. The Lake Morgan water supply meets the water quality demands of the power plant. However, domestic systems have much more stringent water quality standards, including notification requirements if standards are violated. These safe drinking water standards make it much more difficult to use a cooling pond for a municipal domestic water supply. For these reasons, this site was not further evaluated.

- Potential Diversion Site #5: The Ranney Infiltration Gallery

The Ranney Method Western Cooperation (Ranney) conducted an initial assessment of the practicality of developing an infiltrated water supply using the San Juan River aquifer materials to pre-treat the supply. The Ranney staff conducted a site visit to the San Juan River. Theoretically, an infiltration gallery can be installed anywhere along the river. The San Juan River between Shiprock and Farmington was inspected to determine the most suitable sites. One criterion was to locate the infiltration galleries upstream from Uranium Mine Tailing Reclamation Act (UMTRA) site in Shiprock. Additional effort was made to identify sites that would minimize the potential environmental impacts. With these criteria three sites were field inspected.

Ranney reviewed information in their corporate files. Ranney installed a similar unit one mile west of Farmington, New Mexico for the Lower Valley Water Users Association (Brewer, 1977 and 1981). Reports indicate that the gallery yielded approximately 1.0 million gallons per day. But, the water from that gallery had a noticeable hydrogen sulfide odor and it was high in iron and manganese. That gallery has been abandoned. In 1973 Ranney investigated a site near the Hogback Diversion for the Fluer Corporation. For that investigation five test wells were installed. The Fluer investigation indicates that each gallery may yield 2.0 million gallons per day.

Ranney recommends 20 foot deep reinforced concrete caissons with inside diameters of nine feet and concrete top slabs. The caissons would be 500 feet apart. Each caisson would have three 500 foot long horizontal gallery lines installed beneath the streambed. Ranney estimates that individual units would yield approximately 1.5 million gallons per day and have an estimated cost between $900,000 and $1,100,000. This option would require approximately 22 caissons to meet the average annual demand of the Project at full build out and approximately 26 caissons to meet the 1.3 peaking requirement. The reconnaissance level cost for this diversion is $26 million. The cost for pumps, pump houses, access roads, and conveyance pipelines to the treatment facility would be additional.

This proposed configuration for three banks of caissons is down stream from the Hogback Diversion Structure. One bank of caissons would be located directly downstream from the Hogback Diversion Structure on the north side of the river between the river and the Hogback Canal. Another bank of caissons would be approximately two miles downstream from the Hogback Diversion Structure on the south side of the river. The third bank would be about four miles downstream from the Hogback Diversion Structure on the south side of the river. Compared to the San Juan Generating Station Diversion, this site eliminates approximately 36,000 feet, or seven miles, of 52 inch diameter pipe. It may also eliminate the need for a storage reservoir to supply water during times of high turbidity and it may result in lower water treatment costs. However, it will require a more extensive collection system. The banks of caissons could be phased as the Project demand increases over time. This option will be further investigated.

- Potential Diversion Site #6: The San Juan Generating Station Diversion Structure

The Public Service Company of New Mexico (PNM), which operates the San Juan Generating Station, diverts water from the San Juan River approximately 13 miles downstream from the City of Farmington near river mile 166. This diversion was constructed in 1972 and it diverts approximately 30 cubic feet per second or 24,000 acre-feet per year, of which 16,400 acre-feet is under a contract from the Secretary of the Interior. The San Juan Generating Station is a zero discharge facility. The PNM diversion is downstream from the La Plata River confluence and upstream from the Ojo Amarillo Wash confluence. This location may have slightly better water quality than the other downstream sites, but with respect to the endangered species, it has somewhat less hydrologic flexibility.

The water is diverted through a sluice way on the north side of the river to a pumping station. Three 800 horsepower pumps lift the water about 200 feet to a 2,700 acre-foot cooling and regulating pond about three miles away. When the river turbidity exceeds 5,000 NTU's the pumps are shut down and the plant draws on water stored in the pond. After 27 years of operation PNM has lost about 600 acre-feet, or 20 percent, of its capacity due to sediment and suspended solids. PNM and City of Farmington power facilities are located at the pump station. The weir is being modified with a manned fish bypass on the south side of the river to enable endangered species greater access to habitat upstream.

The PNM diversion could readily incorporate an additional sluiceway and pump station. For this Project the sedimentation sluiceway will need to be enlarged to maintain the appropriate velocities to ensure that the suspended solids in the water pumped by the PNM pumps does not increase. It may also be possible to utilize the existing PNM pond during times when the river water is turbid by releasing water down back down the existing pipeline. It also appears that the PNM site is large enough to accommodate the treatment facilities. The PNM Diversion has been used for the cost estimates presented in this technical memorandum. This site will be further evaluated.

- Potential Diversion Site #7: The Hogback Diversion Structure

The Hogback Irrigation Project includes 9,614 acres of irrigable land (BIA, 1962). The Hogback Diversion Structure is located at river mile 158.9 (BIO/WEST, 1996). It is downstream from the La Plata River and the Ojo Amarillo Wash confluences with the San Juan River, and upstream from the Chaco Wash confluence. It was constructed of alluvial fill materials pushed up from the river bed to form a berm across the channel and it is routinely damaged and reconstructed with major flow events. The size and configuration varied from year to year.

As a result of NIIP's Section 7 Consultation with the USFWS for NIIP, the BIA and Reclamation are rebuilding the diversion dam. The new sheet pile diversion will be completed in 2001, and the headworks will be completed in 2002. This upgrade will improve fish passage and improve the water control for the Shiprock irrigators. These upgrades will result in a much more sound structure that may be more suitable for a municipal project than the previous one.

The diversion structure forces water into a side channel where water either passes through radial gates into the canal or returns to the main river channel using a side channel sluiceway. The headgate is a remnant of an older quarry rock structure. Up to 1,700 cubic feet per second (cfs) of water can be diverted into the inlet bay where the majority of flow passes through a sluiceway back to the main channel. Radial gates in the control structure are used to regulate flow into the irrigation canal. Approximately 300 cfs of water typically passes into the irrigation canal. A second sluiceway, located approximately 1,500 feet farther down stream returns about 100 cfs back to the main river channel. Approximately 200 cfs continues down the canal for irrigation. NTUA has a 900 gallon per minute, or 2 cfs, gravity lateral which conveys water from the Hogback Canal to the NTUA Shiprock water treatment plant (Molzen-Corbin, 1993).

The Hogback Canal does not operate during the winter months, and it may have capacity constraints during the summer months. However, water is diverted through the headworks throughout the year. The canal headgates are on the north side of the San Juan River. Consequently, to reach the Project service area, either a new headgate would be needed on the south side, or the diverted water would need to be siphoned across the San Juan River. Compared to the San Juan Generating Station Diversion, this site eliminates approximately 36,000 feet, or seven miles, of 52 inch diameter pipe. Depending on the results of the analysis of the Ranney Infiltration Gallery and the PNM diversion, this site on may be further evaluated.

In conclusion, in 1996 Reclamation concluded that the capital cost of a direct diversion from the San Juan River may be more expensive than utilizing the NIIP facilities. However, that analysis did not include the full costs using the NIIP facilities. For this technical memorandum sites upstream from the La Plata River confluence were not further considered because their limited hydrologic flexibility will make it difficult to accommodate the flow recommendations. Sites downstream from the Chaco Wash and the Shiprock UMTRA site were eliminated due to water quality concerns. The Four Corners Diversion Site was eliminated due to hydraulic constraints and the incompatibility of combining a municipal water supply with the power plant's cooling pond water supply.

Three options may be further considered: (1) A Ranney infiltration gallery downstream from the Hogback Diversion, (2) PNM's San Juan Generating Station Diversion Structure and (3) possibly the Hogback Diversion Structure. For the cost estimates presented in this technical memorandum, the PNM San Juan Generating Station Diversion Structure is used. Reconnaissance evaluations indicate that the overall costs of any of these three options will be similar. More detailed analysis is required to determine a preferred alternative.

8.1.2 The Highway 666 Pipeline Corridor

During the 1980's and 1990's several possible main line alignments were evaluated. The alignment for the San Juan River Diversion Alternative generally follows the Highway 666 corridor and is similar to the "San Juan Alignment "described in the *1984 Environmental Statement and Planning Report*. This alignment was considered the preferred alternative in the 1984 report. Descriptions and cost estimates of the main pipeline and pumping stations from the Hogback Diversion Structure to Yah-ta-hey are presented in the following sections.

For the San Juan River Diversion Alternative, the main pipeline may originate near PNM's San Juan Generating Station Diversion Structure. This pipeline alignment proceeds west along Highway 36 to Highway 666 south of Shiprock. The pipeline route follows Highway 666 to Yah-ta-hey where it connects to laterals serving the Window Rock and Gallup areas. The use of the highway corridor will have to address the concerns of the State of New Mexico Highway Department. This route brings together transportation, power, and water corridors. With this alternative it may also be possible to take advantage of previous environmental compliance investigations conducted for the highway. This alignment is shown in Figures 2.1 and 8.1.

The main line has been sized to accommodate a seasonal peaking factor of 1.3. The diameter of the main line is estimated to be 52 inches at the first reach and it decreases incrementally to 34 inches near Yah-ta-hey. These diameter and lengths are shown in Table 8.1. The pipe material would likely be steel, polyvinyl chloride (PVC), or ductile iron. Steel has been used for this cost estimate. Appurtenant structures such as air valves, blowoffs, meter structures, and sectionalizing valves, will be specified during final design. The diameters, lengths and appraisal level field costs for the main line reaches are presented in Appendix D. The unit cost for the pipelines are based on cost estimates prepared by Reclamation for similar projects in northern Arizona (Reclamation, 2000).

Reclamation evaluated the geology on this pipeline corridor. Approximately 10.2 percent of the Highway 666 pipeline corridor is in possible bedrock. For the cost estimates presented in this technical memorandum, the pipeline corridor is based on 90 percent common excavation and 10 percent rock excavation.

At individual NTUA points of delivery, storage tanks of sufficient capacity are needed to supply water during peak use periods, during system repair, and for fire suppression. These tanks will either be located at high elevations or equipped with booster pumps to provide adequate system pressure. Regulating storage capacity has been included in the cost estimates. The IHS recommends approximately 2,000 gallons of system storage per household. Assuming 4.5 people per household, this standard is equivalent to a 4.4 day supply at 100 gallons per capita per day or a 2.7 day supply at 160 gallons per capita per day. Reclamation's Denver Technical Center recommends three days of storage capacity for a system with multiple water sources, and five days of supply for a system with a single source. These two criterion are very similar to the criterion recommend by Bosserman (et al). The NDWR recommends a local Project storage capacity adequate for five days of average demand.

The cost estimates for the storage tanks are based on Mean's Handbook for ground level tanks. At some sites, more expensive elevated tanks may be required, but that option was not considered in the cost estimate. With this criterion the Project main line will need 33 million gallons of storage at a cost of $8.7 million (or $13.6 million including indirect costs).

8.1.3 San Juan Alternative Pumping Requirements

Approximately 14 pumping plants are needed to lift the water to higher elevations and to supply energy to overcome friction resistance of water moving through the pipeline. The initial pumping plant would be located at the diversion structure on the San Juan River with booster pumping plants located on the main line and on the laterals. Each pumping plant would have multiple pumps with electric motors located indoors. Each pump would have an arrangement of valves and valve operators for startup control and isolation from the pipeline. The pumping plants would have flow meters for measurement of water distribution. The field cost of the pumping plants assumes 70 percent efficiency. Exact locations, sizes, and power requirements will be determined in the final design process. The main line will require a total horsepower of 17,000 and will cost of $10.5 million (or $16.4 million with indirect costs).

Table 8.1
The San Juan River Alternative Main Line Reach Diameters and Lengths

Reach	Length (Feet)	Diameter (Inch)
PNM Diversion to NAPI Junction	8,388	52
NAPI Junction to Highway 666 near Shiprock	91,042	52
Shiprock Junction to Sanostee	94,323	50
Sanostee to Burnham Junction	51,075	48
Burnham Junction to Newcomb Junction	19,088	48
Newcomb Junction to Sheep Springs	51,174	48
Sheep Springs to Naschitti	29,635	46
Naschitti to Tohatchi	90,183	46
Tohatchi to Coyote Canyon Junction	34,954	46
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
Twin Lakes Junction to the Ya-ta-hey Junction	31,161	42
Total	516,617	

8.2 The NIIP Alternative

Several NIIP points of diversion were evaluated including: (1) collection of NIIP subsurface drainage return flows, (2) a direct pipeline from Navajo Reservoir, and (3) conveying water through the NIIP Main Canal to Moncisco Reservoir. Due to the relatively small volume of NIIP return flows, the high cost of the collection system, concerns regarding the expense of water treatment, and the minimal environmental benefits, the sub-surface option was not further considered. Due to the high cost, a direct pipeline from Navajo Reservoir was not further considered. Conveying water through the NIIP facilities is evaluated in this section.

With the NIIP Alternative the Project would convey 36,700 acre-feet per year through the NIIP facilities. The average diversion is 50 cubic feet per second and the peak diversion is 65 cubic feet per second. Water from the Navajo Reservoir would be conveyed through the NIIP Main and Burnham Lateral Canals to the proposed Moncisco Reservoir. Winter operation of the NIIP canals may reduce the size of the required storage. A treatment plant and pumping station would be constructed near Moncisco Reservoir. The pipeline alignment proceeds south from the treatment plant to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The main pipeline route follows the gas line corridor to Twin Lakes where it follows Highway 666 south to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. From the main line three laterals include: (1) a pipeline from Naschitti north along Highway 666 to Sanostee, (2) a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, and (3) a pipeline from the treatment plant near Moncisco Reservoir along Highway 44 to Nageezi then south to Torreon. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.2 and 8.2.

8.2.1 Conveying water through the NIIP Facilities

Conveying water through the NIIP facilities is evaluated in this section. With the NIIP Alternative, the water would be diverted from Navajo Reservoir through the NIIP Main Canal, the water would be lifted approximately 300 feet at Gallegos Pumping Plant into the Burnham Lateral Canal. A pipeline and a stabilized channel would deliver the water from the Burnham Lateral Canal to the proposed Moncisco Reservoir. (The 1996 *Water Supply and Storage Alternatives Gallup Navajo Pipeline Project* report by Reclamation refers to the proposed reservoir as Moncisco Reservoir.) The proposed Moncisco Reservoir would only inundate the Moncisco Wash arm of the facility proposed in the *1984 Plan Formulation and Environmental Study.*

Conveyance losses through the NIIP canal system will need to be addressed. Diversion and metered agricultural deliveries data over the period 1989 to 1993 indicate that the mean conveyance efficiency of the NIIP canal system is 90 percent. The worst case conveyance efficiency is approximately 87 percent. This efficiency will improve if NIIP is not required to deliver selenium dilution water. For this technical memorandum NIIP conveyance losses are assumed to be 10 percent.

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Newcomb Junction to Sheep Springs	51,174	48
Sheep Springs to Naschitti	29,635	46
Naschitti to Tohatchi	90,183	46
Tohatchi to Coyote Canyon Junction	34,954	46
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
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With the NIIP Alternative the Project would convey 36,700 acre-feet per year through the NIIP facilities. The average diversion is 50 cubic feet per second and the peak diversion is 65 cubic feet per second. Water from the Navajo Reservoir would be conveyed through the NIIP Main and Burnham Lateral Canals to the proposed Moncisco Reservoir. Winter operation of the NIIP canals may reduce the size of the required storage. A treatment plant and pumping station would be constructed near Moncisco Reservoir. The pipeline alignment proceeds south from the treatment plant to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The main pipeline route follows the gas line corridor to Twin Lakes where it follows Highway 666 south to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. From the main line three laterals include: (1) a pipeline from Naschitti north along Highway 666 to Sanostee, (2) a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, and (3) a pipeline from the treatment plant near Moncisco Reservoir along Highway 44 to Nageezi then south to Torreon. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.2 and 8.2.

8.2.1 Conveying water through the NIIP Facilities

Conveying water through the NIIP facilities is evaluated in this section. With the NIIP Alternative, the water would be diverted from Navajo Reservoir through the NIIP Main Canal, the water would be lifted approximately 300 feet at Gallegos Pumping Plant into the Burnham Lateral Canal. A pipeline and a stabilized channel would deliver the water from the Burnham Lateral Canal to the proposed Moncisco Reservoir. (The 1996 *Water Supply and Storage Alternatives Gallup Navajo Pipeline Project* report by Reclamation refers to the proposed reservoir as Moncisco Reservoir.) The proposed Moncisco Reservoir would only inundate the Moncisco Wash arm of the facility proposed in the *1984 Plan Formulation and Environmental Study*.

Conveyance losses through the NIIP canal system will need to be addressed. Diversion and metered agricultural deliveries data over the period 1989 to 1993 indicate that the mean conveyance efficiency of the NIIP canal system is 90 percent. The worst case conveyance efficiency is approximately 87 percent. This efficiency will improve if NIIP is not required to deliver selenium dilution water. For this technical memorandum NIIP conveyance losses are assumed to be 10 percent.

Navajo-Gallup Water Supply Project

The ability to convey Project water through the NIIP canals depends on three constraints: (1) the available canal capacity during July, (2) the length of the canal operating seasons, and (3) the storage capacity of the proposed Moncisco Reservoir. Because each of these constraints affects the project configuration differently, each one is described in the following sections. A map of the NIIP canals and the related facilities is shown in Figure 8.4.

- Constraint #1: NIIP canal capacity available during July

  The capacity of the NIIP Gravity Main Canal is 1,285 cfs and the capacity of the Burnham Lateral is 880 cfs. The average municipal demand is approximately 50 cubic feet per second. The peak demand is 65 cubic feet per second. During most, but not all, of the year these facilities have more than adequate capacity to meet the demands of both NAPI's irrigated land and the Project's municipal requirements.

  One of the operating constraints for the Project may be the canal capacity required during the peak NAPI's irrigation demand in July. The irrigation demands for NAPI during a typical year for the Gravity Main Canal, the Burnham Lateral, and the Burnham Lateral West are shown in Table 8.2 (Reclamation, 1996). With an overall irrigation efficiency of 55 percent, NAPI's irrigation demand limits the canal capacity available for the Project during July. The municipal demand, however continues throughout the year. Insufficient midsummer capacity could be addressed if NAPI maintains higher irrigation efficiencies, stresses its irrigated crops or irrigates fewer acres. For instance, with an overall efficiency of 65 percent this limit is almost eliminated. These options may reduce NAPI's operational flexibility and increase NAPI's risks during unexpected weather events or canal breakdowns. Based on Reclamation's operation analysis, approximately 2,000 acre-feet of reservoir capacity is required to supply the municipal demand during July.

Figure 8.4 : Map of NIIP Facilities

Schematic of the NIIP Canals
and proposed NGWSP Facilities

niipproj.apr
By: R.L. Kirk
March 15, 2001
Department of Water Resources

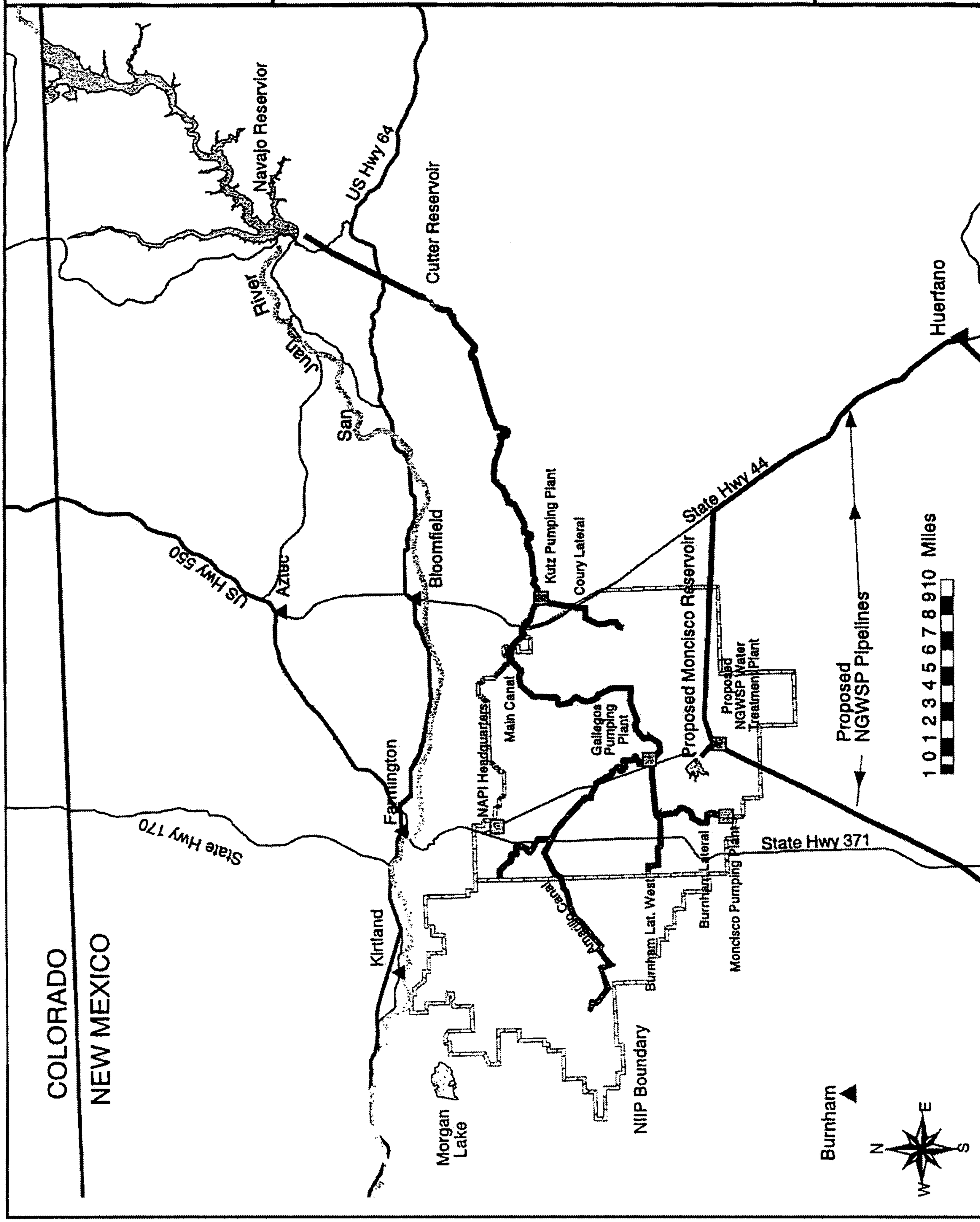


Table 8.2
NIIP Monthly Canal Capacities Available for the Navajo-Gallup Water Supply Project

Month	NAPI Demand as a Percent of the Peak Capacity[1] (Percent)	Gravity Main Canal Capacity Available for NGWSP[2] (cfs)	Burnham Lateral Capacity Available for NGWSP (cfs)	Burnham Lateral West Capacity Available for NGWSP (cfs)	Amarillo Canal Capacity Available for NGWSP (cfs)
January	0	1,285	880	320	190
February	0	1,285	880	320	190
March	0	1,285	880	320	190
April	25	964	660	240	143
May	55	578	396	144	86
June	75	321	220	80	48
July	100	0	0	0	0
August	82	231	158	58	34
September	50	643	440	160	95
October	17	1,067	730	266	158
November	0	1,285	880	320	190
December	0	1,285	880	320	190

[1] These percentages are the ratio of NAPI's peak monthly demand and that months average demand.

[2] Available canal capacities are the design capacity minus the NAPI irrigation demand. Canals are assumed to be operating at full capacity during the peak month to maintain NAPI's operational flexibility.

- Constraint #2: The length of the NIIP canal operating season

Municipal water supply projects require water throughout the year. In contrast, irrigation projects typically only operate during the irrigation season. The shorter the irrigation season lasts, the more storage will be required for the municipal project. The length of the canal operating season is the most critical constraint for determining the municipal storage requirement.

At NIIP the current irrigation season normally extends from April 1 to October 31. During the months that no irrigation occurs, November through March, NAPI conducts maintenance on the NIIP facilities. In addition to the storage required to provide water during the peak summer irrigation season, the Project requires storage while the canals are not in operation. Reclamation analyzed the Project's storage requirement based on three theoretical NIIP canal operating seasons: (1) the current canal operating season from April 1 to October 31, (2) an extended canal operating season from March 1 to October 31, and (3) all year operation of the canal system.

The Current Canal Operating Season. The current canal operating season begins in April and ends in October. This season provides NAPI with five full months during which the canals are not operated and annual maintenance can be conducted. With no water delivery during these winter months, Moncisco Reservoir needs approximately 11,000 acre-feet of active storage to supply the Navajo-Gallup Project.

An Extended Canal Operating Season. The current canal operating season could be extended by beginning water deliveries approximately one month earlier. The extended season would begin March 1 and end October 31. This season would provide NAPI with four months to conduct the annual maintenance. This extended canal operating season would avoid the likelihood of hard winter freezes which may severely damage the canal facilities. The earlier season reduces the required storage capacity at Moncisco Reservoir to approximately 8,800 acre-feet of active storage. The extended season might also provide NAPI with an opportunity to pre-irrigate some of its fields. Pre-irrigation stores water in the soil column reducing the peak irrigation diversion requirements and helps to circumvent canal capacity constraints during the summer months. Pre-irrigation may reduce pumping costs by taking advantage of off-season energy rates. Other local irrigation companies including the Farmers Mutual Ditch Company near Kirtland have extended delivery seasons to encourage pre-irrigation.

All Year Canal Operation. All year operation of NIIP canals and structures will impact NAPI's ability to conduct annual operation and maintenance. Specialized winter operation and preparation may increase NIIP's operation and maintenance expense, but it decreases the storage required to meet the municipal demands. Winter maintenance such as canal lining replacement, drain installation, crack sealing, and silt removal cannot be performed with water in the canal. Maintenance at canal check structures and turnout structures is more difficult if they are under water. All year operation will also require that positive seals be installed at turnouts to pumping plants to keep water out of the pump sumps. The siphon blowoffs also need to be protected from freezing. In addition, winter operation affects the operation of the canal drains. Water under the canal lining combined with the freezing action of the soil can damage the canal linings. Currently the canal drains are open during the winter and closed during summer. This operation drains water under the lining during the winter and conserves water during the summer. There is also the potential for canal lining and other structures to be damaged due to ice dams.

For food processing NAPI may need to operate a portion of the Main Canal and the Gravity Main Canal downstream from Cutter Reservoir during most of the year. NAPI has proposed a factory that would produce frozen french fry potatoes. This factory would have an annual diversion requirement of approximately 3,000 acre-feet and deplete approximately 400 acre-feet. Cutter Reservoir has an active storage of 808 acre-feet and an inactive storage of 942 acre-feet. This reservoir has adequate capacity to meet the factory's water demand for several weeks. This storage will enable NAPI to shut down portions of the Main Canal for brief periods of time for annual maintenance. All year operation reduces, but does not eliminate the need for additional municipal storage.

- Constraint #3: Regulating storage at the proposed Moncisco Reservoir

Gallegos Reservoir was a feature of the original project specifications for the Navajo Indian Irrigation Project and was originally designed to provide 45,000 acre-feet of storage for surface irrigation. In 1973, NIIP was redesigned as an all-sprinkler system operation and Reclamation maintained that the sprinkler modifications eliminated the need for Gallegos Reservoir. Consequently, the 1976 Environmental Impact Statement (EIS) for NIIP is based on all-sprinkler operation that does not include Gallegos Reservoir. After a four-year consumptive use study was completed by Reclamation in 1983, Reclamation and the BIA determined that the storage capacity in Gallegos Reservoir was required, and it was added as a project feature of NIIP. Since Gallegos Reservoir was not included in the 1976 EIS, a supplemental EIS is required before it, or an alternative reservoir, can be constructed.

The proposed Moncisco Reservoir is smaller than the proposed Gallegos Reservoir. It will be located on the Moncisco Wash. It will supply water during periods when the NIIP facilities are not operating. If the NIIP canals do not operate during the five winter months, the Project will need 11,000 acre-feet of active storage capacity to deliver 34,000 acre-feet per year. If the canals do not operate for four months, the Project will only need 8,800 acre-feet of active storage capacity. Even if the NIIP canals operate all year, the Project will need at least 1,850 acre-feet of active storage capacity. The Project cost estimate for the NIIP Alternative presented in this Technical Memorandum is based on 8,800 acre-feet of storage.

Navajo-Gallup Water Supply Project

Two possible sites near NIIP have been identified for the proposed Moncisco Reservoir: the Cottonwood site located in Section 25, R15W, T27N, and the Moncisco site located in Section 18, R12W, T26N. The Moncisco site is within the boundary of the originally proposed Gallegos Reservoir. At either location the proposed dam would be a zoned earth core dam with a concrete spillway and outlet works consisting of an intake structure, outlet pipe with valves, and outlet structure. At either location, a dam approximately 80 to 100 feet high with a 350-surface acre reservoir is expected. Detailed geologic field investigations are still required. Both sites were visited during March of 1998 by Reclamation biologists. Based on those field trips, the proposed reservoir sites are extremely arid and support mixed desert plant communities with small, sparse willows in the bottom of the washes. Neither site has habitat suitable for the Southwestern willow flycatcher, an endangered species. Appraisal level studies identify the Moncisco site as the preferred site. The cost estimates of various capacities are shown in Table 8.3 and a schematic of the Moncisco site is shown in Figure 8.5. The cost estimates presented in this technical memorandum are based on Reclamation's high range cost estimate for 8,800 acre-foot capacity.

The construction of any reservoir will require withdrawing land. Reclamation staff have indicated that there may be some local opposition to withdrawing land for either the Moncisco or Cottonwood sites.

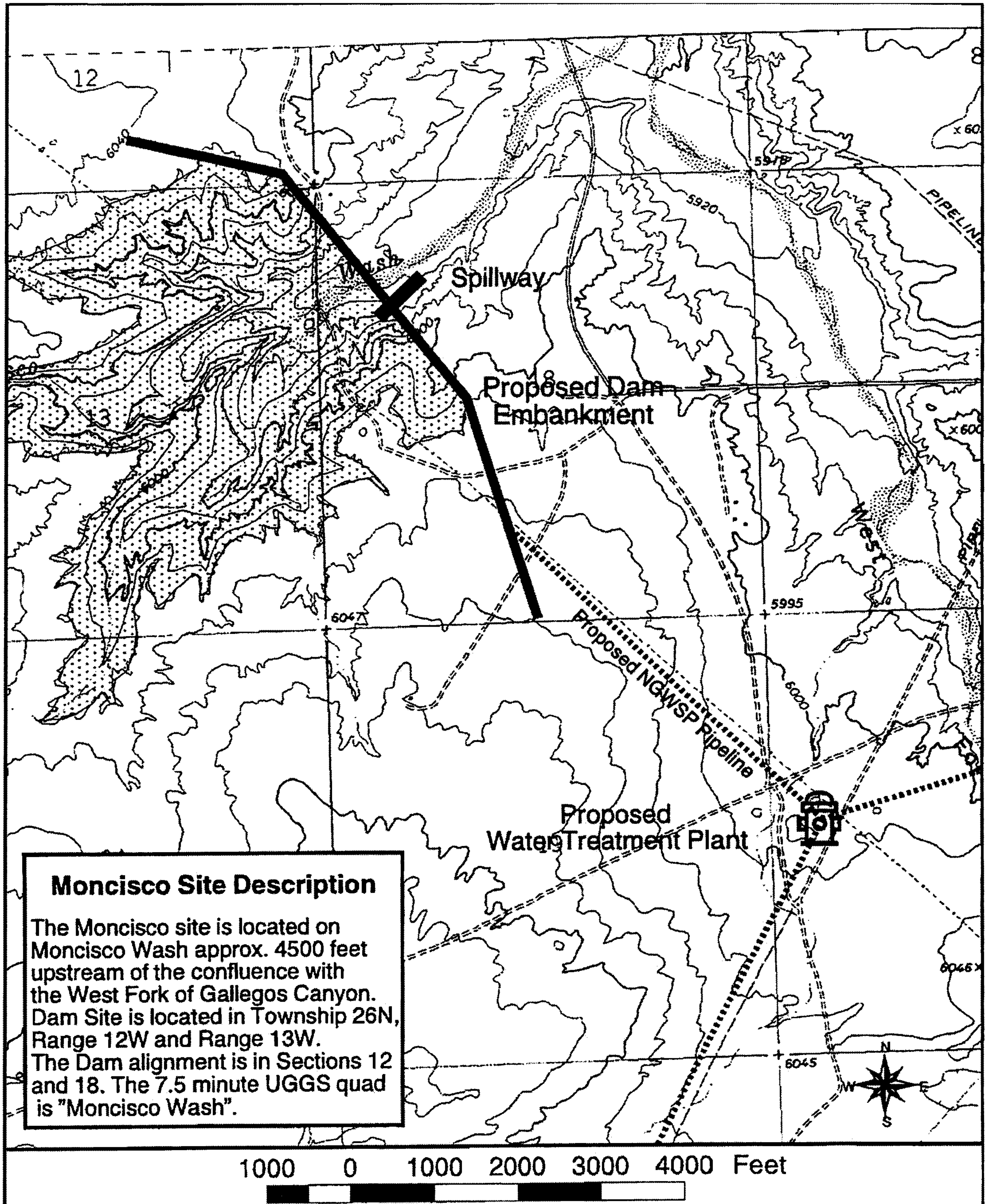
Table 8.3
Range of Estimated Cost for Project Storage Facilities at NIIP
(FY 2000 Dollars)

Capacity (Acre-feet)	Low Range (Million Dollars)	High Range (Million Dollars)
11,000	$38.6	$40.0
8,800	$33.0	$36.1
4,380	$22.5	$27.8

Navajo-Gallup Water Supply Project

To better characterize the three water delivery constraints at NIIP, the NDWR analyzed the operation of the NIIP facilities. The results of a representative scenario are shown in Figure 8.6. For this scenario, the NIIP canals begin operating in early March. During March, April and May the canals have adequate capacity to meet the irrigation and the municipal demand. Late in May and early June the diversions into Moncisco Reservoir are increased. The reservoir is partially filled as late as possible to minimize the duration that it is full and when evaporation and seepage losses are the greatest. Late in June and most of July the irrigation demand requires essentially all of the canal capacity. During this period the municipal demand is met by releases from the reservoir. Depending on the weather, a portion of the irrigation demand may also be met with reservoir releases. By late July the irrigation demand deceases and the canal capacity is again adequate. To keep evaporation and seepage losses to a minimum, the reservoir is filled as late as possible in the fall. The reservoir should be filled some time in early October to supply the municipal water demand during the winter months when the canals are shut down. From October to March the municipal demand is met by releases from the reservoir.

The evaporation and seepage losses from Moncisco Reservoir are impacted by the overall efficiency at NIIP. For this technical memorandum it is assumed that the evaporation loss is a depletion and that the seepage loss returns to the San Juan River. If NIIP's efficiency is 55 percent, there is a canal capacity constraint during July. Consequently, Moncisco Reservoir needs to be partly filled in June. The evaporation loss is approximately 540 acre-feet per year and the seepage loss is approximately 323 acre-feet per year. If NIIP's efficiency is 65 percent, there are no canal capacity constraints during July. Consequently Moncisco Reservoir only needs to be filled in September to provide water during the winter months. The evaporation loss is approximately 210 acre-feet per year and the seepage loss is approximately 130 acre-feet per year. NIIP's 1999 Biological Assessment indicates that NIIP's overall efficiency in the future will be close to 65 percent (Keller Bliesner, 1999). For the depletion estimates in this technical memorandum NIIP's overall irrigation efficiency is assumed to be 65 percent.



LEGEND

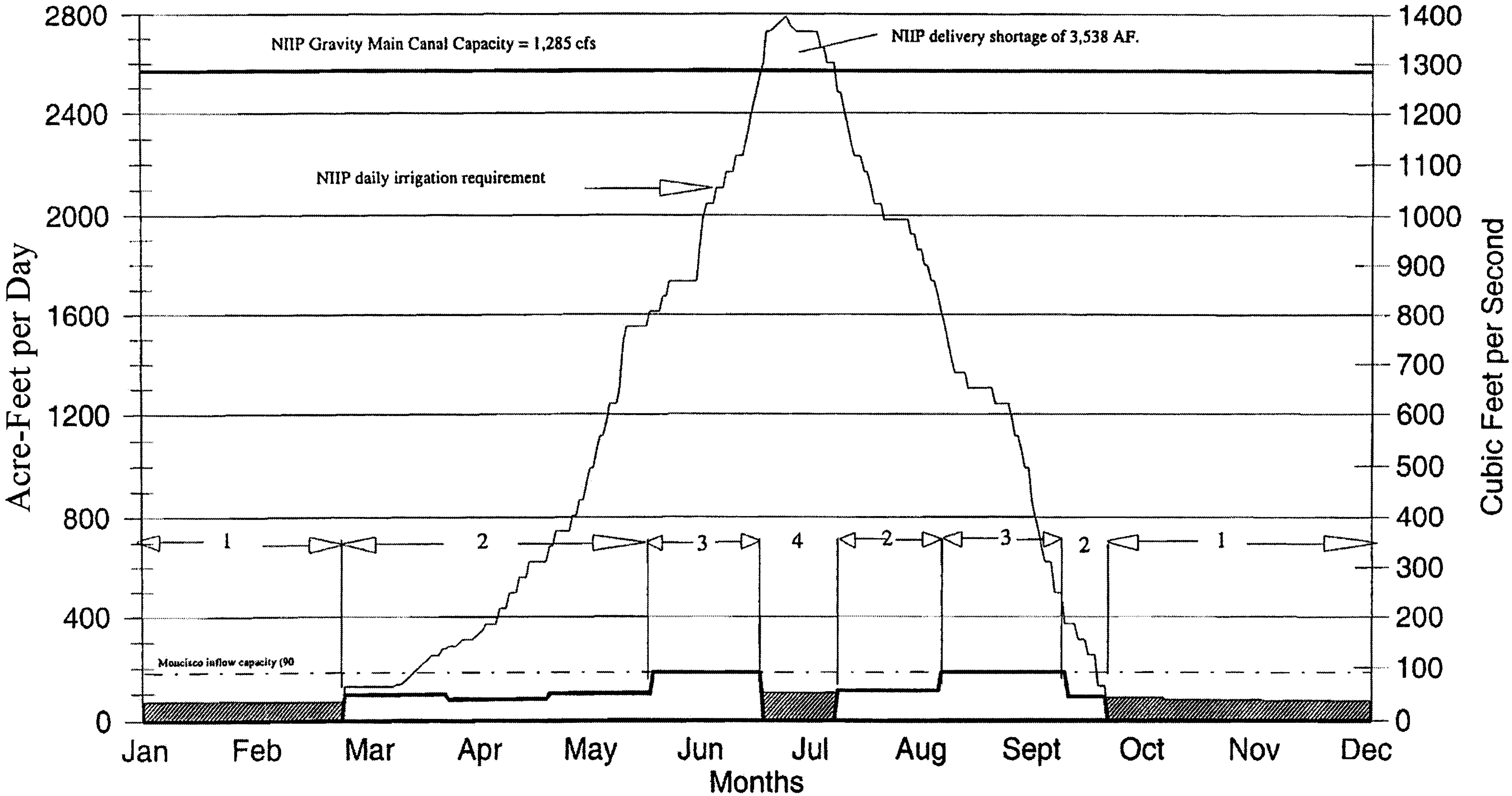
Moncisco Dam Site
Gallegos Water indentations
Navajo-Gallup Pipeline

Figure 8.5
Navajo-Gallup Water Supply Project

Proposed Moncisco Dam Site

Ngwspwork.apr, By: R. Kirk
March 15, 2001

Figure 8.6: Navajo Indian Irrigation Project vs. Navajo-Gallup Water Supply Project Demand



1. NIIP canals closed for winter. NGWSP water delivery from Moncisco Reservoir.

2. Diversions from NIIP canals through Moncisco Reservoir to NGWSP Pipeline.

3. Moncisco Reservoir is filled. Late season fill minimizes reservoir losses. Reservoir only supplys water during summer and winter shortages.

4. Inadequate capacity for NGWSP and NIIP industrial water delivery. Diversions from Moncisco Reservoir are required during summer shortages.

Note:
* NIIP Irrigation delivery requirement is based on the 1994/95 operating season.
* Moncisco Reservoir has a 8,800 AF capacity.
* NIIP overall Efficiency is 55%

8.2.2 The Transwestern Pipeline Corridor

During the 1980's and 1990's several possible alignments for the main line were evaluated. The pipeline alignment for the NIIP Alternative generally follows the Transwestern Pipeline Corridor and is similar to "Alternative C" described in the *San Juan River Gallup/Navajo Water Supply Project Engineering and Cost Estimates Technical Appraisal Report*, November 1993. Of all the alignments between NIIP and Yah-ta-hey considered, this alignment is the shortest and requires the least amount of lift and fewest pumping stations to serve the Project area. The description and cost estimate of the main line from Moncisco Reservoir to Yah-ta-hey are presented in the following section.

For the NIIP Alternative, the main line originates near the pumping plant below the proposed Moncisco Reservoir. This pipeline alignment proceeds south to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The pipeline route follows the gas line corridor to Twin Lakes where it turns south to Yah-ta-hey where it connects to water lines for the Window Rock and Gallup areas. Use of the gas line corridor will have to be negotiated with the respective pipeline representatives. However, a memorandum of understanding between the Navajo Nation and the companies regarding the pipeline right-of-ways should facilitate these discussions. This alignment is shown in Figures 2.2 and 8.2.

The main line has been sized to accommodate a peaking factor of 1.3. The diameter of the main line is estimated to be 52 inches at the beginning and 42 inches near Yah-ta-hey. The pipe material would likely be steel, polyvinyl chloride (PVC), or ductile iron. Appurtenant structures such as air valves, blowoffs, meter structures, and sectionalizing valves, will be specified during final design. The diameters, lengths and appraisal level field costs for the main line reaches are presented in Table 8.4. At individual points of delivery, storage tanks with a total capacity of 33 million gallons and a cost of $8.7 million (or $13.7 million including indirect costs) are included in the cost estimate.

Reclamation evaluated the geology on this pipeline corridor. Approximately 7.7 percent of the Highway 666 pipeline corridor is in possible bedrock. For the cost estimates presented in this technical memorandum, the pipeline corridor is based on 90 percent common excavation and 10 percent rock excavation.

8.2.3 Pumping Requirements

Approximately 14 pumping plants are needed to lift the water and to supply the energy to overcome the frictional resistance of water moving through the pipeline. The initial pumping plant would be located below the forebay of Moncisco Reservoir with booster pumping plants located on the main line and on the lateral pipelines. Six pumping plants are needed. The main line will require 10,000 horsepower at a cost of $6.1 million (or $9.7 million including indirect costs). The exact locations, sizes, and power requirements will be determined in the final design process (Reclamation 1993).

Table 8.4
The NIIP Alternative Main Line Reach Diameters and Lengths

Reach	Length (Feet)	Diameter (Inch)
Moncisco Water Treatment Plant to the Main Line (Huerfano Junction)	4,478	52
Main Line (Huerfano Junction) to the Burnham Junction	55,732	50
Burnham Junction to the Lake Valley Junction	72,046	50
Lake Valley Junction to the Naschitti Junction	76,272	48
Naschitti Junction to the Tohatchi Junction	82,686	46
Tohatchi Junction to the Coyote Canyon Junction	34,954	44
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
Twin Lakes Junction to the Ya-ta-hey Junction	31,161	42
Total	372,923	

8.3 Service to the Municipal Subareas

The objective of this section is to describe the alternatives for conveying water from the main line to each of the communities. One critical goal is to develop a Project that can be readily operated. NTUA raised several operational concerns. First, if a significant portion of the water in a proposed lateral or water tank is not used, the water stagnates. Under these circumstances it is difficult to maintain chlorine residuals and it can result in bacteria problems. Second, the pipelines and other facilities will be subjected to wear and tear as soon as they are installed. Even with a long life expectancy, the water purveyor needs to address maintenance as soon as a facility is built, whether or not the facility is used. Third, additional miles of long laterals which serve relatively small demands create a disproportionate operation and maintenance burden for the water purveyor and the water users. And, fourth, the water users must be able to afford the water. The proposed alternatives combine Project and programmatic components to balance the short-term and long-term demands of the service area in a cost-effective manner.

The laterals are designed with a peaking factor of 1.3 and a per capita water use of 160 gallons per person per day. The pipe diameters of the laterals range from 34 to 6 inches and the pipes would likely be steel, polyvinyl chloride (PVC), or ductile iron. Pipe diameters and lengths for the San Juan River and the NIIP Alternatives shown in Figures 8.1 and 8.2 and Tables 8.5, 8.6, 8.7 and 8.8. Depending on the Project alternative, the total estimated cost for the laterals is between $117 (for the San Juan Alternative) and $123 million (for the NIIP Alternative).

An additional objective of this section is to present surface and groundwater supply options for each municipal subarea. The Project, as proposed, will require additional conjunctive groundwater development. Groundwater development in this region is very difficult and costly. Further study will be required to determine if the conceptual groundwater components described in this memorandum are viable. As shown in Tables 8.7 and 8.8 the cost of the proposed groundwater component is approximately $73 million.

If the entire municipal demand in the service area could be met with groundwater, the capital cost of developing wells to meet those demands would exceed $500 million. For the reasons presented in Chapter 5, groundwater development does not provide a viable option at any cost because groundwater supplies are inadequate to provide a reliable, long-term water supply. However, for comparatives purposes, 100 percent groundwater scenarios are presented for every subarea along with the recommended conjunctive groundwater option. Regulating storage tanks have been included with the surface water components. Presumably the groundwater component and the regulating storage tanks can be phased over the next forty years.

To better characterize the water supply and demand of the region and the Project's service area, the communities have been grouped into twelve municipal subareas. The subareas include: (1) The City of Gallup, (2) Central Project, (3) Crownpoint, (4) Huerfano, (5) NAPI, (6) Navajo Land adjacent to the City of Gallup and the City of Gallup, (7) Rock Springs, (8) Route 666, (9) the San Juan River, (10) Thoreau-Smith Lake (which is within the planning region, but it is not within the Project's proposed service area), (11) Torreon, and (12) Window Rock. The service options for the subareas within the service area are described in the following section.

Table 8.5
The San Juan River Alternative Project Laterals - Lengths, Diameters and Cost including pumps, storage tanks and indirect costs

Lateral	Length (Feet)	Diameter (Inch)	Cost (Million Dollars)
Window Rock Lateral			$25.55
Yah-ta-hey to Rock Springs	29,439	26	
Rock Springs to St. Michaels	58,871	24	
Crownpoint Lateral			$18.94
Coyote Canyon Jct to Coyote Canyon	35,938	16	
Coyote Canyon to Standing Rock	81,321	14	
Standing Rock to Dalton Pass	37,998	14	
Cutter Reservoir - Torreon Lateral			$50.33
Cutter Reservoir to Huerfano	136,961	18	
Huerfano to Nageezi	61,308	18	
Nageezi to Counselor	105,773	16	
Counselor to Torreon	85,396	10	
Gallup Area Lateral			$22.62
Yah-ta-hey to Gamerco Hill	20,482	32	
Gamerco Hill to Gallup Junction	15,072	32	
Gallup Junction to Churchrock	46,041	14	
Gallup Junction to Red Rock	26,320	14	
Gallup Junction to Manuelito	47,050	14	
Total	787,970		$117.44

Navajo-Gallup Water Supply Project

Table 8.6
The NIIP Alternative Project Laterals - Lengths, Diameters and Costs including pumps, storage tanks and indirect costs

Lateral	Length (Feet)	Diameter (Inch)	Cost (Million Dollars)
Window Rock Lateral		0	$25.55
Yah-ta-hey to Rock Springs	29,439	28	
Rock Springs to St. Michaels	58,871	24	
Crownpoint Lateral			$16.46
Coyote Canyon Jct - Coyote Cyn	35,938	14	
Coyote Canyon - Standing Rock	81,321	12	
Standing Rock to Dalton Pass	37,998	12	
Moncisco - Torreon Lateral			$37.91
Huerfano Junction to Huerfano	98,788	18	
Huerfano to Nageezi	61,308	16	
Nageezi to Counselor	105,773	16	
Counselor to Torreon	85,396	10	
Gallup Area Lateral			$22.62
Yah-tah-hey to Gamerco Hill	20,482	32	
Gamerco Hill to Gallup Junction	15,072	32	
Gallup Junction to Churchrock	46,041	14	
Gallup Junction to Red Rock	26,320	14	
Gallup Junction to Manuelito	47,050	14	
Sanostee Lateral			$20.06
Naschitti Jct to Naschitti	51,354	16	
Naschitti to Sheep Springs	29,459	14	
Sheep Springs to Newcomb	51,058	14	
Newcomb to Sanostee	51,019	10	
Shiprock Lateral			$19.59
Moncisco to Hogback	139,824	18	
Hogback to Shirpock	55,532	18	
Total	1,128,043		$122.60

TABLE 8.7
Recommended Municipal Conjunctive Groundwater Development

MUNICIPAL SUBAREA	1998 G.W. PRODUCTION (Acre-feet)	2040 DEMAND (Acre-feet)	PROPOSED 2040 G.W. PRODUCTION (Acre-feet)	PROPOSED CONJUNCTIVE GROUNDWATER COMPONENT
1. Central	27	911	77	Burnham: 1 well at 4,000 feet in the Gallup, Dakota or Morrison at 120 gpm ($4,000,000) Lake Valley: 2 wells at 100 feet the Chaco River Alluvium at 20 gpm ($200,000) White Rock: 1 well at 4,000 feet in the Morrison at 100 gpm ($4,000,000) Whitehorse Lake: 2 wells at 500 feet in the Menefee Formation at 20 gpm ($1,000,000)
2. Crownpoint	330	3,226	752	Coyote Canyon: 2 wells at 1,500 feet in the Dalton Sandstone at 60 gpm ($3,000,000) Crownpoint: 3 wells at 2,000 feet in the Westwater Sandstone at 100 gpm ($6,000,000) Dalton Pass: 2 wells at 2,000 feet in Gallup Sandstone at 20 gpm ($4,000,000) Standing Rock: 2 wells at 2,500 feet in the Westwater at 80 gpm ($5,000,000)
3. Huerfano	90	910	46	2 wells at 1,000 feet in the Ojo Alamo Sandstone at 60 gpm ($2,000,000)
4. Gallup Area	328	4,823	502	Breadsprings: 2 well at 2,000 feet in the Gallup Sandstone at 50 gpm ($4,000,000) Church Rock: 2 well at 2,000 feet in the Chinlee at 30 gpm ($4,000,000) Iyanbito: 2 well at 2,000 feet in the Glorietta at 125 gpm ($4,000,000) Red Rock: 2 well at 2,000 feet in the Gallup Sandstone at 50 gpm ($4,000,000)
5. Rock Springs	58	2,287	169	3 wells at 1,700 feet in the Gallup Sandstone at 40 gpm ($5,100,000)
6. Route 666	551	6,161	795	Naschitti: 2 wells at 1,500 feet in the Point Lookout Sandstone at 80 gpm ($3,000,000) Tohatchi: 3 wells at 1,500 feet in the Point Lookout Sandstone at 150 gpm ($4,500,000)
7. Torreon	113	2,316	77	6 wells at 1,500 feet in the Menefee/Point Lookout Sandstone at 20 gpm ($9,000,000)
9. Window Rock	1,043	7,179	767	6 wells at 750 feet in the Gallup/Dakota/Morrison at 60 gpm ($4,500,000) 6 wells at 300 feet in the C-Aquifer at 50 gpm and conveyance system ($1,800,000)
NAVAJO TOTAL	2,540	27,813	3,185	
GALLUP TOTAL	4,335	8,900	1,400	See City of Gallup's Well Production Planning Report and DePauli Report

Table 8.8
Groundwater Supply Options for the Project Service Area (excluding distribution systems)

Municipal Subarea	2040 Municipal Demand	100 Percent Groundwater Scenario	Recommended Conjunctive Groundwater Scenario
	(Acre-feet)	(Million Dollars)	(Million Dollars)
1. City of Gallup	8,459	n/a	n/a
1. Central	911	$16.5	$9.2
2. Crownpoint	3,225	$67.5	$18.0
3. Huerfano	910	$20.0	$2.0
4. Gallup (Navajo land adjacent to the City)	4,822	$107.0	$16.0
5. Rock Springs	2,287	$95.0	$5.0
6. Route 666	6,161	$52.0	$7.5
7. San Juan River	n/a	n/a	n/a
8. Torreon	2,316	$117.0	$9.0
9. NAPI	n/a	n/a	n/a
10. Window Rock	7,179	$59.0	$6.3
Navajo Nation Total	27,811	$534.0	$73.0

8.3.1 City of Gallup

In 1997 the City assessed its groundwater development options. That year the City produced 4,335 acre-feet of water. By the year 2040, the City's water demand will increase to approximately 8,500 acre-feet. According to the City's *Well Production Planning Report* (Sterling & Mataya, and John W. Shomaker and Associates, Inc, 1998) without a new water source the City anticipates a one million gallon per day shortage during peak periods as early as 2010. This section describes water services options with and without the Project.

- The No-Action Alternative with 100 percent groundwater

  According to the City's reports, the static water level of the Santa Fe Well Field has decline more than 340 feet since the 1960's and the Yah-ta-hey Well Field has declined more than 700 feet since the 1970's. The City's forty-year master plan identified two short-term alternatives including the expansion of the Yah-ta-hey Well Field to the north and developing water in the Ciniza area to the east. The City is also considering developing groundwater near Mount Taylor. None of these options will result in a sustainable, long-term water supply. None of these options meet the Project's purpose and need.

- The NIIP or San Juan River Project Alternative with the preferred conjunctive groundwater development

  With either Project alternative, the City of Gallup's groundwater withdrawals will be dramatically reduced. During the first few years, groundwater withdrawals can be completely eliminated, and the aquifer recharge can be maximized. By the year 2040 the City will again use groundwater during the summer. With the Project, the City estimates that by 2040 it will use approximately 1,440 acre-feet of groundwater per year. One result of the Project is that the City will not need new groundwater development. And, the associated groundwater operation and maintenance expenses will be greatly reduced.

  Depauli Engineering and Surveying Company presented a preliminary design and cost estimate for distributing the Project water from the Yah-ta-hey Junction through the City of Gallup to the NTUA systems in Churchrock on the east, Manuelito and Spencer Valley on the west, and Redrock on the south. The total estimated cost for construction, engineering and contingencies for the regional project is $23.5 million (excluding costs associated with addressing NEPA, cultural resources and rights-of-way).

8.3.2 Central Project Subarea

The Central Project Subarea includes the Chapters of Burnham, Lake Valley, White Rock, and Whitehorse Lake. The projected municipal demand for this area in the year 2040 is 911 acre-feet, of which 77 acre-feet will be met with groundwater. Two options have been considered for serving this subarea, with either alternative a lateral from the main line and conjunctive groundwater development.

- The San Juan River Alternative with a lateral from the main line

  To ensure that the long-term needs of this subarea are not ignored, capacity for these chapters has been included in the main line under the NIIP and San Juan River alternatives. With the San Juan River Alternative a 65,000 foot long programmatic lateral could be constructed from the Highway 666 corridor to Burnham. This lateral would cost $4.0 million. Lake Valley and White Horse Lake would be served from the Crownpoint Lateral. This 165,000 foot long programmatic lateral would cost $9.3 million.

- The NIIP Alternative with a lateral from main line

  With the NIIP Alternative a 82,500 foot long programmatic lateral from the Transwestern Pipeline corridor could be constructed to Burnham and a 83,000 foot long programmatic lateral could be constructed to Whiterock and Lake Valley. These laterals would cost $10.3 million. Depending on the alternative, Whitehorse Lake would be served from either from Crownpoint or Cutter Reservoir. These programmatic options are shown in Figures 8.1 and 8.2.

- Groundwater development

  A possible groundwater option for Burnham is to drill additional wells in the Pictured Cliffs Sandstone Aquifer. Assuming an average of 10 gpm could be attained, 12 wells at depths of about 700 feet would be required. Given the low yields, this alternative is not considered viable. Another alternative would be development of the Gallup, Dakota or Morrison aquifers. Assuming that a well in any of these aquifers could attain 120 gpm, at least one well would be required. This well would need to be between 3,500 and 5,000 feet deep at a cost of $3.5 to $5 million. This option may be viable, but the water quality is poor (specific conductance 2,000 to 5,000 microseimens per centimeter).

  An alternative for Lake Valley is to drill additional wells in the Chaco River alluvial aquifer. Assuming 20 gpm could be attained, two wells with depths of less than 100 feet would be required at a cost of about $200,000. Water quality in the alluvium is generally good (specific conductance about 1,000 microseimens per centimeter). Another alternative would be to complete wells in the Morrison aquifer at depths of more than 4,000 feet. Water quality would be marginal too poor.

An alternative for White Rock is to complete an additional 100 gpm well in the Morrison aquifer at a depth of more than 4,000 feet and a cost of $4 million. Water quality in the Morrison would be marginal too poor (specific conductance 2,000 to 5,000 microseimens).

An alternative for Whitehorse Lake is to complete two wells with a 20 gpm yield in the Menefee formation at a depth of more than 500 feet and a cost of $1 million. Water quality in the Menefee would be marginal too poor (specific conductance 2,000 to 5,000 microseimens). Meeting the total conjunctive groundwater demand will cost $9.2 million.

If the entire demand is to be met with groundwater, the cost of well development would be $16.5 million. These groundwater alternatives will need further study to determine if groundwater is viable. For instance, IHS recently spent one million dollars drilling a well in the Ojo Alamo formation near Whitehorse Lake that was unusable due to benzene. Groundwater can only be incorporated into a preferred alternative if the water supply can be sustained. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.3 Crownpoint Subarea

The Crownpoint Subarea includes the chapters of Becenti, Coyote Canyon, Crownpoint, Dalton Pass, Little Water and Standing Rock. The projected municipal demand for the Crownpoint Subarea in the year 2040 is 3,225 acre-feet, of which 752 acre-feet will be met with groundwater. With either alternative two options have been considered for serving this subarea: a lateral from the main line and conjunctive groundwater development.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both the San Juan River and the NIIP Project alternatives include capacity in the main line and a 118,000 foot long lateral from the main line near Coyote Canyon to the NTUA regional system near Dalton Pass. The estimated cost of this lateral is $17 million. The NTUA system will require additional programmatic upgrades costing an additional $17 million to convey this water. The Project lateral costs for both alternatives are shown in Tables 8.5 and 8.6.

- Groundwater development

  The 752 acre-foot conjunctive groundwater demand for Crownpoint, Becenti and Dalton Pass could be met by increasing groundwater withdrawals from the Westwater Canyon Sandstone Aquifer near Crownpoint and constructing a regional distribution system. The regional distribution system will distribute a combination of San Juan River water and groundwater. Further study is required to ensure that these groundwater withdrawals are sustainable. It is possible that the Westwater Canyon Aquifer is tributary to the San Juan River, and increased groundwater withdrawals may eventually result in depletion to the river.

For Coyote Canyon, additional wells could be drilled in the Menefee Formation or the Dalton Sandstone. This alternative could extend the regional system to meet the combined conjunctive demands of Tohatchi, Mexican Springs, Coyote Canyon, and Twin Lakes. Assuming an average of 60 gpm could be attained, 2 wells at depths of about 1,500 feet and a cost of $3 million are required.

A groundwater option for Crownpoint is to drill additional wells in the Westwater Canyon aquifer. Assuming an average of 100 gpm could be attained, 3 wells at depths of about 2,000 feet at a cost of $6 million is required.

A groundwater option for Dalton Pass is to drill additional wells in the Gallup Sandstone. Assuming an average of 20 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Standing Rock is to drill additional wells in the Westwater Canyon aquifer. Assuming an average of 80 gpm could be attained, 2 wells at depths of about 2,500 feet at a cost of $5 million is required. Meeting the total conjunctive groundwater demand will cost $18 million.

Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $67.5 million, However, it is unlikely that this groundwater could supply more than 25 percent of the total demand. These costs are shown in Table 8.8.

8.3.4 Gallup Area (Navajo Land Adjacent to the City of Gallup)

The Gallup Subarea includes the chapters of Breadsprings, Chichilta, Church Rock, Iyanbito, Mariano Lake, Pinedale, and Red Rock. In addition to 7,500 acre-feet for the City, the projected municipal demand in the year 2040 is 4,823 acre-feet, of which 721 acre-feet will be met with groundwater. Two options have been considered for serving this subarea: a regional City of Gallup distribution system from the main line at Yah-ta-hey and groundwater development.

Previous investigations of this Project resulted in appraisal level designs and cost estimates for the conveyance system as far south as Yah-ta-hey. However, considerable attention needs to be given to the infrastructure south of Yah-ta-hey. The Gallup Subarea distribution system has been explicitly included in this plan formulation.

Navajo-Gallup Water Supply Project

Due to water supply shortages, the City of Gallup has a city ordinance that prevents the deliver of municipal water to the surrounding Navajo trust land. In a letter date March 16, 1998, the Public Works Director for the City of Gallup indicated that the municipal code could be changed once the Project's water becomes available. The City of Gallup, the Indian Health Service and the NDWR are working to remove the administrative and technical obstacles. The trust land raises two delivery opportunities. The first opportunity is delivery to individual Navajo home sites close to the City's current distribution system. If additional water becomes available, these individuals will be able to connect with the City's system in a revenue-neutral manner. This additional system flexibility will provide benefits to the individuals served and for the City's water planning. The second opportunity is to convey water through the City's municipal system to the NTUA public water systems in Bread Springs, Chichiltah, Church Rock, Iyanbito, Pinedale, and Red Rock.

- Regional Gallup Distribution System from Gamerco Hill

  Both Project alternatives include capacity in the main line for the City of Gallup's demands and for the demands for the trust land adjacent to the City. A lateral from the main line near Gamerco Hill would connect to a Regional City distribution system. A 22-cfs pipeline with an initial diameter of 32 inches will convey 12,300 acre-feet of treated water from Yah-ta-hey south toward the City. From the pumping station local laterals will convey water south toward Red Rock, east toward Church Rock, and west toward Manuelito. The NDWR estimated cost of this lateral is $23 million.

  Depauli Engineering followed up the NDWR cost estimate with a more refined estimate for this regional system. The Depauli estimated cost of this regional City distribution system is $23.5 million (excluding costs associated with addressing NEPA, cultural resources and rights-of-way). The Depauli estimate included additional storage tanks and other specific appurtenants. A schematic of this system is presented in Figures 2.1, 2.2, 8.1 and 8.2.

- Groundwater development

  Even with the Project's surface water supply, approximately 721 acre-feet of demand will be met with conjunctive groundwater use by Bread Springs, Chichiltah, Church Rock, Iyanbito, Pinedale, and Red Rock. The NDWR considers this rate of groundwater withdrawal sustainable. This conjunctive component can be met by increasing groundwater withdrawals from the Gallup sandstone, the Glorietta and the Chinle formations. The short-term needs of Church Rock and Iyanbito may be met with groundwater conveyed from the east. However, the Manuelito, Red Rock and Bread Springs Chapters have very limited groundwater development opportunities.

Navajo-Gallup Water Supply Project

A groundwater option for Breadsprings is to drill additional wells in the Gallup Sandstone. Assuming an average of 50 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Church Rock is to drill additional wells in the Chinle Aquifer. Assuming an average of 30 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Iyanbito is to drill additional wells in the Glorietta Sandstone. Assuming an average of 125 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Red Rock is to drill additional wells in the Chinlee aquifer. Assuming an average of 50 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required. Meeting the total conjunctive groundwater demand will cost $16 million.

Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $107 million. However, it is unlikely that this groundwater could supply more than 15 percent of the total demand. These costs are shown in Table 8.8.

8.3.5 Huerfano Subarea

The Huerfano Subarea includes the chapters of Huerfano and Nageezi. The projected municipal demand for the Huerfano Subarea in the year 2040 is 910 acre-feet. Conjunctive groundwater development could supply 92 acre-feet of this demand. Under the NIIP Alternative the remaining 828 acre-feet of demand can be served by a lateral from Moncisco Reservoir. Under the San Juan River Alternative it can be served with a lateral from Cutter Reservoir.

- The San Juan River Alternative with a lateral from Cutter Reservoir

  Under the San Juan River Alternative a lateral from Cutter Reservoir to the NTUA systems at Huerfano, Nageezi and Torreon would be constructed. The estimated cost of this lateral is $50.3 million. This lateral can be readily extended to the TeePee Junction in order to serve the Jicarilla Apache Nation.

  A variation of this alternative is to convey the water for this subarea through the NIIP main canal to the Kutz pumping plant and then on through the Coury Lateral. This variation may enable the delivery of water to this subarea with a minimum of new construction. However, this option may compromise the ability to provide water to some of NIIP's fields.

- The NIIP Alternative with a lateral from Moncisco Dam

  Under the NIIP Alternative a lateral from Moncisco Reservoir to the NTUA systems at Huerfano, Nageezi and Torreon would be constructed. The estimated cost of this lateral is $37.9 million. A schematic of this lateral is shown at Figure 8.2 on page 62.

- Groundwater development

  The 92 acre-foot conjunctive groundwater demand for Huerfano and Nageezi could be met by increasing groundwater withdrawals from the Ojo Alamo Sandstone and connecting the wells to a regional distribution system. Assuming an average of 60 gpm could be attained, 2 wells at depths of about 1,000 feet at a cost of $2 million is required.

  Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $20 million; however, it is unlikely that this groundwater could supply more than 20 percent of the total demand. It is also likely that the Ojo Alamo aquifer is tributary to the San Juan River. Therefore, increased groundwater withdrawals may eventually result in depletions to the river. These costs are shown in Table 8.8.

8.3.6 Rock Springs Subarea

The Rock Springs Subarea includes the chapters of Manuelito, Rock Springs and Tsayatoh. The projected municipal demand for the Rock Springs Subarea in the year 2040 is 2,287 acre-feet, of which 123 acre-feet would be met with conjunctive groundwater. Two options have been considered for serving these demands: with either alternative a lateral can be constructed from the main line and developing additional groundwater.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both Project alternatives include capacity in the main line and the Window Rock Lateral for this subarea. This lateral will connect with the NTUA systems at Rock Springs and Tsayatoh. Manuelito would be served from the Gallup regional system.

- Groundwater development

Navajo-Gallup Water Supply Project

One possible alternative for Rock Springs would be to drill additional wells in the Gallup Sandstone aquifer. Assuming 40 gpm could be attained for each well, three such wells at depths of more than 1,700 feet would be required at a cost of $5.1 million. A regional system could distribute this water to the other chapters.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will require 32 wells in the Gallup Sandstone aquifer at 40 gpm each, or 16 wells in the Morrison aquifer at 80 gpm each, at a cost of $95 million. However, it is unlikely that this groundwater could supply more than 18 percent of the total demand. These costs are shown in Table 8.8.

8.3.7 Route 666 Subarea

The Route 666 Subarea includes the chapters of Mexican Springs, Naschitti, Newcomb, Sanostee, Sheep Springs, Tohatchi, Twin Lakes and Two Grey Hills. These chapters are located along Highway 666. Under either alignment alternative, the public water systems in these communities are well situated to take advantage of the Project water as soon as it is available. The projected municipal demand for the Route 666 Subarea in the year 2040 is 6,161 acre-feet, of which 882 acre-feet could come from groundwater. Two options have been considered for serving these chapters: with either alternative, the subarea can be served from the main line and developing additional groundwater.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both Project alternatives include capacity in the main line for these chapters. These chapters are well positioned to take advantage of the main line without any additional Project laterals. The NTUA systems in the area will need to be upgraded.

- Groundwater development

  An extended regional system could be developed to meet the combined demands of Tohatchi, Mexican Springs, Coyote Canyon, and Twin Lakes. To meet the conjunctive groundwater of the regional system, this extended regional system would require three wells with depths of 1,500 feet in the Point Lookout Sandstone aquifer, or 1,500 to 2,000 feet deep in the Morrison aquifer, at 150 gpm each. Water quality in both the Point Lookout and the Morrison would be good (specific conductance less than 1,000 microseimens per centimeter (Stone and others, 1983)). These wells would cost $4.5 million.

  An alternative for Naschitti would be to drill additional wells in the Point Lookout Sandstone aquifer. Assuming an average of 80 gpm could be attained, two wells at depths of more than 1,500 feet would be required. These wells would cost $3.0 million. Meeting the total conjunctive groundwater demand will cost $7.5 million.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $52 million. However, it is unlikely that this groundwater could supply more than 15 percent of the total demand. These costs are shown in Table 8.8.

8.3.8 San Juan River Subarea

The projected municipal water demand in the San Juan River Subarea by the year 2040 is 8,421 acre-feet per year. The Animas-La Plata Project Supplemental EIS describes three alternatives for delivering approximately 4,680 acre-feet of diversion, or 2,340 acre-feet of depletion, to the Shiprock Area. These alternatives are also described in the NDWR technical memorandum *An Appraisal Level Study of the Proposed Farmington to Shiprock Municipal Pipeline.* The Animas-La Plata Project water supply is only adequate for 55 percent of the Shiprock Subarea's 2040 water demand. This Project includes an additional 3,740 acre-feet of diversion, or 1,870 acre-feet of depletion, to meet the balance of the subarea's municipal demand. Delivery options were considered for both the NIIP Alternative and the San Juan River Alternative. Groundwater is not available in this subarea.

- Serving the San Juan River Subarea with the San Juan River Alternative

  One option is to convey the Project's 3,740 acre-feet of water diversion for this subarea through an enhanced Animas-La Plata Navajo Municipal Pipeline. However, the City of Farmington will have water treatment and conveyance constraints. If Farmington is constrained, this option could include a separate diversion structure which would join the Animas-La Plata Navajo midway between Farmington and Shiprock. The NDWR has estimated that adding this capacity to the Animas-La Plata Navajo pipeline will cost approximately $10 million.

  With the San Juan River Alternative a blind tap can be installed at the Junction of Highway 666 and Highway 34. The NDWR has estimated that adding this capacity to the San Juan River Alternative main line from the from the PNM Diversion to the highway junction will add approximately $ 8.7 million to the Project. For the San Juan River Alternative, this option is the most cost effective and it has been used for the cost estimates in this technical memorandum.

- Serving the San Juan River Subarea with the NIIP Alternative

  It is possible to convey the Project's 3,740 acre-feet of water diversion through an enhanced Animas-La Plata Navajo Municipal Pipeline. The NDWR has estimated that adding this capacity to the Animas-La Plata Navajo pipeline will cost approximately $10 million. For the NIIP Alternative, this option is the most cost effective.

With either alternative it is possible to convey the Project water through a separate stand-alone pipeline. The NDWR estimated that the cost of a stand-alone pipeline from the PNM Diversion to Shiprock would be $20 million.

It is also possible to convey the treated Project water from the proposed Moncisco Reservoir to the Shiprock Junction at Highway 666. The advantage to this option is that is may be able to take advantage of the proposed treatment plant at NAPI. The NDWR estimated that the cost of this option would add $19.6 million. This option has been used for the cost estimates in this technical memorandum.

It is also possible to convey the treated Project water from the proposed Moncisco Reservoir through the main conveyance line to Sanostee. From Sanostee a lateral would convey the water to Shiprock. The NDWR estimated that the cost of this option would be $27.6 million.

8.3.9 Torreon Subarea

The Torreon Subarea includes the chapters of Counselor, Ojo Encino, Torreon and Pueblo Pintado. The projected municipal demand for the Torreon Subarea in the year 2040 is 2,317 acre-feet. Conjunctive groundwater development could supply 177 acre-feet of this demand. The remaining demand can be served by a lateral from the NIIP Main Line or the San Juan River Cutter Lateral.

- The San Juan River Alternative with a lateral from the Cutter Lateral

  Along with serving the Huerfano subarea, with the San Juan River Alternative the Cutter Lateral will also serve the Torreon Subarea. The estimated cost of this lateral is $50.3 million.

- The NIIP Alternative with a lateral from Huerfano

  Under the NIIP Alternative, this subarea will be served from the Huerfano-Torreon Lateral. The estimated cost of this lateral is $37.9 million.

- Conjunctive groundwater development

Navajo-Gallup Water Supply Project

An extended regional system could be developed to meet the combined demands of Counselor, Ojo Encino, Pueblo Pintado, and Torreon. To meet the conjunctive groundwater of the regional system, this extended regional system would require six wells with depths of 1,500 feet in the Menefee or Point Lookout Sandstone aquifer and a yield of 20 gpm. Water quality in both the Point Lookout and the Morrison would be good (specific conductance less than 1,000 µS/cm; Stone and others, 1983). Meeting the conjunctive groundwater demand will cost $9.0 million.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $117 million. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.10 NAPI Subarea

NAPI has plans to develop agricultural processing projects with a total treated water demand of 7,274 acre-feet. The BIA has recently consulted with the USFWS on a french fry processing venture that will require NAPI to deplete 400 acre-feet per year. NAPI is developing a two million gallon per day water treatment plant to provide potable water for the potato processing venture. Both Project alternatives include 300 acre-feet of depletion, in addition to the 400 acre-feet, for food processing opportunities such as vegetable canning. With the NIIP Alternative NAPI will be served from the water treatment plant at the proposed Moncisco Reservoir. With the San Juan River Alternative NAPI will be served from a tap at the junction of the pipeline with Highway 64. No groundwater component is proposed. With either alternative, the cost of water treatment capacity has been included in the cost estimates.

8.3.11 Window Rock Subarea

The Widow Rock Subarea includes the chapters of Fort Defiance and Saint Michaels. The projected municipal demand for this Subarea in the year 2040 is 7,179 acre-feet, of which 767 acre-feet will be groundwater. Two options have been considered for serving these demands including: with either alternative, a lateral from the main line, and groundwater development.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  With either the NIIP or the San Juan River Alternatives, a lateral from the main line near Yah-ta-hey connects to the existing NTUA system serving the Window Rock Subarea. The estimated cost of this lateral is $25.6 million. The NTUA system will require additional programmatic upgrades to convey this water. This later will also have capacity to serve the Rock Springs Subarea. A schematic of this lateral is shown at Figures 8.1 and 8.2.

- Groundwater development near Ganado

The Navajo Nation has considered developing a well field in the Coconino Aquifer near Ganado 30 miles away to augment the Window Rock water supplies. However, the static water level is approximately 200 feet below the surface. From Ganado the water would have to be lifted another 1,400 feet to cross the 7,800 foot pass between Ganado and Window Rock. Based on reconnaissance level estimates, the 26-mile Ganado-Window Rock pipeline would cost approximately $50 million. Importing this water from the Ganado Area to the Window Rock area would strain the limited water supply for the NTUA regional system in Ganado which is Projected to exceed its sustainable supply over the next 40-year planning horizon. The Ganado-Window Rock Project does not meet the purpose and need of the Navajo-Gallup Water Supply Project.

- Groundwater development in the Window Rock Area

An extended regional system could be developed to meet the combined conjunctive groundwater demands of Fort Defiance and St. Michaels. To meet the conjunctive groundwater of the regional system would require six wells with depths of 750 feet in the Gallup, Dakota or Morrison formations with a yield of 60 gpm and a cost of $4.5 million, and six wells with depths of 750 feet in the C-aquifer with a yield of 50 gpm and a cost of $1.8 million. Water quality in both would be good (specific conductance less than 1,000 µS/cm; Stone and others, 1983). Meeting the conjunctive groundwater demand will cost $6.3 million.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $59 million. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.12 Thoreau-Smith Lake Subarea

The Thoreau-Smith Lake Subarea includes the chapters of Baca/Haystack, Casamera Lake, Smith Lake and Thoreau. This subarea is in the planning region, but it is not within the proposed Project service area. The projected municipal demand for the Thoreau Subarea by the year 2040 is 2,196 acre-feet. These chapters are primarily located in the Rio San Jose watershed which is tributary to the Rio Grande. Presently, a significant portion of the water withdrawn by NTUA in this area is conveyed to the Navajo Chapters of Pinedale, Iyanbito, and Church Rock. With the Project, the Thoreau Subarea will benefit because these exports will be greatly reduced. This subarea is also well positioned to take advantage of groundwater in the Mount Taylor Area. The preferred alternative for this subarea is additional groundwater development.

8.4 Power transmission lines, SCADA systems, and cathodic protection

Power lines must be built to furnish the electric power to run the motors and controls of the pumping plants. Electrical connections at existing facilities of the NTUA, Continental Divide Electric Cooperative (CDEC) and Jemez Mountain Electric Cooperative (JMEC) would be required. Power lines of the Navajo Indian Irrigation Project and the City of Farmington may also be an option to provide power. The power lines would be constructed on wood pole structures with overhead conductors. The closest existing 115, 69, or 34.5 kV power line in the vicinity of each pumping plant would be tapped to provide the power to the large horsepower motors. The small horsepower motor of the Huerfano/Nageezi lift pumping plant could be served from a 13.8 Kv power line. Connecting to the larger Kv power lines will require more expensive transformers. The locations and voltages of the transmission lines will be determined after final pumping plant locations are determined. Reclamation's Farmington Construction Office estimated that the power transmission system will cost $3,000,000. This cost could be incorporated into the annual power costs.

A project with over 200 miles of pipelines and tying into over 30 public water systems will need a Supervisory Control and Data Acquisition (SCADA) system to control and monitor the pumping stations, storage and regulating tanks, and the distribution points. The Master control station will cost $318,000, 10 remote stations will cost $232,000 and the installed cable will cost $1.79 per foot (Reclamation, 2000). The total estimated cost for the SCADA system is $1.2 million. Cathodic protection based on stations 1,000 feet apart will cost $0.58 per foot (Reclamation, 2000). The estimated cost of the cathodic protection system is $900,000.

8.5 Water treatment

Reclamation evaluated water treatment options for this Project. Surface water for public drinking systems requires compliance with the Environmental Protection Agency's Surface Water Treatment Rule (SWTR). This rule is part of the National Primary Drinking Water Regulations for public water systems using surface water sources or groundwater under the direct influence of surface water. Each Project alternative was evaluated separately.

NIIP water is characterized by low sulfate concentrations, low total dissolved solids (TDS) concentrations and turbidities less than 100 NTU. Table 8.9 lists potential treatment systems and estimated construction cost for treating NIIP water. Figures 8.7, 8.8 and 8.9 provide preliminary site layouts for a 30 million gallon per day treatment system.

Table 8.9
Treatment Alternatives for the Navajo Indian Irrigation Project Water

Alternative	Generated Waste Streams	Estimated Construction Cost per MGD Capacity
Microfiltration (CMF-S)	Backwash water conveyed to evaporation ponds.	$1,030,000 to $1,240,000
Conventional	Chemical sludge, dried and transported to landfill. Filter backwash water conveyed to evaporation ponds	$900,000 to $1,000,000
Diatomaceous Earth	Spent DE material to Landfill	$770,000 to $973,000

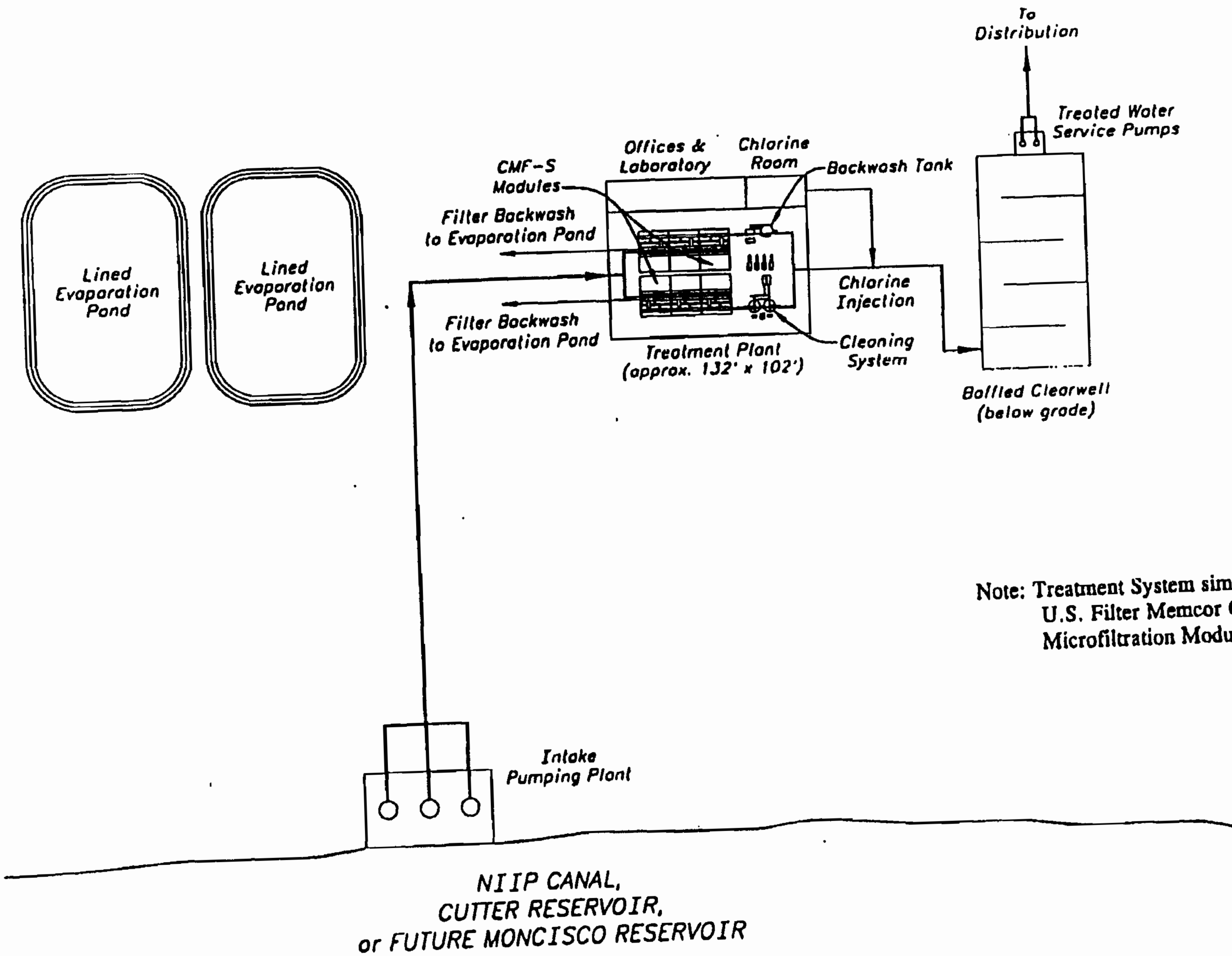
Note: Construction cost is only for treatment system and building. The estimate does not include intake structure, lined evaporation ponds or treated water conveyance system.

Table 8.10 lists treatment alternatives and estimated construction costs for treating water from the San Juan River. To meet the SWTR requirements using these systems, the diversion of water should occur upstream from the Hogback Diversion. Due to high turbidities in the San Juan River during the spring runoff and summer rain storms, a settling pond will be required to decrease the turbidity of the San Juan River water to 500 NTU. Water in the San Juan River upstream from the Hogback Diversion is characterized by sulfate concentrations of less than 200 mg/L and TDS concentrations less than 300 mg/L. To assist in the removal of turbidity in the settling pond, a polymer injection system is required at the pumping plant intake. Figures 8.9 and 8.10 provide preliminary site layouts for a 30 MGD treatment system for each alternative.

Table 8.10
Treatment alternatives and costs for treatment of San Juan River Water at or upstream of the Hogback Diversion

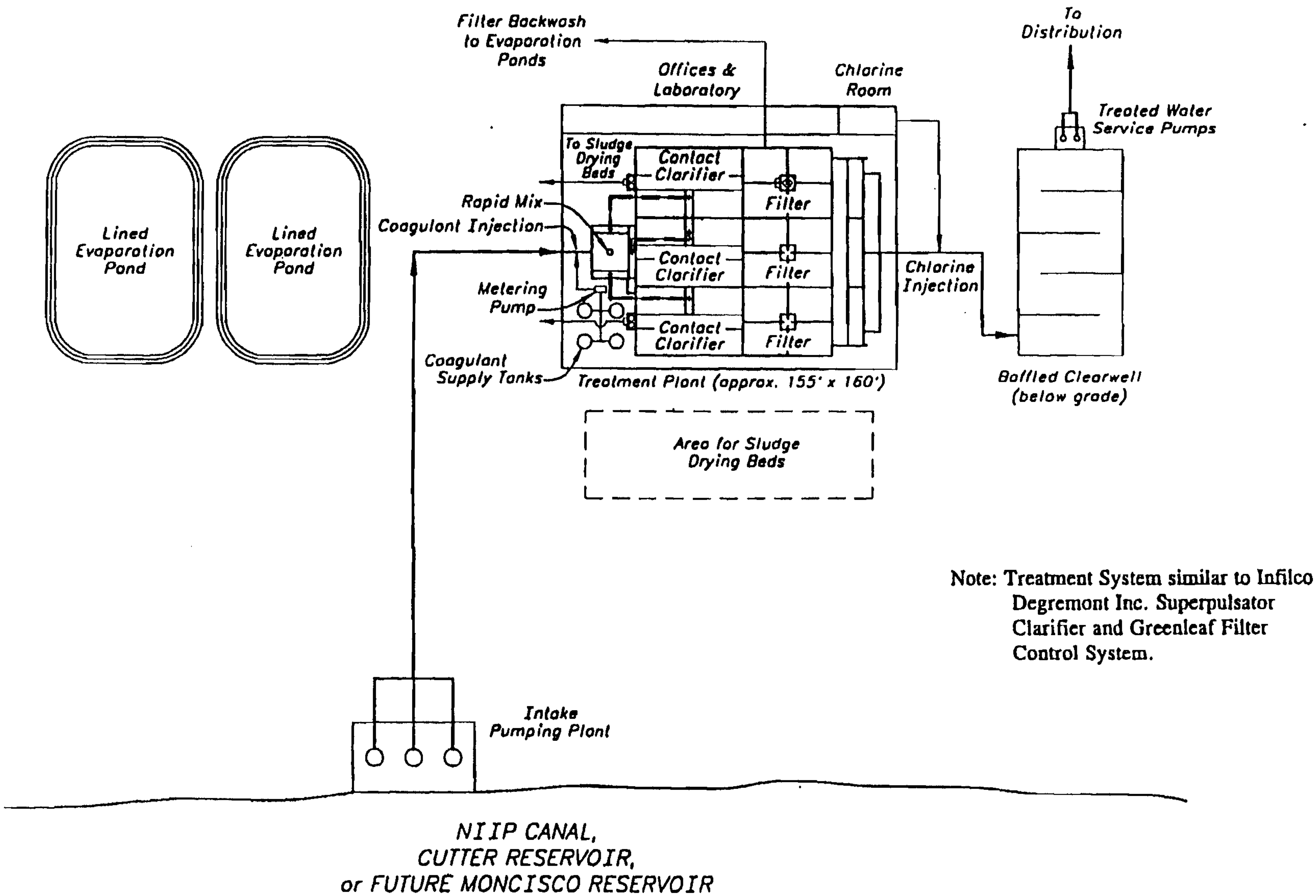
Alternative	Generated Waste Streams	Estimated Construction Cost per MGD Capacity
Pre-settling followed by Microfiltration (CMF-S)	Backwash water routed back to settling pond.	$1,030,000 to $1,240,000
Pre-settling followed by Conventional Treatment	Chemical sludge dried and transported to landfill. Filter backwash water routed back to settling pond.	$900,000 to $1,000,000

Note: Construction cost for treatment system and building only. Estimates do not include river intake, sediment channel, settling pond or treated water conveyance system.



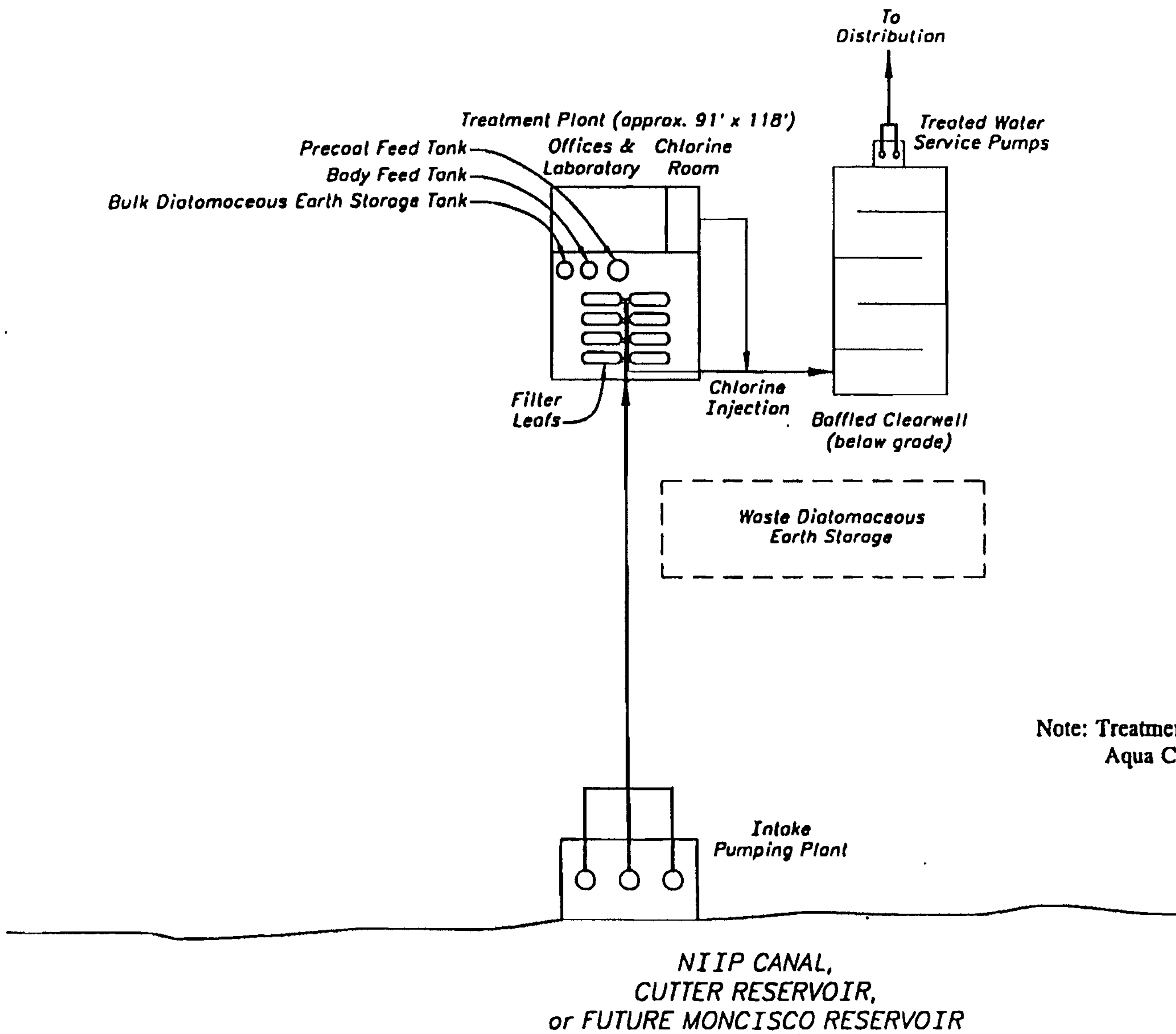
Note: Treatment System similar to U.S. Filter Memcor CMF-S Microfiltration Modules.

Figure 1 - 30 MGD Microfiltration Treatment System, Treating Navajo Indian Irrigation Project (NIIP) Water



Note: Treatment System similar to Infilco Degremont Inc. Superpulsator Clarifier and Greenleaf Filter Control System.

Figure 2 - 30 MGD Conventional Treatment Plant, Treating Navajo Indian Irrigation Project (NIIP) Water

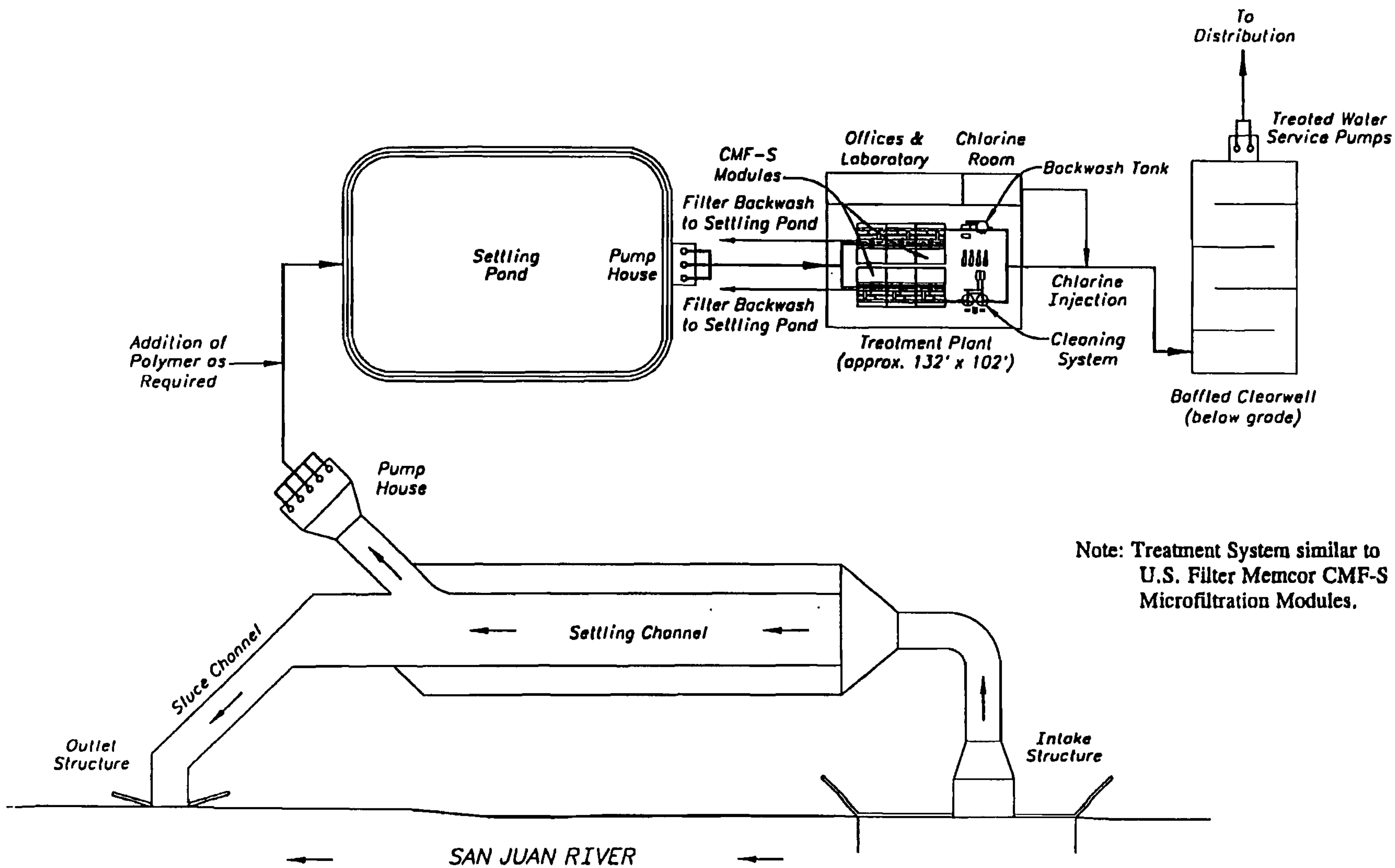


Note: Treatment System similar to Aqua Care Inc. Leaf Filters.

Figure 3 - 30 MGD Diatomaceous Earth Water Treatment Plant for Navajo Indian Irrigation Project (NIIP) Water

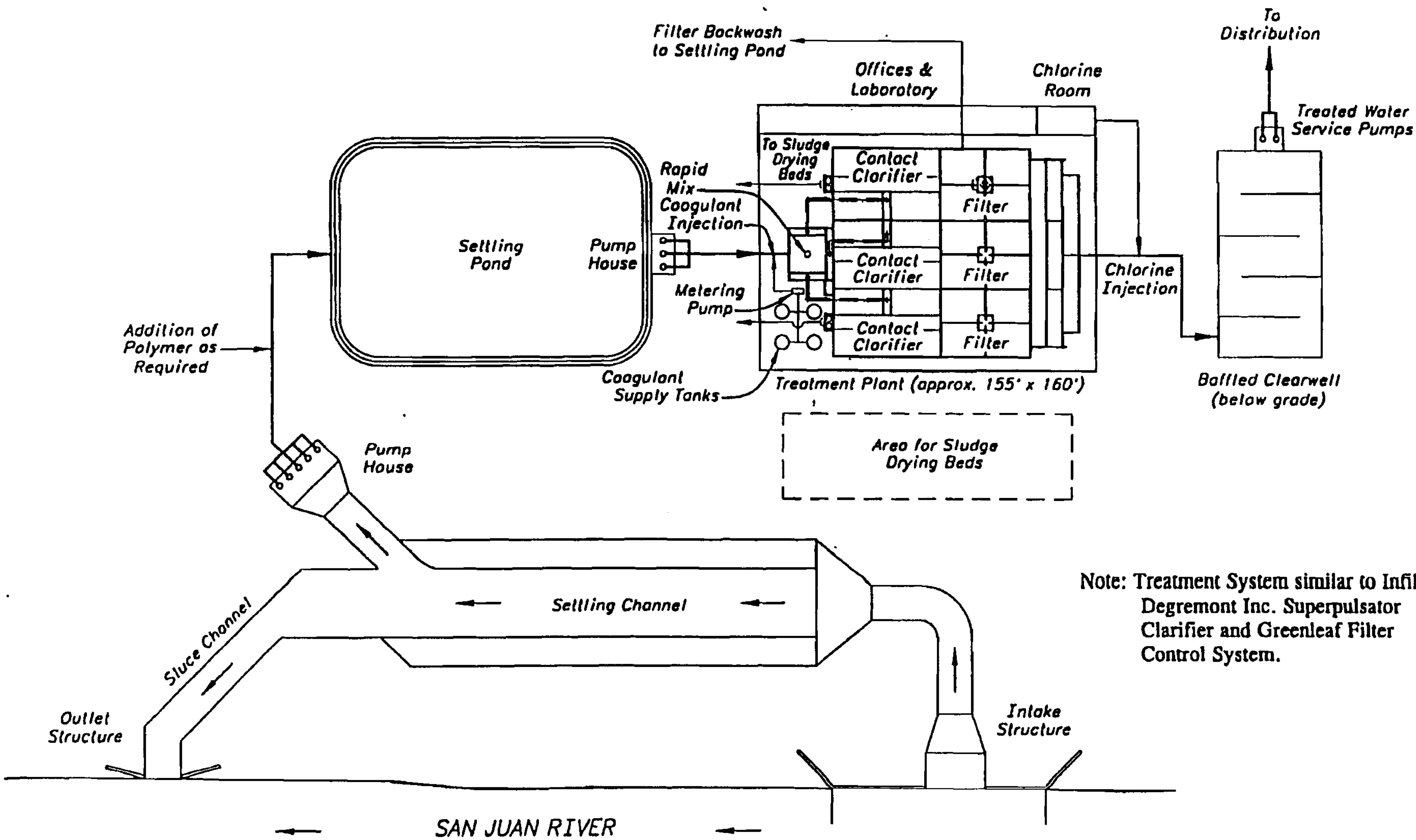
8.5.1 Conventional Water Treatment Systems

Most water treatment plants use conventional treatment systems. Conventional systems use aluminum sulfate (alum) or ferric chloride, and a polymer to coagulate and flocculate inorganics and organics. This process is followed by gravity settling and filtration. Conventional treatment systems generate large quantities of sludge that is typically dewatered in drying beds and disposed in domestic landfills. To reduce the footprint of the conventional treatment systems, solid contact clarifiers and filters are used. Figures 8.10 and 8.11 provide a site layouts of conventional treatment system for NIIP and San Juan River water. The treatment systems shown are similar to the 30 million gallon per day plant that is presently in operation in Green River Wyoming. Estimated costs in Table 8.11 are prorated from the Green River facility. Annual operation and maintenance costs are also provided in Table 8.11. Operation and maintenance costs include: (1) seven operators (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; (3) alum for flocculation; and (4) the annualized cost for replacing the filter media every ten years and the pumps every five years. The annualized costs are based on a plant life of 50 years and an interest rate of eight percent. The estimated construction cost is between $34 and $38 million.



Note: Treatment System similar to U.S. Filter Memcor CMF-S Microfiltration Modules.

Figure 4 - 30 MGD Microfiltration Treatment System on San Juan River



Note: Treatment System similar to Infilco Degremont Inc. Superpulsator Clarifier and Greenleaf Filter Control System.

Figure 5 - 30 MGD Conventional Treatment Plant on San Juan River

8.5.2 Microfiltration Treatment Systems

Microfiltration treatment systems use a relative new technology that does not require chemicals to coagulate suspended solids to meet the drinking water requirements. This process physically separates the suspended particles larger than 0.2 microns from the water. These particles include *Giardia* which are 5 to 15 microns in size, *Cryptosporidium* which are 4 to 6 microns in size, and the majority of organic molecules. The continuous Microfiltration System (CMF-S) is a bundle membrane system which can filter water with high and variable turbidities by drawing untreated water through tubular hollow fiber membranes. Designed for large scale systems, the pre-engineered modules are submerged into open top concrete or steel tanks. The 30 million gallon per day, *US Filters CMF-S Memcor System*, as shown in figures 8.7 and 8.10, provides six Microfiltration cells located in steel tanks. Each cell has a five million gallon per day capacity and contains 576 membrane modules which are continually monitored for proper operation. Large scale CMF-S treatment systems have not been in operation as long as conventional systems. These systems have had great success in meeting the drinking water requirements. Construction cost data are from *US Filter* and are prorated for the proposed plants. The annual operation and maintenance estimates are provided in Table 8.11. The operations and maintenance costs include: (1) seven operators (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; and (3) the annualize cost for the replacement of the microfiltration modules and pumps every five years. The annualized costs are based on a plant life of 50 years and an interest rate of eight percent. The annualized costs used for replacing the microfiltration modules use current costs. Future replacement costs are expected to go down as microfiltration becomes more widely used. This option has been recommended by Reclamation. The estimated construction cost is between $39 and $47 million.

8.5.3 Diatomaceous Earth Water Treatment Systems

Diatomaceous Earth Water Treatment Systems have a precoat filter using diatomaceous earth (DE). These systems require no coagulants and operate effectively in low turbidity water sources. DE is a soft powdery material resembling chalk that contains the remains of single cell algae called diatoms. The system constantly monitors the turbidity of the filtered water. If the turbidity is greater than the determined set point, the system recycles the water until enough DE is added to meet the set point requirements. The spent media cake is air dried before being disposed as a soil amendment or to a domestic landfill. Although different types of DE filters are available, Figure 8.9 is the site plan for a 30 million gallons per day DE system using large diameter leaf filters manufactured by *Aqua Care Systems*. These large leaf filters are typically used in the chemical, steel and mining industry. Construction cost estimates in Table 8.11 are prorated from information from the *Aqua Care Systems*. Annual operation and maintenance estimates are provided in Table 8.11. Estimated operations and maintenance costs include: (1) seven operators, (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; (3) DE material and (4) the annualized cost for the replacement of pumps every five years. The estimated construction cost is between $32 and $40 million.

Table 8.11
Appraisal Level Costs for the Proposed Treatment Plants

Plant Type, Capacity and Location	Estimated Construction Cost	Estimated Annual Operation and Maintenance Cost
Conventional, 38 MGD, Moncisco Reservoir	$34,200,000 to $38,000,000	$1,777,000 to $1,955,000
Microfiltration,38 MGD Moncisco Reservoir	$39,140,000 to $47,120,000	$5,411,000 to $5,914,000
DE Filtration, 38 MGD, Moncisco Reservoir	$29,260,000 to $35,985,000	$1,263,000 to $1,389,000
Conventional, 34.8 MGD, San Juan River	$31,320,000 to $34,800,000	$1,702,000 to $1,872,000
Microfiltration, 34.8 MGD, San Juan River	$35,844,000 to $43,152,000	$5,030,000 to $5,498,000
Conventional, 28.3 MGD, San Juan River	$25,470,000 to $28,300,000	$1,551,000 to $1,706,000
Microfiltration, 28.3 MGD, San Juan River	$29,149,000 to $35,092,000	$4,258,000 to $4,655,000
Conventional, 3.2 MGD, Cutter Reservoir	$2,880,000 to $3,200,000	$969,000 to $1,065,000
Microfiltration, 3.2 MGD, Cutter Reservoir	$3,296,000 to $3,968,000	$1,275,000 to $1,399,000
DE Filtration, 3.2 MGD, Cutter Reservoir	$2,454,000 to $3,115,000	$925,000 to $1,017,000

8.6 Wastewater treatment

Increasing the domestic water supply will result in more wastewater. To protect human health and safety wastewater treatment must be developed in conjunction with the new water supply. Wastewater improvements are considered to be a programmatic cost, not a Project cost. On the Navajo Reservation wastewater treatment facilities are funded by the IHS. Several EPA and USDA programs also provide assistance in developing these facilities which can be phased in as the demands gradually increase.

Wastewater on the Navajo Reservation is typically processed by sewage lagoons or septic tanks. Based on projects in similar regions, Natural Resource Consulting Engineers estimated that the average cost of providing sewerage is $10,000 to $13,000 per household, excluding engineering and contingency costs. Assuming 4.5 people per household, approximately 25,000 new homes will be constructed over the next 40 years in the Project service area. Providing sewerage for those homes is approximately 250 million. However, these expenditures are non-Project costs, and should be considered to be part of the Navajo Nation's ongoing housing program.

In 1999 the City of Gallup produced approximately 3.0 million gallons of waste water pre day. This flow rate exceeded the plant capacity of 2.5 million gallons per day. In 1999 Sterling and Mataya prepared a plan for increasing the City's treatment capacity to 5.5 million gallons per day which will meet the City's needs through the year 2035. The four phase plan has an estimated cost of $24 million. The City has secured grants and loans of approximately $6 million to initiate the first phase of this plan. This phased plan will provide adequate waste treatment capacity for the Project's water supply. Assuming that the unit cost of water treatment for the City's demand is comparable to the unit costs of the on-reservation treatment requirement, the cost for regional waste treatment facilities for the Project service area will be $113 million.

8.7 Terminus storage

Terminus storage stores and facilitates the distribution of water so that instantaneous and daily demands for water can be met without interruptions. This storage may be considered "equalizing" storage because it provides equalizing flow to meet maximum and minimum daily requirements. Terminus storage provides:

- A ready and continuous supply of water during repairs
- Adequate reserve for normal and emergency use without interruptions in supply
- Constant pressure in the system
- Lower energy and pumping costs
- Potential reduction in the peak water treatment plant capacity
- Potential reduction in the maximum pipe sizes

The objective of terminus storage is to ensure that adequate water is available during peak demand and when the conveyance system is under repair. Terminus storage can also be used to reduce the velocity of the water in pipes during high demand periods. The lower velocities result in lower frictional losses and lower energy and maintenance requirements. If the terminus storage is able to manage the peak demands, then a smaller, less expensive conveyance system may be possible. These tradeoffs can only be determined after more extensive site investigations and system hydraulic modeling runs are completed. After careful review,

- The Chuska Dam Site

  Approximately 2,000 acre-feet of terminus storage was considered to increase operational efficiency of the water deliveries to Gallup and Window Rock. From an operational standpoint the best site for terminus storage is as close to the final distribution point as possible. The NDWR identified 17 potential terminus storage sites along the main line using criteria such as proximity to the proposed pipeline alignment, elevation, geology, land status, and capacity. Based on this preliminary investigation, Chuska Reservoir near Tohatchi was the highest ranking site. Chuska Reservoir is close to U.S. Highway 666 between Tohatchi and Gallup. Using this existing reservoir could result in lower construction costs, and it may raise fewer environmental and land status concerns. The existing Chuska Reservoir water supply may help to ensure that the lift pumps are submerged year round. Improvements to Chuska Reservoir to provide terminus storage will cost approximately $7 million. No geologic or environmental field investigations have been performed on any of the potential terminus storage sites. However, the geology of the area is relatively uniform and should not present significant problems. Additional treatment will be needed after the water leaves the reservoir.

The City of Gallup considered several terminus storage options: (1) the Cliff Dwellers site, (2) the Hogback Site, (3) the Mine Dump Site and (4) excavated storage, and (5) concrete covered tanks. These proposed sites may store either San Juan River water from the north or imported groundwater from the east. In August 1999, Reclamation conducted a reconnaissance geology report for the proposed terminus storage sites.

- The Cliff Dwellers Site

  The Cliff Dwellers Canyon Site is located approximately 6 miles northeast of Gallup and east of the Hogback (Section 29 and 30, T.16N, R. 17 W.). The Cliff Dwellers Canyon is a narrow vertical walled canyon which would minimize reservoir evaporation. The Cliff Dwellers Canyon site was not considered feasible by Reclamation because of anticipated high reservoir losses through the Dakota Sandstone.

- The Hogback Site

  The Hogback Site is located approximately 1.5 miles northeast of the Gallup along the topographic feature named "The Hogback"(Section 12, T.15 N., R. 18 W.). The Hogback Site has potential based on reservoir holding capacity, geology, and available construction materials. The Hogback site appears to be a feasible site for a zoned earth fill, but numerous petroleum pipelines cross through the dam axis and would make it an expensive site to use. This site location can take advantage of possible groundwater imported from wells near Mt. Taylor.

- The Mine Dump Site

  The Mine Dump Site is located approximately 3 miles west of Highway 666 and north of Interstate 40 (Section 13 and 14, T.16N., R. 19 W.). The Mine Dump site has potential based on reservoir holding capacity, geology, and available construction materials. The Mine Dump Site appears to be feasible for a zoned earth fill dam. The Mine Dump Site location could receive effluent from the nearby sewage treatment plant. The effluent could be blended with Project water providing for significant water reuse opportunities.

- Excavated Storage

  If the required capacity is relatively small, it may be possible to excavate a storage site. An excavated site can be located in the most convenient location and its lining reduces seepage. Sterling and Mataya estimated that a 1,500 acre-foot storage reservoir with a natural clay liner would cost $5.9 million and a reservoir with a synthetic liner would cost $9.6 million. These costs include engineering, construction and contingency.

- Water tanks

  If the water is treated and the capacity is relatively small, it may be possible to utilize closed tanks to store water for peaking purposes. The current alternatives anticipate that the water will be treated near the San Juan River or at NIIP and that potable water will be conveyed through the water system. For this technical memorandum, steel tanks have been included in the cost estimate.

8.8 Project rights-of-way

According to the 1984 Environmental Statement, the proposed pipeline corridor needs a 66-foot wide permanent easement and a 100-foot temporary easement. The majority of land for the Project lies on the Navajo Nation. In the 1984 cost estimate the cost of a permanent right-of-way easement was included as part of the 15 percent contingency factor.

The Navajo Nation requires that an appraisal of the proposed right of way be conducted. This evaluation is based on the beneficial use of the land and the value of the product in the pipeline. For comparative purposes, a study of the fair market value of rights-of-way by Winius (1991) for the Transwestern pipeline expansion along the same corridor as the NIIP Alternative main line was reviewed. The study identified 25,318 rods of Navajo Tribal Land and 1,902 rods of Individual Allotment land along the corridor. One rod is equal to 16.5 feet. In 1999 the typical right-of-way consideration by the Navajo Nation was 300 to 500 dollars per rod for Tribal land and 25 to 50 dollars per rod for allotted land.

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The total length of the NIIP Alternative pipeline is approximately 240 miles. Of this corridor, 8,300 rods or 12.5 percent is allotted trust land and 47,000 rods, or 61.2 percent, is Tribal trust land. The remainder is split between a variety of state, federal and private ownership. The total length of the San Juan River Alternative pipeline is approximately 287 miles. Of this corridor, 8,300 rods or 10.1 percent is allotted trust land and 47,000 rods or 51 percent is Tribal trust land. The remainder is split between a variety of state, federal and private ownership. The distribution of the land status is shown in Table 8.12. Based on the Winius study the fair market value of the corridor through the allotted land is between $240,000 and $480,000 and the fair market value of the corridor with either alternative through Tribal Trust land is between $14.1 and $23.5 million.

Table 8.12
Land Status of the Navajo-Gallup Water Supply Pipeline

Land Status	NIIP Alternative (Miles)	San Juan River Alternative (Miles)
Main Navajo Reservation	97	117
BLM	11	25
Indian Allotment	29	29
Navajo Fee	21	17
Navajo Trust	50	30
PLO 2198	5	5
Private	17	32
State	8	15
Other		17
Total	240	287

As described in the Code of Federal Regulations 25 Part 169 - Rights-Of-Way Over Indian Lands the BIA has a multi-step process for establishing right-of-ways across trust land. Information on the specific procedures is available from the BIA. Depending on the number of Indian land allotments the Project corridor crosses, the rights-of-way procedures may be complicated. The land affected must be appraised, the individual allotment owners must be contacted and informed about the fair market value of the land, and consents for the Project must be obtained. This process may take up to 18 months to complete.

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The BIA estimates that rights-of-way clearance will require 2 ½ full-time staff plus support services and incidentals including: (1) a full time Real Estate Specialist to work on the process, (2) a half-time appraiser, and (3) other managers, accountants, clerical staff and legal services as needed. As part of these costs, travel, training, and per diem expenses are included. The cost estimate for the BIA to perform the Rights-Of-Way procedures are presented in Table 8.13.

Table 8.13
Estimated BIA Rights-Of-Way Clearance Costs

Personnel	Salary	Travel/Per diem	Training	Incidentals
1 GS-11 Real Estate Specialist – full time	$47, 412	$15,000	$2,000	GSA Vehicle Rental $6500
1 GS-9 Appraiser – half time	$39, 184	$15,000	$2,000	GSA Vehicle Rental $4500
Other personnel, equivalent to full time FTE, GS-11 (Rights Protection Section Chief, clerical staff, and accounting staff)	$47, 412	$5,000	$5,000	Legal Services $1,500.00
Total				**$190,508**

The general process for completing a right-of-way is described in the following section:

- General Approach for Permission to Survey

  The Branch of Real Estate Services, Navajo Region, counsels the applicant concerning right-of-way procedures and assists in determining the land status of the proposed application. The applicant uses Form 5-104B in obtaining the signed consent of the owners of each trust allotment crossed. Official ownership records of Indian allotted land in New Mexico are located at: 1) the Eastern Navajo Agency, Real Estate Services (P.O. Box 328, Crownpoint, New Mexico, 87313), 2) the Shiprock Agency, Real Estate Services (P.O. Box 3538, Shiprock, New Mexico, 87420), the Office of Special Trustee, Records and Litigation Support and 4) the BIA Office of Land, Titles and Records, Southwest Regional Office, P.O. (Box 26567, Albuquerque, NM 87125-6567).

- Action to be taken by the Applicant

  The Applicant will provide an application for the Permit to Survey to the Navajo Regional Office Director (25 CFR 169.4). The application cites the statute under which it is filed and it shows the width, length, area and land status for the entire corridor.

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- Action to be taken by Navajo Region Real Estate Services

  Prior to acceptance, the BIA Regional Office reviews the application for completeness. If the application is complete, the BIA processes the application according to BIA procedures. If there are no conflicts, the map is sent to the Realty Officer for acceptance. The Project sponsors are responsible for the archeological clearance and for complying with environmental laws. For the Project the Navajo Region Real Estate Services Office will coordinate with the Navajo Nation, Reclamation, state, county and local governments.

- Upon compliance with these requirements, Real Estate Services will prepare the Grant of Easement for Right-of-Way.

  After approval from the Navajo Nation for the corridor within tribal lands, the BIA Real Estate Services Office will distribute signed copies of the easement to: 1) the Applicant, 2) the Tribe (through the Project Review Office), and 3) the Title Plant (for recording). For allotted lands the Navajo Nation's approval is not required. However, the BIA anticipates distributing signed copies of the easements.

8.9 Other direct and indirect costs

Different entities have various methods to determine "other direct and indirect costs". Table 8.14 presents the results of methodologies for three Reclamation cost estimates, one prepared by Depauli Engineering, and one prepared by MSE-HKM. Some methods include 5 percent for mobilization, 30 percent for contingency and 25 percent for engineering (Reclamation September 2000). MSE-HKM reports that Reclamation often uses 7 percent for mobilization, 15 percent for preparation, and 25 percent for contingency. After peer review sessions with Reclamation on the Lake Powell Core Pipeline from Lake Powell to Black Mesa, MSE-HKM recommends 10 percent of the construction cost of major items for appurtenances. This total value results in the contract cost. The contingency is 20 percent of the contract cost. The contract costs plus the contingency is the field cost. And, 27 percent of the field cost is added for non-contract cost. The non-contract costs plus the contract costs result in the total cost.

Table 8.14
Indirect Costs Incurred on Municipal Pipeline Projects

Activity	Reclamation NGWSP (1993)	Reclamation Mt Taylor (1999)	Reclamation West. Nav. (2000)	DePauli NGWSP (2000)	MSE-HKM Lake Powell (1997)
Mobilization	5%	5%	5%		
Appurtenants					10%
Unlisted Items	5%	5%			
Contingencies	25%	25%	30%	15%	20%
Engineering			25%	22%	
Indirect	19%	19%			27%
ROW	10%	10%			
Total Percent	64%	64%	60%	37.00%	57.00%

The non-contract costs include engineering design, construction inspection, contract administration, NEPA compliance, easements, geotechnical investigations, archaeological clearances, design survey, and other special investigations. These percentages which are shown in Table 8.15 reflect costs typically incurred on non-Indian projects (MSE-HKM, August 1996, Lake Powell Pipeline Cost Estimate).

Table 8.15
Indirect Costs Incurred on non-Indian Projects

Activity	Percent	Activity	Percent
Facilitation	1%	Archeological	1%
TERO Service	2%	Design survey	1%
Contract Administration	1%	Investigations	2%
Environmental	2%	Design	6%
Easements	1%	Construction Observation	10%
Geochemical	1%		

8.10 Summary of the capital costs

Cost summaries were prepared for the NIIP and the San Juan River Alternatives. As presented in this technical memorandum, both alternatives serve the same area. The total Project cost for the San Juan River Alternative is $368 million and the total Project cost for the NIIP Alternative is $390 million. These estimates include the Gallup Regional System and delivery to the Shiprock Subarea. The cost of power transmission lines is assumed to be incorporated in the unit price of the power. The separate allocated costs for the Navajo Nation and City of Gallup are based on each ones share of the annual capacity of each component or pipe segment. The total project and programmatic costs, and the allocated costs, are shown in Tables 8.16 and 8.17.

The NDWR investigated the mutual benefits due to the shared economy of scale of a joint Navajo /City of Gallup Project. The NDWR estimates that a stand-alone Gallup only system would cost approximately $107 million. A stand-alone Navajo project using the San Juan River Alternative would cost $324 million and a stand-alone NIIP Alternative would cost $354 million. By partnering with the Navajo Nation, the City's share of the resulting project is approximately $60 million. By partnering with the City, the Navajo Nation's share of the resulting project is $310 million for the San Juan Alternative and $326 for the NIIP Alternative. The operation and maintenance costs presented in Tables 8.16 and 8.17 show similar benefits with partnering.

The water delivery costs have been divided between programmatic and Project costs. A number of federal and state programs may be able to assist with water development in the region. For instance, the IHS has P.L. 86-121 authorization to construct domestic water systems on the Navajo Nation. The IHS annual budget is approximately $25 million per year. The EPA, USDA, HUD and other federal agencies also assist with water development. The Project will provide a core system around which programmatic funding can build on.

Table 8.16
Navajo-Gallup Water Supply Project Capital Costs
(Millions of Dollars)

Component	Project Cost	Programmatic Cost	Total Cost
1A. 36,700 af NIIP Alternative			
8,800 af Moncisco Reservoir	$59.72	$0.00	$59.72
65 CFS Treatment Plant	$78.21	$0.00	$78.21
Conveyance to Yah-ta-hey	$129.58	$0.00	$129.58
Project Laterals	$122.60	$27.30	$149.90
Power Lines, SCADA etc.	$5.10	$0.00	$5.10
1B. 36,700 af San Juan River Alternative			
Diversion Structure	$3.14	$0.00	$3.14
Water Treatment Plant	$70.81	$0.00	$70.81
Regulating Reservoir	$15.07	$0.00	$15.07
Conveyance to Yah-ta-hey	$161.47	$0.00	$161.47
Project Laterals	$117.44	$30.30	$147.74
Power lines, SCADA, etc.	$5.10	$0.00	$5.10
2. Groundwater Component	$0.00	$73.00	$73.00
3. Wastewater treatment	$0.00	$113.00	$113.00
4. Value of Water Rights	$0.00	$90.00	$90.00
5. Value of Rights-of-way	$0.00	$24.80	$24.80
Total NIIP Alternative	$395.21	$328.10	$723.31
Total SJR Alternative	$373.03	$331.10	$704.13

Table 8.17
Navajo-Gallup Water Supply Project Summary of Allocated Capital Costs

Scenario	Water Supply (Acre Feet)		Capital Cost (Millions of Dollars)		
	Navajo Nation	City of Gallup	Navajo Nation	City of Gallup	Total
SJR Alternative					
	29,067	0	$324	$0	$324
	29,067	7,500	$310	$58	$368
NIIP Alternative					
	29,067	0	$354	$0	$354
	29,067	7,500	$326	$64	$390

Note: Tabulated costs exclude transmission lines and groundwater components.

Navajo-Gallup Water Supply Project

8.11 Summary of the Project's operation and maintenance

In the 1984 Planning Report and Draft Environmental Statement Reclamation assumed that NTUA would require seven management personnel at half time and 14 field positions at full-time to operate the Project. This staff would have an estimated annual cost of $400,000 (or $3.17 per acre-foot) in 1984 dollars. For this technical memorandum, the annual operation and maintenance expenses are based on the following fixed percentages of the capital investment. For the annual operating costs the following values were used:

- Intake - 6 percent
- Pumps - 4 percent
- Storage - 4 percent
- Conveyance pipes - 0.5 percent
- Wells - 4 percent
- Others - 4 percent

The cost of energy is based on 6.5 cents per kilowatt. If CRSP set aside power is available to NTUA at 3.5 cents per kilowatt, it may be possible to finance the power distribution infrastructure through the power fees.

Table 8.18
Navajo-Gallup Water Supply Project Summary of Allocated O&M Costs

Scenario	Water Supply (Acre Feet)		O&M Cost (Millions of Dollars)		
	Navajo Nation	City of Gallup	Navajo Nation	City of Gallup	Total
SJR Alternative	29,067	0	$8.58	$0.00	$8.58
	29,067	7,500	$7.99	$1.95	$9.95
NIIP Alternative	29,067	0	$6.16	$0.00	$6.16
	29,067	7,500	$5.33	$1.71	$7.04

Note: Tabulated costs exclude transmission lines, Shiprock conveyance, groundwater components, NIIP conveyance losses of 10%, and NIIP canal operation and maintenance.

Navajo-Gallup Water Supply Project

For Project authorization, a contracting entity must be identified for repayment obligations and for the operation and maintenance of the Project. Several other projects may provide constructive examples:

- Mni Wiconi - The Mni Wiconi Project is owned by the federal government and is operated by the Department of the Interior.

- NIIP - NIIP is owned by the federal government. It is authorized for construction by the BIA and Reclamation is providing technical assistance. NIIP facilities are operated under a PL. 638 Indian Self Determination Act contract by NAPI. Upon completion of NIIP, the NIIP facilities will eventually be transferred to the Navajo Nation. The scheduling and the conditions of that transfer are currently being formulated.

- Hammond Irrigation Project - The Hammond Irrigation Project was built by the federal government. A contracting entity, the Hammond Irrigation District, was established to contract with the United States for repayment of the reimbursable portion of the project costs and to operate the facilities.

The Project could be operated by NTUA under a contract to the Department of the Interior. Because this project has a significant non-Indian component, this contract would not necessarily be a P.L. 638 contract, but the same contractual relationship that the Department of the Interior has with other contracting entities.

The eventual ownership of the Project also needs to be evaluated. In other circumstances, after the repayment obligation has been met, federally constructed projects are candidates for transferring to the contracting entity. In some cases the contracting entities are eager to assume control of, and responsibility for, the water control facilities. In other cases the contracting entities have little interest in transferring facilities. Under different administrations the Department of the Interior has maintained different policies to address the transfer and ownership of water projects. This Project has the added complication that it combines Indian and non-Indian interests. Due to the Indian component, this Project will retain a significant residual trust responsibility. On the other hand, the City will only be able to invest in the Project if it has adequate guarantees that its investment will be protected. The eventual transfer to the Tribe or to a joint holding entity can only be considered if these issues are addressed.

9.0 THE UNIT COST OF PROJECT WATER

For the water users the single most important variable is the price that they must pay every month for the water service that they desire. To determine the overall aggregate cost of Project water this technical memorandum includes: (1) amortized capital cost (main line and laterals), (2) Colorado River Storage Project Fees, (3) acquiring water rights, (4) NIIP Cost of Services agreement, (5) the City of Gallup municipal system improvements, (6) NTUA and Gallup retail costs, and (7) Project operation and maintenance. The amortized capital costs are presented in Table 9.1 and the annual unit costs are presented in Table 9.3. These costs are described in the following sections.

9.1 Amortized capital costs

The annual amortized cost depends on the total capital cost, the life cycle or repayment period, and the interest rates. For this estimate it is assumed that the Project will deliver 29,067 acre-feet to the Navajo water users and 7,500 acre-feet to the City of Gallup water users. To determine the annualized cost, it has been assumed that the total capital cost is $370 million. The average unit capital cost of the water is approximately $10,100 per acre-foot of Project capacity. The unit capital cost for the Navajo component is approximately $10,700 per acre-foot and the unit capital cost for the Gallup component is approximately $7,700 per acre-foot.

For every one million dollars of capital expenditures, the annual amortized cost over a forty-year period at 4 percent is $50,523, at 6 percent is $66,461, at 7 percent is $75,009 and at 8 percent is $83,860. At 4 percent, a $370 million Project would have a total annualized cost of $18.7 million per year. This figure results in an average unit cost of 511 dollars per acre-foot or $1.58 per thousand gallons. The annual amortized costs at a range of interests rates are shown in Table 9.1.

NTUA has expressed concerns that during the early life the overall demands will be less than the total. Consequently, the Project costs would be distributed over a smaller volume of water. Based on the Project's 2010 demand, the Project will deliver 11,141 acre feet to Navajo water users. At this rate, the unit capital cost of the water would be $15,169 per acre-foot.

Table 9.1
A Range of Amortized Capital Costs for the Navajo Gallup Water Supply Project which delivers 36,700 acre-feet of water for a Project cost of $370 million

Interest Rate (Percent)	Annual Cost ($/Year)	Annual Unit Cost ($/AF/Year)	Annual Unit Cost ($/1000 Gallon/Year)
4%	$17,694,000	$482	$1.48
6%	$24,591,000	$670	$2.06
7%	$27,753,000	$756	$2.34
8%	$31,028,000	$845	$2.60

9.2 Colorado River Storage Project fees

With either alternative the water may come from Navajo Reservoir. Navajo Dam is a feature of the Colorado River Storage Project Act (CRSPA). Consequently, water from the Navajo Reservoir is subject to a CRSPA fee. The current fee for municipal water is approximately 60 dollars per acre-foot.

9.3 Acquiring water rights

To determine the cost of acquiring the water rights for the Project, a range of values can be applied. The most secure option is to secure water rights that are already within the environmental baseline. For this assessment it has been assumed that these water rights would cost approximately $3,000 per acre-foot, or $90 million. A less costly option may be to pursue a new contract with the Secretary of the Interior. However, the long-term availability of this water has not been established. Presumably this contract water would only be subject to the CRSP fee. However, a new contract will require the tacit approval of the Tribes in the basin, and there may be additional costs associated with environmental compliance. Securing a long-term water supply form either NIIP or the Jicarilla Apache Nation would require lease options and possibly forbearance agreements between the parties. These agreements may cost at least as much as securing water from the Secretary, and potentially as much as securing private water rights. Consequently, for the purposes of this cost estimate, a unit cost of $3,000 per acre-foot has been used. Amortized at 7 percent per year over 40 years, the annualized cost of the water rights is $191 per acre-foot or $0.59 per thousand gallons.

9.4 NIIP Cost of Services and Potential Repayment Obligation

With the San Juan River Alternative most of the water supply will be diverted directly from the San Juan River. Only the 3,600 acre-feet of diversion from Cutter Reservoir will require the use of any of the NIIP facilities. However, for the NIIP Alternative the municipal water conveyed through the NIIP facilities will share some of the operation and maintenance responsibility. This responsibility justifies a cost of services agreement. The cost of services principal suggests that the revenue received from a water user should equal the cost of serving that water user. One component of determining this cost is the degree to which a particular user affects base and peak demands. If the municipal water requires the construction of additional NIIP infrastructure that is only used for brief periods of time, then the municipal water use may be expected to contribute a greater share of the operating revenue. If the municipal water requires extra management to ensure an additional degree of reliability, or if the municipal water requires more expensive delivery during the winter months, then the municipal water users may be expected to contribute a greater share of the overall operating revenue.

There is a trade off between conveying water through the NIIP canals during the winter months and minimizing the storage requirement verses not using the canals during the winter months and providing extra reservoir storage. However, with or without the municipal Project, NIIP is winterizing a portion of the Gravity Main Canal to enable limited winter delivery for the proposed french fry factory.

In addition the municipal Project would only use a small segment of the Main Canal and the Burnham Lateral. Consequently, it could be argued that the cost of delivering water to Moncisco Reservoir should be less than the overall NIIP average water delivery expense. Determining which conveyance scenario is the most cost effective, and what the appropriate share of the overall operating expense should be assigned to the municipal water will require a more refined analysis of the alternatives.

From 1991 through 1996 the NIIP operation and maintenance budget ranged from $3.5 to $3.9 million. Based on the total water diversion from Navajo Dam, the unit operating cost of the water ranged from $19.68 to $29.94 per acre-foot. However, the conveyance efficiency of the NIIP canals ranged from a low of 80 percent to a high of 90 percent. Consequently, the average unit cost of the water delivered is between $21.87 and $33.27 per acre-foot.

Based on NAPI's assessment of its operation, maintenance and repair costs, the actual operating cost in 1996 was $6.1 million per year. Based on NAPI's assessment of its needs, the average unit operating cost is $52.13 per acre-foot. For this technical memorandum an average unit NIIP conveyance cost of $50 per acre-foot is assumed.

The municipal water conveyed through the NIIP system may be subject to a repayment obligation to the federal government for the use of the NIIP facilities. The cost of the main canal is $108 million, the cost of the Moncisco Pump station is $54 million, and the cost of the Burnham Lateral is $8 million. Assuming that the Project has an average capacity of approximately 50 cfs, and that the repayment obligation for irrigation water and municipal water is equally shared, the total repayment obligation for the municipal component may be approximately $7.8 million. These values, which are shown in Table 9.2, have not been included in the total cost estimate.

Assuming a conveyance efficiency of 90 percent, 10 percent of the water diverted from Navajo Reservoir through the NIIP facilities may not reach Moncisco Reservoir. With the NIIP Alternative this loss may be greater than 3,000 acre-feet per year. Some of this loss may return to the San Juan River. However, incidental losses will deplete a portion of the water conveyed. These losses need to be included in the overall cost of the NIIP Alternative

Table 9.2
Potential Capital Repayment Obligation of the Navajo Gallup Water Supply Project for the use of NIIP Facilities

NIIP Facility	Original Cost (Dollars)	Nominal Capacity (CFS)	Design Life (Years)	Percent of Capacity (Percent)	Potential Obligation (Dollars)
Main Canal	$108,000,000	1,200	100	4.17%	$4,500,000
Gallegos Pump	$54,000,000	880	40	5.68%	$3,068,000
1/4 of the Burnham Lateral	$8,000,000	440	100	11.36%	$227,000
Total	$170,000,000				$7,795,000

9.5 The City of Gallup and NTUA municipal system improvements

In addition to the Project components which will convey water from the San Juan River south toward Yah-ta-hey, additional facilities will be needed to distribute the Project water throughout the City. For the cost estimate in presented in this technical memorandum, the Gallup Area Lateral conveys water south to the Gallup Junction and then east toward Church Rock and south toward Red Rock. This lateral has been included with the Project costs. However, the City's internal conveyance system will need programmatic upgrades over the next 40 years to deliver this water to the water users. For this cost estimate it has been assumed that the internal system improvements will cost $40 million. This same unit cost has also been applied to the NTUA system upgrades.

9.6 City of Gallup and NTUA retail costs

In addition to the cost of operating the Project, both NTUA and the City of Gallup will incur additional retail costs for delivering the water to individual water users. These costs include billing, meter reading, and other administrative expenses. To develop an estimate of the retail cost of water, the water rates in the Southwestern Water Rate Survey were reviewed. The City of Page, Arizona delivers slightly more than 3,000 acre-feet of water per year. This volume is approximately the same volume of water delivered by the City of Gallup. The City of Page charges slightly more than $1.00 per thousand gallons ($312 per acre-foot). With its location next to Lake Powell and its intake built into the dam, the City of Page has very few fixed capital or variable costs. Based on its overall water use, the City of Page's nominal water treatment cost should be approximately $380,000 per year. It is reasonable to assume that the balance of their budget, approximately $0.60 per thousand gallons (or $195.per acre-foot), reflects the retail cost of the water.

9.7 Project operation and maintenance

For the San Juan River Alternative with a 36,700 acre-foot diversion, the annual energy cost is approximately $4.3 million per year and the operation and maintenance cost is $5.7 million per year. The average unit cost of this alternative is approximately $272 per acre foot. For the NIIP Alternative with a 36,700 acre-foot diversion, the annual energy cost is approximately $2.9 million per year and the operation and maintenance cost is $4.1 million per year. The unit cost of this alternative is approximately $191 per acre foot. These values are presented in Table 8.18. While the unit cost of the NIIP alternative is less than the San Juan River alternative, the NIIP alternative will require the cost of service agreement with NIIP which may add at least $50 per acre-foot. This value increases the operation and maintenance cost of the NIIP Alternative to $240 per acre-foot. Therefore, the cost advantage of using the NIIP facilities may be eliminated by the cost of utilizing the NIIP canals.

NTUA has expressed concerns that during the early life the overall demands will be less than the total. Consequently, the Project operation and maintenance costs would be distributed over a smaller volume of water. Based on the Project's 2010 demand, the Project will deliver 11,141 acre feet to Navajo water users. At this rate, the unit operation and maintenance cost of the Navajo Nation water would be $424 per acre-foot (or $1.30 per thousand gallons) and the Gallup cost would be $331 per acre-foot (or $1.02 per thousand gallons). Based on the Project's 2020 demand, the Project will deliver 15,430 acre-feet to Navajo water users. At this rate, the unit operation and maintenance cost of the Navajo Nation water would be $368 per acre-foot (or $1.13 per thousand gallons) and the Gallup cost would be $307 per acre-foot (or $0.94 per thousand gallons). Based on the Project's 2030 demand, the Project will deliver 21,391 acre-feet to Navajo water users. At this rate, the unit operation and maintenance cost of the Navajo Nation water would be $282 per acre-foot (or $0.97 per thousand gallons) and the Gallup cost would be $282 per acre-foot (or $0.87 per thousand gallons). And, based on the Project's 2040 demand, the Project will deliver 29,067 acre-feet to Navajo water users. At this rate, the unit operation and maintenance cost of the Navajo

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Nation water would be $275 per acre-foot (or $0.85 per thousand gallons) and the Gallup cost would be $261 per acre-foot (or $0.80 per thousand gallons).

9.8 Phasing and conjunctive use

Some of the Project facilities do not need to be fully built until later in the Project's planning horizon. For instance, the construction of the water treatment plant, pumping stations, regulating storage, and groundwater components can readily be phased as the Project's demands justify the capital expenditures. Deferring these facilities will result in a lower present cost of the Project's facilities.

With the San Juan River Alternative 60 percent of the total cost is for the pipeline which does not lend itself to phasing. The water treatment plant which is 25 percent of the total cost, the storage tanks which are 10 percent, and the pump stations which are 5 percent may be phased. With the NIIP Alternative 50 percent of the total cost is for the pipeline and 15 percent is for Moncisco Reservoir. These costs do not lend themselves to phasing. The water treatment plant which is 20 percent of the total cost, the storage tanks which are 10 percent, and the pump stations which are 5 percent may be phased. An analysis of the potential reduction in the present value of the Project with phasing is beyond the scope of this technical memorandum.

9.9 Conclusion of the Unit Cost Analysis

The unit costs of the Project water including several important noncapital costs are presented in Table 9.3. Based on the data presented in Table 9.3 the total unit cost of the Project water is approximately $4.81 per thousand gallons. Included in this estimated rate is the full cost of amortizing the capital investment and the value of the water rights. This estimate also includes the cost of using the NIIP, improving the local systems and the retail expense of the water utilities. The estimated rate is approximately $2 per thousand gallons more than NTUA and the City of Gallup are currently charging for water. For a family of four, using 160 gallons per capita per day, the monthly water bill would be $94 per month.

Table 9.3
Estimated Average Unit Cost of Navajo-Gallup Water Supply Project Water Based on 36,700 acre-feet of Diversion

Cost Component	Estimated 2000 Cost (Dollars/AF)	Estimated Cost (Dollars/1000 gal)
1.Amortized $370 Million Capital Cost (7% and 40 Years)	$756	$2.34
2. CRSP fee	$60	$0.18
3. Amortized Water Rights ($3,000/af, 7% and 40 years)	$191	$0.59
4. NIIP Cost of Services ($50 to $300 per acre-foot)	$50	$0.16
5. City of Gallup improvements	$36	$0.11
6. City of Gallup retail cost	$195	$0.60
7. Project Operation and Maintenance	$272	$0.83
Total Unit Cost	$1,560	$4.81

Note:

During the first decade of operation the Project operation and maintenance expense will be approximately $1.30 per thousand gallons for the Navajo Nation and $1.02 dollars per thousand gallons for the City of Gallup.

10.0 PLAN OF APPROACH AND PROJECT TIME LINE

To expedite the Project, the Navajo Nation, the City of Gallup and Reclamation have developed a plan of approach. This approach includes a time line for NEPA Compliance, preparing the Planning Report/EIS, Construction Authorization, and Starting Construction. In addition, the planning report and the Environmental Impact Statement will be compiled into a single document. This schedule anticipates Congressional authorization for design and construction by October 2002 and a Record of Decision on the EIS by February 2003.

Any major action supported by federal funding, such as the construction of the Navajo-Gallup Water Supply Project, is subject to the National Environmental Policy Act. The NEPA legislation requires that careful consideration be given to the human and natural environments to attain the widest range of beneficial use of natural resources without environmental degradation, risk to human health, safety and welfare, or destruction of cultural and historic resources. Article 22.1 of NEPA requires preparation of an Environmental Impact Statement (EIS) to assure compliance with the NEPA objectives. The EIS should present a detailed description of the proposed action (a definite plan), discuss probable environmental impacts, analyze the cost and environmental mitigation potential of alternatives to the proposed action, and solicit and consider public comment concerning the proposed action. To the fullest extent feasible, the parties will utilize NEPA compliance, and the funds made available to carry out planning and NEPA compliance to prepare the technical analysis needed for a definite planing document.

In addition to NEPA requirements, the Navajo Nation and the City of Gallup must acquire the water rights, acquire the appropriate rights-of-way, determine repayment obligations, and assess the ability to pay for the proposed Project. On a separate and concurrent track, the participants are seeking Congressional authorization. It is anticipated that authorization will be obtained by October 2002. The legislation will authorize the construction of the Project, subject to the completion of NEPA compliance, and it will describe the repayment obligation. Based on the current schedule, the Draft Planning Report/EIS will be available prior to authorization.

The NEPA public scoping meetings were held in Shiprock, Farmington, Crownpoint, Window Rock and Gallup during April and May 2000. In January 2001 the City and the Navajo requested two new Secretarial water contracts. According to the schedule these contracts will be executed by April 2002. The major components of the time line follow:

- Conduct the appraisal level cost estimates of the facilities by October 2001
- Conduct the appraisal level cost estimates of the operation, maintenance, and replacement by October 2001
- Conduct the Cultural Resource Impact Analysis by October 2001
- Conduct the Terrestrial, Riparian, and Aquatic Impact Analysis by October 2001
- Conduct the Social and Economic Analysis by October 2001

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- Conduct the Repayment Analysis by October 2001
- Conduct the Water Availability Analysis and Draft Water Supply Contracts by October 2001
- Conduct the Hydrologic Impact Analysis by October 2001
- Define the water supply by October 2001
- Analyze alternatives, complete the Draft Planning Report and select the preferred plan by December 2001
- Submit water contracts for Congressional authorization by January 2002
- Complete Analyses that depend on the water supply by February 2002
- Develop the Biological Assessment and submit to the USFWS by February 2002
- Prepare the Preliminary Draft Planning Report/EIS by March 2002
- Execute the Secretarial water contract by April 2002
- Obtain a Biological Opinion from the USFWS and Coordination Act Report by June 2002
- Publish the Preliminary Draft Planning Report/EIS by June 2002
- Public Review and comment on the Draft Planning Report /EIS by July 2002
- Draft required legislation and obtain Congressional authorization beginning January 2002 through October 2002.
- Respond to comments and prepare the Final Draft Planning Report/EIS by November 2002
- Print the Final Planning Report/EIS by January 2003
- Record of Decision by February 2003
- Start Construction by March 2003

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APPENDIX A
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Navajo-Gallup Water Supply Project

APPENDIX B
MEMORANDUM OF UNDERSTANDING

MEMORANDUM OF AGREEMENT

Between the Navajo Nation and the City of Gallup
To Cooperate on the Navajo-Gallup Water Supply Project.

WHEREAS:

1. The Navajo Nation and the City of Gallup have severe water quality and water quantity problems; and

2. During the Congressional Hearings for the proposed Navajo Indian Irrigation Project (NIIP), the New Mexico State Engineer testified that NIIP would be part of the regional water infrastructure intended to provide water from Navajo Dam to Navajo Communities in northwest New Mexico and to the City of Gallup (Hearings before the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs, S. 3648, July 9 and 10, 1958); and

3. In the 1960's, the Bureau of Reclamation first considered a water pipeline project that would bring water to Navajo Communities in northwest New Mexico and to the City of Gallup, and the Bureau was authorized under Public Law 92-199 (approved December 15, 1971) to conduct feasibility studies for such a project; and

4. In 1984, the Bureau of Reclamation completed a draft Environmental Impact Statement for the proposed Gallup-Navajo Indian Water Supply Project which evaluated three alternative routes for a water pipeline and recommended a route parallel to Highway 666; and

5. Following public hearings in 1984 and 1985, the Navajo Nation recommended reformulation of the project to serve additional communities along Highway 371, and a revised EIS in 1985 supported the recommendation of the route along Highway 371; and

6. By letter of March 5, 1992 from Navajo Nation Vice President Marshall Plummer to Gallup Mayor George Galanis, the Navajo Nation agreed to join the City of Gallup in further discussions to evaluate the project; and

7. In 1992, discussions commenced between technical staff from the Navajo Nation and the City of Gallup to further evaluate the project; and

8. In 1992, Congress authorized $300,000 for a preliminary reassessment of the project by the Bureau of Reclamation, and in subsequent years, Congress has authorized additional funding to develop a project definition, conduct a biological assessment, and provide an assessment of alternatives; and

9. In 1995, the Navajo Nation entered into Cooperative Agreement No. 5-FC-40-17490 (authorized by RCAU-205-95 and IGRS-190-95) with the Bureau of Reclamation to engage in public meetings and technical studies related to the project; and

10. Seventeen Chapters within the preliminary project area, including Burnham, Becenti, Coyote Canyon, Crownpoint, Dalton Pass, Nageezi, Whitehorse Lake, Mexican Springs, St. Michaels, Tseyatoh, Huerfano, Lake Valley, Pueblo Pintado, Standing Rock, Twin Lakes, Whiterock, Fort Defiance, Tohatchi, and Naschitti have approved continued planning for the project; and

11. By letter of February 15, 1996 Navajo Area Director Wilson Barber, committed the Bureau of Indian Affairs to serve as the lead agency for consultation with the Fish and Wildlife Service concerning compliance with the requirements of the Endangered Species Act, and directed the Bureau of Indian Affairs-Navajo Indian Irrigation Project Office to initiate this consultation as quickly as possible.

NOW, THEREFORE, THE CITY OF GALLUP AND THE NAVAJO NATION AGREE THAT:

1. A cooperative effort by the Navajo Nation and the City of Gallup (the Parties) to proceed with the planning and development of the Navajo-Gallup Water Supply Project is in the best interests of the Parties; and

2. The Parties are committed to a project that will work conjunctively with the Navajo Indian Irrigation Project and will otherwise be developed in a manner that is consistent with the water rights of the parties; and

3. The Parties are committed to a project that will result in a fair and equitable distribution of project water between the City of Gallup and the Navajo communities; and

4. The Parties are committed to cooperatively investigate all viable alternative project configurations, including a pipeline from the San Juan River; and

5. In order to ensure that the project will be in compliance with the requirements of the Endangered Species Act, the Parties support commitment of the Bureau of Indian Affairs to engage in consultation with the Fish and Wildlife Service as quickly as possible; and

6. The Parties will work together to resolve issues affecting the implementation of the Project; and

7. The planning efforts between the Navajo Nation and the City of Gallup will be voluntary and are without prejudice to any position either party may assert in the San Juan River General Stream Adjudication, or in any other matter concerning the water resources of the Parties.

This Memorandum of Agreement was executed on this 17th day of April, 1998.

THE NAVAJO NATION

Thomas E. Atcitty, President

THE CITY OF GALLUP

George Galanis, Mayor

RESOLUTION OF THE
INTERGOVERNMENTAL RELATIONS COMMITTEE
OF THE NAVAJO NATION COUNCIL

Approving a Memorandum of Agreement Between the City of Gallup and the Navajo Nation to Cooperate on the Navajo-Gallup Water Supply Project

WHEREAS:

1. The Intergovernmental Relations Committee of the Navajo Nation Council is established to ensure the presence and voice of the Navajo Nation, pursuant to 2 N.N.C §822(B), and has the power to authorize, review and approve agreements between the Navajo Nation and any state authority upon the recommendation of the standing committee with oversight authority for such agreement, pursuant to 2 N.N.C. §824(B)(6); and

2. Attached to this resolution as Exhibit A is a proposed Memorandum of Agreement between the City of Gallup and the Navajo Nation to cooperate on the Navajo-Gallup Water Supply Project; and

3. The Resources Committee of the Navajo Nation Council is charged with ensuring the optimum utilization of all resources of the Navajo Nation and to protect the rights, interests and freedoms of the Navajo Nation and People, pursuant to 2 N.N.C. §693 (1995); and

4. By Resolution RCJA-13-98, attached to this resolution as Exhibit B, the Resources Committee of the Navajo Nation Council determined that the water resources of the Navajo Nation are essential to provide a permanent homeland for the Navajo people, that protection of such water resources is essential in order to protect the health, welfare and the economic security of the citizens of the Navajo Nation, that the proposed Memorandum of Agreement would provide opportunity to advance this vitally needed project and that executing this agreement is in the best interests of the Navajo Nation; and

5. The Intergovernmental Relations Committee of the Navajo Nation Council accepts the recommendation of the Resources Committee and concurs that executing the proposed Memorandum of Agreement between the City of Gallup and the Navajo Nation to cooperate on the Navajo-Gallup Water Supply Project is in the best interests of the Navajo Nation.

NOW THEREFORE BE IT RESOLVED THAT:

The Intergovernmental Relations Committee of the Navajo Nation Council authorizes the execution of the proposed Memorandum of Agreement between the Navajo Nation and the City of Gallup to cooperate on the Navajo-Gallup Water Supply Project, attached as Exhibit A.

CERTIFICATION

I hereby certify that the foregoing resolution was duly considered by the Intergovernmental Relations Committee of the Navajo Nation Council at a duly called meeting at Window Rock, Navajo Nation (Arizona), at which a quorum was present and that same was passed by a vote of 4 in favor, 2 opposed and 0 abstained, this 23rd day of February, 1998.

Kelsey A. Begaye, Chairperson
Intergovernmental Relations Committee

Motion: Rex Morris, Jr.
Second: Genevieve Jackson

APPENDIX C
NAVAJO NATION GROUNDWATER PRODUCTION IN THE SERVICE AREA

Navajo-Gallup Groundwater Production and Use (page 1 of 2)

17-Jan-01

Service Area	Chapter	Point of Use [1]	1998 GW production (gal/yr) [2]	1998 G.W. production (ac-ft/yr)	est. sustain. 2040 G.W. production (gal/yr) [3]	est. sustain. 2040 G.W. production (ac-ft/ft)	2000 G.W. use (ac-ft/yr) [4]	2010 G.W. use (ac-ft/yr) [5]	2020 G.W. use (ac-ft/yr) [5]	2030 G.W. use (ac-ft/yr) [5]	2040 G.W. use (ac-ft/yr) [3]	2050 G.W. use (ac-ft/yr) [6]	2060 G.W. use (ac-ft/yr) [6]
City of Gallup, NM[7]	City of Gallup	L.C.	1,412,550,000	4,335	0	0	4,335	0	0	0	1,439	3,947	6,951
Central Area, NM	Burnham	U.C.	8,000	0	0	0	0	0	0	0	0	0	0
	Lake Valley	U.C.	7,224,924	22	15,000,000	46	22	28	34	40	46	46	46
	White Rock	U.C.	0	0	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly	see Lk Vly
	White Horse Lake	U.C.	1,678,712	5	10,000,000	31	5	12	18	24	31	31	31
	SUBTOTAL		*8,911,636*	*27*	*25,000,000*	*77*	*27*	*40*	*52*	*64*	*77*	*77*	*77*
Crown Point, NM	Becenti	U.C.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.
	Coyote Canyon	U.C.	10,553,160	32	20,000,000	61	32	40	47	54	61	61	61
	Crownpoint	U.C.	85,695,314	263	200,000,000	614	263	351	438	526	614	614	614
	Dalton Pass	U.C.	58,700	0	100,000	0	0	0	0	0	0	0	0
	Little Water	U.C.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.	see Crwn Pt.
	Standing Rock	U.C.	11,109,089	34	25,000,000	77	34	45	55	66	77	77	77
	SUBTOTAL		*107,416,263*	*330*	*245,100,000*	*752*	*330*	*435*	*541*	*647*	*752*	*752*	*752*
Gallup Area, NM	Bread Springs	L.C.	13,948,780	43	25,000,000	77	43	51	60	68	77	77	77
	Chichiltah	L.C.	unknown	unknown	see Brd spr.	see Brd spr.	unknown	see Brd spr.	see Brd spr.	see Brd spr.	see Brd spr.	see Brd spr.	see Brd spr.
	Church Rock	L.C.	18,852,450	58	40,000,000	123	58	74	90	107	123	123	123
	Iyanbito	L.C.	unknown	unknown	50,000,000	153	unknown	38	77	115	153	153	153
	Mariano Lake	L.C.	39,804,005	122	30,000,000	92	122	115	107	100	92	92	92
	Pinedale	L.C.	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk	see Mrno Lk
	Red Rock	L.C.	11,565,569	35	20,000,000	61	35	42	48	55	61	61	61
	SUBTOTAL		*84,170,804*	*258*	*165,000,000*	*506*	*258*	*320*	*382*	*444*	*506*	*506*	*506*
Huerfano, NM	Huerfano	U.C.	19,305,279	59	10,000,000	31	59	52	45	38	31	31	31
	Nageezi	U.C.	10,121,491	31	5,000,000	15	31	27	23	19	15	15	15
	SUBTOTAL		*29,426,770*	*90*	*15,000,000*	*46*	*90*	*79*	*68*	*57*	*46*	*46*	*46*
Rock Springs, NM	Manuelito	L.C.	unknown	unknown	15,000,000	46	unknown	12	23	35	46	46	46
	Rock Springs	L.C.	12,995,250	40	25000000	77	40	49	58	68	77	77	77
	Tsayatoh	L.C.	5,771,955	18	15,000,000	46	18	25	32	39	46	46	46
	SUBTOTAL		*18,767,205*	*58*	*55,000,000*	*169*	*58*	*85*	*113*	*141*	*169*	*169*	*169*
Route 666, NM	Mexican Springs	U.C.	13,765,359	42	see Tohatchi	see Tohatchi	42	see Tohatchi	see Tohatchi	see Tohatchi	see Tohatchi	see Tohatchi	see Tohatchi
	Naschitti	U.C.	26,702,440	82	25,000,000	77	82	81	79	78	77	77	77
	Newcomb	U.C.	4,110,826	13	4,000,000	12	13	13	12	12	12	12	12
	Sanostee	U.C.	29,001,234	89	50,000,000	153	89	105	121	137	153	153	153
	Sheep Springs	U.C.	4,000,000	12	5,000,000	15	12	13	14	15	15	15	15
	Tohatchi	U.C.	44,794,400	137	100,000,000	307	137	180	222	265	307	307	307
	Twin Lakes	U.C.	28,419,760	87	50,000,000	153	87	104	120	137	153	153	153
	Two Grey Hills	U.C.	18,036,128	55	25,000,000	77	55	61	66	71	77	77	77
	SUBTOTAL		*168,830,147*	*518*	*259,000,000*	*795*	*518*	*556*	*635*	*715*	*795*	*795*	*795*
Torreon, NM	Counselor	U.C.	see Pbl Pndo	see Pbl Pndo	0	0	0	0	0	0	0	0	0
	Ojo Encino	R.G.	6,839,565	21	5,000,000	15	21	20	18	17	15	15	15
	Pueblo Pintado	U.C.	23,000	0	0	0	0	0	0	0	0	0	0
	Torreon	R.G.	29,920,434	92	20,000,000	61	92	84	77	69	61	61	61
	SUBTOTAL		*36,782,999*	*113*	*25,000,000*	*77*	*113*	*104*	*95*	*86*	*77*	*77*	*77*
San Juan River, NM [8]	Beclabito	U.C.	0	0	0	0	0	0	0	0	0	0	0
	Cudei	U.C.	0	0	0	0	0	0	0	0	0	0	0
	Hogback	U.C.	0	0	0	0	0	0	0	0	0	0	0
	Nenahnezad	U.C.	0	0	0	0	0	0	0	0	0	0	0
	San Juan	U.C.	0	0	0	0	0	0	0	0	0	0	0
	Shiprock	U.C.	0	0	0	0	0	0	0	0	0	0	0
	Upper Fruitland	U.C.	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL		*0*	*0*	*0*	*4,680*	*0*	*4,680*	*4,680*	*4,680*	*4,680*	*4,680*	*4,680*
NAPI Industrial, NM [9]		U.C.	0	0	0	700	0	400	500	600	700	700	700
NEW MEXICO UPPER BASIN		*U.C.*	*351,367,815*	*1,078*	*569,100,000*	*7,127*	*1,078*	*6,294*	*6,571*	*6,849*	*7,127*	*7,127*	*7,127*
NEW MEXICO LOWER BASIN		*L.C.*	*1,515,488,009*	*4,651*	*220,000,000*	*675*	*4,651*	*406*	*498*	*585*	*2,114*	*4,622*	*7,626*
TOTAL NEW MEXICO			*1,866,855,824*	*5,730*	*789,100,000*	*7,802*	*5,730*	*6,700*	*7,067*	*7,434*	*9,241*	*11,749*	*14,753*

Navajo-Gallup Groundwater Production and Use (page 2 of 2)

17-Jan-01

Service Area	Chapter	Point of Use [1]	1998 GW production (gal/yr) [2]	1998 G.W. production (ac-ft/yr)	est. sustain. 2040 G.W. production (gal/yr) [3]	est. sustain. 2040 G.W. production (ac-ft/ft)	2000 G.W. use (ac-ft/yr) [4]	2010 G.W. use (ac-ft/yr) [5]	2020 G.W. use (ac-ft/yr) [5]	2030 G.W. use (ac-ft/yr) [5]	2040 G.W. use (ac-ft/yr) [3]	2050 G.W. use (ac-ft/yr) [6]	2060 G.W. use (ac-ft/yr) [6]
Window Rock, AZ	Fort Defiance	L.C.	339,701,688	1,043	250,000,000	767	1,043	974	905	836	767	767	767
	Saint Michaels	L.C.	65,000	0	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.	see Ft. Dfnc.
TOTAL ARIZONA		*L.C.*	*339,766,688*	*1,043*	*250,000,000*	*767*	*1,043*	*974*	*905*	*836*	*767*	*767*	*767*
PROJECT TOTAL			**2,206,622,512**	**6,772**	**1,039,100,000**	**8,569**	**6,772**	**7,673**	**7,972**	**8,270**	**10,008**	**12,516**	**15,520**
GROUNDWATER ONLY TOTAL [10]			**2,206,622,512**	**6,772**	**1,039,100,000**	**3,189**	**6,772**	**2,593**	**2,792**	**2,990**	**4,628**	**7,136**	**10,140**

Notes: Rounding error may cause subtotals to be off by 1
1 U.C.=Upper Colorado River Basin, L.C.=Lower Colorado River Basin, R.G.=Rio Grande River Basin
2 Compiled from NTUA, NDWR, BIA, and other records
3 Estimates consider current groundwater production and hydrogeologic properties of source aquifers
4 Assumed equal to 1998 production
5 Assumed linear change from year 2000 production to year 2040 production levels
6 Production limited to estimated sustainable levels
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Groundwater production effectively zero. Ignores any potential alluvial production directly from SJR. 4680 ac-ft/yr diversions from ALP assumed to be fully available beginning in
9 400 Ac-ft/yr of depletions from the Navajo-Gallup project assumed available in 2010 and ramping up to 700 ac-ft/yr by 2040.
10 Shows solely groundwater production. Omits NAPI industrial water and additional diversions from ALP.

Navajo-Gallup Water Supply Project

APPENDIX D
COST ESTIMATE SPREADSHEETS

SJR Alternative: Navajo - Gallup Water Supply Project Cost Scenarios. With GW.

SJR Alternative: With Prorated Project Cost for the City of Gallup, New Mexico.

Demand Years	Cost 2000 dollars	Navajo A/F	Navajo $Cost	Gallup A/F	Gallup $Cost	Totals $ Cost $
2040	Project Cost $$	12,940	$188,452,168	3,750	$39,740,045	$228,192,214
50% Demands	Annual Energy $		$1,747,456		$596,600	$2,344,055
	Annual O&M $		$3,446,640		$736,459	$4,183,100
2010	Project Cost $$	11,141	$169,002,355	7,500	$78,300,643	$247,302,998
	Annual Energy $		$1,668,101		$1,160,945	$2,829,046
	Annual O&M $		$3,051,375		$1,322,370	$4,373,745
2020	Project Cost $$	15,230	$206,032,056	7,500	$71,616,358	$277,648,414
	Annual Energy $		$2,092,009		$1,116,018	$3,208,027
	Annual O&M $		$3,521,153		$1,186,149	$4,707,302
2030	Project Cost $$	21,291	$252,600,414	7,500	$64,029,690	$316,630,105
	Annual Energy $		$2,605,354		$1,068,942	$3,674,296
	Annual O&M $		$4,066,108		$1,040,265	$5,106,374
(Attached) 2040	Project Cost $$	29,067	$309,811,865	7,500	$58,121,032	$367,932,897
	Annual Energy $		$3,249,942		$1,028,460	$4,278,402
	Annual O&M $		$4,744,196		$926,440	$5,670,636
2040: No GW	Project Cost $$	32,254	$330,627,493	7,500	$56,113,728	$386,741,221
	Annual Energy $		$3,611,272		$1,014,790	$4,626,062
	Annual O&M $		$4,994,648		$879,979	$5,874,626
2040: Laterals	Project Cost $$		$6,289,466		**Total:**	$393,030,687
Lake Valley, Burnham	Annual Energy $		$45,042			$4,671,104
Whiterock, Whitehorse Lake	Annual O&M $		$50,944			$5,925,570

SJR Alternative: Navajo - Gallup Water Supply Project Cost/AF over Forty-Year Increments

Demand Years	Cost 2000 dollars	Navajo A/F	Navajo $Cost/AF	Gallup A/F	Gallup $Cost/AF
2010	Share Cost $$	11,141	$15,169	7,500	$10,440
	Annual Energy $		$150		$155
	Annual O&M $		$274		$176
2020	Share Cost $$	15,430	$13,528	7,500	$9,549
	Annual Energy $		$137		$149
	Annual O&M $		$231		$158
2030	Share Cost $$	21,391	$11,864	7,500	$8,537
	Annual Energy $		$122		$143
	Annual O&M $		$191		$139
2040	Share Cost $$	29,067	$10,659	7,500	$7,749
	Annual Energy $		$112		$137
	Annual O&M $		$163		$124

NOTE:

1.) ALL COST ESTIMATES HAVE BEEN COST INDEXED TO 2000 DOLLARS
2.) MAINLINE IS CORE LINE FROM GALLEGOS - YAHTAHEY - WINDOW ROCK - GALLUP - CHURCHROCK
3.) NASCHITTI LATERAL INCLUDES SANOSTEE, NEWCOMB, TWO GREY HILLS, SHEEP SPRINGS, NASCHITTI CHAPTERS.
4.) COYOTE CYN. JCT. LATERAL INCLUDES CROWNPOINT, DALTON PASS, BECENTI, COYOTE CANYON, STANDING ROCK, LITTLEWATER CHAPTERS.
5.) GALLEGOS RESERVOIR COST IS $38,037,430 FOR 8,800 A/F
6.) WHOLE PROJECT HAS A PF=1.30.
7.) HUERFANO LATERAL IS FROM GALLEGOS/WTP-HUERFANO, NAGEEZI, PUEBLO PINTADO, TORREON NTUA SYSTEM.
8.) ASSUMME PIPE COST ARE DIVIDED BY 90% COMMON AND 10% ROCK EXCAVATION.
9.) ALL COST ESTIMATES INCLUDES NAPI AND SHIPROCK AREA DEMANDS.

Year 2040

SJR Alternative: Navajo - Gallup Water Supply Project Cost Scenario. With GW.

SJR Alternative: With Prorated Project Cost for the City of Gallup, New Mexico.

Peaking Factor = 1.3 Demands: 29,066 Acre-Feet

	Navajo		Gallup		Totals
	A/F	$Cost	A/F	$Cost	$ Cost $
Project Cost $$	29,066	$323,971,647	0	$0	$323,971,647
Annual Energy $		$3,323,467		$0	$3,323,467
Annual O&M $		$5,257,567		$0	$5,257,567

Peaking Factor = 1.3 Demands: 36,567 Acre-Feet

	Navajo		Gallup		Totals
	A/F	$Cost	A/F	$Cost	$ Cost $
Project Cost $$	29,067	$309,811,865	7,500	$58,121,032	$367,932,897
Annual Energy $		$3,249,942		$1,028,460	$4,278,402
Annual O&M $		$4,744,196		$926,440	$5,670,636

NOTE:

1.) ALL COST ESTIMATES HAVE BEEN COST INDEXED TO 2000 DOLLARS
2.) MAINLINE GOES FROM PNM DIV.-RES./WTP-666HIGHWAY.-WR-GALLUP-GALLUP AREA NAVAJOS.
3.) CUTTER LATERAL INCLUDES HUERFANO, NAGEEZI, PUEBLO PINTADO, TORREON, WHITEHORSE LAKE, COUNSELOR CHAPTERS.
4.) COYOTE CYN. JCT. LATERAL INCLUDES DALTON PASS, BECENTI, LAKE VALLEY, STANDING ROCK, WHITEROCK, AND CROWNPOINT, AND LITTLEWATER CHAPTERS.
5.) RESERVOIR COST IS $9,600,000 FOR 1,500 A/F
6.) WHOLE PROJECT HAS A PF=1.30.
7.) ASSUMME PIPE COST ARE DIVIDED BY 90% COMMON AND 10% ROCK EXCAVATION.

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Main Pipeline to Gallup and Church Rock, with G.W. demands, plus Gallup area Navajo Demands)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (2,3,4) Gal	Annual Ground Water Production: 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cummulative Flow cfs
Hogback Div. Intake	0	0	0	0	0	$0	0	0	0.00	59.18
Reservoir/WTP	0	0	0	0	0	$0	0	0	0.00	59.18
NAPI Jct.	0	0	624,920	0	0	$0	700	624,920	0.97	59.18
Shiprock Jct.	13,804	46,995	3,339,749	0	0	$0	3,741	4,341,674	6.72	58.22
Sanostee	2,081	7,083	1,123,206	89	153	$0	1,117	1,295,734	2.00	51.50
Burnham Jct.	246	837	133,971	0	0	$0	150	174,162	0.27	49.49
Newcomb	1,534	5,221	835,413	113	89	$0	847	982,746	1.52	49.22
Sheepsprings	660	2,246	359,434	0	15	$0	386	449,656	0.70	47.70
Naschitti	1,538	5,238	838,136	82	77	$0	862	1,000,213	1.55	47.01
Tohatchi	2,318	7,890	1,262,378	180	307	$0	1,107	1,284,797	1.99	45.46
Coyote Cyn. Jct.	5,924	20,164	3,226,187	352	796	$0	2,816	3,267,925	5.06	43.47
Twin Lakes	1,957	6,695	1,071,224	87	153	$0	1,047	1,215,024	1.88	38.42
Ya-ta-hey Jct.	14,885	50,665	8,106,337	1,100	890	$0	8,191	9,505,335	14.71	36.53
Gamerco Hill	0	0	0	0	0	$0	0	0	0.00	21.83
Gallup Jct.	23,600	82,330	9,118,848	4,413	184	$0	10,029	11,636,358	18.01	21.83
Church Rock	4,089	13,918	2,225,860	250	365	$0	2,127	2,467,830	3.82	3.82

38.25 MGD

229,273 2040 Population Served

33,121 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions: Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation: Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Hogback Div. Intake	14.80	4.34	52.1	0	5,075	5,075	0	0.0	0.0	0
Reservoir/WTP	14.80	4.34	52.1	288	5,075	5,110	35	0.3	338.2	0
NAPI Jct.	14.80	4.34	52.1	8,100	5,110	5,250	140	7.1	1411.3	0
Shiprock Jct.	14.55	4.30	51.7	91,042	5,250	5,160	-90	80.1	0.0	0
Sanostee	12.87	4.05	48.6	94,323	5,160	5,580	420	86.8	4230.4	4,983,591
Burnham Jct.	12.37	3.97	47.6	51,075	5,580	5,590	10	49.3	475.7	0
Newcomb	12.31	3.96	47.5	19,088	5,590	5,550	-40	18.4	0.0	3,779,794
Sheepsprings	11.93	3.90	46.8	51,174	5,550	5,890	340	49.4	3010.7	1,730,217
Naschitti	11.75	3.87	46.4	29,635	5,890	5,890	0	30.1	229.0	3,846,974
Tohatchi	11.36	3.80	45.6	90,183	5,890	6,100	210	91.5	2221.1	4,941,528
Coyote Cyn. Jct.	10.87	3.72	44.6	34,954	6,100	6,250	150	35.4	1306.6	0
Twin Lakes	9.60	3.50	42.0	15,594	6,250	6,380	130	17.6	918.8	4,673,171
Ya-ta-hey Jct.	8.13	3.41	40.9	31,161	6,380	6,560	180	35.1	1273.8	0
Gamerco Hill	5.46	2.64	31.6	20,482	6,560	6,935	375	31.6	1438.6	0
Gallup Jct.	5.46	2.64	31.6	14,523	6,560	6,477	-83	22.4	0.0	0
Church Rock	0.95	1.10	13.2	48,082	6,477	6,660	183	185.7	228.2	9,491,854

597,634 Total Pipeline Length(ft.)

113.20 Total Pipeline Length (Miles)

17,082

Chapter Community	Total Capital Cost: Reservoir / WTP $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $	Annual: Energy Cost $	O&M Cost $
Hogback Div. Intake	$2,000,000						$2,000,000	$12,000	$120,000
Reservoir/WTP	$54,701,038	$206,955	$0	52	$46,252	$6,031	$54,960,276	$319,974	$2,545,318
NAPI Jct.		$863,698	$0	52	$1,300,839	$169,623	$2,334,161	$276,678	$41,900
Shiprock Jct.		$0	$0	52	$14,621,108	$1,906,525	$16,527,632	$0	$82,638
Sanostee		$2,589,012	$1,296,675	50	$14,532,291	$1,893,441	$20,311,419	$829,367	$237,556
Burnham Jct.		$291,121	$0	46	$7,538,257	$981,444	$8,810,821	$93,258	$54,243
Newcomb		$0	$862,421	48	$2,817,234	$366,790	$4,146,445	$0	$54,417
Sheepsprings		$1,842,530	$599,352	48	$7,552,868	$983,346	$10,978,096	$590,238	$140,356
Naschitti		$140,126	$962,421	46	$4,183,420	$544,286	$5,830,253	$44,888	$67,740
Tohatchi		$1,359,317	$1,296,675	46	$12,730,667	$1,656,331	$17,042,990	$435,445	$178,175
Coyote Cyn. Jct.		$799,648	$0	46	$4,934,275	$641,977	$6,375,900	$256,160	$59,867
Twin Lakes		$562,322	$1,296,675	42	$2,003,236	$260,328	$4,122,561	$180,135	$85,678
Ya-ta-hey Jct.		$779,576	$0	42	$4,003,004	$520,205	$5,302,784	$249,730	$53,799
Gamerco Hill		$880,405	$0	32	$1,998,788	$259,480	$3,138,673	$282,030	$46,508
Gallup Jct.		$0	$0	32	$1,417,264	$183,987	$1,601,251	$0	$8,006
Church Rock		$139,635	$2,305,200	14	$2,081,603	$275,512	$4,801,951	$44,731	$109,579
Sub-Total	$56,701,038	$10,454,345	$8,719,419		$81,761,106	$10,649,306	$168,285,214	$3,602,635	$3,785,781
Capital Cost	$56,701,038	$10,454,345	$8,719,419		$81,761,106	$10,649,306	$168,285,214		
Contingency Cost	20%						$33,657,043		
Mobilization Cost	10%						$16,828,521		
Indirect Cost	27%						$45,437,008		
Totals							$264,207,785		

NOTES.

1) ALL [illegible] POPULATIONS FROM "[illegible] CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", [illegible]

2) CITY OF GALLUP ANNUAL DEMAND IS [illegible] AC-FT.

3) ASSUME NAVAJO DEMANDS OF [illegible] GALLONS PER CAPITA AND BASED ON [illegible] PROJECTED DEMANDS.

4) ASSUME PIPELINE DEMANDS FOR NAPI AT [illegible]

5) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON [illegible] AVERAGE DEMAND. COST FROM THE [illegible] MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO [illegible] DOLLARS. STORAGE COST ARE FOR SANOSTEE, NEWCOMB, TWO GREY HILLS, SHEEPSPRINGS, TOHATCHI, MEXICAN SPR., CHURCH ROCK, PINEDALE, MARIANO LAKE, AND [illegible] FOR THIS COST ESTIMATE SHEET.

6) ASSUME GALLON / DAY PEAKING FACTOR OF 1.50

7) ASSUME VELOCITY [illegible] FEET PER SECOND FROM [illegible] ASSOCIATES, [illegible]

8) ASSUME [illegible] PER PUMP FROM [illegible] ASSOCIATES, [illegible] COST INDEXED TO [illegible] ASSUME PUMPING EFFICIENCY AT 70%

9) HEAD LOSS BASED ON A FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA [illegible]

10) BASED ON [illegible] $45,101,038

11) PIPE INSTALLED COST FROM [illegible]

12) SETTLING RESERVOIR IS ASSUMED TO BE [illegible] $2,600,000

13) ANNUAL ENERGY COST BASED ON [illegible]

14) ANNUAL O&M COST BASED ON: WTP COST, [illegible]

15) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT [illegible]

16) INDIRECT COST [illegible]

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Lateral Waterline from Cutter Reservior to Huerfano, Nageezi, Pueblo Pintado, Torreon)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (3,4) Gal.	Annual Ground Water Production: 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cummulative Flow cfs
Cutter Dam Intake/WTP	0	0	0	0	0	$0	0	0	0.00	6.19
Huerfano	511	1,739	278,289	59	31	$0	281	325,799	0.50	6.19
Nageezi	981	3,339	534,250	21	15	$0	583	677,117	1.05	5.68
Counselor	2,447	8,329	1,332,831	5	31	$0	1,462	1,696,442	2.62	4.64
Torreon	1,960	6,671	1,067,412	113	75	$0	1,120	1,299,432	2.01	2.01

4.00 MGD

20,079 2040 Population Served

3,446 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions: Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation: Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Cutter Dam Intake/WTP	1.55	1.40	16.8	0	5,930	5,930	0	0.0	0.0	0
Huerfano	1.55	1.40	16.8	136,961	5,930	6,850	920	412.4	1336.2	1,253,072
Nageezi	1.42	1.35	16.1	61,308	6,850	6,950	100	211.6	287.1	2,604,296
Counselor	1.16	1.21	14.6	105,773	6,950	6,860	-90	365.1	206.7	4,863,978
Torreon	0.50	0.80	9.6	85,396	6,860	6,600	-260	508.5	81.0	4,997,816

389,438 Total Pipeline Length(ft.)

73.76 Total Pipeline Length (Miles)

1,911

Chapter Community	Total Capital Cost: Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Cutter Dam Intake/WTP	$5,715,197	$0	$0	15	$0	$0	$5,715,197
Huerfano		$817,775	$320,423	18	$7,735,813	$1,014,245	$9,888,256
Nageezi		$175,668	$599,352	15	$3,115,144	$410,084	$4,300,268
Counselor		$126,517	$1,296,675	15	$5,374,472	$707,506	$7,505,170
Torreon		$49,566	$1,296,675	10	$2,912,223	$392,204	$4,650,668
Sub-Total	$5,715,197	$1,169,546	$3,513,125		$19,137,652	$2,524,038	$32,059,559
Capital Cost	$5,715,197	$1,169,546	$3,513,125		$19,137,652	$2,524,038	$32,059,559
Contingency Cost	20%						$6,411,912
Mobilization Cost	10%						$3,205,956
Indirect Cost	27%						$8,656,081
Totals							$50,333,507

Annual Energy Cost	
Treatment	$114,538
Pump Stations	$374,654
	$489,190

Annual Operation and Maintanence Cost	
Treatment	$1,145,359
Pump Stations	$46,782
Storage Tanks	$140,525
Conveyance Pipe	$108,308
	$1,440,974
Total	$1,930,164

NOTES :

1) ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", [illegible]
2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON [illegible] GAL/HOUSEHOLD @ 4.5 PERSONS/HOUSEHOLD. COST FROM THE 1998 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO [illegible] DOLLARS.
4) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.36
5) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, [illegible])
6) ASSUME [illegible] PER PUMP FROM (HKM ASSOCIATES, [illegible]). COST INDEXED TO [illegible] ASSUME PUMPING EFFICIENCY AT: 70%
7) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)
8) BASED ON [illegible] ANALYSIS BASED ON BID COSTS FROM [illegible], MORRISON MAIERLE, & LABOR SOURCES. ASSUME WTP COST OF: $4,715,197
9) PIPE INSTALLED COST FROM [illegible] ANALYSIS BASED ON [illegible] DOLLARS. ASSUME [illegible] OF PIPE LENGTH IS COMMON AND [illegible] IS ROCK EXCAVATION.
10) ASSUME A CUTTER DIVERSION/INTAKE COST OF: $1,000,000
11) ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON [illegible] PER KILOWATT HOUR.
12) ANNUAL O&M COST BASED ON WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * [illegible], PUMP COST * [illegible], STORAGE COST * [illegible], PIPELINE COST * [illegible].
13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.
14) INDIRECT COST INCLUDE FACILITATING [illegible], TERO [illegible], CONTRACT ADMIN. [illegible], ENVIRON. [illegible], EASEMENTS [illegible], [illegible], DESIGN SURVEY 1%, INVEST. [illegible], DESIGN [illegible], AND CONSTRUCTION OBSERV. [illegible]

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Lateral Waterline to Red Rock NTUA Water line)

Chapter Community	Populations(1,2)		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cummulative Flow
	(1) 1990	2040	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. Prog. Dev. Cost $	Ac-Ft	Gal./Day(6)	cfs	cfs
Gallup Jct.	0	0	0	0	0	$0	0	0	0.00	3.93
Red Rock	3,815	12,985	2,077,840	78	138	$0	2,189	2,540,774	3.93	3.93

12,985 2040 Population Served

2,189 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Pump Horsepower	Storage Demands
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Gal
Gallup Jct.	0.98	1.12	13.4	0	6,477	6,477	0	0.0	0.0	0
Red Rock	0.98	1.12	13.4	26,320	6,477	6,750	273	106.1	241.6	9,772,209

26,320 Total Pipeline Length(ft.)

4.98 Total Pipeline Length (Miles)

242

	Total Capital Cost						
	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Gallup Jct.	$0	$0	$0	14	. $0	$0	$0
Red Rock		$147,830	$2,305,200	14	$1,189,436	$157,429	$3,799,894
Sub-Total	$0	$147,830	$2,305,200		$1,189,436	$157,429	$3,799,894
Capital Cost	$0	$147,830	$2,305,200		$1,189,436	$157,429	$3,799,894
Contingency Cost	20%						$759,979
Mobilization Cost	10%						$379,989
Indirect Cost	27%						$1,025,971
Totals							$5,965,834

Annual Energy Cost

Treatment	$0
Pump Stations	$47,356
	$47,356

Annual Operation and Maintenance Cost

Treatment	$0
Pump Stations	$5,913
Storage Tanks	$92,208
Conveyance Pipe	$6,734
	$104,856
Total	$152,211

NOTES :

1) ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", [illegible]
2) ASSUME NAVAJO DEMANDS OF [illegible] GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON [illegible] GAL/HOUSEHOLD @ 4.5 PERSONS/HOUSEHOLD. COST FROM THE [illegible] MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO [illegible] DOLLARS.
4) RED ROCK DEMANDS INCLUDE RED ROCK, BREADSPRINGS, CHICHILTAH CHAPTERS
5) ASSUME GALLON / DAY PEAKING FACTOR OF 1.30
6) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, [illegible])
7) ASSUME [illegible] PER PUMP FROM (HKM ASSOCIATES, [illegible]), COST INDEXED TO [illegible], ASSUME PUMPING EFFICIENCY AT : 70%
8) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA (DUCTILE IRON FRICTION COEFFICIENT)
9) BASED ON KNOWN ANALYSIS BASED ON BID COSTS FROM [illegible], MORRISON [illegible] & LABOR SOURCES. ASSUME WTP COST OF: $0
10) PIPE INSTALLED COST FROM KNOWN ANALYSIS BASED ON [illegible] DOLLARS. ASSUME [illegible] OF PIPE LENGTH IS COMMON AND [illegible] IS ROCK EXCAVATION.
11) ANNUAL ENERGY COST BASED ON: INTAKE/WTP/RESERVOIR ANNUAL O&M COST * [illegible], PUMPING: BASED ON [illegible] PER KILOWATT HOUR.
12) ANNUAL O&M COST BASED ON WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * [illegible], PUMP COST * [illegible], STORAGE COST * [illegible], PIPELINE COST * [illegible]
13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT [illegible]. ADDITIONAL CONTINGENCY COST AT [illegible].
14) INDIRECT COST INCLUDE FACILITATING [illegible], TERO [illegible], CONTRACT ADMIN. [illegible], ENVIRON. [illegible], EASEMENTS [illegible], GEOTECH [illegible], ARCHEOL. [illegible], DESIGN SURVEY [illegible], INVEST. [illegible], DESIGN [illegible], AND CONSTRUCTION OBSERV. [illegible]

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Lateral Waterline to Coyote Canyon, Standing Rock, and Dalton Pass NTUA Water Line)

Chapter Community	Populations(1,2)		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cummulative Flow
	(1) 1990	2040	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. Prog. Dev. Cost $	Ac-Ft	Gal./Day(6)	cfs	cfs
Coyote Cyn. Jct.	0	0	0	0	0	0	0	0	0.00	5.06
Coyote Canyon	1,234	4,200	672,034	32	61	0	692	802,849	1.24	5.06
Standing Rock	251	854	136,694	34	77	0	76	88,339	0.14	3.81
Dalton Pass	4,439	15,109	2,417,469	285	660	0	2,048	2,376,737	3.68	3.68

20,164 2040 Population Served

2,816 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Pump Horsepower	Storage Demands
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Gal
Coyote Cyn. Jct.	1.26	1.27	15.2	0	6,250	6,250	0	0.0	0.0	0
Coyote Canyon	1.26	1.27	15.2	35,938	6,250	6,160	-90	124.1	27.9	3,067,881
Standing Rock	0.95	1.10	13.2	81,321	6,160	6,280	120	327.8	276.8	339,764
Dalton Pass	0.92	1.08	13.0	37,998	6,280	6,740	460	153.2	365.5	8,830,096

155,257 Total Pipeline Length(ft.)

29.40 Total Pipeline Length (Miles)

670

Chapter Community	Total Capital Cost						
	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Coyote Cyn. Jct.	$0	$0	$0	16	$0	$0	$0
Coyote Canyon		$17,086	$962,421	16	$1,826,059	$240,386	$3,045,952
Standing Rock		$169,412	$212,078	14	$3,675,005	$486,408	$4,542,902
Dalton Pass		$223,671	$2,305,200	14	$1,717,180	$227,279	$4,473,330
Sub-Total	$0	$410,169	$3,479,699		$7,218,245	$954,072	$12,062,185
Capital Cost	$0	$410,169	$3,479,699		$7,218,245	$954,072	$12,062,185
Contingency Cost	20%						$2,412,437
Mobilization Cost	10%						$1,206,218
Indirect Cost	27%						$3,256,790
Totals							$18,937,630

Annual Energy Cost

Treatment	$0
Pump Stations	$131,394
	$131,394

Annual Operation and Maintanence Cost

Treatment	$0
Pump Stations	$16,407
Storage Tanks	$139,188
Conveyance Pipe	$40,862
	$196,456
Total	$327,850

NOTES :

1) ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", [illegible]
2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON 2,000 GAL/HOUSEHOLD @ 4.5 PERSONS/HOUSEHOLD. COST FROM THE 1993 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 1998 DOLLARS.
4) DALTON PASS DEMANDS INCLUDE DALTON PASS, CROWNPOINT, LITTLEWATER, BECENTI, LAKE VALLEY, AND WHITEROCK CHAPTERS.
5) ASSUME GALLON / DAY PEAKING FACTOR OF 1.30
6) ASSUME VELOCITY of 4 FEET PER SECOND FROM (HKM ASSOCIATES, 1998)
7) ASSUME $/HP PER PUMP FROM (HKM ASSOCIATES, 1990), COST INDEXED TO [illegible] ASSUME PUMPING EFFICIENCY AT : 70%
8) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA (DUCTILE IRON FRICTION COEFFICIENT)
9) BASED ON NNDWR ANALYSIS BASED ON BID COSTS FROM [illegible], MORRISON MAIERLE, & [illegible] SOURCES. ASSUME WTP COST OF $0
10) PIPE INSTALLED COST FROM NNDWR ANALYSIS BASED ON BOR-PAO 1998 DOLLARS. ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.
11) ANNUAL ENERGY COST BASED ON: INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING: BASED ON $0.06 PER KILOWATT HOUR.
12) ANNUAL O&M COST BASED ON: WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * 5%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%.
13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.
14) INDIRECT COST INCLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN. 1%, ENVIRON. 2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL. 0.5%, DESIGN SURVEY 1%, INVEST. 2%, DESIGN 8%, AND CONSTRUCTION OBSER. 10%.

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Main Waterline from Yahtahey to Rock Springs and Window Rock)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (2,3,4) Gal.	Annual Ground Water Production 1998 Prod. Ac-Ft	Annual Ground Water Production Est. 2040 Prod. Ac-Ft	Annual Ground Water Production Est. Prog. Dev. Cost $	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cummulative Flow cfs
Ya-ta-hey Jct.	0	0	0	0	0	$0	0	0	0.00	14.71
Rock Springs	3,118	10,613	1,698,056	58	123	$0	1,779	2,064,723	3.19	14.71
Window Rock	11,767	40,052	6,408,281	1,043	787	$0	6,412	7,440,612	11.51	11.51

50,665 2040 Population Served

8,191 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions Area sq.ft.(7)	Pipeline Dimensions Diameter ft.	Pipeline Dimensions Diameter inches	Pipeline Dimensions Length ft.	Elevation Beginning ft.	Elevation Ending ft.	Elevation Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Ya-ta-hey Jct.	3.68	2.16	26.0	0	6,560	6,560	0	0.0	0.0	0
Rock Springs	3.68	2.16	26.0	29,439	6,560	6,760	200	57.9	614.7	7,941,242
Window Rock	2.88	1.91	23.0	58,887	6,650	6,760	110	127.0	442.3	28,817,740

88,326 Total Pipeline Length(ft.)

16.73 Total Pipeline Length (Miles)

1,057

Total Capital Cost	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Ya-ta-hey Jct.	$0	$0	$0	26	$0	$0	$0
Rock Springs		$376,203	$1,728,900	26	$2,345,352	$304,981	$4,755,436
Window Rock		$270,670	$6,339,300	24	$4,345,622	$565,779	$11,521,371
Sub-Total	$0	$646,873	$8,068,200		$6,690,974	$870,760	$16,276,807
Capital Cost	$0	$646,873	$8,068,200		$6,690,974	$870,760	$16,276,807
Contingency Cost	20%						$3,255,361
Mobilization Cost	10%						$1,627,681
Indirect Cost	27%						$4,394,738
Totals							$25,554,586

Annual Energy Cost

Treatment	$0
Pump Stations	$207,220
	$207,220

Annual Operation and Maintainence Cost

Treatment	$0
Pump Stations	$25,875
Storage Tanks	$322,728
Conveyance Pipe	$37,809
	$386,412
Total	$593,632

NOTES :

1). ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993

2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS

3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON 2,000 GAL./HOUSEHOLD @ 4.5 PERSONS/HOUSEHOLD. COST FROM THE 1993 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.

4) ROCK SPRINGS DEMANDS INCLUDE ROCK SPRINGS, TSAYATOH, AND MANUELITO CHAPTERS. WINDOW ROCK INCLUDES ST. MICHAELS AND FT. DEFIANCE CHAPTERS

5) ASSUME GALLON/DAY PEAKING FACTOR OF: 1.30

6) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1998)

7). ASSUME [illegible] PER PUMP FROM (HKM ASSOCIATES, 1998), COST INDEXED TO 2000 [illegible] ASSUME PUMPING EFFICIENCY AT : 70%

8). HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)

9). BASED ON KNOWN ANALYSIS BASED ON BID COSTS FROM USE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST OF: $0

10) PIPE INSTALLED COST FROM KNOWN ANALYSIS BASED ON BOR-PN [illegible] DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.

11). ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON [illegible] PER KILOWATT HOUR

12). ANNUAL O&M COST BASED ON: WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * [illegible], PUMP COST * [illegible], STORAGE COST * [illegible], PIPELINE COST * 0.5%

13). MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.

14). INDIRECT COST INCLUDE FACILITATING:1%, TERO:2%, CONTRACT ADMIN.:1%, ENVIRON.:2%, EASEMENTS:1%, GEOCHEM:0.5%, ARCHEOL.:0.5%, DESIGN SURVEY:1%, INVEST.:2%, DESIGN:6%, AND CONSTRUCTION ENGIN.:10%

Navajo - Gallup Water Supply Project - San Juan River Alternative

(Cost Estimate for Lateral Waterline to Manuelito NTUA Water line)

Chapter Community	Populations(1,2)		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cummulative Flow
	(1) 1990	2040	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. Prog. Dev. Cost $	Ac-Ft	Gal./Day(5)	cfs	cfs
Gallup Jct.	0	0	0	0	0	$0	0	0	0.00	0.61
Manuelito	631	2,148	343,641	76	46	$0	339	393,348	0.61	0.61

2,148 2040 Population Served

339 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Pump Horsepower	Storage Demands
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Gal
Gallup Jct.	0.15	0.44	5.3	0	6,477	6,477	0	0.0	0.0	0
Manuelito	0.15	0.44	5.3	47,050	6,477	6,375	-102	506.7	39.9	1,512,875

47,050 Total Pipeline Length(ft.)

8.91 Total Pipeline Length (Miles)

40

	Total Capital Cost						
	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Gallup Jct.	$0	$0	$0	6	$0	$0	$0
Manuelito		$24,434	$599,352	6	$1,092,292	$152,426	$1,868,505
Sub-Total	$0	$24,434	$599,352		$1,092,292	$152,426	$1,868,505
Capital Cost	$0	$24,434	$599,352		$1,092,292	$152,426	$1,868,505
Contingency Cost	20%						$373,701
Mobilization Cost	10%						$186,850
Indirect Cost	27%						$504,496
Totals							$2,933,553

Annual Energy Cost

Treatment	$0
Pump Stations	$7,827
	$7,827

Annual Operation and Maintanence Cost

Treatment	$0
Pump Stations	$977
Storage Tanks	$23,974
Conveyance Pipe	$8,224
	$31,175
Total	$39,002

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible] 1.30
6. [illegible]
7. [illegible] 70%
8. [illegible]
9. [illegible] $0
10. [illegible]
11. [illegible]
12. [illegible]
13. [illegible]
14. [illegible]

NIIP Alternative: Navajo - Gallup Water Supply Project Cost Scenarios. With GW.

NIIP Alternative: With Prorated Project Cost for the City of Gallup, New Mexico.

Demand Years	Cost 2000 dollars	Navajo A/F	Navajo $Cost	Gallup A/F	Gallup $Cost	Totals $ Cost $
2010	Project Cost $$	11,141	$177,472,504	7,500	$84,323,220	$261,795,72
	Annual Energy $		$1,209,292		$677,369	$1,886,66
	Annual O&M $		$929,415		$1,770,058	$2,699,47
2020	Project Cost $$	15,230	$221,037,608	7,500	$76,811,215	$297,848,82
	Annual Energy $		$1,559,858		$644,212	$2,204,07
	Annual O&M $		$1,508,585		$1,553,408	$3,061,99
2030	Project Cost $$	21,291	$289,756,411	7,500	$69,702,466	$359,458,87
	Annual Energy $		$1,862,118		$607,680	$2,469,79
	Annual O&M $		$2,409,182		$1,309,836	$3,719,01
2040	Project Cost $$	29,067	$326,392,762	7,500	$63,733,056	$390,125,81
	Annual Energy $		$2,391,538		$577,956	$2,969,49
	Annual O&M $		$2,947,375		$1,130,182	$4,077,55
2040: No GW	Project Cost $$	32,254	$348,110,088	7,500	$61,334,101	$409,444,18
	Annual Energy $		$2,645,752		$566,693	$3,212,44
	Annual O&M $		$3,243,243		$1,079,273	$4,322,51
2040: Laterals	Project Cost $$		$8,121,709		**Total:**	**$417,565,89**
Lake Valley,Burnham	Annual Energy $		$53,903			$3,266,34
Whiterock,Whitehorse Lake	Annual O&M $		$24,396			$4,346,91

NIIP Alternative: Navajo - Gallup Water Supply Project Cost/AF over Forty-Year Increments

Demand Years	Cost 2000 dollars	Navajo A/F	Navajo $Cost/AF	Gallup A/F	Gallup $Cost/AF
2010	Share Cost $$	11,141	$15,929	7,500	$11,243
	Annual Energy $		$109		$90
	Annual O&M $		$83		$236
2020	Share Cost $$	15,230	$14,514	7,500	$10,241
	Annual Energy $		$102		$86
	Annual O&M $		$99		$207
2030	Share Cost $$	21,291	$13,610	7,500	$9,294
	Annual Energy $		$87		$81
	Annual O&M $		$113		$175
2040	Share Cost $$	29,067	$11,229	7,500	$8,498
	Annual Energy $		$82		$77
	Annual O&M $		$101		$151

NOTE:

1.) ALL COST ESTIMATES HAVE BEEN COST INDEXED TO 2000 DOLLARS

2.) MAINLINE IS CORE LINE FROM GALLEGOS - YAHTAHEY - WINDOW ROCK - GALLUP - CHURCHROCK

3.) NASCHITTI LATERAL INCLUDES SANOSTEE, NEWCOMB,TWO GREY HILLS, SHEEP SPRINGS, NASCHITTI CHAPTERS.

4.) COYOTE CYN. JCT. LATERAL INCLUDES CROWNPOINT, DALTON PASS, BECENTI, COYOTE CANYON, STANDING ROCK, LITTLEWATER CHAPTERS.

5.) GALLEGOS RESERVOIR COST IS $38,037,430 FOR 8,800 A/F

6.) WHOLE PROJECT HAS A PF=1.30.

7.) HUERFANO LATERAL IS FROM GALLEGOS/WTP-HUERFANO,NAGEEZI, PUEBLO PINTADO, TORREON NTUA SYSTEM

8.) ASSUMME PIPE COST ARE DIVIDED BY 90% COMMON AND 10% ROCK EXCAVATION.

9.) ALL COST ESTIMATES INCLUDES NAPI AND SHIPROCK AREA DEMANDS.

2040 NIIP Alternative: Navajo - Gallup Water Supply Project Cost. With GW.

NIIP Alternative: With Prorated Project Cost for the City of Gallup, New Mexico.

Peaking Factor = 1.3 Demands: 29,066 Acre-Feet

	Navajo		Gallup		Totals
	A/F	$Cost	A/F	$Cost	$ Cost $
Project Cost $$	29,066	$353,693,927	0	$0	$353,693,927
Annual Energy $		$2,433,493		$0	$2,433,493
Annual O&M $		$3,734,238		$0	$3,734,238

Peaking Factor = 1.3 Demands: 36,567 Acre-Feet

	Navajo		Gallup		Totals
	A/F	$Cost	A/F	$Cost	$ Cost $
Project Cost $$	29,067	$326,392,762	7,500	$63,733,056	$390,125,818
Annual Energy $		$2,391,538		$577,956	$2,969,494
Annual O&M $		$2,947,375		$1,130,182	$4,077,556

NOTE:

1.) ALL COST ESTIMATES HAVE BEEN COST INDEXED TO 2000 DOLLARS

2.) MAINLINE IS CORE LINE FROM GALLEGOS - YAHTAHEY - WINDOW ROCK - GALLUP - CHURCHROCK

3.) NASCHITTI LATERAL INCLUDES SANOSTEE, NEWCOMB,TWO GREY HILLS, SHEEP SPRINGS, NASCHITTI CHAPT

4.) COYOTE CYN. JCT. LATERAL INCLUDES CROWNPOINT, DALTON PASS, BECENTI, COYOTE CANYON, STANDING ROCK, LITTLEWATER CHAPTERS.

5.) GALLEGOS RESERVOIR COST IS $38,037,430 FOR 8,800 A/F

6.) WHOLE PROJECT HAS A PF=1.30.

7.) HUERFANO LATERAL IS FROM GALLEGOS/WTP-HUERFANO,NAGEEZI, PUEBLO PINTADO, TORREON NTUA SYSTEM.

8.) ASSUMME PIPE COST ARE DIVIDED BY 90% COMMON AND 10% ROCK EXCAVATION.

Navajo - Gallup Water Supply Project - NIIP Alternativ

(Cost Estimate for Main Waterline to Gallup and Church Rock, with G.W. demands, plus Gallup area Navajo Demands)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand Gal.	Annual Ground Water Production 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cummulat Flow cfs
Gallegos Reservoir	0	0	0	0	0	$0	0	0	0.00	65
WTP	0	20,873	3,964,670	0	0	$0	4,441	4,966,595	7.68	65
Huerfano Jct.	5,899	20,079	3,212,582	208	153	$0	3,446	3,998,790	6.19	57
Burnham	245	837	133,971	0	0	$0	150	174,162	0.27	51
Lake Valley	637	2,158	345,909	22	46	$0	343	397,595	0.62	51
Naschitti Jct	5,914	19,789	3,166,291	851	334	$0	3,213	3,728,550	5.77	50
Tohatchi	2,318	7,890	1,262,378	180	307	$0	1,107	1,284,797	1.99	44
Coyote Cyn. Jct.	5,287	17,996	2,879,288	330	752	$0	2,473	2,870,330	4.44	42
Twin Lakes	1,967	6,695	1,071,224	104	153	$0	1,047	1,215,024	1.88	38
Yah-ta-hey Jct.	14,885	50,665	8,106,337	1,048	890	$0	8,191	9,505,335	14.71	36
Gamerco Hill	0	0	0	0	0	$0	0	0	0.00	21
Gallup Jct.	23,600	62,330	9,116,848	105	184	$0	10,029	11,638,358	18.01	21
Church Rock	4,089	13,918	2,226,860	275	368	$0	2,127	2,467,830	3.82	3

42.25 MGD

223,240 2040 Population Served

36,567 Total Annual Demand(AF.

Chapter Community	Pipeline Dimensions Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demand (5) Gal
Gallegos Reservoir	16.34	4.56	54.7	0	5,960	5,960	0	0.0	0.0	
WTP	16.34	4.56	54.7	1,000	5,960	6,005	45	0.8	485.3	
Huerfano Jct.	14.42	4.29	51.4	4,478	6,005	6,010	5	3.9	83.6	
Burnham	12.87	4.05	48.6	58,732	6,010	6,195	185	52.2	1980.1	
Lake Valley	12.81	4.04	48.5	72,046	6,195	5,740	-455	66.3	0.0	
Naschitti Jct.	12.65	4.01	48.2	76,272	5,740	5,695	-45	73.6	234.8	
Tohatchi	11.21	3.78	45.3	82,886	5,695	6,100	405	83.9	3553.1	4,941,
Coyote Cyn. Jct.	10.71	3.69	44.3	34,954	6,100	6,250	150	37.3	1301.2	
Twin Lakes	9.60	3.50	42.0	15,594	6,250	6,380	130	17.6	918.8	4,673,
Yah-ta-hey Jct.	9.13	3.41	40.9	31,161	6,380	6,560	180	35.1	1273.8	
Gamerco Hill	5.46	2.64	31.6	20,482	6,560	6,490	-70	31.6	0.0	
Gallup Jct.	5.46	2.64	31.6	15,072	6,490	6,477	-13	23.3	36.4	
Church Rock	0.95	1.10	13.2	46,041	6,477	6,660	183	185.6	228.1	9,491,

456,518 Total Pipeline Length(ft.)
86.46 Total Pipeline Length (Miles)

10,095

	Total Capital Cost Reservoir / WTP $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $	Annual Energy Cost $	O&M Cost $
Gallegos Reservoir	$38,037,430						$38,037,430	$228,225	$2,282,246
WTP	$49,816,237	$297,025	$0	56	$173,806	$22,702	$50,309,769	$301,448	$2,075,851
Huerfano Jct.		$51,149	$0	52	$719,155	$93,774	$864,079	$16,385	$6,111
Burnham		$1,211,807	$0	50	$8,740,667	$1,138,839	$11,091,313	$388,192	$97,870
Lake Valley		$0	$0	50	$11,100,086	$1,446,253	$12,546,338	$0	$62,732
Naschitti Jct.		$143,688	$0	48	$11,257,130	$1,465,623	$12,866,440	$46,029	$69,361
Tohatchi		$2,174,501	$1,298,675	46	$11,672,354	$1,516,638	$16,662,168	$696,582	$204,802
Coyote Cyn. Jct.		$796,305	$0	44	$4,711,386	$612,596	$6,120,287	$255,069	$58,472
Twin Lakes		$562,322	$962,421	42	$2,003,236	$260,328	$3,788,307	$180,135	$72,308
Yah-ta-hey Jct.		$779,576	$0	42	$4,003,004	$520,205	$5,302,784	$249,730	$53,799
Gamerco Hill		$0	$0	32	$1,998,788	$259,480	$2,258,268	$0	$11,291
Gallup Jct.		$22,267	$0	32	$1,470,840	$190,942	$1,684,049	$7,133	$9,200
Church Rock		$139,603	$2,305,200	14	$2,080,654	$275,386	$4,800,844	$44,721	$109,572
Sub-Total	$87,853,667	$6,178,242	$4,584,296		$59,931,105	$7,804,766	$166,332,077	$2,185,444	$2,831,366
Capital Cost	$87,853,667	$6,178,242	$4,584,296		$59,931,105	$7,804,766	$166,332,077		
Contingency Cost	20%						$33,266,415		
Mobilization Cost	10%						$16,633,208		
Indirect Cost	27%						$44,909,661		
Totals							$261,141,360		

NOTES :

1). NAVAJO 1990 POPULATION FROM CENSUS DATA FROM THE "CHAPTER IMAGES, 1996 EDITION, DIVISION OF COMMUNITY DEVELOPMENT"

2). GALLUP DEMANDS ARE 7,340 AF PER YEAR FOR THE YEAR 2040

3) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS

4.) ASSUME 700 AF PER YEAR FOR NAPI. NAPI DELIVERY WILL BE AT THE WTP FACILITY. SHIPROCK LATERALS DEMANDS AT THE WTP ALSO (3,741 AF/YR).

5) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1996 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.
STORAGE DEMANDS ARE ONLY MET FOR TOHATCHI, MEXICAN SPRINGS, TWIN LAKES, MANUELITO, AND CHURCH ROCK CHAPTERS, SINCE THEY FALL ON THE MAIN LINE TO GALLUP.

6) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.30 EXCEPT FOR NAPI DEMANDS WHICH IS 1.4 P.F.

7) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1999)

8). ASSUME $660/HP PER PUMP FROM (HKM ASSOCIATES, 1999). COST INDEXED TO 2000 ($613/HP) ASSUME PUMPING EFFICIENCY AT : 70%

9). HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)

10). BASED ON KNOWN ANALYSIS BASED ON BID COSTS FROM NISE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST OF: $49,816,237

11) PIPE INSTALLED COST FROM KNOWN ANALYSIS BASED ON BOR-PN 1999 DOLLARS. ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.

12) GALLEGOS RESERVOIR IS ASSUMED TO BE 6,800 AF PLUS CAPACITY. 1999 COST ESTIMATE FROM USBR INDEXED TO 2000. $38,037,430

13) ANNUAL ENERGY COST BASED ON: INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%. PUMPING: BASED ON $0.06 PER KILOWATT HOUR.

14). ANNUAL O&M COST BASED ON: WTP COST: BOR O&M COST, INTAKE/RESERVOIR COST * 6%, PUMP COST * 6%, STORAGE COST * 4%, PIPELINE COST * 0.5%

15). MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%

16). INDIRECT COST INCLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN 1%, ENVIRON. 2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL 0.5%, DESIGN SURVEY 1%, INVEST 2%, DESIGN 6%, AND CONSTRUCTION OBSER. 10%

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral Waterline from Gallegos/WTP to Huerfano, Nageezi, Pueblo Pintado, Torreon)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (3,4) Gal.	Annual Ground Water Production 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	cfs	Cummulative Flow cfs
Huerfano Jct.	0	0	0	0	0	$0	0	0	0.00	6.1
Huerfano	511	1,739	278,289	59	31	$0	281	325,799	0.50	6.1
Nageezi	981	3,339	534,250	31	15	$0	583	677,117	1.05	5.6
Counselor	2,447	8,329	1,332,631	5	31	$0	1,462	1,696,442	2.62	4.6
Torreon	1,960	6,671	1,067,412	113	76	$0	1,120	1,299,432	2.01	2.0

20,079 2040 Population Served $0 3,446 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Huerfano Jct.	1.55	1.40	16.8	0	6,010	6,010	0	0.0	0.0	[illegible]
Huerfano	1.55	1.40	16.8	98,788	6,010	6,803	793	297.5	1093.6	1,253,07
Nageezi	1.42	1.35	16.1	61,308	6,803	6,947	144	211.6	327.8	2,604,29
Counselor	1.16	1.21	14.6	105,773	6,947	6,800	-147	365.1	163.9	5,002,35
Torreon	0.50	0.80	9.6	85,396	6,800	6,692	-108	508.5	130.5	4,997,81

351,265 Total Pipeline Length(ft.)
66.53 Total Pipeline Length (Miles)
1,716

Total Capital Cost	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Huerfano Jct.	$0	$0	$0	18	$0	$0	$0
Huerfano		$669,279	$320,423	18	$5,579,730	$731,560	$7,300,992
Nageezi		$200,493	$962,421	16	$3,115,144	$410,084	$4,688,141
Counselor		$100,306	$1,296,675	16	$5,374,472	$707,506	$7,478,961
Torreon		$79,881	$1,296,675	10	$2,912,223	$392,204	$4,680,983
Sub-Total	$0	$1,049,960	$3,876,194		$16,981,570	$2,241,353	$24,149,077
Capital Cost	$0	$1,049,960	$3,876,194		$16,981,570	$2,241,353	$24,149,077
Contingency Cost	20%						$4,829,815
Mobilization Cost	10%						$2,414,908
Indirect Cost	27%						$6,520,251
Totals							$37,914,051

Annual Energy Cost

Treatment	$0
Pump Stations	$336,345
	$336,345

Annual Operation and Maintanence Cos

Treatment	$0
Pump Stations	$41,998
Storage Tanks	$155,048
Conveyance Pipe	$96,115
	$293,161
Total	$629,506

NOTES:

1). ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993
2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2010 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS, COST FROM THE 1999 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS
4) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.30
5) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1990)
6) ASSUME $600/HP PER PUMP FROM (HKM ASSOCIATES, 1990), COST INDEXED TO 2000 ($612/HP) ASSUME PUMPING EFFICIENCY AT: 70%
7) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA (DUCTILE IRON FRICTION COEFFICIENT)
8) BASED ON NHDWR ANALYSIS BASED ON BID COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST OF: $0
9) PIPE INSTALLED COST FROM NHDWR ANALYSIS BASED ON BOR-PIA(1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION
10) ANNUAL ENERGY COST BASED ON: INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON $0.06 PER KILOWATT HOUR
11) ANNUAL O&M COST BASED ON: WTP COST: BOR O&M COST, INTAKE/RESERVOIR COST * 5%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%
12) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%
13) INDIRECT COST INCLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN. 1%, ENVIRON. 2%, EASEMENTS 1%, GEOCHEM. 0.5%, ARCHEOL. 0.5%, DESIGN SURVEY 1%, INVEST. 2%, DESIGN 6%, AND CONSTRUCTION OBSER. 10%

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral Waterline to Red Rock NTUA Water line)

Chapter Community	Populations(1,2)		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cummu Flo
	(1) 1990	2040	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Ac-Ft	Gal./Day(6)	cfs	cfs
Gallup Jct.	0	0	0	0	0	$0	0	0	0.00	
Red Rock	3,815	12,985	2,077,840	78	138	$0	2,189	2,540,774	3.93	

12,985 2040 Population Served $0 2,189 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Pump Horsepower	Stora Dema
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Ga
Gallup Jct.	0.98	1.12	13.4	0	6,490	6,490	0	0.0	0.0	
Red Rock	0.98	1.12	13.4	26,320	6,490	6,750	260	106.1	233.3	9,77

26,320 Total Pipeline Length(ft.)
4.98 Total Pipeline Length (Miles)

233

	Total Capital Cost						
	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Gallup Jct.	$0	$0		14	$0	$0	$0
Red Rock		$142,760	$2,305,200	14	$1,189,436	$157,429	$3,794,825
Sub-Total	$0	$142,760	$2,306,200		$1,189,436	$157,429	$3,794,825
Capital Cost	$0	$142,780	$2,305,200		$1,189,436	$157,429	$3,794,825
Contingency Cost	20%						$758,965
Mobilization Cost	10%						$379,482
Indirect Cost	27%						$1,024,603
Totals							$5,957,875

Annual Energy Cost	
Treatment	$0
Pump Stations	$45,732
	$45,732
Annual Operation and Maintanence C	
Treatment	$0
Pump Stations	$5,710
Storage Tanks	$92,208
Conveyance Pipe	$6,734
	$104,653
Total	$150,385

NOTES :

1) ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1990
2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1993 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.
4) RED ROCK DEMANDS INCLUDE RED ROCK, BREADSPRINGS, CHICHILTAH CHAPTERS.
5) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.30
6) ASSUME VELOCITY =4 FEET PER SECOND FROM (NKM ASSOCIATES, 1990)
7) ASSUME $500/HP PER PUMP FROM (NKM ASSOCIATES, 1990); COST INDEXED TO 2000 ($612/HP) ASSUME PUMPING EFFICIENCY AT 70%
8) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)
9) BASED ON NNOWR ANALYSIS BASED ON BID COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COS $0
10) PIPE INSTALLED COST FROM NNOWR ANALYSIS BASED ON BOR-PIA(1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION
11) ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON $0.06 PER KILOWATT HOUR.
12) ANNUAL O&M COST BASED ON WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * 6%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%.
13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.
14) INDIRECT COST INCLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN 1%, ENVIRON 2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL 0.5%, DESIGN SURVEY 1%, INVEST 2%, DESIGN 6%, AND CONSTRUCTION OBSER. 10%

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral Waterline to Coyote Canyon, Standing Rock, and Dalton Pass NTUA Water Line)

Chapter Community	Populations(1,2)		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cummulative Flow
	(1) 1990	2040	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Ac-Ft	Gal./Day(6)	cfs	cfs
Coyote Cyn. Jct.	0	0	0	0	0	$0	0	0	0.00	4.44
Coyote Canyon	1,234	4,200	672,034	32	61	$0	692	802,849	1.24	4.44
Standing Rock	251	854	136,694	34	77	$0	76	88,339	0.14	3.20
Dalton Pass	3,802	12,941	2,070,561	263	614	$0	1,705	1,979,142	3.06	3.06

17,996 2040 Population Served $0 2,473 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Pump Horsepower	Storage Demands
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Gal
Coyote Cyn. Jct.	1.11	1.19	14.3	0	6,250	6,250	0	0.0	0.0	0
Coyote Canyon	1.11	1.19	14.3	35,938	6,250	6,160	-90	144.8	39.5	3,087,881
Standing Rock	0.80	1.01	12.1	81,321	6,160	6,280	120	391.9	265.4	339,764
Dalton Pass	0.77	0.99	11.8	37,998	6,280	6,740	460	183.1	319.2	7,612,083

155,257 Total Pipeline Length(ft.)
29.40 Total Pipeline Length (Miles)
624

	Total Capital Cost						
	Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Coyote Cyn. Jct.	$0	$0	$0	14	$0	$0	$0
Coyote Canyon		$24,164	$962,421	14	$1,624,086	$214,957	$2,825,628
Standing Rock		$162,452	$212,078	12	$3,222,079	$429,588	$4,026,197
Dalton Pass		$195,363	$1,728,900	12	$1,505,547	$200,729	$3,630,539
Sub-Total	$0	$381,979	$2,903,399		$6,351,712	$845,273	$10,482,364
Capital Cost	$0	$381,979	$2,903,399		$6,351,712	$845,273	$10,482,364
Contingency Cost	20%						$2,096,473
Mobilization Cost	10%						$1,048,236
Indirect Cost	27%						$2,830,238
Totals							$16,457,311

Annual Energy Cost	
Treatment	$0
Pump Stations	$122,364
	$122,364
Annual Operation and Maintanence Cost	
Treatment	$0
Pump Stations	$15,279
Storage Tanks	$116,136
Conveyance Pipe	$35,985
	$167,400
Total	$289,764

NOTES:

1). ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993

2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.

3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1993 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.

4). DALTON PASS DEMANDS INCLUDE DALTON PASS, CROWNPOINT, LITTLEWATER, BECENTI, LAKE VALLEY, AND WHITEROCK CHAPTERS.

5) ASSUME GALLON/DAY PEAKING FACTOR OF 1.30

6) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1990)

7). ASSUME $300/HP PER PUMP FROM (HKM ASSOCIATES, 1990). COST INDEXED TO 2000 ($612/HP) ASSUME PUMPING EFFICIENCY 70%

8). HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA, (DUCTILE IRON FRICTION COEFFECIENT)

9) BASED ON NNDWR ANALYSIS BASED ON 2000 COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP C $0

10) PIPE INSTALLED COST FROM NNDWR ANALYSIS BASED ON BOR-PN(1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.

11) ANNUAL ENERGY COST BASED ON: INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING: BASED ON $0.08 PER KILOWATT HOUR

12). ANNUAL O&M COST BASED ON: WTP COST: BOR O&M COST, INTAKE/RESERVOIR COST * 6%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%.

13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.

14) INDIRECT COST INLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN. 1%, ENVIRON. 2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL. 0.5%, DESIGN SURVEY 1%, INVEST. 2%, DESIGN 8%, AND CONSRUCTION OBSER. 10%.

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Main Waterline from Yahtahey to Rock Springs and Window Rock)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (2,3,4) Gal.	Annual Ground Water Production 1998 Prod. Ac-Ft	Annual Ground Water Production Est. 2040 Prod. Ac-Ft	Annual Ground Water Production Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cumm[ulative] Flo[w] cf[s]
Ya-ta-hey Jct.	0	0	0	0	0	$0	0	0	0.00	
Rock Springs	3,118	10,613	1,698,056	58	123	$0	1,779	2,064,723	3.19	
Window Rock	11,767	40,052	6,408,281	1,043	767	$0	6,412	7,440,612	11.51	

50,665 2040 Population Served $0 8,191 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions Area sq.ft.(7)	Pipeline Dimensions Diameter ft.	Pipeline Dimensions Diameter inches	Pipeline Dimensions Length ft.	Elevation Beginning ft.	Elevation Ending ft.	Elevation Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Stor[age] Dem[and] (5 G[al])
Ya-ta-hey Jct.	3.68	2.16	26.0	0	6,560	6,560	0	0.0	0.0	
Rock Springs	3.68	2.16	26.0	29,439	6,560	6,760	200	57.9	614.7	7,9
Window Rock	2.88	1.91	23.0	58,887	6,760	6,760	0	127.0	237.0	28,6

88,326 Total Pipeline Length(ft.)
16.73 Total Pipeline Length (Miles)
852

	Total Capital Cost Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (In.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Ya-ta-hey Jct.	$0	$0	$0	26	$0	$0	$0
Rock Springs		$376,203	$1,728,900	26	$2,345,352	$304,981	$4,755,436
Window Rock		$145,049	$6,339,300	24	$4,345,622	$565,779	$11,395,750
Sub-Total	$0	$521,252	$8,068,200		$6,690,974	$870,760	$16,151,187
Capital Cost	$0	$521,252	$8,068,200		$6,690,974	$870,760	$16,151,187
Contingency Cost	20%						$3,230,237
Mobilization Cost	10%						$1,615,119
Indirect Cost	27%						$4,360,820
Totals							$25,357,363

Annual Energy Cost

Treatment	$0
Pump Stations	$166,979
	$166,979

Annual Operation and Maintanence [C]

Treatment	$0
Pump Stations	$20,850
Storage Tanks	$322,728
Conveyance Pipe	$37,809
	$381,387
Total	$548,365

NOTES :

1) ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993
2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.
3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1990 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.
4) ROCK SPRINGS DEMANDS INCLUDE ROCK SPRINGS, TSAYATOH, AND MANUELITO CHAPTERS. WINDOW ROCK INCLUDES ST. MICHAELS AND FT. DEFIANCE CHAPTERS
5) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.30
6) ASSUME VELOCITY =4 FEET PER SECOND FROM (HGM ASSOCIATES, 1990)
7) ASSUME 5000HP PER PUMP FROM (HGM ASSOCIATES, 1990). COST INDEXED TO 2000 ($612/HP) ASSUME PUMPING EFFICIENCY AT : 70%
8) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)
9) BASED ON NNDWR ANALYSIS BASED ON BID COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST C $0
10) PIPE INSTALLED COST FROM NNDWR ANALYSIS BASED ON BOR-PIA(1999 DOLLARS). ASSUMME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION
11) ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON $0.06 PER KILOWATT HOUR
12) ANNUAL O&M COST BASED ON: WTP COST: BOR O&M COST, INTAKE/RESERVOIR COST * 8%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%
13) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%
14) INDIRECT COST INLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN 1%, ENVIRON .2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL 0.5%, DESIGN SURVEY 1%, INVEST .2%, DESIGN 6%, AND CONSTRUCTION OBSER. 10%.

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral Waterline from mainline to Naschitti, Sheepsprings, Newcomb, Two Grey Hills, Sanostee)

Chapter Community	Populations (1) 1990	Populations 2040	Daily Demand (3,4) Gal.	Annual Ground Water Production: 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	Peak Daily Demand cfs	Cummulative Flow cfs
Naschitti Jct.	0	0	0	0	0	$0	0	0	0.00	5.77
Naschitti	1,539	5,238	838,136	82	77	$0	862	1,000,213	1.55	5.77
Sheepsprings	660	2,246	359,434	0	15	$0	386	449,858	0.70	4.22
Newcomb	1,534	5,221	835,413	680	89	$0	847	982,746	1.52	3.53
Sanostee	2,081	7,083	1,133,306	89	153	$0	1,117	1,295,734	2.00	2.00

19,789 2040 Population Served $0 3,213 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions: Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation: Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Naschitti Jct.	1.44	1.36	16.3	0	5,695	5,895	0	0.0	0.0	0
Naschitti	1.44	1.36	16.3	51,679	5,895	5,890	195	178.4	349.2	3,846,974
Sheepsprings	1.06	1.16	13.9	29,635	5,890	5,883	-7	119.4	76.9	1,730,217
Newcomb	0.88	1.06	12.7	51,174	5,883	5,550	-333	206.3	0.0	3,779,794
Sanostee	0.50	0.80	9.6	51,019	5,550	5,580	30	303.8	108.5	4,983,591

183,507 Total Pipeline Length(ft.) 535

34.76 Total Pipeline Length (Miles)

	Total Capital Cost: Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Naschitti Jct.	$0	$0	$0	16	$0	$0	$0
Naschitti		$213,688	$962,421	16	$2,625,881	$345,678	$4,147,667
Sheepsprings		$47,087	$599,352	14	$1,339,245	$177,257	$2,162,941
Newcomb		$0	$962,421	14	$2,312,622	$306,089	$3,581,131
Sanostee		$66,386	$1,296,675	10	$1,739,879	$234,318	$3,337,259
Sub-Total	$0	$327,161	$3,820,869		$8,017,627	$1,063,340	$13,228,997
Capital Cost	$0	$327,161	$3,820,869		$8,017,627	$1,063,340	$13,228,997
Contingency Cost	20%						$2,645,799
Mobilization Cost	10%						$1,322,900
Indirect Cost	27%						$3,571,829
Totals							$20,769,526

Annual Energy Cost	
Treatment	$0
Pump Stations	$104,803
	$104,803
Annual Operation and Maintanence Cost	
Treatment	$0
Pump Stations	$13,086
Storage Tanks	$152,835
Conveyance Pipe	$40,088
	$206,009
Total	$310,813

NOTES:

1). ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993

2) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2040 PROJECTED DEMANDS.

3) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1999 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.

4) ASSUME GALLON / DAY PEAKING FACTOR OF 1.30

5) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1990)

6). ASSUME 350HP PER PUMP FROM (HKM ASSOCIATES, 1990). COST INDEXED TO 2000 ([illegible]/HP) ASSUME PUMPING EFFICIENCY AT : 70%

7). HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)

8). BASED ON NNDWR ANALYSIS BASED ON BID COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST $0

9) PIPE INSTALLED COST FROM NNDWR ANALYSIS BASED ON BOR-FIA(1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION

10). ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING: BASED ON $0.06 PER KILOWATT HOUR

11). ANNUAL O&M COST BASED ON: WTP COST: BOR O&M COST, INTAKE/RESERVOIR COST * 5%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%

12). MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%. ADDITIONAL CONTINGENCY COST AT 20%.

13). INDIRECT COST INCLUDE FACILITATING 1%, TERO 2%, CONTRACT ADMIN. 1%, ENVIRON. 2%, EASEMENTS 1%, GEOCHEM 0.5%, ARCHEOL. 0.5%, DESIGN SURVEY 1%, INVEST. 2%, DESIGN 8%, AND CONSTRUCTION OBSER. 10%.

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral to Shiprock/666 Jct. from Gallegos Reservoir)

Chapter Community	2040 Shiprock Populations		Daily Demand	Annual Ground Water Production			Annual Demand Minus Production	Peak Daily Demand		Cumm… Flo
	Total Population	Population Served	Gal.	1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Ac-Ft	Gal./Day(6)	cfs	cfs
WTP	0	0	0	0	0	$0	0	0	0.00	
Hogback	0	0	0	0	0	$0	0	0	0.00	
Shiprock	46,985	20,873	3,339,749	0	0	$0	3,741	4,341,674	6.72	
								4.34 MGD		

20,873 2040 Population Served

3,741 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions				Elevation			Headloss due to friction	Horsepower	Stor… Dema…
	Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Beginning ft.	Ending ft.	Change ft.	(9) ft.	HP	(5) Ga…
WTP	1.68	1.46	17.5	0	6,010	6,010	0	0.0	0.0	
Hogback	1.68	1.46	17.5	139,824	6,010	5,400	-610	421.1	0.0	
Shiprock	1.68	1.46	17.5	55,532	5,400	5,164	-236	167.2	0.0	

195,356 Total Pipeline Length(ft.) 0

37.00 Total Pipeline Length (Miles)

	Total Capital Cost							Annual	
	Reservoir / WTP $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (in.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $	Energy Cost $	O&M Cost $
WTP	$0	$0	$0	18	$0	$0	$0	$0	$0
Hogback		$0	$0	18	$7,897,520	$1,035,446	$8,932,966	$0	$44,665
Shiprock		$0	$0	18	$3,136,551	$411,234	$3,547,785	$0	$17,739
Sub-Total	$0	$0	$0		$11,034,071	$1,446,680	$12,480,751	$0	$62,404
Capital Cost	$0	$0	$0		$11,034,071	$1,446,680	$12,480,751		
Contingency Cost	20%						$2,496,150		
Mobilization Cost	10%						$1,248,075		
Indirect Cost	27%						$3,369,803		
Totals							$19,594,779		

NOTES :

1) NAVAJO 1990 POPULATION FROM CENSUS DATA FROM THE "CHAPTER IMAGES, 1992 EDITION, DIVISION OF COMMUNITY DEVELOPMENT"

2) GALLUP DEMANDS ARE 4,300 AF PER YEAR FOR THE YEAR 2010.

3) ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2010 PROJECTED DEMANDS.

4) ASSUME NO PIPELINE DEMANDS FOR NAPI, SINCE THEIR DEMANDS ARE MET VIA NIIP CANALS.

5) ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON 2,000 GAL./HOUSEHOLD @ 4.5 PERSONS/HOUSEHOLD. COST FROM THE 1990 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS. STORAGE DEMANDS ARE ONLY MET FOR BURNHAM, NASCHITTI, TOHATCHI, MEXICAN SPRINGS, AND TWIN LAKES CHAPTERS, SINCE THEY FALL ON THE MAIN LINE TO GALLUP.

6) ASSUME GALLON / DAY PEAKING FACTOR OF: 1.30

7) ASSUME VELOCITY =4 FEET PER SECOND FROM (HKM ASSOCIATES, 1990)

8) ASSUME $800/HP PER PUMP FROM (HKM ASSOCIATES, 1990), COST INDEXED TO 2000 ($819/HP) ASSUME PUMPING EFFICIENCY AT : 70%

9) HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA (DUCTILE IRON FRICTION COEFFICIENT)

10) BASED ON NNOWR ANALYSIS BASED ON BID COSTS FROM MSE-HKM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP COST ($5,119,511

11) PIPE INSTALLED COST FROM NNOWR ANALYSIS BASED ON BOR PLA (1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.

12) GALLEGOS RESERVOIR IS ASSUMED TO BE 8,300 AF PLUS CAPACITY, 1996 COST ESTIMATE FROM USBR INDEXED TO 2000. $0

13) ANNUAL ENERGY COST BASED ON INTAKE/WTP/RESERVOIR ANNUAL O&M COST * 10%, PUMPING BASED ON $0.06 PER KILOWATT HOUR.

14) ANNUAL O&M COST BASED ON WTP COST, BOR O&M COST, INTAKE/RESERVOIR COST * 5%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%

15) MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%, ADDITIONAL CONTINGENCY COST AT 20%.

16) INDIRECT COST INLUDE FACILITATING:1%, TERO:2%, CONTRACT ADMIN.:1%, ENVIRON.:2%, EASEMENTS:1%, GEOCHEM:0.5%, ACHEOL.:0.5%, DESIGN SURVEY:1%, INVEST.:2%, DESIGN:6%, AND CONSTRUCTION OBSER.:10%

Navajo - Gallup Water Supply Project - NIIP Alternative

(Cost Estimate for Lateral Waterline to Manuelito NTUA Water line)

Chapter Community	Populations(1,2) (1) 1990	2040	Daily Demand Gal.	Annual Ground Water Production 1998 Prod. Ac-Ft	Est. 2040 Prod. Ac-Ft	Est. GW Dev. Cost $$	Annual Demand Minus Production Ac-Ft	Peak Daily Demand Gal./Day(6)	cfs	Cummulative Flow cfs
Gallup Jct.	0	0	0	0	0	$0	0	0	0.00	0.6
Manuelito	631	2,148	343,641	78	46	$0	339	393,348	0.61	0.6

2,148 2040 Population Served $0 339 Total Annual Demand(AF)

Chapter Community	Pipeline Dimensions Area sq.ft.(7)	Diameter ft.	Diameter inches	Length ft.	Elevation Beginning ft.	Ending ft.	Change ft.	Headloss due to friction (9) ft.	Pump Horsepower HP	Storage Demands (5) Gal
Gallup Jct.	0.15	0.44	5.3	0	6,477	6,477	0	0.0	0.0	(
Manuelito	0.15	0.44	5.3	47,050	6,477	6,375	-102	506.7	39.9	1,512,875

47,050 Total Pipeline Length(ft.)
8.91 Total Pipeline Length (Miles)

40

	Total Capital Cost Water Treatment $(10)	Pump $(8)	Storage $(5)	Pipe Diameter used (In.)	Pipe-Common $(11)	Pipe-Rock $(11)	Total $
Gallup Jct.	$0	$0		6	$0	$0	$0
Manuelito		$24,434	$599,352	6	$1,092,292	$152,426	$1,868,505
Sub-Total	$0	$24,434	$599,352		$1,092,292	$152,426	$1,868,505
Capital Cost	$0	$24,434	$599,352		$1,092,292	$152,426	$1,868,505
Contingency Cost	20%						$373,701
Mobilization Cost	10%						$186,850
Indirect Cost	27%						$504,496
Totals							$2,933,553

Annual Energy Cost	
Treatment	$0
Pump Stations	$7,827
	$7,827

Annual Operation and Maintanence Cost	
Treatment	$0
Pump Stations	$977
Storage Tanks	$23,974
Conveyance Pipe	$6,224
	$31,175
Total	$39,002

NOTES :

1). ALL 1990 POPULATIONS FROM "1990 CENSUS POPULATION AND HOUSING CHARACTERISTICS OF THE NAVAJO NATION", 1993
2). ASSUME NAVAJO DEMANDS OF 160 GALLONS PER CAPITA AND BASED ON 2010 PROJECTED DEMANDS.
3). ESTIMATED NAVAJO STORAGE DEMANDS ARE BASED ON AVG DAILY DEMAND - GW PROD * 5 DAYS. COST FROM THE 1999 MEANS HEAVY CONSTRUCTION COST DATA AND INDEXED TO 2000 DOLLARS.
4). RED ROCK DEMANDS INCLUDE RED ROCK, BREADSPRINGS, CHICHILTAH CHAPTERS.
5). ASSUME GALLON / DAY PEAKING FACTOR C 1.30
6). ASSUME VELOCITY =4 FEET PER SECOND FROM PHCM ASSOCIATES, 1990)
7). ASSUME $500/HP PER PUMP FROM (HKM ASSOCIATES, 1990). COST INDEXED TO 2000 ($612/HP) ASSUME PUMPING EFFICIENCY 70%
8). HEAD LOSS BASED ON 4 FEET PER SECOND BASED ON HAZEN-WILLIAMS HEADLOSS FORMULA. (DUCTILE IRON FRICTION COEFFICIENT)
9). BASED ON NNDWR ANALYSIS BASED ON BID COSTS FROM NSE-HOM, MORRISON MAIERLE, & USBOR SOURCES. ASSUME WTP $0
10). PIPE INSTALLED COST FROM NNDWR ANALYSIS BASED ON BOR-PIA (1999 DOLLARS). ASSUME 90% OF PIPE LENGTH IS COMMON AND 10% IS ROCK EXCAVATION.
11). ANNUAL ENERGY COST BASED ON: INTAKE/INTAKE/RESERVOIR ANNUAL O&M COST * 10%, PUMPING: BASED ON $0.06 PER KILOWATT HOUR
12). ANNUAL O&M COST BASED ON: WTP COST; BOR O&M COST, INTAKE/RESERVOIR COST * 5%, PUMP COST * 4%, STORAGE COST * 4%, PIPELINE COST * 0.5%.
13). MOBILIZATION COST INCLUDES ADDITIONAL MOBILIZATION/PREPARATION AND APPURTENANTS AT 10%, ADDITIONAL CONTINGENCY COST AT 20%.
14). INDIRECT COST INLUDE FACILITATING:1%, TERO:2%, CONTRACT ADMIN.:1%, ENVIRON.:2%, EASEMENTS:1%, GEOCHEM.:0.5%, ACHEOL.:0.5%, DESIGN SURVEY:1%, INVEST.:2%, DESIGN: 8%, AND CONSTRUCTION OBSER.:10%.

Navajo-Gallup Water Supply Project

APPENDIX E
UPPER BASIN DEPLETION SCHEDULES

Navajo-Gallup M&I Demands for Year 2060

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2060 Pop. [2]	2060 SJR Demand [3] (Ac-ft/yr)	2060 G.W. Production [4] (Ac-ft/yr)	2060 SJR Diversion [5] (Ac-ft/yr)	2060 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	67,698	12,134	6,951	7,500	7,500
Central Area, NM	Burnham	U.C.	246	1,367	245	0	245	245
	Lake Valley	U.C.	436	2,422	434	46	388	388
	White Rock	U.C.	201	1,117	200	see Lk Vly	200	200
	White Horse Lake	U.C.	610	3,389	607	31	577	577
	SUBTOTAL		*1,493*	*8,295*	*1,487*	*77*	*1,410*	*1,410*
Crownpoint, NM	Becenti	U.C.	193	1,072	192	see Crwn Pt.	192	192
	Coyote Canyon	U.C.	1,234	6,856	1,229	61	1,167	1,167
	Crownpoint	U.C.	2,658	14,767	2,647	614	2,033	2,033
	Dalton Pass	U.C.	313	1,739	312	0	311	311
	Little Water	U.C.	638	3,545	635	see Crwn Pt.	635	635
	Standing Rock	U.C.	251	1,394	250	77	173	173
	SUBTOTAL		*5,287*	*29,373*	*5,265*	*752*	*4,512*	*4,512*
Gallup Area, NM	Bread Springs	L.C.	1,219	6,772	1,214	77	1,137	1,137
	Chichiltah	L.C.	1,555	8,639	1,548	see Brd spr.	1,548	1,548
	Church Rock	L.C.	1,780	9,889	1,772	123	1,650	1,650
	Iyanbito	L.C.	974	5,411	970	153	816	816
	Mariano Lake	L.C.	726	4,033	723	92	631	631
	Pinedale	L.C.	609	3,383	606	see Mrno Lk	606	606
	Red Rock	L.C.	1,041	5,783	1,037	61	975	975
	SUBTOTAL		*7,904*	*43,912*	*7,871*	*506*	*7,364*	*7,364*
Huerfano, NM	Huerfano	U.C.	511	2,839	509	31	478	478
	Nageezi	U.C.	981	5,450	977	15	962	962
	SUBTOTAL		*1,492*	*8,289*	*1,486*	*46*	*1,440*	*1,440*
Rock Springs, NM	Manuelito	L.C.	631	3,506	628	46	582	582
	Rock Springs	L.C.	1,685	9,361	1,678	77	1,601	1,601
	Tsayatoh	L.C.	1,433	7,961	1,427	46	1,381	1,381
	SUBTOTAL		*3,749*	*20,828*	*3,733*	*169*	*3,564*	*3,564*
Route 666, NM	Mexican Springs	U.C.	711	3,950	708	see Tohatchi	708	708
	Naschitti	U.C.	1,539	8,550	1,532	77	1,456	1,456
	Newcomb	U.C.	651	3,617	648	12	636	636
	Sanostee	U.C.	2,081	11,561	2,072	153	1,919	1,919
	Sheep Springs	U.C.	660	3,667	657	15	642	642
	Tohatchi	U.C.	1,607	8,928	1,600	307	1,293	1,293
	Twin Lakes	U.C.	1,967	10,928	1,959	153	1,805	1,805
	Two Grey Hills	U.C.	883	4,906	879	77	803	803
	SUBTOTAL		*10,099*	*56,107*	*10,056*	*795*	*9,261*	*9,261*
Torreon, NM	Counselor	U.C.	1,365	7,584	1,359	0	1,359	1,359
	Ojo Encino [8]	R.G.	596	3,311	593	15	578	578
	Pueblo Pintado	U.C.	472	2,622	470	0	470	470
	Torreon [8]	R.G.	1,364	7,578	1,358	61	1,297	1,297
	SUBTOTAL		*3,797*	*21,095*	*3,781*	*77*	*3,704*	*3,704*
San Juan River, NM	Beclaibito	U.C.	388	2,156	386	0	386	193
	Cudei	U.C.	495	2,750	493	0	493	246
	Hogback	U.C.	740	4,111	737	0	737	368
	Nenahnezad	U.C.	1,253	6,961	1,248	0	1,248	624
	San Juan	U.C.	540	3,000	538	0	538	269
	Shiprock	U.C.	8,100	45,001	8,066	0	8,066	4,033
	Upper Fruitland	U.C.	2,288	12,711	2,278	0	2,278	1,139
	SUBTOTAL [9]		*13,804*	*76,691*	*13,746*	*4,680*	*9,066*	*4,533*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	700	700	700
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*199,849*	*43,094*	*7,127*	*30,093*	*25,561*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*132,439*	*23,738*	*7,626*	*18,429*	*18,429*
TOTAL NEW MEXICO			*66,779*	*332,288*	*66,832*	*14,753*	*48,522*	*43,989*
Window Rock, AZ	Fort Defiance	L.C.	6,187	34,373	6,161	767	5,394	5,394
	Saint Michaels	L.C.	5,580	31,001	5,556	see Ft. Dfnc.	5,556	5,556
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*65,374*	*11,717*	*767*	*10,950*	*10,950*
PROJECT TOTAL			**78,546**	**397,662**	**78,549**	**15,520**	**59,472**	**54,939**

Notes: Rounding error may cause subtotals to be off by 1

1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is ---- 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2000

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2000 Pop. [2]	2000 SJR Demand [3] (Ac-ft/yr)	2000 G.W. Production [4] (Ac-ft/yr)	2000 SJR Diversion [5] (Ac-ft/yr)	2000 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	22,940	4,112	4,335	0	0
Central Area, NM	Burnham	U.C.	246	314	56	0	56	56
	Lake Valley	U.C.	436	557	100	22	78	78
	White Rock	U.C.	201	257	46	see Lk Vly	46	46
	White Horse Lake	U.C.	610	779	140	5	135	135
	SUBTOTAL		*1,493*	*1,907*	*342*	*27*	*315*	*315*
Crownpoint, NM	Becenti	U.C.	193	247	44	see Crwn Pt.	44	44
	Coyote Canyon	U.C.	1,234	1,577	283	32	250	250
	Crownpoint	U.C.	2,658	3,396	609	263	346	346
	Dalton Pass	U.C.	313	400	72	0	71	71
	Little Water	U.C.	638	815	146	see Crwn Pt.	146	146
	Standing Rock	U.C.	251	321	57	34	23	23
	SUBTOTAL		*5,287*	*6,755*	*1,211*	*330*	*881*	*881*
Gallup Area, NM	Bread Springs	L.C.	1,219	1,557	279	43	236	236
	Chichiltah	L.C.	1,555	1,987	356	unknown	356	356
	Church Rock	L.C.	1,780	2,274	408	58	350	350
	Iyanbito	L.C.	974	1,244	223	unknown	223	223
	Mariano Lake	L.C.	726	928	166	122	44	44
	Pinedale	L.C.	609	778	139	see Mrno Lk	139	139
	Red Rock	L.C.	1,041	1,330	238	35	203	203
	SUBTOTAL		*7,904*	*10,098*	*1,810*	*258*	*1,552*	*1,552*
Huerfano, NM	Huerfano	U.C.	511	653	117	59	58	58
	Nageezi	U.C.	981	1,253	225	31	194	194
	SUBTOTAL		*1,492*	*1,906*	*342*	*90*	*251*	*251*
Rock Springs, NM	Manuelito	L.C.	631	806	144	unknown	144	144
	Rock Springs	L.C.	1,685	2,153	386	40	346	346
	Tsayatoh	L.C.	1,433	1,831	328	18	310	310
	SUBTOTAL		*3,749*	*4,790*	*858*	*58*	*801*	*801*
Route 666, NM	Mexican Springs	U.C.	711	908	163	42	121	121
	Naschitti	U.C.	1,539	1,966	352	82	270	270
	Newcomb	U.C.	651	832	149	13	136	136
	Sanostee	U.C.	2,081	2,659	477	89	388	388
	Sheep Springs	U.C.	660	843	151	12	139	139
	Tohatchi	U.C.	1,607	2,053	368	137	231	231
	Twin Lakes	U.C.	1,967	2,513	450	87	363	363
	Two Grey Hills	U.C.	883	1,128	202	55	147	147
	SUBTOTAL		*10,099*	*12,902*	*2,313*	*518*	*1,794*	*1,794*
Torreon, NM	Counselor	U.C.	1,365	1,744	313	0	313	313
	Ojo Encino [8]	R.G.	596	761	136	21	115	115
	Pueblo Pintado	U.C.	472	603	108	0	108	108
	Torreon [8]	R.G.	1,364	1,743	312	92	221	221
	SUBTOTAL		*3,797*	*4,851*	*869*	*113*	*757*	*757*
San Juan River, NM	Beclabito	U.C.	388	496	89	0	89	44
	Cudei	U.C.	495	632	113	0	113	57
	Hogback	U.C.	740	945	169	0	169	85
	Nenahnezad	U.C.	1,253	1,601	287	0	287	143
	San Juan	U.C.	540	690	124	0	124	62
	Shiprock	U.C.	8,100	10,348	1,855	0	1,855	927
	Upper Fruitland	U.C.	2,288	2,923	524	0	524	262
	SUBTOTAL [9]		*13,804*	*17,636*	*3,161*	*0*	*3,161*	*1,580*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	0	0	0
NEW MEXICO UPPER BASIN & R.G		*U.C.*	*35,972*	*45,957*	*15,511*	*1,078*	*7,159*	*5,578*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*37,828*	*6,780*	*4,651*	*2,352*	*2,352*
TOTAL NEW MEXICO			*66,779*	*83,785*	*22,291*	*5,730*	*9,511*	*7,931*
Window Rock, AZ	Fort Defiance	L.C.	6,187	7,904	1,417	1,043	374	374
	Saint Michaels	L.C.	5,580	7,129	1,278	see Ft. Dfnc.	1,278	1,278
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*15,033*	*2,695*	*1,043*	*1,652*	*1,652*
PROJECT TOTAL			**78,546**	**98,818**	**24,986**	**6,772**	**11,163**	**9,583**

Notes: Rounding error may cause subtotals to be off by 1

1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2010

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2010 Pop. [2]	2010 SJR Demand [3] (Ac-ft/yr)	2010 G.W. Production [4] (Ac-ft/yr)	2010 SJR Diversion [5] (Ac-ft/yr)	2010 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	27,474	4,924	0	7,500	7,500
Central Area, NM	Burnham	U.C.	246	402	72	0	72	72
	Lake Valley	U.C.	436	712	128	28	99	99
	White Rock	U.C.	201	328	59	see Lk Vly	59	59
	White Horse Lake	U.C.	610	996	178	12	167	167
	SUBTOTAL		*1,493*	*2,437*	*437*	*40*	*397*	*397*
Crownpoint, NM	Becenti	U.C.	193	315	56	see Crwn Pt.	56	56
	Coyote Canyon	U.C.	1,234	2,014	361	40	321	321
	Crownpoint	U.C.	2,658	4,338	778	351	427	427
	Dalton Pass	U.C.	313	511	92	0	91	91
	Little Water	U.C.	638	1,041	187	see Crwn Pt.	187	187
	Standing Rock	U.C.	251	410	73	45	29	29
	SUBTOTAL		*5,287*	*8,630*	*1,547*	*435*	*1,111*	*1,111*
Gallup Area, NM	Bread Springs	L.C.	1,219	1,990	357	51	305	305
	Chichiltah	L.C.	1,555	2,538	455	see Brd spr.	455	455
	Church Rock	L.C.	1,780	2,905	521	74	447	447
	Iyanbito	L.C.	974	1,590	285	38	247	247
	Mariano Lake	L.C.	726	1,185	212	115	98	98
	Pinedale	L.C.	609	994	178	see Mrno Lk	178	178
	Red Rock	L.C.	1,041	1,699	305	42	263	263
	SUBTOTAL		*7,904*	*12,901*	*2,312*	*320*	*1,992*	*1,992*
Huerfano, NM	Huerfano	U.C.	511	834	149	52	97	97
	Nageezi	U.C.	981	1,601	287	27	260	260
	SUBTOTAL		*1,492*	*2,435*	*436*	*79*	*357*	*357*
Rock Springs, NM	Manuelito	L.C.	631	1,030	185	12	173	173
	Rock Springs	L.C.	1,685	2,750	493	49	444	444
	Tsayatoh	L.C.	1,433	2,339	419	25	394	394
	SUBTOTAL		*3,749*	*6,119*	*1,097*	*85*	*1,011*	*1,011*
Route 666, NM	Mexican Springs	U.C.	711	1,161	208	see Tohatchi	208	208
	Naschitti	U.C.	1,539	2,512	450	81	370	370
	Newcomb	U.C.	651	1,063	190	13	178	178
	Sanostee	U.C.	2,081	3,397	609	105	504	504
	Sheep Springs	U.C.	660	1,077	193	13	180	180
	Tohatchi	U.C.	1,607	2,623	470	180	290	290
	Twin Lakes	U.C.	1,967	3,211	575	104	472	472
	Two Grey Hills	U.C.	883	1,441	258	61	198	198
	SUBTOTAL		*10,099*	*16,484*	*2,955*	*556*	*2,399*	*2,399*
Torreon, NM	Counselor	U.C.	1,365	2,228	399	0	399	399
	Ojo Encino [8]	R.G.	596	973	174	20	155	155
	Pueblo Pintado	U.C.	472	770	138	0	138	138
	Torreon [8]	R.G.	1,364	2,226	399	84	315	315
	SUBTOTAL		*3,797*	*6,198*	*1,111*	*104*	*1,007*	*1,007*
San Juan River, NM	Beclaibito	U.C.	388	633	114	0	114	57
	Cudei	U.C.	495	808	145	0	145	72
	Hogback	U.C.	740	1,208	216	0	216	108
	Nenahnezad	U.C.	1,253	2,045	367	0	367	183
	San Juan	U.C.	540	881	158	0	158	79
	Shiprock	U.C.	8,100	13,221	2,370	0	2,370	1,185
	Upper Fruitland	U.C.	2,288	3,735	669	0	669	335
	SUBTOTAL [9]		*13,804*	*22,531*	*4,038*	*4,680*	*0*	*0*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	400	400	400
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*58,715*	*17,798*	*6,294*	*5,672*	*5,672*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*46,494*	*8,333*	*406*	*10,503*	*10,503*
TOTAL NEW MEXICO			*66,779*	*105,209*	*26,131*	*6,700*	*16,175*	*16,175*
Window Rock, AZ	Fort Defiance	L.C.	6,187	10,099	1,810	974	836	836
	Saint Michaels	L.C.	5,580	9,108	1,632	see Ft. Dfnc.	1,632	1,632
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*19,206*	*3,442*	*974*	*2,469*	*2,469*
PROJECT TOTAL			**78,546**	**124,416**	**29,574**	**7,673**	**18,644**	**18,644**

Notes: Rounding error may cause subtotals to be off by 1

1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is —— 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2020

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2020 Pop. [2]	2020 SJR Demand [3] (Ac-ft/yr)	2020 G.W. Production [4] (Ac-ft/yr)	2020 SJR Diversion [5] (Ac-ft/yr)	2020 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	32,904	5,898	0	7,500	7,500
Central Area, NM	Burnham	U.C.	246	513	92	0	92	92
	Lake Valley	U.C.	436	909	163	34	129	129
	White Rock	U.C.	201	419	75	see Lk Vly	75	75
	White Horse Lake	U.C.	610	1,272	228	18	210	210
	SUBTOTAL		*1,493*	*3,113*	*558*	*52*	*506*	*506*
Crownpoint, NM	Becenti	U.C.	193	402	72	see Crwn Pt.	72	72
	Coyote Canyon	U.C.	1,234	2,573	461	47	414	414
	Crownpoint	U.C.	2,658	5,543	993	438	555	555
	Dalton Pass	U.C.	313	653	117	0	117	117
	Little Water	U.C.	638	1,330	238	see Crwn Pt.	238	238
	Standing Rock	U.C.	251	523	94	55	38	38
	SUBTOTAL		*5,287*	*11,025*	*1,976*	*541*	*1,435*	*1,435*
Gallup Area, NM	Bread Springs	L.C.	1,219	2,542	456	60	396	396
	Chichiltah	L.C.	1,555	3,243	581	see Brd spr.	581	581
	Church Rock	L.C.	1,780	3,712	665	90	575	575
	Iyanbito	L.C.	974	2,031	364	77	287	287
	Mariano Lake	L.C.	726	1,514	271	107	164	164
	Pinedale	L.C.	609	1,270	228	see Mrno Lk	228	228
	Red Rock	L.C.	1,041	2,171	389	48	341	341
	SUBTOTAL		*7,904*	*16,482*	*2,954*	*382*	*2,572*	*2,572*
Huerfano, NM	Huerfano	U.C.	511	1,066	191	45	146	146
	Nageezi	U.C.	981	2,046	367	23	343	343
	SUBTOTAL		*1,492*	*3,111*	*558*	*68*	*489*	*489*
Rock Springs, NM	Manuelito	L.C.	631	1,316	236	23	213	213
	Rock Springs	L.C.	1,685	3,514	630	58	571	571
	Tsayatoh	L.C.	1,433	2,988	536	32	504	504
	SUBTOTAL		*3,749*	*7,818*	*1,401*	*113*	*1,288*	*1,288*
Route 666, NM	Mexican Springs	U.C.	711	1,483	266	see Tohatchi	266	266
	Naschitti	U.C.	1,539	3,209	575	79	496	496
	Newcomb	U.C.	651	1,358	243	12	231	231
	Sanostee	U.C.	2,081	4,340	778	121	657	657
	Sheep Springs	U.C.	660	1,376	247	14	233	233
	Tohatchi	U.C.	1,607	3,351	601	222	378	378
	Twin Lakes	U.C.	1,967	4,102	735	120	615	615
	Two Grey Hills	U.C.	883	1,841	330	66	264	264
	SUBTOTAL		*10,099*	*21,060*	*3,775*	*635*	*3,139*	*3,139*
Torreon, NM	Counselor	U.C.	1,365	2,846	510	0	510	510
	Ojo Encino [8]	R.G.	596	1,243	223	18	205	205
	Pueblo Pintado	U.C.	472	984	176	0	176	176
	Torreon [8]	R.G.	1,364	2,844	510	77	433	433
	SUBTOTAL		*3,797*	*7,918*	*1,419*	*95*	*1,324*	*1,324*
San Juan River, NM	Beclaibito	U.C.	388	809	145	0	145	73
	Cudei	U.C.	495	1,032	185	0	185	93
	Hogback	U.C.	740	1,543	277	0	277	138
	Nenahnezad	U.C.	1,253	2,613	468	0	468	234
	San Juan	U.C.	540	1,126	202	0	202	101
	Shiprock	U.C.	8,100	16,891	3,027	0	3,027	1,514
	Upper Fruitland	U.C.	2,288	4,771	855	0	855	428
	SUBTOTAL [9]		*13,804*	*28,786*	*5,159*	*4,680*	*479*	*240*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	500	500	500
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*75,013*	*20,719*	*6,571*	*7,874*	*7,634*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*57,205*	*10,253*	*496*	*11,360*	*11,360*
TOTAL NEW MEXICO			*66,779*	*132,218*	*30,972*	*7,067*	*19,234*	*18,994*
Window Rock, AZ	Fort Defiance	L.C.	6,187	12,902	2,312	905	1,408	1,408
	Saint Michaels	L.C.	5,580	11,636	2,086	see Ft. Dfnc.	2,086	2,086
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*24,538*	*4,398*	*905*	*3,493*	*3,493*
PROJECT TOTAL			**78,546**	**156,756**	**35,370**	**7,972**	**22,727**	**22,487**

Notes: Rounding error may cause subtotals to be off by 1
1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is ---- 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2030

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2030 Pop. [2]	2030 SJR Demand [3] (Ac-ft/yr)	2030 G.W. Production [4] (Ac-ft/yr)	2030 SJR Diversion [5] (Ac-ft/yr)	2030 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	39,408	7,063	0	7,500	7,500
Central Area, NM	Burnham	U.C.	246	655	117	0	117	117
	Lake Valley	U.C.	436	1,162	208	40	168	168
	White Rock	U.C.	201	536	96	see Lk Vly	96	96
	White Horse Lake	U.C.	610	1,625	291	24	267	267
	SUBTOTAL		*1,493*	*3,978*	*713*	*64*	*649*	*649*
Crownpoint, NM	Becenti	U.C.	193	514	92	see Crwn Pt.	92	92
	Coyote Canyon	U.C.	1,234	3,288	589	54	535	535
	Crownpoint	U.C.	2,658	7,081	1,269	526	743	743
	Dalton Pass	U.C.	313	834	149	0	149	149
	Little Water	U.C.	638	1,700	305	see Crwn Pt.	305	305
	Standing Rock	U.C.	251	669	120	66	54	54
	SUBTOTAL		*5,287*	*14,086*	*2,525*	*647*	*1,878*	*1,878*
Gallup Area, NM	Bread Springs	L.C.	1,219	3,248	582	68	514	514
	Chichiltah	L.C.	1,555	4,143	743	see Brd spr.	743	743
	Church Rock	L.C.	1,780	4,742	850	107	743	743
	Iyanbito	L.C.	974	2,595	465	115	350	350
	Mariano Lake	L.C.	726	1,934	347	100	247	247
	Pinedale	L.C.	609	1,622	291	see Mrno Lk	291	291
	Red Rock	L.C.	1,041	2,773	497	55	442	442
	SUBTOTAL		*7,904*	*21,058*	*3,774*	*444*	*3,330*	*3,330*
Huerfano, NM	Huerfano	U.C.	511	1,361	244	38	206	206
	Nageezi	U.C.	981	2,614	468	19	449	449
	SUBTOTAL		*1,492*	*3,975*	*712*	*57*	*655*	*655*
Rock Springs, NM	Manuelito	L.C.	631	1,681	301	35	267	267
	Rock Springs	L.C.	1,685	4,489	805	68	737	737
	Tsayatoh	L.C.	1,433	3,818	684	39	645	645
	SUBTOTAL		*3,749*	*9,988*	*1,790*	*141*	*1,649*	*1,649*
Route 666, NM	Mexican Springs	U.C.	711	1,894	340	see Tohatchi	340	340
	Naschitti	U.C.	1,539	4,100	735	78	657	657
	Newcomb	U.C.	651	1,734	311	12	299	299
	Sanostee	U.C.	2,081	5,544	994	137	856	856
	Sheep Springs	U.C.	660	1,758	315	15	301	301
	Tohatchi	U.C.	1,607	4,281	767	265	503	503
	Twin Lakes	U.C.	1,967	5,240	939	137	802	802
	Two Grey Hills	U.C.	883	2,352	422	71	350	350
	SUBTOTAL		*10,099*	*26,906*	*4,822*	*715*	*4,107*	*4,107*
Torreon, NM	Counselor	U.C.	1,365	3,637	652	0	652	652
	Ojo Encino [8]	R.G.	596	1,588	285	17	268	268
	Pueblo Pintado	U.C.	472	1,257	225	0	225	225
	Torreon [8]	R.G.	1,364	3,634	651	69	582	582
	SUBTOTAL		*3,797*	*10,116*	*1,813*	*86*	*1,727*	*1,727*
San Juan River, NM	Beclaibito	U.C.	388	1,034	185	0	185	93
	Cudei	U.C.	495	1,319	236	0	236	118
	Hogback	U.C.	740	1,971	353	0	353	177
	Nenahnezad	U.C.	1,253	3,338	598	0	598	299
	San Juan	U.C.	540	1,439	258	0	258	129
	Shiprock	U.C.	8,100	21,580	3,868	0	3,868	1,934
	Upper Fruitland	U.C.	2,288	6,096	1,093	0	1,093	546
	SUBTOTAL [9]		*13,804*	*36,776*	*6,592*	*4,680*	*1,912*	*956*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	600	600	600
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*95,836*	*24,451*	*6,849*	*11,528*	*10,572*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*70,454*	*12,628*	*585*	*12,479*	*12,479*
TOTAL NEW MEXICO			*66,779*	*166,290*	*37,079*	*7,434*	*24,007*	*23,052*
Window Rock, AZ	Fort Defiance	L.C.	6,187	16,483	2,954	836	2,118	2,118
	Saint Michaels	L.C.	5,580	14,866	2,665	see Ft. Dfnc.	2,665	2,665
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*31,349*	*5,619*	*836*	*4,783*	*4,783*
PROJECT TOTAL			**78,546**	**197,639**	**42,698**	**8,270**	**28,790**	**27,834**

Notes: Rounding error may cause subtotals to be off by 1

1. U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2. Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is ---- 2.48%
3. Demand is 160 gal/capita/day
4. Estimated sustainable groundwater production
5. Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6. Depletions assume zero return flow and use of sustainable groundwater
7. City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8. Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9. 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10. Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11. Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2040

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2040 Pop. [2]	2040 SJR Demand [3] (Ac-ft/yr)	2040 G.W. Production [4] (Ac-ft/yr)	2040 SJR Diversion [5] (Ac-ft/yr)	2040 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	47,197	8,459	1,439	7,500	7,500
Central Area, NM	Burnham	U.C.	246	837	150	0	150	150
	Lake Valley	U.C.	436	1,484	266	46	220	220
	White Rock	U.C.	201	684	123	see Lk Vly	123	123
	White Horse Lake	U.C.	610	2,076	372	31	341	341
	SUBTOTAL		*1,493*	*5,082*	*911*	*77*	*834*	*834*
Crownpoint, NM	Becenti	U.C.	193	657	118	see Crwn Pt.	118	118
	Coyote Canyon	U.C.	1,234	4,200	753	61	691	691
	Crownpoint	U.C.	2,658	9,047	1,622	614	1,008	1,008
	Dalton Pass	U.C.	313	1,065	191	0	191	191
	Little Water	U.C.	638	2,172	389	see Crwn Pt.	389	389
	Standing Rock	U.C.	251	854	153	77	76	76
	SUBTOTAL		*5,287*	*17,996*	*3,225*	*752*	*2,473*	*2,473*
Gallup Area, NM	Bread Springs	L.C.	1,219	4,149	744	77	667	667
	Chichiltah	L.C.	1,555	5,293	949	see Brd spr.	949	949
	Church Rock	L.C.	1,780	6,059	1,086	123	963	963
	Iyanbito	L.C.	974	3,315	594	153	441	441
	Mariano Lake	L.C.	726	2,471	443	92	351	351
	Pinedale	L.C.	609	2,073	372	see Mrno Lk	372	372
	Red Rock	L.C.	1,041	3,543	635	61	574	574
	SUBTOTAL		*7,904*	*26,903*	*4,822*	*506*	*4,316*	*4,316*
Huerfano, NM	Huerfano	U.C.	511	1,739	312	31	281	281
	Nageezi	U.C.	981	3,339	598	15	583	583
	SUBTOTAL		*1,492*	*5,078*	*910*	*46*	*864*	*864*
Rock Springs, NM	Manuelito	L.C.	631	2,148	385	46	339	339
	Rock Springs	L.C.	1,685	5,735	1,028	77	951	951
	Tsayatoh	L.C.	1,433	4,878	874	46	828	828
	SUBTOTAL		*3,749*	*12,761*	*2,287*	*169*	*2,118*	*2,118*
Route 666, NM	Mexican Springs	U.C.	711	2,420	434	see Tohatchi	434	434
	Naschitti	U.C.	1,539	5,238	939	77	862	862
	Newcomb	U.C.	651	2,216	397	12	385	385
	Sanostee	U.C.	2,081	7,083	1,270	153	1,116	1,116
	Sheep Springs	U.C.	660	2,246	403	15	387	387
	Tohatchi	U.C.	1,607	5,470	980	307	673	673
	Twin Lakes	U.C.	1,967	6,695	1,200	153	1,047	1,047
	Two Grey Hills	U.C.	883	3,005	539	77	462	462
	SUBTOTAL		*10,099*	*34,374*	*6,161*	*795*	*5,366*	*5,366*
Torreon, NM	Counselor	U.C.	1,365	4,646	833	0	833	833
	Ojo Encino [8]	R.G.	596	2,029	364	15	348	348
	Pueblo Pintado	U.C.	472	1,607	288	0	288	288
	Torreon [8]	R.G.	1,364	4,643	832	61	771	771
	SUBTOTAL		*3,797*	*12,924*	*2,316*	*77*	*2,240*	*2,240*
San Juan River, NM	Beclaibito	U.C.	388	1,321	237	0	237	118
	Cudei	U.C.	495	1,685	302	0	302	151
	Hogback	U.C.	740	2,519	451	0	451	226
	Nenahnezad	U.C.	1,253	4,265	764	0	764	382
	San Juan	U.C.	540	1,838	329	0	329	165
	Shiprock	U.C.	8,100	27,570	4,942	0	4,942	2,471
	Upper Fruitland	U.C.	2,288	7,788	1,396	0	1,396	698
	SUBTOTAL [9]		*13,804*	*46,985*	*8,421*	*4,680*	*3,741*	*1,871*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	700	700	700
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*122,439*	*29,219*	*7,127*	*16,219*	*14,348*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*86,861*	*15,568*	*2,114*	*13,934*	*13,934*
TOTAL NEW MEXICO			*66,779*	*209,300*	*44,788*	*9,241*	*30,153*	*28,282*
Window Rock, AZ	Fort Defiance	L.C.	6,187	21,059	3,774	767	3,007	3,007
	Saint Michaels	L.C.	5,580	18,993	3,404	see Ft. Dfnc.	3,404	3,404
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*40,052*	*7,179*	*767*	*6,411*	*6,411*
PROJECT TOTAL			78,546	249,352	51,967	10,008	36,564	34,693

Notes: Rounding error may cause subtotals to be off by 1

1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is ----- 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

Navajo-Gallup M&I Demands for Year 2050

17-Jan-01

Service Area	Chapter	Point of Use [1]	1990 Census Pop.	2050 Pop. [2]	2050 SJR Demand [3] (Ac-ft/yr)	2050 G.W. Production [4] (Ac-ft/yr)	2050 SJR Diversion [5] (Ac-ft/yr)	2050 SJR Depletion [6] (Ac-ft/yr)
City of Gallup, NM	City of Gallup [7]	L.C.	19,154	56,526	10,131	3,947	7,500	7,500
Central Area, NM	Burnham	U.C.	246	1,070	192	0	192	192
	Lake Valley	U.C.	436	1,896	340	46	294	294
	White Rock	U.C.	201	874	157	see Lk Vly	157	157
	White Horse Lake	U.C.	610	2,653	475	31	445	445
	SUBTOTAL		*1,493*	*6,492*	*1,164*	*77*	*1,087*	*1,087*
Crownpoint, NM	Becenti	U.C.	193	839	150	see Crwn Pt.	150	150
	Coyote Canyon	U.C.	1,234	5,366	962	61	900	900
	Crownpoint	U.C.	2,658	11,559	2,072	614	1,458	1,458
	Dalton Pass	U.C.	313	1,361	244	0	244	244
	Little Water	U.C.	638	2,774	497	see Crwn Pt.	497	497
	Standing Rock	U.C.	251	1,091	196	77	119	119
	SUBTOTAL		*5,287*	*22,991*	*4,121*	*752*	*3,369*	*3,369*
Gallup Area, NM	Bread Springs	L.C.	1,219	5,301	950	77	873	873
	Chichiltah	L.C.	1,555	6,762	1,212	see Brd spr.	1,212	1,212
	Church Rock	L.C.	1,780	7,740	1,387	123	1,265	1,265
	Iyanbito	L.C.	974	4,236	759	153	606	606
	Mariano Lake	L.C.	726	3,157	566	92	474	474
	Pinedale	L.C.	609	2,648	475	see Mrno Lk	475	475
	Red Rock	L.C.	1,041	4,527	811	61	750	750
	SUBTOTAL		*7,904*	*34,371*	*6,161*	*506*	*5,654*	*5,654*
Huerfano, NM	Huerfano	U.C.	511	2,222	398	31	368	368
	Nageezi	U.C.	981	4,266	765	15	749	749
	SUBTOTAL		*1,492*	*6,488*	*1,163*	*46*	*1,117*	*1,117*
Rock Springs, NM	Manuelito	L.C.	631	2,744	492	46	446	446
	Rock Springs	L.C.	1,685	7,327	1,313	77	1,237	1,237
	Tsayatoh	L.C.	1,433	6,232	1,117	46	1,071	1,071
	SUBTOTAL		*3,749*	*16,303*	*2,922*	*169*	*2,753*	*2,753*
Route 666, NM	Mexican Springs	U.C.	711	3,092	554	see Tohatchi	554	554
	Naschitti	U.C.	1,539	6,692	1,200	77	1,123	1,123
	Newcomb	U.C.	651	2,831	507	12	495	495
	Sanostee	U.C.	2,081	9,049	1,622	153	1,469	1,469
	Sheep Springs	U.C.	660	2,870	514	15	499	499
	Tohatchi	U.C.	1,607	6,988	1,253	307	946	946
	Twin Lakes	U.C.	1,967	8,554	1,533	153	1,380	1,380
	Two Grey Hills	U.C.	883	3,840	688	77	611	611
	SUBTOTAL		*10,099*	*43,916*	*7,871*	*795*	*7,076*	*7,076*
Torreon, NM	Counselor	U.C.	1,365	5,936	1,064	0	1,064	1,064
	Ojo Encino [8]	R.G.	596	2,592	465	15	449	449
	Pueblo Pintado	U.C.	472	2,053	368	0	368	368
	Torreon [8]	R.G.	1,364	5,931	1,063	61	1,002	1,002
	SUBTOTAL		*3,797*	*16,512*	*2,959*	*77*	*2,883*	*2,883*
San Juan River, NM	Beclaibito	U.C.	388	1,687	302	0	302	151
	Cudei	U.C.	495	2,153	386	0	386	193
	Hogback	U.C.	740	3,218	577	0	577	288
	Nenahnezad	U.C.	1,253	5,449	977	0	977	488
	San Juan	U.C.	540	2,348	421	0	421	210
	Shiprock	U.C.	8,100	35,223	6,313	0	6,313	3,157
	Upper Fruitland	U.C.	2,288	9,950	1,783	0	1,783	892
	SUBTOTAL [9]		*13,804*	*60,028*	*10,759*	*4,680*	*6,079*	*3,040*
NAPI Industrial, NM [10]		U.C.	n/a	n/a	7,274	700	700	700
NEW MEXICO UPPER BASIN		*U.C.*	*35,972*	*156,427*	*35,311*	*7,127*	*22,311*	*19,271*
NEW MEXICO LOWER BASIN		*L.C.*	*30,807*	*107,200*	*19,214*	*4,622*	*15,907*	*15,907*
TOTAL NEW MEXICO			*66,779*	*263,626*	*54,525*	*11,749*	*38,218*	*35,178*
Window Rock, AZ	Fort Defiance	L.C.	6,187	26,905	4,822	767	4,055	4,055
	Saint Michaels	L.C.	5,580	24,265	4,349	see Ft. Dfnc.	4,349	4,349
TOTAL ARIZONA [11]		*L.C.*	*11,767*	*51,170*	*9,171*	*767*	*8,404*	*8,404*
PROJECT TOTAL			**78,546**	**314,796**	**63,697**	**12,516**	**46,622**	**43,583**

Notes: Rounding error may cause subtotals to be off by 1

1 U.C.=Upper Colorado Basin, L.C.=Lower Colorado Basin, R.G.=Rio Grande Basin
2 Growth for the City of Gallup is 1.82%. Growth for Navajo Nation is ----- 2.48%
3 Demand is 160 gal/capita/day
4 Estimated sustainable groundwater production
5 Diversions = demand - groundwater use. Gallup limited to 7,500 ac-ft/yr
6 Depletions assume zero return flow and use of sustainable groundwater
7 City of Gallup plans to recharge aquifer and use groundwater for summer daily peaking
8 Point of use in Rio Grande Basin. Depletions counted towards New Mexico U.C. allocation
9 4680 Ac-ft/yr of diversion provided from the ALP Project. Assumes a 50% return flow
10 Div. and depl. limited to 700 Ac-ft/yr including 400 Ac-ft/yr for proposed french fry factory
11 Depletions counted towards Arizona L.C. allocation

APPENDIX B

Appraisal Level Designs and Cost Estimates (April 2002)

NAVAJO GALLUP WATER SUPPLY PROJECT

APPRAISAL LEVEL DESIGNS AND COST ESTIMATES

Prepared for the Bureau of Reclamation - Western Colorado Area Office

By the Bureau of Reclamation, Technical Service Center, Denver, Colorado

April 2002

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I. EXECUTIVE SUMMARY

The Navajo Gallup Water Supply Project would deliver treated municipal water to selected Navajo communities, the Jicarilla Apache Nation, and the City of Gallup, New Mexico. The project would serve approximately 124,000 people in 43 Navajo Chapters in the Navajo Nation, 500 people in the Jicarilla Apache Nation, and approximately 33,000 people in Gallup based on the future demands for the year 2020. Based on the expected populations in the year 2040, the project would serve approximately 203,000 people in 43 Chapters in the Navajo Nation, 1,300 people in the Jicarilla Apache Nation, and approximately 47,000 people in Gallup. The purpose of this document is to provide appraisal-level designs and cost estimates for six project alternatives at each of these demand levels.

This proposed Navajo Gallup Water Supply Project (NGWSP) would serve the New Mexico portion of the Navajo Nation south of the San Juan River, the Navajo Nation in the Window Rock area within Arizona, the Jicarilla Apache Nation, and the City of Gallup, New Mexico. A municipal water supply is needed in these areas to improve the standard of living for current and future populations and to support economic growth. The NGWSP has evolved as a major infrastructure initiative to meet these needs. To achieve this initiative, the following organizations are working closely in a cooperative effort: the Navajo Nation Department of Water Resources, the Jicarilla Apache Nation, the Northwest New Mexico Council of Governments, the New Mexico Office of The State Engineer, the City of Gallup, the Bureau of Indian Affairs, and the Bureau of Reclamation.

This appraisal-level study includes six alternatives with differing configurations. The Navajo Indian Irrigation Project (NIIP) Moncisco Alternative utilizes two connected laterals to deliver the required water (See NIIP Moncisco Alternative Map - Figure 1). The NIIP Cutter Alternative is similar to the NIIP Moncisco Alternative except that it would not require the construction of Moncisco Dam and Reservoir (See NIIP Cutter Lateral Alternative Map - Figure 2). The NIIP Coury Lateral Alternative is similar to the other two NIIP alternatives, but would utilize existing NIIP facilities to convey NGWSP water throughout the year (See NIIP Coury Lateral Alternative Map - Figure 3). The NIIP Amarillo Alternative also utilizes existing NIIP facilities to convey NGWSP water throughout the year, and is made up of two separate lateral systems. One lateral diverts water from the end of the NIIP facilities, and the Cutter Lateral diverts water from Cutter Reservoir (See NIIP Amarillo Alternative Map - Figure 4). The San Juan River, Public Service Company of New Mexico (SJR PNM) Alternative is also made up of two separate lateral systems, the San Juan Lateral and the Cutter Lateral (See SJR PNM Alternative Map - Figure 5), which deliver the same amounts of water to the same locations, but utilize different lateral alignments. Water for this alternative comes from both the NIIP facilities and from the San Juan River. The SJR Infiltration Alternative is similar to the SJR PNM Alternative except that water from the San Juan River would come from an infiltration gallery near the Hogback Irrigation Diversion rather than from a turnout on the river near the PNM facilities (See San Juan River Infiltration Alternative Map - Figure 6). Detailed descriptions for each of these six alternatives are provided later in this document.

Summaries of the total costs for the appraisal-level designs for the six alternatives, each including the City of Gallup, for the years 2020 and 2040 are shown in Tables 1 and 2. Tables 1a and 2a include annual operation, maintenance, and replacement (OM&R) costs, shown both as annual expenses and converted to present worth values. The present worth conversions assumed a 50 year project life and an interest rate of 6.375%.

TABLE 1: Project Construction Costs With Taxes Based on Year 2020 Demand

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Field Costs	$310,000,000	$300,000,000	$300,000,000	$270,000,000	$230,000,000	$250,000,000
Non-Contract Costs	$93,000,000	$90,000,000	$90,000,000	$81,000,000	$69,000,000	$75,000,000
Totals	$403,000,000	$390,000,000	$390,000,000	$351,000,000	$299,000,000	$325,000,000
Gallup Regional Field Cost	$16,500,000	$16,500,000	$16,500,000	$16,500,000	$16,500,000	$16,500,000
Non-Contract Costs	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Totals	$22,000,000	$22,000,000	$22,000,000	$22,000,000	$22,000,000	$22,000,000
Taxes on Field Costs (estimated at 6.0%)	$19,590,000	$18,990,000	$18,990,000	$17,190,000	$14,790,000	$15,990,000
Navajo Nation Tax - Includes Gallup (est. 3%)	$9,795,000	$9,495,000	$9,495,000	$8,595,000	$7,395,000	$7,995,000
Total Project Construction Costs Including Taxes*	$454,385,000	$440,485,000	$440,485,000	$398,785,000	$343,185,000	$370,985,000
Rounded Values	$450,000,000	$440,000,000	$440,000,000	$400,000,000	$340,000,000	$370,000,000

* Costs for Rights-of-way, Land, Environmental Mitigation, and Cultural Resources are not included.

TABLE 1a: Project Total Present Worth Costs Based on Year 2020 Demand (Values Rounded)

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Total Construction Cost With Taxes (From Table 1)	$450,000,000	$440,000,000	$440,000,000	$400,000,000	$340,000,000	$370,000,000
Treatment Plants annual OM&R (NTUA Rates)	$2,100,000	$2,100,000	$2,100,000	$2,900,000	$3,200,000	$2,600,000
Treatment Plants annual OM&R (CRSP Rates)	$1,900,000	$1,950,000	$1,900,000	$2,700,000	$2,900,000	$2,400,000
Pumping Plants and canal annual OM&R (NTUA Rates)	$3,900,000	$3,100,000	$3,900,000	$4,300,000	$5,800,000	$5,800,000
Pumping Plants and canal annual OM&R (CRSP Rates)	$2,400,000	$2,000,000	$2,200,000	$2,700,000	$3,400,000	$3,400,000
Pipelines annual OM&R	$500,000	$550,000	$610,000	$480,000	$380,000	$350,000
Gallup Regional System annual OM&R (NTUA Rates)	$380,000	$380,000	$380,000	$380,000	$380,000	$380,000
Gallup Regional System annual OM&R (CRSP Rates)	$330,000	$330,000	$330,000	$330,000	$330,000	$330,000
Total annual OM&R Costs (NTUA Rates)	$6,900,000	$6,100,000	$7,000,000	$8,100,000	$9,800,000	$9,100,000
Present Worth (NTUA)	$103,000,000	$91,000,000	$105,000,000	$121,000,000	$147,000,000	$136,000,000
Total annual OM&R Costs (CRSP Rates)	$5,100,000	$4,800,000	$5,000,000	$6,200,000	$7,000,000	$6,500,000
Present Worth (CRSP)	$76,000,000	$72,000,000	$75,000,000	$93,000,000	$105,000,000	$97,000,000
Project Total Present Worth (NTUA Rates)	$550,000,000	$530,000,000	$550,000,000	$520,000,000	$490,000,000	$510,000,000
Project Total Present Worth (CRSP Rates)	$530,000,000	$510,000,000	$520,000,000	$490,000,000	$450,000,000	$470,000,000

TABLE 2: Project Construction Costs With Taxes Based on Year 2040 Demand

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Field Costs	$390,000,000	$380,000,000	$430,000,000	$320,000,000	$300,000,000	$320,000,000
Non-Contract Costs	$117,000,000	$114,000,000	$129,000,000	$96,000,000	$90,000,000	$96,000,000
Totals	$507,000,000	$494,000,000	$559,000,000	$416,000,000	$390,000,000	$416,000,000
Gallup Regional Field Cost	$16,500,000	$16,500,000	$16,500,000	$16,500,000	$16,500,000	$16,500,000
Non-Contract Costs	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Totals	$22,000,000	$22,000,000	$22,000,000	$22,000,000	$22,000,000	$22,000,000
Taxes on Field Costs (estimated at 6.0%)	$24,390,000	$23,790,000	$26,790,000	$20,190,000	$18,990,000	$20,190,000
Navajo Nation Tax - Includes Gallup (est. 3%)	$12,195,000	$11,895,000	$13,395,000	$10,095,000	$9,495,000	$10,095,000
Total Project Construction Costs Including Taxes*	$565,585,000	$551,685,000	$621,185,000	$468,285,000	$440,485,000	$468,285,000
Rounded Values	$570,000,000	$550,000,000	$620,000,000	$470,000,000	$440,000,000	$470,000,000

* Costs for Rights-of-way, Land, Environmental Mitigation, and Cultural Resources are not included.

TABLE 2a: Project Total Present Worth Costs Based on Year 2040 Demand (Values Rounded)

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Total Construction Cost With Taxes (From Table 2)	$570,000,000	$550,000,000	$620,000,000	$470,000,000	$440,000,000	$470,000,000
Treatment Plants annual OM&R (NTUA Rates)	$2,900,000	$2,900,000	$2,900,000	$3,700,000	$4,000,000	$3,200,000
Treatment Plants annual OM&R (CRSP Rates)	$2,600,000	$2,600,000	$2,600,000	$3,400,000	$3,600,000	$2,900,000
Pumping Plants and canal annual OM&R (NTUA Rates)	$5,000,000	$3,900,000	$5,200,000	$5,500,000	$7,700,000	$7,400,000
Pumping Plants and canal annual OM&R (CRSP Rates)	$2,800,000	$2,300,000	$2,600,000	$3,200,000	$4,100,000	$4,000,000
Pipelines annual OM&R	$640,000	$780,000	$1,000,000	$520,000	$450,000	$410,000
Gallup Regional System annual OM&R (NTUA Rates)	$380,000	$380,000	$380,000	$380,000	$380,000	$380,000
Gallup Regional System annual OM&R (CRSP Rates)	$330,000	$330,000	$330,000	$330,000	$330,000	$330,000
Total annual OM&R Costs (NTUA Rates)	$8,900,000	$8,000,000	$9,500,000	$10,100,000	$12,500,000	$11,400,000
Present Worth (NTUA)	$133,300,000	$119,800,000	$142,200,000	$151,200,000	$187,200,000	$170,700,000
Total annual OM&R Costs (CRSP Rates)	$6,400,000	$6,000,000	$6,500,000	$7,500,000	$8,500,000	$7,600,000
Present Worth (CRSP)	$96,000,000	$90,000,000	$97,000,000	$112,000,000	$127,000,000	$114,000,000
Project Total Present Worth (NTUA Rates)	$700,000,000	$670,000,000	$760,000,000	$620,000,000	$630,000,000	$640,000,000
Project Total Present Worth (CRSP Rates)	$670,000,000	$640,000,000	$720,000,000	$580,000,000	$570,000,000	$580,000,000

II. PURPOSE AND OBJECTIVE

The purpose of this document is to provide the Navajo Nation, Jicarilla Apache Nation, and the City of Gallup, New Mexico, with appraisal-level designs and cost estimates for six alternatives with differing configurations. This document also provides the estimated operation, maintenance, and replacement costs for the project using two different power rates. The differences between the alternatives are also described. Costs for Rights-of-way, Land, Environmental Mitigation, and Cultural Resources are not included.

III. BACKGROUND AND SCOPE

Over the past 28 years several proposals have been studied to deliver water from the San Juan River and other sources of water to communities in the Navajo Nation and to the City of Gallup. Reclamation's first investigation for the "Gallup Project, New Mexico[1] " culminated in a reconnaissance report dated October 1973. A second study[2] was completed in January 1984 and included expanded service to Navajo communities as well as to the City of Gallup. An appraisal-level estimate[3] for a system having a main transmission line along Highway 371 was completed in September 1986. In November 1993, an appraisal-level study[4] was conducted to deliver water from Gallegos Reservoir, a planned feature of the Navajo Indian Irrigation Project (NIIP).

This proposal for the Navajo Gallup Water Supply Project (NGWSP) serves the New Mexico portion of the Navajo Nation south of the San Juan River, the Navajo Nation in the Window Rock area within Arizona, the Jicarilla Apache Nation, and the City of Gallup, New Mexico. A municipal water supply is needed in these areas to improve the standard of living for current and future populations and to support economic growth. The NGWSP has evolved as a major infrastructure initiative to supply approximately 23,900 acre-feet (2020) or approximately 37,800 acre-feet (2040) of municipal water annually to meet these needs. To achieve this initiative, the following organizations are working closely in a cooperative effort: the Navajo Nation Department of Water Resources, the Jicarilla Apache Nation, the Northwest New Mexico Council of Governments, the New Mexico Office of the State Engineer, the City of Gallup, and the Bureau of Indian Affairs,

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[1] Gallup Project Reconnaissance Report, U.S. Department of the Interior, Bureau of Reclamation, 1973.

[2] Gallup-Nation Indian Water Supply Project, Planning Report/Draft Environmental Statement, U.S. Department of the Interior, Bureau of Reclamation, Southwest Region, January 1984.

[3] Gallup-Navajo Indian Water Supply Project, New Mexico Arizona, Technical Report, U.S. Department of the Interior, Bureau of Reclamation, Southwest Region, September 1986.

[4] San Juan River Gallup/Navajo Water Supply Project, Engineering and Cost Estimates, Technical Appraisal Report, Bureau of Reclamation, November 1993.

and the Bureau of Reclamation. A detailed history and explanation of the project can be found in the final draft of "Technical Memorandum, The Navajo-Gallup Water Supply Project", March 16, 2001, prepared by the Navajo Nation Department of Water Resources.

Appraisal level analyses were conducted for six alternatives with differing configurations, each having two different flow capacities in cubic feet per second (cfs), or MGD as follows:

1. NIIP Moncisco Alternative at 67.52 cfs (43.6 MGD) for year 2040

1a. NIIP Moncisco Alternative at 42.75 cfs (27.6 MGD) for year 2020

2. NIIP Coury Lateral Alternative at 67.52 cfs (43.6 MGD) for year 2040

2a. NIIP Coury Lateral Alternative at 42.75 cfs (27.6 MGD) for year 2020

3. NIIP Cutter Alternative at 67.52 cfs (43.6 MGD) for year 2040

3a. NIIP Cutter Alternative at 42.75 cfs (27.6 MGD) for year 2020

4. NIIP Amarillo Alternative at 67.52 cfs (43.6 MGD) for year 2040
   a. Amarillo Canal Diversion at 59.18 cfs (38.2 MGD) for year 2040
   b. Cutter Lateral at 8.34 cfs (5.38 MGD) for year 2040

4a. NIIP Amarillo Alternative at 42.75 cfs (27.6 MGD) for year 2020
   a. Amarillo Canal Diversion at 36.97 cfs (23.9 MGD) for year 2020
   b. Cutter Lateral at 5.78 cfs (3.7 MGD) for year 2020

5. SJR PNM Alternative (Total Q = 67.52 cfs (43.6 MGD))
   a. PNM Diversion at 59.18 cfs (38.2 MGD) for year 2040
   b. Cutter Lateral at 8.34 cfs (5.38 MGD) for year 2040

5a. SJR PNM Alternative (Total Q = 42.75 cfs (27.6 MGD))
   a. PNM Diversion at 36.97 cfs (23.9 MGD) for year 2020
   b. Cutter Lateral at 5.78 cfs (3.7 MGD) for year 2020

6. SJR Infiltration Alternative (Total Q = 67.52 cfs (43.6 MGD))
   a. Infiltration Gallery System at 59.18 cfs (38.2 MGD) for year 2040
   b. Cutter Lateral at 8.34 cfs (5.38 MGD) for year 2040

6a. SJR Infiltration Alternative (Total Q = 42.75 cfs (27.6 MGD))
   a. Infiltration Gallery System at 36.97 cfs (23.9 MGD) for year 2020
   b. Cutter Lateral at 5.78 cfs (3.7 MGD) for year 2020

IV. DESCRIPTION OF ALTERNATIVES

A. Navajo Indian Irrigation Project (NIIP) Moncisco Alternative

The NIIP Moncisco Alternative would utilize two laterals to deliver water to different portions of the Navajo Nation but both would begin at one location, the proposed Moncisco Reservoir (See NIIP Moncisco Alternative Map - Figure 1). This alternative would use existing NIIP canals and features to convey water to the proposed Moncisco Reservoir during the irrigation season (see Appendix G). From the proposed water treatment plant near Moncisco Reservoir, the East Lateral would convey water south to communities in the eastern portion of the Navajo Nation and the Jicarilla Apache Nation. The West Lateral would convey water south to communities in the western portion of the Navajo Nation, and to the City of Gallup. Several sublaterals would convey water to the communities of Window Rock, Arizona and the Nahodishgish Chapter/Dalton Pass, New Mexico.

Water for the NIIP Moncisco Alternative would be conveyed from the existing Burnham Lateral to the proposed Moncisco Reservoir via a proposed stabilized channel. The NIIP system would convey water from Navajo Reservoir and through a series of canals, siphons, and tunnels to Gallegos Pumping Plant which conveys water to Burnham Lateral. An existing wasteway in Burnham Lateral would be used with the proposed stabilized channel to convey water to Moncisco Reservoir. Moncisco Dam and Reservoir would be constructed specifically for the NGWSP and would have an approximate capacity of 12,000 acre feet of active storage. This storage would be provided because the NIIP system would not operate during the winter months. Previous designs, estimates and quantities from two Bureau of Reclamation reports[5] were evaluated and refined, and the costs for these designs were indexed for this study.

A water treatment plant would be located immediately downstream of Moncisco Dam and Reservoir to treat the water before it is conveyed to the Navajo communities, the Jicarilla Apache Nation, and the City of Gallup. The treatment plant would utilize an enhanced coagulation and hollow fiber ultrafiltration treatment system. Treated water would be pumped into the West and East Laterals. The NIIP Moncisco Alternative would have the a capacity of 42.75 cfs (27.6 Million Gallons per Day (MGD)) for the expected flow requirements in year 2020 or 67.52 cfs (43.6 MGD) in year 2040.

B. NIIP Cutter Alternative

The NIIP Cutter Alternative would also be similar to the NIIP Moncisco Alternative, but would not require the construction of Moncisco Dam and Reservoir (See NIIP Cutter Alternative Map - Figure 2). Water would be released from Navajo Reservoir and conveyed through the existing

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[5] "Technical Memorandum No. GG-8311-2, Gallegos Dam, Reconnaissance Design Summary" and "Water Supply and Storage Options, Gallup Navajo Pipeline Project, Engineering and Cost Estimates Appraisal Level Report".

NIIP system to Cutter Reservoir throughout the year, requiring winterization of a portion of the existing NIIP facilities (see Appendix G). The treatment plant would be constructed at the base of Cutter Dam. Water would be pumped from the base of Cutter Dam through the Cutter Lateral to Highway 550, at which point the pipeline would serve the East and West Laterals following the same alignments as the NIIP Moncisco Alternative.

All flows for the project remain the same as described in Alternative A.

C. NIIP Coury Lateral Alternative

The NIIP Coury Lateral Alternative is similar to the NIIP Moncisco Alternative, but instead of constructing Moncisco Dam and Reservoir, the existing NIIP facilities would be winterized (see Appendix G) to convey NGWSP water throughout the year (See NIIP Coury Lateral Alternative Map - Figure 3). A turnout structure would divert water from the Coury Lateral and tie into the alignment proposed in the NIIP Moncisco Alternative. The turnout structure was sized based upon a standard canal turnout with a 48" diameter outlet pipe. This alternative requires a 4,500 acre foot lined storage pond located near the Coury Lateral, which would provide storage capacity for the summer months when NIIP facilities cannot provide both peak irrigation demand and NGWSP demands (see Appendix G). The pond was assumed to be square, with a 20 foot water depth, and 3 feet of freeboard. The pond was partially excavated below original ground, and a compacted embankment was assumed to be 5 feet above original ground, and 6 feet wide at the top. The interior was assumed to be lined with a 40 mil membrane liner and 6 inches of riprap.

The water treatment plant, as described in Alternative A, would be located near the storage pond and the Coury Lateral, and flows would be the same as discussed in Alternative A.

D. NIIP Amarillo Alternative

The NIIP Amarillo Alternative is similar to the NIIP Coury Lateral Alternative in that the existing NIIP facilities would be winterized (see Appendix G) to convey NGWSP water throughout the year (See NIIP Amarillo Alternative Map - Figure 4). However, this alternative diverts water from the end of the Amarillo Canal for one lateral, as well as from Cutter Reservoir for the Cutter Lateral. A turnout structure would divert water from the Amarillo Canal and tie into the alignment proposed in the SJR PNM Alternative (see below). The turnout structure was sized based upon a standard canal turnout with a 48" diameter outlet pipe. This alternative requires a 4,500 acre foot lined storage pond located near the canal, as described in Alternative C.

A water treatment plant would treat the water from the Amarillo Canal before the water is transmitted to the Navajo communities and the City of Gallup. Another treatment plant immediately downstream of Cutter Dam would provide treated water to the eastern portion of the Navajo Nation and the Jicarilla Apache Nation. Both treatment plants would utilize an enhanced coagulation and hollow fiber ultrafiltration treatment system. Flows would be divided between the Amarillo Canal and the Cutter Reservoir as described in Section III above.

E. San Juan River Public Service Company of New Mexico (SJR PNM) Alternative

The SJR PNM Alternative is made up of two separate lateral systems, the San Juan Lateral and the Cutter Lateral (See SJR PNM Alternative Map - Figure 5). The San Juan Lateral would divert water from the San Juan River downstream of Fruitland, New Mexico, and treat and deliver the water west along Highway N36 and south along US Highway 666 to communities in the western portion of the Navajo Nation and the City of Gallup. This Lateral utilizes several sublaterals to serve such communities as Window Rock, Arizona, and the Nahodishgish Chapter/Dalton Pass, New Mexico. The SJR PNM Alternative would divert water from the San Juan River just upstream from the existing Public Service Company of New Mexico (PNM) diversion structure. A side channel inlet structure would be designed with a sump, and water then pumped to settling basins and a treatment plant. The Cutter Lateral would obtain water from the NIIP system at the existing Cutter Reservoir and treat and deliver the water south to communities in the eastern portion of the Navajo Nation and the Jicarilla Apache Nation.

A water treatment plant would treat the water from the San Juan River before the water is transmitted to the Navajo communities and the City of Gallup. The treatment plant immediately downstream of Cutter Dam would provide treated water to the eastern portion of the Navajo Nation and the Jicarilla Apache Nation. Both treatment plants would utilize an enhanced coagulation and hollow fiber ultrafiltration treatment system. All flows would be the same as those discussed in Alternative D.

F. SJR Infiltration Alternative

The SJR Infiltration Alternative is the same as the SJR PNM Alternative except that the water would be diverted from the San Juan River through an infiltration gallery system downstream from the Hogback Irrigation Diversion (See SJR Infiltration Alternative Map - Figure 6). All other aspects would be the same as for the SJR PNM Alternative.

V. DELIVERY DATA

The Farmington Construction Office created delivery data spread sheets, which listed the delivery points, flow rates, elevations, and required storage for all the communities that would be served by the project. This delivery data was prepared for the water demand in year 2020 and year 2040, based on estimated population. The population and demand for each of the six alternatives was identical for each community for each year. At the delivery points, the project would connect to existing service connections.

The 2040 population of the Navajo Communities (1990 population with 2.48 percent annual growth rate) was used with an average daily water demand of 160 gallons per capita per day (gpcd) to determine the average daily demand. Surface diversion required for NGWSP was the average demand minus the available groundwater sources. Supporting information can be found in the "Technical Memorandum, The Navajo-Gallup Water Supply Project," prepared by The Navajo

Nation Department of Water Resources. Peak daily demand was computed by multiplying the surface diversion for NGWSP by a 1.3 peaking factor. The peaking factor was derived from a seven day average in mid July. The project would connect to approximately 31 existing Navajo municipal systems, and would provide 70 psi pressure at those locations. Storage capacity was based on the individual service area five day demand for the year 2020 for those communities with existing water distribution systems.

The City of Gallup and Jicarilla Apaches Nation surface diversion requirements are 7,500 and 1,200 acre feet per year respectively for all years in the project. An independent analysis (Appendix F) conducted by the City of Gallup identifies the system requirements for Gallup and the surrounding Navajo communities served by the Gallup system. No storage is required for the Jicarilla Apache Nation.

VI. BASIC DESIGN CONSIDERATIONS

Each of the alternatives for this project have very similar design considerations, but the components vary for each alternative.

All of the alternatives have one or more surface water diversion points. The two San Juan River Alternatives divert water from both the San Juan River and from Cutter Reservoir. Cutter Reservoir is an existing feature of the NIIP system which receives water from Navajo Reservoir.

The four NIIP Alternatives divert water entirely from the NIIP system originating at Navajo Reservoir. The difference between the NIIP Alternatives is where the water is diverted from prior to entering the NGWSP pipeline system. The NIIP Moncisco Alternative conveys water through the NIIP system and stores water in the proposed Moncisco Reservoir. The NIIP Coury Lateral Alternative requires construction of a smaller storage facility near the existing Coury Lateral. The NIIP Cutter Alternative diverts water from Cutter Reservoir, an existing NIIP feature. The NIIP Amarillo Alternative conveys water through the NIIP system and requires construction of a storage facility near the end of the Amarillo Canal, but also diverts water from Cutter Reservoir. The NIIP Coury Lateral, NIIP Cutter, and NIIP Amarillo Alternatives require winterization of NIIP facilities (see Appendix G).

In all alternatives, the surface water is treated to meet primary safe water drinking standards before entering the NGWSP conveyance system. Treatment plant designs are based on the quality of the water at the point of diversion. Treated water is then conveyed in pipelines toward points of use. When necessary, relift pumping plants are included to keep the water flowing in the pipeline. Navajo Communities that have an existing water distribution system would have a storage tank and a method to increase (by means of a turnout pumping plant) the pressure for proper distribution. Delivery locations in the transmission line that do not have an existing water distribution system would be provided with a tee and a blind flange for future use.

A typical relift pumping plant has a forebay tank, pumps and motors within an enclosed building, an air chamber, and re-chlorination equipment. The forebay tank provides an adequate supply of water to minimize the number of times the pumps cycle on and off. The air chamber provides protection of the pumping plant and pipeline when the pumps are started and stopped. Re-chlorination equipment provides the required chlorine residual in the treated water.

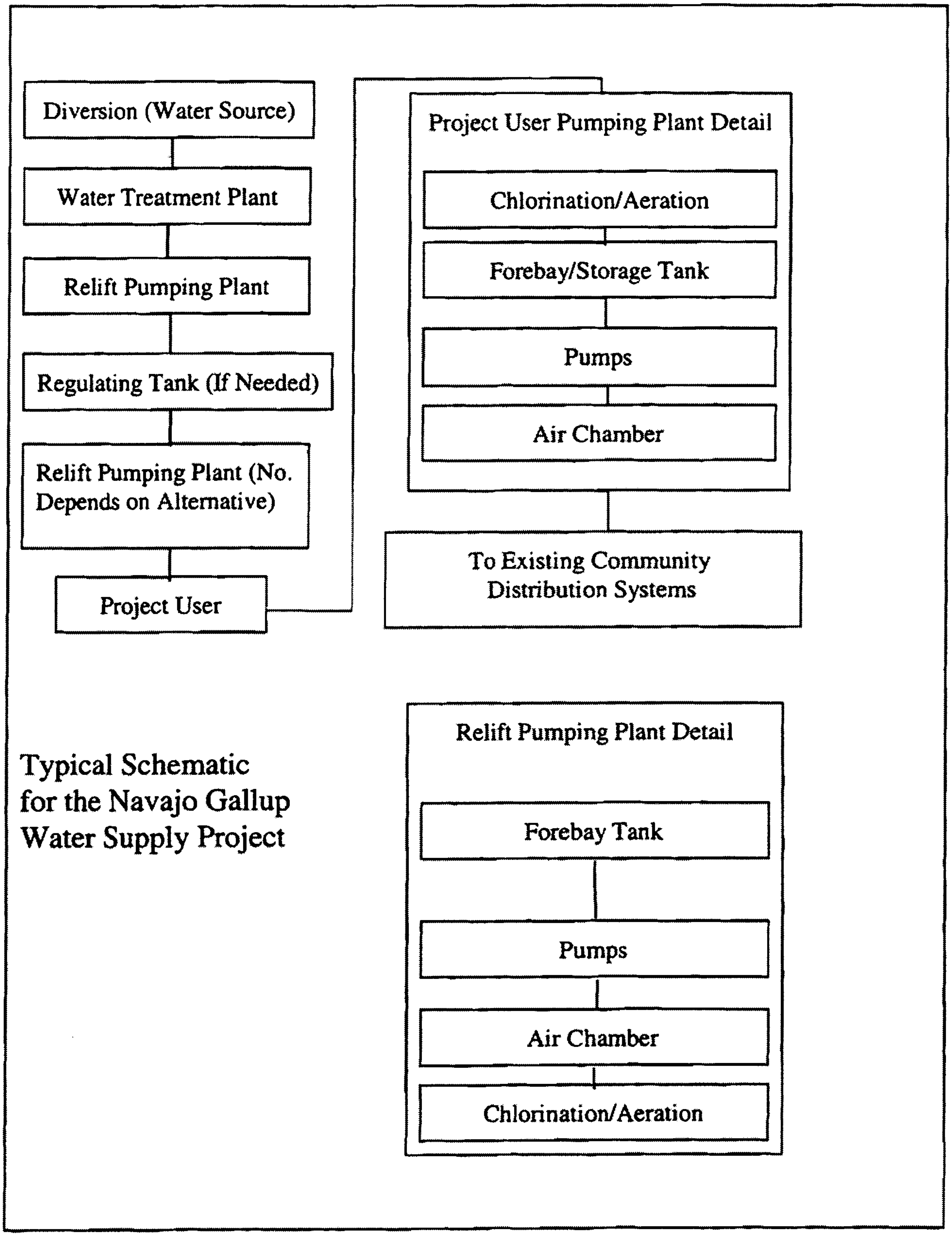
The turnout pumping plants have the same components as the relift pumping plants except a storage tank replaces the forebay tank. Re-chlorination equipment may not be necessary if chlorine residuals are adequate. Shown below is a summary of the major components required for each of the alternatives, followed by a typical schematic of the NGWSP system.

General Summary of Components

Component	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
River Intake					1	
Infiltration Wells						26 (Year 2040)
River Pumping Plant					1	
Treatment Plants	1	1	1	2	2	2
Forebay Tanks	12	8	11	17	19	20
Pumping Plants	12	8	11	17	20	20
Regulating Tanks	5	5	5	6	5	5
Community Storage Tanks	20	20	20	20	20	20
Feet of Pipeline	1,361,954	1,389,378	1,466,248	1,286,082	1,237,792	1,189,145
Miles of Pipeline	258	263	278	244	234	225

Gallup Regional System

Component	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Pumping Plants	4	4	4	4	4	4
Community Storage Tanks	5	5	5	5	5	5
Feet of Pipeline	171,923	171,923	171,923	171,923	171,923	171,923
Miles of Pipeline	32.6	32.6	32.6	32.6	32.6	32.6



Typical Schematic for the Navajo Gallup Water Supply Project

A. Geology

No intensive geological investigations were conducted in the project area. Reclamation's Western Colorado Area Office identified reaches of pipe that may contain rock. These reaches were determined by comparing surface geology maps with the pipe alignments. Specific lengths of the alinement were identified, and rock excavation quantities were calculated based upon the pipe sizes in those areas. Drawings identifying the anticipated rock excavation areas are included in Appendix D.

B. Surface Water Diversions

1. PNM Diversion Structure

One of the options for diverting water from the San Juan River is to construct a new turnout structure just upstream from the existing Public Service Company of New Mexico (PNM) diversion structure, which is located about 1.5 miles northwest of Fruitland, New Mexico. The PNM diversion diverts water for a coal fired steam electric plant. A report was prepared for the Bureau of Reclamation by Tetra-Tech Inc. In this report, Tetra-Tech developed a simple HECRAS model of the PNM diversion and settling channel describing the hydraulics and theoretical settling characteristics of sediment in the PNM intake channel. The Bureau of Reclamation's Technical Service Center reviewed this report, and the review comments, as well as Tetra-Tech's report, are included in Appendix H.

The use of the existing PNM facilities was evaluated, but because of the potential impact on PNM's water quality, it was determined that the appraisal level study should proceed with the concept of constructing a water intake structure independent of the existing PNM intake facility, and to include independent sediment removal facilities. It was assumed that the new concrete structure would be located just upstream from the existing intake/turnout on the San Juan River, and would be similar to a side channel wasteway structure as shown in Bureau of Reclamation Design Standards 3, Chapter 7, Figure 5 (see Drawing 10). The structure would have a side intake with a trash rack and fish screen. The flow was assumed to be 0.5 feet per second through the trash rack. There would be a ramp at a 10:1 slope down which equipment would be driven to the pumping plant sump from which silt buildup would be removed. A pump would also be provided to remove sediment from the sump. The pumping plant would have a maximum capacity of 60 cfs. Each of the vertical turbine pumps would be rated at 100 horsepower. At the top of the ramp would be a 24 foot square parking/loading area. The entire site would be fenced with a 7-foot high chain link fence. The pumping units would pump from the sump to settling basins and the treatment plant.

Drawing 9 is a conceptual layout for the turnout structure and sump. Drawing 2 is a process flow diagram for the water treatment facility at this turnout. Drawing 8 is a conceptual layout for the water treatment plant, which is shown in more detail on Drawing 5. A site layout for both the turnout structure and the water treatment plant is shown on Drawing 11.

2. Infiltration Gallery System

An Infiltration Gallery System (IGS) was proposed as an option for the San Juan River diversion. The IGS would obtain water from the San Juan River downstream of the Hogback and upstream of the confluence of the Chaco River and the San Juan River. This diversion option would tie into the previously proposed alignment for the San Juan River PNM Alternative at the most feasible point. The proposed IGS components would include a series of infiltration galleries placed in the river alluvium, collection wells and pumps, a collection manifold system and tank, a pumping plant, and a pipeline to the proposed water treatment plant site (See Drawing 12). The location and cost estimate for the collection wells were prepared by Ranney, a company that specializes in the design and construction of infiltration gallery systems (See Appendix E). The gallery caissons were spaced approximately 500 feet apart along the San Juan River and were located with environmental considerations. For this study, the yield of each well was estimated at 1.5 million gallons per day (2.33 cfs).

A typical collector well is constructed of a concrete caisson typically ranging from 12 to 20 feet in diameter and approximately 20 feet deep. Each collector well would include a pump and a backup pump housed in a weather-proof enclosure. Numerous perforated infiltration pipes radiate out from the caisson into the river alluvium. The infiltration pipe would be perforated to allow water filtering through the alluvium to enter the pipe and be transported to the collector well, from which it is then pumped. The well pumps would convey water through a collection manifold that gathers the water from the entire infiltration gallery (well field) to a collection sump and pumping plant. The pumping plant would lift the water approximately 120 feet in elevation from the river elevation to the bluffs south of the San Juan River into the water treatment plant.

Drawing 3 is a process flow diagram for the infiltration gallery system. Drawing 12 is a conceptual layout of the proposed water treatment plant, which is shown in more detail on Drawing 7. Drawing 13 shows a plan view of the infiltration system and a section of a typical collection well.

3. Cutter Dam and Reservoir

The Cutter Lateral is part of the San Juan River Alternatives and serves communities in the eastern portion of the Navajo Nation and the Jicarilla Apache Nation. The Cutter Lateral would obtain water from the Cutter Reservoir via the river outlet works as shown on Drawing 14. Cutter Dam and Reservoir are existing features on the NIIP. The Cutter water treatment plant would deliver treated water to a pumping plant, which would then pump the water into Cutter Lateral for transmission to the various communities.

Drawing 1 includes a process flow diagram for the water treatment system at Cutter Reservoir, which is shown in more detail on Drawing 6.

For the NIIP Cutter Alternative, Cutter Reservoir would supply all of the water for the entire project, and there would be no diversion from the San Juan River. Drawing 15 is a conceptual layout of the treatment plant for this alternative, which is shown in more detail on Drawing 4. Additional information on the NIIP operations is included in Appendix G.

4. Moncisco Dam and Reservoir

Moncisco Dam and Reservoir would be constructed specifically for the NGWSP. Water would be delivered to Moncisco Reservoir from the Burnham Lateral. The designs for Moncisco Dam would include a river outlet works with a tee for diverting water into the water treatment plant (See Appendix G for additional information). The Moncisco Water Treatment Plant (See Drawing 15) would deliver treated water to a pumping plant, which would then pump water into the East and West Laterals for transmission to the various communities.

Drawing 1 includes a process flow diagram for this alternative. Drawing 15 is a conceptual layout of the proposed water treatment plant, which is shown in more detail on Drawing 4. Additional information on the NIIP operations is included in Appendix G.

5. Coury Lateral

A canal turnout structure would be constructed near the beginning of Coury Lateral for the NIIP Coury Lateral Alternative. Water from the Coury Lateral would be diverted into a 4500 acre-foot storage pond, and from that point would be pumped into a treatment plant.

Drawing 1 is a process flow diagram for the water treatment facility at this turnout. Drawing 16 is a conceptual layout for the water treatment plant, which is shown in more detail on Drawing 4. Additional information on the NIIP operations is included in Appendix G.

6. Amarillo Canal

A canal turnout structure would be constructed near the end of the Amarillo Canal for the NIIP Amarillo Alternative. Water from the Amarillo Canal would be diverted into a 4500 acre-foot storage pond, and from that point would be pumped into a treatment plant.

Drawing 1 is a process flow diagram for the water treatment facility at this turnout. Drawing 16 is a conceptual layout for the water treatment plant, which is shown in more detail on Drawing 5. Additional information on the NIIP operations is included in Appendix G.

VII. WATER TREATMENT CONSIDERATIONS

A. Water Quality

1. Alternatives and Diversions using Water from the Navajo Indian Irrigation Project (NIIP)

The water source for the NIIP Monsisco, NIIP Cutter, NIIP Coury Lateral, and NIIP Amarillo Alternatives, along with the Cutter Reservoir diversion portion of the SJR Alternatives and the NIIP Amarillo Alternative, is Navajo Reservoir. The water quality parameters, which are provided in Table 3, indicate that the only treatment requirements are filtration and disinfection as required under the Surface Water Treatment Rule (SWTR) which is part of the Safe Drinking Water Act. Further sampling and analysis will be required before final design and construction to verify the data presented in Table 3 is correct, especially during low and high precipitation years.

Table 3 - Water Quality - Navajo Indian Irrigation Project Source Water

Parameter	Average	Design Range	Secondary MCL
Electrical Conductivity, EC (umhos/cm)	195	205-187	
pH	7.72	7.75 - 7.71	
Temperature (of)	46.7	49.1 - 45.3	
Turbidity (NTU)	2.6	3.16 - 1.47	
Total Suspended Solids, TSS (mg/L)	1.15	1.3 - 1	
Total Dissolved Solids, TDS (mg/L)	154	181 - 140	500
Sulfates, SO_4 (mg/L)	32.5	38.2 - 2.29	250
Total Organic Carbon, TOC (mg/L)	4.47	8 - 2.29	
Chlorides (mg/L)	1.6	1.9 - 1.2	250

Notes:

1. Data from three samples collected from the Cutter Diversion April 2000 to June 2000.
2. Secondary standards or MCL's are established by EPA for control of aesthetic qualities relating to public acceptance and includes contaminants that may affect taste, color, odor and appearance.

2. San Juan River Diversions

a. San Juan River Alternatives During Non-Runoff Events

The San Juan River, upstream of the Public Service Company of New Mexico Diversion (PNM), would provide water to the SJR PNM Water Treatment Plant. The San Juan River downstream of the Hogback Diversion would supply water to the San Juan Water Treatment Plant utilizing a infiltration intake system. Table 4 provides water quality parameters for both of these sources during non-runoff events. As shown, the water quality meets all primary standards established by EPA for the parameters shown, resulting in the need for filtration and disinfection to meet the requirements of the SWTR which is discussed below. Further sampling and analysis will be required before final design and construction to verify the average concentration and ranges are correct, especially during low and high precipitation years.

Table 4 - Water Quality - San Juan Alternatives, Non Storm Event						
	Hogback		PNM Historic		Design	
Parameters	Averages	Ranges	Average	Range	Range	Secondary MCL
EC, umhos/cm	301.00	1155-203	446.7	632-214	632-214	
pH	7.99	8.66-7.53	8.1	8.6-7.6.	8.6-7.6.	
Temp (°F)	57.30	74.1-53.0			62.4-74.1	
Turbidity (NTU)	78.00	4266-5.41	506	6700-9	115-5.4	
TSS mg/L	170.00	15334-42	876.6	1080-21	262-21	
TDS mg/L	190.00	884-141	208	350-24	350-24	500
SO_4 mg/L	57.00	476.5-42.2	119	200-38	200 - 38	250
TOC mg/L	3.40	4.76-2.89			4.76-2.89	
Chloride mg/L	4.70	26.6-2.91			26.6-2.91	250.00
T. Hardness mg/L	107.00	1535-106	163	232-84	232-84	
Calcium +2			50.8	78-24	78-24	
Magnesium +2			10.1	54-1.9	54-1.9	
P Alkalinity			0.5	4.0-TRACE	4.0-TRACE	
M Alkalinity			99.3	123-4.5	123-4.5	
SiO_2			8.1	13.2-4.9	13.2-4.9	

Notes
1. Design value for TSS incorporates the reduction of turbidity and suspended solids by the pretreatment settling pond.
2. Data for PNM is based on 50 samples collected between January 5, 1999 and December 24, 1999.
3. Data for Hogback is based on 7 samples collected between April 14, 2000 and August 23, 2000.
4. Secondary standards or MCL's are established by EPA for control of aesthetic qualities relating to public acceptance and includes contaminants that may affect taste, color, odor and appearance.

b. San Juan River Alternatives During High Runoff Events

Table 5 shows the water quality in the San Juan River at the Hogback Canal taken from a sample collected on August 23, 2000 during a large storm event. Based on this data, it appears the water quality in the San Juan River at the Hogback exceeds secondary MCL's for Total Dissolved Solids (TDS) and sulfates. Sulfates and TDS are typically constituents of low quality water which cannot be substantially reduced by the infiltration gallery intake structure, traditional treatment or the proposed ultrafiltration system.

Further investigation is required to confirm the reduction of water quality due to the increase of TDS and sulfates associated with storm water runoff flows at both the SJR PNM and SJR Infiltration Alternative diversion points. Since this water cannot be treated by the proposed system, the following operation scenarios are suggested during major runoff events:

- Significant dilution may be provided in the SJR PNM settling ponds to reduce TDS and sulfate concentrations to below MCL limits.

• Storage capacity in the settling ponds, wastewater polishing ponds and the treated water distribution system may be adequate to temporarily stop diverting water from the San Juan River to the treatment plant during large storm events. Once the concentrations of water at the diversion intakes are below 500 ppm TDS and 250 parts per million sulfate, diversion of San Juan River water can resume.

If the San Juan River is selected as a water supply source, further sampling and analysis will be required to determine the potential impacts of storm water runoff in the water quality diverted from the river, potential impacts to the treatment equipment, and the resultant water quality produced by the proposed water treatment system. As a result of the analysis of this one sample, a review of the USGS water quality databases for Fruitland and Hogback diversion and the PNM diversion database was done. Sorted with respect to water quality during the summer and summer storms, the results of this review do not substantiate the values presented in Table 5. The analysis has confirmed the need for more data and reinforces the need for continued sampling of water at each of the proposed diversion points for total dissolved solids, dissolved sulfates and turbidity during runoff conditions. The results of this database analysis are provided in Appendix C.

Table 5 - Water Quality - Water Quality of the San Juan River at the Hogback Diversion During High Runoff Events

Parameter	Concentration	Secondary MCL
EC, umhos/cm	1,155	
pH	8	
Temp (°F)	62	
Turbidity (NTU)	23,460	
TSS (mg/L)	15,334	
TDS (mg/L)	**884***	500
T SO4 (mg/L)	**477***	250
TOC (mg/L)	4	
Chlorides (mg/L)	27	250

Notes
1. Data from sample collected August 23, 2000.
2. *** Exceeds secondary MCL.**
3. Secondary standards or MCL's are established by EPA for control of aesthetic qualities relating to public acceptance and includes contaminants that may affect taste, color, odor and appearance.

B. Treatment Requirements

The water source for all alternatives considered for the NGWSP use surface water from either the NIIP or the San Juan River. The treatment systems used to provide drinking water to the consumers must comply with the Surface Water Treatment Rule (SWTR). The SWTR was published in the Federal Register on June 29, 1989 and is promulgated by the Environmental

Protection Agency (EPA) as a National Primary Drinking Water Regulation for public water systems using surface water sources or ground water under the direct influence of surface water. The filtration and disinfection requirements under this rule protect consumers against the potential adverse effects of exposure to *Giardia lambia*, *Cryptosporidium*, viruses, Legionella, and heterotrophic bacteria by requiring the inactivation of 99.9% (3 log) for Giardia cysts and 99.99% (4 log) for viruses. The inactivation of potential pathogens, as required by the SWTR, is accomplished by the use of EPA approved technologies for filtration and disinfection methods. Newly adopted regulations to address the risk of disinfection by-products (DBP's) include: Disinfectants - Disinfection Byproducts Rule (D-DBP Rule) and the Interim Enhanced Surface Water Treatment Rule, which requires continual monitoring of filtered water turbidity and routine DBP's monitoring in the distribution system.

The D-DPB Rule is divided into two stages. Stage 1 of the Rule will be required for all community water systems and includes an MCL of 80 micrograms per liter (ug/l) for Total Trihalomenthanes (TTHMs), 60 ug/l for five haloacetric acids (HAA5), 10 ug/l for bromate and 1.0 ug/l for chlorite. Stage 2 of the D-DBP Rule will only pertain to surface water systems serving more than 10,000 people and will further reduce the MCL for TTHMS to 40 ug/l, and HAA5 to 30 ug/L. The proposed microbial/disinfection byproducts (M-DBP), if promulgated, will characterize the required treatment processes based on a "BIN" category as determined by average *Cryptosporidium* concentration in the source water. Sampling at the diversion point will be required to determine the BIN category of all the NIIP and San Juan River alternatives.

The relative high concentrations of total organic carbons (TOC) in samples from the NIIP and San Juan River water sources, as shown in Tables 3 and 4, in combination with the long detention times required to convey the treated water to some of the delivery points, indicate a potential for the production of DBP's that may exceed current and future regulatory limits at the treated water service points or within the domestic water storage and distributions systems used to distribute the water to consumers. In order to determine the expected reduction in TOC concentrations by the proposed treatment system and the potential of DBP's production over time, bench scale distribution simulation studies using chloramine and free chlorine disinfection should be done. If bench scale analysis indicates that the DBP limits are exceeded, additional treatment systems to remove the DBP's before consumption may be required in some locations.

C. Description of the Proposed Water Treatment System

Based on manufacturers data, the proposed treatment system should meet and exceed the requirements of the Surface Water Treatment Rule (SWTR). Long term pilot studies (minimum of 12 months) will be required to verify chemical types, chemical usage rates, and other parameters to optimize treatment and verify regulatory compliance before design and construction can begin. The proposed treatment system consists of enhanced coagulation, ultrafiltration and ultraviolet disinfection to provide multiple treatment barriers for removal of organic molecules, *Giardia*, *Cryptosporidium* and viruses. The use of chloramines to provide a disinfection residual during the conveyance of treated water from the treatment plant to the service areas will not only provide a treated water that is not conducive to the formation of disinfection by products, but will also provide an additional disinfection barrier. Drawings #1, #2 and #3 show the process flow diagrams of the proposed processes for each alternative. Table 7 provides an estimated land requirement for each alternative and Table 8 provides an overview of the main treatment process components for each alternative. Before final design and construction, a comprehensive pilot scale operation of each process will be required to verify the effectiveness and operation of each unit process and resultant water quality.

1. Sediment Removal Ponds (SJR PNM alternative only)

The settling basins considered in this alternative are required to reduce turbidity of the San Juan River water before treatment. Most of the sediment contained in the source water would be removed by the intake and the proposed settling ponds. Each pond is designed with a three hour detention time providing optimum conditions for the reduction of turbidity to acceptable limits before treatment by the enhanced coagulation and ultrafiltration systems. Settling tests using San Juan River water collected during a high turbidity of 4,266 NTU have verified that a two pond system with each pond to provide a detention time of 3 hours will be sufficient to reduce turbidity to acceptable limits before treatment. The settling basins will have minimal effects on the quality of the water, with the exception of some dilution of high TDS and sulfate concentrations occurring during high runoff conditions. The settling pond(s) are sized to meet the hydraulic requirements for the demand year 2040 as shown in Table 6. To reduce the impact of the ponds on regional groundwater through infiltration, and to avoid the need to replace the liner after each sediment removal event, each pond will be lined with six inches of reinforced concrete.

Table 6 Settling Pond Requirements at PNM site based on a 6 hour detention time

Year	Influent Flow Rate (MGD)	Required Volume of Settling Pond (gallons)	Surface Area of each pond with a 10 feet Depth and 1:1 side slopes (Acres)
2040	38.25	9,563,000	1.72

Source water from the NIIP alternatives and NIIP Cutter diversion in the SJR PNM alternative would not require settling basins since the water has already passed through a large surface impoundment which acts like a settling basin. As shown in Table 3, the water is characterized by having low but varying turbidity.

2. Enhanced Coagulation

In waters that have variable annual turbidity or moderate to high total organic carbon concentrations, ultrafiltration systems typically include an enhanced coagulation step prior to filtration to coagulate small suspended materials in the water and increase the filtration efficiency. This process will increase the removal of organic matter before disinfection to meet the requirements of the Stage 1 and Stage 2 D-DPB Rule. This pretreatment process uses aluminum sulfate or other coagulant such that the type and dosage can only be determined by laboratory and field tests. In this study, it will be assumed that aluminum sulfate is the coagulant of choice and that the required concentration is 30 mg/l.

Water generated by the SJR infiltration intake system is expected to drastically reduce turbidity and organic matter in the feed water to the treatment plant. It is expected that a decrease in suspended solids will reduce the coagulant dosage from 30 mg/L to 10 mg/L. This change, along with the no sediment reduction requirement, will decrease the land requirements, capital construction costs and operation and maintenance costs. These are the major benefits of an infiltration intake system. A pilot scale operation that simulates the use of an infiltration intake system will be required to verify that the decrease in coagulant dosage can be made without impacting the quality of the treated water.

3. Hollow Fiber Ultrafiltration Treatment System

Previous studies have evaluated the potential for using conventional, diatomaceous earth and microfiltration/ultrafiltration for the treatment of surface waters associated with this project. A discussion of these studies is included in Section 8.05 of the "Technical Memorandum, The Navajo-Gallup Water Supply Project," prepared by The Navajo Nation Department of Water Resources. Based on this analysis, ultrafiltration using hollow fiber membranes along with enhanced coagulation is the proposed method for filtration due to the system's ability to treat water with varying turbidity, ability to meet current and future regulatory standards, and the ease to operate and maintain.

The hollow fiber ultrafiltration treatment system physically removes suspended particles greater than 0.1 microns in diameter by having a nominal and absolute pore size of .035 and 0.1 microns respectively. Particles found in surface water that exceed this size range are easily filtered. They include Giardia (5-15 microns in size), Cryptosporidium (4-6 microns in size), large viruses and large organic molecules. The continuous hollow fiber ultrafiltration system manufactured by US Filter(CMF-S) or Zenon (ZeeWeed) are bundles or cassettes of tubular membranes that filters water through microscopic holes. Designed for large scale systems, the pre-engineered cassettes are submerged into open top concrete or steel tanks. The study will incorporate the ZeeWeed-500 (ZW-500) hollow tube membranes which are used for applications requiring enhanced coagulation.

a. The Ultrafiltration Filtration (UF) Process Using Hollow Fibers

The proposed ZeeWeed 500 system consists of a series of parallel concrete tanks, or trains, in which cassettes are immersed in modules consisting of four cassettes in the NIPP and San Juan plants and one cassette in the Cutter diversion plant in the SJR Alternative. UF feed water enters each tank from the bottom and flows upward through the cassettes. During the filtration cycle, a vacuum is applied to each hollow fiber to draw water into the tube leaving the flocculated and suspended solids greater than 0.1 micron on the outside of the tube. Untreated water is added to maintain a constant level in each concrete tank.

b. Recovery Rate and Wastewater Treatment

The estimated recovery of treated water is 90 percent of the inflow meaning that 10 percent of the inflow would be used for membrane cleaning and will be discharged as process wastewater. Design flows used in this section to determine size and costs for each alternative are based on the treated water requirements of the treatment system during peak demands. The actual discharge of the potable water from the treatment plant is approximately ten percent less than is shown, with the difference being supplied by treated water storage.

In the proposed concept of operation, the process wastewater will be diverted to two wastewater treatment ponds for treatment and then recycled through the treatment system. In some alternatives there will be zero discharge from the treatment plant for extended periods of time and for other alternatives water from these ponds will be discharged on a continual basis to surface waters. Further discussions on the discharge of treated water for each option is provided in section F.5. below.

c. Description of membrane cleaning techniques.

At the end of a filtration cycle, which is characterized by plugging enough holes in the hollow fiber with filtered material to increase suction pressure, a backwash is performed. During backwash, the membranes are simultaneously aerated and back pulsed with treated water to dislodge solids from the outside of each fiber. The water, which includes the backwashed solids, is routed into the backwash trough and out to the backwash water polishing ponds. The time for backwash varies from 15 minutes to 1 hour. The number of filtration cycles a day is directly related to the amount and type of contaminants or floc particles in the water.

On a daily basis, each process tank is emptied into the wastewater polishing ponds and an extended back pulse using chlorinated water from the clear well is performed. The length of this cleaning is between 10-15 minutes.

Recovery cleaning is performed as required, typically every 2-6 months, at which time the fibers are back pulsed with a cleaning solution followed by in-situ soaking for several hours. After cleaning, the tanks are emptied and the cleaning solution is pumped to a storage tank for future use.

d. Log Credits

According to information provided by ZENON, the enhanced coagulation and ultrafiltration treatment process is expected to provide a 6 log reduction in *Giardia* and *Cryptosporidium* and 2 log reduction in viruses in the source water, thus meeting all the SWTR removal requirements for *Giardia* and *Cryptosporidium* reduction, and half of the requirements for virus reduction.

4. Ultraviolet Disinfection Units

Disinfection after ultrafiltration is accomplished by state of the art "flow through" ultraviolet (UV) disinfection units which are located on the filtered water discharge line from each ultrafiltration treatment train. Each unit consists of a stainless steel chamber containing eight UV lamps, an automatic cleaning system, UV monitoring system and control cabinet. Each unit will provide a minimum UV dose of 40 mJ/cm^2 to the filtered water before being routed to the clear well. Manufacturers data is provided in the water treatment appendix (Appendix C) in the report.

According to the information provided by Aquionics, the proposed UV units will add an additional 3 log (99.9%) reduction of Giardia and Cryptosporidium an additional 4 log (99.99%) reduction in viruses to the water following the ultrafiltration process. Based on this information, the unit processes of ultrafiltration and UV disinfection will provide a reduction of 9 log for Giardia and Cryptosporidium and 6 log for viruses. This reduction far exceeds the SDWA requirements.

5. Chloramination

The mixing of filtered and disinfected water with ammonia gas followed by chlorine gas in the clearwell will provide a chloramine residual prior to being pumped by the service water pumping plant into the treated water mains leading to the service areas. This form of residual is being used to reduce the development of disinfection by-products that would be generated by extended contact times in the conveyance and storage facilities if a free chlorine residual was used. Other benefits of a chloramine residual include prevention of taste and odor problems and the fact that the chloramine residual will last longer in the treated water transmission line and storage system, thus eliminating the number of re-chloramination stations.

Detention times and dosage rates for a chloramination system can only be determined by laboratory and field testing. In this study, an estimated chloramine dosage of 1.00 ppm was used. This consists of a 0.5 ppm demand and 0.5 ppm residual. The ratio of 3 parts chlorine to 1 part ammonia was used to size the ammonia and chlorine gas storage area for the cost estimate. A detention time of 30 minutes was used to size the clearwell where mixing will occur.

Not having the same disinfection power as a free chlorine residual, chloramination will still provide additional disinfection log credit based on the contact time from the plant to the withdrawal point by individual communities. The water treatment appendix (Appendix C) provides an estimate of the contact times and additional log credit removals that occur during conveyance of the treated water.

D. Structures

Drawings 4 through 7 identify the features of each water treatment plant. All plant structures, except intakes, must be located above the 100 year flood plain.

1. Treatment Buildings

a. Treatment Plant Building Requirements for the NIIP and SJR Alternatives

The main treatment building for NIIP and SJR Alternative treatment plants would be approximately the same size with a first floor surface area of approximately 24,500 square feet and a second floor mezzanine that is approximately 22 feet wide and 122 feet long. The proposed floor plan of each treatment plant is shown on the attached drawings. The proposed building would be a pre-engineered, prefabricated structure with metal siding and suitable insulation and ventilation to meet the building code requirements of the State of New Mexico and all other applicable code requirements. The building would house the 10 foot tall flocculation basins, 10 foot tall concrete tanks containing the Ultrafiltration modules for each train, UV units, vacuum pumps and internal piping. The second floor mezzanine would contain the control room for the filters and UV units, air blowers used for module cleaning and the motor control center. The chlorine storage room and ammonia storage room are included in the main building but have outside entrances and separate HVAC systems to eliminate the risk to the operators if leakage occurs in any of the cylinders. The building is designed to house the treatment system required to meet 2040 demands requirement. Further details are shown in the drawing for each plant.

The chlorine and ammonia storage room would house the ton containers of each gas along with the chlorinators and ammoniators which will meter the gases into the clearwell for mixing. Trunnions are provided in the storage room to provide for the storage of full containers to meet two months demand along with spare trunnions for storage of an equal amount of empty or full containers.

b. Treatment Plant Building Requirements for the NIIP Cutter Diversion (SJR and NIIP Amarillo Alternatives) Treatment Plant

The Cutter diversion of the SJR and NIIP Amarillo Alternatives water treatment plant is a scaled down version of the other NIIP and SJR Alternative plants with a building area of approximately 4,600 square feet. Like the larger plants, the flocculation basins would be located inside the building to protect the water from windblown sand and freezing temperatures. Due to its reduced size all treatment components for the Cutter treatment plant would be located on a single floor as shown on the drawing.

2. Regional Operation and Maintenance Buildings

Each alternative includes a 2,500 square foot Regional operations and maintenance building located within the treatment plant "compound". Each building would be on a slab on grade with 15 feet eave heights. The facility would be used for spare equipment/parts storage and for maintenance areas relating to the treatment, conveyance and pumping of water for this project.

3. Clear Well

The below grade clear well will provide a detention time of 30 minutes and will include injection manifolds, baffles and mixers to properly mix ammonia and chlorine with treated water. After chloramination the treated water would be pumped by the service pumping station into the distribution system.

4. Wastewater Storage/Treatment Ponds

Water generated during the routine cleaning of the filters will flow into one of two passive treatment ponds. In these ponds, fine suspended solids filtered by the hollow fiber system will be settled out and removed from the site. After passive treatment, the water can be conveyed back into the treatment plant, discharged back into the source, or discharged to surface waters. The useful life of a pond is estimated to be between 10 to 15 years before settled sediment will need to be removed and conveyed to the sediment drying beds. Each pond will be lined with a 45 mil geomembrane system to reduce the impact on regional groundwater.

5. Sediment Drying Beds for Wastewater Ponds

Sediment drying beds are provided to dry sediment taken from the wastewater polishing ponds for all the alternatives except the SJR PNM. Excavated material will be placed on six-inches of sand. Evaporation along with draining of water into the sand will dry the sediment before it is hauled away for disposal in a sanitary landfill, open pit or abandoned mine shaft. Operation and maintenance costs, associated with excavation and transport of sediment collected from the wastewater ponds, will occur every 15 years.

6. Sediment Drying Beds for SJR PNM Alternative

With the construction of a new diversion upstream of the PNM site, all sediment that is removed by the intake structure and settling ponds must be retained and ultimately disposed of off site. The determination on the frequency of pond cleaning, volume of sediment, volume of dried sediment, size of required sediment drying beds and resulting operation and maintenance costs in this report are based on one water quality sample taken during one storm event. This event occurred on August 23, 2000 and analysis indicated a Turbidity reading over 23,000 NTU units and a suspended solids loading of over 15,000 mg/Liter. The drying bed size and costs should be taken as preliminary as additional sampling and analysis is required prior to design and construction. Using this data point the lead pond will need to be "dredged" of sediment after every 10 days of storm runoff and two sediment drying beds with a surface area of approximately 6 acres each will be required. When the sediment in the 10 foot deep lead pond becomes 2 feet deep, approximately 130,000 cubic feet of sediment will need to be removed and placed on one of the drying beds. The excavated sediment is applied at an approximate depth of 6-inches on the surface of each bed. Beds consist of perforated PVC pipes located in a gravel under drain system followed by sand. The system will remove water from the sediment by drainage and evaporation, reducing the water content by approximately 50% with a dried sediment depth of 2.5 to 3-inches. Once dried, the sludge will be removed from the top of each bed and transported to a nearby abandoned open pit coal mine for final disposal. Operation and maintenance costs, associated with excavation and transport of sediment collected from the settling ponds are based on two "cleaning cycles" per year.

7. Land Requirements

Table 7 provides the approximate land requirement for each alternative. This information is provided for comparing alternatives only and does not represent the actual requirements determined after final design.

Table 7 Estimated Land Requirements for Treatment Systems in the Year 2040

Alterative	Building (Acres)	Clearwell (Acres)	WW Ponds (Acres)	WW Ponds Drying Beds (Acres)	Sediment Settling Ponds (Acres)	Sediment Drying Beds (Acres)	Total (Acres)
NIIP Moncisco	0.56	0.28	0.33	0.16	NR	NR	1.33
NIIP Cutter	0.56	0.28	0.33	0.16	NR	NR	1.33
NIIP Coury Lateral	0.56	0.28	0.33	0.16	NR	NR	1.33
NIIP Amarillo	0.56	0.28	0.30	0.15	NR	NR	1.29
NIIP Cutter Diversion of SJR Alt.	0.11	0.03	0.09	0.03	NR	NR	0.26
SJR PNM	0.56	0.28	0.30	See notes	3.6	12	16.7
SJR Infiltration	0.56	0.28	0.30	0.15	NR	NR	1.29

Notes:

Total land area estimates do not include the diversion structures or the storage ponds for the NIIP Coury Lateral or NIIP Amarillo Alternatives.

Total land area estimate does not include the infiltration system for the SJR infiltration alternative.

Total land area estimate does not include diversion structure for the SJR PNM alternative.

SRJ PNM sediment drying beds would also be used for dewatering wastewater pond sediment.

NR: Not Required

Table 8 Overview of Treatment System Components

System Characteristics	NIIP Alternatives	NIIP Amarillo	SJR PNM Alternative	Cutter Diversions	SJR Infiltration
Design Flows 2020 Demand (MGD) 2040 Demand (MGD)	 27.64 43.63	 23.89 38.25	 23.89 38.25	 3.74 5.39	 23.89 38.25
Rapid Mix Tank (gallons)	21,000	19,600	19,600	6,200	19,600
Splitter Tank (gallons)	21,000	19,600	19,600	6,200	19,600
Flocculation Tanks (gallons)	303,000	266,000	266,000	26,000	266,000
Hollow Fiber Ultrafiltration Number of trains (size) Modules (2020/2040) Cassettes (2020/2040) Flux per Cassette (GPD) Spare Modules (cassettes)	 7 35/55 138/218 200,000 1	 7 30/48 120/192 200,000 7	 7 30/48 120/192 200,000 7	 3 19/27 200,000 0	 7 30/48 120/192 200,000 7
UV Disinfection Units	7	7	7	3	7
Clearwell (L'xW') Volume (gallons) Detention Time (min) Mixers	60 x 205 909,000 30 6	60 x 180 797,000 30 6	60 x 180 797,000 30 6	60 x 25 112,000 30 2	60 x 180 797,000 30 6
Chlorine Room Active Ton Cylinders Spare Capacity	 6 6 24	 6 6 24	 6 6 24	 1 1 4	 6 6 24
Ammonia Room Active Ton Cylinders Spare Capacity	 2 2 8	 2 2 8	 2 2 8	 1 1 4	 2 2 8
Building (square feet) Mezzanine (square feet)	24,500 Yes -2,700	24,500 Yes, 2,700	24,500 Yes-2,700	4,600 No	24,500 Yes, 2,700
Settling Pond (acres)	not required	not required	2@1.8	not required	not required
Wastewater Polishing Ponds Number Surface Area Each, acres (L'xW') Detention Time Per Pond hrs	 2 0.33 (180x80) 3	 2 0.30 (175x80) 3	 2 0.30 (175x80) 3	 2 0.09 (100x40) 3	 2 0.30 (175x80) 3
Drying Beds L' x W' For Sediment (2 of each) Polishing Ponds (2 of each)	 not required 170 x 40	 not required 160 x 40	 721x361 not required	 not required 60 x 20	 not required 160 x 40

Notes: Depth of wastewater polishing ponds is 10 feet, length to width ratio is approximately 2 to 1. Side slopes 1 horizontal to 1 vertical. Surface area provided is top of bank. Maximum level would be with 1 foot of freeboard.

E. Operation and Maintenance Requirements

Annual and annualized operations and maintenance cost estimates with electrical power costs based on the NTUA rates are provided in Table 10. Annual and annualized operations and maintenance cost estimates with electrical power costs based on the CRSP rates are provided in Table 11. Descriptions of each are provided below.

1. Operation

The overall operational system would monitor the demands in the treated water distribution system and activate/deactivate the treatment system as required to maintain required water levels or pressures in the treated water storage tanks. When in operation the water treatment system master control panel would control the local control panels (LCP) for each treatment process. During automatic operation, the water treatment master control system monitors all LCP's and provides inputs for adjustments for optimal treatment efficiency. Operators would be required to monitor operations 24 hours a day along with routine duties such as calibrations of turbidity meters, chemical injection equipment, residual monitors, inventory control, monthly reports, etc.

This control system would be integrated into the overall project control system.

2. Plant Operators

Plant operation for all treatment plants and all demands would require a total staff of six personnel, (four operators, one maintenance and one supervisor). This staff would ensure that a least one operator is at the plant during operation with suitable maintenance and supervisory support. Estimated staffing time and labor costs are provided in Appendix C.

3. Chemicals

Annual costs for chemicals include those required for routine cleaning of the hollow fiber membranes, aluminum sulfate to flocculate the small suspended particles in the source water and chlorine and ammonia gas to form a chloramine residual to keep the water disinfected during its transport from the treatment plants to service.

A reduction in chemical costs is predicted for the San Juan River plant using a infiltration collector since filtration is provided by this type of collector before treatment. It is expected to reduce the required aluminum sulfate dosage from 30 mg/L to 10 mg/L.

4. Power

Annual cost for power to operate each plant includes power to operate vacuum pumps, air compressors, UV disinfection units, low head lift pumps, lights, HVAC units and a percentage increase for other loads required for operation of a large water treatment facility. For the NIIP

Moncisco and NIIP Cutter Alternatives and the Cutter diversion in the SRJ and NIIP Amarillo Alternatives treatment plants, a low lift pump will divert water from the wastewater polishing ponds to the plant influent for recycling. For the NIIP Coury Lateral and NIIP Amarillo Alternatives, two low lift pump stations will be required, one to transfer water from the off-channel storage pond to the water treatment plant and one to recycle water from the wastewater ponds to the water treatment plant. For the SJR PNM Alternative three low head lift stations will be required, one to transfer water from the river diversion to the settling ponds, one to transfer water from the settling ponds to the water treatment plant and one to recycle water from the wastewater ponds to the water treatment plant. Electrical costs for the San Juan plant using infiltration collectors includes one low lift pumping station used to transfer water from the wastewater treatment ponds back into the plant for reuse. The power required to convey water from the infiltration caissons to the treatment plant is not included in the costs provided in Table 10 or Table 11.

To provide uninterrupted treated water, the New Mexico Environmental Department requires backup generators to be provided for all potable water treatment plants. These generators need to be rated to meet the power requirements during the average daily flow or 70 percent of the design flow.

5. Replacement of Equipment

Annualized equipment replacement costs include annual replacement of ultraviolet light bulbs, the replacement of all hollow fiber cassettes every 10 years and the replacement of mechanical equipment every 15 years. Details on the annualized cost of each are provided in Appendix C.

6. Dredging and Disposing of Sediment

When the settling and wastewater polishing ponds contain a maximum of 2 to 3 feet of sediment, a dragline would be used to remove the sediment in the PNM settling pond and each of the wastewater polishing ponds. The sediment would be dried on the sand drying beds and when dry, would be transported off site for disposal. The estimated frequency for dredging and disposing of sediment is every 10 days of storm runoff for the SRJ PNM lead settling pond and every 15 years for the wastewater polishing pond.

F. Miscellaneous

1. Chloramine Booster Stations

Each pumping plant would contain a chloramine booster station that would monitor the chloramine residual of the incoming water and automatically add, as required, additional chlorine to maintain the 0.5 ppm residual to the water being pumped by the plant. The capital and operation and maintenance costs of these re-chloramination systems are included as part of the unlisted items in the water treatment estimate.

2. Blending of Water

Blending of good water quality produced by the proposed surface water treatment plants with low quality ground water presently used by the City of Gallup and many of the Navajo Communities may increase turbidity in the mixed water. Increased turbidity, a secondary MCL, in the blended water will decrease the aesthetic quality of the water. In order to predict and compensate for any reactions, a detailed water quality analysis for each well system is required. This data will then be used in the "Rothberg, Tamburnini & Windsor Model for Corrosion Control and Process Chemistry" to predict turbidity formation. If the modeling determines chemical addition(s) are required to eliminate the formation of turbidity, follow up laboratory verification is required. A copy of a report that models the blending of Colorado River Water with well water for the city of Somerton is provided in Appendix C.

In order to provide funding for modeling and potential chemical injection systems, a 10 percent unlisted additive is included in the capital cost for each treatment system and each demand. To account for potential O&M costs of these systems, a 10 percent miscellaneous additive is provided.

3. Disinfection By-Product Treatment

Included in the unlisted percentage in the capital cost for each alternative is funding for the installation of aeration systems and rechlorination systems at each service point to remove DBP's that may be created during conveyance

4. Pilot Plant Operation

Prior to final design of the selected alternative, a pilot study using the proposed treatment system will be required to optimize each treatment process and collect design data. The pilot plant should operate 24 hours a day over a minimum of 12 consecutive months to determine treatment requirements with changing water conditions. The study will determine the most efficient chemical to use for coagulation, determine chemical injection rates based on changing water quality, determine backwash requirements and membrane cleaning requirements, determine wastewater quality and production rates, verify the ability of the treatment system to meet current and future regulatory standards, determine the potential for DBP formation during conveyance, provide data to update capital and operation and maintenance costs, determine operation requirements, and provide training for future operators of the full scale treatment system. A line item providing a sum of $200,000 to fund the pilot study is included in the capital cost of each alternative.

5. Wastewater Discharges from the Water Treatment Plants

Water generated from cleaning the filters will be discharged to the wastewater treatment ponds for treatment before being recycled or discharged. Domestic wastewater generated by the various restrooms located around each site and "spent" citric acid from filter cleaning will be routed to properly designed septic tanks and leach fields. Citric acid will be reused as much as possible.

The wastewater treatment ponds as proposed in the study will have a minimum detention time of six hours and are intended to settle out suspended solids and treat the water using naturally occurring microorganisms. Depending on the location and operation of each treatment plant, the discharge from the treatment ponds can be completely mixed with plant influent and re-treated, a portion can be retreated with the rest being discharged, or all of the water from the wastewater ponds can be discharged to supplement the source water or surface waters.

When the treated water is recycled back into the plant, the process of dissolved solids accumulation due to chemical additions and evaporation will increase the total dissolved solids in the wastewater pond as well as the TDS in the combined feed to the water treatment plant.

In an attempt to quantify the accumulation of TDS and potential discharge options from the wastewater ponds, a modeling program was developed. The results of the program for the year 2020 is provided in Appendix C. For this report all treated wastewater will be discharged either back to the source water or to natural drainages. With discharge after the ponds the expected increase of TDS and biological oxygen demand over the source water is from 10 to 15 percent and 5 to 10 percent respectively. Actual increases are subject to weather conditions and can only be determined by pilot plant and actual plant operation.

G. Appraisal Level Cost Estimates

1. Capital Costs

Estimated capital cost for each treatment plant and each demand alternative are provided in Table 9. Details of the estimated costs for each of the major components in each plant are provided in Appendix C.

Table 9 Water Treatment Plant Capital Costs[1]

Alternative	Capital Cost to meet year 2020 demands	Additional Capital Cost to upgrade to 2040 demands
NIIP Moncisco, Cutter, and Coury Lateral	$24,478,100	$7,933,400
NIIP Amarillo	$21,746,800	$7,145,600
SJR Infiltration[2]	$21,748,700	$7,145,600
SJR PNM	$22,689,800	$7,145,600
Cutter Diversion	$5,963,700	$1,213,000

[1] Taxes and land costs are not included

[2] Does not include the capital cost of the infiltration system, which is included as a separate item.

2. Annual Operation and Maintenance Costs

The estimated annual operation and maintenance requirement for each plant is summarized in Table 10, using NTUA power rates, and Table 11, using CRSP power rates. Detailed spreadsheets of each annual cost are presented in Appendix C.

Table 10 Estimated Annual Operation and Maintenance Costs using NTUA Rates.

Operation and Maintenance Tasks	NIIP Moncisco & NIIP Cutter	NIIP Coury Lateral	NIIP Amarillo	SJR PNM Alternative	Cutter Diversions	SJR Infiltration
Plant operators (Requires 6 personnel)	$ 695,000	$ 695,000	$ 695,000	$ 695,000	$ 695,000	$ 695,000
Chemicals Year 2020 Year 2040	 $ 592,000 $ 935,000	 $ 592,000 $ 935,000	 $ 512,000 $ 820,000	 $ 512,000 $ 820,000	 $ 80,000 $ 116,000	 $ 232,000 $ 371,000
Power Costs @ $.0185KW-hr Year 2020 Year 2040	 $ 253,000 $ 399,000	 $ 274,000 $ 433,000	 $ 219,000 $ 350,000	 $ 297,000 $ 476,000	 $ 34,000 $ 59,000	Note 2 $ 219,000 $ 350,000
Annualize Equipment Replacement Costs. Year 2020 Year 2040	 $ 380,000 $ 600,000	 $ 380,000 $ 600,000	 $ 329,000 $ 526,000	 $ 329,000 $ 526,000	 $ 52,000 $ 74,000	 $329,000 $526,000
Annualize Costs to Remove/dispose of Sediment in Settling Pond Year 2020 Year 2040	Not Required	Not Required	Not Required	$173,000 $173,000	Not Required	Not Required
Annualize Costs for Cleaning WW Treatment Ponds Year 2020 Year 2040	 $ 4,000 $ 4,000	 $ 4,000 $ 4,000	 $ 3,000 $ 3,000	 $ 3,000 $ 3,000	 $ 1,000 $ 1,000	 $3,000 $3,000
Subtotal Year 2020 Year 2040	 $1,924,000 $2,633,000	 $1,945,000 $2,667,000	 $1,758,000 $2,394,000	 $2,009,000 $2,693,000	 $ 862,000 $ 945,000	 $1,478,000 $1,945,000
Miscellaneous 10% Year 2020 Year 2040	 $ 192,000 $ 263,000	 $ 195,000 $ 267,000	 $ 176,000 $ 239,000	 $ 201,000 $ 269,000	 $ 86,000 $ 95,000	 $ 148,000 $ 195,000
Total Annual O&M Cost Year 2020 Year 2040	 $2,117,000 $2,896,000	 $2,140,000 $2,934,000	 $1,934,000 $2,633,000	 $2,210,000 $2,962,000	 $ 948,000 $1,040,000	 $1,626,000 $2,140,000

Notes

1. All operation and maintenance costs are based on 24 hour a day operation at the average daily demand (design demand divided by 1.3).
2. Does not include power costs for the infiltration intake system.
3. Costs rounded off to the nearest thousand dollars.
4. Costs include a monthly demand charge of $15.40 per KW or an annual demand charge of $184.80 per KW.

Table 11 Estimated Annual Operation and Maintenance Costs using CRSP Rates.

Operation and Maintenance Tasks	NIIP Moncisco & NIIP Cutter	NIIP Coury Lateral	NIIP Amarillo	SJR PNM Alternative	Cutter Diversion of SJR Alt	SJR Infiltration
Plant operators (Requires 6 personnel)	$ 695,000	$ 695,000	$ 695,000	$ 695,000	$ 695,000	$ 695,000
Chemicals Year 2020 Year 2040	 $ 592,000 $ 935,000	 $ 592,000 $ 935,000	 $ 512,000 $ 820,000	 $ 512,000 $ 820,000	 $ 80,000 $ 116,000	 $ 232,000 $ 371,000
Power Costs @ $.0081 KW-hr Year 2020 Year 2040	 $ 76,000 $ 119,000	 $ 84,000 $ 134,000	 $ 73,000 $ 117,000	 $ 91,000 $ 145,000	 $ 10,000 $ 17,000	Note 2 $ 65,000 $ 105,000
Annualize Equipment Replacement Costs. Year 2020 Year 2040	 $ 380,000 $ 600,000	 $ 380,000 $ 600,000	 $ 329,000 $ 526,000	 $ 329,000 $ 526,000	 $ 51,500 $ 74,000	 $ 329,000 $ 526,000
Annualize Costs to Remove/dispose of Sediment in Settling Pond Year 2020 Year 2040	Not Required	Not Required	Not Required	 $173,000 $173,000	Not Required	Not Required
Annualize Costs for cleaning WW Treatment Ponds Year 2020 Year 2040	 $ 4,000 $ 4,000	 $ 4,000 $ 4,000	 $ 3,000 $ 3,000	 $ 3,000 $ 3,000	 $ 1,000 $ 1,000	 $ 3,000 $ 3,000
Subtotal Estimated annual cost Year 2020 Year 2040	 $1,747,000 $2,353,000	 $1,755,000 $2,368,000	 $1,612,000 $2,161,000	 $1,803,000 $2,362,000	 $ 838,000 $ 903,000	 $1,324,000 $1,700,000
Miscellaneous 10% Year 2020 Year 2040	 $ 175,000 $ 235,000	 $ 176,000 $ 237,000	 $ 161,000 $ 216,000	 $ 180,000 $ 236,000	 $ 84,000 $ 90,000	 $ 170,000 $ 192,000
Total Annual O&M Cost Year 2020 Year 2040	 $1,922,000 $2,588,000	 $1,931,000 $2,605,000	 $1,773,000 $2,377,000	 $1,983,000 $2,598,000	 $ 922,000 $ 993,000	 $1,456,000 $1,870,000

Notes

1. All operation and maintenance costs are based on 24 hour a day operation at the average daily demand (design demand divided by 1.3).
2. Does not include power costs for the infiltration intake system.
3. Costs rounded off to the nearest thousand dollars.
4. Costs include a monthly demand charge of $3.44 per KW or an annual demand charge of $41.28 per KW.

VIII. OVERALL OPERATIONAL CONFIGURATION

Each of the proposed Alternatives would be fully automated systems. The main water treatment plants would operate automatically to maintain availability of treated water. The system downstream of the treatment plants is a series of pumping plants, regulating or forebay tanks, and community storage tanks. Each pumping plant operation along the main water transmission line is controlled by float level switches in the forebay or regulating tank downstream from that plant. During periods of low water demand from a local community, water altitude valves in the community storage tanks would reduce flow into the storage tank at predetermined elevations by shutting down pumps as demand decreases. As demand increases, staged pumps (one pump for each increment of 10 ft^3/s) would start. The pumping plants would not need to be attended on a full time basis, but would require physical inspection on a daily basis. Each pumping plant would have one back-up pump and an emergency generator capable of meeting full load power requirements for that plant in the event of a power outage.

A. Pumping Plants

There are four basic versions of pumping plants located throughout the NGWSP.

- The first group of pumping plants would include the pumping plants at the PNM and infiltration gallery system San Juan River sites (See Drawings 9 and 12).

- The second group of plants would generally be downstream of the water treatment plants to pump treated water into the lateral systems (See drawings 14, 15, and 16).

- The numerous relift pumping plants are the third group and are needed to lift the water from lower to higher elevations along the lateral and to overcome the frictional resistance lost in the pipe lateral (See drawing 17, Typical Relift Pumping Plant).

- The last group of pumping plants are part of the delivery turnout and would provide 70 psi of pressure to the community (See drawing 18, Typical Turnout Pumping Plant) .

The TSC used the Bureau of Reclamation computer program, **"PUMPLT"**, to estimate the field costs of the pumping plants. This program estimates costs of pumping plant construction based upon historical data for plants with similar flows, heads, and number of pumping units. The program output includes structural improvements, including the structure itself and civil site work, waterways, pumps, motors, electrical access, and miscellaneous equipment.

B. Pumps

The pumps at the pumping plants were assumed to be equal size units with a maximum capacity of 10 cfs each. There is one standby pump unit at each pumping plant. The majority of the pumps would be the horizontal split case type. Each pump would have a suction and discharge valve with an electric or hydraulic operator. The pumps in the relift pumping plants and the turnout deliveries all would require a minimum of 15 feet of head on the suction side. Pumps would be controlled by level switches that sense the water levels in the regulating, forebay, and storage tanks. Pumping plant locations are shown in Appendix D. There are also two pumps (one plus standby) rated at 2.32 cfs at each infiltration well (Infiltration Gallery) system.

C. Air Chambers

A few waterhammer computer runs were made for typical size pumping plants and pipe systems, and it was determined that a typical air chamber size would be a 20 foot diameter sphere. We assumed that this would be an average size air chamber and used this size at all locations where an air chamber would be needed.

D. Tanks

Forebay tanks would be required upstream of almost every pumping plant to supply water during startup of the pumps and during shutdown to reduce waterhammer effects. Altitude valves would be installed at most sites to prevent the forebay tanks from over topping. For this appraisal level study, all of the forebay tanks were estimated to be 8-foot in diameter and 40-foot tall. In the next level of study, each of these tanks would be sized on an individual basis.

Where possible, regulating tanks were placed at high points and gravity flow could then be used to deliver water to lower points in the system. By assuming that the pumps in the pumping plants would be 10 cfs or less and that the minimum run time was 15 minutes, the regulating tank diameters were found to be 40 feet. Then depending on the number of pumps, the heights of the tanks were computed. Tank heights ranged from 9 feet to 22 feet. The height included two feet for bottom dead space and five feet for overflow and top freeboard space. Tank water surfaces would be the primary control for automatically stopping and starting the pumps.

Storage tanks were provided at the delivery turnouts for the communities that had existing water distribution systems. These tanks store a five-day water supply for the community, which is then boosted by the pumping plant to a pressure of 70 psi into the community water system.

It was assumed that the height of the storage tanks would be 20 feet, and the diameters were computed based on the values for the five-day storage for the year 2020 demands.

Tank locations are shown on the drawings in Appendix D.

IX. ELECTRICAL

1. There are several locations that would be tapped to provide power for the pumping plants and miscellaneous equipment. The NTUA is installing a 115kV line (energized at 69-kV) from Tohatchi to Newcomb. This proposed powerline was assumed to be constructed by the time

NGWSP begins construction. The NGWSP would extend this NTUA powerline along highway 666 north to Shiprock and south along the pipeline alignment to Window Rock and Nahodishgish Chapter/Dalton Pass, New Mexico.

The pumping plants located in the eastern portion of the Navajo Nation would obtain power from and existing 230-kV powerline owned by PNM. There are two locations where this powerline could be tapped to provide power depending on the alternative and the distance of new transmission line construction. The transmission line would include one overhead optical ground wire for T1 fiber optic communications. A small switchyard with at least one circuit breaker would be required to provide electrical protection for the downstream facilities.

2. Assumptions:

a. Taps would be made on the powerline for pumping plants, turnouts, and the infiltration gallery.

b. Security systems, including video cameras, would be provided at each pumping plant.

c. Control and monitoring hardware at each site, including pumping plants, turnouts, and the infiltration gallery, would include an Allen-Bradley SLIC-500 controller, or equal.

d. The infiltration system would require at least a transducer to monitor the condition at each location. Cabling would be required to bring this information to a central point for transmission to the master station.

3. A SCADA system would be provided and installed in the existing NTUA facilities in Fort Defiance.

4. Each plant would have a backup engine-generator to provide full plant operation in the event of a power failure.

The Bureau of Reclamation Farmington Construction Office provided additional information on transmission line lengths and substations as stated below:

The following are the length of miles and substations for each alternative:

San Juan River Alternative - 107 miles and 1 substation near Nageezi
Infiltration System Alternative - 107 miles and 1 substation near Nageezi
NIIP Moncisco Alternative - 73 miles and 1 substation near Moncisco
NIIP Coury Lateral Alternative - 74 miles 1 substation near Nageezi
NIIP Cutter Alternative - 93 miles and 1 substation near Nageezi
NIIP Amarillo Alternative - 107 miles and 1 substation near Nageezi

The substations would tap power from a 230 kV line owned by PNM and would convert to 69kV. Kutz substation would be used to serve the pumping plant near the Coury Lateral on the NIIP Coury Lateral Alternative. Transmission line lengths may change due to pumping plant location changes.

Transmission line locations to be constructed are shown on drawings 19 through 24.

X. PIPELINES

A. General

The Farmington Construction Office created electronic files which contained the pipe alignments and topographic information for all of the pipe laterals. The TSC combined these files and created AutoCAD (Release 15.0) drawings for the general plans for each alternative and profiles for each of the laterals. These drawings were then used to determine pipe lengths and head classes. These drawings are included in Appendix D.

B. Hydraulics

The Hazen-Williams equation was used to compute the loss due to friction in the pipe laterals. The TSC used as a guideline that the design velocity should be about 5 feet per second or less and the maximum pump lift would be about 400 feet. The minimum system pressure along the pipe laterals was 15 feet. Pipe friction losses were limited to about 25 percent of the total dynamic head for the pumps.

C. Pipe Types

When computing the hydraulics, it was assumed that all of the lateral pipe would be mortar lined steel pipe with full inside diameters. In using a Hazen-Williams Coefficient of 140 and steel pipe with full inside diameters, it is felt that the resulting friction losses are conservative. By limiting the pump lift to about 400 feet of head and adding 30 percent for an upsurge allowance, the head class (pressure class) for the pipe was generally limited to 525 feet (235 psi). However, in areas where the topography results in large decreases in the ground surface elevations, pipe head classes often reach values much higher than 525 feet. The pipe head classes, pumping plant locations, pump heads, and pipeline alinements will be more precisely defined in the next level of study.

Steel pipe can be manufactured in all of the pipe diameters and head class increments that have been estimated for this project. At the present time, some of the newer pipe types are not available in the larger diameters and higher pressure ratings. Polyvinyl Chloride (PVC) pipe is currently limited to 48-inch diameter with a 125 psi pressure rating and 42-inch diameter with a 165 psi pressure rating. Polyethylene (PE) pipe is currently limited to 42-inch, 48-inch, and 54-inch diameters, each with a 64 psi pressure rating. Fiberglass pipe is currently limited to 54-inch diameter with a 200 psi pressure rating and 30-inch diameter with a 250-psi pressure rating. In some instances, pipe manufactures may have the capability to make larger diameters with higher pressure ratings.

Since cathodic protection is not required for these non metallic type pipes, they should be considered as at least an option in most of the pipe diameters in the next level of design for this project. Also, every year pipe manufacturers are making larger diameter pipes with higher pressure ratings. These non metallic type pipes generally have a lower coefficient of friction, but in some instances do not have full inside diameters. When more precise design data is available in the next level of design, all of these factors should be considered when computing the hydraulics. Because the pipe types cannot be predicted at this time, no costs were included for cathodic protection. Any costs for cathodic protection of steel pipe were assumed to be included in the 10% allowance for unlisted items.

Since PE pipe is currently available in the higher pressures in 24-inch diameter and smaller sizes, PE pipe costs were used for 24-inch pipe and smaller for this level of study. Steel pipe prices were used for all pipe greater than 24-inch in diameter. The appurtenant structures and mechanical equipment associated with the pipeline are covered under unlisted items in the cost estimates. These would include such items as air valves, blowoffs, drains, flow meters, pressure reducing valves, altitude valves, and sectionalizing valves.

D. Earthwork

Quantities for pipe earthwork, including rock excavation, were based on a typical trench section with an average depth of cover of 5 feet.

E. Operation and Maintenance

Annual operation and maintenance costs for pipelines were estimated to be 0.5 percent of the initial pipe cost. These costs are include in Tables 1a and 2a.

XI. GALLUP REGIONAL SYSTEM, TRANSMISSION AND STORAGE FACILITIES

The Northwest New Mexico Council of Governments (NWNMCOG) secured a USDA Rural Business Enterprise Grant for planning and preliminary design work associated with delivery and distribution of treated NGWSP water to areas within the City of Gallup and adjacent NTUA systems. DePauli Engineering & Surveying Co. of Gallup, NM produced a report entitled "Preliminary Design and Report For The Navajo-Gallup Water Supply Project, City of Gallup Transmission and Storage Facilities", dated January, 2002 (DePauli Report). The DePauli Report can be found in Appendix F.

The DePauli Report's preliminary designs and cost estimates begin near Gamerco Townsite at the Yah-ta-hey Junction and go through the City of Gallup to the NTUA systems located in Churchrock on the east, Manuelito and Spencer Valley on the west, and Redrock on the south. Figure 1 from the DePauli Report shows the Gallup Regional system and the five delivery locations for the Navajo Communities. The following are the Navajo Communities served through the Gallup Regional system: Manuelito, Redrock, Breadsprings, Chichiltah, Iyanbito, Church Rock, Pinedale, and Mariano Lake. The Gallup Regional System's demand is based on delivering 7500 acre-feet of water per year to the City of Gallup, and the Navajo Community deliveries were based on year 2040 demands. The Navajo Communities have a peak demand of 8.36 cubic feet per second and the City of Gallup has a peak demand of 13.47 cubic feet per second. In this report, the DePauli Report flow values were used for both years 2020 and 2040.

A summary for the Gallup Regional System's costs is shown Table 5 of the DePauli Report. For the most part, Reclamation used the quantities contained in the DePauli Report. However the following refinements were made to the DePauli Report's construction cost estimate to be consistent with the Reclamation cost estimates for the other parts of the NGWSP:

- DePauli Report unit prices included New Mexico State Gross Receipt Taxes of 6.4 percent. This tax was backed out of the unit prices to allow taxes to be added for the entire project as one lump sum.

- When the DePauli Report's unit costs are used, they were indexed from December 2000 to October 2001.

- The DePauli Report's unit cost for pipelines included earthwork and furnishing and installing ductile-iron pipe. Reclamation used the diameters and lengths provided and applied unit costs for furnishing and installing pipe with an assumed head class of 275 feet with 10 feet of cover. Earthwork quantities for the pipeline were computed as separate items. An estimate of 15% rock excavation was also assumed.

- The DePauli Report's estimate for crossings and bores were used with the exception of backing out the taxes and indexing.

- The number of water storage tanks and their capacities were used. Reclamation computed the size (diameters and heights) of the tanks based on the reported volumes and applied the applicable unit costs.

- The DePauli Report's estimates for pumping plant construction and upgrading existing pumping plants were used with the exception of backing out the taxes and indexing.

- The DePauli Report's estimates for valve and metering stations and surge control station were used with the exception of backing out the taxes and indexing.

- The cost of the Gallup SCADA system was not used because it is assumed to be included in the total project SCADA system estimated by Reclamation.

Reclamation's estimated cost of constructing the Gallup Regional System, Transmission and Storage Facilities is as follows:

Excavation, common	$271,200
Excavation, rock	$192,000
Backfill, common	$219,000
Furnish and install pipe	$3,468,762
Crossings and Borings	$684,400
Tanks (Reservoirs)	$5,990,000
Pump Stations	$670,240
Valves and Metering Stations	$542,800
Surge Control Station (T1-T2) (24")	$84,960
SCADA System (included in BOR SCADA)	$0
Subtotal Field Cost	$12,123,362
Rounded Total	$12,000,000
Mobilization (± 5%)	$600,000
Unlisted Items (± 10%)	$1,400,000
Contingencies (± 20%)	$2,500,000
Rounded Pre-tax Field Cost	$16,500,000
Non-Contract Costs (± 30%)	$5,000,000
Pre-tax Total	$22,000,000

The DePauli Report also had estimates for annual operation, maintenance and replacement (OM&R) expenses for the transmission and storage facilities within the City of Gallup. These OM&R estimates were not used by Reclamation, but were instead estimated in a different manner, as described later in this report. To be consistent with the entire project, Reclamation calculated annual OM&R cost from pumping plant data presented in the DePauli Report, but again used calculation methods described later in this report.

XII. FIELD COSTS

Summaries of the field costs for the years 2020 and 2040, excluding the Gallup Regional System, are shown in Tables 12 and 13 for each of the six alternatives.

XIII. NON-CONTRACT COSTS

Non-contract costs, include costs for items such as facilitating services, investigations, preparation of designs and specifications and construction supervision. To determine a realistic value for non-contract costs for NGWSP, the Western Colorado Area Office reviewed non-contract costs resulting from the construction of the Dolores Project. The Dolores Project was a large project in Southwestern Colorado constructed in the 1980's and early 1990's. Individual features of Dolores Project had non-contract costs ranging from as low as 16.5% to as high as 82.6% of the feature's field costs. The later features such as the Dove Creek Pumping Plant and associated laterals and Towaoc Laterals (gravity pipelines) are considered similar to the proposed construction of NGWSP. These later Dolores Project features had non-contract costs of approximately 30% of the field costs.

For the purposes of this study, the non-contract costs were assumed to be 30% of the field costs. This value was also applied to the City of Gallup field costs (see Tables 1 and 2).

TABLE 12 SUMMARY OF FIELD COSTS BASED ON YEAR 2020 DEMAND*

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Pipelines	$100,745,160	$109,386,620	$122,079,120	$96,050,930	$76,168,350	$69,725,300
Pumping Plants	$9,910,000	$7,750,000	$10,960,000	$9,770,000	$15,890,000	$15,250,000
Water Treatment Plants	$24,478,100	$24,478,100	$24,478,100	$27,710,510	$28,653,500	$27,712,400
Tanks and Air Chambers	$32,675,000	$41,775,000	$41,660,000	$24,690,000	$30,720,000	$30,875,000
Infiltration Well System						$18,268,500
Transmission Lines	$12,103,800	$13,579,400	$14,444,400	$16,524,200	$16,524,200	$18,139,400
Moncisco Dam	$44,942,000					
Storage Pond		$20,422,700		$20,422,700		
Turnout Structure					$852,400	
Winterization		$240,000	$48,000	$600,000		
Unlisted Items (±10%)	$24,145,985	$21,608,225	$25,878,425	$25,031,660	$17,791,530	$21,029,025
Mobilization (±5%)	$11,000,000	$11,000,000	$10,500,000	$9,800,000	$8,400,000	$9,000,000
Contract Cost	$260,000,000	$250,000,000	$250,000,000	$230,000,000	$195,000,000	$210,000,000
Contingencies (±20%)	$50,000,000	$50,000,000	$50,000,000	$40,000,000	$35,000,000	$40,000,000
Total Field Cost	$310,000,000	$300,000,000	$300,000,000	$270,000,000	$230,000,000	$250,000,000

* DOES NOT INCLUDE GALLUP REGIONAL FIELD COSTS (SEE TABLES 1 AND 2)

TABLE 13 SUMMARY OF FIELD COSTS BASED ON YEAR 2040 DEMAND*

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Pipelines	$128,332,550	$155,156,930	$199,767,570	$103,145,230	$90,515,700	$81,958,850
Pumping Plants	$13,230,000	$10,570,000	$15,765,000	$13,760,000	$21,840,000	$20,750,000
Water Treatment Plants	$32,411,500	$32,411,500	$32,411,500	$36,069,110	$37,012,100	$36,071,000
Tanks and Air Chambers	$45,275,000	$44,805,000	$44,835,000	$37,300,000	$46,330,000	$46,485,000
Infiltration Well System						$29,807,150
Transmission Lines	$12,103,800	$13,579,400	$14,444,400	$16,524,200	$16,524,200	$18,139,400
Moncisco Dam Storage Pond	$50,679,500	 $20,422,700		 $20,422,700		
Turnout Structure					$852,400	
Winterization		$240,000	$48,000	$600,000		
Unlisted Items (±10%)	$33,967,695	$29,054,515	$27,276,575	$21,278,760	$26,429,170	$24,656,815
Mobilization (±5%)	$14,000,000	$14,000,000	$15,500,000	$11,500,000	$10,500,000	$11,500,000
Contract Cost	$330,000,000	$320,000,000	$350,000,000	$260,000,000	$250,000,000	$270,000,000
Contingencies (±20%)	$60,000,000	$60,000,000	$80,000,000	$60,000,000	$50,000,000	$50,000,000
Total Field Cost	$390,000,000	$380,000,000	$430,000,000	$320,000,000	$300,000,000	$320,000,000

* DOES NOT INCLUDE GALLUP REGIONAL FIELD COSTS (SEE TABLES 1 AND 2)

XIV. ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENT COSTS

Annual operation, maintenance, and replacement (OM&R) costs for pumping plants were generated by the Bureau of Reclamation computer program called PMPOM. The computer program is derived from information in "Guidelines for Estimating Pumping Plant Operation and Maintenance Costs", by John Eyer; 1965, Bureau of Reclamation. Estimates of annual OM&R costs were derived from records of 174 existing electric and hydro-powered pumping plants. The procedures cover direct OM&R costs for pumps, motors, accessory electrical equipment, and plant structures for plants up through 15,000 total horsepower, and consider wage rates and price levels. Price levels were updated from 1965 to 2001 levels. For the NIIP Alternatives, annual OM&R costs were calculated for the additional costs to be incurred by year round operations of the existing NIIP conveyance facilities. For additional details, see Appendix G. Energy costs for the existing NIIP facilities were calculated based on CRSP rates only. For all other parts of the system, energy costs were calculated using both CRSP and NTUA rates. The costs are for the maximum pump discharge using the peak pumping rate, except for the power costs, which were determined as outlined below.

XV. POWER COSTS

It was necessary to determine the fraction of pumping at peak demand that would be necessary to deliver the annual Diversion.

The fraction of pumping at peak demand is given by the following equation:

$$P_k = \frac{Q_{AD}}{Q_{peak\_acft}}$$

Where: P_k is the fraction of peak pumping.
Q_{AD} is the annual diversion in acre-ft/year.
Q_{peak_acft} is the peak pumping rate in acre-ft/year.

The cost of power consists of two components. The first cost is the cost of power based on the rate charged per kilowatt-hour of usage. The second is the demand charge that is charged on a per kilowatt per month basis.

A. The Peak Power Demand

The Peak Power demand is given by the following equation:

$$P_{pwd\_ft-lbs/s} = \frac{\gamma_w Q_{pk\_cfs} H}{e}$$

Where: $P_{pwd\_ft\text{-}lbs/s}$ is the peak power demand in: ft-lbs/sec
γ_w is the unit weight of water in lbs/ft^3 (62.4)
Q_{pk_cfs} is the peak pumping discharge in ft^3/sec

H is the pumping head in feet..
e is the efficiency.

Since 1 horsepower (HP) is equal to 550 ft-lbs/sec.

$$P_{pwd\_HP} = \frac{P_{pwd\_ft-lbs/s}}{550}$$

Where : P_{pwd_HP} is the peak power demand in Horse Power.

Since: 1 HP = 0.746 KW (KW is kilowatts), then:

$$P_{pwd\_KW} = 0.746 P_{pwd\_HP}$$

Where: P_{pwd_KW} is the peak power demand in Kilowatts.

B. Kilowatt-Hours of Energy Consumption per Year

The kilowatt Hours of consumption is given by the following equation:

$$E_{kwhrs} = 8760 P_K P_{pwd\_KW}$$

Where: E_{kwhrs} is the energy consumption per year in kilowatt hours
P_k is the fraction of pumping at Peak Demand (as determined previously).
P_{pwd_KW} is the peak power demand in kilowatts.

C. Cost of Power (Based on Charge per kilowatt-hour)

The Cost of Power (Based on the rate per kilowatt hour) is given by the following equation:

$$C_{p\_kwhr} = R_{kwhr} E_{kwhrs}$$

Where: C_{p_kwhr} is the cost of power based on the rate per kilowatt Hour.
R_{kwhr} is the rate per kilowatt hour.

D. Demand Charge (Yearly)

The yearly demand charge is given by the following equation:

$$C_D = 12 P_{pwd\_KW} R_D$$

Where: C_D is the yearly demand charge
R_D is the monthly demand charge in dollars per kilowatt.

The total yearly power costs (C_T) are given by the flowing equation:

$$C_T = C_{p\_kwhr} + C_D$$

Example:

The annual power costs for both CRSP and NTUA rates were computed for the San Juan River Pumping Plant (Pumping Plant 01) for the year 2040.

The following values were used:

Rate	Power Cost (Dollars per Kilowatt Hour)	Demand Charge (Dollars per Kilowatt per month)
CRSP	0.0081	3.44
NTUA	0.0185	15.40

Peak Flow Rate = 59.18 ft^3/s
Efficiency (e) = 80% (combined for both pumps and motors)
Pumping Head (H) = 442 ft.
Annual Diversion (Q_{AD}) = 33,118 Acre-ft.

Q_{peak_acft} = (peak flow rate in acre-ft/year) = (59.18*86,400*365)/43,560= 42,844 acre-ft/year

Therefore P_k(fraction of peak pumping) = 33,118/42,844=0.773

Peak Power Demand= (62.4*59.18*442)/0.8 = 2,040,290 ft-lbs/sec

Peak Power Demand = 2,040,290/550 = 3,710 horsepower

Peak Power Demand = 3,710*0.746= 2,767 kilowatts

Kilowatt hours of consumption (per year) = 8,760*0.773*2767= 18,738,830 kw-hours

Power Cost based on charge per kilowatt Hour (C_{kwhr}):

CRSP Rate: 0.0081*18,738,830 = $151,785

NTUA Rate: 0.0185*18,738,830 = $346,668

Demand Charge (C_D) : **CRSP rate:** 12*3.44*2767= $114,237

NTUA rate: 12*15.40*2767 = $511,411

Total Yearly Power Costs: **CRSP rate:** $151,785 + $114,237 = $266,022
(PP01, Year 2040) **NTUA rate:** $346,668 + $511,411 = $858,079

The pipe diameters, pumping plant locations, pump heads, and monthly energy requirements will be more precisely defined in the next level of study. The summations for all of the pumping plants, as well as the costs associated with winterization of the existing NIIP facilities, are shown below for both 2020 and 2040 demands in Tables 14 and 15.

TABLE 14 SUMMARY OF ANNUAL OM&R COSTS FOR YEAR 2020 DEMAND

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Annual OM&R	$1,365,800	$991,900	$1,095,200	$1,710,300	$1,979,800	$2,042,900
Energy (NTUA)	$2,102,100	$1,700,500	$2,442,400	$2,170,000	$3,479,600	$3,333,800
Energy (CRSP)	$711,300	$691,100	$756,700	$672,000	$1,078,000	$1,032,900
City of Gallup Annual OM&R	$306,200	$306,200	$306,200	$306,200	$306,200	$306,200
Energy (NTUA)	$76,600	$76,600	$76,600	$76,600	$76,600	$76,600
Energy (CRSP)	$23,800	$23,800	$23,800	$23,800	$23,800	$23,800
Total (NTUA)	$3,850,700	$3,075,200	$3,920,400	$4,263,100	$5,842,200	$5,759,500
Total (CRSP)	$2,407,100	$2,013,000	$2,181,900	$2,712,300	$3,387,800	$3,405,800

TABLE 15 SUMMARY OF ANNUAL OM&R COSTS FOR YEAR 2040 DEMAND

Item	NIIP Moncisco Alternative	NIIP Coury Lateral Alternative	NIIP Cutter Alternative	NIIP Amarillo Alternative	SJR PNM Alternative	SJR Infiltration Alternative
Annual OM&R	$1,449,500	$1,053,500	$1,157,100	$1,828,300	$2,120,800	$2,183,500
Energy (NTUA)	$3,118,300	$2,453,100	$3,657,800	$3,303,000	$5,169,200	$4,874,600
Energy (CRSP)	$1,060,700	$962,700	$1,133,300	$1,023,000	$1,601,500	$1,510,200
City of Gallup Annual OM&R	$306,200	$306,200	$306,200	$306,200	$306,200	$306,200
Energy (NTUA)	$76,600	$76,600	$76,600	$76,600	$76,600	$76,600
Energy (CRSP)	$23,800	$23,800	$23,800	$23,800	$23,800	$23,800
Total (NTUA)	$4,950,600	$3,889,400	$5,197,700	$5,514,100	$7,672,800	$7,440,900
Total (CRSP)	$2,840,200	$2,346,200	$2,620,400	$3,181,300	$4,052,300	$4,023,700

XVI. FUTURE REFINEMENTS IN DESIGNS AND COST ESTIMATES

When the preferred Alternative has been identified, the designs and cost estimates for that option will be performed in greater detail. The following are some of the items to be included in that effort:

Update costs to reflect the most recent interest rates, tax information, power costs, and flow rates.

Refinement of hydraulic analyses (including an economic analysis of pumping costs vs. initial cost of pipe). This could impact both the number and size of the pumping plants.

Refinement of OM&R costs for pumping plants, treatment plants, etc.

Additional water quality data for the San Juan River will be available. Water treatment plant sediment handling costs will be reevaluated based on the results of the new data.

The pipeline alinement will be refined based upon possible impacts from cultural resources, endangered species, and existing facilities.

Refinement of pipe unit costs, including revisions to installation (earthwork) costs.

Refinement of rock excavation areas based upon more detailed information

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XVII. LIST OF APPENDICES

Appendix A - Figures and Drawings

Appendix B - Cost Estimate Worksheets (Bound as a separate document)

Appendix C - Water Treatment (Bound as a separate document)

Appendix D - Engineering (Bound as a separate document)

Appendix E - Infiltration Gallery (Bound as a separate document)

Appendix F - City of Gallup Transmission and Storage Facilities, Revised January, 2002, by DePauli Engineering and Surveying Co. (Bound as a separate document)

Appendix G - Moncisco Reservoir and NIIP Operations (Bound as a separate document)

Appendix H - Evaluation of Existing PNM Diversion and Sedimentation Facility (Bound as a separate document)

NAVAJO GALLUP WATER SUPPLY PROJECT

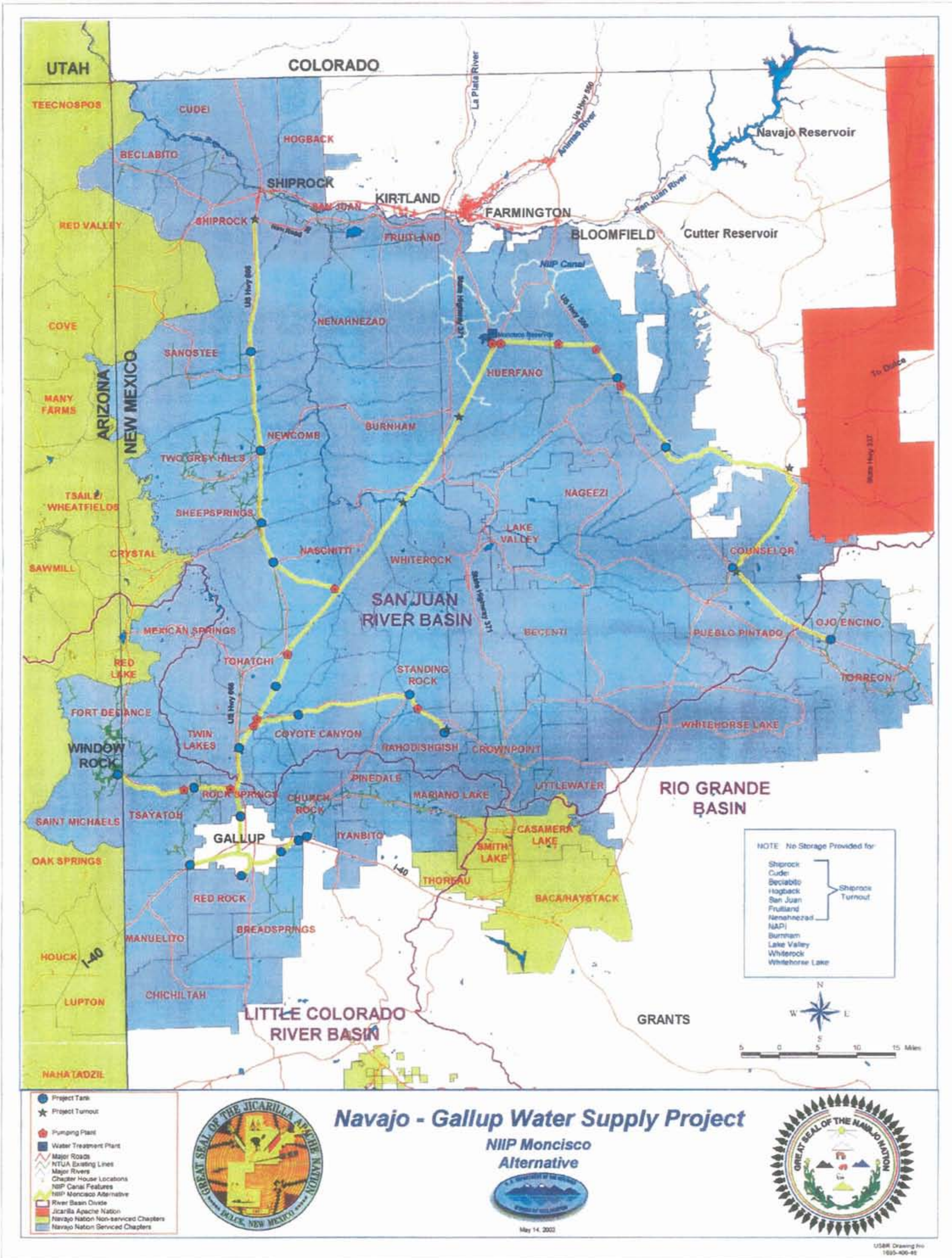
APPRAISAL LEVEL DESIGNS AND COST ESTIMATES

APPENDIX A

FIGURES AND DRAWINGS

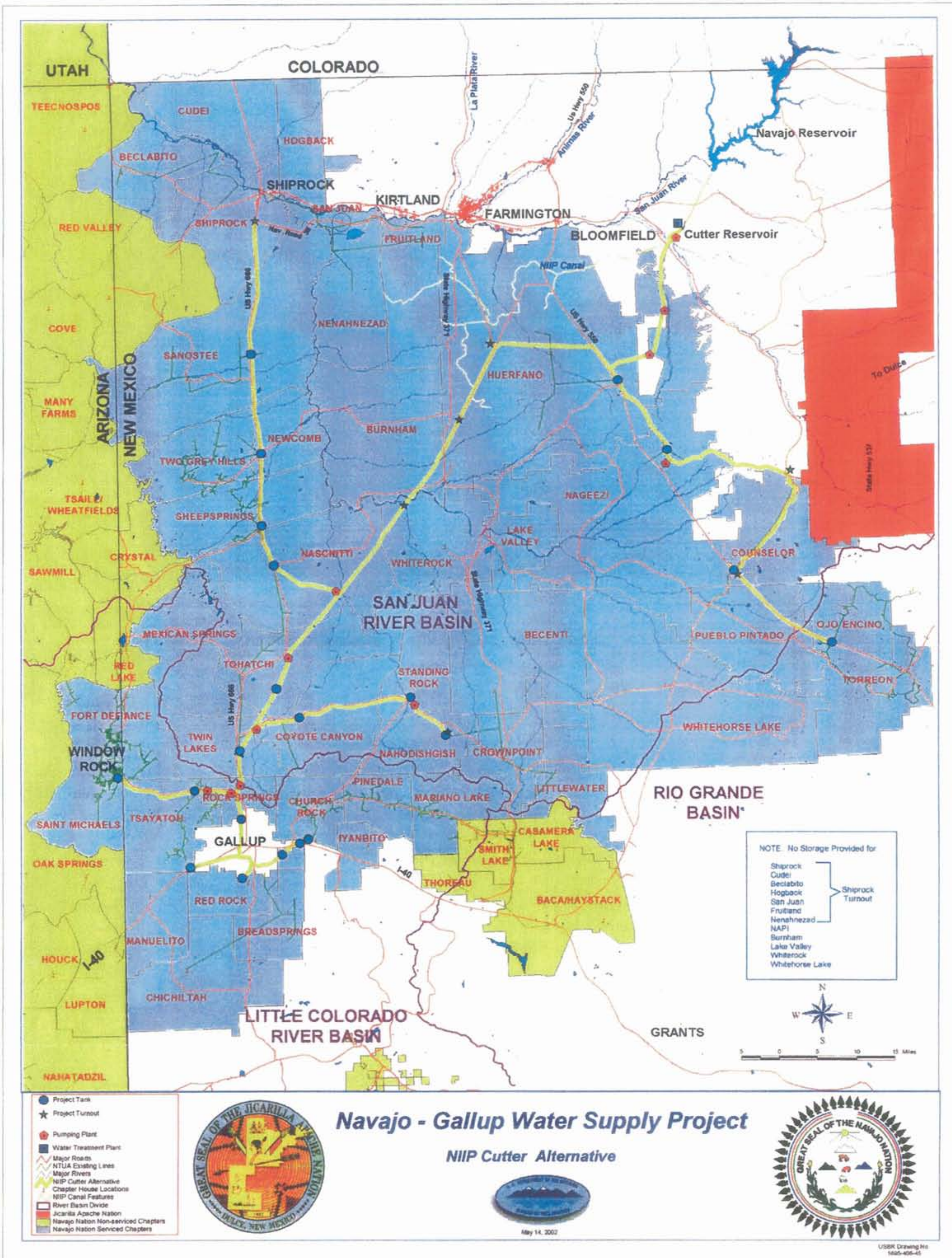
FIGURE LIST

DRAWING LIST



UTAH
COLORADO
ARIZONA
NEW MEXICO
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
Cutter Reservoir
Navajo Reservoir
SAN JUAN RIVER BASIN
RIO GRANDE BASIN
LITTLE COLORADO RIVER BASIN
GALLUP
GRANTS
WINDOW ROCK
NOTE: No Storage Provided for:
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
Shiprock Turnout
Project Tank
Project Turnout
Pumping Plant
Water Treatment Plant
Jicarilla Apache Nation
Navajo Nation Non-serviced Chapters
Navajo Nation Serviced Chapters
Navajo - Gallup Water Supply Project
NIIP Moncisco Alternative
May 14, 2003

Figure 1



UTAH
COLORADO
ARIZONA
NEW MEXICO
La Plata River
US Hwy 550
Animas River
Navajo Reservoir
San Juan River
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
Cutter Reservoir
NIIP Canal
US Hwy 666
State Highway 371
US Hwy 550
To Dulce
State Hwy 537
TEECNOSPOS
CUDEI
HOGBACK
BECLABITO
SAN JUAN
SHIPROCK
FRUITLAND
RED VALLEY
NENAHNEZAD
COVE
SANOSTEE
HUERFANO
MANY FARMS
BURNHAM
NEWCOMB
TWO GREY HILLS
TSAILE/ WHEATFIELDS
NAGEEZI
SHEEPSPRINGS
LAKE VALLEY
CRYSTAL
NASCHITTI
WHITEROCK
COUNSELOR
SAWMILL
SAN JUAN RIVER BASIN
MEXICAN SPRINGS
BECENTI
PUEBLO PINTADO
OJO ENCINO
RED LAKE
TOHATCHI
STANDING ROCK
TORREON
FORT DEFIANCE
TWIN LAKES
COYOTE CANYON
WHITEHORSE LAKE
WINDOW ROCK
NAHODISHGISH
CROWNPOINT
PINEDALE
LITTLEWATER
ROCK SPRINGS
CHURCH ROCK
MARIANO LAKE
RIO GRANDE BASIN
SAINT MICHAELS
TSAYATOH
GALLUP
IYANBITO
CASAMERA LAKE
SMITH LAKE
OAK SPRINGS
I-40
THOREAU
RED ROCK
BACA/HAYSTACK
BREADSPRINGS
MANUELITO
HOUCK
I-40
LUPTON
CHICHILTAH
LITTLE COLORADO RIVER BASIN
GRANTS
NAHATADZIL
NOTE: No Storage Provided for
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
Shiprock Turnout
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
N
W
E
S
5 0 5 10 15 Miles
Project Tank
Project Turnout
Pumping Plant
Water Treatment Plant
Major Roads
NTUA Existing Lines
Major Rivers
NIIP Cutter Alternative
Chapter House Locations
NIIP Canal Features
River Basin Divide
Jicarilla Apache Nation
Navajo Nation Non-serviced Chapters
Navajo Nation Serviced Chapters
GREAT SEAL OF THE JICARILLA APACHE NATION
DULCE, NEW MEXICO
Navajo - Gallup Water Supply Project
NIIP Cutter Alternative
May 14, 2002
GREAT SEAL OF THE NAVAJO NATION
USBR Drawing No

Figure 2

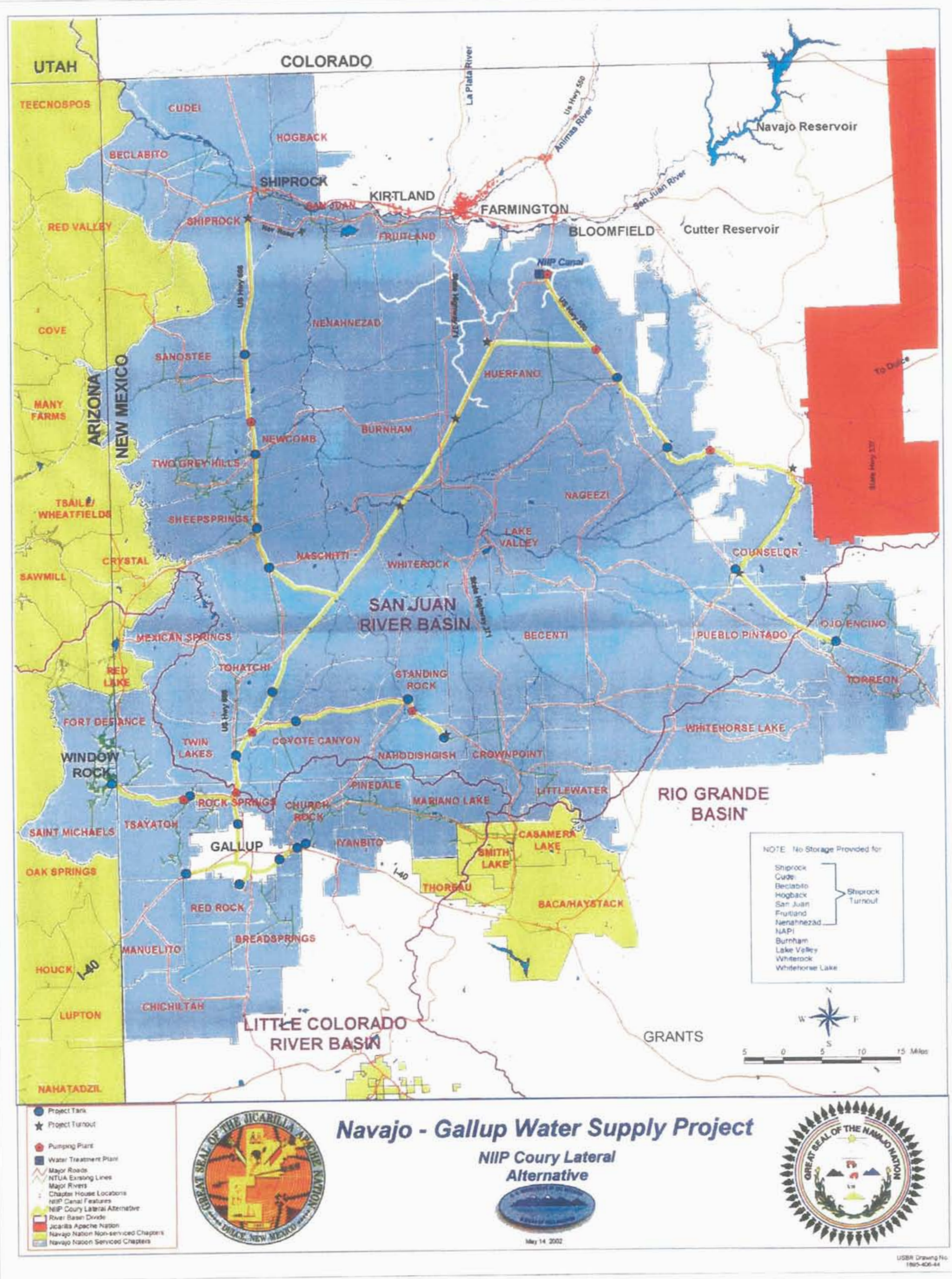
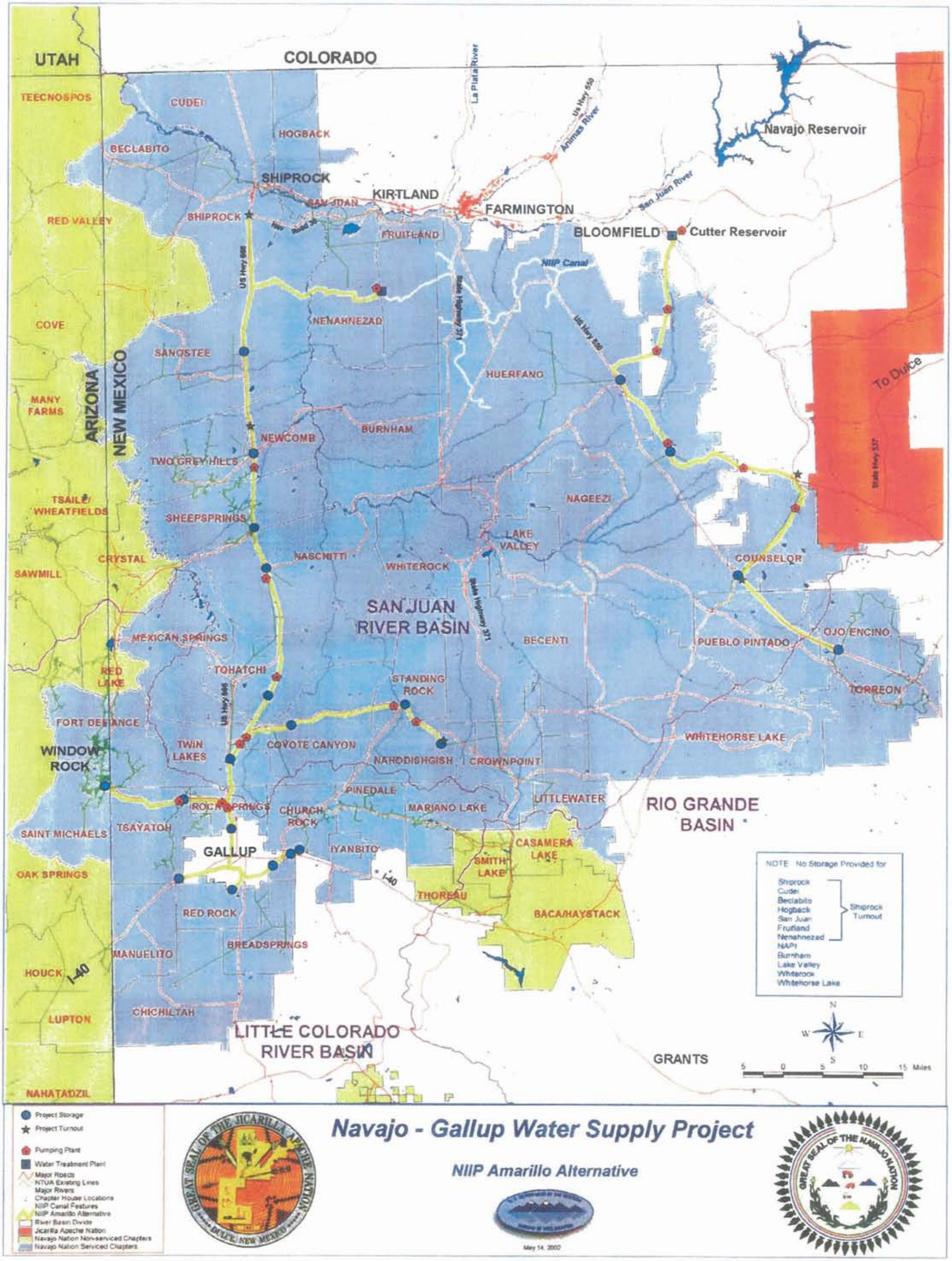
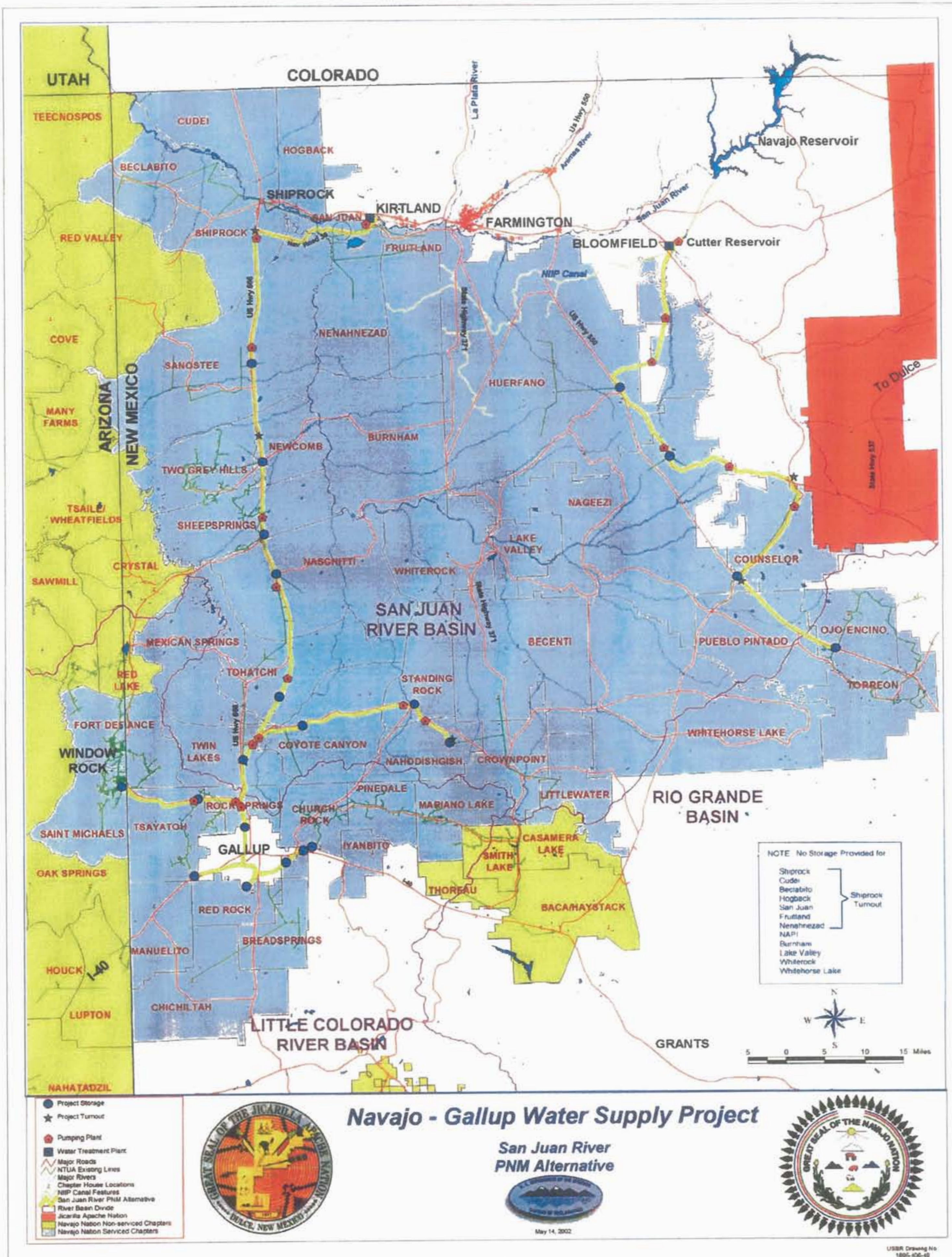

UTAH
COLORADO
ARIZONA
NEW MEXICO
La Plata River
Us Hwy 550
Animas River
Navajo Reservoir
San Juan River
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
Cutter Reservoir
NIIP Canal
TEECNOSPOS
CUDEI
HOGBACK
BECLABITO
RED VALLEY
SHIPROCK
SAN JUAN
FRUITLAND
COVE
NENAHNEZAD
SANOSTEE
HUERFANO
To Dulce
MANY FARMS
NEWCOMB
BURNHAM
TWO GREY HILLS
NAGEEZI
TSAILE/ WHEATFIELDS
SHEEPSPRINGS
LAKE VALLEY
CRYSTAL
NASCHITTI
WHITEROCK
COUNSELOR
SAWMILL
SAN JUAN RIVER BASIN
MEXICAN SPRINGS
BECENTI
PUEBLO PINTADO
OJO ENCINO
TOHATCHI
RED LAKE
STANDING ROCK
TORREON
FORT DEFIANCE
TWIN LAKES
COYOTE CANYON
WHITEHORSE LAKE
WINDOW ROCK
NAHODISHGISH
CROWNPOINT
PINEDALE
LITTLEWATER
RIO GRANDE BASIN
ROCK SPRINGS
CHURCH ROCK
MARIANO LAKE
SAINT MICHAELS
TSAYATOH
CASAMERA LAKE
GALLUP
IYANBITO
SMITH LAKE
OAK SPRINGS
I-40
THOREAU
RED ROCK
BACA/HAYSTACK
BREADSPRINGS
MANUELITO
HOUCK
I-40
CHICHILTAH
LUPTON
LITTLE COLORADO RIVER BASIN
GRANTS
NAHATADZIL
NOTE No Storage Provided for
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
Shiprock Turnout
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
N
W
E
S
5 0 5 10 15 Miles
Project Tank
Project Turnout
Pumping Plant
Water Treatment Plant
Major Roads
NTUA Existing Lines
Major Rivers
Chapter House Locations
NIIP Canal Features
NIIP Coury Lateral Alternative
River Basin Divide
Jicarilla Apache Nation
Navajo Nation Non-serviced Chapters
Navajo Nation Serviced Chapters
GREAT SEAL OF THE JICARILLA APACHE NATION
DULCE, NEW MEXICO
Navajo - Gallup Water Supply Project
NIIP Coury Lateral
Alternative
May 14 2002
GREAT SEAL OF THE NAVAJO NATION
USBR Drawing No. 1865-406-44

Figure 3



UTAH
COLORADO
ARIZONA
NEW MEXICO
Navajo Reservoir
La Plata River
Animas River
San Juan River
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
Cutter Reservoir
NIIP Canal
TEECNOSPOS
CUDEI
HOGBACK
BECLABITO
RED VALLEY
SAN JUAN
FRUITLAND
NENAHNEZAD
COVE
SANOSTEE
HUERFANO
MANY FARMS
NEWCOMB
BURNHAM
TWO GREY HILLS
To Dulce
State Hwy 537
TSAILE/ WHEATFIELDS
SHEEPSPRINGS
NAGEEZI
LAKE VALLEY
CRYSTAL
SAWMILL
NASCHITTI
WHITEROCK
COUNSELOR
SAN JUAN RIVER BASIN
BECENTI
OJO ENCINO
PUEBLO PINTADO
MEXICAN SPRINGS
TOHATCHI
RED LAKE
STANDING ROCK
TORREON
FORT DEFIANCE
WHITEHORSE LAKE
WINDOW ROCK
TWIN LAKES
COYOTE CANYON
NAHODISHGISH
CROWNPOINT
PINEDALE
LITTLEWATER
ROCK SPRINGS
CHURCH ROCK
MARIANO LAKE
RIO GRANDE BASIN
SAINT MICHAELS
TSAYATOH
GALLUP
IYANBITO
CASAMERA LAKE
SMITH LAKE
OAK SPRINGS
I-40
THOREAU
RED ROCK
BACA/HAYSTACK
BREADSPRINGS
MANUELITO
HOUCK
LUPTON
CHICHILTAH
LITTLE COLORADO RIVER BASIN
GRANTS
NAHATADZIL
NOTE No Storage Provided for
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
Shiprock Turnout
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
5 0 5 10 15 Miles
Project Storage
Project Turnout
Pumping Plant
Water Treatment Plant
Major Roads
NTUA Existing Lines
Major Rivers
Chapter House Locations
NIIP Canal Features
NIIP Amarillo Alternative
River Basin Divide
Jicarilla Apache Nation
Navajo Nation Nonserviced Chapters
Navajo Nation Serviced Chapters
GREAT SEAL OF THE JICARILLA APACHE NATION
DULCE, NEW MEXICO
Navajo - Gallup Water Supply Project
NIIP Amarillo Alternative
May 14, 2002
GREAT SEAL OF THE NAVAJO NATION
USBR Drawing No. 1695-406-47

Figure 4



UTAH
COLORADO
ARIZONA
NEW MEXICO
Navajo Reservoir
Cutter Reservoir
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
GALLUP
GRANTS
WINDOW ROCK
SAN JUAN RIVER BASIN
RIO GRANDE BASIN
LITTLE COLORADO RIVER BASIN
To Dulce
TEECNOSPOS
CUDEI
HOGBACK
BECLABITO
RED VALLEY
SAN JUAN
FRUITLAND
NENAHNEZAD
COVE
SANOSTEE
HUERFANO
MANY FARMS
BURNHAM
NEWCOMB
TWO GREY HILLS
NAGEEZI
TSAILE/ WHEATFIELDS
SHEEPSPRINGS
LAKE VALLEY
CRYSTAL
NASCHITTI
WHITEROCK
COUNSELOR
SAWMILL
OJO ENCINO
MEXICAN SPRINGS
BECENTI
PUEBLO PINTADO
RED LAKE
TOHATCHI
STANDING ROCK
TORREON
FORT DEFIANCE
TWIN LAKES
COYOTE CANYON
WHITEHORSE LAKE
NAHODISHGISH
CROWNPOINT
PINEDALE
LITTLEWATER
ROCK SPRINGS
CHURCH ROCK
MARIANO LAKE
SAINT MICHAELS
TSAYATOH
IYANBITO
CASAMERO LAKE
SMITH LAKE
OAK SPRINGS
THOREAU
RED ROCK
BACA/HAYSTACK
BREADSPRINGS
MANUELITO
HOUCK
I-40
CHICHILTAH
LUPTON
NAHATADZIL
NOTE No Storage Provided for
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
Shiprock Turnout
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
5 0 5 10 15 Miles
Project Storage
Project Turnout
Pumping Plant
Water Treatment Plant
Major Roads
NTUA Existing Lines
Major Rivers
Chapter House Locations
NIIP Canal Features
San Juan River PNM Alternative
River Basin Divide
Jicarilla Apache Nation
Navajo Nation Non-serviced Chapters
Navajo Nation Serviced Chapters
Navajo - Gallup Water Supply Project
San Juan River
PNM Alternative
May 14, 2002
USBR Drawing No. 1665-406-40

Figure 5

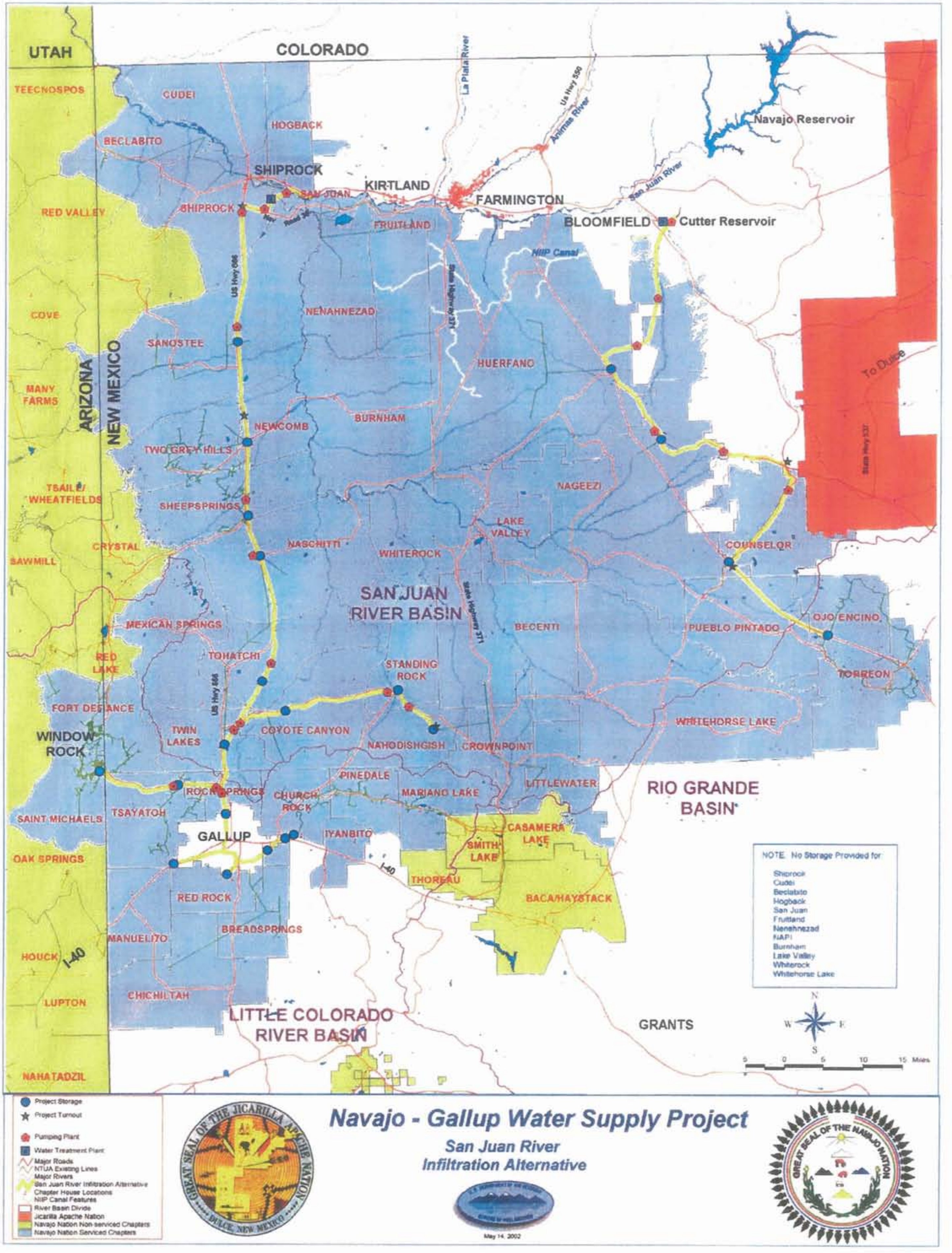
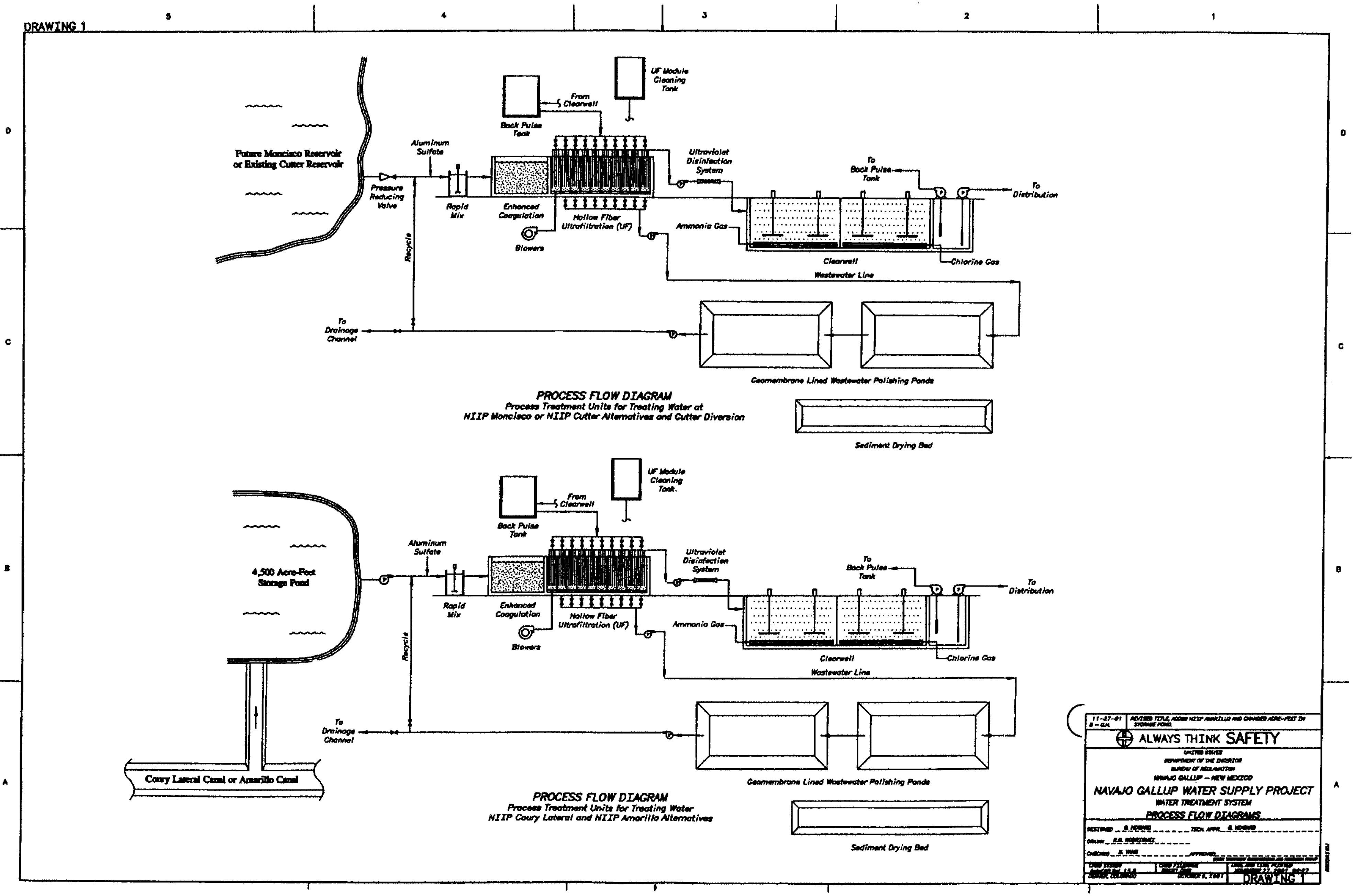
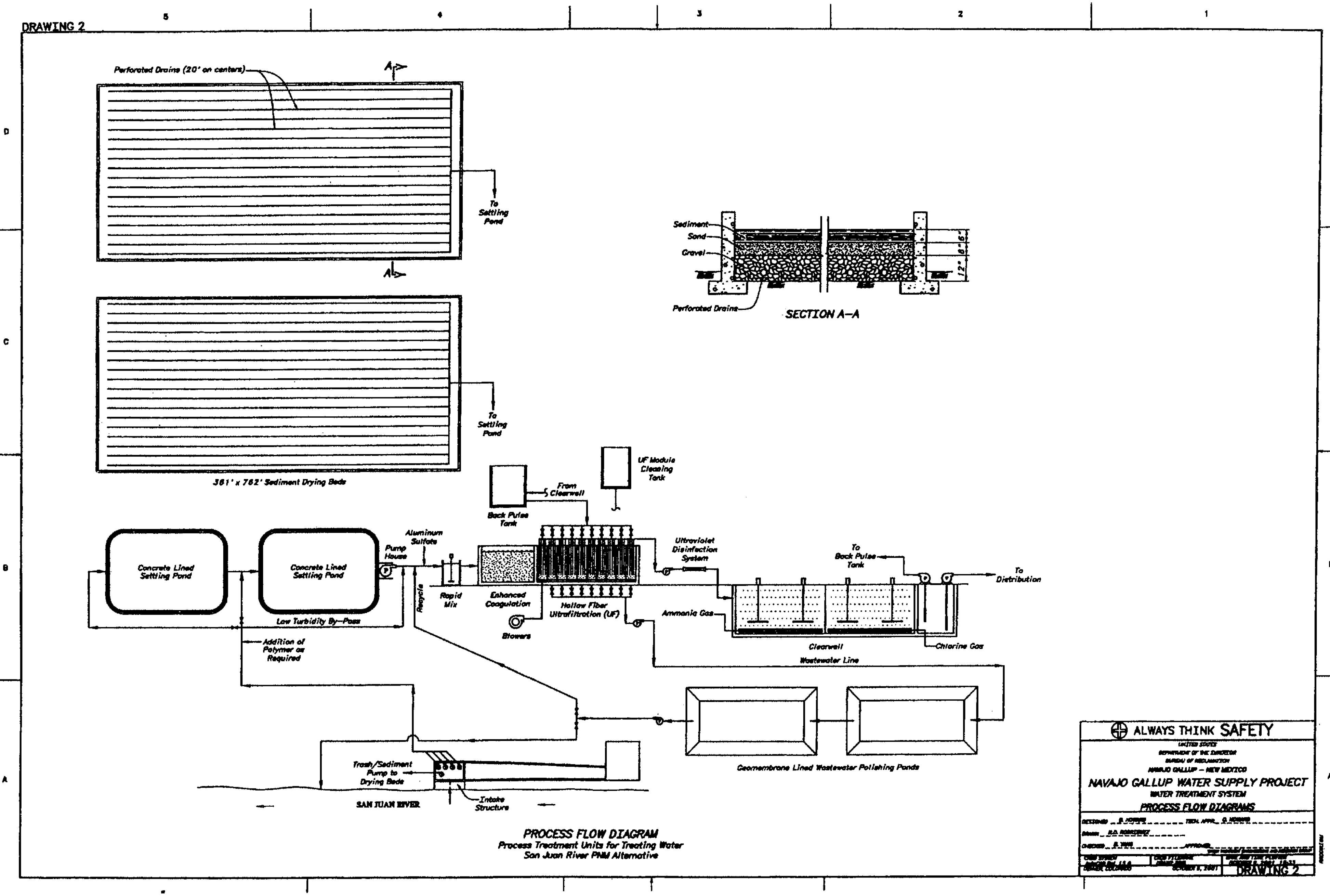

UTAH
COLORADO
ARIZONA
NEW MEXICO
TEECNOSPOS
CUDEI
HOGBACK
BECLABITO
SHIPROCK
KIRTLAND
FARMINGTON
BLOOMFIELD
Cutter Reservoir
Navajo Reservoir
La Plata River
Animas River
San Juan River
Us Hwy 550
SAN JUAN
FRUITLAND
RED VALLEY
NIIP Canal
US Hwy 666
State Highway 371
COVE
NENAHNEZAD
HUERFANO
To Dulce
State Hwy 537
SANOSTEE
MANY FARMS
NEWCOMB
BURNHAM
TWO GREY HILLS
TSAILE/ WHEATFIELDS
NAGEEZI
SHEEPSPRINGS
LAKE VALLEY
CRYSTAL
NASCHITTI
WHITEROCK
COUNSELOR
SAWMILL
SAN JUAN RIVER BASIN
MEXICAN SPRINGS
BECENTI
PUEBLO PINTADO
OJO ENCINO
RED LAKE
TOHATCHI
STANDING ROCK
TORREON
FORT DEFIANCE
WINDOW ROCK
TWIN LAKES
COYOTE CANYON
NAHODISHGISH
CROWNPOINT
WHITEHORSE LAKE
PINEDALE
MARIANO LAKE
LITTLEWATER
RIO GRANDE BASIN
ROCK SPRINGS
CHURCH ROCK
TSAYATOH
SAINT MICHAELS
GALLUP
IYANBITO
CASAMERA LAKE
SMITH LAKE
OAK SPRINGS
I-40
THOREAU
RED ROCK
BACA/HAYSTACK
BREADSPRINGS
MANUELITO
HOUCK
CHICHILTAH
LUPTON
LITTLE COLORADO RIVER BASIN
GRANTS
NAHATADZIL
NOTE: No Storage Provided for:
Shiprock
Cudei
Beclabito
Hogback
San Juan
Fruitland
Nenahnezad
NAPI
Burnham
Lake Valley
Whiterock
Whitehorse Lake
N
W
E
S
5 0 5 10 15 Miles
Project Storage
Project Turnout
Pumping Plant
Water Treatment Plant
Major Roads
NTUA Existing Lines
Major Rivers
San Juan River Infiltration Alternative
Chapter House Locations
NIIP Canal Features
River Basin Divide
Jicarilla Apache Nation
Navajo Nation Non-serviced Chapters
Navajo Nation Serviced Chapters
GREAT SEAL OF THE JICARILLA APACHE NATION
DULCE, NEW MEXICO
Navajo - Gallup Water Supply Project
San Juan River
Infiltration Alternative
May 14, 2002
GREAT SEAL OF THE NAVAJO NATION
USBR Drawing No.
1665-400-48

Figure 6

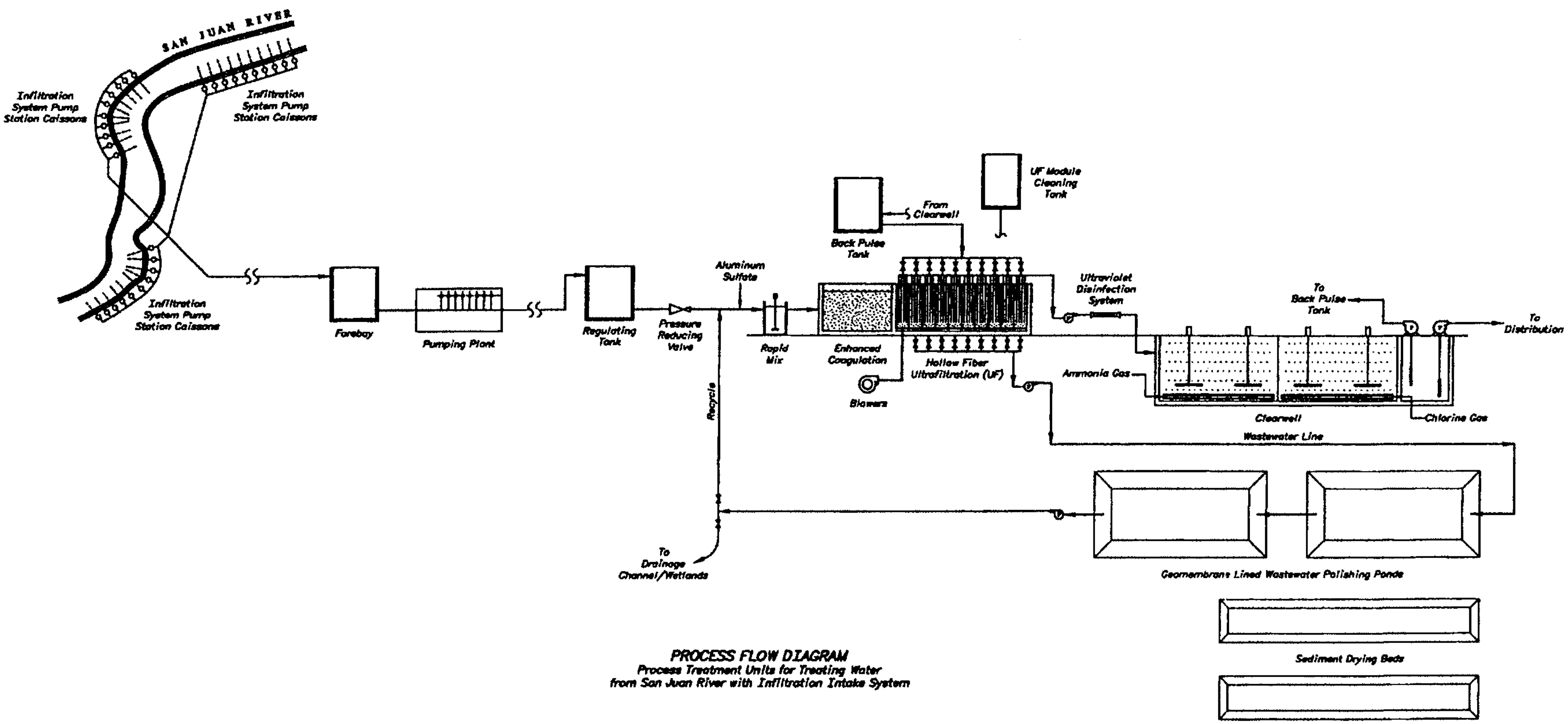

DRAWING 1
Future Moncisco Reservoir or Existing Cutter Reservoir
Pressure Reducing Valve
Aluminum Sulfate
Recycle
Rapid Mix
Enhanced Coagulation
Blowers
Back Pulse Tank
From Clearwell
UF Module Cleaning Tank
Hollow Fiber Ultrafiltration (UF)
Ultraviolet Disinfection System
To Back Pulse Tank
To Distribution
Ammonia Gas
Clearwell
Chlorine Gas
Wastewater Line
To Drainage Channel
Geomembrane Lined Wastewater Polishing Ponds
PROCESS FLOW DIAGRAM
Process Treatment Units for Treating Water at
NIIP Moncisco or NIIP Cutter Alternatives and Cutter Diversion
Sediment Drying Bed
4,500 Acre-Feet Storage Pond
Coury Lateral Canal or Amarillo Canal
Aluminum Sulfate
Recycle
Rapid Mix
Enhanced Coagulation
Blowers
Back Pulse Tank
From Clearwell
UF Module Cleaning Tank.
Hollow Fiber Ultrafiltration (UF)
Ultraviolet Disinfection System
To Back Pulse Tank
To Distribution
Ammonia Gas
Clearwell
Chlorine Gas
Wastewater Line
To Drainage Channel
Geomembrane Lined Wastewater Polishing Ponds
PROCESS FLOW DIAGRAM
Process Treatment Units for Treating Water
NIIP Coury Lateral and NIIP Amarillo Alternatives
Sediment Drying Bed
ALWAYS THINK SAFETY
NAVAJO GALLUP WATER SUPPLY PROJECT
WATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAMS
DRAWING 1



PROCESS FLOW DIAGRAM

Process Treatment Units for Treating Water
San Juan River PNM Alternative

DRAWING 3



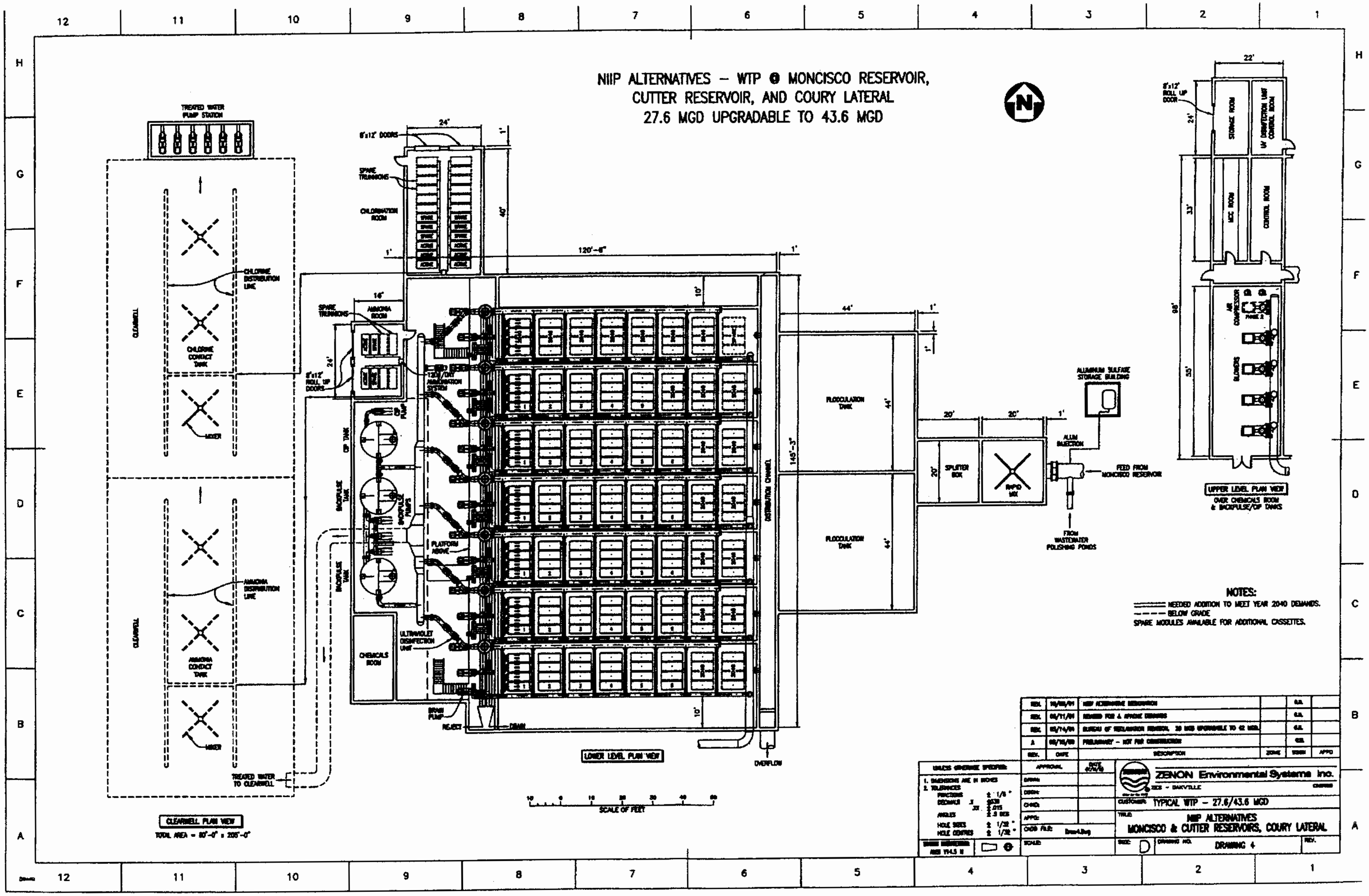
PROCESS FLOW DIAGRAM
Process Treatment Units for Treating Water from San Juan River with Infiltration Intake System

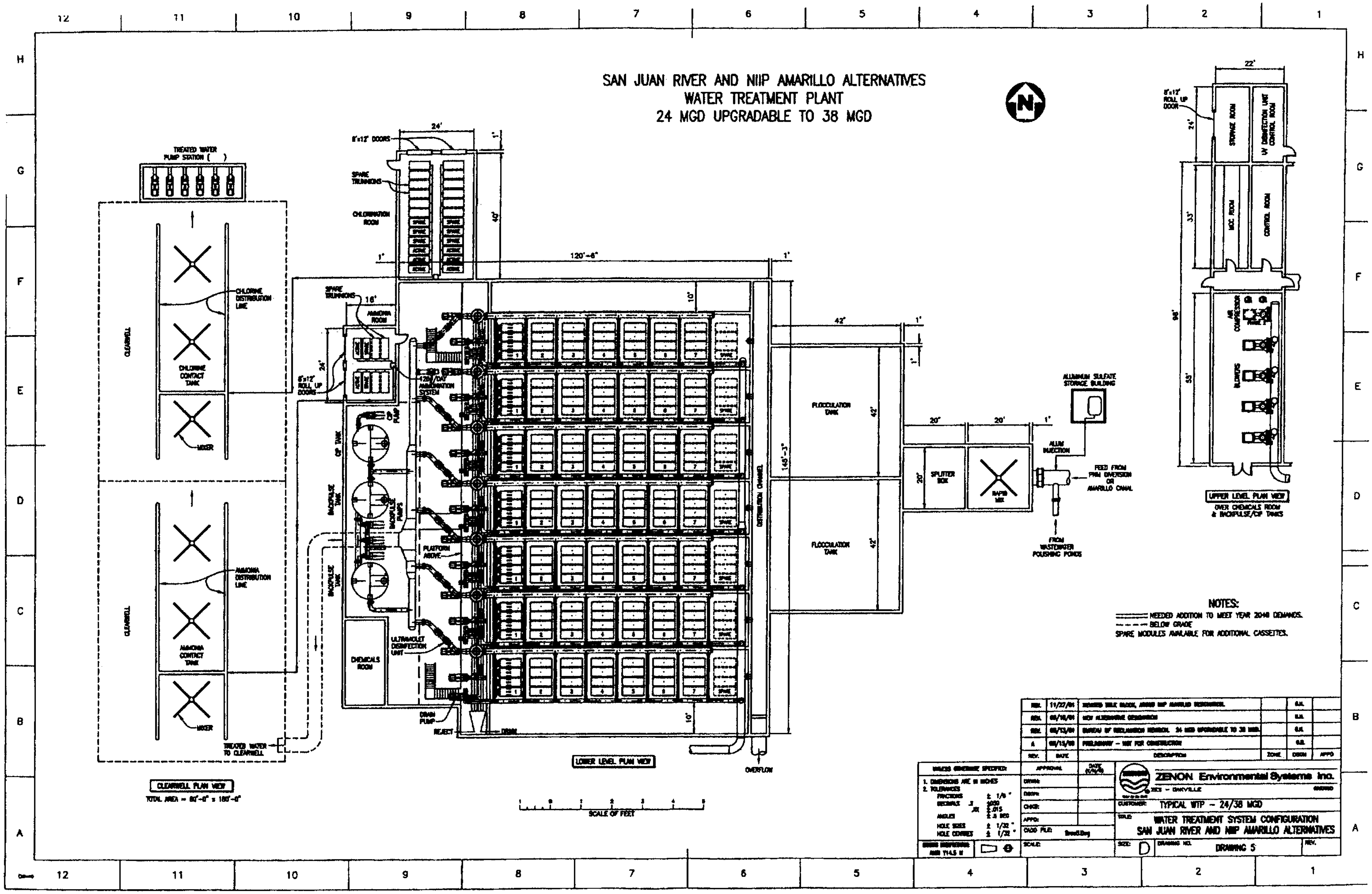
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP — NEW MEXICO

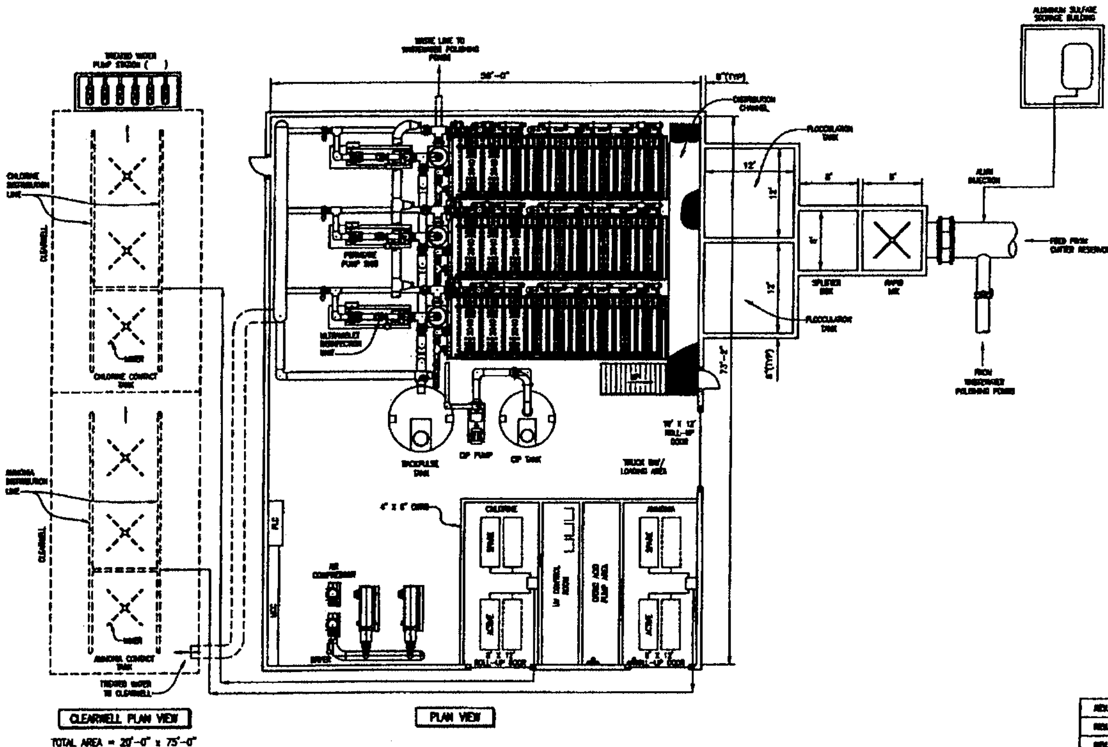
NAVAJO GALLUP WATER SUPPLY PROJECT
WATER TREATMENT SYSTEM
PROCESS FLOW DIAGRAM

DRAWING 3


NIIP ALTERNATIVES – WTP @ MONCISCO RESERVOIR,
CUTTER RESERVOIR, AND COURY LATERAL
27.6 MGD UPGRADABLE TO 43.6 MGD
TREATED WATER PUMP STATION
CLEARWELL
CHLORINE DISTRIBUTION LINE
CHLORINE CONTACT TANK
MIXER
AMMONIA DISTRIBUTION LINE
AMMONIA CONTACT TANK
TREATED WATER TO CLEARWELL
CLEARWELL PLAN VIEW
8'x12' DOORS
SPARE TRUNNIONS
CHLORINATION ROOM
AMMONIA ROOM
8'x12' ROLL UP DOORS
CIP TANK
CIP PUMP
BACKPULSE TANK
BACKPULSE PUMPS
PLATFORM ABOVE
ULTRAVIOLET DISINFECTION UNIT
CHEMICALS ROOM
DRAIN PUMP
REJECT
DRAIN
DISTRIBUTION CHANNEL
OVERFLOW
LOWER LEVEL PLAN VIEW
120'-8"
145'-3"
FLOCCULATION TANK
SPLITTER BOX
RAPID MIX
ALUMINUM SULFATE STORAGE BUILDING
ALUM INJECTION
FEED FROM MONCISCO RESERVOIR
FROM WASTEWATER POLISHING PONDS
SCALE OF FEET
STORAGE ROOM
UV DISINFECTION UNIT CONTROL ROOM
MCC ROOM
CONTROL ROOM
AIR COMPRESSOR
BLOWERS
UPPER LEVEL PLAN VIEW
OVER CHEMICALS ROOM & BACKPULSE/CIP TANKS
NOTES:
NEEDED ADDITION TO MEET YEAR 2040 DEMANDS.
BELOW GRADE
SPARE MODULES AVAILABLE FOR ADDITIONAL CASSETTES.
UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONS ARE IN INCHES
2. TOLERANCES
ZENON Environmental Systems Inc.
ZES – OAKVILLE
CUSTOMER: TYPICAL WTP – 27.6/43.6 MGD
TITLE: NIIP ALTERNATIVES
MONCISCO & CUTTER RESERVOIRS, COURY LATERAL
DRAWING NO. DRAWING 4
SIZE: D


SAN JUAN RIVER AND NIIP AMARILLO ALTERNATIVES
WATER TREATMENT PLANT
24 MGD UPGRADABLE TO 38 MGD
TREATED WATER PUMP STATION
CLEARWELL
CHLORINE DISTRIBUTION LINE
CHLORINE CONTACT TANK
MIXER
AMMONIA DISTRIBUTION LINE
AMMONIA CONTACT TANK
TREATED WATER TO CLEARWELL
CLEARWELL PLAN VIEW
8'x12' DOORS
SPARE TRUNNIONS
CHLORINATION ROOM
AMMONIA ROOM
8'x12' ROLL UP DOORS
CIP TANK
CIP PUMP
BACKPULSE TANK
BACKPULSE PUMPS
PLATFORM ABOVE
ULTRAVIOLET DISINFECTION UNIT
CHEMICALS ROOM
DRAIN PUMP
REJECT
DRAIN
120'-6"
DISTRIBUTION CHANNEL
OVERFLOW
LOWER LEVEL PLAN VIEW
FLOCCULATION TANK
SPLITTER BOX
RAPID MIX
ALUM INJECTION
ALUMINUM SULFATE STORAGE BUILDING
FEED FROM PMM DIVERSION OR AMARILLO CANAL
FROM WASTEWATER POLISHING PONDS
SCALE OF FEET
STORAGE ROOM
UV DISINFECTION UNIT CONTROL ROOM
MCC ROOM
CONTROL ROOM
AIR COMPRESSOR
BLOWERS
UPPER LEVEL PLAN VIEW
OVER CHEMICALS ROOM & BACKPULSE/CIP TANKS
NOTES:
NEEDED ADDITION TO MEET YEAR 2040 DEMANDS.
BELOW GRADE
SPARE MODULES AVAILABLE FOR ADDITIONAL CASSETTES.
1. DIMENSIONS ARE IN INCHES
2. TOLERANCES
ZENON Environmental Systems Inc.
OAKVILLE
CUSTOMER: TYPICAL WTP – 24/38 MGD
TITLE: WATER TREATMENT SYSTEM CONFIGURATION
SAN JUAN RIVER AND NIIP AMARILLO ALTERNATIVES
SIZE: D
DRAWING NO. DRAWING 5

SAN JUAN RIVER AND NIIP AMARILLO ALTERNATIVES
WTP @ CUTTER RESERVOIR DIVERSION
3.7 MGD UPGRADABLE TO 5.4 MGD



CLEARWELL PLAN VIEW

TOTAL AREA = 20'-0" x 75'-0"

PLAN VIEW

SCALE OF FEET

NOTES:

═══ NEEDED ADDITION TO MEET YEAR 2040 DEMANDS.

– – – BELOW GRADE

REV.	DATE	DESCRIPTION	ZONE	DSGN	APPD
REV.	11/20/00	[illegible] NIIP AMARILLO.		G.L.	
REV.	09/16/00	NEW ALTERNATIVE [illegible]		G.L.	
REV.	08/11/00	REVISED FOR J. APACHE DEMANDS		G.L.	
REV.	03/13/00	BUREAU OF RECLAMATION REVISION. 2.35 MGD UPGRADABLE TO 4 MGD		G.L.	
A	07/18/00	PRELIMINARY – NOT FOR CONSTRUCTION		G.L.	

UNLESS OTHERWISE SPECIFIED:

1. DIMENSIONS ARE IN INCHES
2. TOLERANCES
   - FRACTIONS ± 1/8"
   - DECIMALS .X ±.030, .XX ±.015
   - ANGLES ±.5 DEG
   - HOLE SIZES ± 1/32"
   - HOLE CENTRES ± 1/32"

APPROVAL / DATE: DRAWN: / DSGN: / CHKD: / APPD:

CADD FILE: Draw6.Dwg

SCALE:

ZENON Environmental Systems Inc.

ZES – OAKVILLE

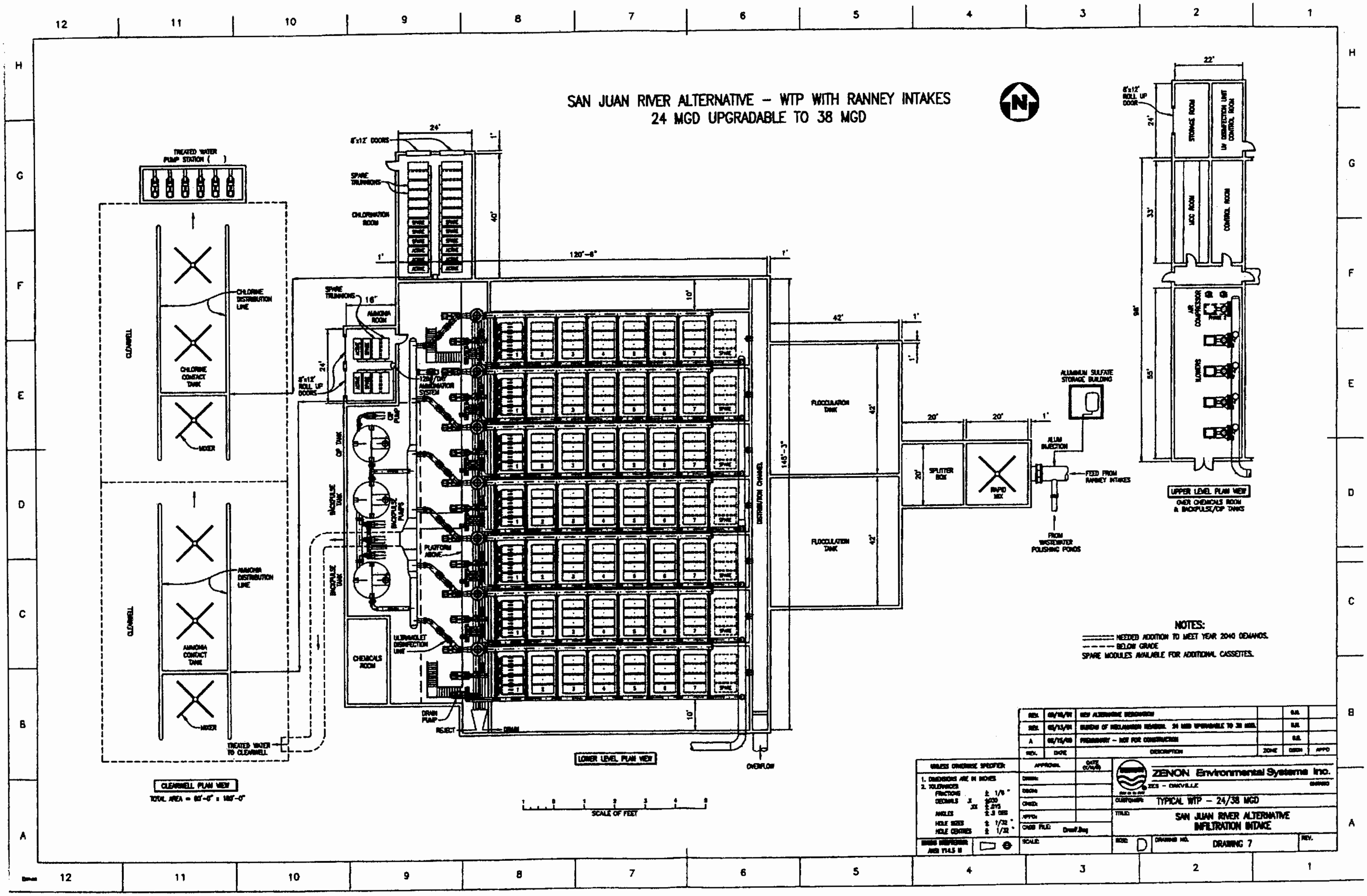
CUSTOMER: TYPICAL WTP – 3.7/5.4 MGD

TITLE: CUTTER RESERVOIR DIVERSION SAN JUAN RIVER AND NIIP AMARILLO ALTERNATIVES

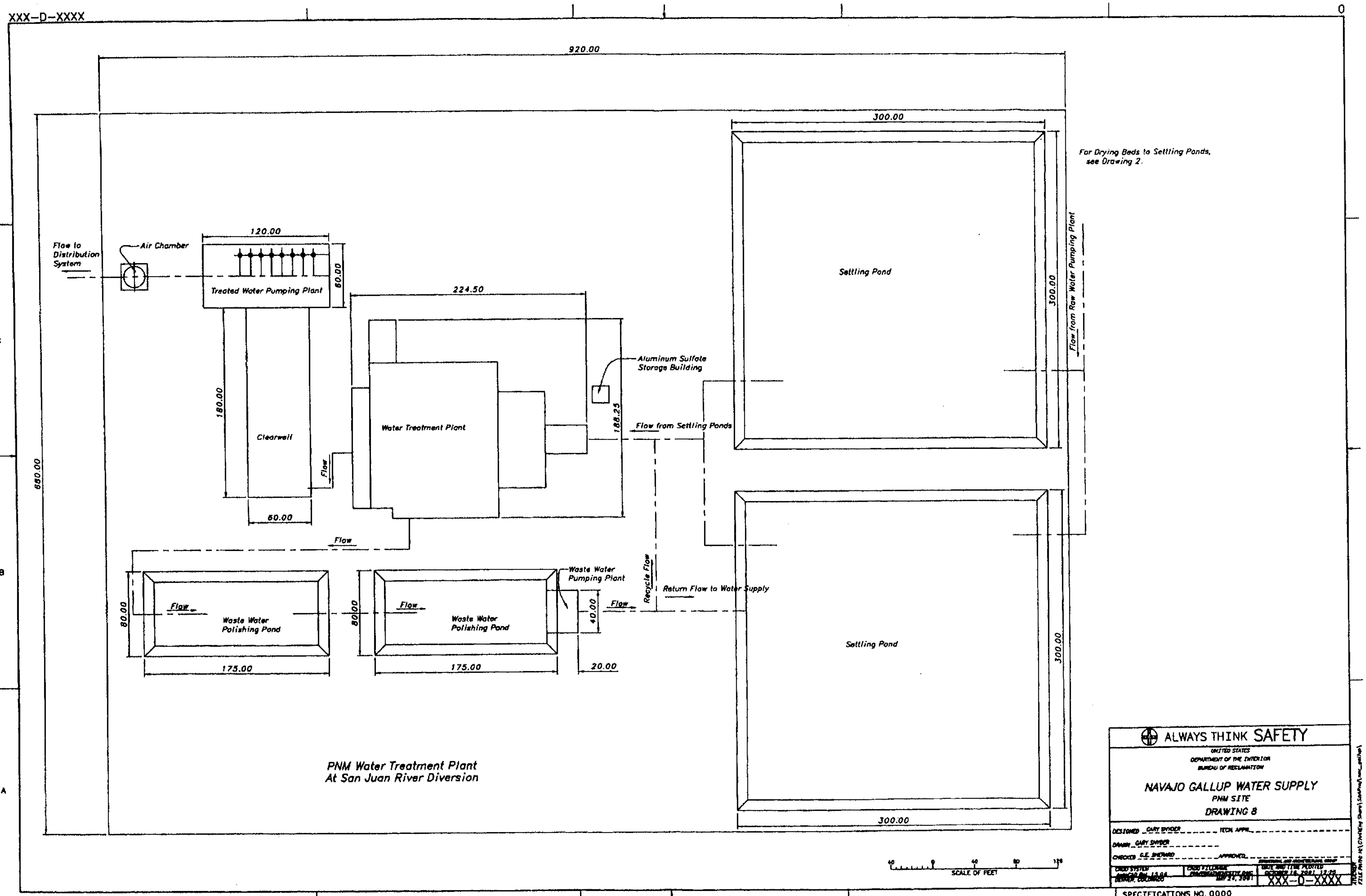
SIZE: D

DRAWING NO. DRAWING 6

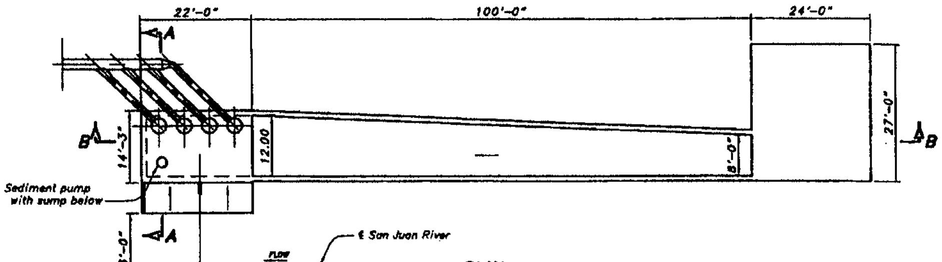
REV.



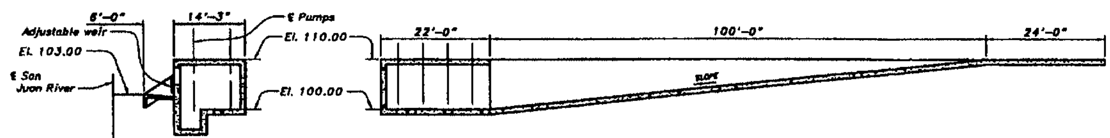
SAN JUAN RIVER ALTERNATIVE – WTP WITH RANNEY INTAKES
24 MGD UPGRADABLE TO 38 MGD
TREATED WATER PUMP STATION
CLEARWELL
CHLORINE DISTRIBUTION LINE
CHLORINE CONTACT TANK
MIXER
AMMONIA DISTRIBUTION LINE
AMMONIA CONTACT TANK
TREATED WATER TO CLEARWELL
CLEARWELL PLAN VIEW
CHLORINATION ROOM
SPARE TRUNNIONS
AMMONIA ROOM
CIP TANK
BACKPULSE TANK
BACKPULSE PUMPS
PLATFORM ABOVE
ULTRAVIOLET DISINFECTION UNIT
CHEMICALS ROOM
DRAIN PUMP
REJECT
DRAIN
DISTRIBUTION CHANNEL
OVERFLOW
LOWER LEVEL PLAN VIEW
SCALE OF FEET
FLOCCULATION TANK
SPLITTER BOX
RAPID MIX
ALUMINUM SULFATE STORAGE BUILDING
ALUM INJECTION
FEED FROM RANNEY INTAKES
FROM WASTEWATER POLISHING PONDS
STORAGE ROOM
UV DISINFECTION UNIT CONTROL ROOM
MCC ROOM
CONTROL ROOM
AIR COMPRESSOR
BLOWERS
UPPER LEVEL PLAN VIEW
OVER CHEMICALS ROOM & BACKPULSE/CIP TANKS
NOTES:
NEEDED ADDITION TO MEET YEAR 2040 DEMANDS.
BELOW GRADE
SPARE MODULES AVAILABLE FOR ADDITIONAL CASSETTES.
A
PRELIMINARY – NOT FOR CONSTRUCTION
REV.
DATE
DESCRIPTION
ZONE
APPD
UNLESS OTHERWISE SPECIFIED
1. DIMENSIONS ARE IN INCHES
2. TOLERANCES
FRACTIONS ± 1/8"
ANGLES
HOLE SIZES ± 1/32"
HOLE CENTRES ± 1/32"
APPROVAL
DATE
CADD FILE:
SCALE:
ZENON Environmental Systems Inc.
CUSTOMER: TYPICAL WTP – 24/38 MGD
TITLE: SAN JUAN RIVER ALTERNATIVE INFILTRATION INTAKE
SIZE: D
DRAWING NO. DRAWING 7
REV.



XXX-D-XXXX
920.00
680.00
300.00
For Drying Beds to Settling Ponds, see Drawing 2.
Flow to Distribution System
Air Chamber
120.00
60.00
Treated Water Pumping Plant
224.50
180.00
Clearwell
60.00
Flow
Water Treatment Plant
188.25
Aluminum Sulfate Storage Building
Flow from Settling Ponds
Settling Pond
Flow from Raw Water Pumping Plant
Flow
Waste Water Pumping Plant
Recycle Flow
Return Flow to Water Supply
80.00
Waste Water Polishing Pond
175.00
40.00
20.00
Settling Pond
300.00
PNM Water Treatment Plant
At San Juan River Diversion
SCALE OF FEET
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY
PNM SITE
DRAWING 8
DESIGNED GARY SNYDER
TECH. APPR.
DRAWN GARY SNYDER
CHECKED G.E. SHEPARD
APPROVED
DENVER, COLORADO
XXX-D-XXXX
SPECIFICATIONS NO. 0000

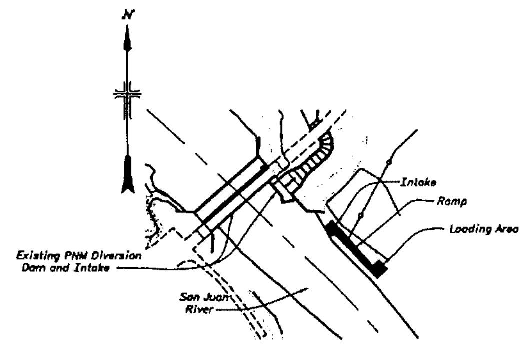


PLAN



SECTION A–A

SECTION B–B



LOCATION

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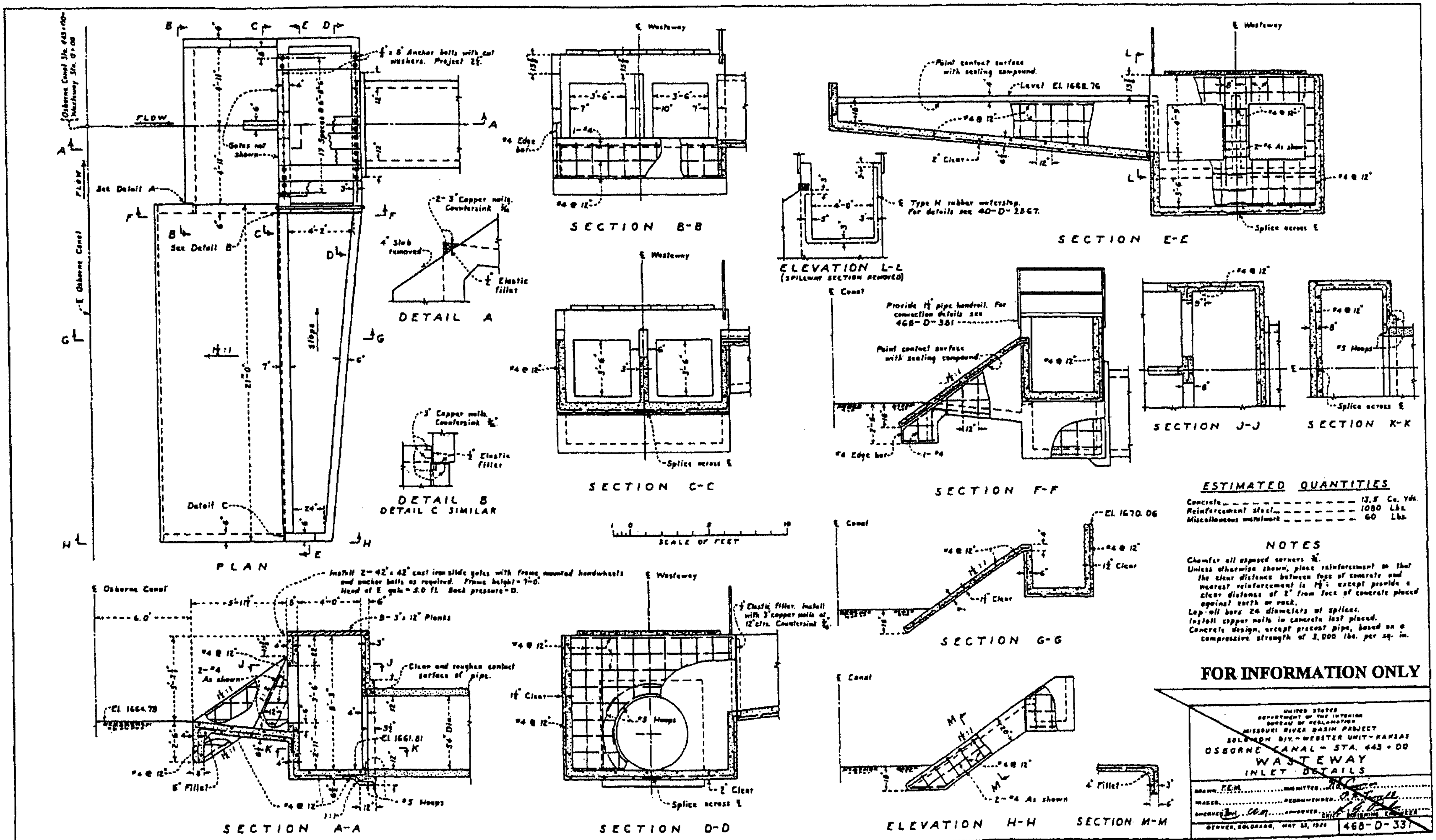
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
TURNOUT STRUCTURE – SJR PNM ALTERNATIVE
DRAWING 9

DESIGNED ________ TECH. APPR. ________
DRAWN A.M. TUCKER
CHECKED ________ APPROVED ________

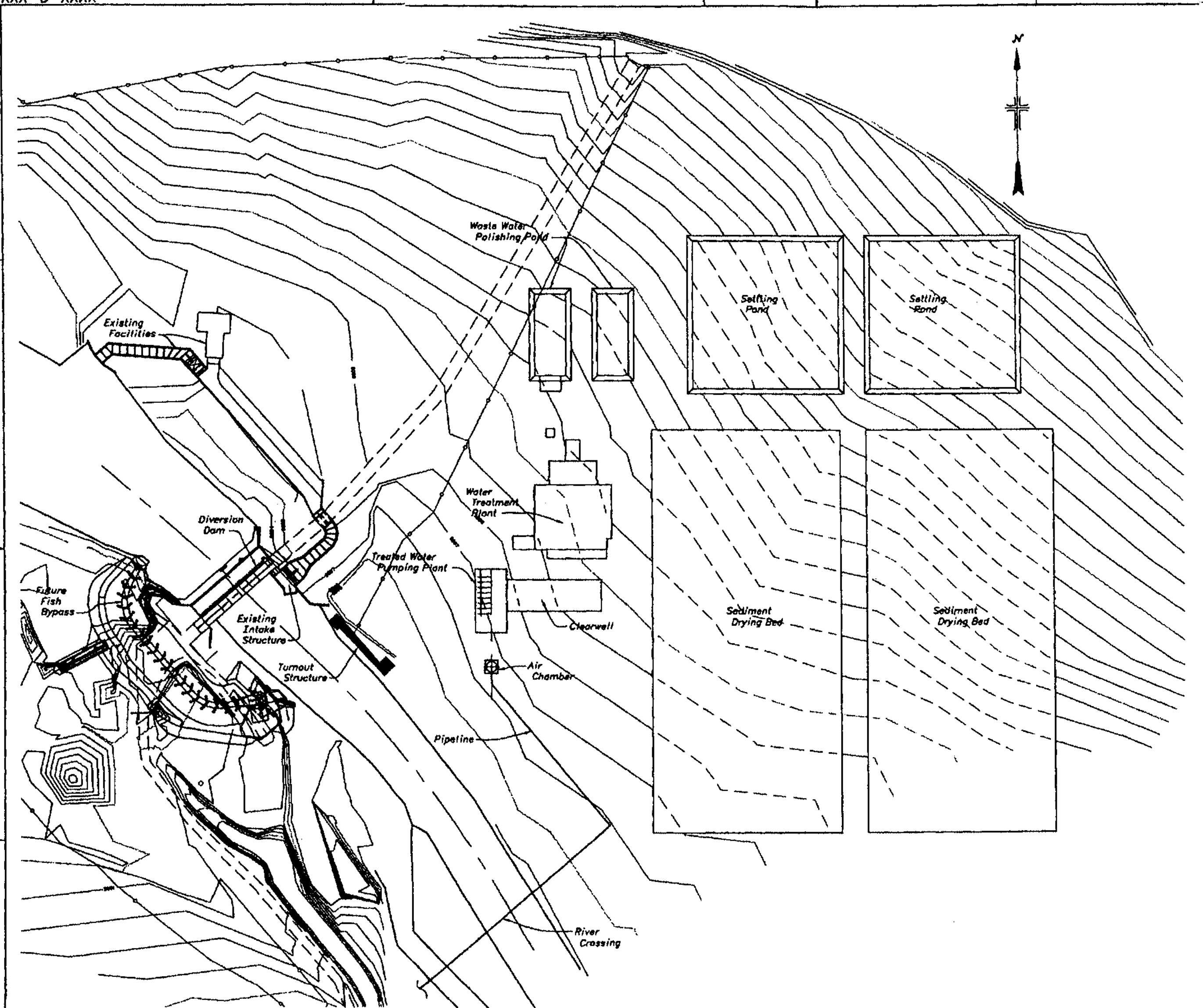
DENVER, COLORADO

XXX–D–XXXX


PLAN
DETAIL A
DETAIL B
DETAIL C SIMILAR
SECTION B-B
SECTION C-C
SECTION D-D
SECTION A-A
SECTION E-E
ELEVATION L-L
(SPILLWAY SECTION REMOVED)
SECTION F-F
SECTION J-J
SECTION K-K
SECTION G-G
ELEVATION H-H
SECTION M-M
SCALE OF FEET
ESTIMATED QUANTITIES
Concrete 13.5 Cu. Yds.
Reinforcement steel 1080 Lbs.
Miscellaneous metalwork 60 Lbs.
NOTES
Chamfer all exposed corners ¾".
Unless otherwise shown, place reinforcement so that the clear distance between face of concrete and nearest reinforcement is 1½"; except provide a clear distance of 2" from face of concrete placed against earth or rock.
Lap all bars 24 diameters at splices.
Install copper nails in concrete last placed.
Concrete design, except precast pipe, based on a compressive strength of 3,000 lbs. per sq. in.
FOR INFORMATION ONLY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI RIVER BASIN PROJECT
SOLOMON DIV. - WEBSTER UNIT - KANSAS
OSBORNE CANAL - STA. 443 + 00
WASTEWAY
INLET DETAILS
DENVER, COLORADO
468-D-331

DRAWING 10

XXX-D-XXXX



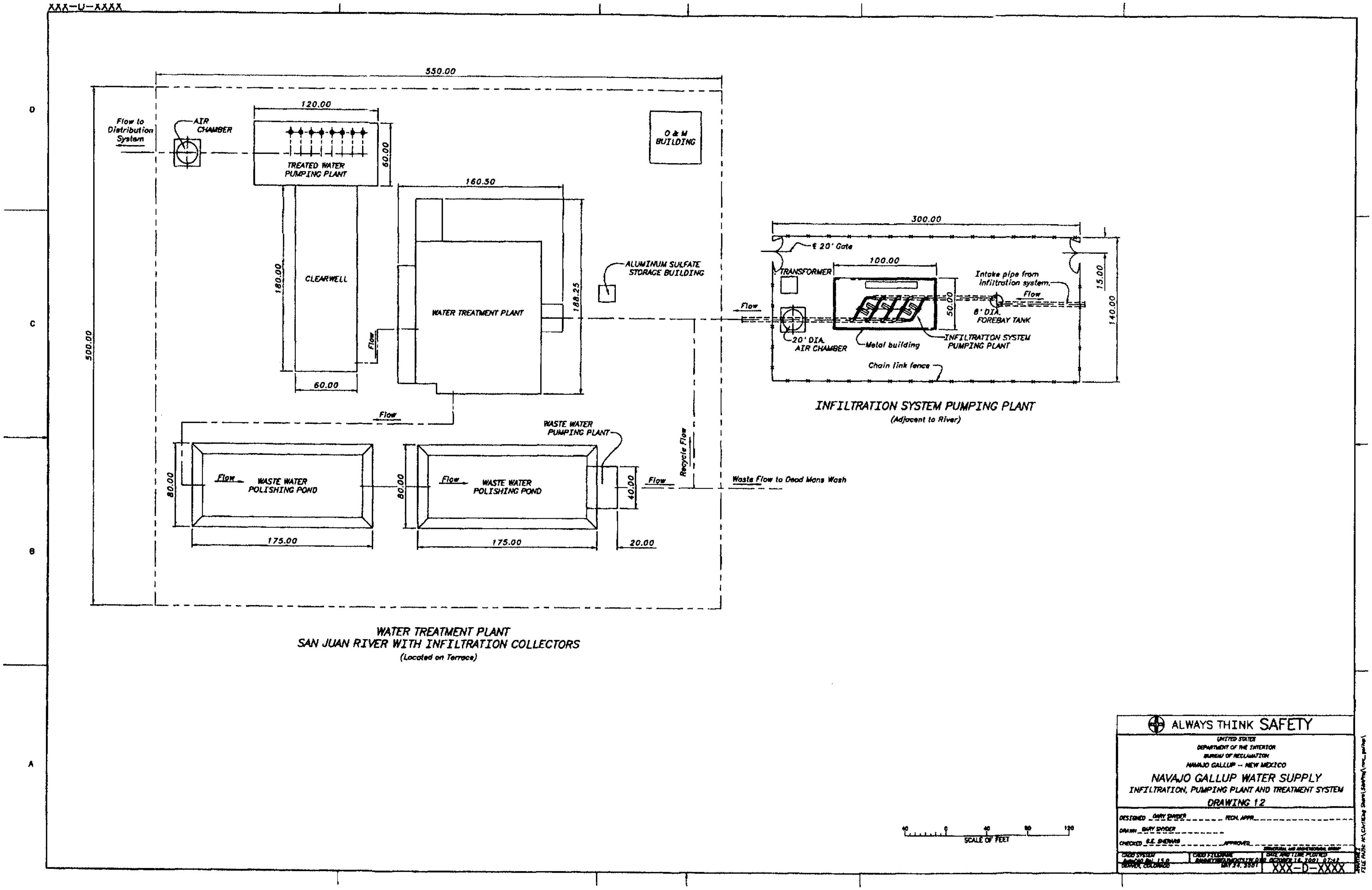
ALWAYS THINK SAFETY

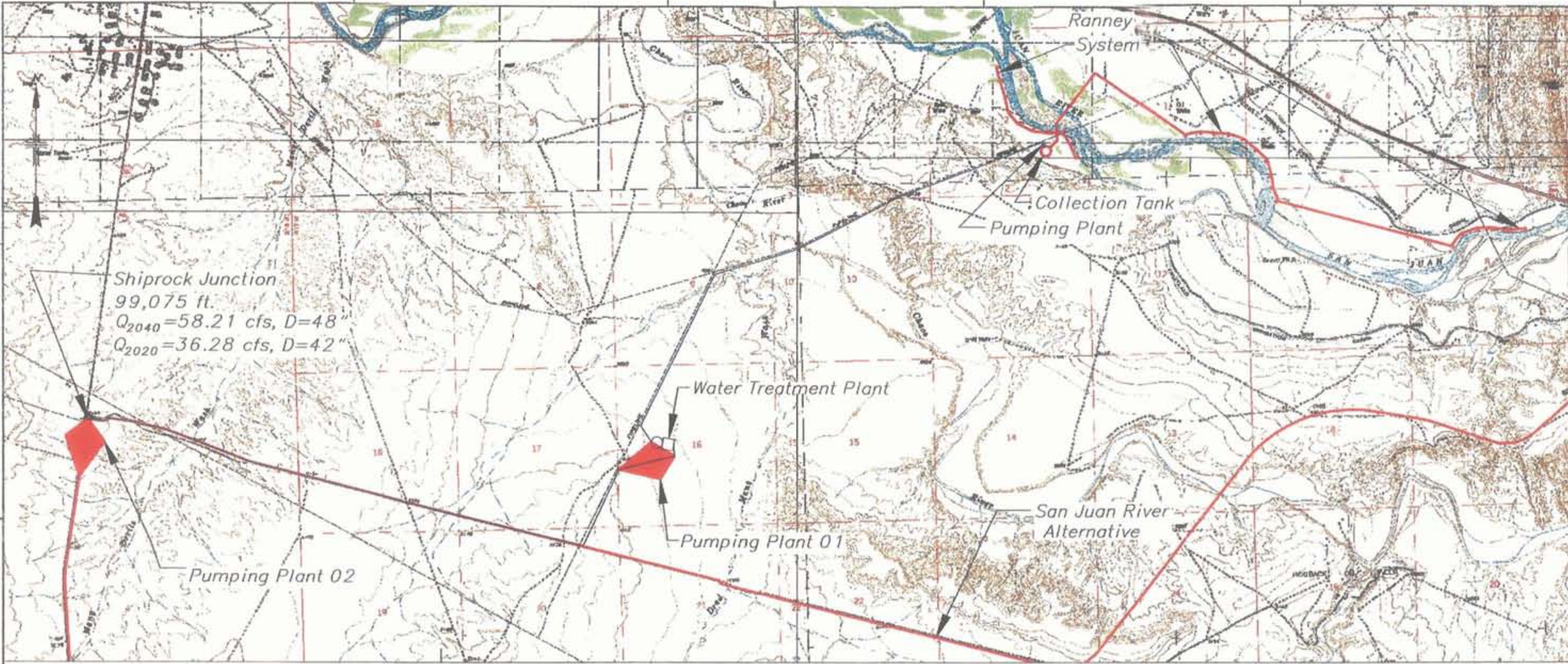
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

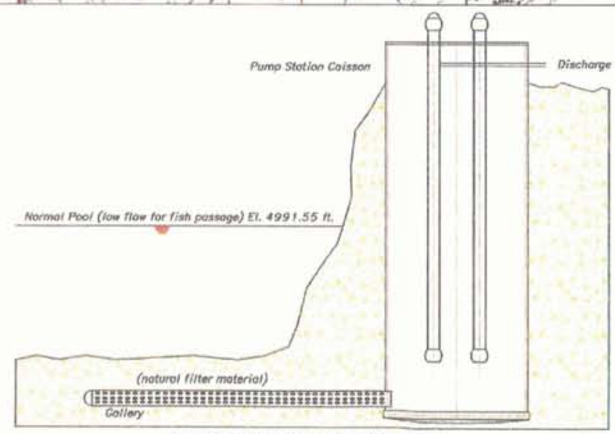
NAVAJO GALLUP WATER SUPPLY
PNM SITE LAYOUT
DRAWING 11

DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED G.E. SHEPARD APPROVED
STRUCTURAL AND ARCHITECTURAL GROUP
CADD SYSTEM AutoCAD Rel. 15.00 | CADD FILENAME | DATE AND TIME PLOTTED DECEMBER 12, 2001 12:48
DENVER, COLORADO MAY 24, 2001
XXX-D-XXXX

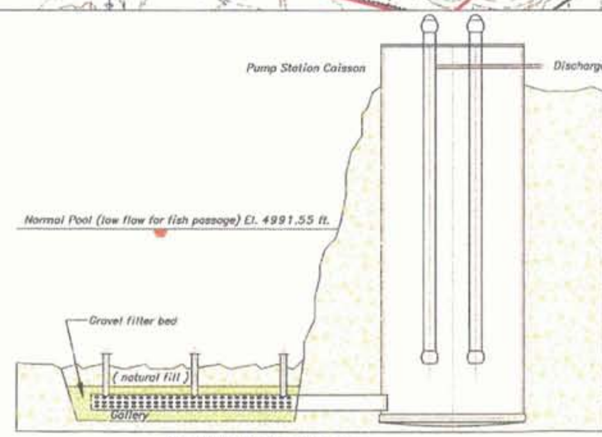
SPECIFICATIONS NO. 0000


XXX-D-XXXX
550.00
120.00
Flow to Distribution System
AIR CHAMBER
TREATED WATER PUMPING PLANT
60.00
O & M BUILDING
160.50
CLEARWELL
180.00
60.00
WATER TREATMENT PLANT
188.25
ALUMINUM SULFATE STORAGE BUILDING
Flow
500.00
WASTE WATER PUMPING PLANT
Recycle Flow
WASTE WATER POLISHING POND
80.00
175.00
40.00
20.00
Waste Flow to Dead Mans Wash
WATER TREATMENT PLANT
SAN JUAN RIVER WITH INFILTRATION COLLECTORS
(Located on Terrace)
300.00
℄ 20' Gate
TRANSFORMER
100.00
Intake pipe from infiltration system.
15.00
50.00
8' DIA. FOREBAY TANK
140.00
20' DIA. AIR CHAMBER
Metal building
INFILTRATION SYSTEM PUMPING PLANT
Chain link fence
INFILTRATION SYSTEM PUMPING PLANT
(Adjacent to River)
SCALE OF FEET
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO
NAVAJO GALLUP WATER SUPPLY
INFILTRATION, PUMPING PLANT AND TREATMENT SYSTEM
DRAWING 12
DESIGNED GARY SNYDER
TECH. APPR.
DRAWN GARY SNYDER
CHECKED
APPROVED
DENVER, COLORADO
MAY 24, 2001
XXX-D-XXXX





Hydraulically Projected Infiltration Gallery



Cut and Fill Infiltration Gallery

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT – NEW MEXICO
SJR INFILTRATION ALTERNATIVE

SAN JUAN LATERAL

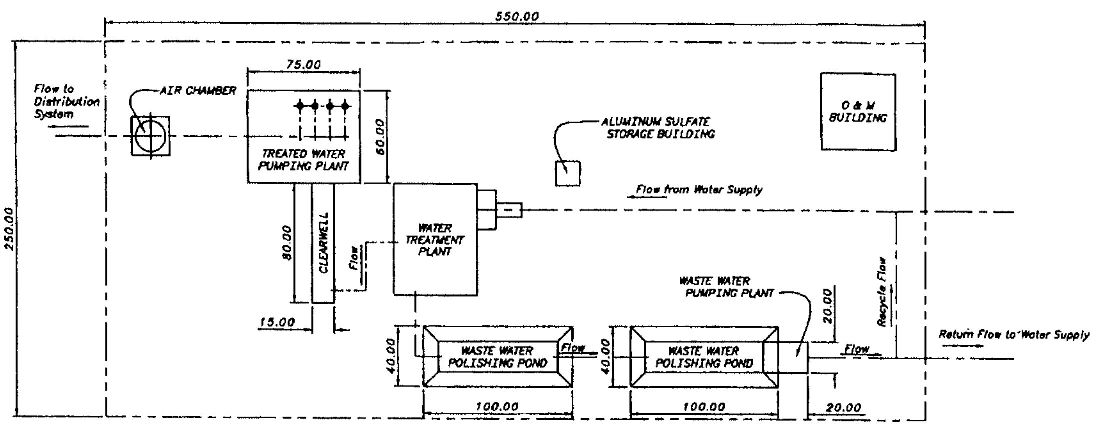
PLAN

DESIGNED Art Streifel   TECH. APPR. Lee Kinney
DRAWN Art Streifel
CHECKED CHECKER   APPROVED Richard Fuerst

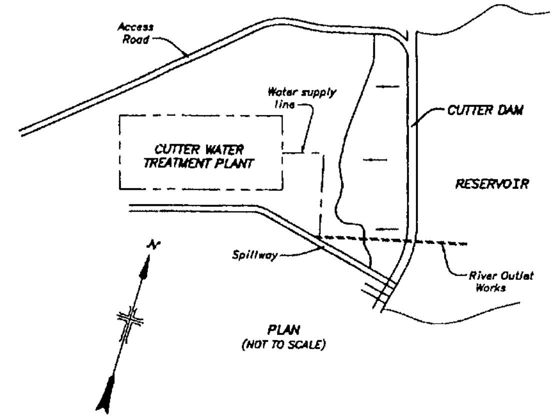
CADD SYSTEM AutoCAD Rel. 15.0A | CADD FILENAME | DATE AND TIME PLOTTED October 15, 2001 12:16
DENVER, COLORADO   MARCH 23, 2001 | Drawing No. 13

SPECIFICATIONS NO. 0000

XXX-D-XXXX



CUTTER WATER TREATMENT PLANT
AT CUTTER RESERVOIR



PLAN
(NOT TO SCALE)

40 0 40 80 120
SCALE OF FEET

ALWAYS THINK SAFETY

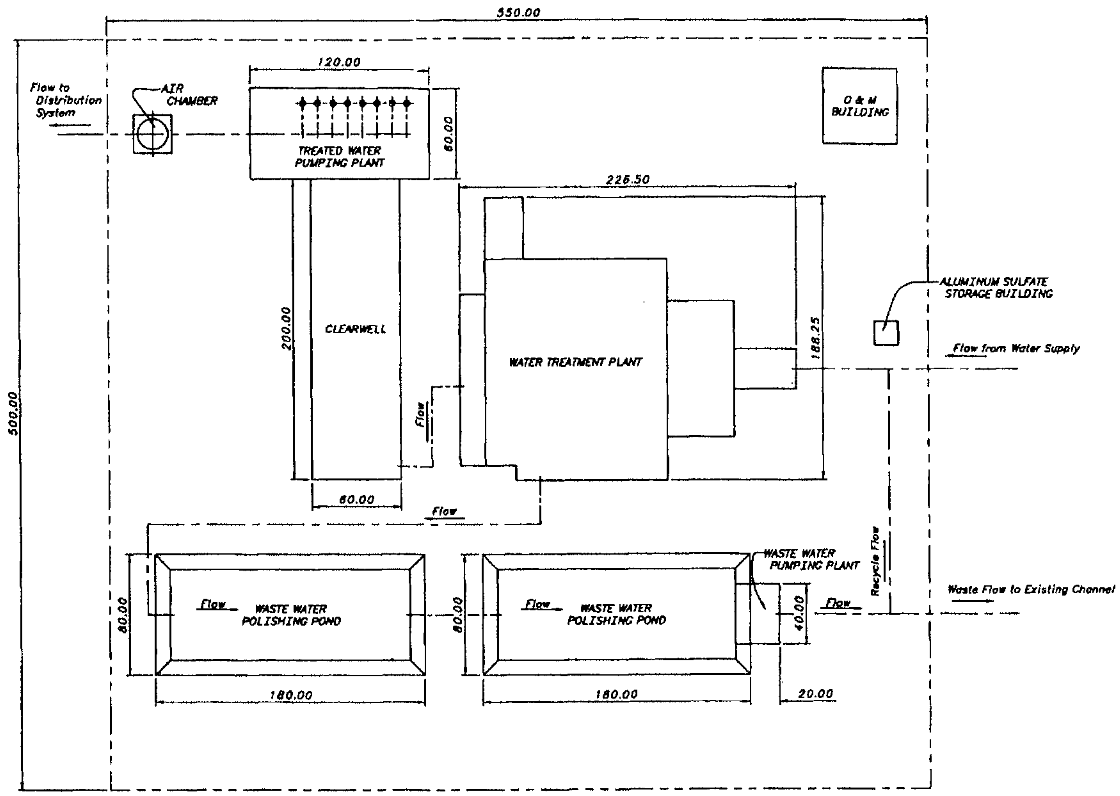
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
SAN JUAN RIVER ALTERNATIVE
CUTTER WATER TREATMENT PLANT
DRAWING 14

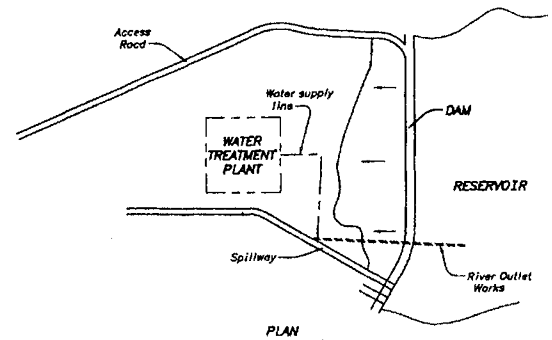
DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED R.E. SHEWARD APPROVED
DENVER, COLORADO MAY 24, 2001

XXX-D-XXXX

XXX-D-XXXX



WATER TREATMENT PLANT



PLAN
(NOT TO SCALE)

ALWAYS THINK SAFETY

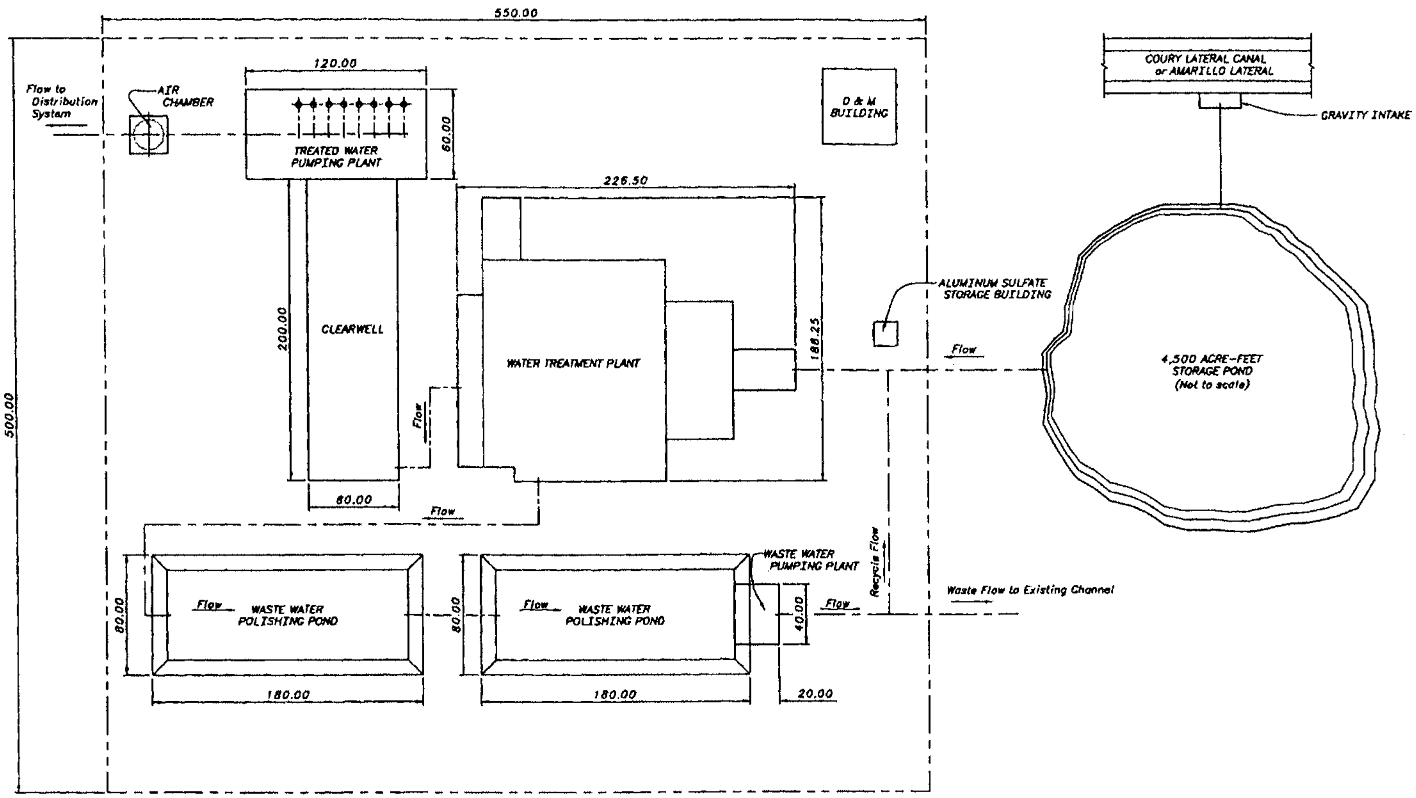
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
TYPICAL WATER TREATMENT PLANT
FOR NIIP MONCISCO/CUTTER ALTERNATIVES
DRAWING 15

DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED APPROVED

XXX-D-XXXX

XXX-D-XXXX



WATER TREATMENT PLANT

NOTE
Dimensions are approximate.

SCALE OF FEET

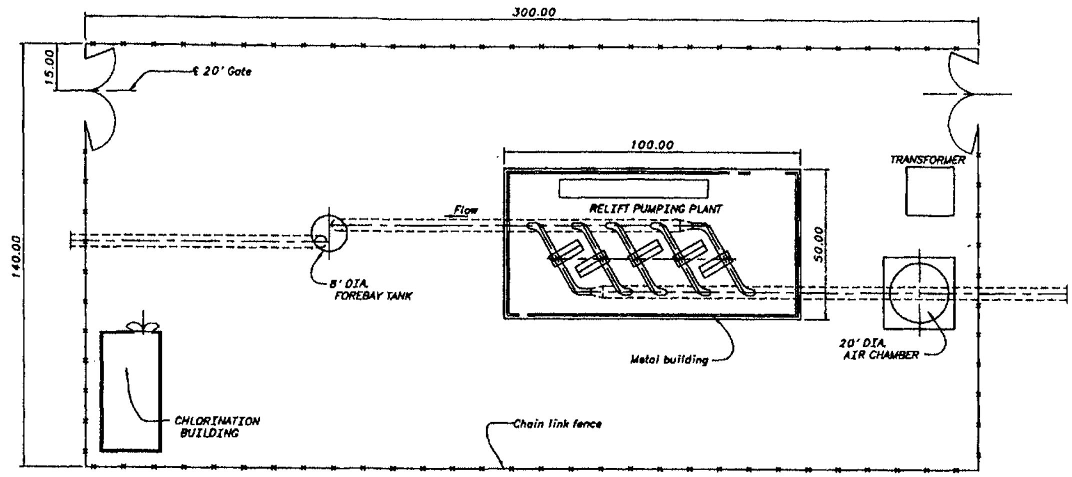
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
TYPICAL WATER TREATMENT PLANT
FOR NIIP COURY LATERAL/AMARILLO ALTERNATIVES
DRAWING 16

DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED G.E. SHERARD APPROVED
STRUCTURAL AND ARCHITECTURAL GROUP
CADD SYSTEM AutoCAD Rel. 15.05 | CADD FILENAME NIIP_DWG_16.DWG | DATE AND TIME PLOTTED NOVEMBER 28, 2001 14:14
DENVER, COLORADO | MAY 24, 2001 | XXX-D-XXXX

XXX-D-XXXX



TYPICAL RELIEF PUMPING PLANT

SCALE OF FEET

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
TYPICAL RELIFT PUMPING PLANT
DRAWING 17

DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED G.E. SHERARD APPROVED
DENVER, COLORADO

XXX-D-XXXX

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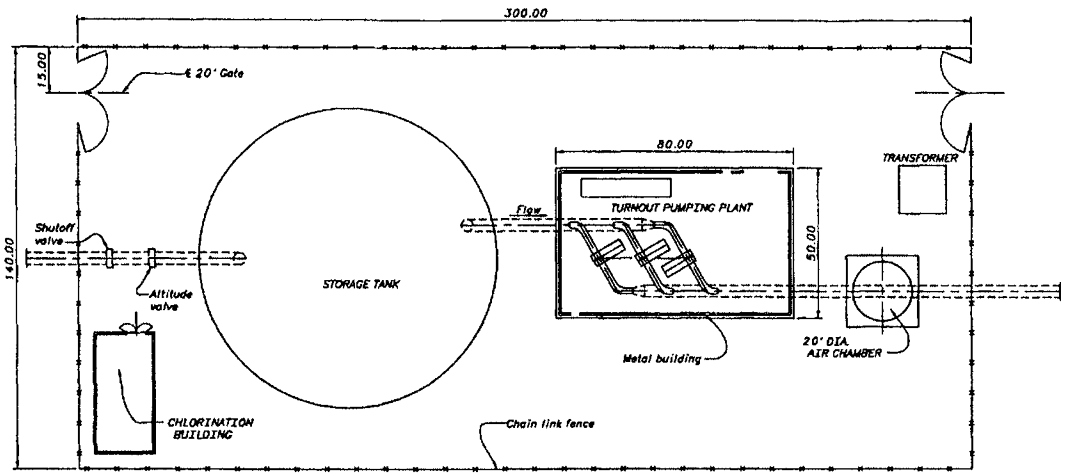

TYPICAL TURNOUT PUMPING PLANT

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP – NEW MEXICO

NAVAJO GALLUP WATER SUPPLY
TYPICAL TURNOUT PUMPING PLANT
DRAWING 18

DESIGNED GARY SNYDER TECH. APPR.
DRAWN GARY SNYDER
CHECKED G.E. SHERARD APPROVED
DENVER, COLORADO MAY 24, 2001

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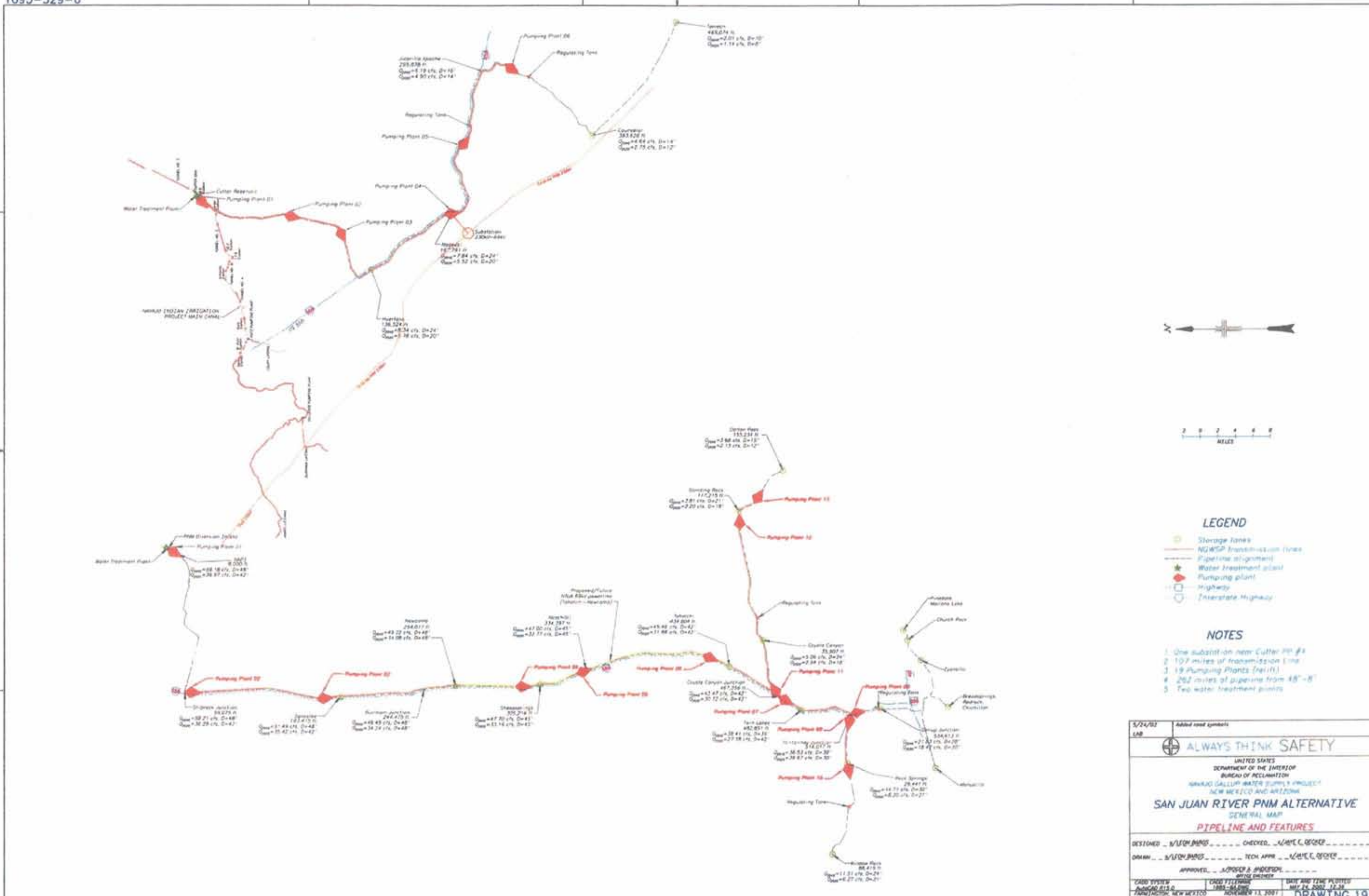
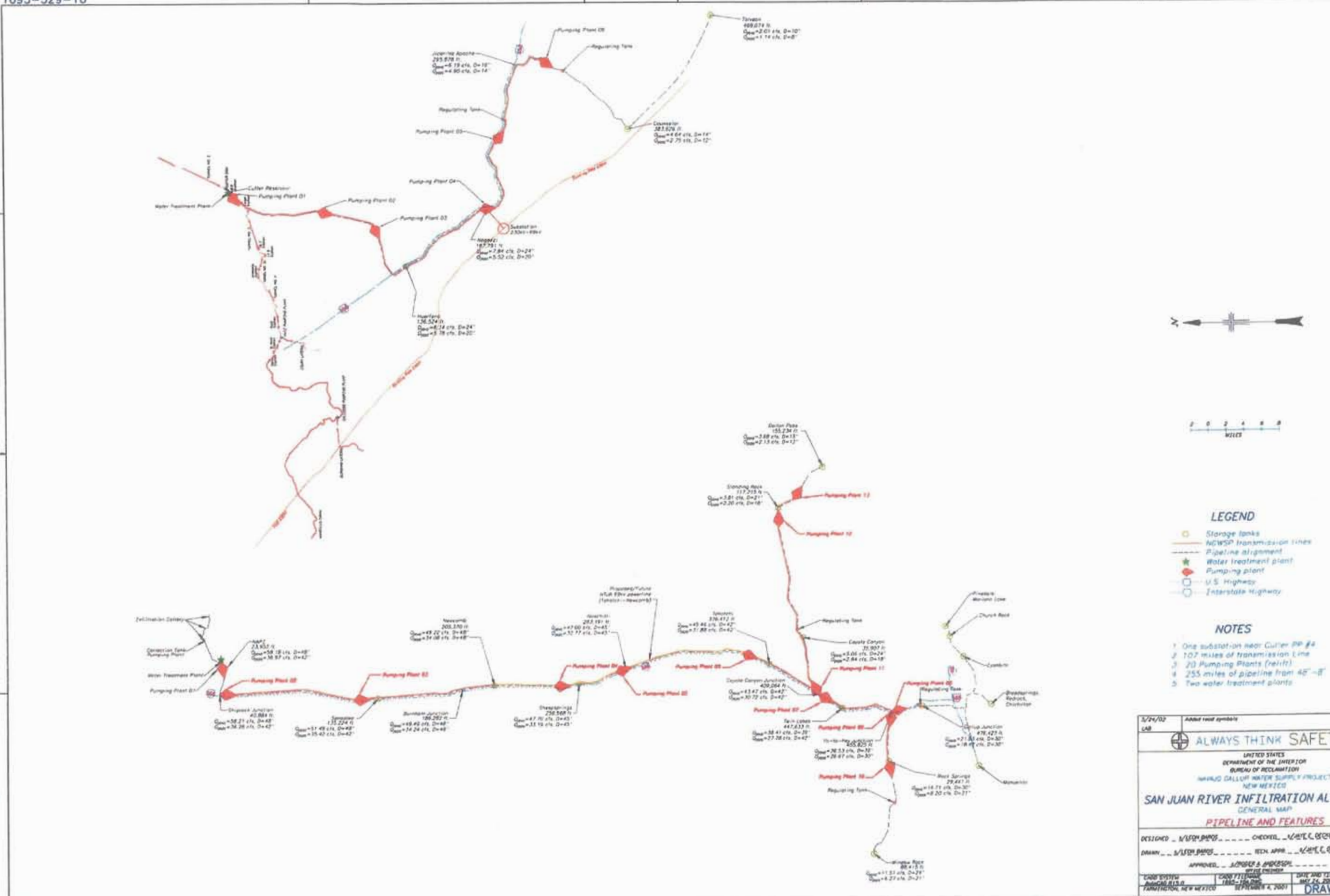
1695-529-6



LEGEND
Storage tanks
NGWSP transmission lines
Pipeline alignment
Water treatment plant
Pumping plant
Highway
Interstate Highway
NOTES
1. One substation near Cutter PP #1
2. 107 miles of transmission line
3. 19 Pumping Plants (relift)
4. 262 miles of pipeline from 48"-8"
5. Two water treatment plants
5/24/02 LAB Added road symbols
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO AND ARIZONA
SAN JUAN RIVER PNM ALTERNATIVE
GENERAL MAP
PIPELINE AND FEATURES
CADD SYSTEM AutoCAD R15.0
FARMINGTON, NEW MEXICO
NOVEMBER 13, 2001
DATE AND TIME PLOTTED MAY 24, 2002 12:38
DRAWING 19

1695-529-10



LEGEND

- Storage tanks
- NGWSP transmission lines
- Pipeline alignment
- Water treatment plant
- Pumping plant
- U.S. Highway
- Interstate Highway

NOTES

1. One substation near Cutter PP #4
2. 107 miles of transmission Line
3. 20 Pumping Plants (relift)
4. 255 miles of pipeline from 48"–8"
5. Two water treatment plants

5/24/02 LAB	Added road symbols

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO

SAN JUAN RIVER INFILTRATION ALTERNATIVE

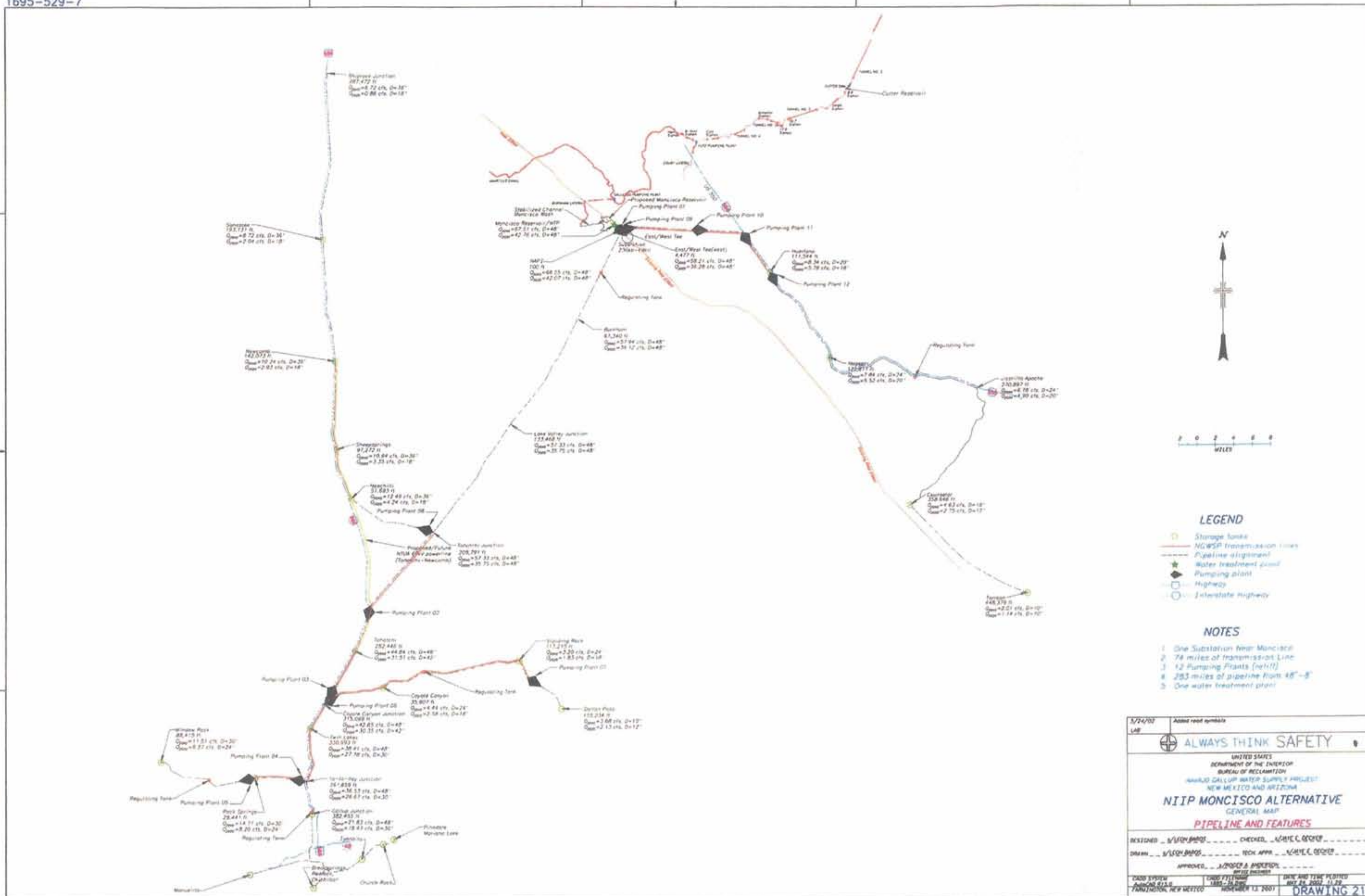
GENERAL MAP

PIPELINE AND FEATURES

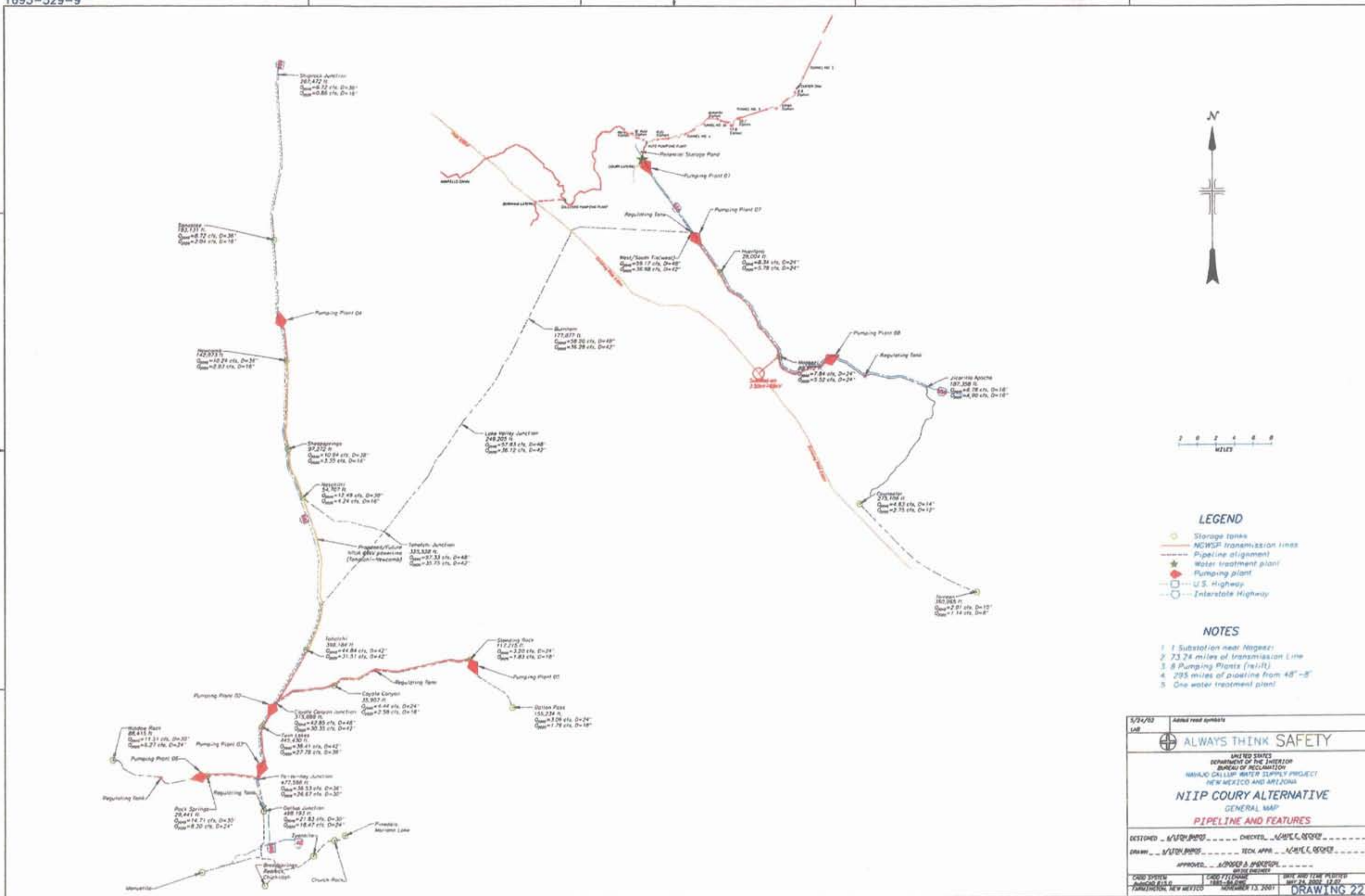
DESIGNED S/LEON BAROS CHECKED S/JAYE C. DECKER
DRAWN S/LEON BAROS TECH. APPR. S/JAYE C. DECKER
APPROVED S/ROGER A. ANDERSON

CADD SYSTEM AutoCAD R13.0 | CADD FILENAME 1695-... | DATE AND TIME PLOTTED MAY 24, 2002 12:1?
FARMINGTON, NEW MEXICO | SEPTEMBER 4, 2001 | DRAWING 20

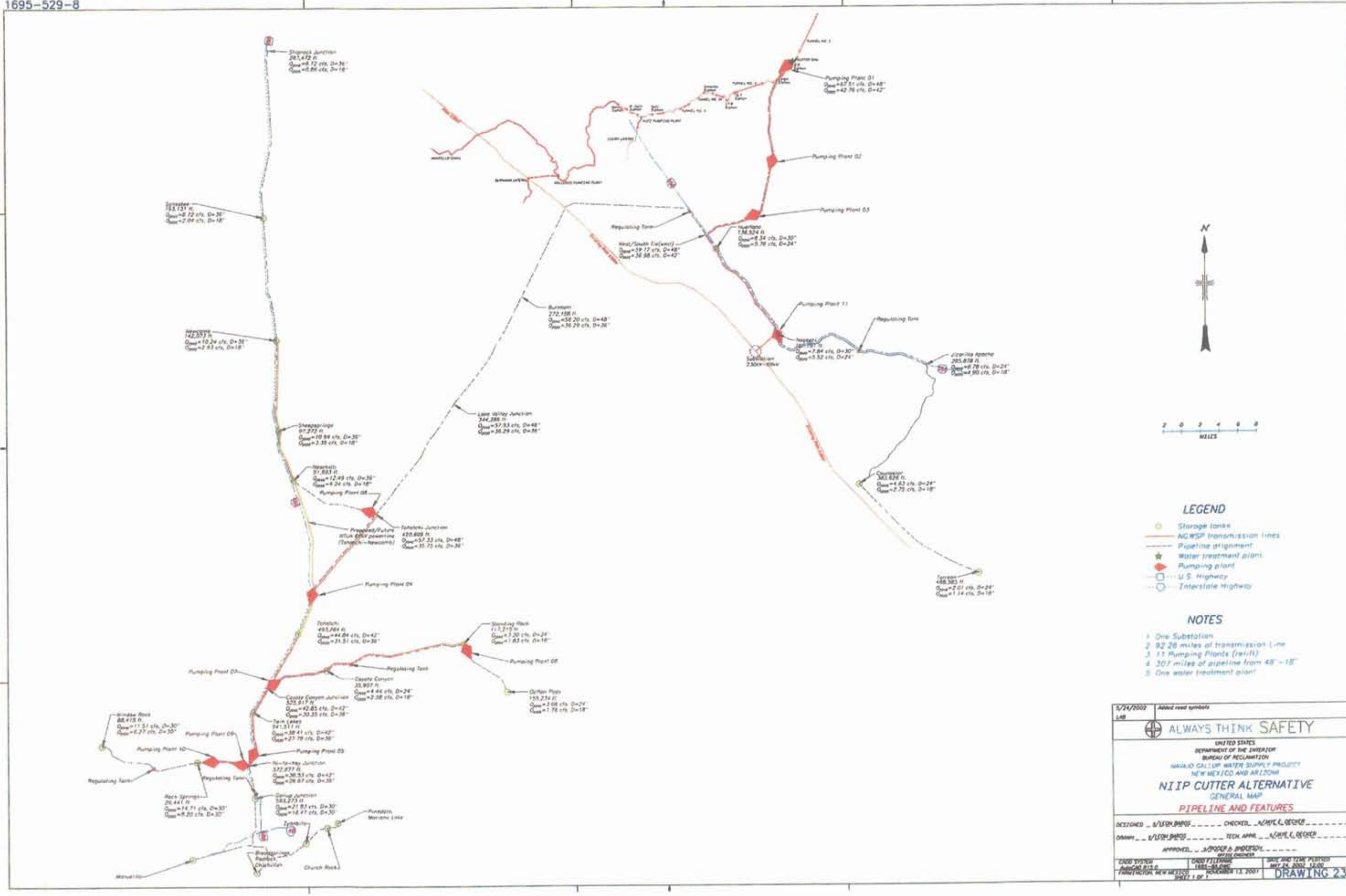
1695-529-7


LEGEND
Storage Tanks
NGWSP transmission lines
Pipeline alignment
Water treatment plant
Pumping plant
Highway
Interstate Highway
NOTES
1 One Substation Near Moncisco
2 74 miles of transmission Line
3 12 Pumping Plants (refill)
4 283 miles of pipeline from 48"–8"
5 One water treatment plant
MILES
5/24/02 LAB
Added road symbols
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO AND ARIZONA
NIIP MONCISCO ALTERNATIVE
GENERAL MAP
PIPELINE AND FEATURES
DESIGNED
CHECKED
DRAWN
TECH. APPR.
APPROVED
CADD SYSTEM
CADD FILENAME
DATE AND TIME PLOTTED
FARMINGTON, NEW MEXICO
NOVEMBER 13, 2001
DRAWING 21

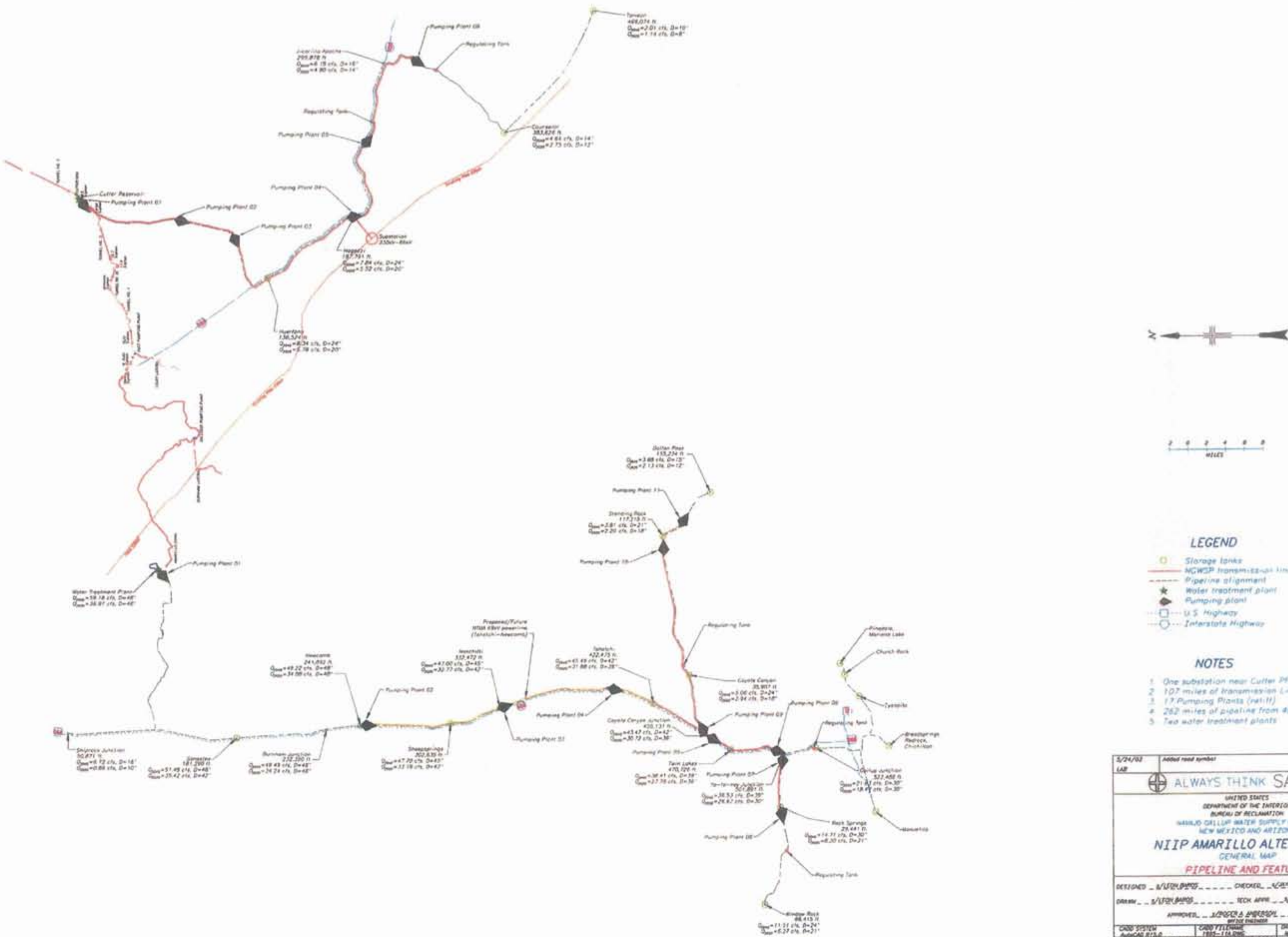
1695-529-9


LEGEND
Storage tanks
NGWSP transmission lines
Pipeline alignment
Water treatment plant
Pumping plant
U.S. Highway
Interstate Highway
NOTES
1 1 Substation near Nageezi
2 73.24 miles of transmission Line
3 8 Pumping Plants (relift)
4 295 miles of pipeline from 48"-8"
5 One water treatment plant
5/24/02 LAB Added road symbols
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO AND ARIZONA
NIIP COURY ALTERNATIVE
GENERAL MAP
PIPELINE AND FEATURES
DESIGNED
CHECKED
DRAWN
TECH. APPR.
APPROVED
CADD SYSTEM
CADD FILENAME
DATE AND TIME PLOTTED
FARMINGTON, NEW MEXICO
NOVEMBER 13, 2001
DRAWING 22

1695-529-8


LEGEND
Storage tanks
NGWSP transmission lines
Pipeline alignment
Water treatment plant
Pumping plant
U.S. Highway
Interstate Highway
NOTES
1. One Substation
2. 92.26 miles of transmission Line
3. 11 Pumping Plants (relift)
4. 307 miles of pipeline from 48" - 18"
5. One water treatment plant
5/24/2002 LAB Added road symbols
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO AND ARIZONA
NIIP CUTTER ALTERNATIVE
GENERAL MAP
PIPELINE AND FEATURES
DRAWING 23

1695-529-11



LEGEND

- Storage tanks
- NGWSP transmission lines
- Pipeline alignment
- Water treatment plant
- Pumping plant
- U.S. Highway
- Interstate Highway

NOTES

1. One substation near Cutter PP #x
2. 107 miles of transmission Line
3. 17 Pumping Plants (retill)
4. 262 miles of pipeline from 48" - 8"
5. Two water treatment plants

5/24/02 LAB — Added road symbol

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NAVAJO GALLUP WATER SUPPLY PROJECT
NEW MEXICO AND ARIZONA

NIIP AMARILLO ALTERNATIVE

GENERAL MAP

PIPELINE AND FEATURES

DESIGNED S/LEON BAROS — CHECKED S/GAYE C. DECKER
DRAWN S/LEON BAROS — TECH APPR S/GAYE C. DECKER
APPROVED S/ROGER A. ANDERSON, OFFICE ENGINEER

CADD SYSTEM: AutoCAD R15.0 — FARMINGTON, NEW MEXICO
CADD FILENAME: 1695-11A.DWG — NOVEMBER 26, 2001
DATE AND TIME PLOTTED: MAY 24, 2002 12:17

DRAWING 24

APPENDIX C

Part I
Fish and Wildlife Service Memorandum
(December 3, 2002)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 346-2525 Fax: (505) 346-2542

December 3, 2002

Memorandum

To: Area Manager, Western Colorado Area Office, Bureau of Reclamation, Grand Junction, Colorado

From: Field Supervisor, New Mexico Ecological Services Field Office, U.S. Fish and Wildlife Service, Albuquerque, New Mexico

Subject: Planning Aid Memorandum for the Navajo - Gallup Water Supply Project Environmental Impact Statement (EIS), New Mexico

The attached Planning Aid Memorandum (PAM) identifies information needs and recommended guidance that should be addressed in the Navajo - Gallup Water Supply Project EIS to protect fish and wildlife resources. The PAM also provides planning input that can be incorporated into the National Environmental Policy Act (NEPA) activities associated with the development of the EIS. A Fish and Wildlife Coordination Act Report will also be prepared by the Service for inclusion in the EIS process.

We appreciate the opportunity to provide information and suggestions concerning fish and wildlife resources. If you have any questions, please contact John Branstetter at (505) 346-2525 ext. 4753.

Joy E Nicholopoulos

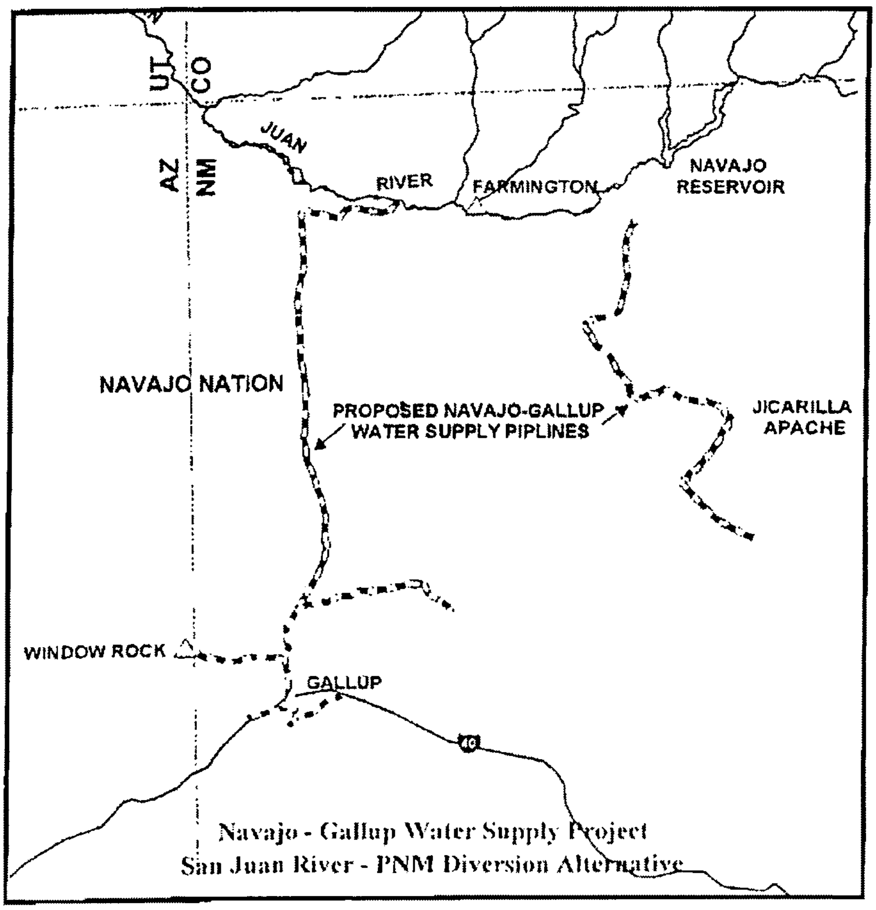
Joy Nicholopoulos

Attachment

cc: (w/ atch)
Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 346-2525 Fax: (505) 346-2542



Navajo - Gallup Water Supply Project Planning Aid Memorandum

December 2002

BACKGROUND

The Navajo Nation and the City of Gallup (Gallup), New Mexico, currently rely on a rapidly diminishing groundwater supply to meet current water needs. Groundwater depletion has been occurring for a number of years and other water sources are needed to meet future water demands. In 1971, the Bureau of Reclamation (Bureau), under Public Law 92-99, was authorized to conduct a feasibility study to provide water to the Navajo Nation and Gallup (U.S. Fish and Wildlife Service (USFWS) 1981).

In the 1970's, the Bureau, under Public Law 92-99, began development of an Environmental Impact Statement for the Gallup - Navajo Indian Water Supply Project, a precursor to the current Navajo - Gallup Water Supply Project. Feasability and appraisal reports were developed for the project in the 1970's and 1980's, but none of the reports moved forward (Bureau 2000).

Other activities and programs have developed in the San Juan Basin which have direct bearing on the Navajo - Gallup Water Supply Project. One such program is the San Juan River Basin Recovery Implementation Program (SJRBRIP). The SJRBRIP was initiated in 1992 to conserve Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) populations in the basin, while proceeding with water development in compliance with Federal and State laws, interstate compacts, Supreme Court decrees, and Federal trust responsibilities to the Southern Utes, Ute Mountain Utes, Jicarillas, and Navajos (Holden 1999).

The SJRBRIP has identified factors that limit Colorado pikeminnow and razorback sucker recovery (Bureau 2002). To conserve and recover endangered fish species in the San Juan River, the SJRBRIP has recommended that water releases from Navajo Reservoir mimic the river's natural hydrograph (Holden 1999). The flow recommendations call for peak spring flows and summer, fall, and winter baseflows in the river between Farmington, New Mexico, and Lake Powell, Utah. Peak spring flows will clean existing cobble sources, build cobble bars, change channel configurations, provide channel diversity, introduce nutrients into the system, and maintain clean backwaters and low-velocity habitat for larval fish in secondary channels (Holden 1999). The recommended baseflows will ensure that backwater nursery habitats will be maintained and enhanced (Holden 1999).

To facilitate water releases from Navajo Reservoir and meet the SJRBRIP flow recommendations, the Bureau is developing an EIS for the reoperation of Navajo Dam and reservoir. Modifying the operating procedures of Navajo Dam and reservoir will allow sufficient water releases to occur at times, quantities, and durations necessary to conserve Colorado pikeminnow and razorback sucker and their designated critical habitat in the San Juan River (Bureau 2002). Operational changes will also allow water development to proceed in the basin in compliance with applicable laws, compacts, court decrees, and Indian Trust Asset responsibilities (Bureau 2002).

The Navajo - Gallup Water Supply Project will provide approximately 40,000 acre-feet of water per year (afy) to the Navajo Nation and Gallup to meet long-term, municipal and industrial needs (Bureau 2000a). Water supplied by the project will also support economic growth and improve the standard of living for current and future populations in the project area (Bureau 2000a).

The four alternatives currently being analyzed in the Navajo - Gallup Water Supply Project EIS include a no action alternative, a water conservation alternative, a Navajo Indian Irrigation Project (NIIP) alternative (structural), and a San Juan River Diversion (SJRD) alternative (structural). Two potential points of diversion have been identified for the SJRD alternative.

Under the NIIP alternative, water would be diverted from Navajo Reservoir through the NIIP Main and Burnham Lateral Canals and delivered to an 8,800 acre-foot reservoir to be constructed as part of this alternative. From the reservoir, water would be piped south to an existing natural gas line corridor. The waterline would follow the gas line corridor to the vicinity of Twin Lakes, New Mexico, where it would turn south to Yah-ta-hey, New Mexico. At Yah-ta-hey, it would connect to smaller waterlines and proceed west along Highway 64 to Window Rock, Arizona, and south along Highway 666 to Gallup. Three additional spur waterlines would connect to the mainline, including a pipeline from Naschitti, New Mexico, north along Highway 666 to Sanostee, New Mexico; a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, New Mexico; and a pipeline along Highway 44 to Nageezi, New Mexico, then south to Torreon, New Mexico.

Under the SJRD alternative, water would be diverted from the San Juan River at the Hogback or Public Service Company (PNM) Diversion. From the diversion, water would be piped south along Highway 666 to Yah-ta-hey. At Yah-ta-hey, the main waterline would connect to spur waterlines extending to Window Rock and Gallup. An additional waterline originating at Cutter Reservoir would be constructed to provide water to the eastern portion of the Navajo Reservation. Water would be transported via pipeline to Huerfano, New Mexico, and follow Highway 44 to Nageezi. From Nageezi, water would be piped south to Torreon.

A baseline San Juan River depletion level of 845,890 afy has been established to allow sufficient flow in the river to protect fish and wildlife resources (Bleisner 2001). Bleisner (2001) estimates that current annual depletions in the San Juan River total approximately 600,590 afy. Water depletions associated with the Navajo - Gallup Water Supply Project will be covered by available unused depletions (Bleisner 2001). As a result, the baseline depletion level will not be exceeded as a result of the project (Bleisner 2001).

Although the baseline depletion level will not be exceeded, impacts to fish, wildlife, and vegetation resources could still occur as a result of the project. Impacts to aquatic organisms may include entrainment of fish or other aquatic species in diversion canals and/or impingement on screens, reduced habitat availability and quality, and reduced accessibility to important habitats. Multiple indirect impacts, some of which may develop over a long time period, could also occur. These impacts may occur as a result of long-term geomorphic and/or hydrologic changes caused by altered sediment transport in the river up- or downstream of the point-of-diversion.

Direct impacts to wildlife and vegetation in the project area may include habitat loss caused by vegetation removal, water inundation or dessication, and/or soil disturbance associated with construction activities. Indirect impacts to wildlife and vegetation, some of which may develop over a long time period, could also occur. Indirect impacts may occur as a result of hydrologic changes up- or downstream of the point of diversion which cause suitable habitat in certain areas to be lost while suitable habitat in previously unoccupied areas develops.

Ecosystems Research Institute (ERI) was contracted to develop an Environmental Assessment (EA) for the Navajo - Gallup Water Supply Project. The purpose of the EA is to identify fish, wildlife, and vegetation resources in the project area, identify potential project related impacts to those resources, and describe how impacts will be mitigated. A draft EA which contains information on fish, wildlife, and vegetation resources has been developed (ERI 2001). A final EA which identifies and evaluates direct and indirect impacts to these resources, and identifies mitigation measures to minimize impacts, will be completed.

Information on fish, wildlife, and vegetation resources in the project area is provided below. The following resource information is based on the draft EA and other published and unpublished sources. The following information should be used during the planning process to identify where impacts may occur, develop measures to avoid or minimize impacts, promote recovery of listed species, and conserve sensitive species.

Vegetation

Between the fall of 1999 and summer of 2000, ERI conducted field surveys for habitats or possible habitats of endangered, threatened, and sensitive floral and faunal species in the proposed pipeline alignments of the Navajo - Gallup Water Supply Project (ERI 2001). Sensitive vegetative species identified during the surveys are shown in Table 1.

Field surveys and Gap Analysis Project (GAP) data were used to quantitatively delineate vegetation communities along the NIIP and SJRD pipeline routes (ERI 2001). Dominant vegetative communities along the NIIP pipeline route include Great Basin lowland/swale grassland (45.7%), Great Basin foothill-Piedmont grassland (27.2%), and Great Basin microphyllous desert scrub (18.2%), respectively. Dominant vegetative communities along the San Juan Diversion pipeline route include Great Basin microphyllous desert scrub (46.3%), Great Basin lowland/swale grassland (22.0%), and Great Basin broadleaf deciduous desert scrub (13.1%), respectively (ERI 2001).

The majority of the pipeline and laterals for both the NIIP and SJRD alternatives will be located in semi-arid grassland desert scrub habitats. Project related impacts to these habitats should be identified during planning. Minimization measures should be developed to reduce impacts to vegetation, particularly native vegetation.

Table 1. Vegetative endangered, threatened, and species of concern identified during ERI surveys of the pipeline alignments for the structural alternatives (ERI 2001).

Pipeline Alignment	Species	Status
*Cutter Lateral	Beautiful (Aztec) gilia (*Gilia formosa*)	Species of Concern
*Cutter Lateral	†Brack's fishhook cactus (*Sclerocactus cloveriae var. brackii*)	Species of Concern
**NIIP	San Juan milkweed (*Asclepias sanjuanensis*)	Species of Concern
***SJRD	Mesa Verde cactus (*Sclerocactus mesae-verdae*)	Threatened

* The Cutter Lateral pipeline alignment is a common element of both structural alternatives
** The NIIP alignment does not include the Cutter Lateral in this table
*** The SJRD alignment does not include the Cutter Lateral in this table
† Only potential habitat for the Brack's cactus was identified, no plants

Riparian and wetland habitats may be impacted in the project area as well. Riparian vegetation near the project site is dominated by salt cedar (*Tamarix chinensis*), Russian olive (*Elaegnus angustifolia*), cottonwoods (*Populus fremontii and P. angustifolia*) and willows (*Salix amygdaloides and S. exiqua*) (Ryden 2000). Ecosystems Research Institute noted that additional investigative field work will need to be conducted in the riparian zone of the San Juan River corridor for threatened and endangered species and wetland identification (ERI 2001a). Wetland and riparian habitats that may be impacted by the project should be delineated as part of the proposed field work.

Terrestrial and Aquatic Wildlife

The Bureau (1983) conducted habitat investigations within a portion of the project area for the Navajo - Gallup (formerly Gallup - Navajo) Water Supply Project. Through their investigations, the Bureau identified that 150 bird and 64 mammalian species had been reported in the project area (ERI 2001). As a part of their project area investigations, the Bureau reviewed New Mexico Department of Game and Fish hunter survey reports from the late 1960's and early 1970's to evaluate wildlife density (ERI 2001). Hunter survey reports revealed low densities of game species in the project area (ERI 2001). These reports were a useful indicator of game density in the study area when quantitative data was unavailable.

A review of current literature should be conducted to determine if changes in species diversity or abundance have occurred over the last several decades. If up-to-date literature is not available, then studies should be developed or hunter survey reports from recent years should be reviewed to determine if changes in wildlife abundance have occurred.

The proposed route was surveyed for habitats or potential habitats of raptors and threatened and endangered species during the ERI surveys (ERI 2001). Sandstone cliffs, trees, and power lines were observed for nests, eyries, perching and roosting sites within one quarter mile of the proposed pipeline routes (ERI 2001). Wildlife species observed or identified as being present are shown in Table 2.

No federally listed wildlife species were observed during the ERI surveys; however, small stands of willows were encountered along wetlands near proposed pipeline crossings (ERI 2001). These willows may provide important habitat for endangered southwestern willow flycatcher (*Empidonax traillii extimus*). Willows and other riparian vegetation which may provide habitat for southwestern willow flycatcher should be delineated, and measures should be developed during the planning process to minimize and mitigate for impacts to these habitats.

Table 2. Wildlife species observed or identified as being present during ERI surveys of the pipeline alignments for the structural alternatives (ERI 2001).

Pipeline Alignment	Species
*Cutter Lateral, **NIIP	ferruginous hawk (*Buteo regalis*)
**NIIP, ***SJRD	golden eagle (*Aquila chrysaetos*)
*Cutter Lateral, **NIIP, ***SJRD	red-tailed hawk (*Buteo jamaicensis*)
*Cutter Lateral, **NIIP	Gunnison's prairie dog (*Cynomys gunnisoni*)
*Cutter Lateral, **NIIP	kangaroo rats (*Dipodomys* spp.)
*Cutter Lateral, **NIIP	deer mice (*Peromyscus* spp.)
*Cutter Lateral	chipmunks (*Tamias* spp.)
*Cutter Lateral, **NIIP	coyote (*Canis latrans*)
*Cutter Lateral	bobcat (*Lynx rufus baileyi*)
**NIIP	fox (*Vulpes vulpes*)
**NIIP	badger (*Taxidea taxus*)

* The Cutter Lateral pipeline alignment is a common element of both structural alternatives
** The NIIP alignment does not include the Cutter Lateral in this table
*** The SJRD alignment does not include the Cutter Lateral in this table

Bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus* spp.), Swainson's hawks (*Buteo swainsoni*) and burrowing owls (*Athene cunicularia hypugaea*) were not observed during the ERI surveys; however, potential habitat for these species was identified (ERI 2001). Potential habitat observed during the surveys may be important to the long-term persistence of these species. Potential habitat should be considered during the planning process and measures developed to avoid or minimize impacts to it.

Two federally endangered fish species are found in the San Juan River within the project area (Colorado pikeminnow and razorback sucker). The roundtail chub (*Gila robusta*), also present in this reach of the San Juan River, is listed by the State of New Mexico as endangered and is classified by the Service as a species of concern. Other fish species commonly found in or near this section of the river include: red shiner (*Cyprinella lutrensis*), fathead minnow, (*Pimephales promelas*), flannelmouth sucker (*Catostomus latipinnis*), mosquitofish (*Gambusia affinis*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), speckled dace (*Rhinichthys osculus*), mottled sculpin (*Cottus bairdi*), plains killifish (*Fundulus zebrinus*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), white sucker (*Catostomus commersoni*), and bluehead sucker (*Catostomus discobolus*) (Platania 1990, Keller-Bliesner Engineering and Ecosystems Research Institute 1991, Platania and Lang 1992).

Endangered Species and Species of Concern

Within the proposed project areas are several federally listed species including: Colorado pikeminnow, razorback sucker, southwestern willow flycatcher, bald eagle, Mexican spotted owl (*Strix occidentalis lucida*), Mesa Verde cactus, and mountain plover (*Charadrius montanus*) (proposed threatened).

Species of concern that may be in the project area and impacted by Bureau activities include: Townsend's big-eared bat (*Corynorhinus townsendii*), American peregrine falcon, Arctic peregrine falcon, Baird's sparrow (*Ammodramus bairdii*), black tern (*Chlidonias niger*), northern goshawk (*Accipiter gentilis*), roundtail chub, New Mexico silverspot butterfly (*Speyeria nokomis nitocris*), San Juan checkerspot butterfly (*Euphydryas anicia chuskae*), San Juan tiger beetle (*Cicindela lengi jordai*), beautiful (Aztec) gilia, Brack's fishhook cactus, and Bisti fleabane (*Erigeron bistiensis*).

Candidates and species of concern have no legal protection under the Act and are included in this document for planning purposes only. However, we monitor the status of candidate species and species of concern. If significant declines are detected, these species could potentially be listed as endangered or threatened. Therefore, these species should be considered during project planning and minimization measures should be developed to ensure that these species are not negatively impacted. Conservation actions which promote population expansion and species protection (*i.e.*, planting native vegetation or noxious weed removal) should be considered during the planning process, and, where possible, incorporated into the project.

Colorado Pikeminnow

The Colorado pikeminnow, a species endemic to the Colorado River basin, was federally listed as endangered in 1967 and given full protection under the Endangered Species Act of 1973, in 1974 (USFWS 1978). Critical habitat has been designated on 1,848 kilometers (km) of the Colorado River and its tributaries, including the San Juan River from Farmington, New Mexico, to Lake Powell, Utah (USFWS 1994).

Colorado pikeminnow are adapted to rivers with seasonally variable flow, high silt loads, and turbulent waters (USFWS 1991). Young-of-year live in shallow backwater areas that have little or no current (over silt and sand substrates). At about 20 centimeters (cm) in length, there is a change in habitat preference, with the larger fish selecting deeper water with low velocities. Adult pikeminnow are large river fish, and are found in a variety of depths and velocities over silt, sand, gravel, and boulder substrates (Holden 1999).

Colorado pikeminnow were once abundant in the mainstem of the Colorado River in the United States and Mexico, and in most of its tributaries in California, Arizona, Nevada, New Mexico, Colorado, Utah, and Wyoming (USFWS 1991). The decline of Colorado pikeminnow is attributed to alteration of river conditions and loss of habitat caused by dam construction, irrigation water withdrawals, channelization, and introduction of non-native fish species (USFWS 1991, USFWS 1994). Today there are fewer than 10,000 adult pikeminnow in the wild, primarily in the Colorado River from Palisade, Colorado, downstream to Lake Powell; the Green River below the confluence with the Yampa River; the Yampa River below Craig, Colorado; and the White River from Taylor Draw Dam near Rangely downstream to the confluence with the Green River (USFWS 1991).

Research and monitoring of Colorado pikeminnow and razorback sucker populations has been ongoing in the San Juan River since 1987. Young-of-year sampling on the river between 1987 and 1996 resulted in the capture of 48 young-of-year Colorado pikeminnow (Holden 1999). Between 1996 and 2001, more than 800,000 Colorado pikeminnow (primarily larvae and young-of-year) were stocked into the San Juan River (Ryden 2002). However, despite good initial returns, relatively few of these stocked fish have been recaptured (Ryden 2002).

Based on research conducted to date, the SJRBRIP has initiated several management actions to meet the ecological needs of Colorado pikeminnow (Holden 1999, Ryden 2002, Bureau 2002). Management actions include reoperation of Navajo Dam and reservoir to better meet species needs, control of non-native fish species, augmentation of Colorado pikeminnow populations, and identification and removal of fish passage barriers (Bureau 2002). A long-term monitoring program has been developed by the SJRBRIP to assess the effectiveness of implemented management actions (Ryden 2002).

Razorback Sucker

Razorback sucker, a species endemic to the Colorado River basin, was federally listed as endangered in 1991 (USFWS 1991a). Critical habitat for razorback sucker has been designated on 2,776 kilometers (km) of the Colorado River and its tributaries, including the San Juan River from the Hogback Diversion in New Mexico, to Lake Powell, Utah (USFWS 1994).

Razorback sucker are adapted to rivers with seasonally variable flow, high silt loads, and turbulent waters (USFWS 1991a). Larval razorback sucker prefer shallow littoral zones in lotic and lentic habitats (Holden 1999). After a few weeks in the littoral zone, larvae disperse to deeper waters. Larvae move into the drift and are transported downstream. Habitat preference of juvenile razorback sucker is not well known, as very few juveniles have been collected in the last 40 years (Holden 1999). Juveniles that have been collected have primarily been captured in backwater areas or flooded bottomlands (Holden 1999). Backwater and flooded bottomland habitats are important to, and may be the preferred habitats of, juvenile razorback sucker. Adult razorback sucker occupy a variety of habitats including edge pools, eddies, main channel runs, shoals, backwaters, and impoundments (USFWS 1991a, Holden 1999).

Razorback sucker populations have declined precipitously in the last 50 years. The population decline is attributed to alteration of riverine conditions and loss of habitat caused by dam construction, irrigation water removal, channelization, and introduction of non-native fish species (USFWS 1991a). Razorback sucker are now present in the San Juan River upstream of Lake Powell, Utah, but few fish have been captured (USFWS 1991a, Holden 1999).

Research and monitoring of razorback suckers has been ongoing in the San Juan River since 1987 (Ryden 2002). Between 1994 and 2001, over 6,836 razorback sucker were released into the San Juan River (Ryden 2002). Recapture data indicates that razorback sucker stocked at a total length of 300 millimeters (mm) or greater have a higher probability of survival than fish stocked at a smaller body size. To increase the probability of survival, the SJRBRIP has committed to releasing only razorback sucker 300 mm or greater into the river (Ryden 2002).

To date, the SJRBRIP has initiated several management actions to meet the ecological needs of razorback sucker (Holden 1999, Ryden 2002, Bureau 2002). Management actions include re-regulation of releases from Navajo Dam to better meet species needs, control of non-native fish species, augmentation of razorback sucker populations, and identification and removal of fish passage barriers (Bureau 2002). A long-term monitoring program, developed by the SJRBRIP, is being used to assess the effectiveness of implemented management actions (Ryden 2002).

Southwestern Willow Flycatcher

The southwestern willow flycatcher is federally listed as an endangered species with critical habitat in Catron, Grant, and Hidalgo Counties (USFWS 1995, USFWS 1997).

Southwestern willow flycatchers are a sparrow-sized, dark-headed, olive-green bird with a whitish throat, pale olive breast and pale yellow belly (USFWS 1995). This species lacks a conspicuous eye ring and has dusky wings which have two whitish bars. Southwestern willow flycatchers have a habit of flicking their tail upward and their song sounds like a sneezy "fitz-bew", a whistle superimposed on a buzz (USFWS 1995).

Deep-shaded mature woodlands, swamps, willow or alder thickets along streams, bogs, muskegs, edges of mountain meadows, orchards, and dry, brushy upland pastures provide habitat for southwestern willow flycatchers (USFWS 1997). They make a neat but loosely woven cup nest in an upright crotch of a low shrub. Southwest willow flycatchers can be found over a wide elevational range, but primarily occur between 1,100-1,700 meters (m) (USFWS 1997).

Currently, southwestern willow flycatcher population centers are small and widely dispersed. The New Mexico portion of the population is estimated at 100 pairs (USFWS 1997). In New Mexico, southwestern willow flycatchers summer in the San Juan, Chama, Rio Grande, San Francisco, Gila Valleys, and San Juan Mountains. Breeding area records for this species in New Mexico include: the Jemez Mountains; Red River, Carson National Forest; Eagle Nest Lake, Colfax County; Philmont Scout Camp, Colfax County; Maxwell National Wildlife Refuge (NWR), Colfax County; Las Vegas, San Miguel County; Santa Rosa, Guadalupe County; Bitter Lake NWR; Silver City, Grant County; and Artesia, Eddy County (USFWS 1997).

The decline of southwest willow flycatchers is in part attributed to loss of riparian habitat and nest parasitism by brown-headed cowbirds (USFWS 1995, USFWS 1997). Protection of existing riparian habitats in the southwest and promotion of native riparian revegetation along stream corridors are important management actions which, if implemented, can help protect and maintain southwest willow flycatcher populations.

Bald Eagle

The bald eagle is federally listed as a threatened species (USFWS 1995a). It is also listed as a threatened species by the New Mexico Department of Game and Fish.

Bald eagles are large hawk-like birds that are 0.9 m long and have a 1.8-2.1 m wingspan (USFWS 1982). Adults have a white head, neck, and tail. Body color is a dark brownish black. While soaring, wings are kept flat, not uplifted like vultures (USFWS 1982). Immature bald eagles are mostly dark without the characteristic white head and tail, and may be confused with golden eagles. Bald eagles have curved yellow beaks and unfeathered feet. They feed primarily on fish, but waterfowl, small mammals, and carrion constitute a portion of their diet (USFWS 1982).

Bald eagles require large trees or cliffs near water with abundant fish for nesting (USFWS 1983). They spend the winters along major rivers, reservoirs, or in areas where fish and/or carrion are available. For nesting eagles, fish are the primary food source. Waterfowl, rabbits, and carrion are important food items for transient and wintering eagles (USFWS 1983). In New Mexico, habitats are found in the riparian zones along the Rio Grande, Pecos, Chama, Gila, San Juan, and Canadian Rivers (USFWS 1982).

Historically, bald eagles ranged throughout the contiguous United States, Canada, and northern Mexico. They were, however, not very abundant in the southwestern United States (USFWS 1982). The species occupies New Mexico primarily as a migrant and winter resident, with several historic and two recent nesting records known from Colfax and Sierra Counties.

The decline of bald eagles is attributed to reproductive failure from pesticide use, namely DDT, and killing by humans (USFWS 1995). Current threats are habitat loss, human encroachment on nesting sites, and lead poisoning, usually from the ingestion of gunshot in carrion (USFWS 1995).

Mexican Spotted Owl

The Mexican spotted owl is federally listed as a threatened species (USFWS 1993). It is a medium-sized owl with large dark eyes and no ear tufts, that closely resembles the barred owl. Plumage is brown with numerous white spots and posterior underparts with short, horizontal bars or spots. Length is about 0.4 m and wingspan is 1.0 m (USFWS 1995).

Mexican spotted owl occur in a variety of habitats, consisting primarily of mature montane forest and woodland, shady wooded canyons, and steep canyons (USFWS 1995). In forested habitats, uneven-aged stands with a high canopy closure, high tree density, and a sloped terrain appear to be key habitat components. Nests are found in live trees, snags, and canyon-lined wall cavities (USFWS 1995).

Historically, the range of the Mexican spotted owl extended from the southern Rocky Mountains in Colorado and the Colorado Plateau in southern Utah southward through Arizona and New Mexico, and western Texas, through the Sierra Madre Occidental and Oriental, to the mountains at the southern end of the Mexican Plateau (USFWS 1993).

The present range is thought to be similar to the historic range. In New Mexico, the owl has been recorded in all montane regions from the San Juan, Jemez, and Sangre de Cristo Mountains in the north, to the Guadalupe and Animas Mountains in the south (USFWS 1995). The largest concentrations occur in the Mogollon and Sacramento Mountains. Other records exist for Navajo Reservoir, Mountainair, Lower San Francisco Valley, Estancia, Grants, Hurley, Burro

Mountains, Carlsbad Caverns National Park, and San Andres National Wildlife Refuge (USFWS 1995). The records probably represent dispersing individuals.

The decline of the Mexican spotted owl is attributed to habitat alteration from uneven-aged forest management practices (USFWS 1993). Fuel accumulation and forests overstocked with trees place spotted owl habitat at risk to stand-replacing and catastrophic fires. Lack of small-scale low intensity ground fires have increased this risk.

Mountain Plover

The mountain plover is classified by the Service as a proposed threatened species. Unbarred white underparts separate this plover from all other brown-backed plover. The mountain plover is sandy brown above and has a black crown patch which is offset by a white forehead and eyebrow and less distinct dark eyeline (Knopf 1996). A thin white wing-line is apparent in flight, as is the white-edged tail with a broad, smudgy dark terminal band (Knopf 1996).

Mountain plover habitat consists of expansive flats of dry short-grass prairie, high plains, dry upland habitats, semidesert, alkali flats, prairie dog towns and over-grazed areas at middle to lower elevations (Knopf 1996). The mountain plover, which migrates almost statewide, is often found far from water and in the winter may be found in bare dirt fields. It summers in the eastern plains westward to the San Augustin Plains and Animas Mountains area, and southward to the Tularosa Basin.

The decline of mountain plover is attributed to loss of habitat from agricultural urbanization, range management, gas and oil development, mining disturbance, prairie dog control, contaminants, and vehicle disturbance (Knopf 1996). The Service monitors populations and trends and is recommending agencies to manage, through appropriate grazing practices, short-grass prairie habitat for both nesting and wintering plovers.

Mesa Verde Cactus

The Mesa Verde cactus is federally listed as a threatened species (USFWS 1984). This species is also protected by the State of New Mexico.

Mesa Verde cactus have spherical stems which grow alone or in clusters, and are about 5-8 cm tall (USFWS 1984). There are about 8-10 tannish or straw colored radial spines per areole (spine cluster), and no central spines. The color of the spines allow the plants to blend in well with the fine soil on which they grow (USFWS 1984). Flowers are yellow to greenish-white, and appear in the spring. The cactus is restricted to dry clay soils along drainage ways on the eastern edge of the Navajoan Desert and is associated with *Atriplex spp.* at 1,219-1,829 m in elevation (USFWS 1984).

Historically, the Mesa Verde cactus was found in San Juan County, New Mexico, and Montezuma and possibly Montrose Counties, Colorado (USFWS 1984). Presently, it is found in the same counties, but reduced in distribution and numbers.

Reasons for decline in the Mesa Verde cactus include: limited distribution, over-collecting, habitat degradation due to overgrazing, habitat destruction due to mining, oil and gas exploration and drilling, commercial and residential development, off-road vehicle use, road building and maintenance, construction of power lines and pipelines, and pesticide use (USFWS 1984).

PROTECTION AND RESTORATION OF IMPORTANT RESOURCES

Under the Endangered Species Act, every Federal agency has a responsibility to recover listed species. As a result, implementation of the preferred alternative in this EIS should further the recovery of listed species in the project area. Designated critical habitat for Colorado pikeminnow and razorback sucker, and habitats important to southwestern willow flycatcher, bald eagle, and Mesa Verde cactus occur in the project area.

Multiple direct impacts to aquatic species may occur as a result of this project. Some of these impacts may include: entrainment of fish or other aquatic species in diversion canals and/or impingement on screens, reduced habitat availability and quality, and reduced accessibility to important habitats. Multiple indirect impacts, some of which may develop over a long time period, could also occur. Indirect impacts may occur as a result of long-term geomorphic and/or hydrologic changes which alter aquatic, riparian, and/or wetland ecosystems.

Maintenance of a natural hydrograph (both quantity and timing) is important to the natural processes which maintain and/or improve fish and wildlife habitat along the San Juan River. Instability in rivers occurs when sediment either aggrades or degrades in the channel (Rosgen 1996). Reduced water flow downstream of the point of diversion may alter sediment transport in the river. If sediment transport is disrupted, aggradation and braiding may occur. Geomorphic and hydrologic studies should be conducted to identify and evaluate changes to the river and/or water table and subsequent impacts to fish, wildlife, and vegetation resulting from a yearly water diversion of 40,000 acre-feet.

Under the SJRD alternative, water would be diverted at either the Hogback site or the PNM Diversion. The PNM Diversion, located several river miles upstream of the Hogback Diversion, would divert water higher in the river system. As a result, water diversions at the PNM

Diversion may impact a greater amount of aquatic habitat than water diversion at the Hogback site. However, water diversions at the Hogback site would likely impact more riparian and wetland habitats, due to the extensive infrastructure developed in the riparian corridor under this alternative.

The Affected Environment section of the draft EA, specifically the Species and Habitat Description subsections, relies heavily upon previously published literature. Much of this literature is nearly twenty years old (*e.g.*, Bureau 1983). Harvest data upon which some of this literature is based are dated and may not reflect current conditions. Recent literature should be reviewed to determine if species diversity and abundance have changed. If recent literature is unavailable, then recent harvest information from within the project area should be analyzed to estimate species abundance and evaluate if changes have occurred over time.

Riparian and wetland habitat along the San Juan River is important to many species, including the endangered southwestern willow flycatcher. Detailed surveys for threatened and endangered species as well as wetlands should be completed in the riparian zone as recommended by ERI (ERI 2001a). At the Hogback site, Ranney Collector Wells would be installed to collect and annually divert water. The total amount of riparian and wetland habitat impacted as a result of well installation should be determined. Well maintenance requirements should be identified and evaluated, as should short- and long-term impacts to riparian and wetland habitat resulting from construction and maintenance activities.

The Mesa Verde cactus is located within the proposed pipeline route identified for the SJRD (USFWS 1981, ERI 2001). The feasibility of altering the pipeline route to protect and preserve this threatened plant species in its current location should be evaluated. Federally listed and sensitive vegetation should be given special consideration during planning. Where appropriate, modifications to the project such as pipeline realignment may be necessary to ensure that listed species are not adversely impacted.

To protect fish, wildlife, and vegetation resources in the project area, a comprehensive mitigation plan should be developed and included into the work plan for this project. Potential impacts to fish, wildlife, and vegetation resources should be included in the plan as should impact avoidance or minimization measures.

MONITORING

Long-term monitoring of fish and wildlife resources in the area will be essential to determine the effects of the proposed project. A monitoring plan should be developed that includes regular surveys for endangered species, representative migratory and resident bird species, and aquatic species (fish and amphibians). In addition, responses of vegetation to changing hydrology, geomorphology, and physical floodplain characteristics should be conducted annually until habitat conditions stabilize. Monitoring of mitigated habitats should also occur until habitat conditions stabilize.

CONCLUSION

The San Juan River and proposed pipeline routes provide important habitat to a variety of fish, wildlife, and vegetation species. Opportunities for protection and enhancement of these resources occur in the project area. Providing year-round natural flows in this reach is important to the survival and recovery of Colorado pikeminnow, razorback sucker, and southwestern willow flycatcher, as well as other fish, wildlife, and vegetation resources. Native riparian vegetation, especially cottonwood and willow, should be protected, and, where possible, enhanced. Existing wetlands in this area should be protected, and, where possible, new wetlands created. The identification and characterization of southwestern willow flycatcher habitat is especially important. Long-term monitoring of these resources in the project area will be essential to determine the effects of the proposed project.

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APPENDIX C

Part II
Fish and Wildlife Service Memorandum
(January 4, 2005)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 346-2525 Fax: (505) 346-2542

January 4, 2005

Memorandum

To: Area Manager, Bureau of Reclamation, Western Colorado Area Office, Grand Junction, Colorado

From: Field Supervisor, U.S. Fish and Wildlife Service, Albuquerque, New Mexico

Subject: Draft Fish and Wildlife Coordination Act Report for the Navajo – Gallup Water Supply Project, New Mexico and Arizona

Attached is the draft Fish and Wildlife Coordination Act Report (CAR) for the Navajo – Gallup Water Supply Project. The proposed project would supply approximately 38,000 acre-feet per year of San Juan River water to the Navajo Nation in New Mexico and the Window Rock area of Arizona, the Jicarilla Apache Nation in New Mexico, and Gallup, New Mexico, to meet their projected demand in the year 2040.

This report has been prepared by the U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, under the authority of and in accordance with the requirements of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667e). Please provide us any comments concerning this report within 30 days.

Susan MacMullin

Susan MacMullin

Attachment

Draft Fish and Wildlife Coordination Act Report
for the
Navajo - Gallup Water Supply Project
New Mexico

Submitted to:
U.S. Army Corps of Engineers
4101 Jefferson Plaza, NE
Albuquerque, New Mexico 87109-3435

Prepared by:
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U.S. Fish and Wildlife Service
New Mexico Ecological Services Field Office
2105 Osuna Road NE
Albuquerque, New Mexico 87113

January 2005

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INTRODUCTION

This is a draft Fish and Wildlife Coordination Act Report (CAR) for the Navajo - Gallup Water Supply Project (Project) prepared by the U.S. Fish and Wildlife Service (Service) under the authority of and in accordance with the requirements of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 USC 661-667e). This report addresses the Navajo - Gallup Water Supply Project and alternatives developed by the U.S. Bureau of Reclamation (Reclamation). This report describes fish and wildlife resources existing without the project, potential project impacts to fish and wildlife resources, a discussion of concerns related to fish and wildlife resources, and recommendations (mitigation) to decrease adverse effects to fish and wildlife resources.

The Navajo Nation and the City of Gallup (Gallup), New Mexico, currently rely on a diminishing groundwater supply. To meet future demand, Reclamation is proposing to construct a water supply project that would divert water from the San Juan River and Navajo Reservoir to the Navajo Nation, Jicarilla Apache Nation, and Gallup. The proposed project would supply approximately 38,000 acre-feet per year (afy) of water to meet the projected demand in the year 2040. The service area would include most of the Navajo Nation in New Mexico and the Window Rock area of Arizona, the Jicarilla Apache Nation in New Mexico, and Gallup. By the year 2040 the project would serve an estimated 203,000 people in the Navajo Nation, 1,300 people in the Jicarilla Apache Nation, and 47,000 people in Gallup.

The project would include the construction of two main water supply pipelines, the San Juan Lateral and the Cutter Lateral. The San Juan Lateral would receive water diverted from the existing Public Service Company of New Mexico (PNM) diversion dam. The Cutter Lateral would receive water diverted from the existing Navajo Indian Irrigation Project (NIIP) main canal at Cutter Reservoir. The project would include the construction of a treatment plant at each diversion point and the construction of main pumping plants that would supply water via 267 miles (430 kilometers (km)) of pipeline. The project would also include the construction of forebay tanks, booster pumping stations, water regulating tanks, water storage tanks, and approximately 107 miles of transmission lines along the pipeline routes. The capacity of the pumping and treatment plants would be staged with initial capacities adequate to meet the projected demand in the year 2020. Capacities would be increased as needed up to the projected demand of approximately 38,000 afy in the year 2040. By the year 2040, the project would supply approximately 26,064 acre-feet per year (afy) (3,585 hectare-meters (hmy)) of water to the Navajo Nation, 1,200 afy (148 hmy) to the Jicarilla Apache Nation, and 7,500 afy (925 hmy) to Gallup.

DESCRIPTION OF STUDY AREA

San Juan River

The San Juan River is a tributary to the Colorado River and drains approximately 38,300 mi^2 (99,200 km^2) in Colorado, New Mexico, Utah, and Arizona (Figure 1). From its origins in the San Juan Mountains of southwestern Colorado (at an elevation exceeding 13,943 ft) (4,250 meters (m)), the river flows westward through New Mexico, Colorado, and into Lake Powell,

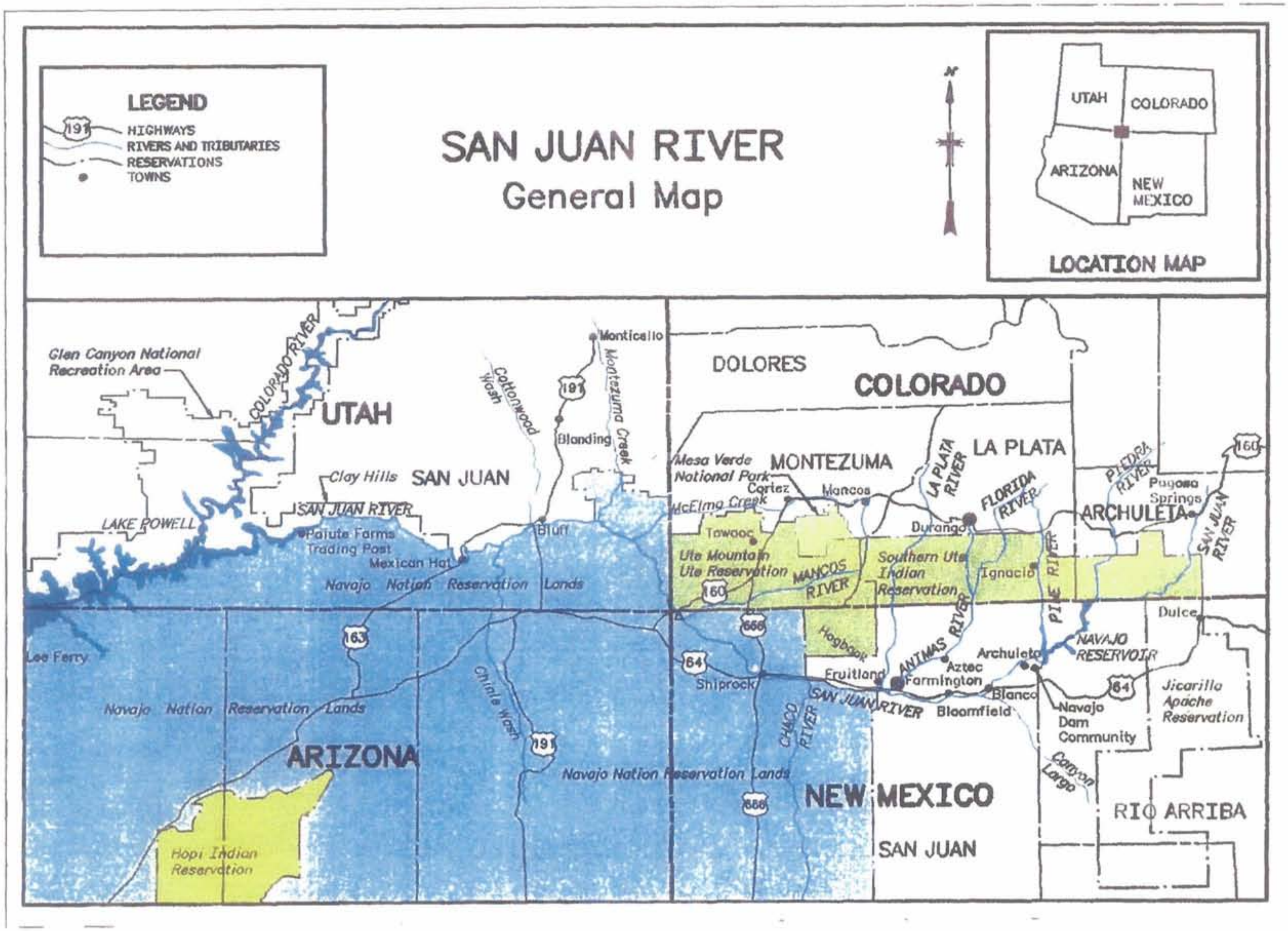

Figure 1. Location map of the San Juan River in the Navajo-Gallup Water Supply project area (provided by Reclamation).

Utah. The majority of surface water for the 345 mi (570 km) of river is from the mountains of Colorado. From a water resources perspective, the area of influence for the project begins at the inflow areas of Navajo Reservoir, and extends west from Navajo Dam approximately 224 mi (359 km) along the San Juan River to Lake Powell. The pre-dam median annual discharge near Bluff, Utah, was 1,620,000 afy (199,825 hmy) with a range of 618,000 afy (76,229 hmy) to 4,242,000 afy (523,245 hmy) (Bliesner and Lamarra 2000). The major perennial tributaries in the project area are the Los Pinos, Piedra, Navajo, Animas, La Plata, and Mancos Rivers, and McElmo Creek. There are also numerous ephemeral arroyos and washes that contribute little flow to the San Juan River, but large sediment loads.

Little is known about the historic condition of the San Juan River in northern New Mexico and southern Utah prior to the 1880s. However, during the past 120 years the San Juan River has undergone a variety of changes. Between 1883 and 1890 major watershed erosion contributed large quantities of sediment that moved through the Colorado River drainage including the San Juan River. In the early 1940s sediment inflow and outflow to the San Juan River was reduced (Thompson 1982). Theories for the change in sediment flow include climate change (Bryan 1925), invasion of tamarisk (Graf 1987), or the natural evolution of land forms (Gellis *et al.* 1991).

The San Juan River is typical of most rivers in the southwestern U.S., characterized by large flows during spring runoff, followed by low but variable summer, fall, and winter base flows. Stream gage data in the San Juan River are inconsistent and incomplete prior to 1929. However, by 1870 there was substantial diversion of water (about 16 percent of natural discharge) for irrigation, primarily during summer months (Bliesner and Lamarra 2000). Between 1929 and 1961 mean daily flows ranged from near 0 to 70,000 cubic feet per second (cfs) (0 to 1,982 cubic meters per second) (cms) near Bluff, Utah. The median daily peak discharge during spring runoff was 10,500 cfs (297 cms), with a range of 3,810 to 33,800 cfs (108 to 957 cms). An average annual hydrograph (USGS Bluff, Utah Gage Station) for the river below Navajo Dam shows that the seasonal peak runoff usually occurred March through July. Mean monthly base flows were as low as 65 cfs (2 cms).

Navajo Dam was completed and began operation in 1963. Navajo Reservoir is used for flood control, water storage, conservation, and irrigation (City of Farmington 1983). The total capacity for the reservoir at spillway crest elevation (6,085 ft) (1,855 m) is 1,708,600 acre-feet (ac-ft) (210,754 hectare-meters (hm)). Regulation from Navajo Dam reduced mean peak spring flows by 54 percent, but increased base flows by 285 percent (250 versus 65 cfs) (7 versus 2 cms) (Bliesner and Lamarra 2000). Completion of the reservoir isolated the upper 77 mi (124 km) of river, while the filling of Lake Powell in the early 1980s inundated the lower 54 mi (87 km). The dam is operated and maintained by Reclamation. Between 1962 and 1991 Navajo Dam was operated to provide stable flows for water storage in a manner that reduced peak spring discharge and elevated flows in other seasons (Bliesner and Lamarra 2000).

In 1992, the San Juan River Basin Recovery Implementation Program (SJRBRIP) was initiated following consultation with the Service pursuant to section 7 of the Endangered Species of Act (Act) for the Animas-La Plata Project and NIIP in 1991. This consultation led to a 7-year research effort funded by Reclamation and the Bureau of Indian Affairs. The research was part of a 15-year recovery program for the Colorado pikeminnow (*Ptychocheilus lucius*) (pikeminnow), and razorback sucker (*Xyrauchen texanus*). During the 7-year research period (1992 to 1998) Navajo Dam was operated to mimic a natural hydrograph with the volume of release during spring linked to the amount of preceding winter precipitation. An average annual hydrograph (USGS Bluff, Utah Gage Station) for the river below Navajo Dam shows that the seasonal peak runoff between 1992 and 1998 usually occurred in May and June. Average monthly discharges at Bluff range from approximately 476 to 8,749 cfs (14 to 248 cms). The average winter base flow of approximately 500 cfs (14 cms) usually persists from November through February and average flows during the irrigation season (post runoff) (August through October) are typically 500 cfs (14 cms) and supplemented by summer storm events.

The environmental consequences of dam operations and main stem diversions include the narrowing and incising of the river channel, the loss of native wetland and riparian vegetation, changes in water temperature, and blockage or limiting of fish passage. Because the Animas River is largely unregulated, it ameliorates many of the impacts of dam operations in the San Juan River downstream of their confluence. The incised channel and dam operations limit overbank flows and periodic scouring of floodplain areas. The changed hydrology largely precludes natural regeneration of native cottonwoods and willows and promotes the growth of non-native vegetation such as salt cedar and Russian olive, which have largely replaced the native cottonwood/willow vegetative complex. Prior to 1962 there was no mention of Russian olive in survey notes along the San Juan River. Russian olive and salt cedar now account for more than 85 percent of the riparian vegetation along the San Juan River (Bliesner and Lamarra 2000). Cumulatively, these changes have altered aquatic habitat and its ability to support a healthy native fish community.

Pipeline Routes

The majority of the pipeline supply routes would be located in previously disturbed highway right-of-ways, primarily in semi-arid upland terrain (Figure 2). Much of the habitat in and adjacent to the pipeline routes has been heavily grazed and vegetative cover is limited. As a result, low densities of wildlife occur in upland areas in and adjacent to the pipeline routes. Dominant vegetative communities along the proposed routes include Great Basin foothill-Piedmont grassland, Great Basin lowland/swale grassland, and Great Basin microphyllous desert scrub (Ecosystems Research Institute [ERI] 2003a). Great Basin foothill-Piedmont grasslands occur at an elevation of 4,500 to 7,200 feet (ft) (1,400 to 2,200 m) and are dominated by galleta (*Hilaria jamesii*), indian ricegrass (*Oryzopsis hymenoides*), four-wing saltbush (*Atriplex canescens*), green rabbitbrush (*Ericameria viscidiflora*), and big sage (*Artemisia tridentata*). Great Basin lowland/swale grassland habitats occur at an elevation of 3,500 to 7,200 ft (1,150 to 2,220 m) and are dominated by alkali sacaton (*Sporobolus airoides*) (ERI 2003a). Great Basin microphyllous desert scrub habitats occur at an elevation of 5,250 to 7,200 ft (1,600 to 2,220 m) and are dominated by big sage, black sagebrush (*Artemisia nova*), four-wing saltbush, shadescale (*Atriplex confertifolia*), and greasewood (*Sarcobatus vermiculatus*).

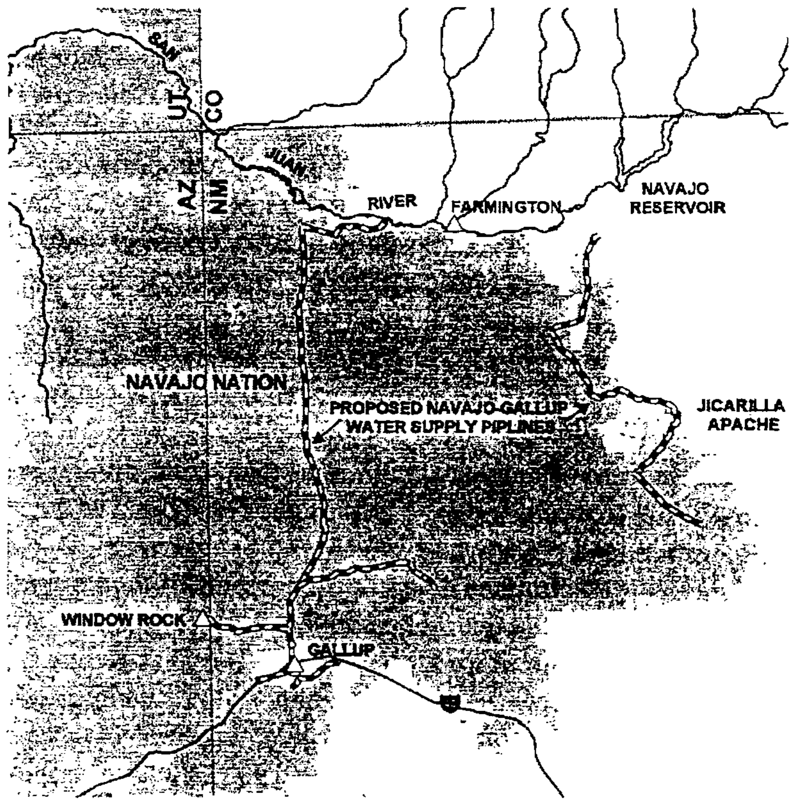

Figure 2. Navajo – Gallup Water Supply Project San Juan and Cutter Laterals (map provided by Reclamation).

The San Juan Lateral pipeline route would be located within federally threatened Mesa Verde cactus habitat. The Mesa Verde cactus occurs south-southeast of the junction of U.S. Highway 491 (U.S. 491) and Navajo Route 36 within the boundary of the proposed San Juan Lateral pipeline alignment and an associated booster pumping station. The cactus also occurs south of the Junction of U.S. 491 and Navajo Route 36 extending approximately 15 miles to the vicinity of Little Water, New Mexico, north of Navajo Route 36 and west of the Hogback diversion, and east of the Hogback diversion from Amarillo Canal to U.S. 491.

PROJECT DESCRIPTION

The Navajo - Gallup Water Supply Project began in 1968 when Reclamation initiated a reconnaissance investigation to formulate and evaluate plans for providing additional water to Gallup and other possible customers from the San Juan Basin and other water sources (Service 1981). The project was expanded in 1975 to include an evaluation of municipal-domestic water supplies for a number of other Navajo communities in New Mexico and Arizona. The Service originally analyzed and completed a Fish and Wildlife Coordination Act Report (CAR) for the proposed project in 1981. Following the completion of the CAR, Reclamation completed a Planning Report and Draft Environmental Impact Statement (DEIS) that evaluated five action alternatives and a no action alternative for the proposed project (U.S. Bureau of Reclamation [Reclamation] 1984). However, the DEIS was never finalized.

In 2000, Reclamation published a *Federal Register* notice of intent to prepare a Draft Environmental Impact Statement on the construction and operation of the Navajo – Gallup Water Supply Project (Reclamation 2000). The Service provided Reclamation a Planning Aid Memorandum (PAM) for the proposed project in December 2002 that contained information on, and planning recommendations for, fish and wildlife resources in the project area. Reclamation anticipates a Record of Decision for the project in 2005.

Four alternatives are being analyzed in the Navajo - Gallup Water Supply Project EIS. Alternatives include: 1) the San Juan Public Service Company of New Mexico (PNM) 2040 Diversion Alternative (Preferred Alternative); 2) the Navajo Indian Irrigation Project (NIIP) Amarillo Alternative; 3) a water conservation alternative; and 4) a no action alternative;.

San Juan River PNM 2040 Alternative (Preferred Alternative)

Under the Preferred Alternative, 33,118 afy (4,085 hmy) of water would be diverted from the San Juan River at the existing PNM diversion dam at River Mile (RM) 166.7. Of the 33,118 afy of water diverted, 1,871 afy would be returned to the river downstream of Shiprock. Water would be diverted from the river and into the San Juan Lateral with a 60 cfs maximum capacity intake pump located immediately upstream of the existing PNM intake structure on the north bank of the river. Water entering the intake would pass through a self-cleaning screen with 3/32-inch (0.2 centimeter (cm)) openings and a through-screen velocity of less than 0.5 feet per second (0.2 m per second). Water passing through the screen would enter a sump where low-head pumps would lift the raw water into settling ponds for removal of suspended sediment. From the settling ponds, water would enter a water treatment and pumping plant. The treatment and pumping plant would occupy approximately 18 acres (7 hectares) of land.

The San Juan Lateral water treatment and pumping plant would include seven ultrafiltration units, seven ultraviolet (UV) disinfection units, a 797,000-gallon water tank, two wastewater ponds, two sediment drying beds, mixing and flocculation tanks, chemical storage buildings, an operation and maintenance building, a 4-unit pumping station, and electrical control equipment. The capacity of the treatment plant would be approximately 38.25 million gallons of water per day (59.19 cfs).

The San Juan Lateral pumping plant would pump treated water into approximately 145 miles (233 km) of buried 12- to 48-inch (30- to 122-cm) diameter pipeline. From the pumping plant, the pipeline would cross the San Juan River upstream of the treatment plant and PNM diversion dam and ascend a mesa south of the river. From the mesa, the pipeline would extend west along the right-of-way of Navajo Highway 64 to U.S. 491. At U.S. 491, the pipeline would extend south along the highway right-of-way to Yah-ta-hey, New Mexico. At Yah-ta-hey, the pipeline would connect to spur waterlines extending to Window Rock and Gallup. In Gallup, one new pumping plant would be constructed, and three existing pumping plants, five storage tanks, and 32 miles of pipeline would be upgraded. Seven booster pumping stations would be constructed along the San Juan Lateral. Each booster pumping station would occupy approximately one acre of land and consist of a water tank, pumping plant, air chamber, chlorination building, and electrical control structure. The San Juan Lateral would also include the construction of 17 water storage tanks, 3 water regulating tanks, junctions to the existing Shiprock, Burnham, and Gallup water supply systems, and a turnout to NIIP. The project would also include the construction of a new overhead electrical transmission line that parallels the San Juan Lateral pipeline, and provides power to the booster pumping stations.

The Preferred Alternative would also include construction of the Cutter Lateral pipeline. The Cutter Lateral would serve Huerfano, Nageezi, Counselor, Pueblo Pentado, Ojo Encino, Toreon, and the Whitehorse Chapters in the eastern portion of the project area in New Mexico. It would also serve the Jicarilla Apache Nation. The Cutter Lateral would originate at Cutter Reservoir and provide up to 4,645 afy (537 hmy) of water to the eastern service area. This lateral would include a water treatment and pumping plant that occupies approximately 3 to 4 acres of land. The Cutter Lateral water treatment and pumping plant would be smaller than the San Juan Lateral plant, but would contain much of the same equipment. The plant would include three ultrafiltration units, three UV disinfection units, a 112,000 gallon subsurface pumping plant forebay, two wastewater ponds, mixing and flocculation tanks, chemical storage buildings, an operation and maintenance building, a 4-unit pumping station, and electrical control equipment. The capacity of the Cutter Lateral treatment plant would be approximately 5.39 million gallons of water per day (8.34 cfs).

The Cutter Lateral pumping plant would pump treated water into approximately 89 miles (143 km) of buried 10- to 24-inch (25- to 61 cm) diameter pipeline. The Cutter Lateral would include the construction of five one-acre booster pumping stations, three community water storage tanks, and two water regulating tanks. Similar to the San Juan Lateral, an overhead electrical transmission line would be constructed along the Cutteral Lateral to power the booster pumping stations. A substation would also be constructed to provide power from an existing PNM transmission line to the newly constructed transmission line.

The Preferred Alternative would also include the release of approximately 40 cfs (1.1 cms) through the NIIP canal down Ojo Amarillo in May when maximum releases from Navajo Dam are 5,000 cfs (142 cms). Ojo Amarillo discharges to the San Juan River at RM 170 downstream from the confluence with the Animas River. Increasing releases from Navajo Dam by 40 cfs (1.1 cms) above 5,000 cfs would violate the Corps of Engineers San Juan River flood control restrictions above the confluence with the Animas River.

<u>NIIP Amarillo Alternative</u>

Under the NIIP Amarillo Alternative, 37,763 afy (4,658 hmy) of water would be diverted from Navajo Reservoir at the NIIP diversion. Of the 37,763 afy of water diverted, 1,871 afy would be returned to the river downstream of Shiprock. The remaining 35,892 afy (4,427 hmy) of water would be supplied to Gallup and the Navajo Nation in Arizona and New Mexico. Under this alternative, water would be diverted from Navajo Reservoir through the existing NIIP Main and Burnham Lateral Canals and delivered to an 8,800 ac-ft (1,085 hm) reservoir that would be constructed as part of this alternative. A water treatment plant and pumping station would be constructed near Moncisco Reservoir. From the treatment plant, water would be piped south to an existing natural gas line right-of-way. The waterline would follow the gas line right-of-way to the vicinity of Twin Lakes, New Mexico, and then to Yah-ta-hey. At Yah-ta-hey it would connect to smaller waterlines and proceed west along Highway 64 to Window Rock, then south along U.S. 491 to Gallup. Three additional spur waterlines would connect to the mainline, including a pipeline from Naschitti, New Mexico, north along U.S. 491 to Sanostee, New Mexico; a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, New Mexico; and a pipeline along Highway 550 to Nageezi, then south to Torreon.

Water Conservation Alternative

The Water Conservation Alternative does not include any structural elements. Under this alternative, efforts would be made to conserve and reuse water using existing infrastructure. Opportunities to conserve water and the amount of water available would be limited by the amount of water in use. Reuse opportunities may be limited by regulations under the Safe Drinking Water Act.

No Action Alternative

Under the No Action Alternative, Reclamation would not construct the project. Gallup and the Navajo Nation in New Mexico and Window Rock, Arizona, would continue to rely on a diminishing groundwater supply. Water would also not be supplied to the Jicarilla Apache Nation in New Mexico. Water for economic growth and improvement of the standard of living for current and future populations in the project area would not be provided. Groundwater withdrawal would continue to lower the water table in the Gallup area.

EVALUATION METHODOLOGY

Since project planning began in 2000, the Service has attended meetings with Reclamation and others to discuss project features, design, and construction methods. Additional biological data and background information were derived through review of relevant literature and personal communications. Reclamation has provided a majority of the technical and background information. Wildlife and vegetation surveys of the project area were performed by ERI in 1999, 2000, and 2002 (ERI 2003a). ERI used Gap Analysis Project (GAP) data to quantitatively delineate vegetation communities along the proposed pipeline routes (ERI 2003a). ERI also developed reports identifying potential project related impacts to fish and wildlife resources and mitigation for those impacts (ERI 2003a, ERI 2003b, ERI 2003c). Numerous fishery studies have been conducted in the San Juan River in and near the project area as part of the SJRBRIP.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Prior to the SJRBRIP research management (1962-1991), discharges from Navajo Reservoir were relatively stable year-round from 1,200 to 1,400 cfs (34 to 40 cms). Regulated releases reduced spring flows and increased base flows. Between 1992 and 1998 winter releases from Navajo Dam were typically about 500 cfs (14 cms). Non-winter releases were typically 500 to 5,000 cfs (14 to 142 cms). In 1999, the SJRBRIP developed flow recommendations for the recovery of the endangered pikeminnow and razorback sucker. The flow recommendations are designed to mimic the natural hydrograph of the San Juan River. Reclamation is proposing to implement the flow recommendations as part of the Navajo Operations Environmental Impact Statement.

Under the flow recommendations Navajo Reservoir would be operated so that releases from Navajo Dam would range from 250 cfs to 5,000 cfs (7 to 142 cms). Navajo Reservoir would provide a peak spring release of 5,000 cfs (142 cms) in most years and make releases to support 500 to 1,000 cfs (14 to 28 cms) base flows downstream of the Animas River confluence for fish habitat. This would require maintaining minimum releases of 250 cfs (7 cms) during certain times of the year. Excess summer water would be released in spike peaks in the fall and winter.

Most juvenile fish prefer shallow, low velocity habitats. For native fishes such as the pikeminnow these habitats include backwaters, shoals, eddies, pools, and slackwaters. In the San Juan River, these habitats comprise less than 15 percent of the total habitat (Bliesner and Lamarra 1996). Habitat modeling results show that area of backwater habitats downstream of the Animas River confluence are maximized between approximately 800 and 1,100 cfs (23 to 31 cms) (Holden 1999). Between 1,100 and 2,500 cfs (28 to 71 cms) there is a decline in area of backwater habitat. Backwater habitat is least abundant at flows near 2,500 cfs (71 cms). At flows between 2,500 and 4,000 cfs (71 to 113 cms) there is an increase in area of backwater habitats and at flows above 4,000 cfs (113 cms) there is little change in area. Shoal, pool, eddy, and slackwater habitats are generally more abundant than backwater habitats, though differ in area with changes in flow. Area of pool and shoal habitats decline from 500 to 1,500 cfs (14 to 42 cms). At flows above 1,500 cfs (42 cms) there is little change in area of pool and shoal habitats. Pool and shoal habitats generally increase with decreasing flows. Area of slackwater habitat varies with flow, but generally increases from 500 to 1,000 cfs (14 to 28 cms) with little change above 1,000 cfs (28 cms). Eddy habitat increases in area as flows increase. Except for eddy and slackwater habitats, low velocity habitats generally decline with increasing flows. However, at flows greater than 4,000 cfs (113 cms) there is nearly as much backwater area as there is at 800 to 1,100 cfs (23 to 28 cms) (Holden 1999).

For larger fish species, habitat preferences are more diverse but tend toward deeper, moderate velocity water compared to juveniles. In the San Juan River, runs typically comprise at least 70 percent of the total habitat at any discharge (Bliesner and Lamarra 1996). Thus, there appears to be adequate adult fish (non-spawning) habitat available for both native (Miller and Ptacek 2000, Ryden 2000a) and non-native species (Holden 1999, Propst and Hobbes 1999).

Nearly all native fishes in the San Juan River require high spring flows to clean and prepare cobble bars for successful reproduction. Lack of suitable spawning habitat for endangered species may be a contributing factor to the poor condition of the San Juan River fishery. At present there is only one confirmed spawning site used by pikeminnow in the San Juan River. As more pikeminnow stocked as young-of-the-year (YOY) reach sexual maturity, additional spawning sites may be identified. Spawning habitat for razorback suckers may also be limited, though individuals stocked as juveniles appear to be locating spawning habitats adjacent to those used by native flannelmouth and bluehead suckers as they reach sexual maturity (Ryden 2000b).

Aquatic Resources

The aquatic resources in the San Juan River evolved in a system that is different than what exists today. Navajo Reservoir altered the temperature and flow regime of the river and has limited the upstream migration of native fishes. The downstream impoundment of Lake Powell has permanently inundated potentially important nursery habitats. The available fish habitat in the San Juan River from these two reservoirs has been reduced by about 80 mi (129 km) (Holden 2000). Encroachment of non-native terrestrial plant species, such as salt cedar and Russian olive, has armored and incised the river channel. Habitat loss and fragmentation from water development, including several (6 major) diversion structures, has contributed to changing the fishery downstream of Navajo Dam to Lake Powell. In addition, fish poisoning prior to the closure of Navajo Dam and the subsequent introduction of non-native fishes (both predators and competitors) has also permanently changed the fish community. Consequently, the existing aquatic communities in the project area differ from those that occurred historically (Platania 1990, Holden 1999).

Comprehensive studies of fish presence, abundance, distribution, or life history were not conducted in the San Juan River until the late 1980s (Holden 2000). Earlier studies were generally conducted to determine fish presence. The native ichthyofauna of the San Juan River is believed to have consisted of at least nine species, four of which are endemic to the Colorado River Basin (Tyus *et al.* 1982, Sublette *et al.* 1990, Platania 1990). Three of these are federally listed as endangered (bonytail chub, *Gila elegans*, pikeminnow, and razorback sucker) and one is State listed by New Mexico as threatened (roundtail chub, *Gila robusta*).

Bonytail chub remains have been collected in middens near Aztec, New Mexico, but are thought to have been extirpated from the San Juan River by the mid-1800s (Sublette *et al.* 1990). Razorback suckers were extirpated from the New Mexico portion of the San Juan River until they were reintroduced during the 7-year research period. Between 1991 and 1997 only 17 adult pikeminnow were collected between Shiprock, New Mexico, and Mexican Hat, Utah (Ryden 2000a). Historically, these latter two species are believed to have occurred in the basin (Animas River) upstream as far as Durango, Colorado, and downstream in the San Juan River to the confluence of the Colorado River. Roundtail chub, commonly found in previous surveys, were only occasionally collected during this same period. The reduction of native fish and the proliferation of non-native fish species in the San Juan River illustrates that the hydrologic and morphological changes in the channel have had an impact on aquatic resources. A list of common and scientific names of fish discussed in this report or that occur in the San Juan River project area is provided in Appendix A.

The San Juan River between Navajo Dam and Lake Powell supports a fish community consisting of 26 known species (and three hybrid sucker forms), including 7 native species (Ryden 2000a). Flannelmouth sucker are the most common large native species. Channel catfish are the most abundant large non-native species, particularly downstream of PNM weir, while red shiner are the most abundant small non-native. Other common native species include bluehead sucker and speckled dace. Other common non-native species include common carp, fathead minnow, and western mosquitofish. Game fish include rainbow trout, brown trout, channel catfish, striped bass, bluegill, largemouth bass, and walleye. Hence, the fishery in this section of river is varied and includes cold-water species in the upper reach, and a mix of warm- and cool-water species in the middle and lower reaches. The popular cold-water fishery is primarily dependent on stocking of rainbow trout by the NMDGF, natural reproduction by brown trout, and on cold water released from the bottom of Navajo Reservoir. Of the non-native species found in the river, at least three originate from Lake Powell. These include striped bass, walleye, and threadfin shad. Many more species probably originate from the drains and off-channel impoundments, particularly largemouth bass and sunfish. In summers with clear base flows, large numbers of striped bass move upstream from Lake Powell as far as the PNM diversion dam (RM 166.7).

The most commonly collected non-native species, channel catfish, common carp, red shiner, and western mosquitofish, are tolerant of disturbed habitat. In the San Juan River, smaller species such as red shiner typically are most abundant in years with low spring peaks and lower, stable base flows (Propst and Hobbes 1999). Red shiners share common food resources (i.e., compete) with and prey upon larval native species including pikeminnow and native suckers (Propst and Hobbes 1999). Channel catfish both prey upon and use common food resources with native fishes (Brooks *et al.* 2000). Native suckers (up to 315 mm SL) have been collected in channel catfish stomachs in the San Juan River (Brooks *et al.* 2000). Channel catfish which have spiny pectoral spines have been documented to become lodged in the mouths of pikeminnow who try to prey upon them (Dale Ryden, Service, pers. comm.).

Though many of the same species were collected in New Mexico, Colorado, and Utah, there were longitudinal differences in species composition and abundance. Coldwater species (e.g., rainbow trout, brown trout, mottled sculpin) were more abundant in upstream reaches, and warmwater species (e.g., channel catfish, red shiners) were more abundant in downstream reaches, particularly downstream of PNM weir. Coolwater species (e.g., speckled dace, common carp) were generally abundant throughout most reaches. The highest proportion of native fishes (>90 percent) collected was between Hammond diversion and the Animas River confluence (NMDGF 1994, unpublished data).

The NMDGF does not intensively manage the river downstream of the tailwater trout fishery (approximately 15 mi (24 km) downstream of Navajo Dam) for any particular species, though there is a substantial channel catfish and a seasonal striped bass fishery downstream of PNM weir (Marc Wethington, NMDGF, pers. comm.). Protecting and enhancing the native fish community is also an objective of both the NMDGF and the Service.

Terrestrial Resources

Vegetation

The project area lies within two physiographic regions including the southern Rocky Mountains and the Colorado Plateau (Dick-Peddie 1993, Brown 1982). Representative plants commonly occurring in the area downstream of Navajo Dam include: bluestems, indian grass, switch grass, sideoats, Harvard shin oak, sand sagebrush, soapweed yucca, mesquites, fourwing saltbush, rabbit brush, and snakeweed. Cacti include several hedgehogs, prickly-pears, and chollas.

Riparian communities comprise the majority of the vegetation community along the San Juan River between Navajo Dam and Lake Powell. Riparian vegetation includes Fremont cottonwood, coyote willow, Russian olive, salt cedar, Siberian elm, black locust, and honey locust. A list of common and scientific names of vegetation discussed in this report is provided in Appendix B.

Much of the project area has been disturbed by cattle and sheep grazing, urban development, oil and gas drilling, and surface mining. The cumulative habitat alterations, combined with large-scale water development, have altered much of the native wetland and riparian communities along the San Juan River. Although native willows and cottonwoods still exist, more than 85 percent of the vegetation community along the floodplain of the San Juan River has been replaced by non-native Russian olive and salt cedar.

Prior to large scale water development projects, the San Juan River floodplain was comprised of trees, shrubs, and grassland dependent upon periodic flooding. A major historical component of native vegetation along the San Juan River was cottonwood woodland. This deciduous woodland is best developed along alluvial floodplains of large, low-gradient, perennial streams that flow through wide, unconstrained valleys. The vegetation is dependent on a subsurface water supply and varies considerably with the height of the water table. Major flood events and consequent flood scour, overbank deposition of water and sediments, and stream meandering are important factors that shape this community (USGS 1998).

Most of the project area is located in upland habitat. Representative shrubs commonly occurring in the uplands include: four-wing saltbush, green rabbitbrush, big sage, black sage, shadscale, grease wood and winterfat. Representative forbs and grasses include indian ricegrass, western wheatgrass, mallow, and galetta.

Wildlife

Wildlife habitats in the project area can be broken into three general categories: 1) bottomland riparian/wetland habitat; 2) irrigated agriculture and urban vegetation; and 3) arid upland (ERI 2003c). Bottomland habitats are located along the San Juan River, Chaco River, and arroyos. These habitats are critical to many species of amphibians, reptiles, birds and mammals (ERI 2003a). Irrigated agriculture and urban areas provide important habitat for many wildlife species in the project area as well. Many bird and mammal species rely on these habitats with the highest number of birds found in the project area occurring within agricultural fencerow habitats (ERI 2003c). Arid upland habitats in the project area have been impacted by grazing (Service 1981). Impacts associated with upland grazing have limited plant and wildlife diversity in the project area.

Reclamation conducted habitat investigations within a portion of the project area in 1983 (Reclamation 1984). During their investigations, Reclamation identified 84 mammals, 11 amphibians, 34 reptiles, and 150 bird species in the general project area (ERI 2003c). As a part of their project area investigations, Reclamation reviewed New Mexico Department of Game and Fish hunter survey reports from the late 1960's and early 1970's to evaluate wildlife density (ERI 2001). Hunter survey reports indicated low densities of game species in the project area.

Recent wildlife information for the project area is limited to elk and deer censuses (ERI 2003c). New Mexico Department of Game and Fish aerial surveys of Game Management Unit (GMU) 7 (Cutter Lateral area) in 2002 revealed approximately four elk and less than one deer per square mile. The NMDGF estimates that Game Management Unit 2B (also in the general Cutter Lateral area) contains a total of approximately 5,100 deer and 1,350 elk (ERI 2003c).

Although upland habitats have been heavily impacted by grazing, San Juan and McKinley Counties exhibit relatively high trapping rates for fur bearing mammals. During the 1999-2000 season, 23 percent of the fur bearing mammals trapped in New Mexico were from these two counties (ERI 2003c). Many of these species are associated with bottomland habitats and habitats associated with irrigated agriculture and would not typically be found in disturbed semi-arid upland habitats that dominate the pipeline routes.

Representative bird species found in bottomland riparian/wetland habitats include: Cooper's hawks, peregrine falcons, Gambel's quail, western sandpipers, mountain plovers, gulls, yellow-bellied sapsuckers, yellowlegs, lark sparrows, dippers, flycatchers, belted kingfishers, great-horned owls, red-winged blackbirds, tree swallows, mountain chickadees, nuthatches, grackles, sparrows, medolarks, pied-billed grebes, northern shovelers, double-brested cormorants, warblers, and teals. Representative bird species found in arid upland habitats include: hawks, peregrine falcons, osprey, chuckar, scaled quail, pheasant, willet, plovers, terns, gulls, doves, short-eared and burrowing owls, swifts, sparrows, orioles, shrikes, swallows, towhees, phoebes, meadowlarks, thrashers, warblers, grebes, and ducks. A list of common and scientific names of birds discussed in this report is provided in Appendix C.

Representative mammal species found in bottomland riparian/wetland habitats include: pallid and big brown bats, little brown and small-footed myotises, free-tailed bats, cottontail, jackrabbit, squirrel, Gunnison's prairie dogs, mice, coyotes, mountain lions, striped skunks, racoons, black bear, and mule deer. Representative mammal species found in arid upland habitats include: shrews, pallid bats, silver-haired bats, myotises, Townsend's big-eared and Mexican free-tailed bats, cottontail, jackrabbit, beaver, Gunnison's prairie dog, kangaroo rats, mice, squirrels, coyotes, river otter, long-tailed weasel, mink, raccoons, skunks, foxes, pronghorn, and mule deer. A list of common and scientific names of mammals discussed in this report is provided in Appendix D.

Representative amphibians found in bottomland riparian/wetland habitats include: tiger salamanders, toads, and frogs. Representative reptiles include: whiptails, corn snakes, many-lined skinks, common kingsnakes, desert spiny lizards, and garter snakes. Representative amphibians found in arid upland habitats include: tiger salamanders, toads, and frogs. Representative reptiles include: whiptails, rattlesnakes, gopher snakes, and lizards. A list of common and scientific names of amphibians and reptiles discussed in this report is provided in Appendix E.

Threatened and Endangered Species

As the quality and quantity of the fish and wildlife habitat within the San Juan River has decreased over time from habitat alteration and large-scale water development, so has its ability to sustain native flora and fauna. Several species native to the project area have been listed as federally threatened and endangered under the Act. Listed species that are present include the pikeminnow, razorback sucker, southwestern willow flycatcher, bald eagle, and Mesa Verde cactus.

Colorado Pikeminnow

The project is also within the known and historic range of the pikeminnow. The pikeminnow was listed by the Service as endangered March 11, 1967 (32 FR 4001). The current range of the pikeminnow includes Colorado, New Mexico, Utah, and Wyoming. Critical habitat for the pikeminnow was designated March 21, 1994 (59 FR 13374). Critical habitat for the pikeminnow begins at the State Highway 371 bridge (T 29 N, R 13 W, Sec. 17) in Farmington, New Mexico, and includes the 100-year floodplain downstream to the mouth of Neskahai Canyon (T 41 S, R 11 E, Sec. 16), Utah, on the San Juan arm of Lake Powell. Critical habitat includes areas of the floodplain that when flooded would provide fish habitat. The primary constituent elements for critical habitat include, but are not limited to, the river channel, bottomlands, side channels, secondary channels, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated, provide spawning, nursery, feeding or rearing habitat. Areas within the 100-year floodplain that do not provide the primary constituent elements do not meet the definition of critical habitat. For example, a parking lot within the 100-year floodplain would not be considered critical habitat.

Razorback Sucker

The project is also within the known and historic range of the razorback sucker. The razorback sucker was federally listed by the Service as endangered on October 23, 1991 (56 FR 54947). The current range of the razorback sucker includes Arizona, California, Colorado, New Mexico, Nevada, Utah, Wyoming, and Mexico. Critical habitat for the razorback sucker was designated March 21, 1994 (59 FR 13374). Critical habitat for razorback sucker begins at the Hogback diversion (T 29 N, R 16 E, Sec. 9) and includes the 100-year floodplain downstream to the mouth of Neskahai Canyon, Utah, on the San Juan arm of Lake Powell. The primary constituent elements for critical habitat are similar to those for pikeminnow and fall into three general areas: water, physical habitat, and the biological environment (Maddux *et al.* 1993).

Southwestern Willow Flycatcher

The Service listed the southwestern willow flycatcher (flycatcher) as endangered on February 27, 1995 (60 FR: 10694-10715). The flycatcher is also classified as endangered by the State of New Mexico (New Mexico Department of Game and Fish 1987). The current range of the flycatcher includes southern California, southern portions of Nevada and Utah, Arizona, New Mexico, western Texas, and southwestern Colorado (Unitt 1987, Browning 1993). In New Mexico, the species has been observed in the Rio Grande, San Juan, Rio Chama, Zuni, San Francisco, and Gila River drainages. Available habitat and overall numbers have declined statewide (62 FR: 39129-39147). A final recovery plan for the flycatcher has been developed (68 FR: 10485).

Loss and modification of nesting habitat is the primary threat to this species (Phillips *et al.* 1964, Unitt 1987, 58 FR: 39495-39522). Loss of migratory stopover habitat also threatens the flycatcher's survival. Large scale losses of southwestern wetlands have occurred, particularly the cottonwood-willow riparian habitats that are used by the flycatcher (Phillips *et al.* 1964, Carothers 1977, Rea 1983, Johnson and Haight 1984, Howe and Knopf 1991). The flycatcher is a riparian obligate and nests in riparian thickets associated with streams and other wetlands where dense growths of willow, buttonbush, boxelder, Russian olive, salt cedar or other plants are present. Nests are often associated with an overstory of scattered cottonwood. Throughout the flycatcher's range, these riparian habitats are now rare, reduced in size, and widely separated by vast expanses of arid lands. Flycatchers begin arriving in New Mexico in late April and May to nest, and the young fledge in early summer. Flycatchers nest in thickets of trees and shrubs approximately 6.5 - 23 ft in height or taller, with a densely vegetated understory from ground or water surface level to 13 ft or more in height. Surface water or saturated soil is usually present beneath or next to occupied thickets (Phillips *et al.* 1964, Muiznieks *et al.* 1994). At some nest sites, surface water may be present early in the nesting season with only damp soil present by late June or early July (Muiznieks *et al.* 1994, Sferra *et al.* 1995). Habitats not selected for nesting or singing are narrower riparian zones with greater distances between willow patches and individual willow plants. Suitable habitat adjacent to high gradient streams does not appear to be used for nesting. Areas not selected for nesting or singing may still be used during migration.

Occupied and potential flycatcher nesting habitat exists along the San Juan River. Although no territories were identified along the San Juan River in 2001, three territories were documented as recently as 1998. Occupied and potential habitat is primarily composed of riparian shrubs and trees, chiefly Goodding's willow and peachleaf willow, Fremont cottonwood, coyote willow, and salt cedar. The habitat within the project area does provide nesting habitat for the flycatcher, and some flycatchers may use the area during migration. Habitat in nesting areas has mature cottonwoods, often bordered or mixed with salt cedar and Russian olive, with small patches of willows along the high flow channels.

Bald Eagle

The project area is also within the known and historic range of the bald eagle. The Service reclassified the bald eagle from endangered to threatened on July 12, 1995 (60 FR: 36000-36010). Adults of this species are easily recognized by their white heads and dark bodies. Wintering bald eagles frequent all major river systems in New Mexico from November through March, including the San Juan River. Bald eagles prefer to roost and perch in large trees near water. Bald eagle prey includes fish, waterfowl, and small mammals.

Mesa Verde Cactus

The Mesa Verde cactus is federally listed as a threatened species (Service 1984). This species is also protected by the State of New Mexico.

Mesa Verde cactus have spherical stems which grow alone or in clusters, and are about 5-8 cm tall (Service 1984). There are about 8-10 tannish or straw colored radial spines per areole (spine cluster), and no central spines. The color of the spines allow the plants to blend in well with the fine soil on which they grow (Service 1984). Flowers are yellow to greenish-white, and appear in the spring. The cactus is restricted to dry clay soils along drainage ways on the eastern edge of the Navajoan Desert and is associated with *Atriplex spp.* at 1,219-1,829 m in elevation (Service 1984).

The Mesa Verde cactus was historically found in San Juan County, New Mexico, and Montezuma County, Colorado (Service 1984). Presently, it is found in the same counties, but reduced in distribution and numbers.

Reasons for decline in the Mesa Verde cactus include: limited distribution, over-collecting, habitat degradation due to overgrazing, habitat destruction due to mining, oil and gas exploration and drilling, commercial and residential development, off-road vehicle use, road building and maintenance, construction of power lines and pipelines, and pesticide use (Service 1984).

Future Conditions without the Project

The No Action Alternative for this project is the affected environment with trends through the life of the project. No project elements would be implemented under the No Action Alternative. Baseline biological conditions were projected through time and include effects associated with implementation of the Navajo Reservoir Operations EIS.

Fish and wildlife habitat in the project area would likely improve as a result of restoring natural processes associated with the SJRBRIP and mimicry of a natural hydrograph (e.g., recruitment of native riparian vegetation, establishment and maintenance of native fish and endangered species habitats) downstream of the Animas River confluence. The frequency of 5,000 cfs releases in the project area are anticipated to increase more than three-fold while lower flows would occur in the summer, winter, and fall. Lower flows would decrease wetted streambed area, reduce primary and secondary productivity, and reduce carrying capacity in the project area.

The frequency of 5,000 cfs (142 cms) peak releases from Navajo Dam during spring runoff would increase above historic spring releases from about 16 to 69 percent, while minimum releases during summer, fall, and winter (July through February) would be about 50 percent lower (250 cfs versus 500 cfs, 7 versus 14 cms). Average monthly releases during summer and fall (July through October) would be about 57 percent lower (430 cfs versus 1,000 cfs, 12 cms versus 28 cms), and during winter about 51 percent lower (390 cfs versus 790 cfs, 11 versus 22 cms).

In most years, peak spring releases from Navajo Dam would increase with a target release of 5,000 cfs. This increase in flow would continue approximately 44 river mi (71 km) downstream to the Animas River. Flows would then continue to increase, or stabilize, to Lake Powell as a result of tributary inflows.

Winter base flow decreases in more than 44 mi (71 km) of river would provide little or no benefit to the native fish community and trout fishery. While lower winter base flows would not likely produce acute effects, these fisheries would be limited by reduced habitat availability, reduced primary and secondary productivity, and possible competition from non-native fishes.

Lower winter, summer, and fall base flow releases would decrease the wetted streambed perimeter. Aquatic productivity is generally related to the amount of streambed area that is wetted. Shallow areas, especially riffles, are the primary production areas for aquatic invertebrates, which constitute much of the food base for fish and many shorebirds. Some losses in wetted perimeter would be realized with reductions in dam releases from 500 cfs (14 cms) to 250 cfs (7 cms). These reductions would be most pronounced upstream of the Animas River confluence where average winter releases would decrease by about 50 percent and summer and fall releases would decrease by about 57 percent. In addition, irrigation depletions and changing releases from Navajo Dam to meet downstream endangered species needs in summer and fall would result in frequent flow fluctuations. These fluctuations would further reduce or limit aquatic productivity. Lower base flows and frequent fluctuations in summer and fall releases would reduce the forage base and the carrying capacity of fisheries upstream of the Animas River confluence. Downstream of the Animas River confluence to Lake Powell, minimum base flows of 500 cfs (14 cms) would be maintained through critical habitat for endangered species.

Decreased winter base flows would increase shallow water habitat, particularly in areas upstream of the Animas River confluence. These habitats are important to shorebirds (e.g., killdeer, least sandpiper), wintering migratory birds, hibernating amphibians and reptiles, and juvenile fish species. Although lower flows would provide more shallow water habitats, they could also reduce the forage or prey base for many of these same species.

During the spring season, reservoir releases would increase to 5,000 cfs (142 cms), primarily to meet endangered fish species spawning and young-of-the-year habitat needs. Flows downstream of the Animas River confluence, for example, would periodically increase to 10,000 cfs (2,830 cms), or greater.

The duration and timing of high flows typical of the spring season (greater than 10,000 cfs, 2,830 cms) provide better spawning habitat for the fish community and provide better conditions for the (native) riparian-wetland plant community. The flow decreases in the San Juan River upstream of the Animas River confluence during summer, fall, and winter seasons would have varying effects on the fish community. Although the effects of reduced flows on the hydrology supporting the riparian-wetland plant community was minimal during low flow tests, long term impacts to these habitats are not known.

The baseline depletion limit for the San Juan River basin is approximately 853,000 afy (105,216 hmy). Approximately 623,000 afy (76,846 hmy) of the baseline are currently being depleted. Of the 853,000 afy, 280,600 afy (34,612 hmy) has been allocated to NIIP. Of the 280,600 afy depletion allocated to NIIP, approximately 160,330 afy (19,777 hmy) are currently being depleted. Therefore, approximately 120,271 afy (14,835 hmy) of NIIP depletions are available for development. By the year 2040, it is reasonable to assume that the remaining unused depletions would be developed. With the project, approximately 33,600 afy (4,145 hmy) of the future NIIP depletions would be passed downstream through Navajo Dam to facilitate the diversion of 33,118 afy into the San Juan Lateral at the PNM diversion dam. Without the project, the full future NIIP depletion would likely be diverted from Navajo Reservoir and an opportunity to allow more than 33,000 afy of water to remain in the river between Navajo Dam and the PNM diversion dam could be missed.

Without the project, construction related impacts to fish, wildlife, and plants would not occur. Impacts to fish and wildlife resources associated with the operation and maintenance of the diversion pump, treatment and pumping plant, pipeline, powerlines, booster pumping stations, and other project features would also not occur.

Threatened and Endangered Species
Issues with federally listed species will be addressed in detail during section 7 consultation under the Act.

FISH AND WILDLIFE RESOURCES WITH THE PROJECT

The proposed project would include both short- and long-term construction related disturbances. Short-term construction related impacts would occur from noise, dust, and the presence of workers and machinery in the project area. Installation of the pipeline across the river could temporarily increase turbidity and reduce water quality in the construction area. Runoff from construction work sites, access routes, staging areas, and unprotected fills could further degrade water quality. Accidental spills of fuels, lubricants, hydraulic fluids and other petrochemicals, although unlikely, would be harmful to aquatic life. Changes in flow caused by de-watering of the construction sites and excavation could cause direct mortality to fish and aquatic invertebrates, disrupt fish spawning, and cause mortality of incubating eggs downstream of construction sites.

Construction of the intake structure, pipeline crossing of the San Juan River and associated facilities would disturb approximately 17.2 acres (7 hectares) of riparian habitat. Construction of 267 miles of San Juan and Cutter Lateral pipelines, 107 miles of overhead transmission lines, booster pumping stations, and other facilities would temporarily disturb approximately 31,477 acres (12,738 hectares) of primarily upland habitat. Pipeline construction activities could temporarily disturb potential raptor nesting habitats along the Defiance Monocline, Nutria Monocline, and areas near Blanco and Cutter Canyons. These activities could disturb raptor hunting areas southwest of Nageezi and east of Sheep Springs. Construction activities could also temporarily impact golden eagles along the corridor from Cutter Canyon to Largo Canyon.

Construction of the proposed pipeline could also disturb the federally threatened Mesa Verde cactus and its habitat. The Mesa Verde cactus occurs south-southeast of the junction of U.S. 491 and Navajo Route 36 within the boundary of the proposed San Juan Lateral pipeline alignment and an associated booster pumping station.

Under the proposed project, 33,600 afy of NIIP water would be released through Navajo Dam to facilitate diversions of 33,118 afy at the PNM diversion dam (RM 166.7). Of the 33,118 afy diverted at the PNM diversion dam, an average of 1,871 afy would return to the San Juan River via the Shiprock wastewater treatment plant. Between Navajo Dam and the PNM diversion dam mean monthly flows would increase 17 to 98 cfs (0.5 to 2.8 cms). Minimum mean monthly flows would remain unchanged or increase up to 32 cfs (0.9 cms). Maximum monthly flows in this same reach would decrease by 54 cfs (1.5 cms) in February, and increase by 405 cfs (11.5 cms) in October. Downstream of the PNM diversion dam, mean monthly flows would increase up to 38 cfs (1.1 cms) in June, and decrease by 37 cfs (1.0 cms) in July. Minimum mean monthly flows would remain unchanged or decrease by 59 cfs (1.7 cms). Maximum mean monthly flows in this same reach would decrease by 92 cfs (2.6 cms) in February, and increase by 361 cfs (10.2 cms) in October.

Overall, withdrawals would reduce annual base flows by less than 0.5 percent on average with the greatest mean monthly reduction being less than 3 percent. Given the magnitude of flow in the river, project related flow reductions of less than 0.5 percent are not expected to negatively impact aquatic habitats, particularly downstream of the Animas River confluence. Increases in flow, particularly upstream of the Animas River confluence, may provide some benefit to aquatic resources. For example, at the Archuleta gage in July, mean monthly flows would increase by approximately 25 cfs (0.7 cms) with the project. During low flow conditions, this could equate a 10 percent increase (or more) in flow between Navajo Dam and the confluence with the Animas River. These flows could help maintain suitable water temperatures and increase available habitat for both the coldwater trout fishery and the native fish community.

Assuming the SJRBRIP flow recommendations are met, the Preferred Alternative should have minimal effects on water quality in the river. For instance, concentrations of constituent elements (i.e., nutrients) in the river water column would increase by approximately 0.2 percent on average with a maximum increase of approximately 1.2 percent below the PNM diversion dam. Conversely, constituent elements would correspondingly decrease between Navajo Dam and the PNM diversion dam due to increases in releases associated with Preferred Alternative. Return flows from the Shiprock wastewater treatment plant would average approximately 5.0 cfs (0.14 cms) annually, equating to about one percent of minimum base flows under the SJRBRIP flow recommendations. The net increase in constituent elements associated with returns from the wastewater treatment plant would be approximately 1.2 percent. Overall, increases in constituent elements would be difficult to detect and would not be expected to negatively impact the San Juan River fishery.

Operation of the intake at the PNM diversion dam could negatively impact fishery resources at the point of diversion. The approximate 60 cfs diversion at the PNM diversion dam would withdraw between 1.2 and 3.87 percent of the flow during peak larval drift for several fish species (ERI 2003b). Assuming that entrainment of larval fish is directly proportional to the diverted flow, ERI (2003b) estimated that as pikeminnow begin spawning above the PNM diversion dam, approximately 3.87 percent of pikeminnow larvae could be entrained at the intake structure. ERI (2003b) also estimated that approximately 1.2 percent of bluehead sucker larvae, flannelmouth sucker larvae, and speckled dace larvae produced upstream of the PNM diversion dam could be entrained at the intake structure.

Short-term, entrainment of pikeminnow larvae is not expected because pikeminnow spawning has not been documented above the PNM diversion dam. Should pikeminnow access spawning areas above the diversion structure, entrainment of their larvae would likely occur. Entrainment of other species currently spawning above the structure would also occur. However, entrainment should be minimized because of the proposed design, location, and low approach velocities associated with the intake structure. As a result, entrainment of larvae would not be expected to be directly proportional to the diverted flow. Thus, the ERI entrainment estimates should be considered the worst case scenario.

Although the Preferred Alternative would entrain a small proportion of the eggs and larvae produced above the PNM diversion dam, long-term the Preferred Alternative would cause the least impacts to the San Juan River fishery of all the alternatives analyzed, assuming the SJRBRIP flow recommendations are met. The Preferred Alternative would ensure that at least 33,118 afy more water would remain in the river between Navajo Dam and the PNM diversion dam than would occur without the project. The release of 33,600 afy from Navajo Dam should slightly increase the amount of habitat available to fish between Navajo Dam and the PNM diversion dam, and could offset project related impacts downstream. Releases associated with the project could also benefit the native fish community and recreational trout fishery downstream of Navajo Dam, while still meeting the flow recommendations.

The Preferred Alternative would also include diversions of 4,645 afy at Navajo Reservoir for Cutter Lateral. To meet this supply, the mean elevation of Navajo Reservoir would increase by approximately 1.3 ft (0.4 m). Depending on the bathometric profile of Navajo Reservoir this increase could change the amount of near shore spawning and foraging habitat.

NIIP Amarillo and Water Conservation Alternatives

Under the NIIP Amarillo Alternative all of the project water (37,763 afy) would be diverted at Navajo Reservoir. This would result in less water in the river between Navajo Dam and the PNM diversion dam than would occur under the Preferred Alternative. Although entrainment would be avoided under the NIIP Amarillo Alternative, more project related impacts to fish and wildlife resources would be expected because of the reduced flows. The NIIP Amarillo Alternative would also include slightly more upland impacts during project construction than would occur under the Preferred Alternative.

Under the Water Conservation Alternative, project related diversions would not occur and project related infrastructure (e.g., pipelines, pumping plants, etc.) would not be constructed. Although entrainment and construction related impacts would be avoided, future depletions at Navajo Reservoir could mean more impacts to fish and wildlife resources downstream of Navajo Dam.

Threatened and Endangered Species

Issues with federally listed species will be addressed in detail during section 7 consultation under the Act.

DISCUSSION

The Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667e) directs the Federal action agency to consult with the Service for purposes of "preventing a net loss of and damage to wildlife resources." It further directs the action agency to give wildlife conservation measures equal consideration to features of water resource development. Consideration is to be given to all wildlife, not simply those that are legally protected under the Endangered Species Act or those with high economic and recreational value. Further, the recommendations of the Service which follow are to be given full consideration by the action agency. All aspects of the Navajo – Gallup Water Supply Project should be designed and constructed to avoid and minimize impacts to wildlife resources.

Construction projects that result in adverse impacts to fish and wildlife require the development of mitigation plans. These plans consider the value of fish and wildlife habitat affected. The Service has established a mitigation policy used as guidance in recommending mitigation (Service 1981). The policy states that the degree of mitigation should correspond to the value and scarcity of the fish and wildlife habitat at risk. Four resource categories in decreasing order of importance are identified:

Resource Category No. 1 Habitats of high value for the species being evaluated that are unique and irreplaceable on a national basis or in the ecoregion section. No loss of existing habitat value should occur.
Resource Category No. 2 Habitats of high value that are relatively scarce or becoming scarce on a national basis or in the ecoregion section. No net loss of in-kind habitat value should occur.
Resource Category No. 3 Habitats of high to medium value that are relatively abundant on a national basis. No net loss of habitat value should occur and loss of in-kind habitat should be minimized.
Resource Category No. 4 Habitats of medium to low value. Loss of habitat value should be minimized.

The habitats in the immediate project area are classified as follows: Resource Category No. 2 - riparian vegetation (includes trees and shrubs such as willows) and aquatic habitat, and Resource Category No. 4 - irrigated agriculture and arid upland habitats.

Riparian habitats are classified in category 2 because they are scarce and are rapidly disappearing. About 90 percent of the historic wetland and riparian habitat in the southwest has been eliminated (Johnson and Jones 1977). The mitigation goal for riparian areas (trees and shrubs) in the project area is no net loss in wildlife value as a result of the proposed project. To ensure that mitigation is successful for project related impacts, we recommend that a long-term mitigation plan be developed.

Aquatic habitats are classified in category 2 because they are relatively scarce in the Southwest and provide high wildlife value for several native fish species (e.g., Colorado pikeminnow, razorback sucker, flannelmouth sucker). The mitigation goal for aquatic habitat (e.g., backwaters, riffles, and runs) in the project area is to have no net loss of habitat value as a result of the proposed project.

Irrigated agricultural and arid upland habitats are classified in category 4 because they are relatively common in the Southwest, yet they provide important wildlife habitat. Project related disturbances should be mitigated to ensure that impacts to these habitats are avoided or minimized.

The Service has ranked the Project alternatives in terms of their potential impacts on aquatic and terrestrial resources from least to most:

- San Juan PNM 2040 Diversion Alternative (Preferred Alternative)
- Water Conservation Alternative
- No Action Alternative
- NIIP Amarillo Alternative

Short-term, the No Action and the Water Conservation Alternatives would be the most environmentally beneficial alternatives, followed by the Preferred Alternative and the NIIP Amarillo Alternative. This is because approximately 230,000 afy (28,370 hm) of San Juan River depletions have yet to be developed, meaning less water would be diverted, and more water would remain in the San Juan River than would remain in the river under the Preferred Alternative or the NIIP Amarillo Alternative. Construction, operation, and maintenance related disturbances would also be avoided since the No Action and Water Conservation Alternatives would not include the infrastructure proposed under the Preferred Alternative and the NIIP Amarillo Alternative.

As water development continues depletions will approach the 853,000 afy San Juan River baseline depletion limit. Of the 230,000 afy (28,370 hmy) of undeveloped depletions, approximately 120,270 afy are designated for NIIP. Under the No Action and Water Conservation Alternatives, the Navajo Nation would continue to develop their unused NIIP depletions until all of their available water has been developed. Under the proposed action, the Navajo Nation would allow 33,600 afy of water to be released downstream of Navajo Dam to facilitate project related diversions into the San Juan Lateral. Thus, the proposed project would ensure that more water would remain in the river than would occur under the No Action, Water Conservation, and NIIP Amarillo Alternatives.

Of all the alternatives evaluated, the NIIP Amarillo Alternative would have the most short- and long-term impacts to fish and wildlife resources. Under this alternative, 37,763 afy (4,658 hmy) of water would be diverted from the San Juan River at the NIIP diversion in Navajo Reservoir. Short-term impacts would include lower flows downstream of Navajo Dam and possibly lower water quality compared to the Preferred Alternative. Long-term, an opportunity to release 33,600 afy of water from Navajo Dam and remain in the river could be missed. The NIIP Amarillo Alternative would also cause temporary construction related disturbances to approximately 31,841 acres (3,928 hectares) of habitats along its pipeline routes.

The Service anticipates minor short-term impacts to fish and wildlife resources associated with project construction. To minimize adverse impacts to birds protected under the Migratory Bird Treaty Act, tree stands or other adequately vegetated areas slated for grubbing or clearing should be surveyed for the presence of nesting birds during the general migratory bird nesting season of March through August. Disturbance to nesting areas should be avoided until nesting is completed.

Vegetation clearing and construction related soil disturbances can cause sediment-laden runoff to enter waterways. To minimize impacts associated with erosion, the contractor should employ silt curtains, coffer dams, dikes, straw bales, or other suitable erosion control measures. Loss of riparian habitat should be avoided or kept to a minimum when avoidance is not possible. Should loss of riparian habitat occur, mitigation would be necessary. Mitigation plantings of coyote willow and black willow whips or poles, and cottonwood poles should be dense and planted down to the water table to help ensure that mitigation is successful.

Under the proposed project, a portion of the eggs and larvae in the drift above the PNM diversion dam would likely be entrained in the San Juan Lateral intake structure. However, the design, location, and approach velocities of the proposed intake structure would minimize the amount of entrainment that could occur. The Service believes that the impacts associated with entrainment would be offset by the benefits of releasing 33,600 afy of NIIP water through Navajo Dam rather than through the NIIP diversion structure. Therefore, the Service believes that the Preferred Alternative meets the mitigation goal of no net loss for this resource category. Although the Preferred Alternative should meet the mitigation goal for this resource category, the Service recommends that Reclamation monitor the intake pump, sump, and settling ponds to estimate entrainment during periods of larval drift. If larval entrainment exceeds the estimates of ERI (2003b), then Reclamation should contact the Service to determine if further project review under the Fish and Wildlife Coordination Act is necessary.

Although no specific mitigation is recommended for long-term project related impacts to aquatic habitats, the Service anticipates that minor short-term construction related impacts to aquatic habitats would occur. To minimize construction related impacts to fishery and other aquatic resources, we recommend that the in-channel construction sites for the intake pump and pipeline crossing of the San Juan River be dewatered and that flows be diverted around the construction sites. Diverted flows should be sufficient to provide fish passage through the construction areas. To further reduce construction related impacts to aquatic resources, construction activities should be conducted during low-flow periods and periods of low precipitation.

To minimize construction related impacts to water quality, we recommend that Reclamation consult with the Surface Water Quality Bureau of the New Mexico Environment Department regarding the proposed project and potential impacts. To ensure that impacts to water quality are minimized during construction, the contractor should conduct water quality monitoring before, during, and after construction to ensure that New Mexico water quality standards are met.

To minimize impacts associated with concrete and concrete-batching, the contractor should contain poured concrete in forms and/or behind cofferdams to prevent discharge into the river. The contractor should also contain and treat or remove for off-site disposal any wastewater from concrete-batching, vehicle wash-down, and aggregate processing.

To minimize the likelihood of petrochemical spills, the contractor should clean construction equipment prior to construction to ensure that no leaks or discharges of lubricants, hydraulic fluids or fuels occur in aquatic or riparian habitats. The contractor should also store and dispense fuels, lubricants, hydraulic fluids and other petrochemicals outside the floodplain, and inspect construction equipment daily to ensure that no leaks or discharges of lubricants, hydraulic fluids or fuels occur in aquatic or riparian habitats. If petrochemical spills or leaks occur, the contractor should contain and remove any petrochemical spills, including contaminated soil, and dispose of these materials at an approved upland site.

To minimize potential impacts to fish and wildlife resources associated with riprap or other fill, we recommend that the contractor use only clean cobble or quarry stone from an upland source. Uncontaminated earth or alluvium suitable for revegetation with indigenous plant species should be used for backfill. Backfill should be revegetated or reseeded with native plants or seeds to accelerate revegetation of disturbed areas. Staging areas should also be revegetated with native plants or reseeded with native vegetation to minimize erosion and reduce impacts to fish and wildlife resources.

Construction of the proposed project would disturb approximately 31,477 acres of primarily upland habitat. The majority of this habitat would be located in previously disturbed highway right-of-ways. To minimize trapping of wildlife during trenching operations we recommend, where possible, that trenching and burying of pipeline be done concurrently. In addition, we recommend leaving the least amount of trench open overnight and providing escape ramps for trapped wildlife. We also recommend that areas disturbed during construction be reseeded with native vegetation to minimize erosion and expedite revegetation. For those upland areas where soils have become compacted by use of heavy equipment, soils should be scarified and/or additional topsoil added prior to revegetation.

The proposed project would include the construction of approximately 107 miles of overhead transmission lines. Birds of prey such as eagles, hawks, and owls frequently use power lines and support structures for perching and nesting. These raptors can be electrocuted while using power lines, thus contributing to the cumulative mortality factors affecting these biologically important and environmentally sensitive birds. Standard techniques have been developed to prevent raptor electrocutions at electric distribution lines. This latest guidance is included in the publication Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996 by the Avian Power Line Interaction Committee. The document may be requested from Edison Electric Institute, P.O. Box 266, Waldorf, Maryland, 20604-0266, telephone (800) 334-5453, or may be requested from the Raptor Research Foundation at 12805 St. Croix Trail, Hastings, Minnesota 55033, phone (612) 437-4359 or by email at JMFITZPTRK@aol.com. New or modified electric distribution lines should be designed and constructed to prevent the electrocution of raptors, using the above-referenced guidance. Proper design should include adequate separation of energized hardware or insulation of wires where sufficient separation cannot be attained. Closely spaced transformer jumper wires, bushing covers, protective cutouts, or surge arresters can be made raptor-safe by the use of special insulating material. The use of grounded steel crossarm braces should be avoided. These measures should be implemented on each line and pole associated with new or converted lines as necessary.

RECOMMENDATIONS

To minimize project related impacts to fish and wildlife resources, we recommend that Reclamation incorporate into their project the mitigation and minimization measures recommended by ERI. We also recommend that Reclamation:

1. Replace any woody vegetation (e.g., willows) unavoidably lost by establishing 2 acres of native vegetation for every acre impacted. If trees are removed, we recommend a minimum ratio of ten saplings be planted for each mature tree lost. Planting of willow and cottonwood poles should be dense and in a location where adequate water is available to ensure that mitigation is successful. Mitigation should cover the direct removal of vegetation during construction, as well as induced mortality that may occur in future years.

2. Tree stands or other vegetated areas slated for grubbing or clearing should be surveyed for the presence of nesting birds during the general migratory bird nesting season of March through August. Avoid disturbing nesting areas until nesting is complete.

3. Employ silt curtains, cofferdams, dikes, straw bales or other suitable erosion control measures during construction.

4. Monitor the intake pump, sump, and settling ponds to estimate larval entrainment during periods of drift. Contact the Service to determine if further project review under the Fish and Wildlife Coordination Act is appropriate if entrainment exceeds the estimates of ERI (2003b).

5. Dewater in-channel construction areas prior to construction. Maintain river flows up- and downstream of construction areas. Maintain fish passage around dewatered construction areas during construction. Construct the project during periods of low flow and low precipitation.

6. Monitor water quality before, during, and after construction to ensure compliance with State Water Quality Standards.

7. Contain poured concrete in forms and/or behind cofferdams to prevent discharge into the river. Contain and treat or remove for off-site disposal any wastewater from concrete-batching, vehicle wash-down, and aggregate processing.

8. Store and dispense fuels, lubricants, hydraulic fluids, and other petrochemicals outside the 100-year floodplain. Inspect construction equipment daily for petrochemical leaks. Contain and remove any petrochemical spills and dispose of these materials at an approved upland site. Park construction equipment outside the 100-year floodplain during periods of inactivity.

9. Carry an oil spill kit or spill blanket at all times. Ensure equipment operators are knowledgeable in the use of spill containment equipment. Develop a spill contingency plan prior to initiation of construction. Immediately notify the proper Federal and State authorities in the event of a spill.

10. Use only clean cobble or quarry stone from an upland source. Use uncontaminated earth or alluvium suitable for revegetation with indigenous plant species for backfill. Revegetate or reseed backfill and other disturbed areas with native plants or seeds to accelerate revegetation with native species.

11. Where possible, minimize trapping of wildlife during pipeline installation by trenching and burying pipeline concurrently. Leave the least amount of trench open overnight, and provide escape ramps for trapped wildlife.

12. Re-vegetate all upland areas disturbed during construction, using native plants or seeds. For those upland areas where soils have become compacted as a result of heavy equipment operation, soils should be scarified or additional topsoil placed prior to revegetation.

13. Minimize electrocution risk to raptors by installing perch guards or raptor safe configurations on all transmission structures. Minimize collision risk to raptors and other bird species by marking transmission lines that pose a high collision risk with spiral vibration dampers or bird flight diverters.

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Appendix A. Common and Scientific Names of Fish That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Iowa darter	*Etheostoma exile*
Mottled sculpin	*Cottus bairdi*
Roundtail chub	*Gila robusta robusta*
Bonytail chub	*Gila elegans*
Colorado pikeminnow	*Ptychocheilus lucius*
Speckled dace	*Rhinichthys osculus*
Bluehead sucker	*Catostomus discobolus discobolus*
Flannelmouth sucker	*Catostomus latipinnis*
Razorback sucker	*Xyrauchen texanus*
White sucker	*Catostomus commersoni*
Black bullhead	*Ictalurus melas*
Channel catfish	*Ictalurus punctatus*
Zuni bluehead sucker	*Catostomus discobolus yarrowi*
Western mosquitofish	*Gambusia affinis*
Plains killifish	*Fundulus zebrinus*
Red shiner	*Cyprinella lutrensis*
Common carp	*Cyprinus carpio*
Fathead minnow	*Pimephales promelas*
Green sunfish	*Lepomis cyanellus*
Largemouth bass	*Micropterus salmoides*
Threadfin shad	*Dorosoma petenense*
Red shiner	*Cyprinella lutrensis*
Green sunfish	*Lepomis cyanellus*
Longear sunfish	*Lepomis megalotis*
Bluegill	*Lepomis macrochirus*
White crappie	*Pomoxis annularis*
Yellow perch	*Perca flavescens*
Striped bass	*Morone saxatilis*
Walleye	*Stizostedion vitreum*
Rainbow trout	*Oncorhynchus gairdneri*
Brown trout	*Salmo trutta*
Mottled sculpin	*Cottus bairdi*

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Appendix B. Common and Scientific Names of Plants That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Box elder	*Acer interius*
Poison ivy	*Rhus radicans*
Squawbush	*Rhus trilobata*
Water hemlock	*Cicuta douglasii*
Cymopterus	*Cymopterus newberryi*
Cymopterus	*Cympoterus fendleri*
Indian root	*Aristolochia watsoni*
Milkweed	*Asclepias fascicularis*
Tarragon	*Artemisia dracunculoides*
Black sagebrush	*Artemisia nova*
White sagebrush	*Artemisia ludoviciana*
Basin big sagebrush	*Artemisia tridentata*
Golden aster	*Heterotheca villosa*
Rubber rabbitbrush	*Chrysothamnus nauseosus*
Green rabbitbrush	*Ericameria viscidiflora*
Chicory	*Cichorium intybus*
Parry's thistle	*Circium parryi*
Canadian fleabane	*Erigeron canadensis*
Common sunflower	*Helianthus annuus*
Blue lettuce	*Lactuca pulchella*
Cutleaf coneflower	*Rudbeckia laciniata*
Senecio	*Senecio cymbalarioides*
Goldenrod	*Solidago sparsiflora*
Common dandelion	*Taraxacum officinale*
Rough cockleburr	*Xanthium strumarium*
Water birch	*Betula occidentalis*
Rockcress	*Arabis perennans*
Western tansymustard	*Descurainia pinnata*
Blister cress	*Erysium rapandum*
Hoary cress	*Lepidium drapa*
Desert pepperweed	*Lepidium fremontii*
Clasping pepperweed	*Lepidium perfoliatum*
Watercress	*Rorippa nasturtium-aquaticum*
Spreading yellowcress	*Rorippa sinuata*
European watercress	*Nasturtium Officinale*
Tumbling mustard	*Sisymbrium altissimum*
Rocky mountain beeplant	*Cleome serrulata*
Four-wing saltbush	*Atriplex canescens*
Annual atriplex	*Atriplex hastata*

Appendix B continued. Common and Scientific Names of Plants That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Redscale	*Atriplex rosea*
Shadescale	*Atriplex confertifolia*
Lambsquarters	*Chenopodium album*
Russian thistle	*Salsola kali tenuifolia*
Tumbleweed	*Amaranthus graecizans*
Field bindweed	*Convolvulus arvensis*
Redosier dogwood	*Cornus stolonifera*
Missoure gourd	*Cucurbita foetidissima*
Emory's Sedge	*Carex emoryi*
Stalkgrain sedge	*Carex stipata*
Fox sedge	*Carex vulpinoidea*
Spike rush	*Eleocharis macrostachya*
Creeping spike rush	*Eleocharis palustris*
Hardstem bulrush	*Scirpus acutus*
Olney bulrush	*Scirpus americanus*
Bulrush	*Scirpus paludosus*
Cloaked bulrush	*Scirpus pallidus*
Giant bulrush	*Scirpus validus*
Russian olive	*Elaeagnus angustifolia*
Common horsetail	*Equisetum arvense*
Smooth scouring rush	*Equisetum laevigatum*
Dwarf horsetail	*Equisetum kansanum*
Ridgeseed spurge	*Euphorbia glyptosperma*
Thyme leaved spurge	*Euphorbia serpyllifolia*
Aspen pea	*Lathyrus laetivirens*
Spurred lupine	*Lupinus laxiflorus*
Small lupine	*Lupinus pusillus*
Black medick	*Medicago lupulina*
Alfalfa	*Medicago sativa*
White sweetclover	*Melilotus albus*
Yellow sweetclover	*Melilotus officinalis*
Rancheria clover	*Trifolium albopurpureum*
White clover	*Trifolium repens*
American licorice	*Glycyrrhiza lepidota*
Red-stemmed filaree	*Erodium cicutarium*
Wax currant	*Ribes cereum*
Wiregrass	*Juncus balticus*
Torrey's rush	*Juncus torreyi*
Horehound	*Marrubium vulgare*

Appendix B continued. Common and Scientific Names of Plants That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Mint	*Mentha penardi*
Pony beebalm	*Monarda pectinata*
Skullcap	*Scutellaria galericulata*
False soloman's seal	*Smilacina stellata*
Blue flax	*Linum lewisii*
Cheeseweed mallow	*Malva parviflora*
Emory's globe mallow	*Sphaeralcea emoryi*
New Mexico olive	*Forestiera neomexicana*
American willowherb	*Epilobium adenocaulon*
Evening primrose	*Oenothera marginata*
Narrowleaf plantain	*Plantago lanceolata*
Common plantain	*Plantago major*
Western wheatgrass	*Agropyron smithii*
Slender wheat grass	*Agropyron trachycaulum*
Redtop	*Agrostis alba*
Creeping bentgrass	*Agrostis palustris*
Water foxtail	*Alopecurus aegaulilis sobol*
Wild oat	*Avena fatua*
American slough grass	*Beckmannia syzigachne*
Meadow brome	*Bromus commutatus*
Cheatgrass	*Bromus tectorum*
Orchard grass	*Dactylis glomerata*
Salt grass	*Distichlis stricta*
Hairy crabgrass	*Digitaria sanguinalis*
Barnyard grass	*Echinochloa crusgalli*
Canada wildrye	*Elymus canadensis*
Meadow fescue	*Festuca elatior*
Reed manna grass	*Glyceria grandis*
Foxtail barley	*Hordeum jubatum caespitosum*
Wall barley	*Hordeum murinum*
Cultivated barley	*Hordeum vulgare*
Scratchgrass	*Muhlenbergia asperifolia*
Witchgrass	*Panicum capillare*
Timothy	*Phleum pratense*
Common reed	*Phragmites communis*
Annual rabbitsfoot grass	*Polypogon monospeliensis*
Kentucky bluegrass	*Poa pratensis*
Alkali grass	*Puccinellia pauciflora*
Rye	*Secale cereale*

Appendix B continued. Common and Scientific Names of Plants That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Green foxtail	*Setaria viridis*
Bottlebrush squirreltail	*Sitanion hystrix*
Alkali sacaton	*Sporobolus airoides*
Spike dropseed	*Sporobolus contractus*
Sand dropseed	*Sporobolus cryptandrus*
Wheat	*Triticum aestivum*
Cultivated corn	*Zea mays*
Knotgrass	*Polygonum aviculare*
Curly dock	*Rumex crispus*
Virgin's bower	*Clematis lingustifolia*
Alkali buttercup	*Ranunculus cymbalaria*
Mountain meadow rue	*Thalictrum fendleri*
Serviceberry	*Amelanchier alnifolia*
Western service berry	*Amelanchier utahensis*
River hawthorn	*Crataegus rivularis*
Silverweed	*Potentilla anserina*
Wildrose	*Rosa fendleri*
Narrow-leaf cottonwood	*Populus angustifolia*
Rio Grande cottonwood	*Populus wislizenii*
Peach-leaf willow	*Salix amygdaloides*
Coyote willow	*Salix exigua*
Pacific willow	*Salix lasiandra*
Indian paintbrush	*Castilleja linariaefolia*
Common monkeyflower	*Mimulus guttatus*
Common mullein	*Verbascum thapsus*
Water speedwell	*Veronica anagallis-aquatica*
Pale wolfberry	*Lycium pallidum*
Cutleaf nightshade	*Solanum triflorum*
Salt cedar	*Tamarix chinensis*
Common cattail	*Typha latifolia*
Netleaf hackberry	*Celtis reticulata*
Brewer nettle	*Urtica breweri*
Virginia creeper	*Parthenocissus inserta*
Puncturevine	*Tribulus terrestris*
Pinyon pine	*Pinus edulis*
Juniper	*Juniperus sp.*
Oak	*Quercus sp.*
Greasewood	*Sarcobatus vermiculatus*
Mountain-mahogany	*Cercocarpus montanus*

Appendix B continued. Common and Scientific Names of Plants That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Antelope bitterbrush	*Purshia tridentata*
Yucca	*Yucca sp.*
Cliffrose	*Cowania mexicana*
Broom snakeweed	*Gutierrezia sarothrae*
Barrel cactus	*Ferocactus wislizenii*
Pricklybear cactus	*Opuntia sp.*
Mesa Verde cactus	*Sclerocactus mesae-verdae*
Buckwheat	*Eriogonum sp.*
Brack's fishhook cactus	*Sclerocactus cloveriae var. brackii*
Threadleaf groundsel	*Senecio longilobus*
Bisti fleabane	*Erigeron bistiensis*
Little hogweed	*Portulaca oleracea*
Golden crownbeard	*Verbesina encelioides*
Colorado four-o'clock	*Mirabilis multiflora*
Nees	*Machaeranthera tanacetifolia*
Globemallow	*Sphaeralcea sp.*
Blue gramma	*Bouteloua gracilis*
Galleta	*Hilaria jamesii*
Indian ricegrass	*Oryzopsis hymenoides*
Alkaki sacaton	*Sporobolus airoides*
Wheatgrass	*Agropyron sp.*
Sandhill muhly	*Muhlenbergia pungens*
Western serviceberry	*Amelanchier utahensis*
Spiny hopsage	*Grayia spinosa*
Adonis blazingstar	*Mentzelia multiflora*
Mexican-fireweed	*Kochia scoparia*
Streambank wheatgrass	*Agropyron riparium*
Foxtail barley	*Hordeum jubatum*
Mormon tea	*Ephedra torreyana*
Green joint-fir	*Ephedra viridis*
Cholla	*Opuntia sp.*
Fringed sage	*Artemisia frigida*
Muhly	*Muhlenbergia torreyi*
Little leaf ratany	*Krameria sp.*
Flatspine burr ragweed	*Ambrosia acanthicarpa*
Three-awns	*Aristida sp.*

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Appendix C. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Turkey vulture	*Cathartes aura*
Horned grebe	*Podiceps auritus*
Eared grebe	*Podiceps nigricollis*
Western grebe	*Aechmorphorus occidentalis*
Pied-billed grebe	*Podilymbus podiceps*
White pelican	*Elecanus erythorhynchos*
Brown pelican	*Pelecanus occidentalis*
Double-crested cormorant	*Phalacrocorax auritus*
Great blue heron	*Ardea herodias*
Green heron	*Butorides virescens*
Great egret	*Ardea alba*
Snowy egret	*Egretta thula*
Black-crowned night heron	*Nycticorax nycticorax*
Least bittern	*Ixobrychus exilis*
American bittern	*Botarus lentiginosus*
White-faced ibis	*Plegadis chihi*
Whistling swan	*Olor columbianus*
Canada goose	*Branta canadensis*
White-fronted goose	*Anser albifrons*
Snow goose	*Chen caerulescens*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Northern pintail	*Anas acuta*
Green-winged teal	*Anas crecca*
Blue-winged teal	*Anas discors*
Cinnamon teal	*Anas cyanoptera*
American wigeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Wood duck	*Aix sponsa*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Canvasback	*Aythya valisineria*
Lesser scaup	*Aythya affinis*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Surf scoter	*Melanitta perspicillata*
Ruddy duck	*Oxyura jamaicensis*
Hooded merganser	*Lophodytes cucullatus*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Mississippi kite	*Ictinia mississippiensis*
Red-tailed hawk	*Buteo jamaicensis*
Ferruginous hawk	*Buteo regalis*
Northern goshawk	*Accipter gentilis*
Cooper's hawk	*Accipiter cooperii*
Sharp-shinned hawk	*Accipiter striatus*
Rough-legged hawk	*Buteo lagopus*
Swainson's hawk	*Buteo swainsoni*
Bald eagle	*Haliaeetus leucocephalus*
Golden eagle	*Aquila chrysaetos*
Norther harrier hawk	*Circus cyaneus*
Osprey	*Pandoin haliaetus*
American peregrine falcon	*Falco peregrinus anatum*
Arctic peregrine falcon	*Falco peregrinus tundrius*
Prairie falcon	*Falco mexicanus*
American kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Scaled quail	*Callipepla squamata*
Gambel's quail	*Callipepla gambelii*
Blue grouse	*Dendragapus obscurus*
Greater Sage grouse	*Centrocercus urophasianus*
Ring-necked pheasant	*Phasianus colchicus*
Chukar	*Alectoris chukar*
Turkey	*Meleagris gallopavo*
Virginia rail	*Rallus limicola*
Sora	*Porzana carolina*
Common gallinule	*Gallinula chloropus*
American coot	*Fulica americana*
Semi-palmated plover	*Charadrius semipalmatus*
Snowy plover	*Charadrius alexandrinus*
Killdeer	*Charadrius vociferus*
Mountain plover	*Charadrius montanus*
Black-bellied plover	*Pluvialis squatarola*
Upland plover	*Bartramia longicauda*
Common snipe	*Gallinago gallinago*
Long-billed curlew	*Numenius americanus*
Upland sandpiper	*Bartramia longicauda*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Spotted sandpiper	*Actitis macularia*
Solitary sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Pectoral sandpiper	*Calidris melanotos*
Baird's sandpiper	*Calidris bairdii*
Least sandpiper	*Calidris minutilla*
Long-billed dowithcher	*Limnodromus scolopaceus*
Western sandpiper	*Calidris mauri*
Marbled godwit	*Limosa fedoa*
Sanderling	*Calidris alba*
American avocet	*Recurvirostra americana*
Black-necked stilt	*Himantopus mexicanus*
Wilson's phalarope	*Phalaropus tricolor*
Red-necked phalarope	*Phalaropus lobatus*
Herring gull	*Larus argentatus*
California gull	*Larus californicus*
Ring-billed gull	*Larus delawarensis*
Laughing gull	*Larus atricilla*
Franklin's gull	*Larus pipixcan*
Bonaparte's gull	*Larus philidelphia*
Sabine's gull	*Xema sabini*
Forster's tern	*Sterna forsteri*
Common tern	*Sterna hirundo*
Caspian tern	*Sterna caspia*
Black tern	*Chlidonias niger*
Band-tailed pigeon	*Columba fasciata*
Rock dove	*Columba livia*
Mourning dove	*Zenaida macroura*
Inca dove	*Columbina inca*
Yellow-billed cuckoo	*Coccyzus americanus*
Greater roadrunner	*Geococcyx californianus*
Mexican spotted owl	*Strix occidentalis lucida*
Western burrowing owl	*Speotyto cunicularia hypugea*
Northern sah-whet owl	*Aeogolius acadicus*
Pygmy owl	*Glaucidium californicum*
Common barn-owl	*Tyto alba*
Screech owl	*Otus asio*
Great-horned owl	*Bubo virginiansus*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Long-eared owl	*Asio otus*
Short-eared owl	*Asio flammeus*
Flammulated owl	*Otus flammeolus*
Common poorwill	*Phalaenoptilus nuttallii*
Common nighthawk	*Chordeiles minor*
Black swift	*Cypseloides niger*
White-throated swift	*Aeronautes saxatalis*
Black-chinned hummingbird	*Archilochus alexandri*
Broad-tailed hummingbird	*Selasphorus platycercus*
Rufous hummingbird	*Selasphorus rufus*
Calliope hummingbird	*Stellula calliope*
Belted kingfisher	*Ceryle alcyon*
Northern flicker	*Colaptes auratus*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Acorn woodpecker	*Melanerpes formicivorus*
Lewis woodpecker	*Melanerpes lewis*
Yellow-billed sapsucker	*Sphyrapicus varius*
Williamson's sapsucker	*Sphyrapicus thyroideus*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Northern three-toed woodpecker	*Picoides tridactylus*
Western kingbird	*Tyrannus verticalis*
Eastern kingbird	*Tyrannus tyrannus*
Cassin's kingbird	*Tyrannus vociferans*
Eastern phoebe	*Sayornis phoebe*
Black phoebe	*Sayornis nigricans*
Say's phoebe	*Sayornis saya*
Southwestern willow flycatcher	*Empidonax traillii extimus*
Hammond's flycatcher	*Empidonax hammondii*
Western flycatcher	*Empidonax difficilis*
Ash-throated flycatcher	*Myiarchus cinerascens*
Western wood-pewee	*Contopus sordidulus*
Greater pewee	*Contopus pertinax*
Olive-sided flycatcher	*Contopus cooperi*
Dusky flycatcher	*Empidonax oberholseri*
Gray flycatcher	*Empidonax wrightii*
Tree swallow	*Tachycineta bicolor*
Bank swallow	*Riparia riparia*
Violet-green swallow	*Trachycineta thalassina*
Barn swallow	*Hirundo rustica*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Purple martin	*Progne subis*
Blue jay	*Cyanocitta crystata*
Gray jay	*Perisoreus canadensis*
Steller's jay	*Cyanocitta stelleri*
PiZon jay	*Gymnorhinus cyanocephalus*
Western scrub jay	*Aphelocoma californica*
Black-billed magpie	*Pica hudsonia*
American crow	*Corvus brachyrhynchos*
Common raven	*Corvus corax*
Plain titmouse	*Parus inornatus*
Clark's nutcracker	*Nucifraga columbiana*
Black-capped chickadee	*Poecile atricapilla*
Mountain chickadee	*Poecile gambeli*
Common bushtit	*Psaltriparus minimus*
White-breasted nuthatch	*Sitta carolinensis*
Red-breasted nuthatch	*Sitta canadensis*
Pygmy nuthatch	*Sitta pygmaea*
Brown creeper	*Certhia americana*
American Dipper	*Cinclus mexicanus*
House wren	*Troglodytes aedon*
Bewick's wren	*Thryomanes bewickii*
Long-billed marsh wren	*Telmatodytes palustris*
Canon wren	*Catherpes mexicanus*
Rock wren	*Salpinctes obsoletus*
Gray catbird	*Dumetella carolinensis*
Northern mockingbird	*Mimus polyglottos*
Brown thrasher	*Toxostoma rufum*
Bendire's thrasher	*Toxostoma bendirei*
Sage thrasher	*Oreoscoptes montanus*
American robin	*Turdus migratorius*
Hermit thrush	*Catharus guttatus*
Swainson's thrush	*Catharus ustulatus*
Western bluebird	*Sialia mexicana*
Eastern bluebird	*Sialia sialis*
Mountain bluebird	*Sialia currucoides*
Townsend's solitaire	*Myadestes townsendi*
Blue-gray gnatcatcher	*Polioptila caerulea*
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Water pipit	*Anthus rebescens*
European starling	*Sturnus vulgaris*
Bohemian waxwing	*Bombycilla garrulus*
Cedar waxwing	*Bombycilla cedrorum*
Northern shrike	*Lanius exubitor*
Loggerhead shrike	*Lanius ludovicianus*
Gray vireo	*Vireo vicinior*
Solitary vireo	*Vireo solitarius*
Warbling vireo	*Vireo gilvus*
Red-eyed vireo	*Vireo olivaceus*
Black and white warbler	*Mniotilta varia*
Orange-crowned warbler	*Vermivora celata*
Nashville warbler	*Vermivora ruficapilla*
Black-throated blue warbler	*Dendroica caerulescens*
Black-throated gray warbler	*Dendroica nigrescens*
Black-throated green warbler	*Dendroica virens*
Yellow-rumped warbler	*Dendroica coronata*
Hermit warbler	*Dendroica occidentalis*
Grace's warbler	*Dendroica graciae*
Palm warbler	*Dendroica palmarum*
Ovenbird	*Seiurus aurocapillus*
Virginia's warbler	*Vermivora virginiae*
Lucy's warbler	*Vermivora luciae*
Yellow warbler	*Dendroica petechia*
Townsend's warbler	*Dendroica townsendi*
Northern waterthrush	*Seiurus noveboracensis*
MacGillivray's warbler	*Oporornsis tolmiei*
Common yellowthroat	*Geothlypis trichas*
Yellow-brested chat	*Icteria virens*
Wilson's warbler	*Wilsonia pusilla*
American redstart	*Setophaga ruticilla*
Horned lark	*Eremophila alpestris*
Eastern meadowlark	*Sturnella magna*
Western meadowlark	*Sturnella neglecta*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Red-winged blackbird	*Agelaius phoeniceus*
Northern oriole	*Icterus galbula*
Scott's oriole	*Icterus parisorum*
Brewer's blackbird	*Euphagus cyanocephalus*
Great-tailed grackle	*Quiscalus mexicanus*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Common grackle	*Quiscalus quiscula*
Brown-headed cowbird	*Molothrus ater*
Western tanager	*Piranga ludoviciana*
Scarlet tanager	*Piranga olivacea*
Hepatic tanager	*Piranga flava*
Rose-breasted grosbeak	*Pheuticus ludovicianus*
Black-headed grosbeak	*Pheuticus melanocephalus*
Blue grosbeak	*Guiraca caerulea*
Evening grosbeak	*Coccothraustes vespertinus*
Indigo bunting	*Passerina cyanea*
Lazuli bunting	*Passerina amoena*
Dickcissel	*Spiza americana*
House finch	*Carpodacus mexicanus*
Cassin's finch	*Carpodacus cassinii*
Gray-crowned rosy finch	*Leucosticte tephrocotis*
Black rosy finch	*Leucosticte atrata*
Brown-capped rosy finch	*Leucosticte australis*
Pine siskin	*Carduelis pinus*
American goldfinch	*Carduelis tristis*
Lesser goldfinch	*Carduelis psaltria*
Lawrence's goldfinch	*Carduelis lawrencei*
Red crossbill	*Loxia curvirostra*
Green-tailed towhee	*Pipilo chlorurus*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Brown towhee	*Pipilo fuscus*
Lark bunting	*Calamospiza melanocorys*
Vesper sparrow	*Pooecetes gramineus*
Lark sparrow	*Chondestes grammacus*
Cassin's sparrow	*Aimophila cassinii*
Black-throated sparrow	Amphispiza bilineata
Sage sparrow	*Amphispiza belli*
Dark-eyed junco	*Junco hyemalis*
Gray-headed junco	*Junco caniceps*
Brewer's sparrow	*Spizella breweri*
Harris' sparrow	*Zonotrichia querula*
House sparrow	*Passer domesticus*
American tree sparrow	*Spizella arborea*
Baird's sparrow	*Ammodramus bairdii*
Savannah sparrow	*Passerculus sandwichensis*
Chipping sparrow	*Spizella passerina*

Appendix C continued. Common and Scientific Names of Birds That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
White-crowned sparrow	*Zonotrichia leucophrys*
Fox sparrow	*Passerella iliaca*
Lincoln's sparrow	*Melospiza lincolnii*
Song sparrow	*Melospiza melodia*

Appendix D. Common and Scientific Names of Mammals That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Merriam shrew	*Sorex merriami*
Dwarf shrew	*Sorex nanus*
Vagrant shrew	*Sorex vagrans*
Desert shrew	*Notiosorex crawfordi*
Pallid bat	*Antrozous pallidus*
Big brown bat	*Eptesicus fuscus*
Spotted bat	*Euderma maculata*
Red bat	*Lasiurus borealis*
Silver-haired bat	*Lasionycteris noctivagans*
Hoary bat	*Lasiurus cinereus*
California myotis	*Myotis californicus*
Long-eared myotis	*Myotis evotis*
Western small-footed myotis	*Myotis ciliolabrum*
Little brown myotis	*Myotis lucifugus*
Fringed myotis	*Myotis thysanodes*
Cave myotis	*Myotis velifer*
Long-legged myotis	*Myotis volans*
Yuma myotis	*Myotis yumanensis*
Western pipistrel	*Pipistrellus hesperus*
Townsend's big-eared bat	*Plecotus tounsendii*
Mexican free-tailed bat	*Tadarida brasiliensis*
Big free-tailed bat	*Nyctinimops macrotis*
Desert cottontail rabbit	*Sylvilagus audobonii*
Eastern cottontail rabbit	*Sylvilagus floridanus*
Nuttall's cottontail rabbit	*Sylvilagus nuttalii*
Blacktail jackrabbit	*Lepus californicus*
Ring-tailed cat	*Bassariscus astutus*
Coyote	*Canis latrans*
Mountain lion	*Felis concolor*
Bobcat	*Lynx rufus*
River otter	*Lutra canadensis*
Marten	*Martes americana*
Striped skunk	*Mephitis mephitis*
Western spotted skunk	*Spilogale gracilis*
Long-tailed weasel	*Mustela frenata*
Black-footed ferret	*Mustela nigripes*
Mink	*Mustela vison*
Raccoon	*Procyon lotor*
Badger	*Taxidea taxus*
Gray fox	*Urocyon cinereoargenteus*

Appendix D continued. Common and Scientific Names of Mammals That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Kit fox	*Vulpes macrotis*
Red fox	*Vulpes vulpes*
Swift fox	*Vulpes velox*
Black bear	*Ursus americanus*
Pronghorn antelope	*Antilocapra americana*
Elk	*Cervus canadensis*
Mule deer	*Odocoileus hemionus*
White-tailed antelope ground squirrel	*Ammospermophilus leucurus*
Beaver	*Castor canadensis*
Spotted ground squirrel	*Spermophilus spilosoma*
Rock squirrel	*Spermophilus variegatus*
Gunnison's prairie dog	*Cynomys gunnisoni*
Ord's kangaroo rat	*Dipodomys ordi*
Banner-tailed kangaroo rat	*Dipodomys spectabilis*
Porcupine	*Erethizon dorsatum*
Cliff chipmunk	*Tamias dorsalis*
Least chipmunk	*Tamias minimus*
Colorado chipmunk	*Tamias quadrivittatus*
Meadow vole	*Microtus pennsylvanicus*
Montane vole	*Microtus montanus*
Mexican vole	*Microtus mexicanus*
Long-tailed vole	*Microtus longicaudus*
House mouse	*Mus musculus*
White-throated woodrat	*Neotoma albigula*
Bushy-tailed woodrat	*Neotoma cinerea*
Mexican woodrat	*Neotoma mexicana*
Stephen's woodrat	*Neotoma stephensi*
Muskrat	*Ondatra zibethica*
Northern grasshopper mouse	*Onychomys leucogaster*
Silky pocket mouse	*Perognathus flavus*
Plains pocket mouse	*Perognathus flavescens*
Brush mouse	*Peromyscus boylii*
Canyon mouse	*Peromyscus crinitus*
Rock mouse	*Peromyscus difficilis*
White-footed mouse	*Peromyscus leucopus*
Deer mouse	*Peromyscus maniculatus*
PiZon mouse	*Peromyscus truei*
Western harvest mouse	*Reithrodontomys megalotis*
Abert's squirrel	*Sciurus aberti*
Spotted ground squirrel	*Spermophilus spilosoma*

Appendix D continued. Common and Scientific Names of Mammals That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Rock squirrel	*Spermophilus variegatus*
American red squirrel	*Tamiasciurus hudsonicus*
Botta's pocket gopher	*Thomomys bottae*
Northern pocket gopher	*Thomomys talpoides*

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Appendix E. Common and Scientific Names of Amphibians and Reptiles That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	Scientific Name
Amphibians	
Tiger salamander	*Ambystoma tigrinum*
Western spadefoot	*Spea hammondii*
Plains spadefoot	*Scaphiopus bombifrons*
Great Plains toad	*Bufo cognatus*
Red-spotted toad	*Bufo punctatus*
Woodhouse's toad	*Bufo woodhousii*
Canyon treefrog	*Hyla arenicolor*
Western chorus frog	*Pseudacris triseriata*
Bullfrog	*Rana catesbeiana*
Northern leopard frog	*Rana pipiens*
Reptiles	
Chuckwalla	*Sauromalus obesus*
Collard lizard	*Crotophytus collaris*
Longnose leopard lizard	*Crotophytus wislezenii*
Lesser earless lizard	*Holbrookia maculata*
Eastern fence lizard	*Sceloporus undulatus*
Desert spiny lizard	*Sceloporus magister*
Common sagebrush lizard	*Sceloporus graciosus*
Ornate tree lizard	*Urosaurus ornatus*
Common side-blotched lizard	*Uta stansburiana*
Short-horned lizard	*Phrynosoma douglassi*
Little striped whiptail	*Cnemidophorus inornatus*
Western whiptail	*Cnemidophorus tigris*
Plateau striped whiptail	*Cnemidophorus velox*
Desert night lizard	*Xantusia vigilis*
Many-lined skink	*Eumeces multivirgatus*
Smooth green snake	*Ophedrys vernalis*
Ring-neck snake	*Diadophis punctatus*
Striped whipsnake	*Masticophis taeniatus*
Coachwhip	*Masticophis flagellum*
Racer	*Coluber constrictor*
Corn snake	*Elaphe guttata*
Gopher snake	*Pituophis melanoleucus*
Milk snake	*Lampropeltis triangulum*
Common king snake	*Lampropeltis getulus*
Longnose snake	*Rhinocheilus lecontei*
Western terrestrial garter snake	*Thamnophis elegans*

Appendix E. Common and Scientific Names of Amphibians and Reptiles That May Occur in the Navajo - Gallup Water Supply Project Area.

Common Name	**Scientific Name**
Common garter snake	*Thamnophis sirtalis*
Blackneck garter snake	*Thamnophis cyrtopsis*
Western blackhead snake	*Tantilla planiceps*
Night snake	*Hypsiglena torquata*
Glossy snake	*Arizona elegans*
Western rattlesnake	*Crotalus viridis*
Western diamondback rattlesnake	*Crotalus atrox*
Mountain patch-nosed snake	*Salvadora grahamiae*

APPENDIX C

Part III
Draft Biological Opinion

DRAFT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
Phone: (505) 346-2525 Fax: (505) 346-2542

January 23, 2007

Cons. # 2-22-01-F-532

Memorandum

To: Regional Director, Bureau of Reclamation, Upper Colorado Regional Office, Salt Lake City, Utah

From: Field Supervisor, U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office, Albuquerque, New Mexico

Subject: DRAFT Biological Opinion for the Navajo-Gallup Water Supply Project, U.S. Bureau of Reclamation, Durango, Colorado

This transmits the U.S. Fish and Wildlife Service's (Service) draft biological opinion (BO) on the effects of actions associated with the Bureau of Reclamation's (Reclamation) Navajo-Gallup Water Supply Project. The duration of this action will be from the acceptance of the final BO to whatever time that reinitation may be necessary. This draft BO concerns the effects of the action on the federally endangered Colorado pikeminnow (*Ptychocheilus lucius*) (pikeminnow) and its designated critical habitat, the federally endangered razorback sucker (*Xyrauchen texanus*) and its designated critical habitat, the endangered southwestern willow flycatcher *(Empidonax traillii extimus*) (flycatcher), the threatened Mesa Verde cactus (*Sclerocactus mesae-verdae*), and the threatened bald eagle (*Haliaeetus leucocephalus*). Reclamation determined that the proposed action "may affect, is likely to adversely affect" the pikeminnow, the razorback sucker and the Mesa Verde cactus; and "may effect, is not likely to adversely affect" the flycatcher and the bald eagle. The proposed action will have no adverse modification of critical habitat for pikeminnow or razorback sucker. The Service concurs with Reclamation's determination of "may effect, is not likely to adversely affect" the bald eagle and flycatcher.

The current BO does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. USDI Fish and Wildlife Service (CIV No. 03-35279) to complete the following analysis with respect to critical habitat. This consultation analyzes the effects of the action and its relationship to the function and conservation role of razorback sucker and pikeminnow critical habitat to determine whether the current proposal destroys or adversely modifies critical habitat. This document represents our biological opinion for the razorback sucker and pikeminnow and their designated critical habitat in accordance with section 7 of the Act.

In accordance with section 7 of the Act, as amended (16 U.S.C. 1531 et seq.), and the Interagency Cooperation Regulations (50 CFR 402), this document transmits the Service's BO for impacts to federally listed threatened and endangered species as a result of the Reclamation's proposed action. A complete administrative record of this consultation is on file at the Service's New Mexico Ecological Services Field Office.

If you have questions regarding this consultation, please contact David Campbell, at (505) 761-4745.

Wally Murphy
Field Supervisor

Attachment

cc:
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Assistant Regional Director (ES), U.S. Fish and Wildlife Service, Region 2, Albuquerque, New Mexico
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DRAFT

Endangered Species Act – Section 7 Consultation
DRAFT Biological Opinion

Navajo-Gallup Water Supply Project
New Mexico

Agency:	U.S. Bureau of Reclamation
Consultation Conducted By:	U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office
Date Issued:	
Approved by: Field Supervisor	Wally Murphy
Biological Opinion Number:	2-22-01-F-532

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Introduction

This document prepared by the U.S. Fish and Wildlife Service (Service) includes a Biological Opinion (BO) and incidental take statement in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402. The administrative record for this consultation is on file at the New Mexico Ecological Services Field Office, Albuquerque, New Mexico.

Background and Consultation History

The Bureau of Reclamation (Reclamation) is proposing to construct a water supply project that would divert water from the San Juan River and Navajo Reservoir to the Navajo Nation, Jicarilla Apache Nation, and City of Gallup.

On August 29, 2005, the Service received a letter and draft Biological Assessment (BA) from Reclamation requesting initiation of formal section 7 consultation under the ESA. The BA documented Reclamation's finding that the proposed action is "likely to adversely affect" pikeminnow, razorback sucker, Mesa Verde cactus, flycatcher, and bald eagle and the critical habitat for pikeminnow. However, the letter failed to request formal section 7 consultation on the effects of the proposed project on razorback sucker critical habitat.

On September 16, 2005, the Service requested a conference call with Reclamation to discuss and clarify information provided in the BA.

On September 22, 2005, the Service responded to Reclamation with a letter requesting that Reclamation clarify its intention regarding inclusion of razorback sucker critical habitat in this formal consultation.

This BO is based on information provided in the current BA; electronic mail and telephone conversations between our staffs; data in our files; data presented in the Recovery Plan (USDI Fish and Wildlife Service 1984); literature review; and other sources of information including the final rules to federally list the cactus as threatened (USDI Fish and Wildlife Service 1979; 44 FR 62472). A notice of intent to prepare an environmental impact statement (EIS) and project scoping under the National Environmental Policy Act of 1969, as amended (NEPA) began in March 2000 (59 FR 16219). A draft EIS has not been completed and released for public comment. A complete administrative record of this consultation is on file at this office. We received all the information necessary for formal consultation on December 1, 2006.

Description of the Proposed Action

Action Area

The Service has defined the action area considered in this BO for the proposed action to be from the diversion points at the Navajo Indian Irrigation Project (NIIP) main canal at Cutter Reservoir and at the Public Service Company of New Mexico (PNM) diversion dam on the San Juan River downstream to Lake Powell. The action area also includes one-half mile around the main water treatment plants located at each diversion location, the 19 forebay tanks, the 24 pumping plants, the 5 regulating tanks and approximately 25 community storage tanks; and one-half mile on either side of the 267 miles of pipeline.

The action area includes most of the Navajo Nation in New Mexico and the Window Rock area of Arizona, the Jicarilla Apache Nation in New Mexico, and Gallup. By the year 2040 the project would serve an estimated 203,000 people in the Navajo Nation, 1,300 people in the Jicarilla Apache Nation, and 47,000 people in Gallup.

Proposed Action

The Navajo-Gallup Water Supply Project (NGWSP) is proposed to deliver treated municipal water to selected Navajo communities, a portion of the Jicarilla Apache Nation and the City of Gallup, New Mexico. The project is planned with adequate capacity to serve approximately 203,000 people (43 Chapters) in the Navajo Nation, 1,300 people in the Jicarilla Apache Nation, and approximately 47,000 people in Gallup, the projected populations as of year 2040. The service area for the proposed pipeline includes most of the New Mexico portion of the Navajo Nation, the Navajo Nation in the Window Rock area within Arizona, the Jicarilla Apache Nation and the City of Gallup, New Mexico (Figure 1). The water supply will be from the San Juan River with surface return flow in the San Juan basin and groundwater recharge to the San Juan, Rio San Jose and Rio Puerco Basins. For water balance considerations, the groundwater recharge is not assumed to return to surface flow in any of the basins due to the distance from the surface water bodies and existing pumping within the basins that keep the water surface elevation in the aquifers from rising to levels that would allow surface discharge.

Reclamation examined 12 alternatives for the NGWSP. The proposed preferred alternative is called the San Juan River Public Service Company of New Mexico 2040 Alternative, with diversion points from the NIIP main canal at Cutter Reservoir and at the PNM diversion dam on the San Juan River. A treatment plant would be located at each diversion location, along with main pumping plants supplying water to 267 miles of pipeline. The system would consist of 19 forebay tanks, 24 pumping plants, 5 regulating tanks and approximately 25 community storage tanks. The general project layout and service area are shown in Figure 1.

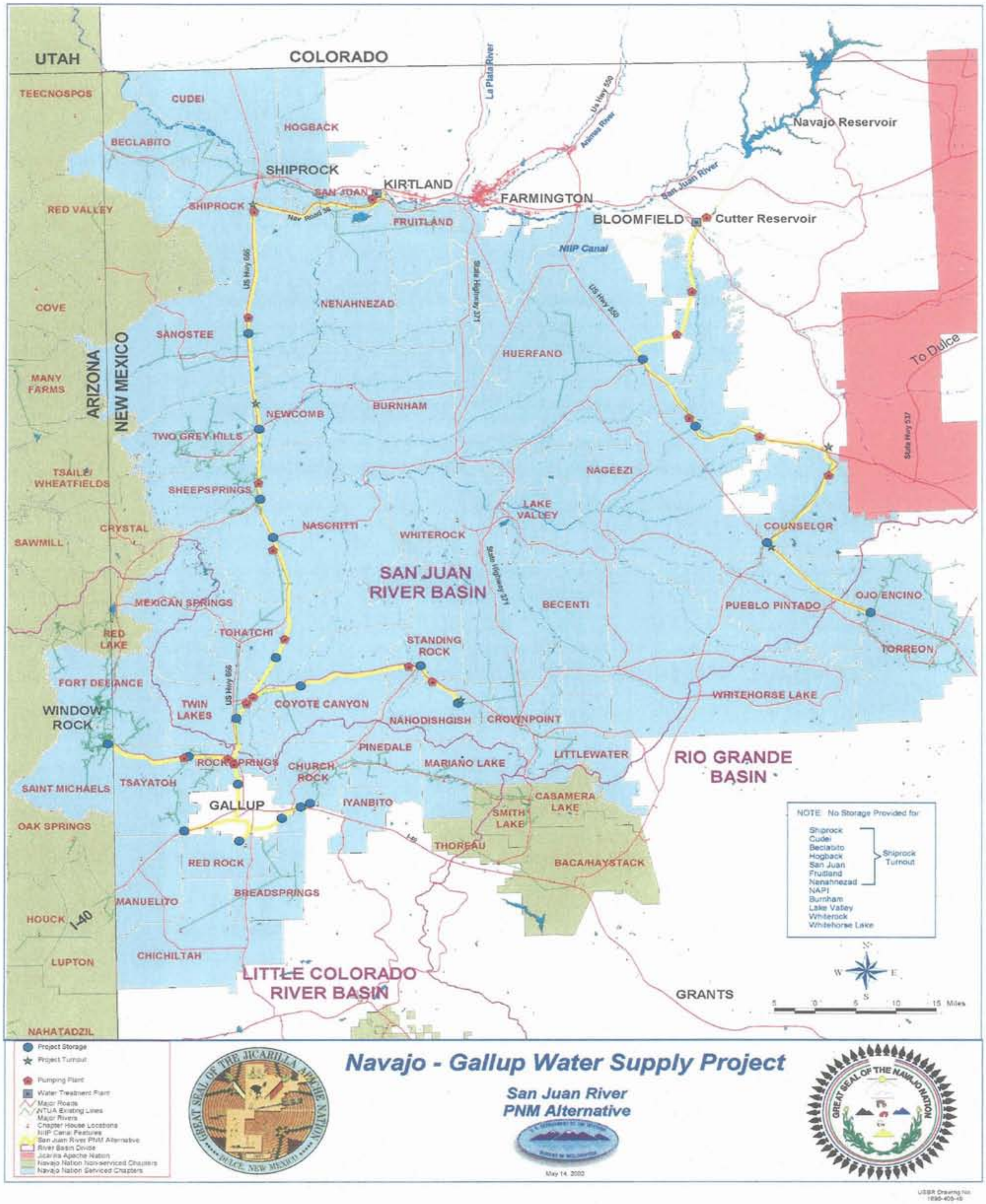

Figure 1.—Navajo Gallup Water Supply Project Service Area and Project Layout.

Cutter Lateral

The Cutter Lateral would serve Huerfano, Nageezi, Counselor, Pueblo Pentado, Ojo Encino, Torreon and Whitehorse Chapters in the eastern portion of the Navajo Nation and a portion of the western Jicarilla Apache Nation, delivering up to 4,645 acre-feet per year. The Cutter Lateral would obtain water from the Cutter Reservoir, a feature of the NIIP main canal (Figure 1).

The treatment and pumping plant would have a footprint of about 3-4 acres located downstream of Cutter Dam in a previously disturbed area. The plant would have a capacity of 5.39 million gallons per day (mgd) or 8.34 cubic feet per second (cfs). Facilities would include mixing and flocculation tanks, three ultrafiltration units, three ultraviolet light (UV) disinfection units, a 112,000 gallon subsurface pumping plant forebay, two wastewater polishing ponds, chemical storage buildings, an operations and maintenance (O&M) building and a 4-unit pumping plant. The associated electrical control equipment necessary to power and control the electrically driven pumps and other ancillary equipment would also be contained on this site.

The plant would feed approximately 89 miles of buried pipeline ranging in diameter from 10 to 24 inches. There would be 5 re-lift pumps along the route to maintain required delivery pressure, along with three community storage tanks and two regulating tanks. Much of the pipeline route is paralleled with an overhead electrical transmission line to power the pumping plants. A 230/69 kilovolt (KV) substation would provide power from the existing 230 KV PNM transmission line.

Each re-lift pump would consist of a forebay tank, pumping plant, air chamber, chlorination building, electrical control and ancillary equipment. The typical footprint would be about one acre, enclosed in a chain link fence. Each site would be totally contained with no open water.

Storage tank locations typically would include the storage tank (size varies depending on location), chlorination building, pumping plant, air chamber, electrical control and ancillary equipment in an enclosed yard. The typical footprint is about one acre.

San Juan Lateral

The San Juan Lateral would have its diversion point at the existing PNM diversion dam (Figure 1). The pumping plant intake would be located just upstream of the PNM intake on the north bank of the San Juan River. It will supply the main pipeline, delivering up to 33,118 acre-feet per year to the 36 Navajo Nation Chapters and the City of Gallup, New Mexico.

Water would be diverted through a self-cleaning fish screen with 3/32 inch openings and a through-screen velocity of less than 0.5 feet per second to a sump where low-head pumps would lift the raw water into settling ponds for removal of suspended sediment. The remaining treatment and pumping plant facilities would be as described for the Cutter Lateral, except that the capacity is greater at 38.25 million gallons per day (mgd) (59.19 cfs). There would be seven ultrafiltration units, seven UV disinfection units, and a 797,000 gallon clear well. There would be two settling ponds and two sediment drying beds at this site that are required to handle the elevated suspended sediment concentration. The associated buildings and ancillary equipment listed for the Cutter Lateral would also be required at this site, although of a larger size. The total footprint at this site is expected to be about 18 acres, much of which is previously disturbed in a sparsely inhabited trailer park.

The San Juan Lateral pumping plant would feed approximately 145 miles of buried pipeline ranging in diameter from 12 inch to 48 inch. The buried pipeline would cross the San Juan River just upstream of the treatment plant and ascend to the mesa on the south side of the river. From there it would proceed west following Navajo Highway 64 to U.S. Highway 491, following the highway route through the City of Gallup to connect to 5 Navajo chapters on the southern border of the city. The project facilities serving the Gallup area are called the Gallup Regional System and consist of 1 new pumping plant and upgrades to 5 storage tanks and 32 miles of pipeline. There would be 7 re-lift stations along the main line, with 3 on the Dalton Pass branch and 2 on the Window Rock branch. Along the route there would be 17 storage tanks (plus 5 community storage tanks in the Gallup Regional System), 3 regulating tanks, with additional junctions to Shiprock, Burnham and Gallup water supply systems and a turnout to NIIP. The electrical transmission line parallels the pipeline over much of its route.

Impacts from Construction

Pipeline Construction Impacts

The pipeline and accompanying facilities would permanently impact 27 acres of vegetation, including 3,920 square feet of tamarisk and Russian olive habitat. Clearing and grading will temporarily impact 31,477 acres. Much of the pipeline would be adjacent to existing highways or well-traveled roads. Project construction would be phased over approximately 14 years, with only small portions of the area disturbed at any one time. The pipeline construction would occur almost exclusively in upland habitat, much of which has been previously disturbed.

San Juan River Crossing

The method of construction to be used at the San Juan River crossing (Figure 1) has not been determined. Consequently, the Service has analyzed the impacts for both potential river crossing construction methods: 1) open trench with construction of coffer dams in one-half of the river width at any one time; and 2) directional boring. Impact to aquatic resources will be minimized by the actions outlined in the "Conservation Measures" section below.

Impacts of the Open Trench Method

The open trench would include clearing and grading of 0.9 acres of degraded riparian habitat that consists of tamarisk and Russian olive and 0.10 acres of temporary impacts to an emergent wetland. Of the 0.9 acres of riparian impact, 0.65 acres will result in temporary impacts and will be replanted with native riparian species; 0.25 acres will be placed in the pipeline right-of -way and planted in grasses. The 0.10 acres of wetland area temporarily impacted will be replanted with native emergent wetland species.

Impacts of the Directional Boring Method

All the impacts associated with the directional boring method would be within the project's evaporation pond footprint which will be constructed on 4.5 acres of previously developed upland.

Water Treatment and Pumping Facilities

For either method used to cross the San Juan River, construction of water treatment and pumping facilities adjacent to the San Juan River would permanently impact 1.5 acres, temporarily impact 3.2 acres of degraded riparian habitat that consists of tamarisk and Russian olive and would include the conversion of 4.5 acres of a previously developed area to an evaporation pond.

Water Depletion Impacts

San Juan River Water Depletion

The project is designed to divert a total of 37,764 acre-feet of water per year from the San Juan River with a resulting depletion of 35,893 acre-feet to the San Juan Basin, based on 2040 projected population with a demand rate of 160 gallons per capita per day. The Cutter Diversion would require 4,645 acre-feet per year with no return flow to the San Juan River. The PNM diversion would take the remaining 33,119 acre-feet of diversion, with an average return flow of 1,871 acre-feet. The planned diversion and depletion by location is shown in Table 1.

It is assumed that the only return flow from the project to the San Juan River would enter the river at the Shiprock wastewater treatment plant. There may be some water delivery to users with individual septic systems in the Shiprock area, but the delivery is expected to be a small percentage of the total. The return flow through the treatment plant is assumed to be 50 percent for the Shiprock deliveries. All other deliveries would also have similar losses, but the system losses would be due to evaporation, or recharge local groundwater aquifers. For water balance purposes, no return flow to the San Juan River from these other locations is expected or accounted. Return flow to the Rio Grande or Little Colorado Rivers is highly unlikely, even though there will be discharge to the groundwater in these areas. Local groundwater storage space together with local pumping will limit the potential for surface discharge. Even if surface discharge does occur, the distance to the Rio Grande or Little Colorado Rivers is so great that it is unlikely that return flow would reach these rivers.

Table 1.—Forecast 2040 Demand and Design Capacity by Service Area

Location	SJR Diversion ac-ft/yr	SJR Depletion ac-ft/yr
City of Gallup, NM	7,500	7,500
Jicarilla Apache Nation	1,200	1,200
Navajo Nation, New Mexico		
Central Area	834	834
Crownpoint	2,473	2,473
Gallup Area	4,316	4,316
Huerfano	864	864
Rock Springs	2,118	2,118
Route 491	5,366	5,366
Torreon	2,240	2,240
San Juan River	3,742	1,871
NAPI industrial uses	700	700
Navajo Nation, Arizona (Window Rock area)	6,411	6,411
Total Navajo Nation	**29,064**	**27,193**
Project Total	**37,764**	**35,893**

Deliveries typically vary depending on changes in demand with the largest demand in summer months. The Shiprock water delivery pattern for March 1992 through February 1993, shown in Table 2, was used to determine average monthly deliveries. Return flows were assumed to follow the same distribution.

Table 2.—Monthly Demand Pattern for All Deliveries

Month	% Demand	Month	% Demand
January	7	July	10
February	6	August	10
March	9	September	10
April	7	October	8
May	9	November	7
June	10	December	7

The system design capacity to handle a 7-day peak demand for pumping plants and pipelines is computed as 1.3 times the peak average monthly demand. Daily and diurnal demand peaking are handled by the community storage tanks.

Operational Flexibility

Jicarilla Apache Nation and Gallup Water Supply

Table 1 shows a project annual water depletion for the Jicarilla Apache Nation (JAN) of 1,200 acre feet and for the City of Gallup, 7,500 acre feet. The plans for the Jicarilla Apache Nation Navajo River Water Supply Project (JANNRWSP) include the allowance to deliver all or part of this water to other uses, including the NGWSP, at a time that it should be needed. The NGWSP plans to use 6,570 acre-feet previously committed to JANNRWSP plus 170 acre feet of other unused JAN water supply, requiring 1,960 acre-feet of new depletion (Table 3). The City of Gallup depletion is assumed to be included in JAN depletions in Table 3.

Table 3—Summary of Depletions for full NGWSP Development

Water Right Holder	In Baseline (changed use) ac-ft	New Depletion ac-ft	Met w/ unused baseline depletion[1] ac-ft	Total Depletion ac-ft
Jicarilla Apache Nation	6,740[2]	1,960		8,700
Navajo Nation		6,411	20,782	27,193
NGWSP Total	6,740	8,371	20,782	35,893

[1] See Depletion Guarantee description.
[2] Includes 170 acre-feet from unused historical rights and 6,570 acre-feet from the JANNRWSP.

Navajo Nation Supply

The Navajo Nation portion of the NGWSP depletion is 27,193 acre feet per year (Table 3). The Navajo Nation portion of the NGWSP is comprised of 20,782 acre feet per year of unused depletions currently in the hydrologic baseline and 6,411 acre feet per year of new depletions (Table 3). Another 3,100 acre-feet will be returned to the San Juan River by return flow from the Navajo Indian Irrigation Project (NIIP) by the time the Navajo Nation demands reach the full 27,193 acre feet. This reduces the net new depletion to 5,271 acre feet per year.

If at some point in the future the amount of the unused depletions is less than 20,782 acre feet per year, the Navajo Nation will guarantee the availability of this remaining depletion by reducing their total water use in the basin.

Depletion Guarantee

This section clarifies the conditions of the Depletion Guarantee and describes the commitments necessary to monitor depletions and maintain compliance with the ESA. ***The Depletion Guarantee is a commitment by the Navajo Nation that ensures that depletion for the NGWSP will be offset by unused Navajo Nation NIIP depletions in the basin***. That portion of the NGWSP depletion that consists of unused depletions currently in the hydrologic baseline (20,782 acre feet) is attributed to Navajo Nation uses in New Mexico. Unless the sum of actual depletions from all uses listed in the hydrologic baseline shown in Table 4, plus all NGWSP uses reach the total listed in the baseline (854,371 acre feet) plus 5,271 acre feet, the full NGWSP depletion of 35,893 acre feet will be allowed (Table 3). The depletion for projects that may be added to the hydrologic baseline at a date later than the date of the Biological Opinion for NGWSP will not be counted in this analysis.

If the depletion conditions described in the paragraph above are reached, the Navajo Nation will reduce its total depletion to stay below the allowed total for the basin. This could be accomplished by changes in operation of any of the Navajo projects that deplete water from the San Juan River. The maximum depletion guarantee requirement is 20,782 acre feet. Changes in the flow recommendation or in species status may result in reduction or removal of this guarantee in the future, based upon reconsultation.

Monitoring Requirements

No specific, detailed accounting of depletions will be required unless the sum of NIIP and Animas LaPlata Project (ALP) depletions reaches 290,000 acre-feet (Table 4). Since these projects are easily tracked, it will limit monitoring requirements for the entire basin. If this condition is met, all the depletions listed in the baseline for NGWSP will be monitored and reported on a 5-year cycle to coincide with the USBR Consumptive Use and Loss report. Depletions will be reported by the categories listed in the hydrologic baseline shown in Table 4 and the total computed.

If the sum of these depletions reaches the hydrologic baseline level for NGWSP plus 5,271 acre-feet, the elements of the depletion guarantee will be implemented. At that point, modeling will be completed for the limits the Navajo Nation proposes putting in place to meet flow conditions specified in the BA.

Responsibilities

San Juan River Basin Recovery Implementation Program
The SJRRIP Hydrology Committee will be responsible for reviewing the accounting of depletions. The Committee will also implement the San Juan River Basin Hydrology Model (SJRBHM) to assure compliance with the flow recommendations as specified in the NGWSP BA for limits identified by the Navajo Nation at the time the depletion guarantee is implemented.

Bureau of Reclamation
The Bureau will identify the point at which ALP and NIIP annual depletions reach 290,000 acre-feet. If that target depletion is reached, Reclamation will initiate reporting of depletions for the categories listed in the hydrologic baseline for NGWSP (Table 4) on a 5-year cycle as a part of the consumptive use and loss reporting procedure. As a result of the monitoring, Reclamation will identify the point at which the sum of actual uses for these categories plus the NGWSP reach

Table 4.—Baseline and Current Depletion Summary in the San Juan River Basin[1]

Depletion Category	Riverware Baseline (ac-ft)	Estimated Current (ac-ft)	Presently Unused (ac-ft)
New Mexico Depletions			
Navajo Lands Irrigation Depletion			
Navajo Indian Irrigation Project	280,600[2]	160,330	120,270
Hogback	12,100	9,535	2,565
Fruitland	7,898	6,147	1,751
Cudei	900	715	185
Subtotal	**301,498**	**176,727**	**124,771**
Non-Navajo Lands Irrigation Depletion			
Above Navajo Dam - Private	738	575	163
Above Navajo Dam - Jicarilla	2,190	350	1,840
Animas River	36,711	24,878	11,833
La Plata River	9,808	8,470	1,338
Upper San Juan	9,137	6,680	2,457
Hammond Area	10,268	7,507	2,761
Farmers Mutual Ditch	9,532	7,457	2,075
Jewett Valley	3,088	2,379	709
Westwater	110	110	0
Subtotal	**81,582**	**58,406**	**23,176**
Total NM Irrigation Depletion	**383,080**	**235,133**	**147,949**
Non-Irrigation Depletions			
Navajo Reservoir Evaporation	27,350	29,235	-1,885
Utah International	39,000	31,388	7,612
San Juan Power Plant	16,200	16,200	0
Industrial Diversions near Bloomfield	2,500	2,500	0
Municipal and Industrial Uses	8,453	7,443	1,010
Scattered Rural Domestic Uses	1,400[3]	1,400	0
Scattered Stockponds & Livestock Uses	2,200[3]	2,200	0
Fish and Wildlife	1,400[3]	1,400	0
Total NM Non-Irrigation Depletion	**98,503**	**91,766**	**6,735**
San Juan-Chama Project Exportation	107,514	107,514	0
Unspecified Minor Depletions	4,500[4]	2,500	2,000
JANNRWSP	6,570[5]	0	6,570
Total NM Depletions (Excluding ALP)	**600,168**	**436,914**	**163,254**

Table 4.— Baseline and Current Depletion Summary in the San Juan River Basin – continued

Depletion Category	Riverware Baseline (ac-ft)	Estimated Current (ac-ft)	Presently Unused (ac-ft)
Colorado Depletions – Upstream of Navajo			
Upper San Juan	10,858	9,270	1,588
Navajo-Blanco	7,865	6,972	893
Piedra	8,098	6,892	1,206
Pine River	71,671	69,775	1,886
Subtotal	**98,492**	**92,909**	**5,583**
Colorado Depletions – Downstream of Navajo			
Florida	28,607	27,749	858
Animas	25,119	24,099	1,020
La Plata	13,245	13,049	196
Long Hollow	1,339	0	1,339
Mancos	19,532	15,516	4,016
Subtotal	**87,842**	**80,413**	**7,429**
Total CO Depletions (Excluding ALP)	**186,334**	**173,322**	**13,012**
Total CO & NM Combined Depletions	**786,502**	**610,236**	**176,266**
ALP	57,133[6]	1,620	55,513
Subtotal	**843,635**	**611,856**	**231,779**
McElmo Basin Imports	-11,769	-11,769	0
Utah Depletions	9,140[7]	9,140	0
Arizona Depletions	10,010[5]	10,010	0
NET NM, CO, UT, AZ Depletion	**851,016**	**619,237**	**231,779**
NM Off River Depletions			
Chaco River	2,832[5]	2,832	0
Whiskey Creek	523[5]	523	0
GRAND TOTAL	**854,371**	**622,592**	**231,779**

[1] Baseline depletion values are from the Generation 2 San Juan River Basin Hydrology Model operated by the SJRIP and may change with new versions of the model or new basin hydrology. They are provided here as a reference point and would naturally be adjusted to match changes approved by the SJRIP.

[2] Includes 10,600 af of annual groundwater storage. At equilibrium this drops to 270,000 af, based on irrigation of the full 110,630 acres every year. The proposed schedule of anticipated depletions prepared by the New Mexico Interstate Stream Commission to reflect the Navajo Water Rights Settlement Agreement includes an equilibrium depletion for NIIP of 256,500 AF based on an average fallow acreage of 5%. While including fallow land in the depletion calculation is reasonable, the larger number is used here to be consistent with the NIIP Section 7 consultation and the full capacity of the project.

[3] Indicates offstream depletion accounted for in calculated natural gains.

[4] 1500 af of depletion from minor depletions approved of SJRIP in 1992. 3,000 af from 1999 Intra-service consultation, a portion of which may be in Colorado

[5] Biological Opinion lists this depletion as 6,654 af, but model configuration shows 6,570. Model configuration used.

[6] Actual approved depletion is 57,100 af. Small changes in reservoir evaporation between runs results in small variation from actual project depletion. Exact match would require multiple iterations because of model limitations.

[7] 1,705 San Juan River depletion, 7,435 off stream depletion.

the total stated in the hydrologic baseline for NGWSP plus 5,271 acre-feet. If this level of depletion is reached, Reclamation will limit deliveries to Navajo projects as directed by the Navajo Nation, to levels required by implementation of the depletion guarantee. In the event that the SJRRIP terminates, Reclamation will assume the responsibilities listed above for the SJRRIP.

Navajo Nation

The Navajo Nation will limit uses as specified in the depletion guarantee if the conditions stated above are reached and provide to the SJRIP and Reclamation the projects it wishes limited.

Conditions

None of the actions and conditions listed here shall limit the ability of the Reclamation to reinitiate consultation on the NGWSP to increase its baseline depletion or alter the requirements of the depletion guarantee.

Conservation Measures

The following conservation measures are part of the proposed action.

San Juan River and Other Water Crossings

1. Silt curtains, cofferdams, dikes, straw bales or other suitable erosion control measures will be used to prevent erosion from entering water bodies during construction.
2. Water quality parameters will be monitored before, during, and after construction to ensure compliance with State Water Quality Standards. In-water work will stop if State Water Quality Standards are exceeded at or below the worksite.
3. Construction of the cofferdam will be scheduled during minimal low flows to avoid and minimize direct or indirect effects to fish species. River flows up- and downstream of construction areas will be maintained. Fish passage around dewatered construction areas will be maintained at all times.
4. A fish net barrier will be installed upstream and downstream of the construction site during construction to exclude fish from the work area during periods of in-water work.
5. Reclamation will coordinate with the Service to have a biologist(s) on site to rescue any fish species stranded as a result of construction activities.
6. Concrete pours will occur in forms and/or behind cofferdams to prevent discharge into the river. Any wastewater from concrete-batching, vehicle wash-down and aggregate processing will be contained and treated or removed for off-site disposal.

7. Fuels, lubricants, hydraulic fluids, and other petrochemicals will be stored and dispensed outside the 100-year floodplain in an approved staging area. Equipment will be inspected daily for petrochemical leaks. Construction equipment will be parked, stored and serviced only at approved staging area, outside of the 100-year floodplain.
8. An oil spill response plan will be prepared for areas of work where spilled contaminants could flow into water bodies. The plan will be developed prior to initiation of construction. Oil spill response kit, which includes appropriate sized spill blankets, shall be on-site at all times.
9. On-site supervisors and equipment operators will be knowledgeable in the use of spill containment equipment.
10. Appropriate Federal and State authorities will be notified in the event of any contaminant spill.
11. Disturbed areas within the wetted channel will be covered with clean cobble or quarry stone from an upland source. Disturbed areas adjacent to the wetted channel will be stabilized and planted with native riparian vegetation.

The following conservation measures will be implemented for the cactus:

1. Cactus surveys will be conducted prior to construction to identify individual plants and avoid where possible.
2. Where possible, refine the pipeline alignment to avoid individual cacti and populations as a whole.
3. Select an alternative site for the pumping plant currently planned for the intersection of Highways 491 and 36.
4. Mark cacti with protective cones when construction activity occurs in their vicinity.
5. Prior to disturbing areas where cacti are found, dig up susceptible plants and place them in a safe area, replant these cacti without delay once construction in the area is complete.
6. Consult with a qualified local botanist during marking and/or transplant of cacti.

Additionally, the following conservation measures will be implemented within areas of upland vegetation:

1. The footprints of pipeline and accessory components will be minimized.
2. Noxious weeds will be continually controlled within disturbed areas.

The Service requires, as part of the Terms and Conditions that documentation and reporting on the implementation of the conservation measures will occur within six months after completion of the project. Annually, thereafter for a period of five years, documentation and reporting will occur on the status of transplanted and relocated cacti and on control of noxious weeds within the disturbed sites.

Status of the Species and Critical Habitat

Colorado Pikeminnow

The pikeminnow is the largest cyprinid (member of the minnow family, Cyprinidae) native to North America and it evolved as the top predator in the Colorado River system. It is an elongated pike-like fish that once grew as large as 1.8 meters (m) (6 feet) in length and weighed nearly 45 kilograms (100 pounds) (Behnke and Benson 1983); such fish were estimated to be 45-55 years old (Osmundson et al. 1997). Today, fish rarely exceed 1 m (approximately 3 feet) in length or weigh more than 8 kilograms (18 pounds). The mouth of this species is large and nearly horizontal with long slender pharyngeal teeth (located in the throat), adapted for grasping and holding prey. The diet of pikeminnow longer than 80 to 100 millimeters (mm) (3 or 4 inches [in]) consists almost entirely of other fishes (Vanicek and Kramer 1969). Adults are strongly counter-shaded with a dark, olive back, and a white belly. Young are silvery and usually have a dark, wedge-shaped spot at the base of the caudal fin.

Based on early fish collection records, archaeological finds, and other observations, the pikeminnow was once found throughout warm water reaches of the entire Colorado River Basin down to the Gulf of California, including reaches of the upper Colorado River and its major tributaries, the Green River and its major tributaries, the San Juan River and some of its tributaries, and the Gila River system in Arizona (Seethaler 1978, Platania 1990). Pikeminnow apparently were never found in colder, headwater areas. Seethaler (1978) indicates that the species was abundant in suitable habitat throughout the entire Colorado River Basin prior to the 1850s. By the 1970s they were extirpated from the entire lower Basin (downstream of Glen Canyon Dam) and from portions of the upper Basin as a result of major alterations to the riverine environment. Having lost approximately 75-80 percent of its former range, the pikeminnow was federally listed as an endangered species in 1967 (Service 1967, Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998).

Critical habitat is defined as the areas that provide physical or biological features that are essential for the recovery of the species. Critical habitat was designated for the pikeminnow in 1994, within the 100-year floodplain of the species' historical range in the following areas of the San Juan River Basin (59 FR 13374): New Mexico, San Juan County; and Utah, San Juan County. The San Juan River from the State Route 371 Bridge in T. 29 N., R. 13 W., section 17 to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T. 41 S., R. 11 E., section 26.

The Service identified water, physical habitat, and the biological environment as primary constituent elements of critical habitat. This includes a quantity of water of sufficient quality that is delivered to specific habitats in accordance with a hydrologic regime that is required for the particular life stage for the species. The physical habitat includes areas of the Colorado River system that are inhabited or potentially habitable for use in spawning and feeding, as a nursery, or serve as corridors between these areas. In addition, oxbows, backwaters, and other areas in the 100-year floodplain, which when inundated provide access to spawning, nursery, feeding, and rearing habitats, are included. Food supply, predation, and competition are important elements of the biological environment.

Life History

The life history phases that appear to be most limiting for pikeminnow populations include spawning, egg hatching, development of larvae, and the first year of life. These phases of pikeminnow development are tied closely to specific habitat requirements. Natural spawning of pikeminnow is initiated on the descending limb of the annual hydrograph as water temperatures approach the range of 16°C (60.8°F) to 20°C (68°F) (Vanicek and Kramer 1969, Hamman 1981, Haynes et al. 1984, Tyus 1990, McAda and Kaeding 1991). Temperature at initiation of spawning varies by river. In the Green River, spawning begins as temperatures exceed 20-23°C (68-73°F); in the Yampa River, 16-23°C (61-68°F) (Bestgen et al. 1998); in the Colorado River, 18-22°C (64-72°F) (McAda and Kaeding 1991); in the San Juan River temperatures were estimated to be 16-22°C (61-72°F). Spawning, both in the hatchery and under natural riverine conditions, generally occurs in a 2-month period between late June and late August. However, sustained high flows during wet years may suppress river temperatures and extend spawning into September (McAda and Kaeding 1991). Conversely, during low flow years, when the water warms earlier, spawning may commence in mid-June.

Temperature also has an effect on egg development and hatching success. In the laboratory, egg development was tested at 5 temperatures and hatching success was found to be highest at 20°C (68°F), and lower at 25°C (77°F). Mortality was 100 percent at 5, 10, 15, and 30°C (41, 50, 59, and 86°F). In addition, larval abnormalities were twice as high at 25°C (77°F) than at 20°C (68°F) (Marsh 1985). Experimental tests of temperature preference of yearling (Black and Bulkley 1985a) and adult (Bulkley et al. 1981) pikeminnow indicated that 25°C (77°F) was the most preferred temperature for both life phases. Additional experiments indicated that optimum growth of yearlings also occurs at temperatures near 25°C (77°F) (Black and Bulkley 1985b). Although no such tests were conducted using adults, the tests with yearlings supported the conclusions of Jobling (1981) that the final thermal preference of 25°C (77°F) provides a good indication of optimum growth temperature for all life phases.

Males become sexually mature earlier and at a smaller size than do females, though all are mature by about age 7 and 500 mm (20 in) in length (Vanicek and Kramer 1969, Seethaler 1978, Hamman 1981). Hatchery-reared males became sexually mature at 4 years of age and females at 5 years. Average fecundity of 24, 9-year old females was 77,400 (range, 57,766–113,341) or 55,533 eggs/kg, and average fecundity of 9 ten-year old females was 66,185 (range, 11,977–91,040) or 45,451 eggs/kg (Hamman 1986).

Most information on pikeminnow reproduction has been gathered from spawning sites on the lower 20 miles (12.2 kilometers) of the Yampa River and in Gray Canyon on the Green River (Tyus and McAda 1984, Tyus 1985, Wick et al. 1985, Tyus 1990). Pikeminnow spawn after peak runoff subsides. Spawning is probably triggered by several interacting variables such as day length, temperature, flow level, and perhaps substrate characteristics. Known spawning sites in the Yampa River are characterized by riffles or shallow runs with well-washed coarse substrate (cobble containing relatively deep interstitial voids (for egg deposition)) in association with deep pools or areas of slow non-turbulent flow used as staging areas by adults (Lamarra et al. 1985, Tyus 1990). Recent investigations at a spawning site in the San Juan River by Bliesner and Lamarra (1995) and at one site in the upper Colorado River (Service unpubl. data) indicate a similar association of habitats. The most unique feature at the sites used for spawning, in comparison with otherwise similar sites nearby, is the lack of embeddedness of the cobble substrate and the depth to which the rocks are devoid of fine sediments; this appears consistent at the sites in all three rivers (Lamarra et al. 1985, Bliesner and Lamarra 1995).

Collections of larvae and young-of-year (YOY) downstream of known spawning sites in the Green, Yampa, and San Juan Rivers demonstrate that downstream drift of larval pikeminnow occurs following hatching (Haynes et al. 1984, Nesler et al. 1988, Tyus 1990, Tyus and Haines 1991, Platania 1990, Ryden 2003a). Studies on the Green and Colorado Rivers found that YOY used backwaters almost exclusively (Holden 2000). During their first year of life, pikeminnow prefer warm, turbid, relatively deep (averaging 0.4 m [1.3 feet]) backwater areas of zero velocity (Tyus and Haines 1991). After about 1 year, young are rarely found in such habitats, although juveniles and subadults are often located in large deep backwaters during spring runoff (Service, unpublished data; Osmundson and Burnham 1998).

Pikeminnow often migrate considerable distances to spawn in the Green and Yampa Rivers (Miller et al. 1982, Archer et al. 1986, Tyus and McAda 1984, Tyus 1985, Tyus 1990), and similar movement has been noted in the main stem San Juan River. A fish captured and tagged in the San Juan arm of Lake Powell in April 1987, was recaptured in the San Juan River approximately 80 miles upstream in September 1987 (Platania 1990). Ryden and Ahlm (1996) report that a pikeminnow captured at river mile (RM) 74.8 (between Bluff and Mexican Hat) made a 50-60 mile migration during the spawning season in 1994, before returning to within 0.4 river miles of its original capture location.

Although migratory behavior has been documented for pikeminnow in the San Juan River (Platania 1990, Ryden and Ahlm 1996), of 13 radio-tagged fish tracked from 1991 to 1994, 12 were classified as sedentary and only one as migratory (Ryden and Ahlm 1996). Miller and Ptacek (2000) followed 7 radio-tagged wild pikeminnow in the San Juan River and found these fish to also use a localized area of the river (RM 120 to RM142). In contrast to pikeminnow in the Green and Yampa rivers, the majority of pikeminnow in the San Juan River reside near the area in which they spawn (Ryden and Ahlm 1996, Miller and Ptacek 2000). During their study, Ryden and Ahlm (1996) found that pikeminnow in the San Juan River aggregated at the mouth of the Mancos River prior to spawning, a behavior not documented in other rivers in the upper Colorado River Basin. Miller and Ptacek (2000) also recorded 2 pikeminnow in both 1993 and 1994 at the mouth of the Mancos River prior to the spawning period.

Historical spawning areas for the pikeminnow in the San Juan River are unknown; however, Platania (1990) speculated that spawning likely occurred upstream at least to Rosa, New Mexico. Two locations in the San Juan River have been identified as potential spawning areas based on radio telemetry and visual observations (Ryden and Pfeifer 1994, Miller and Ptacek 2000). Both locations occur within the "Mixer" (RM 133.4 to 129.8), a geomorphically distinct reach of the San Juan River. The upper spawning location is located at RM 132 and the lower spawning location at approximately RM 131.1. Both locations consist of complex habitat associated with cobble bar and island complexes. Habitat at these locations is similar to spawning habitats described for the Yampa River and is composed of side channels, chutes, riffles, slow runs, backwaters, and slackwater areas near bars and islands. Substrate in the riffle areas is clean cobbles, primarily 7.6 to 10.2 centimeters (3 to 4 in) in diameter (Miller and Ptacek 2000). Habitat characteristics at the lower spawning area, based on radio telemetry and visual observations, include a fast narrow chute adjacent to a small eddy.

During 1993, radio-tagged pikeminnow were observed moving to potential spawning locations in the Mixer beginning around July 1. Fish were in the spawning areas from approximately July 12 to July 25. During this period flows in the San Juan River were on the descending limb of the spring runoff. Temperatures increased from approximately 20 to 25°C (68 to 77°F) during the same time period. Observations in other years show a similar pattern. However, specific spawning times and duration of the spawning period appear to vary from year to year. Information on radio-tagged adult pikeminnow during the fall suggests that pikeminnow seek out deep water areas in the Colorado River (Miller et al. 1982, Osmundson and Kaeding 1989), as do many other riverine species. Pools, runs, and other deep water areas, especially in upstream reaches, are important winter habitats for pikeminnow (Osmundson et al. 1995).

On the Green River, tributaries are an important habitat component for pikeminnow (Holden 2000). Both the Yampa River and White River were heavily used by pikeminnow subadults and adults, apparently as foraging areas (Tyus 1991). The tributaries were the primary area of residence to which the adults returned after spawning. Tributaries to the San Juan River no longer provide habitat for adults because they are dewatered or access is restricted (Holden 2000). Pikeminnow utilized the Animas River in the late 1800s. This river could still provide suitable habitat; however, the present pikeminnow population is downstream from the mouth of the Animas River about 50 miles (Holden 2000). Pikeminnow aggregated at the mouth of the Mancos River prior to spawning in the early 1990s (Ryden and Ahlm 1996, Miller and Ptacek 2000).

Very little information is available on the influence of turbidity on the endangered Colorado River fishes. Osmundson and Kaeding (1989) found that turbidity allows use of relatively shallow habitats ostensibly by providing adults with cover; this allows foraging and resting in areas otherwise exposed to avian or terrestrial predators. Tyus and Haines (1991) found that young pikeminnow in the Green River preferred backwaters that were turbid. Clear conditions in these shallow waters might expose young fish to predation from wading birds or exotic, sight-feeding, piscivorous fish. It is unknown whether the river was as turbid historically as it is today. For now, it is assumed that these endemic fishes evolved under conditions of high turbidity. Therefore, the retention of these highly turbid conditions is probably an important factor in maintaining the ability of these fish to compete with non-natives that may not have evolved under similar conditions.

Population Dynamics

Due to the low numbers of pikeminnow collected in the San Juan River, it is not possible to quantify population size or trends. Estimates during the seven-year research period between 1991 and 1997 suggest that there were fewer than 50 adults in a given year (Ryden 2000a). The ability of the pikeminnow to withstand adverse impacts to its populations and its habitat is difficult to discern given the longevity of individuals and their scarcity within the San Juan River Basin. At this stage of investigations on the San Juan River, the younger life stages are considered the most vulnerable to predation, competition, toxic chemicals, and habitat degradation. The ability of a population to rebound from these impacts may take several years or more.

Between 1991 and 1995, 19 (17 adult and 2 juvenile) wild pikeminnow were collected in the San Juan River by electrofishing (Ryden 2000a). Wild adult pikeminnow were most abundant between RM 142 (the former Cudei Diversion) and Four Corners at RM 119 (Ryden and Ahlm 1996) and they primarily use the San Juan River between these points (Ryden and Pfeifer 1993, 1994, 1995a, 1996). The multi-threaded channel, habitat complexity, and mixture of substrate types in this area of the river appear to provide a diversity of habitats favorable to pikeminnow on a year-round basis (Holden and Masslich 1997).

Successful reproduction was documented in the San Juan River in 1987, 1988, and 1992 through 1996, by the collection of larval and/or YOY pikeminnow. The majority of the YOY pikeminnow were collected in the San Juan River inflow to Lake Powell (Archer et al. 1995, Buntjer et al. 1994, Lashmett 1994, Platania 1990). Some YOY pikeminnow have been collected near the Mancos River confluence, New Mexico and in the vicinity of the Montezuma Creek confluence near Bluff, Utah, and at a drift station near Mexican Hat, Utah (Buntjer et al. 1994, Snyder and Platania 1995). The collection of larval fish (only a few days old) at Mexican Hat in two different years suggests that perhaps another spawning area for pikeminnow exists somewhere below the Mixer (Platania 1996). Capture of a larval pikeminnow at RM 128 during August 1996 was the first larva collected immediately below the suspected spawning site in the Mixer (Holden and Masslich 1997).

Platania (1990) noted that, during 3 years of studies on the San Juan River (1987 - 1989), spring flows and pikeminnow reproduction were highest in 1987. He further noted catch rates for channel catfish were lowest in 1987. Subsequent studies (Brooks et al. 1994) found declines in channel catfish in 1993; these declines have been attributed to a successive series of higher than normal spring runoffs from 1991 through 1993. Recent studies also found catch rates for YOY pikeminnow to be highest in high water years, such as 1993 (Buntjer et al. 1994, Lashmett 1994).

Tissue samples from pikeminnow caught during research conducted under the SJRRIP have been analyzed as part of a Basin-wide analysis of endangered fish genetics. The results of that analysis indicate that the San Juan River fish exhibit less genetic variability than the Green River and Colorado River populations, likely due to the small population size, but were very similar to pikeminnow from the Green, Colorado, and Yampa Rivers (Morizot in litt. 1996). These data suggest that the San Juan population is probably not a separate stock (Holden and Masslich 1997).

Competition and Predation

Pikeminnow in the upper Colorado River Basin live with about 20 species of warm-water non-native fishes (Tyus et al. 1982, Lentsch et al. 1996) that are potential predators, competitors, and vectors for parasites and disease. Backwaters and other low-velocity habitats in the San Juan River are important nursery areas for larval and juvenile pikeminnow (Holden 1999) and researchers believe that non-native fish species limit the success of pikeminnow recruitment (Bestgen 1997, Bestgen et al. 1997, McAda and Ryel 1999). Osmundson (1987) documented predation by black bullhead (*Ameiurus melas*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), and black crappie (*Pomoxis nigromaculatus*) as a significant mortality factor for YOY and yearling pikeminnow stocked in riverside ponds along the upper Colorado River. Adult red shiners (*Cyprinella lutrensis*) are known predators of larval native fish in backwaters of the upper Basin (Ruppert et al. 1993). High spatial overlap in habitat use has been documented among young pikeminnow, red shiner, sand shiner (*Notropis stramineus*), and fathead minnow (*Pimephales promelas*). In laboratory experiments on behavioral interactions, Karp and Tyus (1990) observed that red shiner, fathead minnow, and green sunfish shared activity schedules and space with young pikeminnow and exhibited antagonistic behaviors to smaller pikeminnow. They hypothesized that pikeminnow may be at a competitive disadvantage in an environment that is resource limited.

Channel catfish (*Ictalurus punctatus*) has been identified as a threat to juvenile, subadult, and adult pikeminnow in the San Juan River. Channel catfish were first introduced in the upper Colorado River Basin in 1892 (Tyus and Nikirk 1990) and are now considered common to abundant throughout much of the upper Basin (Tyus et al. 1982, Nelson et al. 1995). The species is one of the most prolific predators in the upper Basin and, among the non-native fishes, is thought to have the greatest adverse effect on endangered fishes due to predation on juveniles and resource overlap with subadults and adults (Hawkins and Nesler 1991, Lentsch et al. 1996, Tyus and Saunders 1996). Stocked juvenile and adult pikeminnow that have preyed on channel catfish have died from choking on the pectoral spines (McAda 1983, Pimental et al. 1985). Although mechanical removal (electrofishing, seining) of channel catfish began in 1995, intensive efforts (10 trips/year) did not begin until 2001. Mechanical removal has not yet led to a positive population response in pikeminnow (Davis 2003); however, because the pikeminnow population is so low, documenting a population response would be extremely difficult.

Status and Distribution

The pikeminnow was designated as endangered prior to the ESA; therefore, a formal listing package identifying threats was not prepared. Construction and operation of mainstem dams, non-native fish, and local eradication of native minnow and suckers in the early 1960s were recognized as early threats (Miller 1961, Holden 1991). The pikeminnow recovery goals (Service 2002a) summarize threats to the species as follows: stream regulation, habitat modification, competition with and predation by non-native fish, and pesticides and pollutants.

Major declines in pikeminnow populations occurred in the lower Colorado River Basin during the dam-building era of the 1930s through the 1960s. Behnke and Benson (1983) summarized the decline of the natural ecosystem, pointing out that dams, impoundments, and water use practices drastically modified the river's natural hydrology and channel characteristics throughout the Colorado River Basin. Dams on the main stem fragmented the river ecosystem into a series of disjunct segments, blocked native fish migrations, reduced water temperatures downstream of dams, created lake habitat, and provided conditions that allow competitive and predatory non-native fishes to thrive both within the impounded reservoirs and in the modified river segments that connect them. The highly modified flow regime in the lower Basin coupled with the introduction of non-native fishes decimated populations of native fish.

In the upper Colorado River Basin, declines in pikeminnow populations occurred primarily after the 1960s, when the following dams were constructed: Glen Canyon Dam on the main stem Colorado River, Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan River, and the Aspinall Unit dams on the Gunnison River. Some native fish populations in the upper Basin have managed to persist, while others are nearly extirpated. River reaches where native fish have declined more slowly, more closely resemble pre-dam hydrologic regimes, where adequate habitat for all life phases still exists, and where migration corridors allow connectivity among habitats used during the various life phases.

A factor not considered when the pikeminnow was listed was water quality. Surface and ground water quality in the Animas, La Plata, Mancos, and San Juan River drainages have become concerns in recent years (Abell 1994). Changes in water quality and contamination of associated biota are known to occur in Reclamation projects in the San Juan drainage (i.e., irrigated lands on the Pine and Mancos Rivers) where return flows from irrigation make up a portion of the river flow (Sylvester et al. 1988). Increased loading of the San Juan River and its tributaries with heavy metals; elemental contaminants such as selenium, salts, polycyclic aromatic hydrocarbons (PAHs); and pesticides has degraded water quality of the San Juan River in critical habitat (Abell 1994, Wilson et. al. 1995, Holden 1999).

Razorback Sucker

Like all suckers (family Catastomidae, meaning "down mouth"), the razorback sucker has a ventral mouth with thick lips covered with papillae and no scales on its head. In general, suckers are bottom browsers, sucking up or scraping off small invertebrates, algae, and organic matter with their fleshy, protrusible lips (Moyle 1976). The razorback sucker is the only sucker with an abrupt sharp-edged dorsal keel behind its head. The keel becomes more massive with age. The head and keel are dark, the back is olive-colored, the sides are brownish or reddish, and the abdomen is yellowish white (Sublette et al. 1990). Adults often exceed 3 kg (6 lbs) in weight and 600 mm (2 ft) in length. Like pikeminnow, razorback suckers may live 40-plus years.

Historically, razorback suckers were found in the main stem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (Ellis 1914; Minckley 1983). Bestgen (1990) reported that this species was once so numerous that it was commonly used as food by early settlers and that a commercially marketable quantity was caught in Arizona as recently as 1949. In the upper Colorado River Basin, razorback suckers were reported to be very abundant in the Green River near Green River, Utah, in the late 1800s (Jordan 1891). An account in Osmundson and Kaeding (1989) reported that residents living along the Colorado River near Clifton, Colorado, observed several thousand razorback suckers during spring runoff in the 1930s and early 1940s. In the San Juan River drainage, the first documented razorback sucker from the river was documented in 1988 (Platania 1990); however, two adults were also collected from an irrigation pond attached to the river by a canal in 1976 (Platania 1990) and it is very likely that razorback sucker once occurred in the main stem as far upstream as Rosa, New Mexico (Ryden 1997).

A marked decline in populations of razorback suckers can be attributed to construction of dams and reservoirs, introduction of non-native fishes, and removal of large quantities of water from the Colorado River system. Dams on the main stem Colorado River and its major tributaries have fragmented populations and blocked migration routes. Dams also have drastically altered flows, water temperatures, and channel geomorphology. These changes have modified habitats in many areas so that they are no longer suitable for breeding, feeding, or sheltering. Major changes in species composition have occurred due to the introduction of non-native fishes, many of which have thrived due to man-induced changes to the natural riverine system. Habitat has been significantly degraded to a point where it impairs the essential life history functions of razorback sucker, such as reproduction and recruitment into the adult population.

On March 14, 1989, the Service was petitioned to conduct a status review of the razorback sucker. Subsequently, the razorback sucker was designated as endangered under a final rule published on October 23, 1991 (56 FR 54957). The final rule stated that "Little evidence of natural recruitment has been found in the past 30 years, and numbers of adult fish captured in the last 10 years demonstrate a downward trend relative to historic abundance. Significant changes have occurred in razorback sucker habitat through diversion and depletion of water, introduction of nonnative fishes, and construction and operation of dams" (59 FR 13374). Recruitment of larval razorback suckers to juveniles and adults continues to be a problem.

Critical habitat was designated in 1994, within the 100-year flood plain of the razorback sucker's historical range in the following area of the San Juan River Basin (59 FR 13374): New Mexico, San Juan County; and Utah, San Juan County. The San Juan River from the Hogback Diversion in T. 29 N., R. 16 W., section 9 to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T. 41 S., R. 11 E., section 26.

The primary constituent elements of critical habitat are the same as those described earlier for pikeminnow.

Life History

McAda and Wydoski (1980) and Tyus (1987) reported springtime aggregations of razorback suckers in off-channel habitats and tributaries; such aggregations are believed to be associated with reproductive activities. Tyus and Karp (1990) and Osmundson and Kaeding (1991) reported off-channel habitats to be much warmer than the main stem river and that razorback suckers presumably moved to these areas for feeding, resting, sexual maturation, spawning, and other activities associated with their reproductive cycle.

While razorback suckers have never been directly observed spawning in turbid riverine environments within the upper Colorado River Basin, captures of ripe specimens, both males and females, have been recorded in the Yampa, Green, Colorado, and San Juan Rivers (Valdez et al. 1982, McAda and Wydoski 1980, Tyus 1987, Osmundson and Kaeding 1989, Tyus and Karp 1989, Tyus and Karp 1990, Osmundson and Kaeding 1991, Platania 1990, Ryden 2000b). Because of the relatively steep gradient in the San Juan River and lack of a wide flood plain, razorback sucker are likely spawning in low velocity, turbid, main channel habitats. Aggregations of ripe adults have been documented in two locations. The capture of larval razorback sucker approximately 48 km (30 mi) upstream from the other sites suggests a third spawning location (Ryden, Service, in litt. 2004).

Sexually mature razorback suckers are generally collected on the ascending limb of the hydrograph from mid-April through June and are associated with coarse gravel substrates. Both sexes mature as early as age four (McAda and Wydoski 1980). Fecundity, based on ovarian egg counts, ranges from 75,000-144,000 eggs (Minckley 1983). McAda and Wydoski (1980) reported an average fecundity (N=10) of 46,740 eggs/fish (27,614–76,576). Several males attend each female; no nest is built. The adhesive eggs drift to the bottom and hatch there (Sublette et al. 1990). Marsh (1985) reported that percentage egg hatch was greatest at 20°C (68°F) and all embryos died at incubation temperatures of 5, 10, and 30°C (41, 50, and 86°F).

Because young and juvenile razorback suckers are rarely encountered, their habitat requirements in the wild are not well known, particularly in native riverine environments. However, it is assumed that low-velocity backwaters and side channels are important for YOY and juveniles, as it is to the early life stages of most riverine fish. Prior to construction of large main stem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the upper Colorado River Basin (Tyus and Karp 1989, Osmundson and Kaeding 1991). Modde (1996) found that on the Green River, larval razorback suckers entered flooded bottomlands that are connected to the main channel during high flow. However, as mentioned earlier, because of the relatively steep gradient of the San Juan River and the lack of a wide flood plain, flooded bottomlands are probably much less important in this system than are other low velocity habitats such as backwaters and secondary channels (Ryden, Service, in litt. 2004).

Reduction in spring peak flows eliminates or reduces the frequency of inundation of off-channel and bottomland habitats. The absence of these seasonally flooded riverine habitats is believed to be a limiting factor in the successful recruitment of razorback suckers in other upper Colorado River streams (Tyus and Karp 1989, Osmundson and Kaeding 1991). Wydoski and Wick (1998) identified starvation of larval razorback suckers due to low zooplankton densities in the main channel and loss of floodplain habitats that provide adequate zooplankton densities for larval food as one of the most important factors limiting recruitment. Maintaining low velocity habitats is important for the survival of larval razorback suckers.

Outside of the spawning season, adult razorback suckers occupy a variety of shoreline and main channel habitats including slow runs, shallow to deep pools, backwaters, eddies, and other relatively slow velocity areas associated with sand substrates (Tyus 1987, Tyus and Karp 1989, Osmundson and Kaeding 1989, Valdez and Masslich 1989, Osmundson and Kaeding 1991, Tyus and Karp 1990). The diet consists primarily of algae, plant debris, and aquatic insect larvae (Sublette et al. 1990).

Population Dynamics

Because wild razorback sucker are rarely encountered and they are a long-lived fish, it is difficult to determine natural fluctuations in the population. The existing scientific literature and historic accounts by local residents strongly suggest that razorback suckers were once a viable, reproducing member of the native fish community in the San Juan River drainage. Currently, razorback sucker is rare throughout its historic range and extremely rare in the main stem San Juan River. Until 2003, there was very limited evidence indicating natural recruitment to any population of razorback sucker in the Colorado River system (Bestgen 1990, Platania 1990, Platania et al. 1991, Tyus 1987, McCarthy and Minckley 1987, Osmundson and Kaeding 1989, Modde et al. 1996). In 2003, two juvenile (age-2) razorback sucker, 249 and 270 mm (9.8 and 10.6 in), thought to be wild-produced from stocked fish were collected in the lower San Juan River (RM 35.7 and 4.8) (Ryden, Service, in litt., 2004).

Competition and Predation

Many species of non-native fishes occur in occupied habitat of the razorback sucker. These non-native fishes are predators, competitors, and vectors of parasites and diseases (Tyus et al. 1982, Lentsch et al. 1996, Pacey and Marsh 1999, Marsh et al. 2001). Many researchers believe that non-native species are a major cause for the lack of recruitment (e.g., McAda and Wydoski 1980, Minckley 1983, Tyus 1987, Muth et al. 2000). There are reports of predation of razorback sucker eggs and larvae by common carp (*Cyprinus carpio*), channel catfish, smallmouth bass (*Micropterus dolomeiui*), largemouth bass, bluegill (*Lepomis macrochirus*), green sunfish, and redear sunfish (*Lepomis microlophus*) (Jonez and Sumner 1954, Marsh and Langshorst 1988, Langhorst 1989). Marsh and Langhorst (1988) found higher growth rates in larval razorback sucker in the absence of predators in Lake Mohave, and Marsh and Brooks (1989) reported that channel catfish and flathead catfish were major predators of stocked razorback sucker in the Gila River. Juvenile razorback sucker (average total length 171 mm [6.7 in]) stocked in isolated coves along the Colorado River in California, suffered extensive predation by channel catfish and largemouth bass (Langhorst 1989). Aggressive behavior between channel catfish and adult razorback sucker has been inferred from the presence of distinct bite marks on the dorsal keels of four razorback suckers that match the bite characteristics of channel catfish (Ryden, Service, in litt. 2004).

Lentsch et al. (1996) identified six species of non-native fishes in the upper Colorado River Basin as threats to razorback sucker: red shiner, common carp, sand shiner, fathead minnow, channel catfish, and green sunfish. Smaller fish, such as adult red shiner, are known predators of larval native fish (Ruppert et al. 1993). Large predators, such as walleye (*Stizostedion vitreum*), northern pike, and striped bass (*Morone saxatilis*), also pose a threat to subadult and adult razorback sucker (Tyus and Beard 1990).

Status and Distribution

Currently, the largest concentration of razorback sucker remaining in the Colorado River Basin is in Lake Mohave. Estimates of the wild stock in Lake Mohave have fallen precipitously in recent years from 60,000 as late as 1991, to 25,000 in 1993 (Marsh 1993, Holden 1994), to about 9,000 in 2000 (Service 2002b). Until recently, efforts to introduce young razorback sucker into Lake Mohave have failed because of predation by non-native species (Minckley et al. 1991, Clarkson et al. 1993, Burke 1994). While limited numbers of razorback suckers persist in other locations in the Lower Colorado River, they are considered rare or incidental and may be continuing to decline.

In the upper Colorado River Basin, above Glen Canyon Dam, razorback suckers are found in limited numbers in both lentic (lake-like) and riverine environments. The largest populations of razorback suckers in the upper Basin are found in the upper Green and lower Yampa Rivers (Tyus 1987). Lanigan and Tyus (1989) estimated a population of 948 adults (95 percent confidence interval: 758 to 1,138) in the upper Green River. Eight years later, the population was estimated at 524 adults (95 percent confidence interval: 351-696) and the population was characterized as stable or declining slowly with some evidence of recruitment (Modde et al. 1996). They attributed this suspected recruitment to unusually high spring flows during 1983–1986 that inundated portions of the floodplain used as nurseries by young. In the Colorado

River, most razorback suckers occur in the Grand Valley area near Grand Junction, Colorado; however, they are increasingly rare. Osmundson and Kaeding (1991) reported that the number of razorback sucker captures in the Grand Junction area has declined dramatically since 1974. Between 1984 and 1990, intensive collecting effort captured only 12 individuals in the Grand Valley (Osmundson and Kaeding 1991). The wild population of razorback sucker is considered extirpated from the Gunnison River (Burdick and Bonar 1997).

Scientifically documented records of wild razorback sucker adults in the San Juan River are limited to two fish captured in a riverside pond near Bluff, Utah in 1976, and one fish captured in the river in 1988, also near Bluff (Platania 1990). Large numbers were anecdotally reported from a drained pond near Bluff in 1976, but no specimens were preserved to verify the species. No wild razorback sucker were found during the 7-year research period (1991-1997) of the SJRRIP (Holden 1999). Hatchery-reared razorback sucker, especially fish greater than 350 mm (13.8 in), introduced into the San Juan River in the 1990s have survived and reproduced, as evidenced by recapture data and collection of larval fish (Ryden 2000b).

Razorback suckers are in imminent danger of extirpation in the wild. The razorback sucker was listed as endangered October 23, 1991 (56 FR 54957). As Bestgen (1990) pointed out:

> Reasons for decline of most native fishes in the Colorado River Basin have been attributed to habitat loss due to construction of mainstream dams and subsequent interruption or alteration of natural flow and physio-chemical regimes, inundation of river reaches by reservoirs, channelization, water quality degradation, introduction of non-native fish species and resulting competitive interactions or predation, and other man-induced disturbances (Miller 1961, Joseph et al. 1977, Behnke and Benson 1983, Carlson and Muth 1989, Tyus and Karp 1989). These factors are almost certainly not mutually exclusive; therefore it is often difficult to determine exact cause and effect relationships.

The razorback sucker recovery goals identified streamflow regulation, habitat modification, predation by non-native fish species, and pesticides and pollutants as the primary threats to the species (Service 2002b). Within the upper Colorado River Basin, recovery efforts include the capture and removal of razorback suckers from all known locations for genetic analyses and development of brood stocks. In the short-term, augmentation (stocking) may be the only means to prevent the extirpation of razorback sucker in the upper Colorado River Basin. However, in the long-term it is expected that natural reproduction and recruitment will occur. A genetics management plan and augmentation plan have been written for the razorback sucker (Crist and Ryden 2003).

Mesa Verde Cactus

The cactus was listed as a threatened species on October 30, 1979 (44 FR 62472). No critical habitat was designated. When listed, existing or potential threats included coal, oil, and gas exploration and production; commercial and residential development; road, powerline, and pipeline construction; commercial and private collecting; off-road vehicle (ORV) impacts; livestock trampling; and natural threats of disease and predation.

The Mesa Verde cactus is a small globose, usually single-stemmed, plant 3.2 - 6.6 centimeters (1.5 - 3 inches) in diameter. The spines are 6 - 13 mm (0.25 - 0.50 in) long in clusters of 8 - 11. The flowers are about 2 cm (0.75 inch) in diameter, cream to yellow-colored, and bloom in late April or early May. Mesa Verde cactus grows in clay soils derived from shales of the Mancos and Fruitland formations. These formations erode easily forming low rolling hills. The soils have high alkalinity, are gypsiferous, and have shrink-swell properties that make them harsh sites for plant growth. The sparse vegetation is dominated by two species of saltbush (*Atriplex corrugata* and *A. nuttallii*) on the uplands and several species of forbs and grasses (*Chrysothamnus greenei*, *Sphaeralcea coccinea*, *Abronia elliptica*, *Sporobolus cryptandrus*, and *Hilaria jamesii*) in the drainages.

The distribution of Mesa Verde cactus encompasses a roughly rectangular area extending north to south from about 15 miles north of the Colorado-New Mexico border to the vicinity of Sheep Springs, New Mexico, and east to west from the vicinity of Waterflow, New Mexico, to about 15 miles west of Shiprock, New Mexico. Plants can occur sporadically anywhere that soils are suitable, but there appear to be five areas of plant concentration. These areas are near the base of the Mesa Verde Escarpment in Montezuma County, Colorado, near the Colorado-New Mexico state line, in the vicinity of Shiprock, in the vicinity of Sheep Springs, and north of Waterflow. The New Mexico plants all occur in San Juan County.

The Mesa Verde Cactus Recovery Plan estimates 5,000 to 10,000 plants occur within the species' range, but this number is probably low (Spellenberg 1978, Service 1984). The number of individuals of cacti per unit area varies tremendously. As many as 20 individual plants have been seen within 50 square meters or as few as a single specimen with no other Mesa Verde cacti within several hundred meters. This cactus does not have an even distribution throughout its range but tends to form major populations within certain favorable habitats (Spellenberg 1978, Knight 1981, Service 1984).

Most Mesa Verde cactus populations occur on tribal lands. Perhaps 70 percent of occurrences are on the Navajo Reservation and another 20 percent on the Ute Mountain Indian Reservation. The other 10 percent of the populations occur east of the Hogback on private lands and on public lands administered by the BLM.

A 2-hectare monitoring plot was established on BLM land in 1986 and data were recorded annually through 1995 by personnel from the New Mexico Forestry Division (1995). During the 10-year study period, 240 new plants were found and 230 were lost. The reason for most mortality could not be determined, but a small number could be attributed to ORVs, cow tracks, rodent predation, cactus poaching, and investigator damage. The study showed that reproduction is episodic with the greatest population increases coming after the wet year of 1990, which followed two years of extreme drought. This monitoring found that the population is generally stable.

Environmental Baseline

The environmental baseline includes the past and present impacts of all Federal, State, and private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal section 7 consultation; and the impact of State or private actions contemporaneous with the consultation process. All projects previously built or consulted on, and those State or private projects presently being built or considered that deplete water from the San Juan River Basin are in the Environmental Baseline for this proposed action. The baseline does not include the effects of the action under review, only actions that have occurred previously.

The Service describes the environmental baseline in terms of the biological requirements for habitat features and processes necessary to support life stages of the subject species within the action area. When the environmental baseline departs from those biological requirements, the adverse effects of a proposed action on the species or proposed critical habitat are more likely to jeopardize the listed species or result in destruction or adverse modification of proposed critical habitat.

Status of the Species within the Action Area

Colorado Pikeminnow

Platania and Young (1989) summarized historic fish collections in the San Juan River drainage that indicate that pikeminnow once inhabited reaches above what is now Navajo Dam and Reservoir near Rosa, New Mexico. Lake Powell and Navajo Reservoir resulted in the direct loss of approximately 161 km (100 mi) of San Juan River habitat for the two endangered fishes (Holden 2000). Since closure of Navajo Dam in 1963, the accompanying fish eradication program, physical changes associated with the dam, and barriers to movement, wild pikeminnow have been eliminated from the upper San Juan River upstream of Navajo Dam. Below Navajo Dam, summer water temperatures are colder and winter water temperatures are warmer than the pre-dam condition. The first10 km (6.2 mi) below the dam are essentially sediment free, resulting in the clearest water of any reach (Miller and Ptacek 2000). The cool, clear water has allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of most native species (Miller and Ptacek 2000).

Mark and recapture estimates place 19 wild adult pikeminnow in the San Juan River from river-mile (RM) 136.6 to RM 119.2 (95 percent C.I. 10-42; Ryden 2000a). Radio tagged adults appear to have relatively small home ranges and primarily use habitats from RM 109 to RM 142. The exception to this trend was one fish that consistently used habitats immediately downstream of Bluff, UT (RM 80; Ryden 2000a). Spawning has been documented in a region of high channel complexity characterized by shifting gravel bars from RM 133.4 to RM 129.8 (Ryden 2000a). Additional suitable spawning habitat has been identified at RM 178.7 and 168.4 (Bliesner 2003). Drift data from 1995 suggested a spawning site considerably downstream of RM 129 (Platania, et al. 2000) but its location was not identified. Prior to spawning, adults stage at the mouth of the Mancos River. Spawning dates (back calculated from larval drift) range from July 8 to August 12 (Platania et al. 2000). Larval and juvenile pikeminnow have been collected from low velocity shoreline and pocketwater habitats downstream of RM 130 (Ryden 2000a).

Between 1987 and 1996, no wild pikeminnow adults were caught above Shiprock (approximately RM 150). Radio telemetry studies conducted from 1991 to 1995 indicated that pikeminnow remained within a relatively small area of the river, between RM 110 to RM 142 (Holden 2000). The removal of the diversion at Cudei (RM 142), construction of non-selective fish passage at the Hogback Diversion (158.6) and the completion of the PNM (RM 166.1) selective fish passage ladder in 2003 has restored fish access to about 36 miles of critical habitat on the San Juan River for pikeminnow. In 2004, 5 pikeminnow (226-250 total length [8.9-9.8 in]) were caught in the lower few miles of the Animas River (Ryden and McAda 2005). These fish were all age-2 that had been stocked in June 2004 about 0.3 RMs downstream of the Animas River confluence (Ryden and McAda 2005). During the seven-year research period (1991 to 1997) it was estimated that there were fewer than 50 adults in the San Juan River in any given year (Ryden 2000a).

Experimental stocking of pikeminnow in the San Juan River began in 1996. Between 1996 and 2000, approximately 832,000 larval pikeminnow were stocked in the San Juan River. About 727,000 were stocked between RM 141 and 158. The balance was stocked at RM 52 (Ryden, 2003). Initial retention was encouraging and over winter survival was high (spring captures = 62.5-62.7 percent of fall captures) and survival between age-one and age-two based on recapture rates neared 100 percent (Archer et al. 2000). As a result of this initial success an augmentation plan began in 2002 and calls for stocking and monitoring 300,000 age-0 pikeminnow at RM 180.2 and RM 158.6 for seven years (Ryden and McAda 2003). In addition to augmentation, ongoing recovery efforts include mimicry of a natural hydrograph, adult and larval fish monitoring, habitat and water quality monitoring and control of non-native species and removal of migration barriers.

In 2003, the fish passage at the PNM weir was finished and put into operation. During the summer of 2003, 9 pikeminnow used the fish passage (Lapahie 2004). One of the goals of the SJRRIP is the expansion of range of Colorado Pikeminnow and removal of barriers to migration (SJRRIP 1995). The removal of the Cudei diversion dam and construction of fish passage at the Hogback diversion dam in 2001 and the documented use of the PNM weir has provided opportunity for and documented use of this upper portion of the river by pikeminnow; an important step toward recovery.

Razorback Sucker

From 1991 to 1997, no wild adult razorback suckers were collected in the San Juan River and only one was caught during studies conducted in the late 1980s (Holden 2000). Beginning in May 1987, and continuing through October 1989, complementary investigations of fishes in the San Juan River were conducted in Colorado, New Mexico, and Utah (Platania 1990, Platania et al. 1991). In 1987, a total of 18 adult razorbacks were collected (six were recaptured once) on the south shore of the San Juan arm of Lake Powell (Platania 1990, Platania et al. 1991). These fish were captured near a concrete boat ramp at Piute Farms Marina and were believed to be either a spawning aggregation or possibly a staging area used in preparation for migration to a spawning site. Of the 12 razorback suckers handled in 1987, 8 were ripe males and the other 4 specimens were females that appeared gravid.

In 1988, a total of 10 razorback suckers were handled at the same general location, 5 of which were in reproductive condition (Platania et al. 1991). Six of the 10 individual specimens in the 1988 samples were recaptures from 1987. Also in 1988, a single adult tuberculate male razorback sucker was captured in the San Juan River near Bluff, Utah (RM 80) (Platania 1990, Platania et al. 1991). This was the first confirmed record of this species from the main stem San Juan River. The presence of this reproductively mature specimen suggested that razorback suckers were attempting to spawn within the riverine portion of the San Juan drainage. However, no wild razorback suckers have been collected on the San Juan River since 1988 (Ryden, Service, pers. comm., 2005). A Schnabel multiple-census population model estimated that there were 1200 razorback suckers in the San Juan River from RM 158.6 to 2.9 in October 2004 (Ryden, Service, pers. comm., 2006). This population estimate refers to stocked razorback sucker.

Mesa Verde Cactus

Numerous activities in Mesa Verde cactus habitat have required section 7 consultations, but only four have resulted in formal consultations. A formal consultation was conducted with the Federal Water and Power Resources Service in March 1980. The action was the Gallup-Navajo Indian Water Supply Project, which proposed to deliver domestic water in a buried pipeline from the San Juan River to several communities in northwestern New Mexico. The project had the potential to impact about 200 cacti. A non-jeopardy opinion with conservation recommendations was given. A formal consultation was conducted with Bureau of Indian Affairs (BIA) in May 1985 (Cons. #2-22-83-F-039). The action included improvements to Navajo Route 36 from Shiprock to Fruitland. It was estimated the project would impact 40 plants. A non-jeopardy opinion was given with recommendations that the plants are transplanted to a safe locality and that transplanting success after one year be reported to the Service. A formal consultation was conducted with BLM in February 1997 (Cons. #2-22-96-F-010). The proposed action was continued implementation of the BLM, Farmington District, Resource Management Plan (RMP). A non-jeopardy opinion was given with the conclusion that management provisions and protective measures in the RMP are sufficient to prevent adverse effects to the cactus. No conservation recommendations were given. The final formal consultation was conducted with the BIA in 2000 on the proposed Shiprock Northern Navajo Fairgrounds located on the Navajo Nation, San Juan County, New Mexico (Cons. #2-22-99-F-467). A non-jeopardy opinion with conservation recommendations was given.

During field surveys along the western pipeline route adjacent to US Highway 491, fewer than 100 individual Mesa Verde cacti were documented. The population is located south-southeast of the junction of US Highway 666 and Navajo Route 36 and is within the boundary of both proposed pipeline alignments. Three additional areas of potential habitat were documented: 1) south of the junction of Hwy 666 and 36 for approximately 15 miles to the vicinity of Little Water, New Mexico; 2) north of Navajo Route 36 and west of the Hogback; and 3) immediately east of the Hogback, from the Amarillo Canal to Highway 666. During the spring and early summer of 2002 additional surveys were conducted in these areas (Ecosystems Research Institute 2002). Approximately 150 acres were surveyed. No Mesa Verde cactus were observed, however the area has experienced a prolonged drought. During drought conditions cacti recede into the ground and become very difficult to distinguish. Mesa Verde cactus were also historically known from about 1 mile south of Sheep Springs adjacent to Highway 666 and in the vicinity of Shiprock and Waterflow, New Mexico (Spellenberg 1978, Knight 1981).

Factors Affecting Species Environment within the Action Area

Colorado Pikeminnow and Razorback Sucker

The San Juan River is a tributary to the Colorado River and drains a basin of approximately 25,000 mi^2 (65,000 km^2) located in Colorado, New Mexico, Utah, and Arizona (Reclamation 2003). From its origins in the San Juan Mountains of southwestern Colorado (at an elevation exceeding 13,943 ft) (4,250 m), the river flows westward through New Mexico, Colorado, and into Lake Powell, Utah. The majority of water that feeds the 345 mi (570 km) of river is from the mountains of Colorado. From a water resources perspective, the area of influence for the proposed project begins at the inflow areas of Navajo Reservoir, and extends west from Navajo Dam approximately 224 mi (359 km) along the San Juan River to Lake Powell. The dam is operated and maintained by Reclamation (Reclamation 2003). The major perennial tributaries in the project area are the Los Pinos, Piedra, Navajo, Animas, La Plata, and Mancos Rivers, and McElmo Creek. There are also numerous ephemeral arroyos and washes that contribute little flow to the San Juan River, but large sediment loads.

As recognized in the Draft Environmental Impact Statement for Navajo Reservoir Operations (Reclamation 2002) (DEIS), changes in biodiversity associated with the historical San Juan River occurred when Navajo Dam was placed into operation. The reservoir physically altered the San Juan River and surrounding terrain and modified the pattern of flows downstream. Similar to rivers downstream of other dam operations in the southwestern United States, the San Juan River downstream of the dam became clearer due to sediment retained in the reservoir, and the water became colder, because it is released from a deep pool of water. The DEIS states that all species of plants and animals that existed along the river channel were affected to varying degrees. The disruption of natural patterns of flow caused changes to the vegetation along the river banks by altering the previously established conditions under which the plants reproduced and survived.

Navajo Dam regulates river flows, provides flood control and contributes to recreational and fishery activities (Reclamation 2002). In addition to the changes caused to the river by dam operations, the DEIS (Reclamation 2002) recognized that there were changes to how the lands in the area were used. Irrigation water provided by Navajo Dam contributed to agriculture being practiced on a large scale. The reservoir stores water for the NIIP (Consultations #2-22-91-F-241, #2-22-92-F-080, and #2-22-99-F-381), the Hammond Irrigation Project, and various municipal and industrial uses making it possible to nearly double the amount of irrigation in the basin. At present, the NIIP diverts an annual average of approximately 160,000 af from the reservoir for irrigation south of Farmington (Reclamation 2002). In the future, this use is expected to approximately double (Reclamation 2002). This will further affect the river and the native species dependent on the river both directly, through flow diversions, and indirectly, through changes in water quality, as a result of the water acquiring salts, pesticides, and fertilizers from the irrigated lands' return flows to the river (Reclamation 2002).

In addition to the effects of operating Navajo Dam, over the last century, the San Juan River has experienced diversions for municipal use, resulting in a variety of return flows to the river, including industrial waste, stormwater runoff, and discharges from sewage treatment plants. Compounding these changes has been the appearance of non-native species of fish and plants, creating competition with native species (Reclamation 2002).

Although there are impacts to the river ecosystem from dam construction itself, dams have many impacts that continue after the structure is complete. Dams affect the physical, chemical, and biological components of a stream ecosystem (Williams and Wolman 1984, Collier et al. 2000, Service 1998, Mueller and Marsh 2002). Some of these effects include a change in water temperature, a reduction in lateral channel migration, channel scouring, blockage of fish passage, transformation of riverine habitat into lake habitat, channel narrowing, changes in the riparian community, diminished peak flows, changes in the timing of high and low flows, and a loss of connectivity between the river and its flood plain (e.g., Sherrard and Erskine 1991, Power et al. 1996, Kondolf 1997, Polzin and Rood 2000, Collier et al. 2000, Shields et al. 2000). Of these, change in water temperature, blockage of fish passage, transformation of riverine habitat into lake habitat, changes in the timing and magnitude of high and low flows, and changes in channel morphology are discussed in greater detail.

Water Temperature

The cold water below Navajo Dam limits the potential spawning habitat of the endangered fishes in the San Juan River. Prior to dam construction water temperatures at Archuleta (approximately 10 km [6.1 mi] below the dam) were above the threshold spawning temperature of 20° C (68° F) for approximately 2 months (Holden 1999). Since dam construction, water temperature is rarely over 15° C (59° F) and is too cold for successful pikeminnow spawning (Holden 1999, Miller, SJRRIP Biology Committee, pers. comm., 2004). The threshold temperatures for spawning at

Shiprock (approximately 125 km [78 mi] below the dam) occur about 2 weeks later on average than pre-dam (Holden 1999). Consequently, spawning is unlikely to occur from Navajo Dam to the confluence of the Animas River (approximately 72 km [45 mi] below the dam) and would be delayed for two weeks or more from the confluence with the Animas River down to Shiprock.

Water temperatures at Shiprock before the construction of Navajo Dam were above 20° C (68° F) from approximately mid-June until mid-September (three months) (Holden 1999). Projected temperatures at Shiprock from 1993-1996, during a portion of the 7-year research period, were above 20° C (68° F) for more than one month (August) (Holden 1999). Because fish are cold-blooded, their metabolism and growth depend on water temperature. The amount of food eaten, assimilation efficiency, and time to sexual maturity are affected by temperature (Lagler et al. 1977). Cold water typically decreases food consumption, decreases assimilation efficiency, decreases growth rate, and increases the time to sexual maturity (Lagler et al. 1977). Development time of pikeminnow and razorback sucker embryos is inversely related to temperature and survival is reduced at temperatures that depart from 20° C (68° F) (Bulkley et al. 1981, Hamman 1982). Marsh (1985) found that for razorback suckers, time to peak hatch was 216 hours (9 days) at 15° C (59° F) and 84 hours (3.5 days) at 25° C (77° F) and that the percent of eggs hatched was highest at 20° C (68° F). All the pikeminnow eggs tested died at incubation temperatures of 15° C (59° F) or lower (Marsh 1985). Marsh (1985) concluded that his results indicated that survival and hatching success were maximized near 20° C (68° F). Reducing the number of days water temperature is near 20°C (68°F) is expected to have a negative impact on the hatching success and growth of razorback sucker and pikeminnow.

Because the combination of a suitable spawning bar (an area of sediment-free cobbles) and suitable temperatures occur downstream on the San Juan (at the Mixer [RM 133.4 to RM 129.8]), there is a greater chance that larval fish will drift into Lake Powell and be lost from the population. Dudley and Platania (2000) found, based on a neutral buoyancy bead study, that drifting larval pikeminnow would be transported from the Mixer to Lake Powell in as little as three days. For those larval fish not carried into Lake Powell, a delay in spawning (which reduces the amount of time YOY have to grow before winter) and overall colder water temperatures (resulting in slower growth) could lead to smaller, less fit YOY, and reduce survival. While this reasoning is biologically sound, because there are so few pikeminnow in the San Juan River, the consequences of lower water temperatures on survival and recruitment of pikeminnow have not been tested for this river. There is speculation that the large volume of cold water in the upper Green River may be a major reason why larval pikeminnow drift so far downstream (Holden 2000). The same pattern may also occur on the San Juan River.

In conclusion, cold water released from Navajo Dam has the following effects on razorback sucker and pikeminnow; water temperatures that were once suitable for spawning for pikeminnow near Archuleta are no longer suitable; and, if spawning were to occur near Shiprock, it would be delayed by approximately 2 weeks compared to pre-dam. A delay in spawning reduces the amount of time that larval fish have to grow before winter.

Blockage of Fish Passage

Like other major dams on the Colorado River and its tributaries, Navajo Dam blocked all fish passage. While native fish once could move unimpeded from the San Juan River into the Colorado River and its tributaries, they are now confined to a relatively short reach of 362 km (225 mi) between Lake Powell and Navajo Dam. If adverse conditions occur (extreme low flow, extreme high flow, unfavorable temperatures or water quality) the fish can not escape or seek refuge in the Colorado River as they once could. Razorback sucker and pikeminnow that may have been trapped above the reservoir have all died or were killed during treatment with rotenone (Olson 1962, Holden 1999). In addition to the major dams, diversion structures constructed in the San Juan River have also created barriers to fish passage.

Ryden and Pfeifer (1993) identified five diversion structures between Farmington, New Mexico, and the Utah state line that potentially acted as barriers to fish passage at certain flows (Cudei, Hogback, Four Corners Power Plant, San Juan Generating Station (PNM weir), and Fruitland Irrigation Canal diversions). When radio telemetry studies were initiated on the San Juan River in 1991, only one radio-tagged pikeminnow was recorded moving upstream past one of the diversions. In 1995, an adult pikeminnow moved above the Cudei Diversion and then returned back downstream (Miller and Ptacek 2000). Other native fish had been found to move either upstream or downstream over all five of the weirs (Buntjer and Brooks 1997, Ryden 2000a). In 2001, Cudei Diversion (RM 142) was removed from the river and Hogback Diversion (previously an earth and gravel berm structure), which had to be rebuilt every year, was made into a permanent structure with non-selective fish passage. Channel catfish that were tagged downstream of the Hogback Diversion in spring and summer 2002 were recaptured upstream of the structure in summer and fall 2002. It is likely that pikeminnow, razorback sucker, and other native fishes can negotiate the ladder. The removal of Cudei Diversion and installation of the fish ladder at Hogback Diversion improved access for native fishes over a 24.5 mile reach of river.

Until 2003, the PNM weir (RM 166) was also a barrier to fish passage. Thanks to funding and technical assistance from the SJRRIP and operation and maintenance by the Navajo Nation, the PNM selective fish ladder was completed and has been operational since 2003. This has allowed passage past that structure by pikeminnow and razorback suckers. Between June and December 2003, 17,394 native fish used the passage including 9 pikeminnow and 4 razorback suckers (LaPahie 2003). However, the Four Corners Power Plant (Arizona Public Service) Diversion at RM 163.3 can act as a fish barrier when the control gate for the structure is closed (Masslich and Holden 1996). Above the PNM weir, at the Fruitland Irrigation Canal Diversion (RM 178.5), model results reported in Evaluation of the Need for Fish Passage (Stamp and Golden, 2005) suggest that the rock dam structure does not significantly hinder fish passage, expect perhaps at very high discharges (8,000 cfs and greater).

Dams have fragmented razorback sucker and pikeminnow habitat throughout the Colorado River system. Within the San Juan River, fish passage was once impeded by five in-stream structures. One of these structures has been removed, two have been equipped with fish passage structures, and two remain as impediments to fish passage for part of the year depending on flow. However, no remaining structures are complete barriers within critical habitat. Pikeminnow and razorback sucker can potentially navigate from Lake Powell, past the Animas River, up to the Hammond Diversion Dam, a total of approximately 338 km (210 mi).

Transformation of Riverine into Lake Habitat

Lake Powell inundated the lower 87 km (54 mi) of the San Juan River and Navajo Reservoir inundated another 43 km (27 mi). The two reservoirs reduced the potential range and habitat for the two endangered fishes from about 523 km (325 mi) to 362 km (225 mi) and inundated potential pikeminnow spawning areas in the upper San Juan River (Holden 2000). Although the loss of habitat is substantial, several other problems for native fishes resulted from the creation of lakes. The larvae of razorback sucker and pikeminnow drift downstream until they find suitable nursery habitat (backwaters or other low velocity areas) (Holden 2000). Because the river has been truncated 87 km (54 mi) on the lower end, there are many fewer stream miles available for nursery habitat. Some pikeminnow in the Green and Colorado River systems drift up to 322 km (200 mi) from spawning areas before finding nursery habitat, while others use nursery areas only a few miles below the spawning areas (Trammell and Chart 1999). The majority of YOY pikeminnow that have been collected in the San Juan River have been at the inflow to Lake Powell (Buntjer et al. 1994, Lashmett 1994, Archer et al. 1995, Platania 1996). Because of the many predators present and lack of suitable habitat, it is unlikely that larvae survive in Lake Powell.

In 1961, prior to the filling of Navajo Dam, New Mexico Department of Game and Fish used rotenone "to eliminate trash fish species" from the Pine River (24 km [15 mi]), the Navajo River (9.6 km [6 mi]), and the San Juan River (120 km [75 mi]) (Olson 1962). Fourteen species of fish were eliminated in the treated section of river (Olson 1962). There were three drip stations on the San Juan River that effectively killed the majority of the fish from the Colorado state line, near Rosa, New Mexico, down to Fruitland, approximately 64 km (40 mi) below Navajo Dam (Olson 1962). Included in the list of fish eliminated was pikeminnow (Olson 1962). The number of fish killed was not recorded because of the large scale of the project (Olson 1962). The intent of the project was to reduce (eliminate) competition and predation between native fish and the non-native trout fishery that was to be established.

Lake Powell is populated by several fish species not native to the Colorado River that are predators on native fish. As mentioned earlier, larval native fish that drift into Lake Powell are almost certainly lost to predation by largemouth bass, smallmouth bass, striped bass, walleye, or crappie (*Pomoxis* sp.). Striped bass migrates up the San Juan River as far upstream as the PNM weir (RM 166) in some years (Davis 2003). Adult striped bass are piscivorous (Moyle 1976). In 2000, 432 striped bass were captured during monitoring trips for pikeminnow and during trips to remove non-native fishes (Davis 2003). The contents of 38 stomachs were analyzed and native suckers were found in 41 percent (Davis 2003). This migratory predator is a threat to both YOY and juvenile native fish.

In conclusion, the transformation of riverine habitat into lake habitat had the following impacts on razorback sucker and pikeminnow:

1) Approximately 128 km (80 mi) of river was inundated and no longer provide suitable habitat for both fish with the exception of adult razorback sucker, which can use portions of Lake Powell (Platania et al. 1991).

2) Nursery habitat for both species was inundated when Lake Powell was created (and filled).

3) The emphasis of fisheries management shifted to game fish production. Consequently riverine habitat that supported native fish, including razorback sucker and pikeminnow, was treated with rotenone (after Navajo Dam was constructed) so that game fish production in the reservoirs could be promoted (Olson 1962, Holden 1991, Quartarone and Young 1995).

4) Non-native game fish were stocked in Lake Powell and Navajo Reservoir. Non-native fish are believed to limit the success of pikeminnow and razorback sucker recruitment and are considered biological threats to the species (McAda and Wydoski 1980, Minckley 1983, Osmundson 1987, Tyus 1987, Ruppert et al. 1993, Bestgen 1997, Bestgen et al. 1997, Service 1998, McAda and Ryel 1999, Muth et al. 2000).

Changes in the Timing and Magnitude of Flows

Typical of rivers in the Southwest, the San Juan was originally characterized by large spring snowmelt peak flows, low summer and winter base flows, and high-magnitude, short-duration summer and fall storm events (Holden 1999). Historically, flows in the San Juan River were highly variable and ranged from a low of 44 cfs in September 1956, to a high of 19,790 cfs in May 1941 (mean monthly values) at the U.S. Geological Survey (USGS) Station gauge near Shiprock, New Mexico. The flows for this period of time do not necessarily represent a "natural" condition because water development began in the basin near the turn of the century and many irrigation projects that diverted and depleted water from the San Juan River were already in place. For the 49 years of record prior to Navajo Dam a peak spring flow greater than 15,200 cfs occurred 13 times (25 percent of the time). The highest spring peak flow recorded (daily mean) was 52,000 cfs (June 30, 1927).

The completion of Navajo Dam in 1962, and subsequent dam operations through 1991, altered the natural hydrograph of the San Juan River substantially (Holden 1999). There was an appreciable reduction in the magnitude, and a change in timing of the annual spring peak. In wet years, dam releases began early to create space in the reservoir to store runoff (Holden 1999). The peak discharge averaged 54 percent of the spring peak of pre-dam years. The highest mean monthly flow was 9,508 cfs (June 1979), a decrease of more than 10,000 cfs compared to pre-dam years. Base flows were substantially elevated in comparison to pre-dam years. The median monthly flow for the base flow months (August-February) averaged 168 percent of the pre-dam period (Holden 1999). Minimum flows were elevated and periods of near-zero flow were eliminated with a minimum monthly flow during base-flow periods of 250 cfs compared to 65 cfs for the pre-dam period (Holden 1999). The hydrograph was flatter during this time period).

During the 1991 to 1997 research period, flows were manipulated by Reclamation in coordination with the SJRRIP to determine fish population and habitat responses when Navajo Dam was operated to mimic a natural hydrograph (Holden 1999). Thanks to Reclamation's flexibility in managing flows and the technical input from the SJRRIP this period of experimental flow manipulations allowed researchers an opportunity to develop flow recommendations. A more natural hydrograph was maintained during this period (1991 to 1997) of experimental flows. The research flow period was more similar to the years that followed (1998 to present) than they were prior to 1991. For this reason, the years from 1991 to present were used to analyze the effects of the Flow Recommendations on physical habitat and endangered fish populations.

Since the Flow Recommendations were published (Holden 1999), Navajo Dam has been operated to meet them. A natural hydrograph has been mimicked, although the pre-Navajo Dam peak magnitudes are no longer possible because of outlet restrictions at the dam. Although higher peak flows could be beneficial in maintenance of desirable channel morphology, it is also possible that because the river is truncated by Lake Powell, higher peak spring flows would carry more larval fish into Lake Powell. The more natural hydrograph created by the Flow Recommendations is an improvement over the pre-1991 hydrograph in that native fish receive the proper cues at the proper times to trigger spawning, more suitable habitat is available at the proper times for young fish, and over time, it is expected that suitable physical habitat characteristics for native fishes will be maintained. Although the magnitude of flows that once existed on the San Juan cannot be duplicated because of the existence of Navajo Dam, the timing of natural peak flows can be closely approximated. The implementation of the Flow Recommendations is an important improvement over the dam operations that were in effect from 1962-1991.

Changes in Channel Morphology

The quantity and timing of flows influence how the channel and various habitats are formed and maintained. It is hypothesized that the channel width during the 1930s was much wider than the historical condition as large amounts of sediment entered the river in response to upland habitat degradation and erosion caused by overgrazing (Holden 1999). Channel narrowing is a problem because as the channel width decreases, water velocity increases, and the amount of low velocity habitats, important to the early life stages of the fish, decreases (Service 1998). Between the 1930s and 1950s the channel narrowed by an average of 29 percent between the present day site of Navajo Dam (RM 224) and River Mile 67 (Holden 1999). From 1930 to 1942, suspended sediment load was approximately 47,200,000 tons/year (Holden 1999). Between 1943 and 1973, suspended load dropped by half to 20,100,000 tons/year (Holden 1999). The 1930s aerial photography shows a sand-loaded system, and where the channel was not confined, the river was broad during high flows and braided during low flows (Holden 1999). Channel narrowing before

1962 was most likely due primarily to the reduction in sediment load. Channel narrowing in later years (after 1962) corresponds to the modification of flows by Navajo Dam and the introduction and encroachment of Russian olive (Holden 1999). Indications are that the trend towards a narrower channel flattened or stopped by 1988 (Bliesner 2004).

Reduced peak flows after Navajo Dam was completed (1962 to 1991) exacerbated the growth of exotic riparian vegetation (primarily salt cedar and Russian olive). These non-native trees armored the channel banks and contributed to the creation of a narrower channel (Bliesner and Lamarra 1994). Modification of flows and non-native vegetation led to more stabilized channel banks, a deeper, narrower main channel, and fewer active secondary channels (Holden 1999).

Since 1992, when a natural hydrograph was mimicked, peak flows have been higher than in the pre-experimental research flow period (prior to 1991). During this period of time, the amount of backwater habitat has decreased in 4 of 6 reaches (Bliesner 2004). However, the base year used to track backwater habitat (1962-1991) may have had an unusually large amount of backwater habitat as a result of several above average wet years (Bliesner 2004). Other low velocity habitat (i.e., pools, eddies), slackwater, and shoal areas have not changed significantly since 1992 (Bliesner 2004). Because backwaters are an important habitat for young native fishes (e.g., young stocked pikeminnow were found in backwaters 60 percent of the time and in other low-velocity habitats nearly 40 percent of the time (Holden 1999)), loss of backwaters remains a concern. The drought and lack of high flows may also be contributing to the short-term loss of backwater habitat that is currently being observed.

Channel complexity is another important component of razorback sucker and pikeminnow habitat. One measure of channel complexity is the number and area of islands present. Between 1950 and 1960 there was a large decrease in island area (Bliesner 2004). Vegetation encroached on the channel and long secondary channels were cut off as the floodplain stabilized. The increase in vegetation during this period coincided with a long-term drought, which contributed to channel simplification (Bliesner 2004). Between 1960 and 1988, island area increased to the historic levels that were present in 1934 (Bliesner 2004). The 10 years prior to 1988 were the wettest on record, so although vegetation continued to increase in the floodplain, the large flows opened secondary channels, creating large islands. During this period, Russian olive invaded the system and spread rapidly (Bliesner 2004). Since 1992, the trend in island area and island number have shown slight (but statistically insignificant) increases in all reaches except for one (Bliesner 2004). At this point, the data indicate that there has been no loss of bank full channel complexity since 1992. The period of monitoring has been short; confirmation of these trends is tentative until there is another hydrologic wet period (Bliesner 2004).

Large flows (bank full and above) are most effective at moving sediment through the system and long duration of high flows appears to maintain backwater and low velocity habitats and assist in maintaining channel complexity. Flows above 8,000 cfs are effective in maintaining backwater habitat, while flows in the range of 5,000 cfs are not (Bliesner 2004). While manipulation of the hydrograph through dam releases can maximize the utilization of available water for habitat maintenance, some periodic swings in the availability of particular habitats are likely to occur in response to natural hydrologic cycles. At current population levels, habitat does not appear to be a limiting factor for either the razorback sucker or pikeminnow adults (Holden 2000). However, the habitat needs of larval fish have not been thoroughly explored and further research may find specific habitat needs that are not being met or that are limiting (Holden 2000).

In conclusion, the trend towards a narrower channel appears to have stopped and although the amount of backwater habitat has decreased, other important low velocity habitats and channel complexity have not changed significantly (Bliesner 2004). Channel morphology has been monitored for a relatively short time and the recent drought and lack of high flows may have an over-riding influence on channel-forming processes. Monitoring over a longer period with the inclusion of wet years and high flows will give a better picture of how the Flow Recommendations are maintaining favorable channel characteristics for the pikeminnow and razorback sucker. However, it appears that suitable channel morphology is being maintained and improved.

Water Quality

In addition to the physical changes from dams and water diversions, and biological changes from introduction of non-native fish, chemical changes have occurred as a result of widespread irrigation and drainwater disposal in the Colorado River Basin (Finger et al. 1995, Thomas et al. 1997, Engberg et al. 1998). Quartarone and Young (1995) interviewed 111 people who recounted numerous experiences from the 1920s to the early 1950s and noted that in the late 1940s and early 1950s, Colorado "whitefish" (as pikeminnow were called at the time) were becoming rare in the upper Colorado River Basin. They believed that this rarity was the result of pollution in the rivers from dumping of raw sewage, railroad oil, and wastewaters.

Surface and groundwater quality in the Animas, La Plata, Mancos, and San Juan River drainages have become significant concerns (Abell 1994). Changes in water quality and contamination of associated biota are known to occur in Reclamation projects in the San Juan drainage (specifically associated with irrigated lands on the Pine and Mancos Rivers) where return flows from irrigation make up a portion of the river flow (Sylvester et al. 1988). Increased loading of the San Juan River and its tributaries with heavy metals; elemental contaminants such as selenium, salts, polycyclic aromatic hydrocarbons (PAHs); and pesticides has degraded water quality of the San Juan River in critical habitat (Abell 1994, Wilson et al. 1995, Simpson and Lusk 1999).

Information on existing water quality in the San Juan River has been derived from data gathered by the U.S. Department of the Interior (DOI) as part of its National Irrigation Water Quality Program investigation of the San Juan River area in Colorado, New Mexico, and Utah; results from Reclamation's water quality data for the Animas-La Plata Project; and ongoing contaminant monitoring and research conducted as part of the SJRRIP. Some of this information has been presented in Blanchard et al. (1993), Abell (1994), Wilson et al. (1995), Thomas et al. (1998), and other references cited in Simpson and Lusk (1999). Thomas et al. (1998) found that concentrations of most potentially toxic elements analyzed from the San Juan River drainage in their study, other than selenium, were generally not high enough to be of concern to fish, wildlife, or humans.

PAHs are compounds that may reach aquatic environments in domestic and industrial sewage effluents, in surface runoff from land, from deposition of airborne particulates, and particularly from spillage of petroleum and petroleum products into water bodies (Eisler 1989). Wilson et al. (1995) reported that concentrations of PAHs were elevated in the Animas River, but no identification of source location or activity has been made. The San Juan River below Montezuma Creek also had elevated levels of PAHs; and seasonal increases in PAH concentrations were detected in the Mixer area of the river (a potential spawning site for pikeminnow). PAH levels in the bile of common carp and channel catfish sampled were high in one fish and moderate in several other fish from the San Juan River. The presence of PAH metabolites in bile of every fish sampled suggested some level of exposure to hydrocarbons (Wilson et al. 1995). Service analyses of PAH contamination of aquatic biota of the San Juan River, and liver tissue examinations of fish in the river, raised concerns regarding the exposure of these organisms to contaminants introduced into the basin. However, PAHs do not appear to be a limiting factor to native fishes in the San Juan at this time (Holden 2000).

Selenium (a trace element) occurs naturally in many soil types, and is abundant in the drier soils of the West. Selenium enters surface waters through erosion, leaching and runoff. Sources of selenium, both anthropogenic and natural, in the San Juan River, have been reported by O'Brien (1987), Blanchard et al. (1993), and Thomas et al. (1998). Selenium, although required in the diet of fish at very low concentrations (less than 0.5 micrograms per gram on a dry weight basis (μg/g), is toxic at higher levels (> 3 μg/g), and may be adversely affecting endangered fish in the upper Colorado River Basin (Hamilton 1999). Excess dietary selenium causes elevated concentrations of selenium to be deposited into developing eggs, particularly the yolk (Buhl and Hamilton 2000). If concentrations in the egg are sufficiently high, developing proteins and enzymes become dysfunctional and lead to deformed embryos that may be at higher risk for mortality.

Selenium concentrations in the San Juan River Basin are of concern because of its documented effects on fish and wildlife reproduction and survival and high levels detected in some locations within the basin (Blanchard et al. 1993, Wilson et al. 1995, Thomas et al. 1998). Selenium concentrations can be elevated in areas where irrigation occurs on soils which are derived from or which overlie Upper Cretaceous marine sediments. Thomas et al. (1998) found that water samples from DOI project irrigation-drainage sites developed on Cretaceous soils contained a mean selenium concentration about 10 times greater than those in samples from DOI project sites developed on non-Cretaceous soils. Percolation of irrigation water through these soils and sediments leaches selenium into receiving waters. Other sources of selenium include power plant fly ash and oil refineries. Water depletions, by reducing dilution effects, can increase the concentrations of selenium and other contaminants in water, sediments, and biota (Osmundson et al. 2000).

Tributaries to the San Juan River carry higher concentrations of selenium than found in the main stem river immediately upstream from their confluence with the San Juan River. Increased selenium concentrations may also result from the introduction of ground water to the main stem of the river along its course. Although these levels are diluted by the flow of the San Juan River, the net effect is a gradual accumulation of the element in the river as it travels downstream. For example, concentrations of selenium in water samples collected from the main stem of the San Juan River exhibited a general increase in maximum recorded values with distance downstream from Archuleta, New Mexico, to Bluff, Utah, (less than 1 μg/L [micrograms per liter] to 4 μg/L) (Wilson et al. 1995). The safe levels of selenium concentrations for protection of fish and wildlife in water are considered to be less than 2 μg/L and toxic levels are considered to be greater than 2.7 μg/L (Lemly 1993, Maier and Knight 1994, Wilson et al. 1995). However, dietary selenium is the primary source for selenium in fish (Lemly 1993, Buhl and Hamilton 1995). Thus, sediment and biotic analyses are necessary to understand the risk of selenium to fish and wildlife.

The SJRRIP arranged for toxicity tests to be conducted to determine the effects of environmental contaminants in water (Hamilton and Buhl 1995), and in diet and tissues of the razorback sucker and pikeminnow in the San Juan River. The waterborne toxicity tests showed a potential threat to endangered fishes from waterborne concentrations of copper and contaminant mixtures created to simulate the water quality conditions of two irrigation drains (Hamilton and Buhl 1995, 1997). However, the results of the dietary toxicity tests showed that dietary selenium (as opposed to water borne selenium) was the primary source of selenium accumulation in pikeminnow, accumulated selenium left the tissues slowly after exposure ended, and the selenium concentrations in eggs were significantly greater than concentrations in the parent (Buhl and Hamilton 2000). However, the concentrations in the eggs (9.8-11.6 μg/gram) were lower than those in eggs linked with reproductive impairment in fish (Buhl and Hamilton 2000). Unfortunately, due to small sample size, the reproductive metrics (number of eggs expressed, egg weight, hatchability, time to hatch, and survival, growth, and deformities of the larvae) could not be statistically evaluated in this study (Buhl and Hamilton 2000).

Quartarone and Young (1995) suggested that irrigation and pollution were contributing factors to razorback sucker and pikeminnow population declines, and Hamilton (1999) hypothesized that historic selenium contamination of the upper and lower Colorado River Basins contributed to the decline of these endangered fish by affecting their overall reproductive success. However, because riverine systems are open systems where concentrations can vary considerably over time in relation to flow (as opposed to a closed system like a lake where concentrations tend to remain steady or increase), and because results from the 7-year research period were inconclusive, selenium concentrations are not currently seen as a limiting factor to native fishes in the San Juan River (Holden 2000). However, as recovery of the pikeminnow and razorback sucker proceeds, research should continue on this issue. These fish can live over 40 years (Behnke and Benson 1983), increasing their susceptibility to bioaccumulation of selenium. In addition, they often stage at tributary mouths such as the Mancos River before spawning, increasing their exposure to elevated levels of dietary selenium (Wilson et al. 1995). Therefore, the impact of selenium on reproductive success may become more important in coming years as adults survive and age in the river.

From 1998 to 2005 the SJRRIP annually monitored water quality constituents. Trends of the constituents with time were examined by linear correlation. There were no statistically significant trends for this data set. During the drought years in the latter part of the record there was a slight elevation in TDS and the associated constituents due to reduced flows and increased percentage of return flow during the late summer. However, the water quality remains good even during these drought times.

Selenium concentrations remain low in the mainstem, with most readings below detection. Looking at the trend with time from 1994 to 2003, there appear to be fewer detectable readings, and those readings tend to be smaller. There is an increasing trend of detectable readings down river as more tributary flow enters the system, but this has not increased with time. With the exception of the measurement of 9 ppb total recoverable selenium at Mexican Hat, the maximum concentration measured in the San Juan River during the 1994 to 2003 period is 2 ppb, with most of the detectable readings at 1 ppb, the detection limit. The water quality standard exceedences do not appear to be a result of implementation of the flow recommendations and there is no trend with time.

As a result of the lack of statistically significant trend data, the SJRRIP discontinued annually monitoring of water quality constituents in 2005 and has recommended conducting toxicity tests every five years to determine the effects of environmental contaminants in water, and in diet and tissues of the razorback sucker and pikeminnow in the San Juan River.

Propagation and Stocking

Colorado Pikeminnow.—Because of the extremely low numbers of wild pikeminnow and poor recruitment into the population, a stocking program was initiated to augment pikeminnow numbers. Experimental stocking of 100,000 YOY pikeminnow was conducted in November 1996, to test habitat suitability and quality for young life stages (Lentsch et al. 1996). Monitoring in late 1996 and 1997, found these fish scattered in suitable habitats from just below the upstream stocking site at Shiprock, New Mexico, to Lake Powell. During the fall of 1997, the fish stocked in 1996 were caught in relatively high numbers and exhibited good growth and survival rates (Holden and Masslich 1997). In August 1997, an additional 100,000 YOY pikeminnow were stocked in the river. In October 1997, the YOY stocked two months previously were found distributed below stocking sites and in relatively large numbers nearly 10 miles above the Shiprock stocking location. The 1997 stocked fish were smaller in size than those stocked in 1996, but apparently could move about the river to find suitable habitats (Holden and Masslich 1997).

In July 1998, 10,571 YOY pikeminnow were stocked at Shiprock but only one was found through March 1999, in the lower San Juan River (Archer et al. 2000). In July 1999, 500,000 larval pikeminnow were stocked just below Hogback Diversion (RM 158.6). The larvae were found 157 miles below the stocking site 62 hours later and were never recaptured again. High flows in 1999, likely washed them into Lake Powell (Jackson 2001). In June 2000, 105,000 larvae were stocked just below Cudei Diversion (RM 142). Despite more normal flows in 2000, only four larvae were found and three had floated 64 miles downstream two days after stocking (Jackson 2001). No larvae stocked in 2000 were found during a sampling trip four weeks later, but a pikeminnow fitting the size class of the 1999 stocking was found. During an October 2000 sampling trip three pikeminnow that were likely stocked in 1999, were captured but, again, no larvae stocked in 2000 were found (Jackson 2001). In October 2002 approximately 210,418 age-0 pikeminnow were stocked, half at RM 180.2 and half at RM 158.6. In November 2003 another 176,933 age-0 and age-1 were stocked at numerous sites between RM 188 and RM 148 (Ryden 2005). In 2004, 280,000 age-0 pikeminnow were stocked in numerous low-velocity habitats from RM 188 to RM 148 (Ryden 2005a). In 2005, 302,270 age-0 pikeminnow were stocked in numerous low-velocity habitats from RM 188 to RM 148 (Ryden, Service, in litt. 2006).

Forty-nine pikeminnow adults were stocked at the Highway 371 bridge (RM 180.2) in 1997; however, these fish did not remain in the reach of river above the PNM weir (RM 166.6) for more than a few months (Miller and Ptacek 2000). In 2001, 148 adult pikeminnow were stocked at RM 180.2. These fish went below PNM weir shortly thereafter, but 7 of these adults used the PNM fish ladder in 2003 (Ryden 2005). In 2002, there were 39 total recapture events with pikeminnow during all field studies; 36 of these 39 recapture events were with fish stocked as adults in April 2001 (Ryden 2003b). In 2003, 1,005 age-1 pikeminnow were stocked at RM 180.2 (Ryden 2005). In 2003, 32 juvenile pikeminnow were collected during adult monitoring; these fish had been stocked as juveniles in October 2002 (Ryden 2005). In 2004, 1,219 age-2 pikeminnow were stocked at RM 180.2 (Ryden 2005). In 2004, 159 juvenile pikeminnow were collected during adult monitoring; the majority of these fish had been stocked as age-0 juveniles in either fall 2002 or fall 2003, although some of the fish that were originally stocked as older age-classes were recaptured as well (Ryden 2005). In 2005, 500 age-1 and 4,041 age-2 pikeminnow were stocked at RM 180.2 (Ryden, Service, in litt. 2006). In 2006, a total of 127 juvenile pikeminnow were collected during adult monitoring (Ryden, Service, in litt. 2006). As in previous years, the majority of these fish had been stocked as age-0 juveniles in either fall 2003 or fall 2004, although some of the fish that were originally stocked as older age-classes were recaptured as well. Very few fish that had been stocked as age-0 juveniles in the fall of 2002 were recaptured during the 2005 adult monitoring trip. Survival of the fall 2002 stocking of age-0 fish does not appear to have been very good through age-3 (i.e., 2005) (Ryden, Service, in litt. 2006). Between 1996 and 2005, over 1,800,000 pikeminnow of varying age-classes have been stocked into the San Juan River (Ryden, Service, in litt. 2006).

Because of human impacts to the Colorado and San Juan Rivers, pikeminnow was thought to be extirpated from the San Juan River (Tyus et al. 1982). Surveys conducted from 1987-1989 revealed that pikeminnow was still present in the San Juan River, but in very low numbers (Platania et al. 1991). When the SJRRIP was established in 1992, one of the program elements was the protection of genetic integrity, management, and augmentation of populations of the endangered fish. Pikeminnow have been stocked every year since 1996 (Ryden 2003a) and in 2005 a total of 306,811 fish were stocked, meeting the augmentation plan target for the first time. Pikeminnow from a wide range of size-classes were captured in the San Juan in 2004 and 2005, indicating that there has been survival from numerous years' stockings (Ryden 2005, Ryden, Service, in litt. 2006). In addition, the catch per unit effort for pikeminnow in 2004 was the highest recorded since river-wide sampling began in 1996 (Ryden 2005). The SJRRIPs augmentation program has been successful in increasing the number of pikeminnow in the San Juan River in a relatively short time, increasing the number of fish much faster than if augmentation had not taken place.

Razorback Sucker.—Although evidence suggests that razorback suckers were once abundant in the San Juan River at least up to the confluence with the Animas River (Platania and Young 1989), wild razorback suckers, if they still exist, are extremely rare in the river. Even with intensive sampling only one adult was captured in the river from 1987- 1989, and 292 collections of larval fish during that same time recovered no razorback sucker (Platania et al. 1991). Because of the limited number of razorback sucker and the lack of recruitment, a stocking program was begun to supplement the population. Between 1994 and 2005, a total of 12,843 hatchery and pond raised razorback suckers were stocked into the San Juan River (Ryden, Service, in litt. 2006).

Fish that were stocked in 1994 and 1995 are still being collected during annual sampling (Ryden 2001, Ryden, Service, in litt. 2006). Larval razorback suckers have been collected each year since 1998, indicating that the stocked fish are successfully spawning in the San Juan River (Brandenburg et al. 2003, Brandenburg and Farrington 2005, Brandenburg et al., in litt. 2006). Despite the small number of stocked fish, many stocked razorback sucker recruited to adulthood and successful spawning by these fish has been recorded every year since 1998 (Ryden 2003b, Brandenburg and Farrington 2005). In addition, the catch per unit effort for razorback sucker in 2004 was higher than in any previous year (Ryden 2005). The augmentation program has been successful in increasing the number of razorback sucker in the San Juan River in a relatively short time, increasing the number of fish much faster than if augmentation had not taken place.

In March 1994, 15 radio-tagged razorback suckers were stocked in the San Juan River at Bluff, Utah (RM 79.6); near Four Corners Bridge (RM 117.5); and above the Mixer in New Mexico (RM 136.6). In October 1994, an additional 16 radio-tagged adults and 656 PIT-tagged fish were stocked in the same locations and at an additional site just below the Hogback Diversion in New Mexico (RM 158.5). Monitoring found that these razorback suckers used slow or slackwater habitats such as eddies, pools, backwaters, and shoals in March and April, and fast water 92.2 percent of the time in June and August (Ryden and Pfeifer 1995b). During 1995, both radio-tagged fish and PIT-tagged fish were contacted or captured. Razorback suckers were found in small numbers from the Hogback Diversion (RM 158.6) to 38.1 river miles above Lake Powell. In September 1995 and October 1996, 16 and 237 razorback suckers were stocked, respectively. Results of the monitoring efforts indicated that the San Juan River provides suitable habitat to support subadult and adult razorback sucker on a year-round basis (Ryden and Pfeifer 1996). This led the SJRRIP to initiate a 5-year augmentation program for the razorback sucker in 1997 (Ryden 1997). Between September 1997, and November 2001, 5,896 subadult razorback sucker were stocked below Hogback Diversion Dam. An additional 25 subadults were stocked in 2002 (Service, unpubl. data). As of 2001, about 2 percent of the fish stocked from 1994 to 2001 were recaptured and 40 adult or subadult razorback suckers were recaptured in 2002 (Service, unpubl. data). In 2002, 62 razorback suckers were collected, all were stocked fish (Ryden 2003b).

Five razorback sucker spawning aggregations have been identified at various river locations. These aggregations occurred at RM 100.2 in 1997, 1999, and 2001 (Ryden 2004), at RM 17.6 in 2002 (Jackson 2003, Ryden 2004) and at RM 154.27 in 2004 (Ryden 2005). Collection of larval razorback sucker for eight consecutive years (1998 – 2005) indicates that even though groups of spawning adults were not observed every year, spawning did occur.

Water Depletions

Significant depletions and redistribution of flows of the San Juan River have occurred as a result of other major water development projects, including the NIIP and the San Juan-Chama Project. At the current level of development, average annual flows at Bluff, Utah, already have been depleted by 30 percent (Holden 1999). By comparison, the Green and Colorado Rivers have been depleted approximately 20 percent (at Green River) and 32 percent (at Cisco), respectively (Holden 1999). These depletions have likely contributed to the decline in pikeminnow and razorback sucker populations (Service 1998). Depletions are expected to increase as full development of water rights and water projects occurs. To the extent that water is exported out of the basin (San Juan-Chama Project) or consumptively used (e.g., evaporation from fields, irrigation canals, reservoir surface) it is not available to maintain flows within the river. Maintenance of streamflow is essential to the ecological integrity of large western rivers (Service 1998).

Water depletion projects that were in existence prior to November 1, 1992, are considered to be historic depletions because they occurred before the initiation of the SJRRIP. Projects that began after this date are considered new projects. On May 21, 1999 the Service issued a BO (R2/ES-TE CL 04-054) determining that new depletions of 100 af or less, up to a cumulative total of 3,000 af, would not: 1) Limit the provision of flows identified for the recovery of the pikeminnow and razorback sucker, 2) be likely to jeopardize the endangered fish species, or 3) result in the destruction or adverse modification of their critical habitat. Consequently, any new depletions under 100 af, up to a cumulative total of 3,000 af, may be incorporated under the May 21, 1999, BO, but would still require consultation.

Consultations contributing to the baseline conditions used reoperation of Navajo Reservoir in accordance with the Flow Recommendations as part of their section 7 compliance. Some of these projects have been completed (e.g., PNM Water Contract with Jicarilla Apache Nation), some are partially complete (e.g., NIIP), and some have not been fully implemented (e.g., Animas-La Plata Project). As these projects are fully implemented, the amount of water available for operational flexibility will decrease.

Diversion Structures

There are numerous points of diversion on the San Juan River for irrigation and energy production. In addition to acting as fish passage impediments (as discussed earlier), most of these structures do not have screens or other devices to prevent fish from entering (Holden 2000). Although anecdotal, Quartarone and Young (1995) present many stories from senior citizens that recalled seeing or catching razorback suckers from irrigation ditches, sometimes in very large numbers. Trammell (2000) reported that after stocking 500,000 larval pikeminnow below Hogback Diversion structure, 63 larvae were collected from the Cudei Diversion canal. This number represented 0.013 percent of the total stocked. Catch rate was 4.39 pikeminnow/100 m^3 of water sampled.

In December 2004, 140 pikeminnow in 3 size classes were caught in the Hogback Diversion (Platania and Renfro 2005). Most of the individuals (92 percent) were between 33-65 mm standard length (SL) (1.3-2.5 in) that had been stocked in October 2004. Seven were between 130-187 mm SL (5.1-7.4 in) and 4 were 210-264 mm SL (8.3-10.4 in) (Platania and Renfro 2005). Pikeminnow were caught from 0.5 to 17.8 canal miles from the diversion structure (Platania and Renfro 2005). In 2005, recently-stocked pikeminnow were captured in the Hogback and Fruitland Diversion canals.

Pikeminnow that enter diversion structures face an uncertain fate, although fish may find their way back to the river. Because the number of fish entrained at diversion structures is unknown the SJRRIP is analyzing entrainment at all of the diversion structures. Diversions that entrain fish will be addressed by the SJRRIP. Razorback suckers are not currently found high enough in the system to enter the diversion structures.

Non-Native Fish

Nearly 70 non-native fish species have been introduced into the Colorado River system over the last 100 years (Service 1998). Non-native fish in the San Juan River include rainbow trout (*Oncorhynchus gairdneri*), brown trout (*Salmo trutta*), striped bass, walleye, channel catfish, black bullhead, yellow bullhead, largemouth bass, smallmouth bass, green sunfish, long-ear sunfish (*Lepomis megalotis*), bluegill, white crappie, fathead minnow, red shiner, Western mosquitofish, common carp, white sucker, white sucker x flannelmouth sucker hybrids, white sucker x bluehead sucker hybrids, threadfin shad, grass carp, and plains killifish (Ryden 2000 Buntjer 2003). Channel catfish was first introduced in the upper Colorado River Basin in 1892 (Tyus and Nikirk 1990) and is thought to have the greatest adverse effect on endangered fishes due to predation on juveniles and resource overlap with subadults and adults (Hawkins and Nesler 1991, Lentsch et al. 1996, Tyus and Saunders 1996). Adult and juvenile pikeminnow that have preyed on channel catfish and black bullhead have died from choking on the pectoral spines (McAda 1983, Pimental et al. 1985, Quartarone and Young 1995, SJRRIP 2003b, Laphie 2003). Mechanical removal of non-native fish (seining and electrofishing) from the San Juan River began in 1995, but was not instituted as a management tool until 1998 (Smith and Brooks 2000).

Removal efforts have focused on channel catfish and common carp because they are the most abundant large-bodied non-native fishes and are known predators on native fish and eggs (Davis 2003).

For more than 50 years, researchers have been concerned that non-native fishes have contributed to the decline of native fishes in the Colorado River Basin (Service 1989). Non-native species are potential predators, competitors and vectors for parasites and disease (Tyus et al. 1982, Lentsch et al. 1996, Pacey and Marsh 1999, Marsh et al. 2001). Because non-native fish are considered to be an important biological threat to pikeminnow and razorback sucker, control of non-native fishes through removal has become part of the SJRRIP. Recent adult monitoring reports show evidence that the nonnative fish removal efforts are having a marked and measurable effect on the channel catfish and common carp populations in the San Juan River (Ryden 2005, Ryden, Service, in litt. 2006). There is also an upward trend in both abundance and longitudinal distribution among both flannelmouth sucker and bluehead sucker that corresponds with the intensive nonnative fish removal efforts which began in 2001 (RM 166.6 – 147.9) and (RM 52.9 – 2.9).

From 1998-2005, 32,367 channel catfish and 16,335 common carp were removed from the river (Davis 2005). Catch rates did not decrease for either species. For channel catfish, both adult and juvenile size classes saw general, although not significant, declines in 2005 (Davis 2005). The advantages of reducing the mean length of channel catfish is that they are not thought to be piscivorous until they reach a length of about 450 mm (17.7 in), and fecundity (number of eggs) is much greater in larger fish (Davis 2005). An increase in the number of smaller fish could potentially lead to an increase in competitive or aggressive interactions with native fish. However, it is expected that continued removal efforts will eventually reduce the numbers of smaller channel catfish as well (Davis 2005).

The primary method used to capture large-bodied non-native species is electrofishing. In 1999, one, three-day trip was made and non-natives were removed from Hogback diversion structure to the PNM weir. In 2000, two trips were made and in 2001 and 2002, 10 trips were made each year to this same section. In 2003, non-natives were removed from a second reach, RM 166.6 down to Shiprock (RM 148). During non-native fish removal, razorback sucker and pikeminnow are also shocked and captured. Electrofishing has been shown to have negative effects on trout (Kocovsky et al. 1997, Nielsen 1998). While no direct mortality has been documented, there could be adverse effects to pikeminnow and razorback sucker from repeated shocking and handling.

Mesa Verde Cactus

Numerous commercial activities are occurring within Mesa Verde cactus habitat. Oil, gas, and coal resources are all being developed in the area. Associated development includes roads, pipelines, powerlines, and expanding commercial and residential development. Road realignments and upgrades to serve rural communities in the vicinity of Shiprock have impacted

Mesa Verde cactus. The installation of new water pipelines to serve rural customers has also impacted some plants and habitat. The growth of Shiprock, New Mexico, oil and gas development, and off-road vehicle (ORV) use threaten populations of the Mesa Verde cactus (NMRPTC 1999).

The sparsely vegetated rolling hills occupied by Mesa Verde cactus are attractive to ORV enthusiasts. The potential for ORV impacts is greatest near towns. Mesa Verde cactus populations that occur in the suburban fringes of Farmington and Shiprock have been impacted by ORVs in the past, and this threat continues.

Mesa Verde cactus is a rare species attractive to some cactus enthusiasts. Because of its specialized soil requirements, it is difficult to grow in cultivation and, therefore, not readily available from legitimate commercial sources as are many other endangered cacti. Illegal collecting was observed during the 1995 monitoring study and several instances of suspected illegal collecting have been reported (New Mexico Forestry Division 1995). The overall impact of illegal collecting is probably minor, but it can be significant in populations that are known to collectors and visited repeatedly.

Livestock impacts to Mesa Verde cactus are from the result of trampling. There is little available forage in Mesa Verde cactus habitat so livestock numbers are usually low. There have been some reports of livestock trampling in monitoring plots, but this is considered a minor threat.

Impacts to Mesa Verde cactus populations from predation or disease can be significant. A species of moth lays its eggs on Mesa Verde cactus plants and the larvae burrow into the interior. Plants then rot and die (Service 1984). Between 2001 and 2002, Mesa Verde cactus populations exhibited population declines in response to predation from the longhorn cactus beetle (*Moneilema semipunctatum*), a native predator of cacti (New Mexico State Forestry Division 2003). Mesa Verde cactus population plots on BLM lands near Waterflow, New Mexico had mortality rates of 68.5 and 97.1 percent (New Mexico State Forestry Division 2003). Similar declines were noted in 2003 on the Navajo Nation in New Mexico and the Ute Mountain Ute Reservation in Colorado (Daniela Roth, Navajo Natural Heritage Program, pers. comm.). Increased beetle predation may have been a natural response to high cactus density in the population plots, and might not have been correlated with drought conditions (New Mexico State Forestry Division 2003). These predators may explain the scattered distribution of Mesa Verde cactus because dense populations of plants would be more susceptible to attack than scattered individuals. These threats as well as past and present projects contribute to the environmental baseline of the cactus.

Effects of the Action

'Effects of the action' means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). If the proposed action includes offsite measures to reduce net adverse impacts by improving habitat conditions and survival, the Service will evaluate the net combined effects of the proposed action and the offsite measures as interrelated actions.

'Interrelated actions' are those that are part of a larger action and depend on the larger action for their justification; 'interdependent actions' are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Future Federal actions that are not a direct effect of the action under consideration, and not included in the environmental baseline or treated as indirect effects, are not considered in this BO.

Effects to Endangered Species

Colorado Pikeminnow and Razorback Sucker

Entrainment of Larval Fish

Colorado Pikeminnow.—The project will adversely affect future recruitment of pikeminnow spawning above the proposed intake (RM 167). While no spawning sites have been documented above the proposed diversion, the quality of gravel bars suggests spawning potential between the diversion and RM 180 (Bliesner 2003). Spawning has been documented between RM 129.8 and RM 133.4 (Ryden 2000a), while drift data suggest spawning likely occurred at a location somewhat downstream of RM 128 (Platania et al. 2000). Given the known range of spawning, the availability of spawning habitat above the diversion and a relatively uniform distribution of available spawning habitat between RM 128 and RM 180, about 25 percent of pikeminnow spawning activity could occur above the proposed intake at some point in the future (13 of 52 miles above the diversion). If spawning habitat below RM 128 exists as the drift data suggests, then something less than 25 percent of the spawn would be above the diversion.

Based on spawning dates in the San Juan River, larvae typically enter the drift from mid-July to mid-August (Platania et al. 2000) and are passive in the drift for 3 to 6 days after emergence (Dudley and Platania 2000). Therefore, larval pikeminnow spawned above the diversion would be subject to entrainment in the fish screen for about 35 to 40 days. Flows during peak pikeminnow larvae drift average about 1,500 cfs at the Farmington gage (1993-2003; USGS 2003). The proposed intake will divert about 4 percent (59 cfs) of the total river flow during this time frame. Larval pikeminnow will not be excluded by a 3/32 inch screen (Platania et al. 2000). Thus, we estimate that about 4 percent of larvae spawned above the intake will be subject to entrainment. Since only 25 percent or less of the spawn is expected above the diversion, the net loss is expected to be approximately 1 percent of all pikeminnow larvae produced in the San Juan River.

There are no additional measures that could be used to minimize take from this diversion. While no spawning sites have been documented above the proposed diversion, the net loss of pikeminnow larvae is expected to be approximately 1 percent of all pikeminnow larvae produced in the San Juan River once a viable pikeminnow population is reestablished. Because the SJJRIP will continue to augment the establishment of a viable pikeminnow population, the take of 1 percent of all pikeminnow larvae produced in the San Juan River is expected to be diminished during reestablishment. After a viable pikeminnow population is reestablished, the take of 1 percent of all pikeminnow larvae produced in the San Juan River is expected to be diminimiss and the level of anticipated take is not likely to result in jeopardy to pikeminnow.

Razorback Sucker.—The razorback sucker will be adversely affected by the NGWSP due to the possibility of entrainment of larval fish during spawning. Spawning typically occurs on the ascending limb of the hydrograph during May (Brandenburg et al. 2004). With an assumed potential spawning range between RM 100 to RM 180 and a uniform distribution of spawning adults in the future, about 16 percent of the larval drift would occur above the diversion. During May the flow averages about 4,100 cfs of which 59 cfs or 1.4 percent enters the NGWSP diversion. Therefore, not more than 0.2 percent of the non-retained drifting larvae would be subject to entrainment in the diversion.

There are no additional measures that could be used to minimize take from this diversion. While no spawning sites have been documented above the proposed diversion, the net loss of razorback sucker larvae is expected to be approximately 0.2 percent of all razorback sucker larvae produced in the San Juan River once a viable razorback sucker population is reestablished. Because the SJJRIP will continue to augment the establishment of a viable razorback sucker population, the take of 0.2 percent of all razorback sucker larvae produced in the San Juan River is expected to be diminimiss during reestablishment. After a viable razorback sucker population is reestablished, the take of 0.2 percent of all razorback sucker larvae produced in the San Juan River is expected to be diminimiss and the level of anticipated take is not likely to result in jeopardy to razorback sucker.

Water Quality

Water quality changes will be undetectable because project withdrawals will only reduce minimum flow by less than 0.5 percent on average with the greatest impact being less than 3 percent (Reclamation 2002). Return flow from all sources accounts for about 10 percent of the flow of the river during base flow periods. Most constituents are concentrated about 4 fold in return flow through evaporative losses so the increase in water quality constituent concentrations below the diversion due to withdrawal will be about 0.9 percent, with a similar reduction in concentrations above that location due to increased flow. Return flow at Shiprock will be through the Shiprock treatment plant, meeting the requirements of the NPDES permit, with an average annual flow of 5.0 cfs (1 percent of the minimum flow). During runoff months, flows are slightly increased, so water contaminant concentrations in the water will decrease. The net increase in any water quality parameter will be less than 2 percent. The Biological Assessment for the NIIP (Keller-Bliesner Engineering, 1999) concluded that the water quality risk to the endangered species was low for all parameters. Because the increase in water quality constituents will be undetectable, the effect to pikeminnow and razorback sucker will be insignificant and discountable.

Depletions
The project would reduce the amount of water in the river system by 5,271 af /year. The effects to pikeminnow and razorback sucker would result from the effects of the action upon their habitats. In general, the SJRRIP determined that mimicry of a natural hydrograph would create, maintain, and maximize key habitats, and that it could be accomplished through reoperating Navajo Dam. The Flow Recommendations (Holden 1999) were developed by the SJRRIP to address this directly and the Flow Report (Holden 1999) is the primary source of information concerning the research and management actions taken to meet accomplish this.

The SJRRIP determined that to maximize key habitats for native fishes, flows in the San Juan River needed to more closely match a natural hydrograph in magnitude, duration, and timing than they had since Navajo Dam's completion. High spring flows were a natural San Juan River characteristic and a characteristic that is needed to create and maintain key habitats for the endangered and native species. The life histories of the endangered species are closely tied to the magnitude, duration, and timing of the natural hydrograph. Habitat for spawning and rearing young, although very different for the two endangered species is expected to improve and be maximized with a relatively natural annual hydrograph. To meet this need, the Flow Recommendations provided increased spring peak magnitude and duration, while maintaining timing more similar to pre-dam conditions than to post-dam flows. Base flows were also altered to resemble the magnitude and timing of pre-dam conditions.

To the extent that the proposed diversion would reduce flows and contribute to further habitat alteration, the depletion was modeled using the San Juan River Basin Riverware model to determine its effect on the Flow Recommendations developed by the SJRRIP Biology Committee for the recovery of the listed fish species. The modeled results show that the depletion will prevent the flow recommendations from being met less than 0.01 percent of the time for 2,500 cfs criteria of recommended discharges. Which means the 2,500 cfs criteria will be missed by about 12 percent for three days in one year out of the 65 year analysis period. All other flow recommendations are fully met, including base flow requirements and runoff flow statistics. While base flows are slightly reduced from baseline conditions (less than 3 percent in any month and less than 0.5 percent average), minimum flow requirements and runoff flow statistics of the flow recommendations are met. Baseline flows upstream of the PNM weir will be increased with return flows from the project (Table 5).

Because the Integration Report found that the flows at 5,000 cfs and 2,500 cfs are not causing the expected response (Miller 2005), minor effects to these flows are not expected to have a measurable adverse effect for the endangered fish or their designated critical habitat and will not preclude recovery of the species.

Table 5.—Summary Flow Statistics for the NGWSP plus Baseline with NIIP Equilibrium Depletion Limited to 249,218 Acre-Feet

	Discharge (cfs)			
Duration	>10,000	>8,000	>5,000	>2,500
	Average Frequency			
1 days	33.8%	55.4%	73.8%	95.4%
5 days	27.7%	46.2%	70.8%	86.2%
10 days	15.4%	38.5%	66.2%	78.5%
15 days	7.7%	30.8%	60.0%	73.8%
20 days		24.6%		69.2%
21 days			55.4%	
30 days		13.8%	41.5%	66.2%
40 days			32.3%	55.4%
50 days			26.2%	47.7%
60 days			18.5%	41.5%
80 days			10.8%	27.7%

Maximum Years Without Meeting Criteria

Flow Criteria - Max Duration	Allowed	Modeled
9700 cfs for 5-days – 10-years	10	10
7760 cfs for 10-days – 6-years	6	6
4850 cfs for 21-days – 4-years	4	4
2450 cfs for 10-days – 2 years	2	3

Effects to Pikeminnow and Razorback Sucker Critical Habitat

Water Quantity

The proposed action will result in an increase in depletions in the San Juan River of not more than 5,271 af /year over the environmental baseline but does not impact the ability for the San Juan River Flow Recommendations to be met.

The SJRRIP determined that mimicry of a natural hydrograph would create, maintain, and maximize key habitats, and that it could be accomplished through reoperating Navajo Dam. The

Flow Recommendations (Holden 1999) were developed by the SJRRIP to address this directly and the Flow Report (Holden 1999) is the primary source of information concerning the research and management actions taken to meet accomplish this.

The SJRRIP determined that to maximize key habitats for native fishes, flows in the San Juan River needed to more-closely match a natural hydrograph in magnitude, duration, and timing than they had since Navajo Dam's completion. High spring flows were a natural San Juan River characteristic and a characteristic that is needed to create and maintain key habitats for the endangered and native species. The life histories of the endangered species are closely tied to the magnitude, duration, and timing of the natural hydrograph. Habitat for spawning and rearing young, although very different for the two endangered species is expected to improve and be maximized with a relatively natural annual hydrograph. To meet this need, the Flow Recommendations provided increased spring peak magnitude and duration, while maintaining timing more similar to pre-dam conditions than to post-dam flows. Base flows were also altered to resemble the magnitude and timing of pre-dam conditions.

Because the proposed diversion does not impact the ability for the San Juan River Flow Recommendations to be met with the 5,271 af /year depletion, it is expected that key habitats for the endangered fish will continue to be created, maintained and maximized and the proposed diversion will not have a adverse effect on pikeminnow or razorback sucker critical habitat.

Water Quality

Water quality changes will be undetectable because project withdrawals will only reduce base flow by less than 0.5 percent on average with the greatest impact being less than 3 percent. Return flow from all sources accounts for about 10 percent of the flow of the river during base flow periods. Most constituents are concentrated about 4 fold in return flow through evaporative losses so the increase in water quality constituent concentrations below the diversion due to withdrawal will be about 0.9 percent, with a similar reduction in concentrations above that location due to increased flow. Return flow at Shiprock will be through the Shiprock treatment plant, meeting the requirements of the NPDES permit, with an average annual flow of 5.0 cfs (1 percent of the minimum flow). During runoff months, flows are slightly increased, so water contaminant concentrations in the water will decrease. The net increase in any water quality parameter will be less than 2 percent. The Biological Assessment for the NIIP (Keller-Bliesner Engineering, 1999) concluded that the water quality risk to the endangered species was low for all parameters. Because the increase in water quality constituents will be undetectable, the effect to pikeminnow and razorback sucker will be insignificant and discountable.

Physical Habitat

The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has contributed to alteration of many habitat elements important to pikeminnow and razorback sucker. Water depletions during spring runoff affect physical habitat in several ways. High spring flows are important for creating and maintaining complex channel geomorphology and suitable spawning substrates, and in creating and providing larvae, YOY and juvenile access to off-channel habitats. The Flow Recommendations were developed because native fish species evolved under certain flow patterns. A basic premise of the SJRRIP was that reoperation of Navajo Dam to mimic a natural hydrograph would improve both habitat quantity and quality by re-establishing a spring peak and low late-summer, autumn, and winter base flows. It was the consensus of biologists working with the endangered fishes in the Colorado River Basin that natural flow patterns and magnitudes were needed by these fishes (Holden 1979, Minckley et al. 1991, Tyus 1991). The life histories of most native species are integrally tied to the timing, duration, and magnitude of the natural hydrograph. Razorback sucker spawn during high spring flows, and their larvae are adapted to utilize habitats that are most available during that time of year. Pikeminnow spawn later in the summer as flows recede, and their larvae utilize habitats that are most available during the low flow periods of late summer and autumn. Because the depletion does not affect the implementation of the Flow Recommendations, the depletion is not expected to impact the recovery of the pikeminnow or razorback sucker in the San Juan River. The depletions caused by the proposed project will not adversely modify critical habitat for pikeminnow and razorback sucker.

Biological Environment

The Flow Recommendations were developed because native fish species evolved under certain flow patterns. A basic premise of the SJRRIP was that reoperation of Navajo Dam to mimic a natural hydrograph would improve both habitat quantity and quality by re-establishing a spring peak and low late-summer, autumn, and winter base flows (Holden 1979, Minckley et al. 1991, Tyus 1991). The life histories of most native species are integrally tied to the timing, duration, and magnitude of the natural hydrograph. Razorback sucker spawn during high spring flows, and their larvae are adapted to utilize habitats that are most available during that time of year. Pikeminnow spawn later in the summer as flows recede, and their larvae utilize habitats that are most available during the low flow periods of late summer and autumn. Because the depletion does not affect the implementation of the Flow Recommendations, the depletion is not expected to impact the recovery of the pikeminnow or razorback sucker in the San Juan River. The modification of flow regimes, water temperatures, sediment levels, and other habitat conditions caused by water depletions has also contributed to the establishment of nonnative fishes.

Future projects and depletions that occur in the San Juan River Basin will reduce the amount of water available to the river; however, the Flow Recommendations were developed to provide suitable flows for the endangered fish. The hydrologic model on which the Flow Recommendations is based is currently being updated and revised and will include hydrologic data through 2000. It will not be until 2006, at the earliest, that the drought years of 2002 and 2003 will be incorporated into the model because of the lag time it takes to calculate and update depletions that occur in the Basin. However, even when the drought years are incorporated into the model, it is not anticipated that the Flow Recommendations would change. Flow Recommendations would only change if the SJRRIP Biology and Hydrology Committees recommended a change.

Because of current depletions and structural limitations of Navajo Dam, there are limitations on the amount of water that can be delivered to the San Juan River. The largest spring peak flow to occur in the 40 years since the construction of Navajo Dam is 15,200 cfs (2.5 percent of the years) (measured at the USGS Bluff gauge, May 30, 1979). In the 49 years prior to dam construction there were spring peak flows greater than 15,200 cfs in 13 years (26 percent of the time). Because of the short period of time that the Flow Recommendations have been in place, it is unknown if a peak flow of 10,000 cfs will be sufficient to maintain the channel and habitat complexity over the long-term. However, monitoring of key habitat characteristics is ongoing. The Service expects that adjustments to the San Juan River Flow Recommendations will be made if long-term monitoring indicates that changes are warranted.

Summary

The proposed action will result in an increase in depletions in the San Juan River of not more than 5,271 af /year over the environmental baseline but does not impact the ability for the San Juan River Flow Recommendations to be met. By following the Flow Recommendations, the operation of Navajo Dam will mimic the natural hydrograph and result in flow patterns similar to those that occurred prior to 1962. Because the flows now mimic the natural hydrograph, the Service anticipates that the response of designated critical habitat will be that key habitats for the endangered fish continue to be created, maintained and maximized. The anticipated response of pikeminnow and razorback sucker to the Flow Recommendations would be increased population size.

Mesa Verde Cactus

Cactus surveys were conducted in 2000 and 2002, prior to and coinciding with the population decline in 2001 and 2002. Fewer than 100 cacti were found south-southeast of the junction of US Highway 491 and Navajo Route 36. This population is within the proposed route for the San Juan Lateral pipeline and an associated booster pumping station. The pumping station would remove about one acre of cactus habitat. Two additional areas of cactus habitat may also be affected by the pipeline and associated structures: 1) south of the junction of Hwy 491 (formerly Hwy 666) and 36 for approximately 15 miles to the vicinity of Little Water, New Mexico; and 2) north of Navajo Route 36 and west of the Hogback Diversion.

Although the pipeline would be buried, the proposed action could potentially destroy up to 100 Mesa Verde cactus plants. Construction activities will include fencing, utilities installation, heavy equipment grading, and vegetation clearing. This will destroy Mesa Verde cactus habitat and any plants in the direct path of these activities. Parts of the project footprint not graded and cleared could be impacted by foot traffic, vehicle use, and parking with the resulting destruction of additional habitat and plants. Project construction would be staged over a 14-year period and result in temporary impacts to upland vegetation, the majority of which has been previously disturbed. The proposed conservation measures may limit some of these impacts to the cactus. However, there are conflicting reports whether transplanting this cactus minimizes impacts. For example, Spellenberg (1978) notes that Mesa Verde cacti does not transplant well, but Brack (1986) found that 34 of 35 cacti survived short-term following a transplant attempt. As noted, these cacti are difficult to locate, especially during drought conditions. Not all cacti will be found during surveys and some will be destroyed by construction-related activities. For these reasons, we anticipate that adverse effects resulting in mortality of individual cacti will occur.

Indirect Effects

Indirect effects are those that are caused by, or result from, the proposed action, and are later in time, but are reasonably certain to occur.

Colorado Pikeminnow and Razorback Sucker

Occasional maintenance activities for the diversion structure and fish screen are indirect effects resulting from the implementation of the proposed action. It is our expectation that injury or mortality of individuals could occur through the implementation of maintenance activities.

Mesa Verde Cactus

Occasional vehicle use for maintenance activities will affect cacti by alteration of habitat, erosion, alteration of drainage, and crushing of individuals through vehicle road use. Over the 34-year period of this consultation it is not possible to quantify the number of plants affected.

Additional indirect impacts to the cactus may occur from soil deposition related to construction activities, which could reduce reproduction and/or recruitment. Moreover, individual plant mortality could be caused from root exposure due to soil loss. Still, removal and trampling of vegetation around individual cacti are expected to be short-term in duration and vegetation is expected to recover following construction activities.

The pipeline and associated structures would not facilitate OHV travel because the majority of the pipeline route parallels existing roads. Moreover, the pipeline corridor would be reseeded with native vegetation and in most cases, fenced to exclude livestock grazing and promote re-establishment of native vegetation. Fencing would also deter OHV travel and access from potential plant collectors. Because best management practices will be used during construction activities, we do not anticipate an increase in fugitive dust, sedimentation/erosion, or increased risk of fire or fuel spill.

Interrelated and Interdependent Effects

Colorado Pikeminnow and Razorback Sucker

As proposed, the NGWSP could not operate without the presence of Navajo Dam, therefore it is also interrelated with this proposed action. Because the effects of Navajo Dam and NIIP projects were already considered in previous consultations, they are part of the environmental baseline of this consultation.

Mesa Verde Cactus

The use of access roads and vehicles in the action area is considered interrelated and interdependent with the construction of current proposed project. Although the majority of vehicles will likely stay on roads, effects of the project from interdependent and interrelated actions will likely result in cacti being crushed by vehicles or personnel while constructing the proposed pipeline.

The Federal Register notice of intent to prepare an environmental impact statement and announcement of public scoping meetings identified that a long-term high quality municipal and industrial water supply is needed to improve the standard of living for current and future populations and to support economic growth of the Navajo Nation, the City of Gallup, New Mexico, and the City of Window Rock, Arizona (59 FR 16219). NEPA had not yet been completed for the project. However, the BA further explains that the proposed project will deliver treated municipal water to selected Navajo communities and a portion of the Jicarilla Apache Nation. Although the proposed project would provide water for future residential or commercial development activities within the action area, the majority of the water supply would service the southeastern area of the Navajo Nation, which is not considered cactus habitat. Reclamation indicated that additional development and changes in land use to meet expected future population demands will likely occur on Tribal lands as directed by the Tribes. The proposed project connects to existing systems and additional residential development is expected to be limited to those areas. It is unknown whether any of these developments would occur within occupied cactus habitat. If information becomes available through the NEPA analysis that indicates future development would occur within cactus habitat and adversely affect the species, this consultation must be reinitiated.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions on endangered or threatened species or critical habitat that are reasonably certain to occur in the foreseeable future in the action area considered in this BO. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. Cumulative effects analysis as stated here applies to section 7 of the Act and should not be confused with the broader use of this term in the NEPA or other environmental laws.

Colorado Pikeminnow and Razorback Sucker

(1) Coalbed Methane Development

The San Juan Basin in southwestern Colorado and northwestern New Mexico is rich in coalbed methane and development of this resource has increased rapidly in the last ten years. There are currently more than 3,000 coalbed methane wells in the San Juan Basin in the Fruitland Coal Formation. Historically, one well per 320 acres was allowed in this area; however, the Colorado Oil and Gas Commission approved an increase of the well spacing to one well per 160 acres. Potentially more than 700 additional wells may be drilled and approximately 250 of these could occur on private or State land. Coalbed methane development requires the extraction of groundwater to induce gas flow. It was estimated that the wells would be drilled in about 10 years (by 2013) but, because of slow groundwater movement, water depletion effects would not be incurred until at least 2025.

A study was initiated in 1998 to determine the effects of groundwater extraction from the Fruitland Formation. The study is called the 3M Project (mapping, modeling, and monitoring) and is being conducted by the Colorado Oil and Gas Conservation Commission (COGCC) in cooperation with the Southern Ute Indian Tribe, the BLM, the Forest Service and the industry. The mapping and modeling studies were completed in 2000. Mapping results are presented in the Colorado Geological Survey's Open File Report 00-18. Modeling results are available at the COGCC's website and through the BLM's San Juan Public Lands Center. A follow-up project was funded by the Ground Water Protection Research Foundation (GWPRF), and the report is available through the BLM.

The Fruitland Formation and the underlying Pictured Cliffs Sandstone were shown to be an aquifer system. In general terms, the groundwater produced from near-outcrop coalbed methane wells is recent recharge water that would, under predevelopment conditions, discharge to the Animas, Pine, Florida and Piedra rivers. These rivers provide flow to the San Juan River. Coalbed methane wells occur on Federal, State, Tribal and private lands. The BLM prepared an Environmental Impact Statement to address coalbed methane development on the Southern Ute Indian Reservation. The BLM also prepared a separate EIS to address coalbed methane development on Federal lands. Water depletions associated with coalbed methane development on Tribal and Federal lands will be addressed during future section 7 consultation with the BLM. There will not be future section 7 consultations for coalbed methane development on private or State lands if there is no Federal action associated with these wells. Therefore, water depletions associated with coalbed methane development on private and State lands are considered a cumulative effect that is reasonably certain to occur within the action area.

The GWPRF used a groundwater model and a reservoir model to determine water budgets and depletions associated with coalbed methane development. Three areas around the Animas, Pine, and Florida rivers were modeled using 3-D multi-layer models to account for aquifer-river interactions and the effects of coalbed methane development. Baseline conditions were simulated with a single-phase ground water flow model (MODFLOW), and predictive runs were made using two-phase flow models (EXODUS and COALGAS). The predictive model run results are summarized in Table 6.

Table 6.—Surface Water Depletions: Model Summaries

River	Pre-CBM Discharge (AF/yr)	Current Depletion (AF/yr)	Maximum Depletion (AF/yr)	Year when Max Depletions Begin
Animas	66	41	66	2045
Pine	61	31	61	2025
Florida	17.5	2	12.5	2050
Piedra[1]	60	0	60	[2]
Total	204.5	74	199.5	

[1] Piedra River depletions are estimated based on discharges simulated from the 3M Project and the depletions modeled in the GWPRF at other rivers.

[2] Maximum depletions at the Piedra River will depend on the rate of coalbed methane development in the northeastern portion of the San Juan Basin.

The model results show that prior to coalbed methane development, the Fruitland Formation discharged approximately 205 ac-ft /year to the San Juan River. Modeling shows approximately 74 ac-ft /year is currently being depleted with existing wells and predicts the maximum depletions to be approximately 200 ac-ft /year.

The RiverWare Model, which is used to evaluate hydrologic conditions on the San Juan River and its tributaries, requires a defined project to determine project compatibility with the San Juan River flow recommendations. Because future coalbed methane development on State and private land is not a defined project and the depletions associated with it are relatively small and not specifically quantified, the RiverWare Model is not an appropriate tool to use to determine the compatibility with the flow recommendations. However, on May 21, 1999, the Service issued a biological opinion that addressed the impacts of future Federal projects that individually involve small water depletions up to a total of 3,000 ac-ft /year. It was determined in that biological opinion that these small depletions would not diminish the capability of the system to meet the flow levels, durations, or frequencies outlined in the San Juan River flow recommendations. The coalbed methane development on State and private lands was not addressed in the small depletion biological opinion. This development does not involve future Federal actions but does involve small individual depletions similar to the projects addressed by the small depletion biological opinion. Therefore, the Service concludes that an additional future depletion of approximately 200 ac-ft /year from the San Juan River associated with coalbed methane development on State and private land, would not significantly impact the ability to meet the San Juan River Flow Recommendations.

Future section 7 consultations in the San Juan River Basin will need to consider the cumulative effects of coalbed methane development on State and private land using the best scientific information available to determine the water depletions associated with development.

(2) Future depletions and diversions from the San Juan River Basin that do not have a Federal nexus and therefore have not completed section 7 consultation

We believe most of these depletions are accounted for in the environmental baseline depletions and are therefore considered in meeting the Flow Recommendations. There are irrigation ditches and canals below Navajo Dam that could entrain pikeminnow and razorback sucker: Citizens, Hammond, Fruitland, San Juan Generating Station, Jewett Ditch, Four Corners Power Plant Diversion, and Hogback. Increased urban and suburban use of water, including municipal and private uses will increase demands for water. Further use of surface water from the San Juan River will reduce river flow and decrease available habitat for the razorback sucker and pikeminnow. Livestock grazing may adversely impact razorback sucker and pikeminnow by removal of water for drinking and the reduction in soil water holding capacity in the floodplain, and resulting reduction in base flows.

(3) Increases in development and urbanization in the historic floodplain that result in reduced peak flows because of the flooding threat

Development in the floodplain makes it more difficult to transport large quantities of water that would overbank and create low velocity habitats that the razorback sucker and pikeminnow need for their various life history stages.

(4) Contamination of the water (i.e., sewage treatment plants, runoff from feedlots, and residential development)

A decrease in water quality could adversely affect the razorback sucker and pikeminnow, and their critical habitat.

(5) Gradual change in floodplain vegetation from native riparian species to non-native species e.g., Russian olive)

Channel narrowing leads to a deeper channel with higher water velocity. Pikeminnow and razorback sucker larvae require low velocity habitats for development. Therefore, there will be less nursery habitat available for both species.

(6) The presence of striped bass and walleye in Lake Powell constitutes a future threat to pikeminnow and razorback sucker in the San Juan River

(7) Increased boating, fishing, off-highway vehicle use, and camping in the San Juan River basin is expected to increase as the human population increases

Potential impacts include angling pressure, non-point source pollution, increased fire threat, and the potential for harassment of native fishes.

Mesa Verde Cactus

The growth of Shiprock, New Mexico, has affected plants in the vicinity of the town. The open clay badlands where this plant occurs are attractive for ORV use. Oil and gas development and pipeline and powerline construction occur throughout the range of this species. This plant is very difficult to keep alive under cultivation because of its specialized soil requirements, so there are few commercial sources of plants. As a result, signs of limited collecting are periodically seen at the best known localities. Depending on the intensity of these actions, individual cacti can be killed or habitat may be fragmented. These types of activities contribute to the cumulative effects of the proposed action.

Conclusion

Pikeminnow and Razorback Sucker

After reviewing the current status of the pikeminnow and razorback sucker, the Environmental Baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the proposed action, as described, is not likely to jeopardize the continued existence of the pikeminnow and razorback sucker and is not likely to adversely modify their designated critical habitat. The rationale for our opinion is provided below.

According to the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin," (2001) the Service must determine if progress toward recovery of the two fish species has been sufficient for the SJRRIP to serve as a Reasonable and Prudent Measure for water development projects. To make this determination we have reviewed: 1) the Program Evaluation Report (Holden 2000), 2) The Long Range Plan (1995), 3) the Draft Final Program Integration Report (Miller 2005), 4) scopes of work proposed for 2005-2007, 5) SJRRIP Biology Committee meeting notes, hydrological and biological data, and 6) have spoken with SJRRIP committee members to evaluate the effectiveness of the Flow Recommendations and other elements of the SJRRIP in conserving populations of pikeminnow and razorback sucker in the San Juan River.

Under the principles, the Service is to determine progress toward recovery based on (SJRRIP 2001):

- Actions that will result in a measurable positive population response, a measurable improvement in habitat for the fishes, legal protection of flows needed for recovery, or a reduction in the threat of immediate extinction.
- Status of fish populations.
- Adequacy of flow.
- Magnitude of the impact of the activity (including but not limited to, contaminant and fish migration impacts).

It is the intent of the SJRRIP to provide demographically and genetically viable populations of the pikeminnow and razorback sucker in the San Juan River (Holden 2000). Demographically viable populations are self-sustaining with natural recruitment and an appropriate size and age-structure. Genetically viable populations are of sufficient size that inbreeding is not a concern (Holden 2000). The primary goals of the initial SJRRIP studies were to determine the factors that are limiting the pikeminnow, razorback sucker, and other native fishes, and to determine ways to reduce or eliminate the limiting factors. Because the numbers of pikeminnow and razorback sucker were so few at the time research began, population monitoring was an immediate need.

While initial emphasis was on identification of limiting factors, the seven-year research period also addressed recovery potential through mimicry of the natural hydrograph and study of hatchery-reared endangered fishes released into the San Juan River. The seven objectives identified in the 1995 Long Range Plan pertained to: 1) development of interim management objectives for the endangered fishes and native fish community, 2) habitat identification and restoration, 3) endangered fish species restoration and native fish community management, 4) nonnative fish species management, 5) water quality impacts, 6) public awareness, and 7) adaptive management. The 1995 Long Range Plan identified tasks and milestones for each of these objectives. A total of 51 tasks were listed, of which 22 were identified as milestones. Of these, 42 tasks and 14 milestones have been completed or are ongoing (SJRRIP Biology Committee 2002), indicating that progress is being made.

The SJRRIP actions implemented to date have addressed all of the management actions identified in the 2002 recovery plans and the short-term (2002-2006) population response criteria developed for razorback sucker and pikeminnow in 2001 have been met. The population response criteria for pikeminnow and razorback sucker are listed below. Population responses for each criterion are summarized from emails received from Dale Ryden (Service, in. litt. 2005).

Pikeminnow

1A) *Collection of 10 or more pikeminnow (greater than 350 mm [13.8 in] total length) during a standardized monitoring trip.* On the fall 2003 standardized monitoring trip, 32 pikeminnow with total lengths ranging from 150-259 mm (5.9 to 10.2 in) were captured. On the fall 2004 standardized monitoring trip, 159 pikeminnow ranging from 130-360 mm TL were captured, two of which were > 350 mm TL (Ryden 2005). On the fall 2005 standardized monitoring trip, 127 pikeminnow ranging from 125-419 mm TL were captured, four of which were > 350 mm TL.

1B) *A population estimate of pikeminnow (greater than 350 mm [13.8 in] total length) which is significantly greater (alpha = 0.05) than the Ryden (2000a) estimate of 50 fish. This estimate (N=19; 95 percent CI 10-42) was for adult fish collected between RM 136.6 and 119.2 and is the only such metric available for this species in the San Juan River.* If criterion 1A is met in large enough numbers, it may be possible to meet this goal's target in the near future.

2A) *Presence of wild larval or YOY pikeminnow in standardized monitoring collections in 2 of 5 years.* The capture of wild larval pikeminnow has been infrequent. Larval pikeminnow were caught in 2001 and two individuals were caught in 2004 (Brandenburg and Farrington 2005). Not until stocked pikeminnow become adults and begin reproducing in fairly large numbers will wild larval fish begin to be detected more regularly. The very low survival rates observed from previous (1996-2000) stocking/augmentation of early life stage pikeminnow and the subsequent lack of recruitment of those fish into adulthood is partially responsible for this criterion not being met. However, the lack of wild adult fish and associated progeny is also a factor.

2B) Range expansion above Hogback Diversion following removal and/or modification of this and other fish barriers identified by the SJRRIP. This criterion has been met, via augmentation efforts. Cudei Diversion has been removed from the river and both Hogback Diversion and the PNM Weir have fish passage structures that are in operation. Studies are now in progress to assess the need for fish passage at both the Arizona Public Service Weir and the Fruitland Diversion. Pikeminnow are being stocked on an annual basis upstream of all of these diversions, as well as immediately downstream of Hogback.

Razorback Sucker

1A) *Collection of more than 20 razorback sucker greater than 300 mm (11.8 in) total length during the annual fall standardized monitoring.* This criterion was met in 2002 (23 fish caught), but fell 2 fish short in 2003. In 2004 and 2005, this criterion was again met, when 113 and 51 razorback sucker (> 300 mm TL) were collected, respectively.

1B) *Collection of greater than 0.15 razorback sucker greater than 300 mm (11.8 in) total length per hour of electrofishing.* This criterion was met in 2002, 2003, 2004, and 2005 with the collection of 0.25, 0.19, 1.21, and 0.59 razorback sucker (> 300 mm TL) per hour of electrofishing, respectively.

2) *Evidence of reproduction (i.e., presence of wild larvae and/or YOY) during standardized monitoring in at least 2 of 5 years.* This criterion has been met. Larval razor back suckers have been caught in every year from 2000 to 2004 (Brandenburg et al. 2003, Brandenburg and Farrington 2005).

From these data, we conclude that the razorback sucker and pikeminnow populations in the San Juan River are more secure today than they were in the 1980s and 1990s and that the threat of extinction has been reduced. Of the two species, the razorback sucker population currently appears to be benefiting more from management efforts. The number of razorback sucker larval fish caught appears to be increasing (Brandenburg et al. 2003) and in 2003, two juvenile razorback sucker (249 and 274 mm TL) were collected in the lower San Juan River (at RM 35.7 and 4.8, respectively). Their size at time of capture and lack of a PIT tag strongly implies that these are likely wild-produced progeny of stocked razorback sucker, providing the first evidence of recruitment in the San Juan River. Between 1991 and 1995, 19 (17 adult and 2 juvenile) wild pikeminnow were collected in the San Juan River by electrofishing (Ryden 2000a). In 2004 and 2005 159 and 127 sub-adult pikeminnow were caught during the fall standardized monitoring trips. While it is still too early to determine if these fish will survive to the adult stage and reproduce, the trend is encouraging. Because the effective riverine habitat in the San Juan River has been shortened by 87 km (54 mi) by inundation of Lake Powell (at full pool) and 150 km (93 mi) by cold water releases from Navajo Dam, it is unclear if truly self-sustaining populations of pikeminnow can be established without the presence of warmer water so that spawning can occur farther upstream. However, with continued management (e.g., adherence to the Flow Recommendations, removal of fish passage barriers) and stocking/augmentation, it is expected that population numbers will increase and be maintained.

The action that has probably led to the largest population response is stocking/augmentation because it has had the direct effect of increasing fish numbers. Because both species are long-lived it will take many years to determine whether the SJRRIP is successful. However, the Service will continue to annually review the progress of the SJRRIP according to the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin" (2001). As part of the annual review, the Service will determine if progress toward recovery of the two fish species has been sufficient for the SJRRIP to continue to serve as the Reasonable and Prudent Measure for water development projects.

Other actions that have been taken by the SJRRIP that are intended or expected to have a positive population response are:

(1) Providing and Restoring Habitat

Flow Recommendations were developed in 1999 and have been implemented. The Biological Opinion on Navajo Reservoir Operations, Colorado River Storage Project, Colorado-New Mexico-Utah was completed on January 6, 2006; the NEPA EIS Record of Decision was signed July 31, 2006.

With the Flow Recommendations in place, the annual hydrograph mimics the natural hydrograph more closely than in the pre-Flow Recommendations period. The Flow Recommendations provide a peak spring flow improving spawning conditions and the summer base flows are lower, more closely resembling the pre-dam conditions. We expect that a more natural hydrograph provided by the implementation of the Flow Recommendations will have a beneficial effect on native species compared to the pre-Flow Recommendation conditions. However, because population numbers of the endangered fish are so low and because so many actions are occurring simultaneously, documenting a positive population response that is a direct result of any one particular action alone may not be possible.

Temperature suppression associated with hypolimnic releases from Navajo Dam is being studied, and if found to be limiting, the SJRRIP will identify any resulting appropriate options that should be implemented and funded through the SJRRIP.

(2) Providing passage over, around or through fish migration and movement barriers within occupied habitat

The SJRRIP has restored access to approximately 36 miles of critical habitat. In 2002, the Hogback Diversion was reconstructed to provide for improved fish passage as well as improved irrigation diversion control. The SJRRIP funded that portion of the Hogback Diversion reconstruction assignable to fish passage.

In 2002, the Program funded removal of the Cudei Diversion and installation of a siphon to connect the Cudei project to the Hogback canal to improve upstream passage for endangered fish species in the river.

The SJRRIP also funded the construction in 2003 and operation of a selective fish passage facility at the San Juan Generating Station diversion weir, located just downstream of Fruitland. The SJRRIP provides annual funding to the Navajo Nation to operate the selective fish passage facility.

In 2005, the APS and Fruitland Diversion structures were technically evaluated as to their effect on access to spawning and rearing habitat upstream in 2005; the final report was issued in October 2005 and the Biology Committee is currently evaluating the need for any future remedial work at these two diversion structures. The Fruitland Diversion is located at RM 178.5 on the San Juan River, between the confluence of the Animas and the confluence of the La Plata River with the San Juan River near Farmington, New Mexico. The APS diversion - also known as the Four Corners Power Plant Diversion – is located at RM 163.3. Both of these diversions are located within the designated critical habitat for pikeminnow and razorback sucker.

(3) Minimize entrainment of sub-adults and adults at diversion structures, including canal headings and pumping stations

In 2004, the SJRRIP funded an assessment of fish entrainment in the Hogback Diversion canal, San Juan River, New Mexico. The results of this assessment lead to a 2005 project for a design study of a fish screen at the Hogback Diversion.

Concerns regarding potential entrainment of endangered fish into the diversion structures located below the confluence of the San Juan and Animas rivers are currently being evaluated.

(4) Control problematic non-native fishes

While a positive endangered fish population response cannot yet be linked to this effort, it is expected that the amount of predation and competition between native and non-native fish is reduced, promoting the survival of native fish. Nonnative mechanical removal began in 1997 and continues as a stand-alone program. Additionally, nonnative fish removal during research and monitoring activities augment this program. Intensive removal efforts began in 1999 in the upper river near Farmington, New Mexico, and in 2002 in the canyon section between Mexican Hat and Clay Hills, Utah. Other control measures such as the selective fish passage structure at PNM Weir have been implemented and will continue. Flow manipulation with Navajo Dam releases and Lake Powell elevation regulation will be evaluated as to their effect on nonnative populations. Measurable objectives and methods for assessing and maintaining effectiveness of removal efforts will be developed and implemented. Non-native fish stocking and baitfish policies of affected states will be implemented.

Other conditions we must consider in evaluating habitat conditions are: 1) The Flow Recommendations have been implemented for a short period of time; 2) the channel may still be adjusting to the new hydrologic regime and changes in watershed conditions. It appears that implementation of the Flow Recommendations has maintained nearly all important physical habitat characteristics over the last several years (Bliesner 2004). As studies continue and the Flow Recommendations are implemented over a longer period of time, the improvement, maintenance, or deterioration of habitat can be assessed more accurately. The SJRRIP has appropriate long-term monitoring in place to make this assessment.

The proposed action is significant since it affects the full length of San Juan River occupied by the two endangered fish and extends in perpetuity. It is essential that the SJRRIP continue with the same level of agency commitment and funding to be able to monitor and address the effects of this proposed action. As full implementation of projects increases in the Basin, leading to greater depletions, the SJRRIP will need to determine if, and when, conditions which currently are not detrimental to the endangered fishes become more severe with additional depletions. Continued long-term monitoring is essential. The SJRRIP has implemented new studies over time to help understand the biological and physical characteristics of the San Juan River and the Service believes that the SJRRIP has been prudent in its selection of research topics and monitoring.

Mesa Verde Cactus

After reviewing the current status of the cactus, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that implementation of the action, as proposed, is not likely to jeopardize the continued existence of the cactus. No critical habitat has been designated for this species; therefore, none will be affected.

We find that the implementation of the proposed action is not expected to result in high levels of cactus mortality, especially with the implementation of Reclamation's conservation measures, which are part of the proposed action, to limit adverse effects. The range of Mesa Verde cactus includes remote areas that have not been thoroughly surveyed. The plant is sporadically distributed within its suitable habitat with the total number of plants probably exceeding 10,000 (Service 1984). For the most part, Federal agencies have been able to effectively conserve Mesa Verde cactus by making only minor modifications in project plans or by carefully executing project activities to avoid plants that might otherwise have been damaged or destroyed. Because Mesa Verde cactus is almost completely on either Indian lands or Federal lands managed by the BLM, a very high proportion of the activities that might affect the cactus are subject to section 7 consultation, and this process has contributed measurably to conservation of the species. The Mesa Verde cactus population on BLM-lands north of Waterflow, New Mexico, was monitored for 14 years, and recently found a dramatic decline in the number of cacti in 2001 and 2002. This was attributed to a native predatory beetle (New Mexico Forestry Division 1985, 2003). This population appears to be slowly recovering (B. Sivinski, pers. comm., 2006). Given that conservation efforts for the species have been effective, that population numbers for the species are large enough to sustain some losses without detriment to the species as a whole, and that monitoring indicates populations are stable, the Service concludes that the potential loss of up to 100 Mesa Verde cactus plants from the proposed Navajo-Gallup Water Supply Project would not be likely to jeopardize the continued existence of the species. In addition, even these losses can be greatly reduced with implementation of the conservation recommendations given below. As noted above, when the NEPA analysis is completed for this project, if the analysis indicates that project related future development would occur within cactus habitat and adversely affect the species, this consultation must be reinitiated.

Incidental Take Statement

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), take that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such take is in compliance with the terms and conditions of an incidental take statement. Our incidental take statement is specific to a particular life stage and that stage only. For example, the following incidental take statement is specific to larval fish. We make no assumptions about how many adult fish these larval fish may produce and do not predict the number of juvenile or adult fish lost based on the larval number taken.

The measures described below are non-discretionary, and must be undertaken by Reclamation so that they become binding conditions of any grant or permit issued to any applicants, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this incidental take statement. If Reclamation (1) fails to assume and implement the terms and conditions, or (2) fails to require applicants to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

Amount or Extent of Take

The Service anticipates that take in the form of direct take of larvae during the spawning season and harm will occur in association with the water depletion and entrainment.

Depletion

Because the proposed 5,271 af/year depletion does not impact the ability for the San Juan River Flow Recommendations to be met, it is expected that key habitats for the endangered fish will continue to be created, maintained and maximized and the proposed diversion will not have a adverse affect on pikeminnow or razorback sucker critical habitat. Any amount of net depletion above 5,271 af/year may result in incidental take and would require reinitiation of consultation.

Entrainment

Colorado Pikeminnow

Based on the best available information concerning the habitat needs of this species, the project description, and information furnished by Reclamation, the Service anticipates that pikeminnow larvae will be taken as a result of this proposed action. This incidental take is expected to be in the form of harm, harass, and kill as the result of entrainment of larvae during the spawning season.

Based on spawning dates in the San Juan River, larvae typically enter the drift from mid-July to Mid-August (Platania et al. 2000) and are passive in the drift for 3 to 6 days after emergence (Dudley and Platania 2000). Therefore, larval pikeminnow spawned above the diversion would be subject to entrainment for about 35 to 40 days. Flows during this period average about 1,500 cfs at the Farmington gage (1993-2003; USGS 2003). The proposed intake will divert about 4 percent (59 cfs) of the total river flow during peak pikeminnow drift. Pikeminnow exit the drift at 0.55 inches and will not be excluded by a 3/32 inch screen (Platania et al. 2000). We estimate that about 4 percent of larvae spawned above the intake will be subject to entrainment. Since only 25 percent or less of the spawn is expected above the diversion, the net loss is expected to be less than 1 percent of all pikeminnow larvae produced in the San Juan River.

The implementation of the SJRRIP is intended to minimize impacts of water depletions and therefore, implementation of the SJRRIP will serve as reasonable and prudent measures for minimizing the take that result from the withdrawal of 59 cfs of river flow. Any amount of water withdrawal above this level during larval drift would exceed the anticipated level of incidental take.

Razorback Sucker

Based on the best available information concerning the habitat needs of this species, the project description, and information furnished by Reclamation, the Service anticipates that razorback sucker larvae will be taken as a result of this proposed action. This incidental take is expected to be in the form of harm, harass, and kill as the result of entrainment of larvae during the spawning season.

Spawning typically occurs on the ascending limb of the hydrograph during May (Brandenburg, et al. 2004). With an assumed potential spawning range from RM 100 to RM 180 and a uniform distribution of spawning adults in the future, about 16 percent of the larval drift would occur above the diversion. During May the flow averages about 4,100 cfs of which 59 cfs or 1.4 percent enters the NGWSP diversion. Therefore, not more than 0.2 percent of drifting larvae would be subject to entrainment in the diversion in the San Juan River on any given year.

Because of the nature of the larvae life history stage and the variation in population sizes from year to year, it is difficult to estimate the number of individuals that will be taken with implementation of this project. Based upon the proposed project, it is estimated that a maximum 59 cfs of the occupied habitat (total river flow) will be taken during peak razorback sucker drift.

The implementation of the SJRRIP is intended to minimize impacts of water depletions and therefore, implementation of the SJRRIP will also serve as the reasonable and prudent measure for minimizing the take that result from the withdrawal of 59 cfs of river flow. Any amount of water withdrawal above this level during larval drift would exceed the anticipated level of incidental take.

Mesa Verde Cactus

Sections 7(b)(4) and 7(o)(2) of the ESA generally do not apply to listed plant species. However, limited protection of plants from take is provided to the extent that the ESA prohibits the removal and reduction to possession of federally endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of State law or regulation or in the course of any violation of a State criminal trespass law.

Effect of the Take

In the accompanying BO, the Service determined that the level of anticipated take is not likely to result in jeopardy to the razorback sucker and pikeminnow or result in the destruction or adverse modification of their critical habitat.

Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measure is necessary and appropriate to minimize impacts of incidental take of the razorback sucker and pikeminnow:

1) Reclamation will continue to support and participate in the implementation of the SJRRIP as a reasonable and prudent measure to minimize take.

Terms and Conditions

Compliance with the following terms and conditions must be achieved in order to be exempt from the prohibitions of section 9 of the ESA. The terms and conditions implement the reasonable and prudent measure described above and outlines required reporting/monitoring requirements. These terms and conditions are non-discretionary:

1. Reclamation will continue to seek funding for the implementation of the SJRRIP as a reasonable and prudent measure to minimize take.

2. Reclamation will spend funding, as appropriated, for the implementation of the SJRRIP as a reasonable and prudent measure to minimize take.

Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of the agency's section 7(a)(1) responsibility for these species. In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or that benefit listed species and their habitats, we request notification of the implementation of the conservation recommendations. We suggest the following conservation recommendations be implemented:

1. Reclamation should increase survey efforts during wet years and concentrate within the project footprint during the cactus flowering season (typically April and May) in order to increase the probability of sighting and avoiding individual cacti;

2. Any suspicious collection of cacti related activity within the action area should be reported to the Service.

3. Resurvey the area to determine the present distribution and abundance of Mesa Verde cactus plants. Provide a buffer of 100 feet and fence the entire area including the buffer to exclude livestock.

4. If possible, transplant cacti during the period March 1 - April 15 because this has been shown to be a time of year when high transplant success can be achieved (Roth 1997). Provide supplemental watering for the first growing season, if needed. Monitor the transplanted plants for three years and report the results to the Service.

Reporting Requirements

Documentation and reporting on the implementation of the conservation measures and terms and conditions will occur within six months after completion of the project and annually thereafter for a period of five years. The nearest Service Law Enforcement Office must be notified within 24 hours in writing should any listed species be found dead, injured, or sick. Notification must include the date, time, and location of the carcass, cause of injury or death (if known), and any pertinent information. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. If necessary, the Service will provide a protocol for the handling of dead or injured listed animals. In the event Reclamation suspects that a species has been taken in violation of Federal, State, or local law, all relevant information should be reported in writing within 24 hours to the Service's New Mexico Law Enforcement Office (505/883-7814) or the New Mexico Ecological Services Field Office (505/346-2525).

Reinitiation Notice

This concludes formal consultation on the proposed Navajo-Gallup Water Supply Project. As required by 50 FR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) The amount or extent of incidental take is exceeded. See section on Amount or Extent of Take; 2) new information reveals effects of the agency action that may impact listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that may cause an effect to the listed species or critical habitat that was not considered in this opinion; 4) a new species is listed or critical habitat designated that may be affected by the action; or 5) if the SJRRIP ceases to exist or if funding levels are reduced so that critical deadlines for specified recovery actions are not met.

The SJRRIP is expected to result in a positive population response for the pikeminnow and razorback sucker in the San Juan River. If a positive population response for both species is not realized, as measured by the criteria developed by Reclamation dated July 6, 2001, this would be considered new information that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion. Therefore, reinitiation of section 7 consultation would be required for all projects dependent on the Recovery Program, including the subject action. If reinitiation is required, the Service will follow the procedures regarding reinitiation of consultation pursuant to the "Principles for Conducting Endangered Species Act Section 7 Consultations on Water Development and Water Management Activities Affecting Endangered Fish Species in the San Juan River Basin".

In future communications regarding this project please refer to consultation number 2-22-01-F-532. If you have any questions or would like to discuss any part of this biological opinion, please contact David Campbell of my staff at (505) 761-4745.

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APPENDIX D

Part I

Allocation of Capital and OM&R Costs Among Project Participants

NAVAJO - GALLUP WATER SUPPLY PROJECT

ALLOCATION OF CAPITAL AND O,M&R COSTS

AMONG PROJECT PARTICIPANTS

SAN JUAN RIVER - PNM ALTERNATIVE

James P. Merchant
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Berkeley, CA
April 13, 2006

Executive Summary

This report is intended to describe the procedure used to allocate capital and operation, maintenance and replacement (O,M&R) costs for the preferred alignment and capacity scenario being considered for the Navajo-Gallup Water Supply Project (NGWSP). The report first explains the principles used for allocation, and then applies the principles to the 2040 version of the San Juan River PNM alternative. Costs are separated into capital costs, fixed O,M&R costs and variable O,M&R costs. Each of these cost categories is further divided into specific project reaches and then allocated to the participating parties. The allocation for the Gallup Regional System is included in the summary table but is developed separately in the detailed tables. The report assumes that construction would begin in 2008, with a construction budget of approximately $60 million per year (2005$). Full project completion would be January 1, 2021.

Allocation Principles

The purpose of cost allocation is to assign shares of the overall project costs to the various participants. This project will provide municipal water supplies to three groups of participants -- the Navajo Nation, the City of Gallup and the Jicarilla Apache Nation. The overriding philosophy in allocating project costs is that the three participants are equal partners in the project. Alternative allocation approaches NOT adopted include (1) assigning the same cost per gallon to all project participants regardless of their location (a "postage stamp" approach), or (2) assuming that one participant was primary and that the other two should pay only the additional costs incurred due to their participation (a "marginal cost" approach).

In allocating costs we first separated specific project components that will be dedicated for the exclusive use by any single participant, and we assigned the cost of those ***dedicated components*** to the beneficiary participant. These dedicated components typically include water storage tanks and pressurization pumps at most of the major delivery points. The bulk of the project cost, however, is for components that will benefit more than one participant. These ***joint costs*** were allocated among the project participants to derive each participant's share of the total costs.

Joint costs were allocated according to the following principles:

- ***Capital costs were allocated according to each participant's share of design capacity***. The idea is that the size and cost of the facilities depend upon each participant's desired capacity and not on average use or use in any particular period.
- ***Fixed O,M&R costs were also allocated according to each participant's share of design capacity***. Here again, the fixed O,M&R costs (staff size, dredging, equipment replacement, pump maintenance) are primarily a function of the design capacity, not of flows in any particular period.
- ***Variable O,M&R costs were allocated according to each participant's share of annual water deliveries***. The variable O,M&R costs consist mainly of

energy and water treatment chemical costs. These costs vary according to the water flows in any period, so the method used to allocate these costs assigns cost shares in each year according to the projected use in that year.

The project envisions water deliveries at many locations along (in this alignment alternative) two main branches. Every delivery to one party changes the relative shares of the water flow that continues along the pipeline beyond the delivery point. Because, as described above, the relative share of design capacity and projected flow serve as the basis for the cost allocation, the cost allocation changes after every delivery point. Therefore, we have separated each pipeline branch into specific ***reaches*** that are defined as the intervals between each two succeeding delivery points. The diversion structure and water treatment plant on each branch is also treated as a separate segment or reach. We computed each participant's share of design capacity on each reach in order to serve as the basis for allocating capital and fixed O,M&R costs (Table A1).

Capital Costs

All of the capital construction costs were assigned to specific reaches and then split into dedicated costs and joint costs. Specific types of costs were allocated as follows: Pumping plant costs were itemized by the Bureau of Reclamation and we assigned each cost to its specific reach (Table B4). We assigned pipeline costs to each reach by accumulating the linear feet of each pipeline diameter and head class designed for each reach, then multiplying the accumulated length of each pipeline diameter and head class by its respective cost per foot (Table B5). Electric and communication facilities were distributed to the reaches per the design, while transmission lines were allocated according to the miles of new transmission line required for each reach (Table B6). Diversion structures, river pumping plants and water treatment plant costs were assigned to the initial reach of each branch (Table B7).

The various components of joint capital costs were added together for each reach and then allocated to the participants using the design capacities (Table B3). We then added the allocated joint capital costs to the dedicated capital costs for each party in each reach (Table B2).

Finally, we added unlisted items (10% of listed items), mobilization costs (5% of listed plus unlisted items) and contingency costs (25% of listed items, unlisted items and mobilization costs) to derive the total construction cost, or field cost, for each participant. We then added non-contract cost (30% of field costs) to determine total construction cost before taxes, and then added taxes (9% of total construction cost for most costs and 6% of the construction cost for the Gallup Regional System) to arrive at total construction cost with taxes. Table B1 shows this total as allocated to each participant.

Fixed OM&R Costs

The fixed O,M&R costs (we use "O,M&R" as shorthand for operation, maintenance and replacement) are comprised of the annual components that do not vary substantially with differences in flows through the system. These costs include staff costs, dredging, equipment maintenance and annualized cost for equipment replacement. Allocation of fixed O,M&R costs was done analogously to the allocation of capital costs: the costs were assigned to the different reaches and then the O,M&R cost for each reach was apportioned among the participants according to their respective share of design capacity. About one-half of the fixed O,M&R cost was associated with the water treatment plants, so those costs were assigned entirely to the first reach of each branch, which contained the treatment plants. The remainder of the fixed O,M&R costs were pumping plant maintenance costs, and these costs were assigned to the reaches containing the pumping plants. Table D2 shows the fixed O,M&R costs for each reach, and allocates the costs to the participants.

Variable O,M&R Costs

The variable O,M&R costs are those annual operating costs that vary significantly with changes in system flows. These costs are primarily comprised of energy and water treatment chemical costs. Because these costs by definition change with changes in system flows we projected system flows over the 50-year life of the project (Table D3). The projected annual flows are based on the following assumptions:

- peak flows will be proportional to total water flows
- peak flows for Gallup and for the Jicarilla Apache Tribe would remain constant over the life of the project.
- peak flows for the Navajos would reach design capacity in the year designated in the Scenario: 2040.
- peak flows for the Navajos would remain constant following the year in which peak flows first reached design capacity
- peak flows for the Navajos would increase at a growth rate of 2.48% per year up to the year in which design capacity was first reached.

The Bureau of Reclamation provided energy and chemical costs associated with build-out project flows. We assumed that these costs would remain constant per unit of flow and then calculated the energy and chemical costs associated with each year's total flow. These total costs were allocated among the participants based on each year's respective shares of total flow. We performed these calculations for two different energy rate structures: Colorado River Storage Project (CRSP) rates (Table D6) and Navajo Tribal Utility Authority (NTUA) rates (Table D7). The applicable energy rates are shown as footnotes in Tables D6 and D7. Deliveries from Navajo Dam are subject to an estimated $1.00 per acre-foot O&M charge by the Bureau of Reclamation. This cost is included as a variable O,M&R cost in Tables D6 and D7.

Gallup Regional System Costs

The design work and cost estimates for the Gallup Regional System were first prepared by DePauli Engineering. The Bureau of Reclamation used the DePauli design but re-estimated much of the cost. Some of the Gallup System components were included in the Bureau's cost estimate worksheets for the overall system (eg. Navajo Chapter water storage tanks), but most components were listed separately on a Gallup-specific worksheet. We treated the components included with the other Bureau elements as part of the overall system cost allocation. We allocated the remaining items (all joint facilities) by allocating their cost to participants based on their respective shares of design capacity (Table C1).

O,M&R costs were estimated by the Bureau as a lump sum (one each for the CRSP and NTUA energy rates). We allocated this overall annual O,M&R cost to the participants based on their respective shares of design capacity (Table C2).

Water Costs

Table C3 estimates the City of Gallup's cost of purchasing 7,500 acre-feet per year of water that would be conveyed by the project. At this point Gallup has not reached an agreement with any water supplier, so the cost estimates included in these tables may change. We used the terms of a possible agreement with the Jicarilla Apache Nation as the basis for our cost estimates, but they have not yet been agreed to.

In the absence of a water rights settlement that establishes different terms the Navajo Nation would pay for water from Navajo Reservoir used for non-agricultural purposes. These payments were estimated by the Bureau of Reclamation to have a present value of $108.45 per acre-foot. We amortized that present value over the Navajo water deliveries using the CRSP interest rate of 2.875%. This cost is shown in Table D8.

We did not include any financial cost for the water to be delivered to the Jicarilla Apache Nation, pursuant to the terms of the Jicarilla Apache Tribe Water Rights Settlement Act (P.L. 102-441, section 8(d)(1)).

Overall Summation

Table 1 summarizes the above analysis. The table addresses the capital, annual O,M&R and present value of O,M&R costs for a scenario that assumes a construction budget of $60 million per year in 2005$. The table combines total construction cost including taxes for the Bureau-designed system and for the Gallup Regional System, developed separately in Tables B1 and C1. We added costs for environmental mitigation, cultural resources and right-of-way acquisition that were allocated in Table B8. We then added interest during construction that was calculated in Table B9. We calculated the present value of the annual fixed plus variable O,M&R costs (discounted at 5.375%), estimated under both the CRSP and NTUA energy rates. All financial costs are expressed as of the beginning of the year in which the project is completed: 2021. Interest during construction and interest on pre-project completion water purchase fees are compiled up to January 1, 2021, and post-completion O,M&R and post-completion water purchase fees are discounted to January 1, 2021. We then show the total present value of all costs, including capital, fixed O,M&R and variable O,M&R costs. Table 1 allocates these costs to each of the participants. All costs are based on January, 2005, price levels.

Figures 1 and 2 illustrate the components of overall cost. Figure 1 shows how total project costs are split among capital cost, interest during construction, the present value of future OM&R costs and the present value of water cost. Figure 2 shows how total project costs are allocation to the three project participants. Figures 3, 4 and 5 show how the cost allocated to each project participant are composed of capital, interest during construction, OM&R and water costs. Finally, Figure 6 shows what the levelized cost per thousand gallons (in 2005$) would be to each project participant, assuming full self-funding.

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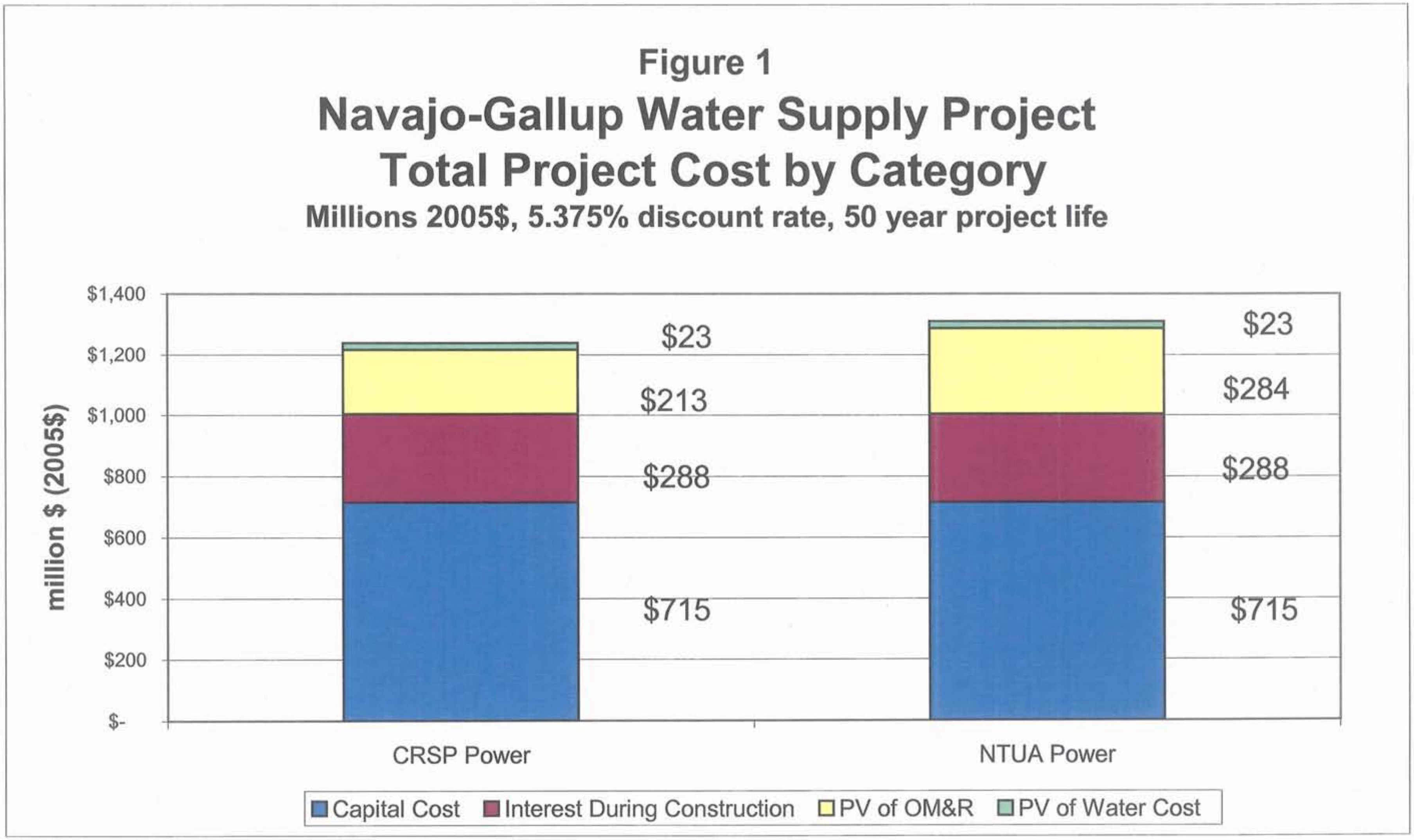


Figure 1
Navajo-Gallup Water Supply Project
Total Project Cost by Category
Millions 2005$, 5.375% discount rate, 50 year project life
$1,400
$1,200
$1,000
$800
$600
$400
$200
$-
million $ (2005$)
$23
$213
$288
$715
$23
$284
$288
$715
CRSP Power
NTUA Power
Capital Cost
Interest During Construction
PV of OM&R
PV of Water Cost

5/9/2006

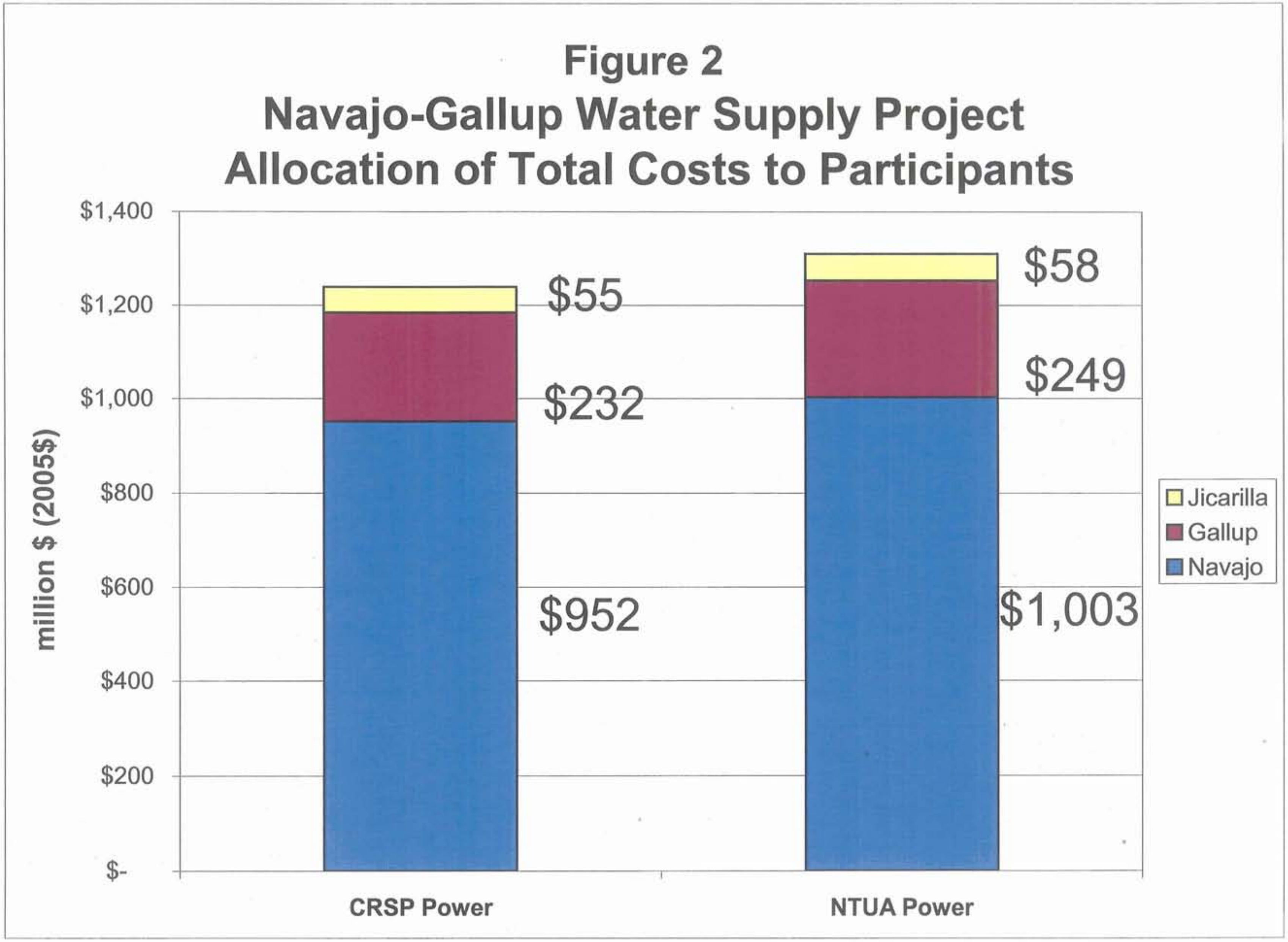


Figure 2
Navajo-Gallup Water Supply Project
Allocation of Total Costs to Participants
$1,400
$1,200
$1,000
$800
$600
$400
$200
$-
million $ (2005$)
$55
$232
$952
$58
$249
$1,003
Jicarilla
Gallup
Navajo
CRSP Power
NTUA Power

5/9/2006

Figure 3
Navajo-Gallup Water Supply Project
NTUA Power Rates
Breakdown of Navajo Costs

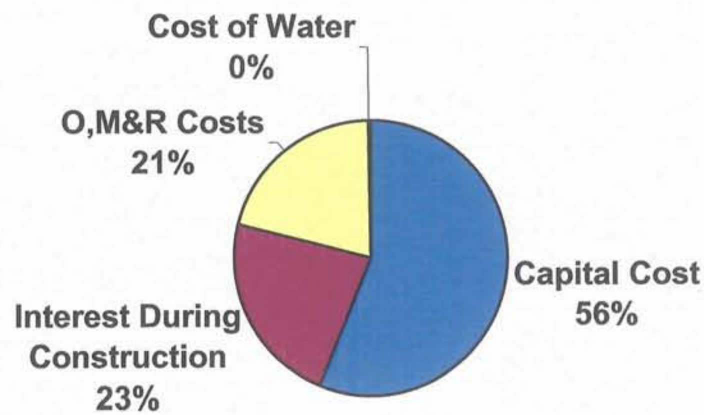


Figure 4
Navajo-Gallup Water Supply Project
NTUA Power Rates
Breakdown of Gallup Costs

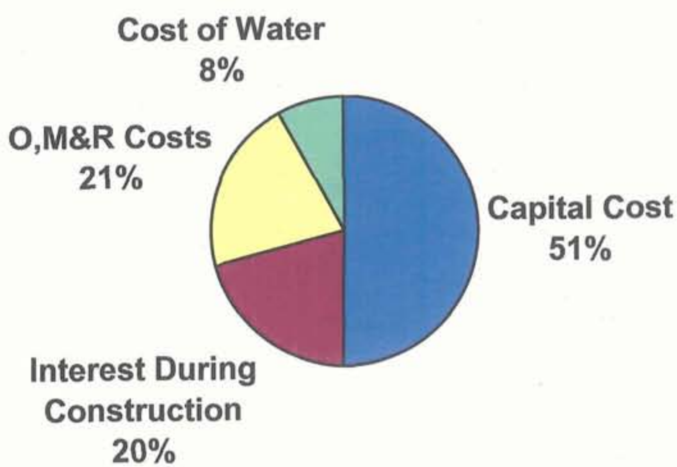


Figure 5
Navajo-Gallup Water Supply Project
NTUA Power Rates
Breakdown of Jicarilla Costs

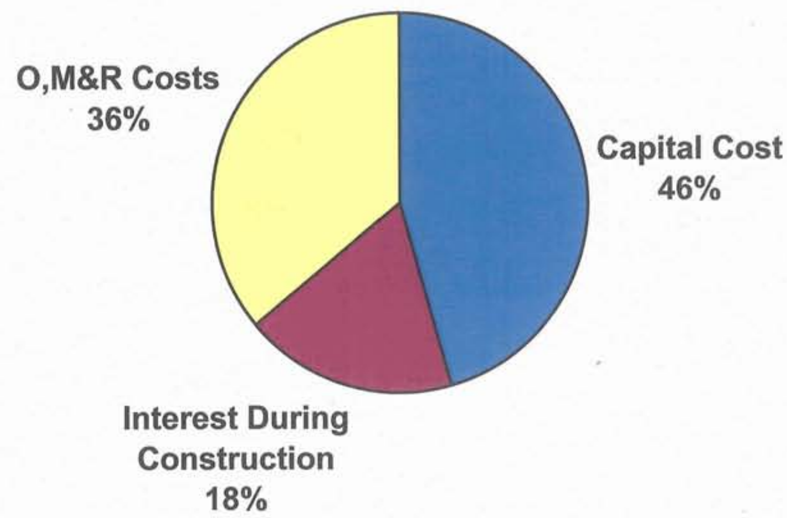
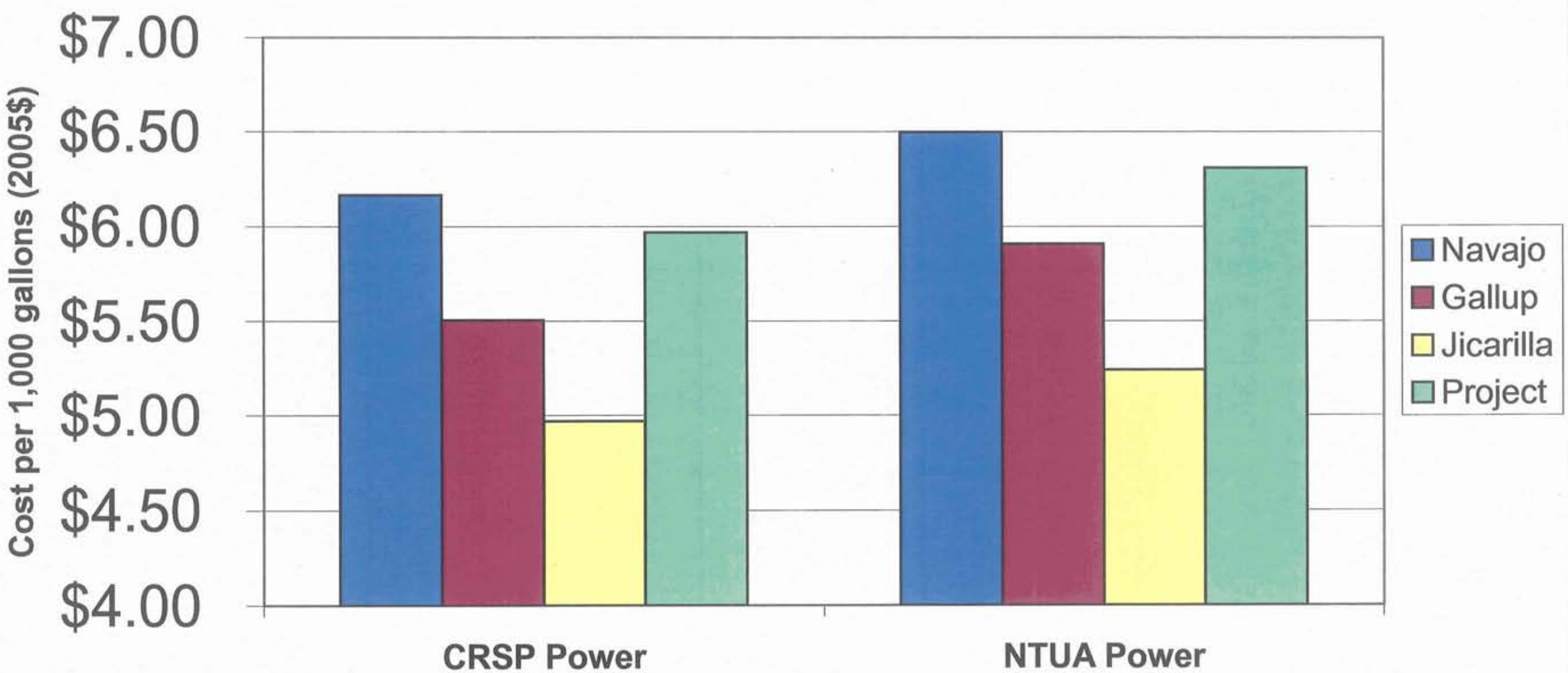


Figure 6
Navajo-Gallup Water Supply Project
Cost per Thousand Gallons
Federal Financing at 5.375%, Full Repayment



Note: these costs do not include non-Project facilities

5/9/2006

Table 1
Navajo - Gallup Water Supply Project 2040
San Juan PNM Alternative - $60 million/year Construction Schedule
Present Value of Total Costs (2005$)
5.375% Discount Rate, 50 Year Project Life

Total Capital Costs By User	Navajo	Gallup	Jicarilla	Total
Allocated Construction Costs - Main System	$530,300,000	$96,300,000	$25,600,000	$652,200,000
Allocated Capital Costs - Gallup Regional	$15,700,000	$25,300,000	$0	$41,000,000
Allocated Environmental Mitigation Cost	$3,100,000	$700,000	$100,000	$3,900,000
Allocated Cultural Resources Cost	$8,700,000	$1,900,000	$400,000	$11,000,000
Allocated Right-of-Way Cost	$5,500,000	$1,200,000	$300,000	$7,000,000
Total Project Capital Cost before Interest	$563,300,000	$125,400,000	$26,400,000	$715,100,000
Allocated Interest During Construction	$226,900,000	$50,500,000	$10,600,000	$288,100,000
Total Project Capital Cost	$790,200,000	$175,900,000	$37,000,000	$1,003,100,000
Rounded Values	$790,000,000	$176,000,000	$37,000,000	$1,003,000,000

Annual O,M&R Costs By User (at Design Capacity)

CRSP Rates	Navajo	Gallup	Jicarilla	Total
Allocated O,M&R Costs - Main System	$7,894,428	$1,723,449	$640,163	$10,258,040
Allocated O,M&R Costs - Gallup Regional	$160,000	$259,000	$0	$419,000
Annual Cost of Water	$171,051	$1,145,612	$0	$1,316,663
Total Allocated O,M&R Costs	$8,225,479	$3,128,061	$640,163	$11,993,703
Rounded Values	$8,200,000	$3,100,000	$600,000	$12,000,000

NTUA Rates	Navajo	Gallup	Jicarilla	Total
Allocated O,M&R Costs - Main System	$11,105,201	$2,672,307	$748,114	$14,525,622
Allocated O,M&R Costs - Gallup Regional	$181,000	$292,000	$0	$473,000
Annual Cost of Water	$171,051	$1,145,612	$0	$1,316,663
Total Allocated O,M&R Costs	$11,457,252	$4,109,919	$748,114	$16,315,285
Rounded Values	$11,500,000	$4,100,000	$700,000	$16,300,000

Present Value of Total O,M&R Costs By User

CRSP Rates	Navajo	Gallup	Jicarilla	Total
Allocated O,M&R Costs - Main System	$156,546,000	$31,322,000	$18,087,000	$205,955,000
Allocated O,M&R Costs - Gallup Regional	$2,767,000	$4,459,000	$0	$7,226,000
Cost of Water	$2,950,140	$19,758,536	$0	$22,708,677
Total Allocated O,M&R Costs	$162,263,140	$55,539,536	$18,087,000	$235,889,677
Rounded Values	$162,000,000	$56,000,000	$18,000,000	$236,000,000

NTUA Rates	Navajo	Gallup	Jicarilla	Total
Allocated O,M&R Costs - Main System	$206,675,000	$47,917,000	$20,967,000	$275,559,000
Allocated O,M&R Costs - Gallup Regional	$3,124,000	$5,034,000	$0	$8,158,000
Cost of Water	$2,950,140	$19,758,536	$0	$22,708,677
Total Allocated O,M&R Costs	$212,749,140	$72,709,536	$20,967,000	$306,425,677
Rounded Values	$213,000,000	$73,000,000	$21,000,000	$306,000,000

Note: Present value of O,M&R costs include fixed and variable O,M&R costs incurred for partial water delivery before project completion

Present Value of Total Capital and O,M&R Costs By User

CRSP Rates				
Capital	$790,000,000	$176,000,000	$37,000,000	$1,003,000,000
O,M&R (including cost of water)	$162,000,000	$56,000,000	$18,000,000	$236,000,000
Total All Costs	**$952,000,000**	**$232,000,000**	**$55,000,000**	**$1,239,000,000**

NTUA Rates				
Capital	$790,000,000	$176,000,000	$37,000,000	$1,003,000,000
O,M&R	$213,000,000	$73,000,000	$21,000,000	$306,000,000
Total All Costs	**$1,003,000,000**	**$249,000,000**	**$58,000,000**	**$1,309,000,000**

Table A1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Flow Capacities to Participants by Reach

San Juan Branch Number	Start	End	Pumping Plants	Peak Flow in Reach cfs	Peak Deliveries in Reach cfs	Allocation of Peak Flows By Reach: Navajo cfs	Gallup cfs	Jicarilla cfs	Navajo %	Gallup %	Jicarilla %
1	San Juan River	Water Treatment Plant (WTP)	River	59.18	0.00	45.71	13.47	0.00	0.7724	0.2276	0.0000
2	WTP	NAPI turnout	01	59.18	0.97	45.71	13.47	0.00	0.7724	0.2276	0.0000
3	NAPI	Shiprock Junction		58.21	6.72	44.74	13.47	0.00	0.7686	0.2314	0.0000
4	Shiprock J.	Sanostee turnout	02, 03	51.49	2.00	38.02	13.47	0.00	0.7384	0.2616	0.0000
5	Sanostee	Burnham Junction		49.49	0.27	36.02	13.47	0.00	0.7278	0.2722	0.0000
6	Burnham J.	Newcomb turnout		49.22	1.52	35.75	13.47	0.00	0.7263	0.2737	0.0000
7	Newcomb	Sheepsprings turnout	04	47.70	0.70	34.23	13.47	0.00	0.7176	0.2824	0.0000
8	Sheepsprings	Naschitti turnout	05	47.00	1.54	33.53	13.47	0.00	0.7134	0.2866	0.0000
9	Naschitti	Tohatchi turnout	06	45.46	1.99	31.99	13.47	0.00	0.7037	0.2963	0.0000
10	Tohatchi	Coyote Canyon Junction		43.47	5.06	30.00	13.47	0.00	0.6901	0.3099	0.0000
11	Coyote Canyon J.	Twin Lakes turnout	07	38.41	1.88	24.94	13.47	0.00	0.6493	0.3507	0.0000
12	Twin Lakes	Ya-ta-hey Junction	08	36.53	14.70	23.06	13.47	0.00	0.6313	0.3687	0.0000
13	Ya-ta-hey J.	Gallup Junction		21.83	13.47	8.36	13.47	0.00	0.3830	0.6170	0.0000
14	Gallup J.	Navajo Chapters		8.36	8.36	8.36	0.00	0.00	1.0000	0.0000	0.0000
					59.18						
10.1	Coyote Canyon J.	Coyote Canyon turnout	11	5.06	1.25	5.06	0.00	0.00	1.0000	0.0000	0.0000
10.2	Coyote Canyon	Standing Rock turnout	12	3.81	0.13	3.81	0.00	0.00	1.0000	0.0000	0.0000
10.3	Standing Rock	Dalton Pass turnout	13	3.68	3.68	3.68	0.00	0.00	1.0000	0.0000	0.0000
					5.06						
12.1	Ya-ta-hey J.	Rock Springs turnout	09	14.70	3.19	14.70	0.00	0.00	1.0000	0.0000	0.0000
12.2	Rock Springs	Window Rock turnout	10	11.51	11.51	11.51	0.00	0.00	1.0000	0.0000	0.0000
					14.70						

Cutter Branch Number	Start	End	Pumping Plants	Flow in Reach cfs	Deliveries in Reach cfs	Allocation of Peak Flows By Reach: Navajo cfs	Gallup cfs	Jicarilla cfs	Navajo %	Gallup %	Jicarilla %
21	NIIP Canal	WTP	Reservoir	8.34	0.00	6.19	0.00	2.15	0.7422	0.0000	0.2578
22	WTP	Huerfano turnout	01, 02, 03	8.34	0.50	6.19	0.00	2.15	0.7422	0.0000	0.2578
23	Huerfano	Nageezi turnout	04	7.84	1.05	5.69	0.00	2.15	0.7258	0.0000	0.2742
24	Nageezi	Jicarilla turnout	05	6.79	2.15	4.64	0.00	2.15	0.6834	0.0000	0.3166
25	Jicarilla	Counselor turnout	06	4.64	2.63	4.64	0.00	0.00	1.0000	0.0000	0.0000
26	Counselor	Torreon turnout		2.01	2.01	2.01	0.00	0.00	1.0000	0.0000	0.0000
					8.34						

Table B1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Total Capital Costs - Main System
Jan-05 $

		Navajo	Gallup	Jicarilla	Total
Allocated Capital Costs		$264,235,766	$47,981,089	$12,777,157	$324,994,013
Mobilization @	5%	$13,211,788	$2,399,054	$638,858	$16,249,701
Subtotal		$277,447,555	$50,380,144	$13,416,015	$341,243,713
Unlisted Items @	10%	$27,744,755	$5,038,014	$1,341,601	$34,124,371
Subtotal		$305,192,310	$55,418,158	$14,757,616	$375,368,084
Contingencies @	25%	$76,298,078	$13,854,539	$3,689,404	$93,842,021
Total Field Costs		$381,490,388	$69,272,697	$18,447,021	$469,210,106
Non-Contract Costs @	30%	$114,447,116	$20,781,809	$5,534,106	$140,763,032
Total Construction Costs		$495,937,504	$90,054,507	$23,981,127	$609,973,137
Taxes on Field Cost @	9%	$34,334,135	$6,234,543	$1,660,232	$42,228,910
Total with Taxes		$530,271,639	$96,289,049	$25,641,359	$652,202,047
Rounded Total		$530,300,000	$96,300,000	$25,600,000	$652,200,000

Note: The costs in this table exclude the cost for the Gallup Regional System, which are shown in Table C1. The costs also exclude the environmental mitigation, cultural resourcs, right-of-way acquisition and interest during construction costs, which are shown in Table 1.

Table B2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Total Capital Costs by Participant
Jan-05 $

		Joint Costs							Dedicated Costs			Total Costs		
San Juan Branch		Total	Allocation Ratios			Allocated Joint Costs								
Reach	End	Joint Costs	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla
1	Water Treatment Plant (WTP)	$41,796,965	0.7724	0.2276	-	$32,283,529	$9,513,436	$0	$0	$0	$0	$32,283,529	$9,513,436	$0
2	NAPI turnout	$6,471,016	0.7724	0.2276	-	$4,998,143	$1,472,872	$0	$0	$0	$0	$4,998,143	$1,472,872	$0
3	Shiprock Junction	$18,501,899	0.7686	0.2314	-	$14,220,494	$4,281,405	$0	$0	$0	$0	$14,220,494	$4,281,405	$0
4	Sanostee turnout	$26,968,471	0.7384	0.2616	-	$19,913,406	$7,055,065	$0	$3,280,000	$0	$0	$23,193,406	$7,055,065	$0
5	Burnham Junction	$10,043,769	0.7278	0.2722	-	$7,310,094	$2,733,675	$0	$0	$0	$0	$7,310,094	$2,733,675	$0
6	Newcomb turnout	$5,178,155	0.7263	0.2737	-	$3,761,053	$1,417,102	$0	$2,520,000	$0	$0	$6,281,053	$1,417,102	$0
7	Sheepsprings turnout	$14,199,125	0.7176	0.2824	-	$10,189,435	$4,009,690	$0	$1,430,000	$0	$0	$11,619,435	$4,009,690	$0
8	Naschitti turnout	$9,909,254	0.7134	0.2866	-	$7,069,304	$2,839,950	$0	$2,670,000	$0	$0	$9,739,304	$2,839,950	$0
9	Tohatchi turnout	$20,974,030	0.7037	0.2963	-	$14,759,332	$6,214,698	$0	$3,280,000	$0	$0	$18,039,332	$6,214,698	$0
10	Coyote Canyon Junction	$5,750,137	0.6901	0.3099	-	$3,968,348	$1,781,788	$0	$0	$0	$0	$3,968,348	$1,781,788	$0
11	Twin Lakes turnout	$5,968,759	0.6493	0.3507	-	$3,875,575	$2,093,184	$0	$2,930,000	$0	$0	$6,805,575	$2,093,184	$0
12	Ya-ta-hey Junction	$7,869,756	0.6313	0.3687	-	$4,967,878	$2,901,878	$0	$0	$0	$0	$4,967,878	$2,901,878	$0
13	Gallup Junction	$2,700,544	0.3830	0.6170	-	$1,034,198	$1,666,346	$0	$0	$0	$0	$1,034,198	$1,666,346	$0
14	Navajo Chapters	$507,825	1.0000	-	-	$507,825	$0	$0	$13,400,000	$0	$0	$13,907,825	$0	$0
										$0	$0			
10.1	Coyote Canyon turnout	$4,434,735	1.0000	-	-	$4,434,735	$0	$0	$2,250,000	$0	$0	$6,684,735	$0	$0
10.2	Standing Rock turnout	$7,574,548	1.0000	-	-	$7,574,548	$0	$0	$460,000	$0	$0	$8,034,548	$0	$0
10.3	Dalton Pass turnout	$2,580,221	1.0000	-	-	$2,580,221	$0	$0	$4,550,000	$0	$0	$7,130,221	$0	$0
										$0	$0			
12.1	Rock Springs turnout	$4,627,368	1.0000	-	-	$4,627,368	$0	$0	$4,680,000	$0	$0	$9,307,368	$0	$0
12.2	Window Rock turnout	$8,040,436	1.0000	-	-	$8,040,436	$0	$0	$15,100,000	$0	$0	$23,140,436	$0	$0
Cutter Branch														
Reach	End													
21	WTP	$8,157,420	0.7422	-	0.2578	$6,054,488	$0	$2,102,932	$0	$0	$0	$6,054,488	$0	$2,102,932
22	Huerfano turnout	$22,690,037	0.7422	-	0.2578	$16,840,687	$0	$5,849,350	$1,100,000	$0	$0	$17,940,687	$0	$5,849,350
23	Nageezi turnout	$6,206,378	0.7258	-	0.2742	$4,504,374	$0	$1,702,004	$1,840,000	$0	$0	$6,344,374	$0	$1,702,004
24	Jicarilla turnout	$9,862,462	0.6834	-	0.3166	$6,739,591	$0	$3,122,871	$0	$0	$0	$6,739,591	$0	$3,122,871
25	Counselor turnout	$5,215,426	1.0000	-	-	$5,215,426	$0	$0	$3,200,000	$0	$0	$8,415,426	$0	$0
26	Torreon turnout	$2,895,276	1.0000	-	-	$2,895,276	$0	$0	$3,180,000	$0	$0	$6,075,276	$0	$0
	Total	$259,124,013				$198,365,766	$47,981,089	$12,777,157	$65,870,000	$0	$0	$264,235,766	$47,981,089	$12,777,157

Grand Total $324,994,013

This table allocates the capital costs shown in Table B3 using the allocation percentages developed in Table A1.

Table B3
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Total Capital Costs by Reach
Jan-05 $

		Joint Costs					*Dedicated Costs*		
San Juan Branch									
Reach	End	Diversion Str. & Water Treatment	Pipeline	Tanks & Pumping Plants	Transm. Lines	Total	Navajo	Gallup	Jicarilla
1	Water Treatment Plant (WTP)	$40,240,555	$0	$1,300,000	$256,410	$41,796,965	$0	$0	$0
2	NAPI turnout	$0	$2,062,306	$4,230,000	$178,710	$6,471,016	$0	$0	$0
3	Shiprock Junction	$0	$18,271,899	$230,000	$0	$18,501,899	$0	$0	$0
4	Sanostee turnout	$0	$20,349,486	$6,160,000	$458,985	$26,968,471	$3,280,000	$0	$0
5	Burnham Junction	$0	$10,043,769	$0	$0	$10,043,769	$0	$0	$0
6	Newcomb turnout	$0	$3,858,141	$0	$1,320,014	$5,178,155	$2,520,000	$0	$0
7	Sheepsprings turnout	$0	$10,733,526	$2,480,000	$985,599	$14,199,125	$1,430,000	$0	$0
8	Naschitti turnout	$0	$5,252,164	$2,230,000	$2,427,090	$9,909,254	$2,670,000	$0	$0
9	Tohatchi turnout	$0	$16,986,678	$2,930,000	$1,057,352	$20,974,030	$3,280,000	$0	$0
10	Coyote Canyon Junction	$0	$5,379,019	$0	$371,118	$5,750,137	$0	$0	$0
11	Twin Lakes turnout	$0	$2,516,748	$2,430,000	$1,022,011	$5,968,759	$2,930,000	$0	$0
12	Ya-ta-hey Junction	$0	$5,011,046	$2,680,000	$178,710	$7,869,756	$0	$0	$0
13	Gallup Junction	$0	$2,383,979	$215,000	$101,565	$2,700,544	$0	$0	$0
14	Navajo Chapters	$0	$0	$0	$507,825	$507,825	$13,400,000	$0	$0
10.1	Coyote Canyon turnout	$0	$3,624,460	$530,000	$280,275	$4,434,735	$2,250,000	$0	$0
10.2	Standing Rock turnout	$0	$6,559,273	$735,000	$280,275	$7,574,548	$460,000	$0	$0
10.3	Dalton Pass turnout	$0	$1,719,946	$580,000	$280,275	$2,580,221	$4,550,000	$0	$0
12.1	Rock Springs turnout	$0	$3,277,093	$1,070,000	$280,275	$4,627,368	$4,680,000	$0	$0
12.2	Window Rock turnout	$0	$5,646,502	$1,080,000	$1,313,934	$8,040,436	$15,100,000	$0	$0
Cutter Branch									
Reach	End								
21	WTP	$8,079,720	$0	$0	$77,700	$8,157,420	$0	$0	$0
22	Huerfano turnout	$0	$13,226,330	$2,650,000	$6,813,707	$22,690,037	$1,100,000	$0	$0
23	Nageezi turnout	$0	$5,196,103	$730,000	$280,275	$6,206,378	$1,840,000	$0	$0
24	Jicarilla turnout	$0	$6,329,402	$1,020,000	$2,513,060	$9,862,462	$0	$0	$0
25	Counselor turnout	$0	$3,690,497	$850,000	$674,930	$5,215,426	$3,200,000	$0	$0
26	Torreon turnout	$0	$2,793,711	$0	$101,565	$2,895,276	$3,180,000	$0	$0
	Total	$48,320,275	$154,912,077	$34,130,000	$21,761,661	$259,124,013	$65,870,000	$0	$0

This table summarizes Joint and Dedicated Costs detailed in Tables B4, B5, B6 and B7.

Table B4
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Pumping Plant and Tank Costs by Reach
Jan-05 $

					Joint Costs					*Dedicated Costs*								
San Juan Branch		No.	No.	No.	Pipeline Pumping	Forebay	Air	Water Regualting		Storage Tanks			Service Area Pumping Plants			Total		
Reach	End	WTP	Turnouts	Pump P.	Plants	Tanks	Chambers	Tanks	Total	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla
1	Water Treatment Plant (WTP)	1	0	0	$1,300,000	$0	$0		$1,300,000							$0	$0	$0
2	NAPI turnout	0	0	1	$4,000,000	$80,000	$150,000		$4,230,000							$0	$0	$0
3	Shiprock Junction	0	0	0		$0	$0	$230,000	$230,000							$0	$0	$0
4	Sanostee turnout	0	1	2	$5,700,000	$160,000	$300,000		$6,160,000	$3,100,000			$180,000			$3,280,000	$0	$0
5	Burnham Junction	0	0	0		$0	$0		$0							$0	$0	$0
6	Newcomb turnout	0	1	0		$0	$0		$0	$2,350,000			$170,000			$2,520,000	$0	$0
7	Sheepsprings turnout	0	1	1	$2,250,000	$80,000	$150,000		$2,480,000	$1,300,000			$130,000			$1,430,000	$0	$0
8	Naschitti turnout	0	1	1	$2,000,000	$80,000	$150,000		$2,230,000	$2,500,000			$170,000			$2,670,000	$0	$0
9	Tohatchi turnout	0	1	1	$2,700,000	$80,000	$150,000		$2,930,000	$3,100,000			$180,000			$3,280,000	$0	$0
10	Coyote Canyon Junction	0	0	0		$0	$0		$0							$0	$0	$0
11	Twin Lakes turnout	0	1	1	$2,200,000	$80,000	$150,000		$2,430,000	$2,750,000			$180,000			$2,930,000	$0	$0
12	Ya-ta-hey Junction	0	0	1	$2,450,000	$80,000	$150,000		$2,680,000							$0	$0	$0
13	Gallup Junction	0	1	0	$0	$0	$0	$215,000	$215,000							$0	$0	$0
14	Navajo Chapters	0	5	0		$0	$0		$0	$12,550,000			$850,000			$13,400,000	$0	$0
10.1	Coyote Canyon turnout	0	1	1	$300,000	$80,000	$150,000		$530,000	$2,100,000			$150,000			$2,250,000	$0	$0
10.2	Standing Rock turnout	0	1	1	$310,000	$80,000	$150,000	$195,000	$735,000	$360,000			$100,000			$460,000	$0	$0
10.3	Dalton Pass turnout	0	1	1	$350,000	$80,000	$150,000		$580,000	$4,300,000			$250,000			$4,550,000	$0	$0
12.1	Rock Springs turnout	0	1	1	$840,000	$80,000	$150,000		$1,070,000	$4,450,000			$230,000			$4,680,000	$0	$0
12.2	Window Rock turnout	0	1	1	$650,000	$80,000	$150,000	$200,000	$1,080,000	$14,600,000			$500,000			$15,100,000	$0	$0
Cutter Branch																		
Reach	End																	
21	WTP	1	0	0		$0	$0		$0							$0	$0	$0
22	Huerfano turnout	0	1	3	$1,960,000	$240,000	$450,000		$2,650,000	$980,000			$120,000			$1,100,000	$0	$0
23	Nageezi turnout	0	1	1	$500,000	$80,000	$150,000		$730,000	$1,700,000			$140,000			$1,840,000	$0	$0
24	Jicarilla turnout	0	0	1	$600,000	$80,000	$150,000	$190,000	$1,020,000							$0	$0	$0
25	Counselor turnout	0	1	1	$430,000	$80,000	$150,000	$190,000	$850,000	$3,000,000			$200,000			$3,200,000	$0	$0
26	Torreon turnout	0	1	0	$0	$0	$0		$0	$3,000,000			$180,000			$3,180,000	$0	$0
	Total	2	21	19	$28,540,000	$1,520,000	$2,850,000	$1,220,000	$34,130,000	$62,140,000	$0	$0	$3,730,000	$0	$0	$65,870,000	$0	$0

Cost per Unit

Forebay Tanks	$80,000
Air Chambers	$150,000

Table B5
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Pipeline Costs by Reach
Jan-05 $

San Juan Branch Reach	End	Total Excavation cubic yards	Soil Cement Embedment cubic yards	Backfill cubic yards	Joint Costs: Total Excavation $	Soil Cement Embedment $	Backfill $	Butterfly Valves $	Pipeline $	Total
1	Water Treatment Plant (WTP)				$0	$0	$0	$0	$0	$0
2	NAPI turnout	22,720	4,385	13,991	$81,906	$263,087	$34,978	$43,000	$1,639,334	$2,062,306
3	Shiprock Junction	258,690	49,923	159,300	$932,583	$2,995,359	$398,251	$387,000	$13,558,706	$18,271,899
4	Sanostee turnout	267,961	51,713	165,008	$966,006	$3,102,760	$412,521	$408,500	$15,459,699	$20,349,486
5	Burnham Junction	145,024	27,987	89,305	$522,815	$1,679,249	$223,261	$215,000	$7,403,444	$10,043,769
6	Newcomb turnout	54,217	10,463	33,387	$195,454	$627,775	$83,468	$86,000	$2,865,445	$3,858,141
7	Sheepsprings turnout	135,808	26,168	85,199	$489,591	$1,570,096	$212,997	$215,000	$8,245,842	$10,733,526
8	Naschitti turnout	70,620	15,148	42,763	$254,587	$908,866	$106,908	$129,000	$3,852,803	$5,252,164
9	Tohatchi turnout	241,956	45,020	154,240	$872,257	$2,701,178	$385,601	$354,000	$12,673,642	$16,986,678
10	Coyote Canyon Junction	80,687	15,480	51,629	$290,878	$928,779	$129,073	$112,000	$3,918,288	$5,379,019
11	Twin Lakes turnout	35,803	6,815	23,397	$129,071	$408,919	$58,492	$48,000	$1,872,266	$2,516,748
12	Ya-ta-hey Junction	71,559	13,621	46,762	$257,972	$817,235	$116,906	$96,000	$3,722,933	$5,011,046
13	Gallup Junction	37,248	6,904	25,973	$134,280	$414,218	$64,933	$30,000	$1,740,548	$2,383,979
14	Navajo Chapters				$0	$0	$0	$0	$0	$0
10.1	Coyote Canyon turnout	52,013	9,309	37,829	$187,508	$558,549	$94,572	$37,800	$2,746,032	$3,624,460
10.2	Standing Rock turnout	108,432	19,695	80,284	$390,900	$1,181,685	$200,711	$86,400	$4,699,578	$6,559,273
10.3	Dalton Pass turnout	28,983	4,295	22,932	$104,484	$257,679	$57,331	$17,600	$1,282,851	$1,719,946
12.1	Rock Springs turnout	53,238	9,868	37,124	$191,924	$592,089	$92,810	$45,000	$2,355,270	$3,277,093
12.2	Window Rock turnout	95,688	17,455	68,047	$344,957	$1,047,303	$170,117	$77,400	$4,006,724	$5,646,502
		1,760,647	334,247	1,137,172						
Cutter Branch Reach	End									
21	WTP				$0	$0	$0	$0	$0	$0
22	Huerfano turnout	192,709	34,512	137,970	$694,720	$2,070,709	$344,925	$130,400	$9,985,575	$13,226,330
23	Nageezi turnout	88,749	15,884	63,162	$319,942	$953,051	$157,905	$64,800	$3,700,405	$5,196,103
24	Jicarilla turnout	110,898	18,269	80,964	$399,790	$1,096,119	$202,411	$83,800	$4,547,282	$6,329,402
25	Counselor turnout	66,894	9,912	51,239	$241,154	$594,737	$128,097	$39,600	$2,686,908	$3,690,497
26	Torreon turnout	55,295	7,754	44,158	$199,340	$465,220	$110,396	$37,400	$1,981,356	$2,793,711
	Total	2,275,192	420,578	1,514,665	$8,202,119	$25,234,662	$3,786,663	$2,743,700	$114,944,932	$154,912,077

Cost per Unit

Rock Excavation, per cy	$10.00	Total Excavation, cy	2,275,192
Common Excavation, per cy	$3.00	Rock Excavation, cy	196,649
Average Excavation cost, per cy	$3.61	Rock/Total, ratio	0.0864
Backfill, per cy	$2.50		

Table B6
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Transmission Line Costs by Reach
Jan-05 $

						Joint Costs							
San Juan Branch		No.	No.	No.	Miles		Elect.						
Reach	End	WTP	Turnouts	Pump P.	Trans Ln	Trans. Ln	Equip	SCADA	Comm.	Security	Pwr Tap	Other	Total
1	Water Treatment Plant (WTP)	1	0	1		$0	$155,400	$5,550	$22,200	$6,660	$66,600		$256,410
2	NAPI turnout	0	0	1		$0	$77,700	$5,550	$22,200	$6,660	$66,600		$178,710
3	Shiprock Junction	0	0	0		$0	$0	$0	$0	$0	$0		$0
4	Sanostee turnout	0	1	2		$0	$162,615	$16,650	$66,600	$13,320	$199,800		$458,985
5	Burnham Junction	0	0	0		$0	$0	$0	$0	$0	$0		$0
6	Newcomb turnout	0	1	0	10.11	$1,218,449	$7,215	$5,550	$22,200	$0	$66,600		$1,320,014
7	Sheepsprings turnout	0	1	1	5.85	$705,324	$84,915	$11,100	$44,400	$6,660	$133,200		$985,599
8	Naschitti turnout	0	1	1	17.82	$2,146,815	$84,915	$11,100	$44,400	$6,660	$133,200		$2,427,090
9	Tohatchi turnout	0	1	1	6.45	$777,077	$84,915	$11,100	$44,400	$6,660	$133,200		$1,057,352
10	Coyote Canyon Junction	0	0	0	3.08	$371,118	$0	$0	$0	$0	$0		$371,118
11	Twin Lakes turnout	0	1	1	6.16	$741,736	$84,915	$11,100	$44,400	$6,660	$133,200		$1,022,011
12	Ya-ta-hey Junction	0	0	1		$0	$77,700	$5,550	$22,200	$6,660	$66,600		$178,710
13	Gallup Junction	0	1	0		$0	$7,215	$5,550	$22,200	$0	$66,600		$101,565
14	Navajo Chapters	0	5	0		$0	$36,075	$27,750	$111,000	$0	$333,000		$507,825
10.1	Coyote Canyon turnout	0	1	1		$0	$84,915	$11,100	$44,400	$6,660	$133,200		$280,275
10.2	Standing Rock turnout	0	1	1		$0	$84,915	$11,100	$44,400	$6,660	$133,200		$280,275
10.3	Dalton Pass turnout	0	1	1		$0	$84,915	$11,100	$44,400	$6,660	$133,200		$280,275
12.1	Rock Springs turnout	0	1	1		$0	$84,915	$11,100	$44,400	$6,660	$133,200		$280,275
12.2	Window Rock turnout	0	1	1	5.82	$700,659	$84,915	$11,100	$44,400	$6,660	$133,200	$333,000	$1,313,934
Cutter Branch													
Reach	End												
21	WTP	1	0	0		$0	$77,700	$0	$0	$0	$0		$77,700
22	Huerfano turnout	0	1	3	42.05	$5,066,012	$240,315	$22,200	$88,800	$19,980	$266,400	$1,110,000	$6,813,707
23	Nageezi turnout	0	1	1		$0	$84,915	$11,100	$44,400	$6,660	$133,200		$280,275
24	Jicarilla turnout	0	0	1	19.38	$2,334,350	$77,700	$5,550	$22,200	$6,660	$66,600		$2,513,060
25	Counselor turnout	0	1	1	3.28	$394,655	$84,915	$11,100	$44,400	$6,660	$133,200		$674,930
26	Torreon turnout	0	1	0	0.00	$0	$7,215	$5,550	$22,200	$0	$66,600		$101,565
	Total	2	21	20	120.00	$14,456,196	$1,860,915	$227,550	$910,200	$133,200	$2,730,600	$1,443,000	$21,761,661

Cost per unit

Transimission line per mile	$120,468
Electrical equipment per pumping plant	$77,700
Electrical equipment per WTP	$77,700
Electrical equipment per turnout	$7,215
SCADA equipment per pp and turnout	$5,550
SCADA system for Ft. Defiance	$333,000
Comm. equipment per pp and turnout	$22,200
Sceurity system per pp	$6,660
Substation near Huerfano	$1,110,000
Power tap poles per pp and turnout	$66,600

4/26/2006

Table B7
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Dam, Diversion Structure, Wells and Water Treatment Costs by Reach
Jan-05 $

		Joint Costs				
San Juan Branch						
Reach	End	Dams	Diversion Structures	Wells	Water Treatment Plants	Total
1	Water Treatment Plant (WTP)		$1,778,494		$38,462,061	$40,240,555
2	NAPI turnout					$0
3	Shiprock Junction					$0
4	Sanostee turnout					$0
5	Burnham Junction					$0
6	Newcomb turnout					$0
7	Sheepsprings turnout					$0
8	Naschitti turnout					$0
9	Tohatchi turnout					$0
10	Coyote Canyon Junction					$0
11	Twin Lakes turnout					$0
12	Ya-ta-hey Junction					$0
13	Gallup Junction					$0
14	Navajo Chapters					$0
10.1	Coyote Canyon turnout					$0
10.2	Standing Rock turnout					$0
10.3	Dalton Pass turnout					$0
12.1	Rock Springs turnout					$0
12.2	Window Rock turnout					$0
Cutter Branch						
Reach	End					
21	WTP				$8,079,720	$8,079,720
22	Huerfano turnout					$0
23	Nageezi turnout					$0
24	Jicarilla turnout					$0
25	Counselor turnout					$0
26	Torreon turnout					$0
	Total	$0	$1,778,494	$0	$46,541,781	$48,320,275

Table B8
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2020
Allocation of Environmental Mitiagation, Cultural Resources and Right-of-Way Costs
Jan-05 $

	Main Navajo-Gallup Pipeline Project				Gallup Regional Water Supply System				
	Navajo	Gallup	Jicarilla	Total	Navajo	Gallup	Jicarilla	Total	Total
Total Field Costs	$381,500,000	$69,300,000	$18,400,000	$469,200,000	$11,600,000	$18,600,000	$0	$30,200,000	$499,400,000
% Distribution of Field Costs	76.39%	13.88%	3.68%	93.95%	2.32%	3.72%	0.00%	6.05%	100.00%
Environmental Mitigation Costs	$3,055,667	$555,066	$147,377	$3,758,110	$92,911	$148,979	$0	$241,890	$4,000,000
Cultural Resources Costs	$8,403,084	$1,526,432	$405,286	$10,334,802	$255,507	$409,692	$0	$665,198	$11,000,000
Right-of-Way Costs	$5,347,417	$971,366	$257,909	$6,576,692	$162,595	$260,713	$0	$423,308	$7,000,000
Total	$16,806,167	$3,052,863	$810,573	$20,669,604	$511,013	$819,383	$0	$1,330,396	$22,000,000
Total (rounded)	$16,810,000	$3,050,000	$810,000	$20,670,000	$510,000	$820,000	$0	$1,330,000	$22,000,000

Notes: Environmental mitigation costs estimated at $4,000,000 (Jan. 05 $) and allocated between systems and among users by share of field costs.
Cultural resources costs estimated at $11,000,000 (Jan. 05 $) and allocated between systems and among users by share of field costs.
Right-of-way costs consist of land purchased from private parties for the water treatment plants, cost of relocating Navajo families who live in the pipeline route, and administration costs, totalling $7,000,000 (Jan. 05 $). These costs are allocated between systems and among users by share of field costs. It is assumed that both the Navajo Nation and the City of Gallup will contribute any other land needed for their respective systems.
Environmental mitigation costs, cultural resource costs and right-of-way costs include allowances for contingencies, non-contract costs and taxes.

Table B9
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Interest During Construction
5.375% Discount Rate
Jan-05 $

CONSTRUCTION SCHEDULE
Costs in millions

Scenario 1 - $60 million/year Schedule

	Year														
Construction phase	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
NGWSP Project	$3.92	$14.03	0.28												$18.23
Cutter Lateral	$7.89	$4.04	$38.84	$32.58	$11.92										$95.27
Twin Lakes/ Window Rock	$0.86	$0.23				$32.12	$10.63								$43.84
Cutter Power	$1.37	$0.89	$2.73	$8.00	$8.00										$20.99
San Juan Power	$0.82	$1.62	$0.01				$4.50	$15.73							$22.68
Gallup Regional System	$2.56	$3.33	$1.96		$32.62	$27.90									$68.37
San Juan Lateral		$8.43	$15.53	$12.16					$35.00	$60.00	$60.00	$59.94	$50.00		$301.06
San Juan Pumping Plant		$3.89	$1.27				$19.67	$23.00							$47.83
San Juan Water Treatment Plant	$5.95	$2.76					$25.00	$22.04	$25.00						$80.75
Cutter Water Treatment Plant	$1.24	$0.51		$7.00	$7.46										$16.21
TOTAL Allocated Spending	$24.61	$39.73	$60.62	$59.74	$60.00	$60.02	$59.80	$60.77	$60.00	$60.00	$60.00	$59.94	$50.00	$0.00	$715.23
Percent Distribution	3.44%	5.55%	8.48%	8.35%	8.39%	8.39%	8.36%	8.50%	8.39%	8.39%	8.39%	8.38%	6.99%	0.00%	100.00%
Overall Spending	$24.61	$39.72	$60.61	$59.73	$59.99	$60.01	$59.79	$60.76	$59.99	$59.99	$59.99	$59.93	$49.99	$0.00	$715.10
Interest During Construction to January 1 of year 14	$22.74	$32.81	$44.41	$38.49	$33.63	$28.86	$24.24	$20.27	$15.94	$12.06	$8.39	$4.90	$1.33	$0.00	$288.06

Note: The construction schedule assumes that annual appropriations will be indexed to keep in step with construction cost trends.

Table C1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Gallup Regional System Capital Costs
Jan-05 $

Category	Total Cost	Joint Cost	Allocation Factors		Allocated Joint Costs		Total Costs	
			Gallup	Navajo	Gallup	Navajo	Gallup	Navajo
Excavation, common	$406,800	$406,800	0.6170	0.3830	$251,012	$155,788	$251,012	$155,788
Excavation, rock	$240,000	$240,000	0.6170	0.3830	$148,090	$91,910	$148,090	$91,910
Backfill	$306,750	$306,750	0.6170	0.3830	$189,277	$117,473	$189,277	$117,473
Soil Cement Embedment	$1,398,000	$1,398,000	0.6170	0.3830	$862,623	$535,377	$862,623	$535,377
Pipeline	$6,891,812	$6,891,812	0.6170	0.3830	$4,252,529	$2,639,283	$4,252,529	$2,639,283
Crossings and borings	$1,000,000	$1,000,000	0.6170	0.3830	$617,041	$382,959	$617,041	$382,959
Water Storage Tanks	$8,650,000	$8,650,000	0.6170	0.3830	$5,337,403	$3,312,597	$5,337,403	$3,312,597
Pumping Plants	$1,230,000	$1,230,000	0.6170	0.3830	$758,960	$471,040	$758,960	$471,040
Valve & Metering Sta.	$637,100	$637,100	0.6170	0.3830	$393,117	$243,983	$393,117	$243,983
Surge Control	$150,000	$150,000	0.6170	0.3830	$92,556	$57,444	$92,556	$57,444
Subtotal	$20,910,462	$20,910,462			$12,902,608	$8,007,854	$12,902,608	$8,007,854
Mobilization @5%	$1,045,523						$645,130	$400,393
Subtotal	$21,955,985						$13,547,738	$8,408,247
Unlisted @10%	$2,195,599						$1,354,774	$840,825
Subtotal	$24,151,584						$14,902,512	$9,249,072
Contingency @25%	$6,037,896						$3,725,628	$2,312,268
Total Field Cost	$30,189,480						$18,628,140	$11,561,340
Non-Contract Costs @30%	$9,056,844						$5,588,442	$3,468,402
Total Construction Costs	$39,246,323						$24,216,582	$15,029,742
Taxes @6% of Field Cost	$1,811,369						$1,117,688	$693,680
Total with Taxes	$41,057,692						$25,334,270	$15,723,422
Rounded Total	$41,100,000						$25,300,000	$15,700,000

Note: The costs in this table include only the cost for the Gallup Regional System. The costs for the main water supply pipeline are shown in Table B1. The costs also exclude the environmental mitigation, cultural resources, right-of-way acquisition and interest during construction costs, which are shown in Table 1.

Table C2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Gallup Regional System O,M & R Costs
Jan-05 $

							Present Value @	5.375%		
	Annual	Allocation Factors			Allocated Annual Cost			Allocated Present Value Cost		
	Cost	Gallup	Navajo		Gallup	Navajo		Gallup	Navajo	Total
CRSP Rates	$419,000	0.6170	0.3830		$258,540	$160,460		$4,459,078	$2,767,475	$7,226,553
				rounded	$259,000	$160,000	rounded	$4,459,000	$2,767,000	$7,227,000
NTUA Rate	$473,000	0.6170	0.3830		$291,860	$181,140		$5,033,756	$3,124,143	$8,157,899
				rounded	$292,000	$181,000	rounded	$5,034,000	$3,124,000	$8,158,000

Table C3 - Scenario 1 $60 million/yr Construction Schedule
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Cost of Water to City of Gallup
Jan-05 $

Event	Year	Cost to Gallup $/af	PV @ 5.375%
	2006	$36	$80
	2007	$38	$80
Construction Begins	2008	$41	$80
	2009	$43	$80
	2010	$45	$80
	2011	$47	$80
	2012	$50	$80
	2013	$53	$80
	2014	$55	$80
	2015	$58	$80
	2016	$62	$80
	2017	$65	$80
	2018	$68	$80
	2019	$72	$80
Project Completion	2020	$76	$80
Full Gallup Water Use	2021	$80	$80
	2022	$80	$76
	2023	$80	$72
	2024	$80	$68
	2025	$80	$65
	2026	$80	$62
	2027	$80	$58
	2028	$80	$55
	2029	$80	$53
	2030	$80	$50
	2031	$80	$47
	2032	$80	$45
	2033	$80	$43
	2034	$80	$41
	2035	$80	$38
	2036	$80	$36
	2037	$80	$35
	2038	$80	$33
	2039	$80	$31
	2040	$80	$30
	2041	$80	$28
	2042	$80	$27
	2043	$80	$25
	2044	$80	$24
	2045	$80	$23
	2046	$80	$22
	2047	$80	$21
	2048	$80	$19
	2049	$80	$18
	2050	$80	$18
	2051	$80	$17
	2052	$80	$16
	2053	$80	$15
	2054	$80	$14
	2055	$80	$13
	2056	$80	$13
	2057	$80	$12
	2058	$80	$12
	2059	$80	$11
	2060	$80	$10
	2061	$80	$10
	2062	$80	$9
	2063	$80	$9
	2064	$80	$8
	2065	$80	$8
	2066	$80	$8
	2067	$80	$7
		Total per acre-foot	$2,634
		Total for 7500 af	$19,758,536
Present Values as of	2021		

Note: The City of Gallup has not yet reached an agreement with the Jicarilla Apache Nation on the terms of a long-term water lease. For purposes of this report we have assumed that the price will be $80 per acre-foot (in 2005$), beginning when the City begins taking water in the year 2021. We also assume that prior to that time the City will pay an annual option fee equivalent in present value to the price for water in 2021. The City and the Jicarilla Nation may agree on terms very different from these.

Table D1- Scenario 1 - $60 million/year Construction Schedule
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Summary of Annual O,M&R Charges by User
Project Completion In 2021
Jan-05 $

CRSP Power Rate

	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Navajo	Fixed	$0	$0	$0	$1,670,058	$1,670,058	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$5,301,442	$5,301,442
	Variable	$0	$0	$0	$152,911	$156,683	$193,027	$196,815	$200,696	$204,673	$208,749	$212,926	$1,630,341	$1,670,618
	Total	$0	$0	$0	$1,822,969	$1,826,741	$2,285,623	$2,289,411	$2,293,292	$2,297,269	$2,301,345	$2,305,522	$6,931,783	$6,972,060
Gallup	Fixed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$998,668	$998,668
	Variable	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$724,781	$724,781
	Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,723,449	$1,723,449
Jicarilla	Fixed	$0	$0	$0	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378
	Variable	$0	$0	$0	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$101,785	$101,785
	Total	$0	$0	$0	$632,662	$632,662	$632,662	$632,662	$632,662	$632,662	$632,662	$632,662	$640,163	$640,163
Total	Fixed	$0	$0	$0	$2,208,436	$2,208,436	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$6,838,488	$6,838,488
	Variable	$0	$0	$0	$247,195	$250,967	$287,311	$291,099	$294,980	$298,957	$303,033	$307,210	$2,456,907	$2,497,184
	Total	$0	$0	$0	$2,455,631	$2,459,403	$2,918,285	$2,922,073	$2,925,954	$2,929,931	$2,934,007	$2,938,184	$9,295,395	$9,335,672
	Rounded	$0	$0	$0	$2,456,000	$2,459,000	$2,918,000	$2,922,000	$2,926,000	$2,930,000	$2,934,000	$2,938,000	$9,295,000	$9,336,000

NTUA Power Rate

	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Navajo	Fixed	$0	$0	$0	$1,670,058	$1,670,058	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$2,092,596	$5,301,442	$5,301,442
	Variable	$0	$0	$0	$338,397	$346,730	$451,326	$459,562	$468,002	$476,651	$485,514	$494,597	$3,650,792	$3,740,872
	Total	$0	$0	$0	$2,008,455	$2,016,788	$2,543,922	$2,552,158	$2,560,597	$2,569,246	$2,578,110	$2,587,193	$8,952,234	$9,042,314
Gallup	Fixed	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$998,668	$998,668
	Variable	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,673,639	$1,673,639
	Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2,672,307	$2,672,307
Jicarilla	Fixed	$0	$0	$0	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378
	Variable	$0	$0	$0	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$209,736	$209,736
	Total	$0	$0	$0	$740,614	$740,614	$740,614	$740,614	$740,614	$740,614	$740,614	$740,614	$748,114	$748,114
Total	Fixed	$0	$0	$0	$2,208,436	$2,208,436	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$2,630,974	$6,838,488	$6,838,488
	Variable	$0	$0	$0	$540,632	$548,965	$653,562	$661,797	$670,237	$678,886	$687,750	$696,833	$5,534,167	$5,624,247
	Total	$0	$0	$0	$2,749,068	$2,757,402	$3,284,536	$3,292,771	$3,301,211	$3,309,860	$3,318,723	$3,327,807	$12,372,655	$12,462,735
	Rounded	$0	$0	$0	$2,749,000	$2,757,000	$3,285,000	$3,293,000	$3,301,000	$3,310,000	$3,319,000	$3,328,000	$12,373,000	$12,463,000

Table D1- Scenario 1 - $60 million/year Construction Schedule
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Summary of Annual O,M&R Charges by User
Project Completion In 2021
page 2

2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065-70
$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442
$1,711,894	$1,754,193	$1,797,542	$2,030,954	$2,400,803	$2,592,986	$2,592,986	$2,592,986	$2,592,986	$2,592,986	$2,592,986
$7,013,336	$7,055,635	$7,098,984	$7,332,396	$7,702,245	$7,894,428	$7,894,428	$7,894,428	$7,894,428	$7,894,428	$7,894,428
$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668
$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781
$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449	$1,723,449
$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378
$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785
$640,163	$640,163	$640,163	$640,163	$640,163	$640,163	$640,163	$640,163	$640,163	$640,163	$640,163
$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488
$2,538,460	$2,580,759	$2,624,108	$2,857,520	$3,227,369	$3,419,552	$3,419,552	$3,419,552	$3,419,552	$3,419,552	$3,419,552
$9,376,948	$9,419,247	$9,462,596	$9,696,008	$10,065,857	$10,258,040	$10,258,040	$10,258,040	$10,258,040	$10,258,040	$10,258,040
$9,377,000	$9,419,000	$9,463,000	$9,696,000	$10,066,000	$10,258,000	$10,258,000	$10,258,000	$10,258,000	$10,258,000	$10,258,000

2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065-70
$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442	$5,301,442
$3,833,186	$3,927,790	$4,024,740	$4,546,769	$5,450,388	$5,803,759	$5,803,759	$5,803,759	$5,803,759	$5,803,759	$5,803,759
$9,134,628	$9,229,232	$9,326,181	$9,848,210	$10,751,829	$11,105,201	$11,105,201	$11,105,201	$11,105,201	$11,105,201	$11,105,201
$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668	$998,668
$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639
$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307	$2,672,307
$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378	$538,378
$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736
$748,114	$748,114	$748,114	$748,114	$748,114	$748,114	$748,114	$748,114	$748,114	$748,114	$748,114
$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488	$6,838,488
$5,716,562	$5,811,165	$5,908,115	$6,430,144	$7,333,763	$7,687,134	$7,687,134	$7,687,134	$7,687,134	$7,687,134	$7,687,134
$12,555,049	$12,649,653	$12,746,603	$13,268,632	$14,172,251	$14,525,622	$14,525,622	$14,525,622	$14,525,622	$14,525,622	$14,525,622
$12,555,000	$12,650,000	$12,747,000	$13,269,000	$14,172,000	$14,526,000	$14,526,000	$14,526,000	$14,526,000	$14,526,000	$14,526,000

Table D2 - 2040
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Fixed O,M&R Costs by User
Jan-05 $

		Joint Costs									
		Pumping Plants		**Pipelines**	**Elec.Trans. Line**	**NIIP Canal**	**Water Treatment Plant Fixed O,M&R**				
San Juan Branch											
Reach	End	Pumping Plants	Annual Maintenance	Annual Maintenance	Annual Maintenance	Annual Maintenance	Operators	Equipment Replacement	Dredging	Misc. @ 10%	Total
1	Water Treatment Plant (WTP)	River	$86,751	$0	$7,692		$815,741	$617,381	$206,576	$163,970	$1,803,669
2	NAPI turnout	01	$171,628	$10,312	$5,361						
3	Shiprock Junction		$0	$91,359	$0						
4	Sanostee turnout	02, 03	$301,642	$101,747	$13,770						
5	Burnham Junction		$0	$50,219	$0						
6	Newcomb turnout		$0	$19,291	$39,600						
7	Sheepsprings turnout	04	$140,630	$53,668	$29,568						
8	Naschitti turnout	05	$131,941	$26,261	$72,813						
9	Tohatchi turnout	06	$153,398	$84,933	$31,721						
10	Coyote Canyon Junction		$0	$26,895	$11,134						
11	Twin Lakes turnout	07	$144,678	$12,584	$30,660						
12	Ya-ta-hey Junction	08	$152,870	$25,055	$5,361						
13	Gallup Junction		$0	$11,920	$3,047						
14	Navajo Chapters		$0	$0	$15,235						
10.1	Coyote Canyon turnout	11	$80,434	$18,122	$8,408						
10.2	Standing Rock turnout	12	$98,567	$32,796	$8,408						
10.3	Dalton Pass turnout	13	$106,943	$8,600	$8,408						
12.1	Rock Springs turnout	09	$116,819	$16,385	$8,408						
12.2	Window Rock turnout	10	$109,915	$28,233	$39,418						
Cutter Branch											
Reach	End										
21	WTP	Reservoir	$0	$0	$2,331	$37,559	$815,741	$86,856	$822	$90,342	$993,761
22	Huerfano turnout	01, 02, 03	$354,966	$66,132	$204,411						
23	Nageezi turnout	04	$106,955	$25,981	$8,408						
24	Jicarilla turnout	05	$120,017	$31,647	$75,392						
25	Counselor turnout	06	$111,076	$18,452	$20,248						
26	Torreon turnout		$0	$13,969	$3,047						
		Total	$2,489,233	$774,560	$652,850	$37,559	$1,631,483	$704,237	$207,398	$254,312	$2,797,429

Annual pipeline OM&R estimated at 0.5% of capital cost
Annual electric transmission line OM&R estimated at 3.0% of capital cost

Table D2 - 2040, page 2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Fixed O,M&R Costs by User

Allocated Joint Costs							*Dedicated Costs* — Service Area Pumping Plants			Total Annual Fixed OM&R Costs — Dedicated Costs Plus Allocated Joint Costs		
Total Joint Costs	Allocation Ratios			Allocated Joint Costs			Annual Maintenance					
	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla
$1,898,112	0.7724	0.2276	-	$1,466,082	$432,031	$0				$1,466,082	$432,031	$0
$187,301	0.7724	0.2276	-	$144,670	$42,632	$0				$144,670	$42,632	$0
$91,359	0.7686	0.2314	-	$70,219	$21,141	$0				$70,219	$21,141	$0
$417,159	0.7384	0.2616	-	$308,029	$109,131	$0	$3,521			$311,550	$109,131	$0
$50,219	0.7278	0.2722	-	$36,550	$13,668	$0				$36,550	$13,668	$0
$58,891	0.7263	0.2737	-	$42,774	$16,117	$0	$3,521			$46,296	$16,117	$0
$223,866	0.7176	0.2824	-	$160,648	$63,217	$0	$3,521			$164,170	$63,217	$0
$231,015	0.7134	0.2866	-	$164,807	$66,208	$0	$3,521			$168,328	$66,208	$0
$270,052	0.7037	0.2963	-	$190,034	$80,018	$0	$3,521			$193,556	$80,018	$0
$38,029	0.6901	0.3099	-	$26,245	$11,784	$0				$26,245	$11,784	$0
$187,923	0.6493	0.3507	-	$122,020	$65,903	$0	$3,521			$125,541	$65,903	$0
$183,286	0.6313	0.3687	-	$115,702	$67,585	$0				$115,702	$67,585	$0
$14,967	0.3830	0.6170	-	$5,732	$9,235	$0				$5,732	$9,235	$0
$15,235	1.0000	-	-	$15,235	$0	$0	$17,606			$32,841	$0	$0
$106,965	1.0000	-	-	$106,965	$0	$0	$3,521			$110,486	$0	$0
$139,772	1.0000	-	-	$139,772	$0	$0	$3,521			$143,293	$0	$0
$123,951	1.0000	-	-	$123,951	$0	$0	$3,521			$127,472	$0	$0
$141,613	1.0000	-	-	$141,613	$0	$0	$3,521			$145,134	$0	$0
$177,566	1.0000	-	-	$177,566	$0	$0	$19,953			$197,519	$0	$0
$1,033,651	0.7422	-	0.2578	$767,182	$0	$266,469				$767,182	$0	$266,469
$625,509	0.7422	-	0.2578	$464,257	$0	$161,252	$3,521			$467,778	$0	$161,252
$141,344	0.7258	-	0.2742	$102,582	$0	$38,761	$3,521			$106,103	$0	$38,761
$227,056	0.6834	-	0.3166	$155,161	$0	$71,896				$155,161	$0	$71,896
$149,776	1.0000	-	-	$149,776	$0	$0	$3,521			$153,297	$0	$0
$17,016	1.0000	-	-	$17,016	$0	$0	$3,521			$20,537	$0	$0
$6,751,632				$5,214,586	$998,668	$538,378	$86,856			$5,301,442	$998,668	$538,378

Table D2 - 2040, page 3
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Fixed O,M&R Costs by User

Total Annual Fixed OM&R Costs Cutter Lateral Only Scenario			Total Annual Fixed OM&R Costs Gallup Chapters Scenario		
Navajo	Gallup	Jicarilla	Navajo	Gallup	Jicarilla
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$191,444	$0	$0
$0	$0	$0	$183,286	$0	$0
$0	$0	$0	$14,967	$0	$0
$0	$0	$0	$32,841	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$767,182	$0	$266,469	$0	$0	$0
$467,778	$0	$161,252	$0	$0	$0
$106,103	$0	$38,761	$0	$0	$0
$155,161	$0	$71,896	$0	$0	$0
$153,297	$0	$0	$0	$0	$0
$20,537	$0	$0	$0	$0	$0
$1,670,058	$0	$538,378	$422,538	$0	$0

Table D3 - 2040
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Projection of Peak Flows by Reach, Annually 2010-2020 and then by 5-Year Period, 2020 - 2070

		Design Capacity by Reach	Design Peak Deliveries by Reach	Total Deliveries (peak flows)																						
San Juan Branch				2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
Number	End	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
1	Water Treatment Plant (WTP)	59.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	NAPI turnout	59.18	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.62	0.64	0.66	0.67	0.76	0.86	0.97	0.97	0.97	0.97	0.97
3	Shiprock Junction	58.21	6.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.22	4.32	4.43	4.54	4.65	5.26	5.95	6.72	6.72	6.72	6.72	6.72
4	Sanostee turnout	51.49	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	1.29	1.32	1.35	1.38	1.57	1.77	2.00	2.00	2.00	2.00	2.00
5	Burnham Junction	49.49	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.18	0.18	0.19	0.21	0.24	0.27	0.27	0.27	0.27	0.27
6	Newcomb turnout	49.22	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.98	1.00	1.03	1.05	1.19	1.34	1.52	1.52	1.52	1.52	1.52
7	Sheepsprings turnout	47.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	0.45	0.46	0.47	0.48	0.55	0.62	0.70	0.70	0.70	0.70	0.70
8	Naschitti turnout	47.00	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.99	1.02	1.04	1.07	1.21	1.36	1.54	1.54	1.54	1.54	1.54
9	Tohatchi turnout	45.46	1.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	1.28	1.31	1.34	1.38	1.56	1.76	1.99	1.99	1.99	1.99	1.99
10	Coyote Canyon Junction	43.47	5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.26	3.34	3.42	3.50	3.96	4.48	5.06	5.06	5.06	5.06	5.06
11	Twin Lakes turnout	38.41	1.88	0.00	0.00	0.00	0.00	0.00	1.02	1.04	1.07	1.10	1.12	1.15	1.18	1.21	1.24	1.27	1.30	1.47	1.66	1.88	1.88	1.88	1.88	1.88
12	Ya-ta-hey Junction	36.53	14.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.23	9.46	9.69	9.93	10.18	11.51	13.01	14.70	14.70	14.70	14.70	14.70
13	Gallup Junction	21.83	13.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47	13.47	13.47	13.47	13.47	13.47	13.47	13.47
14	Navajo Chapters	8.36	8.36	0.00	0.00	0.00	0.00	0.00	2.57	2.55	2.52	2.49	2.47	2.44	5.25	5.38	5.51	5.65	5.79	6.54	7.40	8.36	8.36	8.36	8.36	8.36
			59.18	0.00	0.00	0.00	0.00	0.00	3.59	3.59	3.59	3.59	3.59	3.59	42.17	42.88	43.61	44.36	45.12	49.25	53.91	59.18	59.18	59.18	59.18	59.18
10.1	Coyote Canyon turnout	5.06	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.80	0.82	0.84	0.87	0.98	1.11	1.25	1.25	1.25	1.25	1.25
10.2	Standing Rock turnout	3.81	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.09	0.09	0.09	0.10	0.12	0.13	0.13	0.13	0.13	0.13
10.3	Dalton Pass turnout	3.68	3.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.31	2.37	2.43	2.49	2.55	2.88	3.26	3.68	3.68	3.68	3.68	3.68
			5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.26	3.34	3.42	3.50	3.96	4.48	5.06	5.06	5.06	5.06	5.06
12.1	Rock Springs turnout	14.70	3.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.05	2.10	2.16	2.21	2.50	2.82	3.19	3.19	3.19	3.19	3.19
12.2	Window Rock turnout	11.51	11.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.23	7.41	7.59	7.78	7.97	9.01	10.18	11.51	11.51	11.51	11.51	11.51
			14.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.23	9.46	9.69	9.93	10.18	11.51	13.01	14.70	14.70	14.70	14.70	14.70
Cutter Branch				2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-5
21	WTP	8.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	Huerfano turnout	8.34	0.50	0.00	0.00	0.00	0.26	0.26	0.27	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.39	0.44	0.50	0.50	0.50	0.50	0.50
23	Nageezi turnout	7.84	1.05	0.00	0.00	0.00	0.54	0.56	0.57	0.58	0.60	0.61	0.63	0.64	0.66	0.68	0.69	0.71	0.73	0.82	0.93	1.05	1.05	1.05	1.05	1.05
24	Jicarilla turnout	6.79	2.15	0.00	0.00	0.00	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
25	Counselor turnout	4.64	2.63	0.00	0.00	0.00	1.36	1.39	1.43	1.46	1.50	1.53	1.57	1.61	1.65	1.69	1.73	1.78	1.82	2.06	2.33	2.63	2.63	2.63	2.63	2.63
26	Torreon turnout	2.01	2.01	0.00	0.00	0.00	1.04	1.06	1.09	1.12	1.14	1.17	1.20	1.23	1.26	1.29	1.33	1.36	1.39	1.57	1.78	2.01	2.01	2.01	2.01	2.01
			8.34	0.00	0.00	0.00	5.34	5.42	5.51	5.59	5.67	5.76	5.85	5.94	6.04	6.13	6.23	6.33	6.44	7.00	7.63	8.34	8.34	8.34	8.34	8.34

Note: Peak flows = average flows times 1.3 peaking factor

Table D4, page 1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Projection of Peak Flows in Each Reach Allocated to Each Party, Annually 2010-2025
and then by 5-Year Period, 2020 - 2070

	Navajo																						
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
Reach	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.70	29.41	30.14	30.89	31.65	35.78	40.44	45.71	45.71	45.71	45.71	45.71
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.70	29.41	30.14	30.89	31.65	35.78	40.44	45.71	45.71	45.71	45.71	45.71
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.09	28.79	29.50	30.23	30.98	35.02	39.58	44.74	44.74	44.74	44.74	44.74
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.87	24.46	25.07	25.69	26.33	29.76	33.64	38.02	38.02	38.02	38.02	38.02
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.62	23.18	23.75	24.34	24.94	28.19	31.87	36.02	36.02	36.02	36.02	36.02
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.45	23.00	23.57	24.16	24.76	27.98	31.63	35.75	35.75	35.75	35.75	35.75
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.49	22.02	22.57	23.13	23.70	26.79	30.28	34.23	34.23	34.23	34.23	34.23
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.05	21.57	22.11	22.66	23.22	26.24	29.66	33.53	33.53	33.53	33.53	33.53
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.08	20.58	21.09	21.62	22.15	25.04	28.30	31.99	31.99	31.99	31.99	31.99
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.84	19.30	19.78	20.27	20.77	23.48	26.54	30.00	30.00	30.00	30.00	30.00
11	0.00	0.00	0.00	0.00	0.00	3.59	3.59	3.59	3.59	3.59	3.59	15.66	16.05	16.44	16.85	17.27	19.52	22.06	24.94	24.94	24.94	24.94	24.94
12	0.00	0.00	0.00	0.00	0.00	2.57	2.55	2.52	2.49	2.47	2.44	14.48	14.84	15.21	15.58	15.97	18.05	20.40	23.06	23.06	23.06	23.06	23.06
13	0.00	0.00	0.00	0.00	0.00	2.57	2.55	2.52	2.49	2.47	2.44	5.25	5.38	5.51	5.65	5.79	6.54	7.40	8.36	8.36	8.36	8.36	8.36
14	0.00	0.00	0.00	0.00	0.00	2.57	2.55	2.52	2.49	2.47	2.44	5.25	5.38	5.51	5.65	5.79	6.54	7.40	8.36	8.36	8.36	8.36	8.36
10.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18	3.26	3.34	3.42	3.50	3.96	4.48	5.06	5.06	5.06	5.06	5.06
10.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.39	2.45	2.51	2.57	2.64	2.98	3.37	3.81	3.81	3.81	3.81	3.81
10.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.31	2.37	2.43	2.49	2.55	2.88	3.26	3.68	3.68	3.68	3.68	3.68
12.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.23	9.46	9.69	9.93	10.18	11.51	13.01	14.70	14.70	14.70	14.70	14.70
12.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.23	7.41	7.59	7.78	7.97	9.01	10.18	11.51	11.51	11.51	11.51	11.51

	Navajo																						
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-5
21	0.00	0.00	0.00	3.19	3.27	3.36	3.44	3.52	3.61	3.70	3.79	3.89	3.98	4.08	4.18	4.29	4.85	5.48	6.19	6.19	6.19	6.19	6.19
22	0.00	0.00	0.00	3.19	3.27	3.36	3.44	3.52	3.61	3.70	3.79	3.89	3.98	4.08	4.18	4.29	4.85	5.48	6.19	6.19	6.19	6.19	6.19
23	0.00	0.00	0.00	2.94	3.01	3.08	3.16	3.24	3.32	3.40	3.49	3.57	3.66	3.75	3.84	3.94	4.45	5.03	5.69	5.69	5.69	5.69	5.69
24	0.00	0.00	0.00	2.39	2.45	2.52	2.58	2.64	2.71	2.77	2.84	2.91	2.99	3.06	3.14	3.21	3.63	4.11	4.64	4.64	4.64	4.64	4.64
25	0.00	0.00	0.00	2.39	2.45	2.52	2.58	2.64	2.71	2.77	2.84	2.91	2.99	3.06	3.14	3.21	3.63	4.11	4.64	4.64	4.64	4.64	4.64
26	0.00	0.00	0.00	1.04	1.06	1.09	1.12	1.14	1.17	1.20	1.23	1.26	1.29	1.33	1.36	1.39	1.57	1.78	2.01	2.01	2.01	2.01	2.01

Table D4, page 2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Projection of Peak Flows in Each Reach Allocated to Each Party, Annually 2010-2025
and then by 5-Year Period, 2025 - 2070

Jicarilla	Gallup															
All yrs.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025-70
cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.47	13.47	13.47	13.47	13.47
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gallup	Jicarilla															
All yrs.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025-70
0.00	0.00	0.00	0.00	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
0.00	0.00	0.00	0.00	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
0.00	0.00	0.00	0.00	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
0.00	0.00	0.00	0.00	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table D5, page 1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Projection of Flows by Reach
Percentage of Peak Flows in Each Reach Allocated to Each Party, Annually 2010-2025
and then by 5-Year Period, 2025 - 2070

	Navajo																						
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
Reach	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6806	0.6859	0.6911	0.6963	0.7015	0.7265	0.7501	0.7724	0.7724	0.7724	0.7724	0.7724
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6806	0.6859	0.6911	0.6963	0.7015	0.7265	0.7501	0.7724	0.7724	0.7724	0.7724	0.7724
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6759	0.6812	0.6865	0.6918	0.6970	0.7222	0.7461	0.7686	0.7686	0.7686	0.7686	0.7686
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6393	0.6449	0.6505	0.6560	0.6615	0.6884	0.7141	0.7384	0.7384	0.7384	0.7384	0.7384
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6267	0.6324	0.6381	0.6437	0.6493	0.6767	0.7029	0.7278	0.7278	0.7278	0.7278	0.7278
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6250	0.6307	0.6364	0.6420	0.6476	0.6750	0.7013	0.7263	0.7263	0.7263	0.7263	0.7263
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6147	0.6205	0.6263	0.6320	0.6376	0.6654	0.6921	0.7176	0.7176	0.7176	0.7176	0.7176
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6098	0.6156	0.6214	0.6272	0.6329	0.6608	0.6877	0.7134	0.7134	0.7134	0.7134	0.7134
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5986	0.6044	0.6103	0.6161	0.6219	0.6502	0.6775	0.7037	0.7037	0.7037	0.7037	0.7037
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5830	0.5890	0.5949	0.6008	0.6067	0.6355	0.6633	0.6901	0.6901	0.6901	0.6901	0.6901
11	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.5376	0.5437	0.5497	0.5558	0.5618	0.5917	0.6209	0.6493	0.6493	0.6493	0.6493	0.6493
12	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.5180	0.5242	0.5303	0.5364	0.5424	0.5726	0.6023	0.6313	0.6313	0.6313	0.6313	0.6313
13	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.2804	0.2854	0.2904	0.2955	0.3006	0.3270	0.3545	0.3830	0.3830	0.3830	0.3830	0.3830
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
10.3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	Navajo																						
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
21	0.0000	0.0000	0.0000	0.5977	0.6036	0.6095	0.6153	0.6211	0.6268	0.6325	0.6382	0.6438	0.6494	0.6550	0.6605	0.6660	0.6926	0.7181	0.7422	0.7422	0.7422	0.7422	0.7422
22	0.0000	0.0000	0.0000	0.5977	0.6036	0.6095	0.6153	0.6211	0.6268	0.6325	0.6382	0.6438	0.6494	0.6550	0.6605	0.6660	0.6926	0.7181	0.7422	0.7422	0.7422	0.7422	0.7422
23	0.0000	0.0000	0.0000	0.5773	0.5833	0.5892	0.5952	0.6010	0.6069	0.6127	0.6185	0.6243	0.6300	0.6357	0.6414	0.6470	0.6744	0.7007	0.7258	0.7258	0.7258	0.7258	0.7258
24	0.0000	0.0000	0.0000	0.5269	0.5330	0.5391	0.5452	0.5513	0.5573	0.5634	0.5694	0.5754	0.5813	0.5873	0.5932	0.5991	0.6281	0.6563	0.6834	0.6834	0.6834	0.6834	0.6834
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
26	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table D5, page 2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Projection of Flows by Reach
Percentage of Peak Flows in Each Reach Allocated to Each Party, Annually 2010-2025
and then by 5-Year Period, 2025 - 2070

Gallup																							Jicarilla
2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70	All Years
%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3194	0.3141	0.3089	0.3037	0.2985	0.2735	0.2499	0.2276	0.2276	0.2276	0.2276	0.2276	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3194	0.3141	0.3089	0.3037	0.2985	0.2735	0.2499	0.2276	0.2276	0.2276	0.2276	0.2276	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3241	0.3188	0.3135	0.3082	0.3030	0.2778	0.2539	0.2314	0.2314	0.2314	0.2314	0.2314	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3607	0.3551	0.3495	0.3440	0.3385	0.3116	0.2859	0.2616	0.2616	0.2616	0.2616	0.2616	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3733	0.3676	0.3619	0.3563	0.3507	0.3233	0.2971	0.2722	0.2722	0.2722	0.2722	0.2722	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3750	0.3693	0.3636	0.3580	0.3524	0.3250	0.2987	0.2737	0.2737	0.2737	0.2737	0.2737	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3853	0.3795	0.3737	0.3680	0.3624	0.3346	0.3079	0.2824	0.2824	0.2824	0.2824	0.2824	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3902	0.3844	0.3786	0.3728	0.3671	0.3392	0.3123	0.2866	0.2866	0.2866	0.2866	0.2866	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4014	0.3956	0.3897	0.3839	0.3781	0.3498	0.3225	0.2963	0.2963	0.2963	0.2963	0.2963	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4170	0.4110	0.4051	0.3992	0.3933	0.3645	0.3367	0.3099	0.3099	0.3099	0.3099	0.3099	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4624	0.4563	0.4503	0.4442	0.4382	0.4083	0.3791	0.3507	0.3507	0.3507	0.3507	0.3507	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4820	0.4758	0.4697	0.4636	0.4576	0.4274	0.3977	0.3687	0.3687	0.3687	0.3687	0.3687	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7196	0.7146	0.7096	0.7045	0.6994	0.6730	0.6455	0.6170	0.6170	0.6170	0.6170	0.6170	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Jicarilla																							Gallup
2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70	All Years
0.0000	0.0000	0.0000	0.4023	0.3964	0.3905	0.3847	0.3789	0.3732	0.3675	0.3618	0.3562	0.3506	0.3450	0.3395	0.3340	0.3074	0.2819	0.2578	0.2578	0.2578	0.2578	0.2578	0.0000
0.0000	0.0000	0.0000	0.4023	0.3964	0.3905	0.3847	0.3789	0.3732	0.3675	0.3618	0.3562	0.3506	0.3450	0.3395	0.3340	0.3074	0.2819	0.2578	0.2578	0.2578	0.2578	0.2578	0.0000
0.0000	0.0000	0.0000	0.4227	0.4167	0.4108	0.4048	0.3990	0.3931	0.3873	0.3815	0.3757	0.3700	0.3643	0.3586	0.3530	0.3256	0.2993	0.2742	0.2742	0.2742	0.2742	0.2742	0.0000
0.0000	0.0000	0.0000	0.4731	0.4670	0.4609	0.4548	0.4487	0.4427	0.4366	0.4306	0.4246	0.4187	0.4127	0.4068	0.4009	0.3719	0.3437	0.3166	0.3166	0.3166	0.3166	0.3166	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table D6, page 1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
CRSP Power Rates
Jan-05 $

San Juan Branch		Dedicated Variable OM&R Costs at Design Capacity (all Navajo)	Joint Variable O,M&R at Design Capacity					
Reach	End	Booster Pump Energy	Pump Plant Energy	WTP Energy	WTP Chemicals	WTP Misc.	Sub Total	Navajo Dam OM&R
1	Water Treatment Plant (WTP)		$31,713	$170,516	$962,457	$113,297	$1,277,984	$32,955
2	NAPI turnout		$311,494				$311,494	
3	Shiprock Junction						$0	
4	Sanostee turnout	$3,858	$405,914				$405,914	
5	Burnham Junction						$0	
6	Newcomb turnout	$2,932					$0	
7	Sheepsprings turnout	$1,350	$150,528				$150,528	
8	Naschitti turnout	$2,990	$120,894				$120,894	
9	Tohatchi turnout	$3,839	$198,136				$198,136	
10	Coyote Canyon Junction						$0	
11	Twin Lakes turnout	$3,627	$153,687				$153,687	
12	Ya-ta-hey Junction		$181,835				$181,835	
13	Gallup Junction						$0	
14	Navajo Chapters	$16,128					$0	
10.1	Coyote Canyon turnout	$2,392	$10,123				$10,123	
10.2	Standing Rock turnout	$270	$12,613				$12,613	
10.3	Dalton Pass turnout	$7,099	$16,740				$16,740	
12.1	Rock Springs turnout	$6,154	$49,048				$49,048	
12.2	Window Rock turnout	$22,205	$34,952				$34,952	
	subtotal	$72,844					$2,923,948	$32,955
Cutter Branch								
21	WTP			$19,754	$136,153	$15,591	$171,497	$4,644
22	Huerfano turnout	$965	$117,392				$117,392	
23	Nageezi turnout	$2,026	$25,861				$25,861	
24	Jicarilla turnout		$36,386				$36,386	
25	Counselor turnout	$5,054	$22,102				$22,102	
26	Torreon turnout	$3,878					$0	
		$84,767	$1,879,418	$190,270	$1,098,610	$128,888	$3,297,186	$37,599

Projected Peak Flows as a Percentage of Design Flow by Year

Reach	End	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	Water Treatment Plant (WTP)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7126	0.7246	0.7369	0.7495	0.7625	0.8322	0.9110	1.0000	1.0000	1.0000	1.0000	1.0000
2	NAPI turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7126	0.7246	0.7369	0.7495	0.7625	0.8322	0.9110	1.0000	1.0000	1.0000	1.0000	1.0000
3	Shiprock Junction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7140	0.7259	0.7382	0.7508	0.7636	0.8330	0.9114	1.0000	1.0000	1.0000	1.0000	1.0000
4	Sanostee turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7252	0.7367	0.7485	0.7606	0.7729	0.8396	0.9149	1.0000	1.0000	1.0000	1.0000	1.0000
5	Burnham Junction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7291	0.7405	0.7521	0.7640	0.7762	0.8419	0.9161	1.0000	1.0000	1.0000	1.0000	1.0000
6	Newcomb turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7297	0.7410	0.7526	0.7645	0.7766	0.8422	0.9163	1.0000	1.0000	1.0000	1.0000	1.0000
7	Sheepsprings turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7329	0.7441	0.7556	0.7673	0.7793	0.8441	0.9173	1.0000	1.0000	1.0000	1.0000	1.0000
8	Naschitti turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7345	0.7456	0.7570	0.7687	0.7806	0.8450	0.9178	1.0000	1.0000	1.0000	1.0000	1.0000
9	Tohatchi turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7381	0.7491	0.7603	0.7718	0.7836	0.8471	0.9189	1.0000	1.0000	1.0000	1.0000	1.0000
10	Coyote Canyon Junction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7432	0.7539	0.7649	0.7762	0.7878	0.8501	0.9204	1.0000	1.0000	1.0000	1.0000	1.0000
11	Twin Lakes turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935	0.7584	0.7685	0.7788	0.7894	0.8003	0.8589	0.9251	1.0000	1.0000	1.0000	1.0000	1.0000
12	Ya-ta-hey Junction	0.0000	0.0000	0.0000	0.0000	0.0000	0.0704	0.0697	0.0690	0.0683	0.0676	0.0668	0.7651	0.7749	0.7850	0.7953	0.8059	0.8628	0.9272	1.0000	1.0000	1.0000	1.0000	1.0000
13	Gallup Junction	0.0000	0.0000	0.0000	0.0000	0.0000	0.1178	0.1167	0.1155	0.1143	0.1130	0.1118	0.8575	0.8634	0.8696	0.8758	0.8822	0.9168	0.9559	1.0000	1.0000	1.0000	1.0000	1.0000
14	Navajo Chapters	0.0000	0.0000	0.0000	0.0000	0.0000	0.3077	0.3047	0.3016	0.2984	0.2952	0.2918	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.1	Coyote Canyon turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.2	Standing Rock turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.3	Dalton Pass turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
12.1	Rock Springs turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	1.7078	1.0000	1.0000	1.0000	1.0000	1.0000
12.2	Window Rock turnout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	1.9447	1.0000	1.0000	1.0000	1.0000	1.0000
21	WTP	0.0000	0.0000	0.0000	0.6409	0.6504	0.6601	0.6701	0.6803	0.6908	0.7015	0.7125	0.7238	0.7353	0.7472	0.7593	0.7718	0.8387	0.9144	1.0000	1.0000	1.0000	1.0000	1.0000
22	Huerfano turnout	0.0000	0.0000	0.0000	0.6409	0.6504	0.6601	0.6701	0.6803	0.6908	0.7015	0.7125	0.7238	0.7353	0.7472	0.7593	0.7718	0.8387	0.9144	1.0000	1.0000	1.0000	1.0000	1.0000
23	Nageezi turnout	0.0000	0.0000	0.0000	0.6488	0.6581	0.6676	0.6774	0.6874	0.6976	0.7081	0.7189	0.7299	0.7412	0.7528	0.7647	0.7768	0.8423	0.9163	1.0000	1.0000	1.0000	1.0000	1.0000
24	Jicarilla turnout	0.0000	0.0000	0.0000	0.6693	0.6781	0.6870	0.6962	0.7056	0.7153	0.7252	0.7353	0.7457	0.7563	0.7672	0.7784	0.7899	0.8515	0.9212	1.0000	1.0000	1.0000	1.0000	1.0000
25	Counselor turnout	0.0000	0.0000	0.0000	0.5161	0.5289	0.5420	0.5555	0.5692	0.5834	0.5978	0.6127	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
26	Torreon turnout	0.0000	0.0000	0.0000	0.5161	0.5289	0.5420	0.5555	0.5692	0.5834	0.5978	0.6127	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000

CRSP rates used in this table are $.0095 per KWH plus $48.48 per year per KW.
Navajo Dam OM&R estimated at $1.00 per acre-foot; Gallup's share assumed included in payments to Jicarilla Apache Nation; therefore Jicarilla assumed to pay both Jicarilla and Gallup OM&R directly to dam operator.

Table D6, page 2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
CRSP Power Rates
Jan-05 $

											Navajo Share of Variable O,M&R Costs by Year												
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$635,734	$651,500	$667,657	$684,215	$701,184	$792,551	$895,825	$1,012,555	$1,012,555	$1,012,555	$1,012,555	$1,012,555
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$151,058	$154,804	$158,643	$162,577	$166,609	$188,319	$212,858	$240,595	$240,595	$240,595	$240,595	$240,595
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$190,981	$195,692	$200,520	$205,468	$210,539	$237,841	$268,702	$303,583	$303,583	$303,583	$303,583	$303,583
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2,139	$2,173	$2,207	$2,241	$2,277	$2,469	$2,686	$2,932	$2,932	$2,932	$2,932	$2,932
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$68,810	$70,507	$72,246	$74,029	$75,855	$85,690	$96,806	$109,370	$109,370	$109,370	$109,370	$109,370
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$56,346	$57,722	$59,132	$60,578	$62,059	$70,034	$79,048	$89,236	$89,236	$89,236	$89,236	$89,236
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$90,373	$92,586	$94,854	$97,178	$99,560	$112,385	$126,881	$143,266	$143,266	$143,266	$143,266	$143,266
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$14,710	$14,710	$14,710	$14,710	$14,710	$14,710	$65,404	$66,995	$68,625	$70,295	$72,007	$81,224	$91,642	$103,418	$103,418	$103,418	$103,418	$103,418
12	$0	$0	$0	$0	$0	$12,805	$12,680	$12,551	$12,419	$12,283	$12,144	$72,068	$73,856	$75,687	$77,564	$79,488	$89,845	$101,553	$114,786	$114,786	$114,786	$114,786	$114,786
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$4,963	$4,914	$4,864	$4,813	$4,761	$4,707	$10,126	$10,377	$10,634	$10,898	$11,168	$12,624	$14,269	$16,128	$16,128	$16,128	$16,128	$16,128
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,858	$8,052	$8,252	$8,457	$8,667	$9,796	$11,072	$12,515	$12,515	$12,515	$12,515	$12,515
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$8,089	$8,289	$8,495	$8,705	$8,921	$10,084	$11,398	$12,883	$12,883	$12,883	$12,883	$12,883
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$14,967	$15,339	$15,719	$16,109	$16,508	$18,659	$21,091	$23,839	$23,839	$23,839	$23,839	$23,839
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$34,659	$35,518	$36,399	$37,302	$38,227	$43,208	$94,277	$55,202	$55,202	$55,202	$55,202	$55,202
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$35,886	$36,776	$37,688	$38,623	$39,581	$44,738	$111,151	$57,157	$57,157	$57,157	$57,157	$57,157
21	$0	$0	$0	$67,473	$69,146	$70,861	$72,618	$74,419	$76,265	$78,156	$80,095	$82,081	$84,117	$86,203	$88,341	$90,531	$102,328	$115,662	$130,733	$130,733	$130,733	$130,733	$130,733
22	$0	$0	$0	$45,587	$46,711	$47,863	$49,044	$50,254	$51,495	$52,765	$54,068	$55,403	$56,770	$58,172	$59,609	$61,081	$69,007	$77,967	$88,094	$88,094	$88,094	$88,094	$88,094
23	$0	$0	$0	$11,001	$11,260	$11,526	$11,798	$12,077	$12,363	$12,655	$12,955	$13,263	$13,578	$13,901	$14,232	$14,571	$16,397	$18,462	$20,795	$20,795	$20,795	$20,795	$20,795
24	$0	$0	$0	$12,833	$13,151	$13,477	$13,812	$14,154	$14,505	$14,865	$15,234	$15,611	$15,998	$16,395	$16,802	$17,219	$19,462	$21,998	$24,865	$24,865	$24,865	$24,865	$24,865
25	$0	$0	$0	$14,016	$14,363	$14,719	$15,084	$15,458	$15,842	$16,235	$16,637	$17,050	$17,473	$17,906	$18,350	$18,805	$21,256	$24,025	$27,156	$27,156	$27,156	$27,156	$27,156
26	$0	$0	$0	$2,001	$2,051	$2,102	$2,154	$2,208	$2,262	$2,318	$2,376	$2,435	$2,495	$2,557	$2,620	$2,685	$3,035	$3,431	$3,878	$3,878	$3,878	$3,878	$3,878
Total	$0	$0	$0	$152,911	$156,683	$193,027	$196,815	$200,696	$204,673	$208,749	$212,926	$1,630,341	$1,670,618	$1,711,894	$1,754,193	$1,797,542	$2,030,954	$2,400,803	$2,592,986	$2,592,986	$2,592,986	$2,592,986	$2,592,986

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Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
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	Gallup Share of Variable O,M&R Costs by Year																						
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883	$290,883
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899	$70,899
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189	$106,189
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508	$42,508
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648	$34,648
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709	$58,709
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896	$53,896
12	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049	$67,049
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781	$724,781

Table D6, page 4
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
CRSP Power Rates
Jan-05 $

	Jicarilla Share of Variable O,M&R Costs by Year																						
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408	$45,408
22	$0	$0	$0	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263	$30,263
23	$0	$0	$0	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092	$7,092
24	$0	$0	$0	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521	$11,521
25	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$0	$0	$0	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$94,284	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785	$101,785

Table D7, page 1
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
NTUA Power Rates
Jan-05 $

Reach	End	Dedicated Variable OM&R Costs at Design Capacity (all Navajo) Booster Pump Energy	Joint Variable O,M&R at Design Capacity: Pump Plant Energy	WTP Energy	WTP Chemicals	WTP Misc.	Total	Navajo Dam OM&R
San Juan Branch								
1	Water Treatment Plant (WTP)		$93,794	$511,354	$962,457	$147,381	$1,714,987	$32,955
2	NAPI turnout		$921,270				$921,270	
3	Shiprock Junction						$0	
4	Sanostee turnout	$11,411	$1,200,523				$1,200,523	
5	Burnham Junction						$0	
6	Newcomb turnout	$8,673					$0	
7	Sheepsprings turnout	$3,994	$445,199				$445,199	
8	Naschitti turnout	$8,844	$357,554				$357,554	
9	Tohatchi turnout	$11,354	$586,004				$586,004	
10	Coyote Canyon Junction						$0	
11	Twin Lakes turnout	$10,727	$454,541				$454,541	
12	Ya-ta-hey Junction		$537,794				$537,794	
13	Gallup Junction						$0	
14	Navajo Chapters	$47,698					$0	
10.1	Coyote Canyon turnout	$7,075	$29,940				$29,940	
10.2	Standing Rock turnout	$799	$37,304				$37,304	
10.3	Dalton Pass turnout	$20,997	$49,511				$49,511	
12.1	Rock Springs turnout	$18,201	$145,064				$145,064	
12.2	Window Rock turnout	$65,672	$103,373				$103,373	
Cutter Branch								
21	WTP			$63,030	$136,153	$19,918	$219,101	$4,644
22	Huerfano turnout	$2,853	$347,195				$347,195	
23	Nageezi turnout	$5,991	$76,487				$76,487	
24	Jicarilla turnout		$107,615				$107,615	
25	Counselor turnout	$14,949	$65,368				$65,368	
26	Torreon turnout	$11,468					$0	
		$250,706	$5,558,536	$574,384	$1,098,610	$167,299	$7,398,829	$37,599

Projected Flow as a Percentage of Design Flow by Year

Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7126	0.7246	0.7369	0.7495	0.7625	0.8322	0.9110	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7126	0.7246	0.7369	0.7495	0.7625	0.8322	0.9110	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7140	0.7259	0.7382	0.7508	0.7636	0.8330	0.9114	1.0000	1.0000	1.0000	1.0000	1.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7252	0.7367	0.7485	0.7606	0.7729	0.8396	0.9149	1.0000	1.0000	1.0000	1.0000	1.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7291	0.7405	0.7521	0.7640	0.7762	0.8419	0.9161	1.0000	1.0000	1.0000	1.0000	1.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7297	0.7410	0.7526	0.7645	0.7766	0.8422	0.9163	1.0000	1.0000	1.0000	1.0000	1.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7329	0.7441	0.7556	0.7673	0.7793	0.8441	0.9173	1.0000	1.0000	1.0000	1.0000	1.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7345	0.7456	0.7570	0.7687	0.7806	0.8450	0.9178	1.0000	1.0000	1.0000	1.0000	1.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7381	0.7491	0.7603	0.7718	0.7836	0.8471	0.9189	1.0000	1.0000	1.0000	1.0000	1.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7432	0.7539	0.7649	0.7762	0.7878	0.8501	0.9204	1.0000	1.0000	1.0000	1.0000	1.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935	0.7584	0.7685	0.7788	0.7894	0.8003	0.8589	0.9251	1.0000	1.0000	1.0000	1.0000	1.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0704	0.0697	0.0690	0.0683	0.0676	0.0668	0.7651	0.7749	0.7850	0.7953	0.8059	0.8628	0.9272	1.0000	1.0000	1.0000	1.0000	1.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.1178	0.1167	0.1155	0.1143	0.1130	0.1118	0.8575	0.8634	0.8696	0.8758	0.8822	0.9168	0.9559	1.0000	1.0000	1.0000	1.0000	1.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.3077	0.3047	0.3016	0.2984	0.2952	0.2918	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
10.3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
12.1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	1.7078	1.0000	1.0000	1.0000	1.0000	1.0000
12.2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	1.9447	1.0000	1.0000	1.0000	1.0000	1.0000
21	0.0000	0.0000	0.0000	0.6409	0.6504	0.6601	0.6701	0.6803	0.6908	0.7015	0.7125	0.7238	0.7353	0.7472	0.7593	0.7718	0.8387	0.9144	1.0000	1.0000	1.0000	1.0000	1.0000
22	0.0000	0.0000	0.0000	0.6409	0.6504	0.6601	0.6701	0.6803	0.6908	0.7015	0.7125	0.7238	0.7353	0.7472	0.7593	0.7718	0.8387	0.9144	1.0000	1.0000	1.0000	1.0000	1.0000
23	0.0000	0.0000	0.0000	0.6488	0.6581	0.6676	0.6774	0.6874	0.6976	0.7081	0.7189	0.7299	0.7412	0.7528	0.7647	0.7768	0.8423	0.9163	1.0000	1.0000	1.0000	1.0000	1.0000
24	0.0000	0.0000	0.0000	0.6693	0.6781	0.6870	0.6962	0.7056	0.7153	0.7252	0.7353	0.7457	0.7563	0.7672	0.7784	0.7899	0.8515	0.9212	1.0000	1.0000	1.0000	1.0000	1.0000
25	0.0000	0.0000	0.0000	0.5161	0.5289	0.5420	0.5555	0.5692	0.5834	0.5978	0.6127	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000
26	0.0000	0.0000	0.0000	0.5161	0.5289	0.5420	0.5555	0.5692	0.5834	0.5978	0.6127	0.6279	0.6434	0.6594	0.6757	0.6925	0.7827	0.8847	1.0000	1.0000	1.0000	1.0000	1.0000

NTUA rates used in this table are $.0200 per KWH plus $198.00 per year per KW.
Navajo Dam OM&R estimated at $1.00 per acre-foot; Gallup's share assumed included in payments to Jicarilla Apache Nation; therefore Jicarilla assumed to pay both Jicarilla and Gallup OM&R directly to dam operator.

Table D7, page 2
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
NTUA Power Rates
Jan-05 $

	Navajo Share of Variable O,M&R Costs by Year																						
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$847,657	$868,678	$890,222	$912,299	$934,924	$1,056,749	$1,194,449	$1,350,091	$1,350,091	$1,350,091	$1,350,091	$1,350,091
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$446,766	$457,846	$469,200	$480,836	$492,761	$556,970	$629,546	$711,579	$711,579	$711,579	$711,579	$711,579
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$564,841	$578,775	$593,055	$607,688	$622,685	$703,435	$794,707	$897,872	$897,872	$897,872	$897,872	$897,872
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$6,329	$6,427	$6,527	$6,630	$6,736	$7,304	$7,947	$8,673	$8,673	$8,673	$8,673	$8,673
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$203,513	$208,532	$213,676	$218,947	$224,349	$253,435	$286,312	$323,473	$323,473	$323,473	$323,473	$323,473
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$166,649	$170,719	$174,890	$179,164	$183,544	$207,131	$233,791	$263,925	$263,925	$263,925	$263,925	$263,925
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$267,287	$273,832	$280,540	$287,413	$294,458	$332,389	$375,262	$423,722	$423,722	$423,722	$423,722	$423,722
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$43,506	$43,506	$43,506	$43,506	$43,506	$43,506	$193,438	$198,142	$202,962	$207,902	$212,965	$240,225	$271,038	$305,865	$305,865	$305,865	$305,865	$305,865
12	$0	$0	$0	$0	$0	$37,873	$37,501	$37,120	$36,729	$36,329	$35,918	$213,149	$218,435	$223,852	$229,403	$235,093	$265,726	$300,352	$339,489	$339,489	$339,489	$339,489	$339,489
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$14,678	$14,534	$14,386	$14,234	$14,079	$13,920	$29,947	$30,690	$31,451	$32,231	$33,030	$37,334	$42,199	$47,698	$47,698	$47,698	$47,698	$47,698
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$23,240	$23,816	$24,407	$25,012	$25,633	$28,973	$32,748	$37,015	$37,015	$37,015	$37,015	$37,015
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$23,923	$24,516	$25,124	$25,747	$26,386	$29,824	$33,710	$38,103	$38,103	$38,103	$38,103	$38,103
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$44,269	$45,366	$46,491	$47,644	$48,826	$55,188	$62,380	$70,508	$70,508	$70,508	$70,508	$70,508
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$102,506	$105,048	$107,653	$110,323	$113,059	$127,791	$278,832	$163,265	$163,265	$163,265	$163,265	$163,265
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$106,135	$108,767	$111,465	$114,229	$117,062	$132,316	$328,736	$169,045	$169,045	$169,045	$169,045	$169,045
21	$0	$0	$0	$85,708	$87,834	$90,012	$92,244	$94,532	$96,876	$99,279	$101,741	$104,264	$106,850	$109,500	$112,215	$114,998	$129,983	$146,920	$166,065	$166,065	$166,065	$166,065	$166,065
22	$0	$0	$0	$134,825	$138,151	$141,559	$145,051	$148,630	$152,298	$156,057	$159,909	$163,856	$167,902	$172,047	$176,296	$180,650	$204,093	$230,592	$260,543	$260,543	$260,543	$260,543	$260,543
23	$0	$0	$0	$32,537	$33,303	$34,089	$34,893	$35,718	$36,563	$37,429	$38,316	$39,226	$40,158	$41,113	$42,092	$43,095	$48,497	$54,602	$61,503	$61,503	$61,503	$61,503	$61,503
24	$0	$0	$0	$37,955	$38,896	$39,861	$40,849	$41,862	$42,900	$43,964	$45,055	$46,172	$47,317	$48,490	$49,693	$50,925	$57,561	$65,062	$73,540	$73,540	$73,540	$73,540	$73,540
25	$0	$0	$0	$41,453	$42,481	$43,534	$44,614	$45,720	$46,854	$48,016	$49,207	$50,427	$51,678	$52,959	$54,273	$55,619	$62,866	$71,058	$80,317	$80,317	$80,317	$80,317	$80,317
26	$0	$0	$0	$5,919	$6,066	$6,216	$6,370	$6,528	$6,690	$6,856	$7,026	$7,200	$7,379	$7,562	$7,749	$7,941	$8,976	$10,146	$11,468	$11,468	$11,468	$11,468	$11,468
Total	$0	$0	$0	$338,397	$346,730	$451,326	$459,562	$468,002	$476,651	$485,514	$494,597	$3,650,792	$3,740,872	$3,833,186	$3,927,790	$4,024,740	$4,546,769	$5,450,388	$5,803,759	$5,803,759	$5,803,759	$5,803,759	$5,803,759

Table D7, page 3
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
NTUA Power Rates
Jan-05 $

	Gallup Share of Variable O,M&R Costs by Year																						
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060-70
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349	$390,349
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691	$209,691
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062	$314,062
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720	$125,720
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473	$102,473
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636	$173,636
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403	$159,403
12	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305	$198,305
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639	$1,673,639

Table D7, page 4
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Allocation of Annual Variable O,M&R Costs by User
NTUA Power Rates
Jan-05 $

	Jicarilla Share of Variable O,M&R Costs by Year																						
Reach	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501	$7,501
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
8	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
9	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
11	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
13	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
10.3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12.2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680	$57,680
22	$0	$0	$0	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505	$89,505
23	$0	$0	$0	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975	$20,975
24	$0	$0	$0	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075	$34,075
25	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$0	$0	$0	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$202,236	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736	$209,736

Table D8 - 2040
Navajo - Gallup Water Supply Project
San Juan River PNM Alternative - 2040
Cost of Water to Navajo Nation
Discount rate = 2.875%

Year		peak cfs Main Lateral	Cutter Lateral	Total	Annual afy	Discounted Peak cfs	Annual afy	CRSP charge $4.12/af	Discounted to 2021
2013	1	-	3.19	3.19	1,779	4.01	2,232	$7,321	$9,185
2014	2	-	3.27	3.27	1,823	3.99	2,223	$7,503	$9,150
2015	3	3.59	3.36	6.95	3,868	8.23	4,585	$15,920	$18,871
2016	4	3.59	3.44	7.03	3,915	8.10	4,511	$16,111	$18,563
2017	5	3.59	3.52	7.12	3,962	7.97	4,438	$16,306	$18,264
2018	6	3.59	3.61	7.20	4,011	7.84	4,367	$16,506	$17,971
2019	7	3.59	3.70	7.29	4,061	7.72	4,297	$16,711	$17,686
2020	8	3.59	3.79	7.38	4,112	7.60	4,230	$16,922	$17,408
2021	9	28.70	3.89	32.59	18,145	32.59	18,145	$74,676	$74,676
2022	10	29.41	3.98	33.39	18,595	32.46	18,076	$76,528	$74,389
2023	11	30.14	4.08	34.22	19,056	32.34	18,006	$78,426	$74,104
2024	12	30.89	4.18	35.07	19,529	32.21	17,937	$80,371	$73,819
2025	13	31.65	4.29	35.94	20,013	32.09	17,868	$82,364	$73,536
2026	14	32.44	4.39	36.83	20,510	31.96	17,800	$84,407	$73,253
2027	15	33.24	4.50	37.74	21,018	31.84	17,731	$86,500	$72,972
2028	16	34.07	4.61	38.68	21,540	31.72	17,663	$88,645	$72,692
2029	17	34.91	4.73	39.64	22,074	31.60	17,595	$90,844	$72,413
2030	18	35.78	4.85	40.62	22,621	31.48	17,528	$93,097	$72,135
2031	19	36.67	4.97	41.63	23,182	31.36	17,460	$95,405	$71,858
2032	20	37.57	5.09	42.66	23,757	31.24	17,393	$97,771	$71,582
2033	21	38.51	5.21	43.72	24,346	31.12	17,327	$100,196	$71,307
2034	22	39.46	5.34	44.81	24,950	31.00	17,260	$102,681	$71,033
2035	23	40.44	5.48	45.92	25,569	30.88	17,194	$105,227	$70,761
2036	24	41.44	5.61	47.06	26,203	30.76	17,128	$107,837	$70,489
2037	25	42.47	5.75	48.22	26,853	30.64	17,062	$110,511	$70,218
2038	26	43.52	5.89	49.42	27,519	30.52	16,997	$113,252	$69,949
2039	27	44.60	6.04	50.64	28,201	30.41	16,931	$116,061	$69,680
2040	28	45.71	6.19	51.90	28,900	30.29	16,866	$118,939	$69,412
2041	29	45.71	6.19	51.90	28,900	29.44	16,395	$118,939	$67,473
2042	30	45.71	6.19	51.90	28,900	28.62	15,937	$118,939	$65,587
2043	31	45.71	6.19	51.90	28,900	27.82	15,491	$118,939	$63,754
2044	32	45.71	6.19	51.90	28,900	27.04	15,058	$118,939	$61,972
2045	33	45.71	6.19	51.90	28,900	26.29	14,638	$118,939	$60,240
2046	34	45.71	6.19	51.90	28,900	25.55	14,228	$118,939	$58,557
2047	35	45.71	6.19	51.90	28,900	24.84	13,831	$118,939	$56,920
2048	36	45.71	6.19	51.90	28,900	24.14	13,444	$118,939	$55,330
2049	37	45.71	6.19	51.90	28,900	23.47	13,069	$118,939	$53,783
2050	38	45.71	6.19	51.90	28,900	22.81	12,703	$118,939	$52,280
2051	39	45.71	6.19	51.90	28,900	22.18	12,348	$118,939	$50,819
2052	40	45.71	6.19	51.90	28,900	21.56	12,003	$118,939	$49,399
2053	41	45.71	6.19	51.90	28,900	20.95	11,668	$118,939	$48,019
2054	42	45.71	6.19	51.90	28,900	20.37	11,342	$118,939	$46,677
2055	43	45.71	6.19	51.90	28,900	19.80	11,025	$118,939	$45,372
2056	44	45.71	6.19	51.90	28,900	19.25	10,717	$118,939	$44,104
2057	45	45.71	6.19	51.90	28,900	18.71	10,417	$118,939	$42,872
2058	46	45.71	6.19	51.90	28,900	18.18	10,126	$118,939	$41,674
2059	47	45.71	6.19	51.90	28,900	17.68	9,843	$118,939	$40,509
2060	48	45.71	6.19	51.90	28,900	17.18	9,568	$118,939	$39,377
2061	49	45.71	6.19	51.90	28,900	16.70	9,301	$118,939	$38,276
2062	50	45.71	6.19	51.90	28,900	16.24	9,041	$118,939	$37,207
2063	51	45.71	6.19	51.90	28,900	15.78	8,788	$118,939	$36,167
2064	52	45.71	6.19	51.90	28,900	15.34	8,542	$118,939	$35,156
2065	53	45.71	6.19	51.90	28,900	14.91	8,304	$118,939	$34,174
2066	54	45.71	6.19	51.90	28,900	14.50	8,072	$118,939	$33,219
2067	55	45.71	6.19	51.90	28,900	14.09	7,846	$118,939	$32,290
2068	56	45.71	6.19	51.90	28,900	13.70	7,627	$118,939	$31,388
2069	57	45.71	6.19	51.90	28,900	13.31	7,414	$118,939	$30,511
2070	58	45.71	6.19	51.90	28,900	12.94	7,206	$118,939	$29,658
					Total	1,287.32	716,842	$5,585,213	$2,950,140
					Annual Equivalent	48.85	27,203		27,203
							Total PV per acre foot		$108.45

Note: Navajo annual equivalent is calculated for the purpose of determining the levelized cost per acre foot to amortize the present value capital costs over the 58 year period of water deliveries. CRSP charge for water has a present value of $108.45 per acre foot. This charge was amortized over 50 years at the CRSP interest rate of 2.875% to determine an annual charge of $4.12 per acre foot. This charge is then applied to all water delivered to the Navajos.

APPENDIX D

Part II
Economic Benefit/Cost Analysis

ECONOMIC BENEFIT/COST ANALYSIS
NAVAJO – GALLUP WATER SUPPLY PROJECT

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April 11, 2006

TABLE OF CONTENTS

A. Executive Summary

This report focuses on the economic benefits and costs associated with the proposed Navajo – Gallup Water Supply Project in northwestern New Mexico. The Project would be developed to deliver water for domestic, commercial, municipal and industrial use to the City of Gallup, to numerous Navajo Chapters and to an undeveloped section of the Jicarilla Apache Nation. Water is currently scarce in all of these areas, and the Project will ultimately deliver water to some individuals who presently drive many miles to haul water.

The economic analysis in this report is distinct from a financial analysis. While a financial analysis traces cash receipts and expenditure, the economic analysis is instead more concerned with the generation and use of societal resources. Because the U.S. Bureau of Reclamation is overseeing the planning of this Project, and because the Project participants are seeking monetary support from the Federal government, the society whose resources we are concerned about is the United States as a whole. The principal differences between this economic analysis and a financial analysis are (1) inclusion of non-cash Project costs that would affect third parties (diminished power generation and increased salinity effects), (2) exclusion of Project cash costs that do not represent use of scarce national resources (use of otherwise unemployed people for construction workforce), and (3) exclusion of Project transfer payments that do not represent use of scarce national resources (taxes paid on construction spending).

The Project will principally benefit people in the northwest corner of New Mexico by providing water to which they otherwise would not have access or could only have access at a relatively higher cost. The measure of the benefits to the City of Gallup and to the Navajo people who would be supplied by the Project is the willingness of these beneficiaries to pay for Project water. Gallup's willingness to pay was estimated from data on the current use of water by people in communities throughout the mountain states. The Navajo people's willingness to pay was estimated from data on their spending for piped water service when available and on spending to haul water when no service is available. Benefits to the Jicarilla Apache people were estimated from the cost of the next cheapest alternative source of water for the area of the Reservation to be served by the Project.

The Indian Health Service identifies the availability of a community water supply as critical for maintaining the health of Indian people. This report roughly estimates the indirect health benefits to Navajo people that would accrue from the provision of a clean water supply.

The completion of the water supply project will also provide infrastructure that is a necessary prerequisite to economic development and poverty relief on the Reservations. While it is uncertain how much economic development would be encouraged by the Project, it is clear that the lack of a reliable water supply presently poses a significant constraint to most types of economic development. Table ES-1 summarizes the economic costs and benefits associated with the Project.

Table ES-1

Summary of Navajo-Gallup Water Supply Project Economic Benefits and Costs

Millions 2005$, 5.375% Discount Rate, 50 year Project life

BENEFITS	**Direct**	**Direct Plus Other**
Gallup Willingness to Pay	$269	$269
Navajo Willingness to Pay	$1,037	$1,037
Jicarilla Avoided Cost	$54	$54
Construction Employment	$183	$183
Indirect and Induced Employment	$0	$87
Health Benefits	$0	$318
Total Benefits	$1,543	$1,948
COSTS		
Project Construction	$944	$944
Distribution System Construction	$38	$38
O,M&R	$283	$283
Gallup Water Cost	$20	$20
Navajo Water Cost	$20	$20
Power Generating Cost	$17	$17
Salinity Increase Cost	$17	$17
Total Costs	$1,339	$1,339
BENEFIT/COST RATIO	1.15	1.46

The benefit/cost ratio greater than 1.0 indicates that the anticipated project benefits are greater than cost and thus, that the Project represents a beneficial use of national resources.

B. Analytical Framework

Dornbusch Associates was engaged by the Bureau of Reclamation et al. to evaluate the economic feasibility of the proposed Navajo-Gallup Water Supply Project (NGWSP). This report summarizes the Dornbusch analysis findings as well as the supporting data and technical methodologies. While a Cost Allocation Report, under separate cover, analyzes the distribution of the Project's estimated ***financial*** cost between the Project's stakeholders, this report focuses on the Project's overall ***economic*** benefits and costs and thus economic feasibility. The Project's economic benefits and costs are compared to a base case that is expected to occur if the Project is not built (a "with vs. without" comparison).

An economic as opposed to a financial analysis approach is used to evaluate projects by international and federal agencies because those agencies are concerned with using a country's resources most effectively. The economic analysis approach considers the value to the country's overall economy of the resources potentially used and produced by a project, so that the sponsoring agency can determine whether that project represents a good investment of the country's resources. In general, if a substantial source of financing for a project is to be national government funds then it is appropriate to conduct a national level economic analysis to determine whether the project contributes to the country's overall economic well-being. This economic approach is also recommended by the Water Resource Council's Principles and Guidelines [Water Resource Council, p. iv], which the Bureau of Reclamation is required to follow.

In contrast, a financial analysis focuses only on whether a project is or will be a profitable investment for a participant. If, for example, a city were able to obtain private financing to develop a water project the city would use a financial analysis to determine what the project would cost and how to pay for it. Depending on some of the factors discussed below, such as subsidies or the cost of money, financial and economic analyses may reach similar or diverse conclusions as to the feasibility of a project.

The approach in this report is to use an economic rather than a financial perspective to evaluate the potential benefits and costs from the proposed NGWSP. The primary source of funding for the NGWSP would most likely be the federal government; hence it is appropriate to assess the Project's feasibility from the perspective of the U.S. as a whole. The remainder of this section discusses the important differences between economic and financial analyses and explains several key aspects of the economic analysis methodology used to evaluate the proposed project.

The primary technical differences between an economic and a financial analysis relate to valuing commodity prices, investment subsidies, taxes, discount rates, labor and water. Each of these is explained as follows:

1. Commodity prices

In a financial analysis it would be appropriate to use whatever prices a project paid for materials and services or would receive for water sold. The actual prices (including any subsidies) would accurately reflect the cash flow from the perspective of the project participants. The objective of an economic analysis, however, is to price commodities at a level that indicates their value to the economy. Government subsidies are a type of transfer payment as they represent payments from the government without the government receiving any goods or services in return. Accordingly, in an economic analysis subsidies paid within the economy are removed from commodity prices. If a participating agency chooses to subsidize water sales, for example, an economic analysis would impute a price reflective of the water's value to the economy and disregard the subsidized price. In contrast, a financial analysis would use the subsidized price to reflect actual revenues realized by the direct participants from the sale of water.

2. Investment costs

Investment costs are treated in a similar fashion to commodity prices (as discussed above). In an economic analysis, even if a project's investment costs are subsidized by a federal program, the full costs of the resources used to build the project are counted. Costs for goods and services used to build a project are measured by their value in other uses that would be displaced by the project (opportunity cost). This concept is discussed in greater detail below, in the sections addressing labor and water costs.

3. Taxes

Most taxes are levied simply to raise general revenues and are not payments that are directly exchanged for something of value. Taxes levied to raise general revenues include, for example, income and sales taxes. Income tax payments go into a general fund and do not pay for specific goods or services that the taxpayer only receives if he pays taxes. Because taxes are not usually linked to an exchange of goods or services they are excluded from an economic analysis. Such general taxes can be thought of not as determining whether a project is feasible but as determining how the benefits from a project are split between the project participants and the government. These taxes are a type of transfer payment because they "transfer" resources from one entity (a taxpayer) to another (the government) without the direct exchange of goods or services.

A use tax is one of the few examples of a tax levied in exchange for goods or services. In the case of use taxes a government entity levies the tax as a fee for services rendered, such as payments for the use of a public facility like a park. In this case value is being received (enjoyment of a park) that is linked directly to the payment of the tax. In an economic analysis such a use tax payment would be recognized as a purchase of goods or services and would be counted as a cost or a benefit.

Both general taxes and use taxes are included in a financial analysis because both represent cash outflows that increase the cost of a project. Only the use tax would be included in an economic analysis, however, because the general tax is a transfer payment that does not represent a purchase of specific goods and services.

For the NGWSP analysis, we consider taxes on field costs to be a type of transfer payment and accordingly we exclude them from our estimates of the Project's economic cost.

4. Discount rate

A development project is considered to be economically feasible when its potential benefits are equal to or exceed its estimated costs. A problem in comparing a project's benefits with its costs is that those benefits and costs do not typically occur at the same point in time. Construction costs are incurred only during the development phase of a project, whereas replacement of equipment occurs periodically throughout a project's life, and operating costs and economic benefits occur annually throughout a project's life.

To relate the stream of benefits and costs to each other, it is necessary to recognize that money has a "time value". A dollar today has a greater value than a dollar in the future – a reality that is recognized in every loan transaction. To illustrate, if Party A loans $100 to Party B for ten years, Party A will require Party B to repay something more than $100 at the end of the ten year period. The additional amount that must be paid reflects the "time value" of the $100 loan. Or, looking at it another way, if someone is offered a choice between $100 today or $100 in ten years, he or she will certainly prefer receiving the $100 today, recognizing that the money can be invested and subsequently yield more than $100 at the end of the ten-year period.

For the purpose of discounting future benefits and costs for the NGWSP we have used the federal rate of 5.375% that is applicable during FY2005 to water resource projects [US Treasury Department]. This federal rate is a constrained, lagged, nominal (includes inflation) rate computed annually by the Treasury Department. It reflects average yields on marketable securities with a term of 15 years or more, but is constrained from changing more than .25% per year. Absent this constraint the 2005 rate would be 5.0877% [Ibid.]. For sensitivity analysis we have also evaluated the Project's economic feasibility applying a real (inflation removed) discount rate of 3%. This real rate is based on an average between inflation-free rates of return on long-term federal bonds and inflation-free returns that have been obtained historically by all taxpayers, including all industrial and commercial sectors, households, and institutions [Fraumeni, pp. 161-244].

A financial analysis would use an actual market rate of interest, adjusted so to be consistent with the inflation assumption built into the benefit and cost projections for the project. For example, if the project benefits were projected in inflation-free (constant) dollars, then the interest rate should be net of the expected inflation rate.

5. Labor

In an economic analysis the cost of labor is determined based on its value as a productive resource. This means that in a national economic analysis the cost of labor for the subject project depends on how much it would contribute to the national economy if that labor was not used for the project being evaluated. This cost is measured by labor's opportunity cost, which is its value in its next best use. For that portion of the labor pool that would be otherwise fully employed in another project, the labor cost is its value as reflected in the full wage rate. However, for that portion of the labor pool that would be otherwise unemployed, and for whom no alternative employment opportunities would be available in the absence of the proposed development project, the opportunity cost of that labor is assumed to be zero. The implication of a zero opportunity cost in analyzing the proposed NGWSP is that in the absence of the project the workers would be unlikely to otherwise be employed in some type of work that added to the nation's supply of goods and services.

This method of using the opportunity cost to reflect the cost of labor in an economic analysis is standard practice among international development agencies such as the World Bank and the U.S. Agency for International Development. The Principles and Guidelines recommend using this method of labor valuation in assessing the costs of a project's construction phase but not its operational phase [Water Resource Council, section 2.11.2(b)].

A financial analysis would account for all wage costs that may be incurred by a project regardless of whether the workers would otherwise be employed or not.

6. Water

In a financial analysis the water used in a project would be valued at whatever dollar cost was paid for the use of water by the project participants. In an economic analysis the water is valued at its opportunity cost, or its value in its next best use. To the extent that project participants pay market prices for the water then the two approaches (financial and economic) should converge. If a participant already owns rights to water, however, then its financial cost would be zero while its economic cost would be the value in whatever other uses were precluded by the project.

C. Project Benefits

In an economic analysis the basis for estimating benefits from a water project is the *Willingness to Pay* for the "increase in value of goods and services attributable to the [project] water supply." [see Water Resource Council, section 2.2.2(a)]. In a municipal water use setting it is impractical to measure the increase in value for each use of water (bathing, toilet flushing, cooking, drinking washing, lawn and garden watering, etc.) Instead we try to estimate what users are willing to pay for the water itself, assuming they are best placed to know the value of water's various uses. This estimated willingness to pay is the amount of money that water users would be willing to pay for project water; it reflects the economic value of the water to the users and thereby to society as a whole. In performing an economic feasibility analysis of the NGWSP, we estimated this willingness to pay separately for the three project participants: the City of Gallup, the Navajo Nation and the Jicarilla Apache Nation.

1. City of Gallup Willingness to Pay

Willingness to pay is commonly estimated in one of two ways: deducing what people are willing to pay by analyzing their actual payment patterns (revealed preference) or by asking them what they would pay in a structured hypothetical situation (stated preference). We have used a revealed preference approach to estimate a water demand function for 79 mountain states mid-sized communities, including Gallup. Towards this end, we compiled data on each communities water use during 2000, price for water, median income levels, household size and average rainfall. From this data we estimated a generalized demand curve that relates these variables to the demand for water. This approach implicitly assumes that water use patterns are substantially similar among the communities in the database, except for those differences accounted for by the explanatory variables (see also the discussion of other variables in part C.1.e, below). Equation (1) shows the estimated relationships. The data and regression results are shown in Appendices A and B.

$$(1)\ \ln GPCD = 2.913 + .372 * \ln HHY - 1.348 * \ln HHS - .554 * \ln P$$

$$(2.258)^{**} \quad (2.805)^{**} \quad (-5.680)^{**} \quad (-10.878)^{**}$$

where GPCD = water use in gallons per capita per day

HHY = median household income

HHS = average household size

P = average price for water

Numbers in parentheses are t-statistics. All coefficients are different from zero at 90% (*) or 95% (**) level of confidence.

Adjusted $R^2 = .630$

Observations = 79

Degrees of freedom = 75

Converting the logarithmic equation (1) to an exponential equation form gives equation (2), which was used to estimate the demand for water in Gallup.

$$(2)\ GPCD = 18.405 * HHY^{.372} * HHS^{-1.348} * P^{-.554}$$

a. Household Income

Our expectation is that increasing income will lead to increasing water use, and the estimated exponent in equation (2) is consistent with that expectation. The exponent of the income term can be interpreted at the ***Income Elasticity*** of demand for water, that is, the amount by which the demand for water will increase given an increase in household income. The estimated income elasticity of .372 in equation (2) is similar to other income elasticities reported in the literature. Table 1 shows examples of reported income elasticities for water.

Table 1

Income Elasticities Reported in the Economics Literature

STUDY	INCOME ELASTICITY
Jones & Morris	0.40 to 0.55
Martin & Wilder	0.04 to 0.27
Nieswiadomy & Cobb	0.64
Nieswiadomy	0.28 to 0.44
Schneider & Whitlatch	0.207
Morgan	0.33 to 0.39

The income elasticity was used in the willingness to pay analysis to estimate how the demand for water in Gallup (willingness to pay for water) would increase in the future with increases in median household income. Median household income was assumed to continue growing at a real (adjusted for inflation) rate of slightly above 1.0% per year, which was the rate of growth in McKinley County personal income from 1969 to 1999 [US Census Bureau, 2004].

b. Household Size

Some researchers have observed that per capita water use is inversely related to household size [see eg. Brown]. This inverse relationship seems logical, as outdoor use in particular should not increase linearly with the number of people in a household. Our data analysis did find a strong inverse correlation between household size and per capita water use. The estimated exponent in equation (2) is negative 1.348, which is substantially larger than some other values reported in the literature. Nieswiadomy reports a household size water use elasticity of .69 for western cities, on a dependent variable defined as total household use. Converting the dependent variable in Niewswiadomy's estimate to per capita terms would reduce the exponent of the household size independent variable to negative .31. Jones and Morris report a household size elasticity of 0.17 (also on total household use), which converts to an elasticity estimate of negative .83 for per capita use.

This household size variable is used in the willingness to pay analysis to adjust per capita water demand in accordance with the expected future decrease in average Gallup household size. Gallup presently has an average household size of 2.85 persons per household, compared to the national average of 2.63 persons per household, and Gallup's average household size has been declining. For the analysis, we assumed that Gallup's household size would continue to decline at 0.005 persons per household per year until it converged with the 2000 national average, and then would remain at that level.

c. *Price for Water*

Economic theory suggests that, if all else is equal, people demand less of most goods and services the more expensive they are. Our data analysis showed a strong inverse correlation between per capita water use and the price for water. The estimate exponent of the water price term in equation (2) is negative 0.554. This estimate is generally consistent with other price elasticity results reported in the literature, examples of which are shown in Table 2.

Table 2

Price Elasticities Reported in the Economics Literature

STUDY	PRICE ELASTICITY
Jones & Morris	-0.34
Nieswiadomy	-0.22 to -0.60
Agthe & Billings	-0.595 to -0.624
Billings & Agthe	-0.267
Martin & Wilder	-0.49 to -0.70
Nieswiadomy & Cobb	-0.63
Schneider & Whitlatch	-0.63
Weber	-0.202
Nieswiadomy & Molina	-0.36 to -0.86
Hasson	-0.22 to -0.34
Young	-0.41 to -0.60
Foster & Beattie	-0.27 to -0.76
Brookshire et al. (summarizing other studies)	-0.11 to -1.59 (average -0.49)

The estimated price elasticity, income elasticity and household size elasticity of water consumption are used in the willingness to pay analysis to estimate the implicit price associated with various quantities of water use. These price estimates are necessary in order to calculate the total willingness to pay by Gallup residents for different quantities of water. These elasticity estimates are used in conjunction with the assumptions about future changes in income and household size levels, previously discussed. Table 3 shows for various future years the implicit price per thousand gallons for total average water use of 160 gpcd. This price represents the amount that average Gallup water users would be willing to pay for water, at the 160 gpcd level of average consumption. The price that we expect Gallup water users to be willing to pay for water increases over time as incomes rise and household size decreases.

Table 3

Estimated Willingness to Pay for Domestic Water (160 gpcd)

Price Per Thousand Gallons of Water, Gallup, New Mexico (2005$)

YEAR	PRICE PER THOUSAND GALLONS
2000	$1.96
2010	$2.12
2020	$2.30
2030	$2.50
2040	$2.71
2050	$2.87

d. Climate variables

Some researchers have found a significant relationship between per capita water use in an area and climatic variables for that area, such as rainfall or growing season temperatures. We compiled data on average annual rainfall and average annual growing degree hours[1] for each community in our data set. While we found plausible results from statistical analyses (linear regression) that included those variables the coefficients were not significant at reasonable levels (less that 80% likely different from zero and they did not add to the overall explanatory power of the overall equation. Accordingly, the linear regression

[1] "Growing degree hours" is a measure of the temperature above a certain threshold multiplied by the hours at that temperature, accumulated throughout the growing season. It is an indication of how vigorously plants will grow and is generally correlated with water use by plants.

equation used to estimate Gallup's willingness to pay for water does not include those variables.

e. Other Variables

Although our demand equation includes water price, household income, household size and rainfall variables, other factors may also influence per capita water use in different cities. Differences in water quality and reliability, for example, may affect per capita water use. We have no reason to suspect that these and other omitted variables significantly affect our results, and we expect that any bias from omitting these variables would be small. However, to the extent that an omitted water quality variable would be significant we have probably underestimated the project benefits because the project will provide very high quality water to its users.

f. Gallup Without-Project Condition

Gallup currently relies on groundwater pumping to supply water to its residents. The water levels have been falling by 7 to 29 feet per year over an extended period, and at some point the production capacity of the current well system is expected to diminish. For purposes of our analysis we have assumed that annual production capacity will peak at 5MGD (5600 afy) in the year 2010, and that the production capacity will decline linearly to 1439 afy by the year 2040 [Navajo Nation et al., "Technical Memorandum", Table 4.2]. The production capacity of 5600 afy exceeds the City's projected water needs of about 4500 afy in 2010, but the progressively increasing needs and diminishing capacity indicate that Gallup will need a supplemental water supply to meet demand by the year 2016. Gallup is currently investigating a water reuse facility to treat effluent as a source for this supplemental supply. For purpose of our analyses we have assumed that by 2012 Gallup will construct such a reuse facility that will supply one MGD (1,120 afy) to help meet forecasted water needs [Allgood]. Once the Project is operating, Gallup plans to shut down its wells and rely entirely on water from the Project and from the planned reuse facility.

Even following implementation of the assumed additional water reuse facility, due to population growth the City of Gallup cannot continue to supply its residents with their current level of average per capita water use (171 gpcd) beyond the year 2018. Absent the Project, therefore, Gallup would be faced with some combination of the following scenarios: (1) development of alternative water supply projects, (2) diminishing per capita water supply, and/or (3) curtailment of population growth. Gallup has not been able to identify any other water supply project that is as cost-effective as the Navajo Gallup Water Supply Project. Without new water supplies in addition to the assumed water reuse facility it is estimated that the available water per capita would fall to less than one-half of existing water use by the year 2033. Thus without the Project, Gallup would have to make major changes in water use patterns, with consequential negative implications for the city's economic well-being. While the Willingness to Pay approach does address the amount of money that Gallup residents would be willing to spend for a supplemental water supply, the approach does not address the overall economic losses to the City that would occur if future water shortages caused residents and businesses to locate elsewhere.

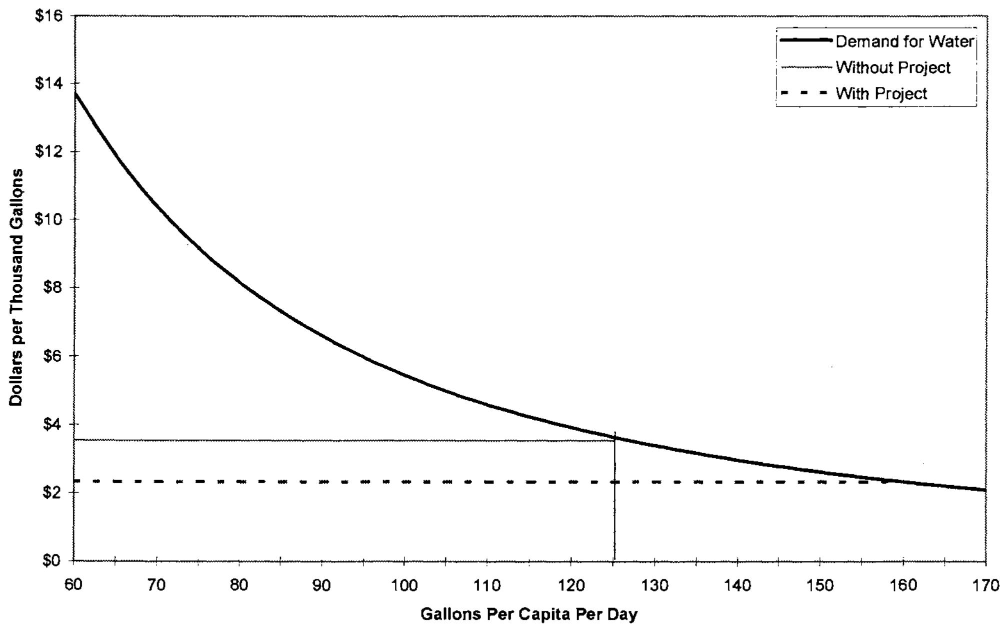
g. Gallup With-Project Condition

For purposes of the economic analysis we assume that the Project will be operational by January, 2021. We further assume that in the future, average Gallup water consumption per capita will decline slightly from today's 171 gpcd to 160 gpcd. Two factors should affect per capita water consumption in the future. First, water rates may be somewhat higher in the future in order to pay for a supplemental water supply, and higher rates should cause water use per capita to decline. Second, per capita water use may currently be somewhat elevated due to water use by non-Gallup residents who haul water from Gallup sources. When the Project is completed the need for water hauling should diminish.

h. Calculation of Project Benefits for Gallup

The potential economic benefits to Gallup from the Project can be measured by the area under the demand curve between (1) the projected use without the Project and (2) 160 gpcd. We measured this area for each year for the 50 year period beginning with planned Project completion in 2021. Each year's benefits are slightly different, due to decreasing household size and increasing population and income. Figure 1 shows Gallup's demand for water estimated for the year 2025. The area below the solid horizontal line and the curve shows the total willingness to pay (WTP) for 160 gpcd. However, the area below only the horizontal solid line indicates WTP for water that could be supplied in 2025 even in the absence of the Project; that area is not included in the benefit calculation. In addition to the benefits from supplemental water Gallup residents will benefit from the cost savings generated by replacing expensive deep wells with Project water. Gallup estimates that the city will save approximately $790,000 per year once the Project water supplies allow it to shut down deep wells [Munn]. Future benefits were discounted back to 2021, using the current (FY2005) federal discount rate of 5.375%. The discounted estimated annual benefits of the Project sum to a total present value of $315 million.

Figure 1
Demand for Water in 2025
Gallup, New Mexico



Note 1: The area under the demand curve was calculated by integrating equation (2) and solving for the area under the demand curve between the implicit price for projected water use without the project and the price at 160 gpcd water use with the project. This calculation is shown as equation (3).

$$(3)\ \text{Area} = 18.405 * HHY^{.372} * HHS^{-1.348} * (P1^{(1-.554)} - P0^{(1-.554)}) / (1-.554),$$

where Area = area under demand curve between P1 and P0

HHY = household income

HHS = household size

P1 = price at 160 gpcd

P0 = price at base (without Project) per capita water use

Coefficients and exponents as estimated in equation (2)

The above calculation provides the area under the demand curve and to the right of the y-axis. Finally, to derive the economic benefits we adjust the above calculation to find the area below the demand curve but above the x-axis. This was done by subtracting the rectangle Q0 * (P1-P0) and adding the rectangle P1 * (Q1-Q0), where Q0 is the base (without Project) per capita water use and Q1 is the per capita water use with the Project.

2. Navajo Nation Willingness to Pay

Water use patterns on the Navajo Indian Reservation are substantially different from that in most off-Reservation communities, including Gallup. Most notably, about 40 percent of Navajo Reservation residents have no piped water supply so they must haul water to their homes. Water hauling is time consuming and expensive, with the result that those Navajos who do haul water tend to consume far less water per capita than those who have piped water. The circumstances of water hauling (price and per capita water use) are completely outside the range of data for any community surveyed as part of the Gallup analysis. Hence we concluded that it would be questionable to apply the price elasticity used for Gallup or that for any other community with a predominantly piped water supply to an assessment of Navajo willingness to pay for water. Instead, because of the importance of water hauling among the Navajo people we have estimated a Navajo-specific water demand function instead of using the demand curve developed for Gallup.

The Navajo water demand equation is based on fitting a log-log equation (similar to that used in the Gallup analysis) to the year 2005 water use and price data from Navajos who either (1) pay for water piped to their homes by the Navajo Tribal Utilities Authority (NTUA), or (2) purchase bulk water and haul it to their homes.[2] This estimated demand relationship is shown in equation (4):

$$(4)\ \ln GPCD = -.1454 + -.8402 * \ln P$$

where GPCD = water use in gallons per capita per day

P = price for water

Converting the logarithmic equation (4) to an exponential equation form gives equation (5):

$$(5)\ GPCD = .8646 * P^{-.8402}$$

The price elasticity of negative .8402 estimated in equation (5) is somewhat higher than the average reported for communities having piped water supplies but is within the range of reported results (shown in Table 2).

Because the Navajo water use data did not include income for the water users we could not estimate a Navajo-specific income elasticity for water use. Since the Navajo household income is within the range of incomes in our community survey, we used the income elasticity from that survey for that Navajos. Essentially, we assumed that the Navajo would exhibit the same income response to water use (income elasticity) as we found in our sample of 79 mountain state communities in equation (2). We therefore added the income

[2] We recognize that piped and hauled water are dissimilar commodities. However, by including the cost of hauling to and storing at the household we attempted to define both as an "in-home water supply." There remains the possibility that even after accounting for the difference in cost, people's demand for hauled water would be less than that for piped water, due to the heightened awareness of resource scarcity. To the extent that this difference exists we may have underestimated the project benefits.

elasticity term to equation (5) and solved for an adjusted constant term, deriving equation (6) that was used to estimate Navajo benefits from water use.

$$(6)\ GPCD = .021 * P^{-.840} * HHY^{.372}$$

where HHY = median household income

a. NTUA Water Use

About 60 percent of Navajo Reservation households obtain piped water supplied by the NTUA. Average annual consumption is about 100 gpcd [Foley]. Average household size is 4.5 persons per household [U.S. Census Bureau], which translates to an average monthly household water consumption of 13,500 gallons (100 x 4.5 x 30 = 13,500). NTUA charges $2.20 per thousand gallons for the first 3,000 gallons per month and $3.35 per thousand gallons for additional use [Navajo Tribal Utility Authority]. NTUA also levies a monthly service charge of $5.50 for each hook-up. Given the average monthly household water use of 13,500 gallons the average monthly household water bill is $47.28 (3 x $2.20 + 10.5 x $3.35 + $5.50 = $47.28). Dividing the monthly bill by average monthly water use gives an average price of $3.502 per thousand gallons.

b. Water Hauling

About 40 percent of Navajo Reservation households do not have water piped to their homes [Navajo Department of Water Resources, 2000, p. ES-3]. These households instead haul water from NTUA distribution points, from wells, from vending machines, or from other water sources. Data from a recent survey indicates that Navajo households without a piped water supply haul an average of 5.4 gpcd [Ecosystem, 2003]. We used data for about 45 households from the same survey to estimate a delivered cost for hauled water. The delivered cost is necessary for the demand analysis so the cost for hauled water can be put in comparable terms to the cost for piped (delivered) water. We estimated four components of the delivered cost of hauled water: (1) purchase cost, (2) container cost, (3) transportation cost and (4) the opportunity cost of time.

Navajos hauling water pay a range of prices for water, from zero for water obtained from wells to as much a $0.25 per gallon for water purchased from vending machines. The survey average price paid for water in 2003 was $0.032 per gallon, or $32.00 per thousand gallons [Ibid.]. We used the Consumer Price Index (CPI) to convert this cost to a January, 2005 cost of $33.17 per thousand gallons.

The cost of sanitary containers used to haul water averaged $35.00 per household in 2003 [Ibid.]. Indexed by the CPI to 2005$ this cost is $36.27. We assume that the containers are replaced annually. Given water use of 5.4 gpcd and 4.5 persons per household, the 2005 container cost is $4.09 per thousand gallons ($36.27 per container per year / 5.4 gpcd x 4.5 persons per household x 365 days/year = $4.09 per thousand gallons).

The Ecosystem survey found that the average distance per hauling trip was 14 miles each way, for a 28 mile round trip [Ibid.]. We value the economic cost of transportation at the marginal cost for a light truck or van. This marginal cost includes both variable operating costs (gasoline, oil, tires, repairs, etc.), as well as additional vehicle depreciation associated with excess vehicle mileage. The variable operating costs are estimated to average $0.1755 per mile [Victoria Transport Policy Institute, indexed to 2005$ by CPI]. Additional depreciation was estimated to average $0.1085 per mile [Kelly Blue Book]. Total marginal cost per mile is thus estimated at $0.2840. The Ecosystem report adds 25% to average vehicle operating costs to allow for the use of more expensive than average vehicle maintenance and for extra costs due to rough roads. We have addressed the first issue by using data for light trucks instead of for automobiles. Our resulting costs per vehicle-mile may still be conservative because we have not made any allowance for extra costs due to rough roads. Given an average roundtrip mileage of 28 miles and average haulage of 173 gallons per load, transportation costs are estimated to be $45.97 per thousand gallons (28 miles per load x $0.2840 per mile / 173 gallons per load = $45.97 per thousand gallons).

Finally, we estimated the value of the time spent by Navajos who haul water. While in a financial analysis we would value their time only at whatever monetary compensation was sacrificed in order to haul water, in an economic analysis such as this it is important to consider the implicit value that people hauling water place on their time. [see, eg., Asian

Development Bank]. Economists recognize that people place a value on their time, even if they are unemployed. While employment status may affect the magnitude of the value that water haulers place on their time it does not affect the principle that people generally put some positive value on the time they spend doing chores. The value of time is recognized repeatedly as people make choices that trade off money against time. A good example is the premium people pay for convenience food over food needing preparation.

The value of time spent in transit is an issue that is commonly addressed in studies of recreational values. Many such studies simply assume that time spent traveling to a recreation site has some value relative to the wage rate, typically 25% to 50%, regardless of the employment status of those traveling [Cesario, Smith, Chia-Yu, Bhat, Bowder, Loomis]. Some recreational studies have attempted to calculate the value of time in transit in comparison to the wage rate [Bockstael (one to three times the wage rate), Feather (6% to 100% of the wage rate), Larson (48% to 79% of the wage rate), Shaikh (65% to 90% of the wage rate)]. A few studies have tried to estimate directly the value of time spent to haul water [World Bank (52% of wage rate), Whittington (100% or more of wage rate)]. For purposes of this economic analysis we have assumed that Navajo people value their time hauling water at 50 percent of the minimum wage rate. A Navajo survey cited in the Ecosystems report found that average hauling time was 52 minutes. Doubling that to allow for a round trip and rounding up to allow for filling and emptying time we assume that each load takes 2 hours. At one-half of the 2005 New Mexico minimum wage of $5.15 per hour and 173 gallons per load, the estimated opportunity cost per thousand gallons is $29.77 per thousand gallons ($5.15 per hour x one-half x 2 hours/load / 173 gallons/load = $29.77 per thousand gallons).

This approach implicitly assumes that the sole purpose of the trips is for water hauling. Unfortunately, the survey did not collect trip purpose information, so we assumed that water hauling was the primary purpose of each trip and that other trip purposes were incidental. Given the importance of water hauling and the relatively small window of time that each household may have to schedule trip when their water containers are nearing empty, this assumption may be generally reasonable.

The total economic cost for hauling water is the sum of the costs for purchasing water, purchasing containers, operating a vehicle and allowing for the opportunity cost of the time required. This sum is $113.00 per thousand gallons ($33.17 + $4.09 + $45.97 + $29.77 = $113.00).

We also contacted two commercial water haulers who were prepared to deliver water to Navajo households. Including the cost of a 1,000 gallon cistern (amortized over 25 years) the delivered cost of water averaged about $133 per thousand gallons, about 20% higher than the $113 per TG used in this analysis.

Note 2: The water use and cost per thousand gallons data for NTUA customers and for water haulers, described above, was used to estimate the a and b parameters in equation (4).

$Q = a * P^{b}$

NTUA customers: $Q1 = 100, P1 = 3.502$

Water haulers: $Q2 = 5.4, P2 = 113.00$

$\ln Q = \ln(a) + b * \ln P$

NTUA customers: $\ln Q1 = 4.605, \ln P1 = -5.654$

Water haulers: $\ln Q2 = 1.686, \ln P2 = -2.180$

$$b = \frac{\ln Q1 - \ln Q2}{\ln P1 - \ln P2} = -0.8402$$

$\ln a = \ln Q1 - b * \ln P1 = -0.1454$

c. Navajo Without-Project Condition

In the absence of the Project the Navajo Nation will continue to extend piped water service to a portion of its growing population, but for this analysis we assume that in the future the proportion of Navajos who haul water will remain at today's 40 percent. We also assume that without water from the Project and the economic growth facilitated by the Project that per capita water use among NTUA customers will remain at 100 gpcd into the foreseeable future.

d. Navajo With-Project Condition

The Project will deliver water to two different areas of the Navajo Reservation. The Cutter Lateral will convey water to a corridor of communities on the far eastern edge of the Navajo Reservation, eventually delivering water to the Jicarilla Apache Nation as well. We assume that this lateral will be operational by 2013.

A western lateral (San Juan Lateral) will convey water from the San Juan River directly south to Gallup, serving Navajo chapters along the way, with a branch that delivers water as far west as Window Rock and Fort Defiance. This analysis assumes that the section of this lateral that serves the Twin Lakes Chapter and is connected to the Chapters around Gallup will be completed by 2015. A well field will supply up to 2,000 afy to these chapters until the entire San Juan Lateral is completed in 2021.

For purposes of this economic analysis we assume that Project water will go first to NTUA customers to supplement their existing water supplies, and then to Navajos who would otherwise be hauling water. The reason is that the delivery infrastructure is already largely in place for NTUA customers but still needs to be constructed for water haulers. Because of the remote location for some water haulers we assume that 10 percent of today's Navajo population will continue to haul water despite implementation of the Project.

e. Calculation of Project Benefits for the Navajo Nation

The calculation of Project benefits accruing to the Navajo Nation is similar to that for the City of Gallup in that Willingness to Pay is measured by the area under a demand curve. We used the demand curve shown as equation (6) to estimate these benefits. We assume that household use for NTUA customers will increase from 100 gpcd to 130 gpcd, and that household water use for people who would otherwise haul water would increase from 5.4 gpcd to 130 gpcd. We further assume that an additional 22.5 gpcd will be used to support increased commercial activity and non-metered productive uses, such as community landscaping, construction and fire protection. A final 7.5 gpcd will go to other non-metered uses and losses. Benefits for NTUA customers were measured as the willingness to pay for supplemental water to increase per capita consumption from 100 gpcd to 130 gpcd. Benefits to commercial and other productive uses were assumed proportional to residential uses, so the final benefit is 152.5/130 times the residential-only benefit. No benefits were counted for system losses and any other non-productive uses. Per capita benefits were calculated for each year of the 50-year Project life, multiplied by the projected population in that year, and discounted using the current federal discount rate of 5.375% per year. Based on this calculation, the estimated present value of benefits of the Project to the Navajo Nation is $1,037 million.

Note 3: The area under the demand curve was calculated by integrating equation (6) and solving for the area under the demand curve between the implicit price for projected water use without the project and the price at 130 gpcd water use with the project. This calculation is shown as equation (7).

$$(7)\ \text{Area} = .021 * HHY^{.372} * (P1^{(1-.846)} - P0^{(1-.846)}) / (1-.846),$$

where Area = area under demand curve between P1 and P0

HHY = household income

P1 = price at 130 gpcd

P0 = price at base (without Project) per capita water use

Coefficients and exponents as estimated in equation (6)

The above calculation provides the area under the demand curve and to the right of the y-axis. Finally, to derive the economic benefits we adjust the above calculation to find the area below the demand curve but above the x-axis. This was done by subtracting the rectangle Q0 * (P1-P0) and adding the rectangle P1 * (Q1-Q0). The calculations were done separately for water haulers and for NTUA customers because their respective base prices (P) and quantities of water use (Q) were different.

3. Jicarilla Apache Nation Willingness to Pay

The Jicarilla Apache Nation has long-term plans to develop the southwest area of their reservation, which is not presently populated. The Nation's development plans include housing and commercial projects, and are contingent on securing a reliable and high-quality water supply for the area [Jicarilla Apache Nation].

a. Basis for Estimating Benefits

The absence of a population base for which to estimate Willingness to Pay for the Navajo Gallup Water Supply Project makes it difficult to use a demand function to estimate benefits for the Jicarilla Apache Nation as was done for the City of Gallup and the Navajo Nation. Moreover, much of the anticipated Project benefit is expected to come from the commercial enterprises facilitated by the new water supply, rather than from household use. Under these circumstances, coupled with the articulated tribal policy to develop this area, we believe it is appropriate to estimate Project benefits by comparing the cost of the Project to the most likely alternative means of supplying water to the area. This method is a proxy for willingness to pay insofar as it reflects the amount the Apache Nation is willing to pay to secure a water supply, and is also consistent with the approach recommended by the Water Resource Council's Principles and Guidelines [Water Resource Council, section 2.2.2].

b. Jicarilla Without-Project Condition

As discussed above, The Jicarilla Apache Nation has adopted a policy of developing the southwest area of their reservation, and in case the Navajo Gallup Water Supply Project is not approved, they have investigated alternative means of conveying water to this area. We reviewed the associated project construction and operating cost estimates provided to the Nation [Frick (September) and Frick (October)], and adjusted those cost estimates to be comparable to the estimated costs for the NGWSP. These adjustments include (1) updating the costs to January, 2005 dollar terms, (2) making consistent assumptions regarding unlisted items (10% of listed items), contingencies (25% of listed plus unlisted items), engineering (30% of listed plus unlisted items plus contingencies), and cultural resource investigations (2.4% of listed plus unlisted items plus contingencies), and (3) adding interest during construction at the current federal rate for project analysis of 5.375%. Following these adjustments, we calculate that the average of the high and low cost estimates for the Jicarilla Nation's alternative water supply project is approximately $54 million.

c. Jicarilla With-Project Condition

The Jicarilla Apache Nation would be full partners in the Navajo Gallup Water Supply Project. They would receive 1,200 afy through the Cutter Lateral, which is assumed to be operational by 2013. The costs for the Nation are included in the construction cost estimates discussed below.

d. Calculation of Project Benefits for Jicarilla Apache Nation

The Jicarilla Apache Nation would receive Project benefits of $54 million, measured by the cost of constructing and operating an alternative water supply project, discussed in section b, above.

4. Comparison of benefits per thousand gallons

Because Project benefits were estimated for the three participants using separate analytical techniques we believe it useful to compare the per unit benefits for the participants. Table 4 shows that the benefits are in fact reasonably similar. This table shows only direct benefits and does not include regional benefits such as unemployment relief or health care efficiency improvement.

Table 4

Comparison of Benefits per Thousand Gallons among Project Participants

	Navajo	Gallup	Jicarilla Apache
Present Value of Benefits	$1,037,000,000	$269,000,000	$54,000,000
Annualized Benefits	$60,126,000	$15,597,000	$3,131,000
Levelized Water Use (TG/yr)	8,951,000	2,444,000	642,000
Benefits / TG	$6.72	$6.38	$4.88

5. Unemployment Relief Benefits – Construction Employment

As discussed in section A.5, above, in an economic analysis the measured cost of employing labor is less than the wage rate if the labor would otherwise be unemployed. The Principles and Guidelines recognize this principle [Water Resource Council, section

2.11] and recommend applying a zero opportunity cost to construction phase labor that would otherwise be unemployed.

Unemployment is well above the national average in the Project area. Table 5 shows recent unemployment rates for the two counties and two Indian reservations in the Project area, as well as nationally. Most of the Project would be constructed on Navajo Reservation land to serve Navajo chapters, and we are assuming that a local hire rule encouraging Indian employment would be in effect. The very high unemployment rates on the Indian reservations clearly support the conclusion that much of the labor force used to construct the Project would come from the ranks of the otherwise unemployed.

Table 5

Unemployment Rates in United States and Vicinity of Navajo Gallup Water Supply Project

Year	United States	San Juan County, NM	McKinley County, NM	Navajo Reservation	Jicarilla Apache Reservation
1999	4.2%	7.5%	7.1%	34%	40%
2000	4.0%	5.8%	6.6%		
2001	4.7%	6.2%	6.2%	52%	33%
2002	5.8%	6.9%	6.2%		
2003	6.0%	7.6%	7.4%		
2004	5.5%	6.1%	7.6%		

Sources: National and county unemployment rates from U.S. Bureau of Labor Statistics, "Local Area Unemployment Statistics;" Reservation unemployment rates from U.S. Bureau of Indian Affairs, "American Indian Population and Labor Force Report," 1999 and 2001.

The Principles and Guidelines recommend that in an area of substantial and persistent unemployment and in the case of a local hire rule we assume for the economic analysis that 43% of skilled workers and 58% of unskilled workers be considered as otherwise unemployed during the construction phase of the Project [Water Resource Council, section 2.11.4]. We used an IMPLAN input-output model [IMPLAN, "Professional 2.0;" IMPLAN, "County Data"]to estimate the average earnings of workers needed for the Project, and used Bureau of Reclamation data to split the total earnings estimate between earnings for skilled and unskilled workers [U.S. Bureau of Reclamation, 1988]. We estimated the earnings for each year of construction, and accumulated interest during construction until the year of completion (2021) using the federal discount rate of 5.375%. The estimated present value (as of 2021) of the construction earnings going to otherwise unemployed persons is $183 million.

6. Other Project Benefits

a. Unemployment Relief Benefits – Secondary Employment

The wages and salaries paid to area construction employees will in turn provide a substantial boost to the local economy, known as an "induced" impact. The Principles and Guidelines suggest that because of measurement and identification problems and because unemployment is regarded as a temporary phenonemon that a project analysis should only account for the benefits from employing construction labor and not the associated induced employment [Water Resource Council, section 2.11.2]. However, high unemployment levels have been persistent on both the Navajo and Jicarilla Apache reservations for generations, directly contrary to the "full employment economy" premise of the Principles and Guidelines [Water Resource Council, section 1.7.2(e)(3)]. We have therefore estimated the value of earnings going to otherwise unemployed people in the non-construction industries stimulated by local construction spending, particularly for labor. We used the same methodology as in estimating earnings of construction workers, except that we did not assume any local hiring preference and assume that only 30 percent of skilled workers and 47 percent of unskilled workers would be otherwise unemployed [Water Resources Council, p. 94]. The present value of wages in non-construction industries that will go to otherwise unemployed persons is estimated at $87 million.

b. Health Benefits

A primary rationale for the public policy of providing clean and reliable water to all people in the United States is the resulting health benefit. For example, Congress has found specifically for Indians that a "major national goal of the United States is to provide the quantity and quality of health services which will permit the health status of Indians to be raised to the highest possible level ..." [25 USC 1601], and that "the provision of safe water supply systems and sanitary sewage and solid waste disposal systems is primarily a health consideration and function," and that "it is in the interest of the United States, and it is the policy of the United States, that all Indian communities and Indian homes, new and existing, be provided with safe and adequate water supply systems... as soon as possible." [25 USC 1632].

There is a clear connection between sanitation facilities (water & sewerage) and Indian health. The Indian Health Service considers the availability of essential sanitation facilities to be "critical to breaking the chain of waterborne communicable disease episodes... In addition, many other communicable diseases, including hepatitis A, shigella, and impetigo are associated with the limited hand washing and bathing practices often found in households lacking adequate water supplies. This is particularly true for families that haul water" [Indian Health Service, 2004]. The Indian Health Service reports that American Indian families living in homes with satisfactory environmental conditions required about one-fourth the medical services as those with unsatisfactory environmental conditions [Ibid.].

Benefits from an improved water supply will accrue both to consumers and providers of health care. The Navajo people will enjoy better health as a result of their access to a clean and reliable water supply. Their benefit should be reflected in their willingness to pay for water and is already addressed in that analysis. The Indian Health Service, which provides health care to the Navajos, will also experience a reduction in their cost of providing health care services as a result of the reduced case load from water-related illness. This efficiency improvement is the focus of the present section.

The Indian Health Service concludes that the average annual cost for medical care in the Shiprock-Gallup-Fort Defiance area that would be equivalent to the Federal Employees Health Plan is $3,218 per person in 2005$ [Indian Health Service, 2002, US BLS, 2005]. If even 10% of this cost could be saved by the provision of a clean piped water supply to those households who would otherwise haul water, that savings would amount to a present value of as much as $10,000 per person for those people connecting to the Project by 2013, or $4,400 per person for those connecting by 2025. The Navajo-Gallup Water Supply Project will ultimately provide water to over 100,000 people who would otherwise haul water, for an estimated total savings in medical expenses of over $318 million over the life of the Project.

c. Increase in Economic Activity

The entire project area and the Navajo Reservation in particular are characterized by persistent poverty and above national average unemployment rates [USDA; Table 4, supra]. Over 40 percent of Navajo families have income below the poverty level, compared with less than 10 percent nationwide [Navajo Division of Community Development, 2004, p. 22], and median income for Navajo households is less than one-half of the national average [Ibid.].

Provision of a clean, reliable water supply can serve to promote economic activity in the project area. International agencies recognize that not only is water an important factor of production in some industries (eg. cooling water in a power plant), but that investments in water infrastructure can also serve as a catalyst for more general development [Lenton, p. 129]. A recent study of foreign aid focused on short-term projects (eg. roads, irrigation systems, electricity generators and ports) concluded that every $1 invested in short-term aid returned a present value of $1.64 in increased output and income [Clemens]. Although the study objective was to estimate the effect from short-term aid the results also suggest "an important long-run positive impact on growth from long-term aid" (such as a water supply project)[Clemens, p. 41 and Table 5].

Two recent studies in the United States examined the extent to which development of water projects stimulated the regional economy. The first study investigated the effects of dams on local economic growth and development by analyzing the effects on county income, employment, population and earnings [Aleseyed]. Control group counties were paired with counties with new water projects. The study concluded that large dam reservoirs had a statistically significant positive effect on growth in the local areas, with the strongest positive effects from non-flood control projects, and weaker effects from regions without a large city [Aleseyed, pp. 17-18].

The second study focused on the extent to which water and sewer projects can save and/or create jobs, spur private investment, attract government funds and enlarge the property tax base [Bagi]. The study found that "[e]very dollar spent in constructing an average water/sewer project generated almost $15 of private investment, leveraged $2 of public funds, and added $14 to the local property tax base" [Bagi, p. 46]. In addition, the study found that many more permanent jobs were either saved or created by the project than the number of construction jobs needed to build the project [Bagi, p. 49].

It is difficult to forecast the extent to which the NGWSP will promote economic growth in the region. The evidence cited above, however, clearly indicates that we should expect a substantial regional economic stimulus from the project.

d. Curtailment of Navajo Outmigration

Finally, the Project may indirectly help reduce the outmigration of Navajo people. The improved economic climate facilitated by the Project will provide more employment opportunities for the minority and low-income populations. This increased employment opportunity, together with an improved water infrastructure, will make the area more attractive for young adults who might otherwise consider moving outside the area. This impact is discussed in the companion report "Social Impacts from the Navajo-Gallup Water Supply Project." [Merchant, 2006b]

D. Economic Costs

The Project's economic costs were estimated using the same principles as in estimating project benefits. The primary categories of Project costs include (1) Project construction costs, (2) distribution line construction costs, (3) operation, maintenance and replacement costs, (4) costs for water, (5) downstream effects on power generation, and (6) downstream effects on salinity.

1. Project Construction Cost

In a companion report we estimated the total financial Project costs and the respective shares of cost for each of the three Project participants [Merchant, 2006a]. The total project capital cost before interest during construction (IDC) is estimated at $715 million. Two adjustments of this number are necessary to derive the Project's economic cost. First, as explained in section A.3, above, the $42 million of taxes included in this total are transfer payments and should be excluded [Ibid.], leaving a net cost before taxes of $673 million.

The second adjustment necessary is to add IDC to reflect the cost to the economy of tying up resources used during construction of the Project and before the project begins to deliver water and to provide benefits. We assume that Project construction would begin in 2008, full Project operation would begin in 2021, and we compound IDC to the completion date at the rate of 5.375% per year. IDC based on a pre-tax construction cost of $673 million amounts to $271 million [Ibid., adjusted to remove IDC on taxes]. The total economic construction cost is thus estimated at $944 million.

2. Distribution Line Construction Cost

The Project construction cost includes all costs necessary to build the main laterals that would convey water to each participant. It also includes the costs for water treatment, pumping plants and storage tanks. However, it does not include the cost for the distribution lines needed to deliver water to each connection. Because the benefits were estimated based on the assumption that nearly all residents would have a piped water supply, it is important that the costs include whatever additional facilities are needed to provide those connections. Each of the three participants begin with different circumstances.

a. City of Gallup

The Project capital cost estimates for the City of Gallup already includes a substantial portion of the distribution system necessary to deliver water within the City and to the neighboring Navajo Chapters. Additional costs incurred by the City to hook up new customers are normally passed on to the customers by means of a connection fee. These costs will therefore be covered by the water users and will not be charged to the Project.

b. Navajo Nation

Recall that the "Without-Project" condition described in section B.2.c, above, is that even in the absence of the Project the Navajo Nation will continue to extend piped water service to about 60% of a growing population. The Project will deliver supplemental water to these people. The Project will also deliver water to most of the remaining 40%, who are those who would otherwise be hauling water. We have included a cost allowance to provide distribution systems for the Navajos who would otherwise haul water. We estimated the number of connections added per year for the life of the Project and calculated an annual Project cost using a cost of $611 per connection [MSE-HKM, indexed for inflation]. These annual totals were discounted to 2021 using the federal discount rate of 5.375%. The total discounted cost amounts to $38 million.

c. Jicarilla Apache Nation

Although the Jicarilla Apache Nation will incur some cost for distribution lines they would incur the same cost if they were to develop an alternative water supply in lieu of the Navajo Gallup Water Supply Project. Because the benefits included in the economic analysis are based only on the cost savings of this Project compared to other projects, the added cost of distribution lines does not affect the difference and should therefore not be included as either a Project cost or the cost of any alternative projects.

3. Operation, Maintenance and Replacement Cost

The Project's annual operation, maintenance and replacement (O,M&R) costs were estimated for each year of the Project and discounted to the assumed initial year of full Project operation, 2021. These costs were estimated for both commercial (NTUA) power rates and Colorado River Storage Project rates. A financial analysis would use whichever rates were ultimately charged to the Project. However, an economic analysis from the perspective of the federal government would use the market rate regardless of whether the Project qualified for a concessionary rate since the market rate presumably reflects the value to the Nation of power. (see discussion in section A.1, above). We therefore used the NTUA rates to determine the economic cost of Project O,M&R. This cost is $283 million [Merchant, 2006a].

4. Cost of Water

An economic analysis should address the cost of the water dedicated to the Project. While a financial analysis would consider only the actual payments for water an economic analysis evaluates the opportunity cost of water even in the absence of financial payments (see discussion in section A.6, above). The relevant perspective for the opportunity cost is that of the water rights holder because the uses of water are limited to whatever opportunities are available to whoever owns the water. The analysis is different for all three Project participants.

a. City of Gallup

The City of Gallup does not presently hold the water rights for its intended Project use. The City is negotiating with the Jicarilla Apache Nation and presumably will reach an arms length agreement to appropriately compensate the Jicarilla for Gallup use of Jicarilla watter. This cost will reflect the market conditions for water and should offer a fair assessment of the opportunity cost of water for the Jicarillas. Pending completion of the negotiations we have assumed an annual price of $80 per acre foot during Project operation, plus an option fee to hold the water until the Project is completed, which together have a present value over the life of the Project of $20 million.

b. Navajo Nation

Absent a water rights settlement providing other terms, the Navajo Nation will pay an estimated $4.12 per acre-foot for their non-agricultural use of water from Navajo Reservoir. This cost represents a financial cost to the Navajos, but because it is based on historical investment costs and not a current use of resources it is not an economic cost. The relevant economic cost is the lowest-returning opportunity available to the Navajos that would be displaced by dedicating water to the Project. For the Navajos we assume that this opportunity is probably growing irrigated alfalfa. We used New Mexico Cooperative Extension Service crop budgets [Libbins] and New Mexico Agricultural Statistics [New Mexico Agricultural Statistics Service] to estimate the returns to water used in growing alfalfa. The expected annual average return is $162 per acre in 2005$. Assuming 4 afy are diverted to grow each acre of alfalfa the opportunity cost for each acre-foot is $41. The present value of the opportunity cost for the 28,900 afy of average Project water use is thus estimated at $20 million in 2005$.

c. Jicarilla Apache Nation

Although the Jicarilla Apache Nation will incur some opportunity cost for dedicating some of their water supply to the Project, the Jicarillas would incur the same opportunity cost if they were to develop an alternative water supply besides the Navajo Gallup Water Supply Project. Because the benefits included in the economic analysis are based only on the cost savings of this Project compared to other projects, the added water opportunity cost does not affect the difference and should therefore not be included as either a Project cost or the cost of any alternative projects.

5. Other Project Costs

The Project will have some effect on downstream water users (externalities). These effects include a reduction in Colorado River power generation and increases in Colorado River salinity. Similar downstream effects would result from any depletion in the Upper Colorado River Basin. Because the Project water use will be within the scope of the water rights held (or leased) by Project participants, the participants can legitimately deplete water without regard to the impact on lower priority users. And since there is no mechanism for Lower Basin users (who would be most impacted by any increase in salinity) to compensate Upper Basin water rights holders for not using water, the Upper Basin water users have no financial opportunity cost that recognizes the impact of their water use on Lower Basin users. From a national perspective, however, we should recognize the broader effect of Upper Basin water rights holder exercising their water rights.

a. Loss in Electrical Power Revenues

Water diverted for the Project from the San Juan River will deplete Lake Powell inflow. This depletion could have a range of impacts on power generation at Glen Canyon Dam, depending on total flows into Lake Powell and on total water use in the Upper Basin.

The Upper Basin is obligated to release a minimum amount of water from Lake Powell for the benefit of Lower Basin and Mexico users of the Colorado River. Diversions for the Navajo-Gallup Water Supply Project will not relieve the Upper Basin from this obligation, so at one extreme the total releases from Lake Powell may not change. On the other hand, until the Upper Basin uses its full water allocation and during periods of above-normal nature runoff in the Upper Basin, the Upper Basin may release more than its obligated minimum from Lake Powell. Under these circumstances the depletion from the Navajo-Gallup Water Supply Project will cause a reduction in power generation at Glen Canyon Dam. In order to determine the maximum impact of the Navajo-Gallup Project we have estimated the cost of diminished power generation under the second set of assumptions.

The estimated average flow of the Navajo-Gallup Water Supply Project will reach 51.94 cfs [Merchant]. A Bureau of Reclamation study reports that the power generation lost at Glen Canyon Dam amounts to .0408 MW/cfs [U.S. Bureau of Reclamation, 2000b], so the total capacity lost due to the Project would be 2.12 MW. At 8,760 hours per year the total electrical energy lost would be 18,563 MWh. We valued this lost energy at its estimated replacement cost of 53.12 mills per kwh (2004$) [Energy Information Administration, p. 78]. At the federal discount rate of 5.375% the present value of these lost power benefits over the 50 year Project life is estimated to be $17 million.

b. Downstream Salinity Effects

The Navajo-Gallup Water Supply Project will have two effects on downstream salinity. First, the Project depletions will diminish the flow of relatively high quality water into into Lake Powell, raising the average total dissolved solids (TDS) of Lake Powell inflows by an estimated approximately 0.7 mg/L. Second, the Project will produce some return flow that would enter Lake Powell. This return flow is higher in TDS than the average inflow and would raise the average TDS by an estimated about 0.8 mg/L [U.S. Bureau of Reclamation, 2004; Leach]. The total increase in TDS will thus be about 1.5 mg/L.

The cost of this 1.5 mg/L increase in salinity is the lesser of two factors. First, the Bureau of Reclamation has estimated that in 2000 the annual cost to Lower Basin water users for each 1.0 mg/L increase in salinity is about $2,500,000 [U.S. Bureau of Reclamation, 2000a]. Updating this cost to 2005$ [U.S. Bureau of Labor Statistics, CPI] and applying it to the 1.5 mg/L increase converts to an annual cost of $4,000,000. The second factor is the cost of mitigating the increase in salinity. The Bureau of Reclamation is actively soliciting proposals from Colorado Basin water users to reduce the salinity load of the Colorado River. The average cost of this program is less than one-quarter of the cost of tolerating increased salinity loads [[U.S. Bureau of Reclamation, 2003]. The annual cost to mitigate the salinity increase due to the Project would therefore be about $1,000,000. The present value of these mitigation costs over the 50 year Project life would be about $17 million (again applying the federal discount rate of 5.375%).

E. Benefit – Cost Summary

Table 6 summarizes the estimated benefits and costs from the Navajo-Gallup Water Supply Project.

Table 6

Summary of Navajo-Gallup Water Supply Project Economic Benefits and Costs

(5.375% discount rate, 50 year project life)

Millions 2005$

BENEFITS	**Direct**	**Direct plus Other**
Gallup Willingness to Pay	269	269
Navajo Willingness to Pay	1,037	1,037
Jicarilla Avoided Cost	54	54
Construction Employment	183	183
Induced Employment	-	87
Health Benefits	-	318
Total Benefits	1,543	1,948
COSTS		
Project Construction	944	944
Distribution System Construction	38	38
O,M&R	283	283

Gallup Water Cost	20	20
Navajo Water Cost	20	20
Power Generating Cost	17	17
Salinity Increase Cost	17	17
Total Costs	1,339	1,339
BENEFIT/COST RATIO	**1.15**	**1.46+**

F. Discount Rate Sensitivity Analysis

Federal legislation requires an annual determination of a discount rate to be used by federal agencies in water resources planning. During fiscal year 2005 the federal rate is 5.375% [Federal Register]. This federal rate is a constrained, lagged, nominal (includes inflation) rate computed annually by the Treasury Department. The rate is constrained because it cannot move more than .25% per year regardless of how much market interest rates move between consecutive years. During 2005 the constraint means that the rate is nearly three tenths of one percentage point higher than it would otherwise be (5.375% instead of 5.088%) [Ibid.]. The rate is lagged because it reflects *average* yields on marketable securities with a term of 15 years or more, not just the most recent yields on securities. The rate is nominal because no effort has been made to subtract the expected inflation that is built into the rate (lenders always ask for a premium above a real or inflation-free interest rate to compensate them for the expected loss in purchasing power that is caused by future inflation).

This federal rate is not well suited to cost-benefit analysis because its use violates a fundamental economic principle, viz. consistent treatment of inflation in both the discount rate and the estimation of future benefits and costs. The federal rate is based on nominal (inflation-including) rates because it does not attempt to adjust market rates for the expected inflation that is implicitly built into the rates. On the other hand, the federal rate is not an accurate measure of current nominal rates, either, because the rate is both lagged and constrained, as explained above.

In keeping with the Principles and Guidelines [Water Resources Council, section 1.4.10] all of the future costs and benefits for the Navajo-Gallup Water Supply Project have been estimated in constant 2005 price levels. To maintain consistency these constant dollar prices should be discounted at a rate that also assumes constant price levels, and as explained above, the federal rate does not meet that condition.

The real (net of inflation) cost of long-term federal funds is in the range of 2.0% to 4.0% per year. The Office of Management and Budget, for example, concludes that the real rate on 10-year bonds is 2.8% and the real rate on 30-year bonds is 3.5% [OMB]. For the purpose of evaluating the sensitivity of the benefit cost analysis results to the level of the discount rate we have recomputed all costs and benefits using a real discount rate of 3%. The results of this analysis are shown in Table 7.

Table 7 shows that using a real discount rate of 3% significantly increases the Benefit/Cost ratio. The lower rate increases the importance of future events (predominantly benefits) relative to the near term events (predominantly costs), resulting in the increased ratio of benefits to costs.

Table 7

Summary of Navajo-Gallup Water Supply Project Benefits and Costs

(3% discount rate, 50 year project life, millions 2005$)

BENEFITS	Direct	Direct Plus Other
Gallup Willingness to Pay	$546	$546
Navajo Willingness to Pay	$1,612	$1,612
Jicarilla Avoided Cost	$56	$56
Construction Employment	$157	$157
Indirect and Induced Employment	$0	$75
Health Benefits	$0	$519
Total Benefits	$2,371	$2,965
COSTS		
Project Construction	$811	$811
Distribution System Construction	$45	$45
O,M&R	$397	$397
Gallup Water Cost	$24	$24
Navajo Water Cost	$31	$31
Power Generating Cost	$25	$25
Salinity Increase Cost	$25	$25
Total Costs	$1,358	$1,358
BENEFIT/COST RATIO	1.76	2.18

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APPENDIX A
DATA USED TO ESTIMATE WATER DEMAND FUNCTION

City	State	GPCD	1999 HH Inc	HH size	Cost/ 1000 gal.	ln GPCD	ln HH Inc	ln HH size	ln Cost
Camp Verde	AZ	80	$31,868	2.57	$6.88	4.382	10.369	0.944	1.929
Flagstaff	AZ	122	$37,146	2.59	$3.07	4.804	10.523	0.952	1.122
Page	AZ	141	$46,935	3.26	$2.01	4.950	10.757	1.182	0.700
Payson, AZ	AZ	95	$33,638	2.25	$4.20	4.554	10.423	0.811	1.434
Prescott Valley	AZ	99	$34,341	2.53	$3.36	4.591	10.444	0.928	1.212
Show Low	AZ	126	$32,356	2.85	$6.35	4.836	10.385	1.047	1.848
Brighton	CO	137	$46,779	2.81	$3.09	4.918	10.753	1.033	1.127
Broomfield	CO	142	$63,903	2.82	$2.62	4.955	11.065	1.037	0.965
Brush	CO	282	$31,333	2.48	$2.59	5.641	10.352	0.908	0.950
Canon City	CO	347	$31,736	2.26	$1.97	5.850	10.365	0.815	0.677
Delta	CO	161	$27,415	2.27	$2.65	5.084	10.219	0.820	0.974
Durango	CO	225	$34,892	2.37	$1.51	5.416	10.460	0.863	0.414
Englewood	CO	192	$38,943	2.18	$1.69	5.257	10.570	0.779	0.523
Estes Park	CO	221	$43,262	2.27	$2.73	5.397	10.675	0.820	1.004
Federal Heights	CO	109	$33,750	2.72	$2.71	4.690	10.427	1.001	0.996
Fort Morgan	CO	313	$33,128	2.54	$1.52	5.746	10.408	0.932	0.417
Golden	CO	198	$49,115	2.22	$2.65	5.289	10.802	0.798	0.973
Grand Junction	CO	136	$33,152	2.15	$2.34	4.915	10.409	0.765	0.850
Gunnison	CO	167	$25,768	2.21	$1.40	5.119	10.157	0.793	0.334
La Junta	CO	289	$29,002	2.56	$0.87	5.668	10.275	0.940	-0.137
Lamar	CO	193	$28,660	2.58	$1.34	5.264	10.263	0.948	0.293
Louisville	CO	198	$69,945	2.65	$2.31	5.287	11.155	0.975	0.836
Montrose	CO	173	$33,750	2.29	$2.47	5.152	10.427	0.829	0.906
Northglenn	CO	123	$48,276	2.78	$2.52	4.813	10.785	1.022	0.924
Sterling	CO	207	$27,337	2.33	$1.10	5.335	10.216	0.846	0.097
Alamagordo	NM	185	$30,928	2.57	$1.63	5.220	10.339	0.944	0.488
Aztec	NM	98	$33,110	2.69	$2.76	4.583	10.408	0.990	1.014
Belen	NM	275	$26,754	2.79	$1.63	5.617	10.194	1.026	0.489
Bernalillo	NM	151	$30,864	3.06	$2.37	5.019	10.337	1.118	0.863
Carlsbad	NM	296	$30,658	2.51	$1.55	5.690	10.331	0.920	0.441
Clovis	NM	156	$28,878	2.57	$2.52	5.050	10.271	0.944	0.924
Deming	NM	195	$20,081	2.65	$0.55	5.273	9.908	0.975	-0.597
Farmington	NM	214	$37,663	2.81	$2.14	5.366	10.536	1.033	0.762
Gallup	NM	172	$34,868	2.85	$2.48	5.147	10.459	1.047	0.909
Hobbs	NM	72	$28,100	2.87	$1.43	4.272	10.244	1.054	0.357
Las Cruces	NM	135	$30,375	2.83	$1.71	4.904	10.321	1.040	0.537
Los Alamos	NM	197	$71,536	2.31	$4.22	5.283	11.178	0.837	1.439
Portales	NM	250	$24,658	2.51	$1.40	5.521	10.113	0.920	0.335
Rio Rancho	NM	184	$47,169	2.70	$2.42	5.215	10.761	0.993	0.883
Santa Fe	NM	166	$40,392	2.20	$3.91	5.112	10.606	0.788	1.364
Socorro	NM	110	$20,728	2.58	$3.42	4.700	9.939	0.948	1.230
Tucumcari	NM	123	$22,560	2.40	$2.65	4.808	10.024	0.875	0.976
Boulder City	NV	251	$50,523	2.41	$1.41	5.525	10.830	0.880	0.346
Elko	NV	700	$48,608	2.62	$0.30	6.551	10.792	0.963	-1.207
Fallon	NV	240	$35,935	2.40	$0.63	5.481	10.489	0.875	-0.468
Mesquite	NV	152	$40,392	3.16	$1.88	5.024	10.606	1.151	0.631
Alpine	UT	134	$72,880	4.51	$1.60	4.901	11.197	1.506	0.473
American Fork	UT	186	$51,955	3.74	$1.00	5.228	10.858	1.319	0.002

Brigham City	UT	203	$42,335	3.18	$0.91	5.315	10.653	1.157	-0.090
Centerville	UT	101	$64,818	3.83	$1.76	4.618	11.079	1.343	0.565
Clinton	UT	97	$53,909	3.91	$1.22	4.571	10.895	1.364	0.195
Grantsville	UT	167	$45,614	3.20	$1.83	5.115	10.728	1.163	0.605
Heber	UT	183	$45,394	2.96	$1.08	5.208	10.723	1.085	0.073
Holliday	UT	278	$66,468	2.91	$1.22	5.628	11.104	1.068	0.199
Midvale	UT	388	$40,130	2.56	$0.57	5.962	10.600	0.940	-0.562
Murray	UT	263	$45,569	2.66	$1.05	5.571	10.727	0.978	0.051
North Logan	UT	120	$49,154	3.90	$1.94	4.787	10.803	1.361	0.661
North Salt Lake	UT	219	$47,052	3.14	$1.23	5.391	10.759	1.144	0.209
Park City	UT	224	$65,800	2.50	$1.39	5.413	11.094	0.916	0.331
Pleasant Grove	UT	18	$52,036	3.83	$9.14	2.891	10.860	1.343	2.213
Price	UT	131	$31,687	2.85	$2.93	4.874	10.364	1.047	1.073
Riverdale	UT	326	$44,375	2.78	$0.36	5.788	10.700	1.022	-1.021
Riverton	UT	183	$63,980	4.14	$1.19	5.211	11.066	1.421	0.177
South Jordan	UT	216	$75,433	4.39	$1.31	5.376	11.231	1.479	0.270
Spanish Fork	UT	156	$48,705	3.39	$1.29	5.052	10.794	1.221	0.257
Springville	UT	223	$46,472	3.28	$0.96	5.408	10.747	1.188	-0.038
Sunset	UT	176	$41,726	2.95	$1.02	5.168	10.639	1.082	0.021
Tremonton	UT	196	$44,784	3.12	$1.24	5.276	10.710	1.138	0.214
Washington	UT	201	$35,341	3.29	$0.83	5.301	10.473	1.191	-0.182
Cody	WY	74	$34,450	2.38	$5.41	4.309	10.447	0.867	1.688
Douglas	WY	247	$36,944	2.66	$2.10	5.511	10.517	0.978	0.740
Evanston	WY	234	$42,019	2.99	$1.69	5.456	10.646	1.095	0.522
Lander	WY	121	$32,397	2.48	$3.06	4.798	10.386	0.908	1.117
Powell	WY	131	$27,364	2.41	$4.07	4.877	10.217	0.880	1.405
Rawlins	WY	419	$36,600	2.60	$0.34	6.037	10.508	0.956	-1.092
Riverton	WY	190	$31,531	2.58	$2.24	5.249	10.359	0.948	0.806
Rock Springs	WY	92	$42,584	2.66	$11.24	4.523	10.659	0.978	2.419
Sheridan	WY	177	$31,420	2.31	$1.94	5.175	10.355	0.837	0.664
Worland	WY	95	$31,447	2.63	$2.53	4.556	10.356	0.967	0.926

Sources:

Black & Veatch, "Arizona Water/Wastewater Rate Survey, 2000," 2000.

Colorado Municipal League, "Water and Wastewate Utility Charges and Practices in Colorado," 1997.

Dornbusch Associates, telephone interviews.

Utah Department of Environmental Quality, Division of Drinking Water, "1999 Survey of Community Drinking Water Systems," 2000.

Wyoming Water Development Commission, "1998 Water System Survey Report," 1998.

APPENDIX B - SUMMARY OUTPUT FROM REGRESSION

Regression Statistics	
Multiple R	0.8028
R Square	0.6445
Adjusted R Square	0.6303
Standard Error	0.2961
Observations	79

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	11.9214	3.9738	45.3229	0.0000
Residual	75	6.5758	0.0877		
Total	78	18.4972			

	Coefficients	*Standard Err*	*t Stat*	*P-value*
Intercept	2.9126	1.2897	2.2583	0.0268
Household Income	0.3716	0.1325	2.8051	0.0064
Household Size	-1.3483	0.2374	-5.6802	0.0000
Cost of Water	-0.5538	0.0509	-10.8778	0.0000

APPENDIX D

Part III
Financial and Repayment Analysis

FINANCIAL AND REPAYMENT ANALYSIS
NAVAJO – GALLUP WATER SUPPLY PROJECT

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April 13, 2006

TABLE OF CONTENTS

I. Executive Summary

This report is one of a series of reports concerning economic issues pertaining to the Navajo Gallup Water Supply Project. While another report addresses the *economic* benefits and costs of the Project, this report deals with the Project's *financial* or cash costs. Specifically, the report discusses the capital costs, operation, maintenance and replacement costs, cost of water, and non-Project cash costs that each participant must pay to deliver water to their users. The costs are averaged over the projected water deliveries during the life of the Project to determine a levelized cost, or the constant cost (in 2005$) per thousand gallons that would repay all Project costs if charged on all Project deliveries. Table EX-1 shows this levelized cost for all participants.

Table EX-1
NAVAJO-GALLUP WATER SUPPLY PROJECT
SUMMARY OF LEVELIZED COST / THOUSAND GALLONS
Federal Financing at 5.375%, NTUA Rates for Energy, 2005$

	Navajo	Gallup	Jicarilla	Project Total
Total Levelized Cost	**$6.74**	**$8.02**	**$7.94**	**$6.98**

Several federal programs are available to assist in financing rural and small community water projects. The Department of Agriculture and Environmental Projection Agency both have programs that distribute annual appropriations to qualifying projects. Unfortunately, neither program appears to be a good fit for the Navajo Gallup Water Supply Project.

Although the Bureau of Reclamation has no program to distribute annual appropriations to projects it is designated by Congress to assist in planning, constructing and funding water projects that are specifically approved by legislation. We conducted a review of the capital costs of other projects that have either been approved by Congress or are in the planning stages. The Navajo Gallup Water Supply Project capital costs per person served and per acre-foot delivered are both at the lower end of the range represented by these other projects. When the available information on annual operation and maintenance costs are included, Navajo-Gallup Water Supply Project is still within the range of other western U.S. projects, but at the upper end.

Some agency funding programs assess the affordability of community Project costs, and often the programs will provide more assistance if the costs exceed some threshold of affordability. The most common measure of affordability is cost as a percent of median household income, and by that measure the operation, maintenance and water costs for all three Project participants would fall below the EPA threshold, but exceed that threshold once all Project capital costs are added.

II. Introduction

This report focuses on the ***financial*** costs of the Navajo Gallup Water Supply Project and how those costs might be paid. The report is a companion to three other reports that address different economic aspects of the Project: (1) "Navajo-Gallup Water Supply Project, Allocation of Capital and OM&R Costs Among Project Participants, San Juan River – PNM Alternative," (2) "Economic Benefit/Cost Analysis, Navajo-Gallup Water Supply Project," and (3) "Navajo-Gallup Water Supply Project, Socioeconomic Impacts."

The financial analysis estimates the cash cost of the Project and determines what the overall cost per thousand gallons would be for Project participants, under different financing scenarios. The financing alternatives considered include various assumptions about the degree to which the Project may be subsidized by the federal government.

III. Financial Analysis of Project Costs

A. Financial costs

In this report the term "financial analysis" refers to the compilation of Project cash costs assigned to the Project participants. The financial analysis differs from the economic analysis in the "Economic Benefit/Cost Analysis" report in two important respects. First, the financial analysis focuses on cash flow, excluding non-cash costs such as the opportunity cost of Project water used by the Navajo Nation and Jicarilla Apache Nation, and including cash costs that do not represent a use of economic resources, such as the projected Project-associated tax expenditures. Second, the financial analysis focuses on the projected costs incurred by the Project participants, excluding costs that may be borne by non-participants, such as the loss of downstream power generation capability. Please refer to Chapter B of the "Economic Benefit/Cost Analysis" report [Merchant, 2005a] for a more complete discussion of the differences between the financial and economic analysis frameworks.

B. Project financial costs

1. Capital costs

The Project's financial costs include both costs for (1) the main system of pipelines, treatment plants and storage tanks, and (2) the facilities build in and around Gallup to distribute Project water. The total cost for these facilities is expected to be $715 million (2005$). In addition, because most of the capital investment will be incurred before Project completion, interest during construction will add an additional $288 million (2005$) for which Project participants will also be responsible, assuming full repayment of Project costs. These costs include all construction, right-of-way acquisition, environmental mitigation, cultural resource investigations and taxes [Merchant, 2005b].

The estimated Project construction and interest costs are translated to a constant annual amount by amortizing those costs over the anticipated life of the Project using the current federal discount rate for water projects of 5.375% per year. Then the annual amortized amount is divided by the annual equivalent amount of water deliveries to determine the levelized rate per thousand gallons needed to repay those costs. In this report the term "levelized cost" refers to a constant rate per thousand gallons (in 2005$), which if applied to all water delivered would repay the capital, interest, OM&R, water and other utility costs over the life of the Project.[1] This rate is calculated by discounting the costs to be paid and all water to be delivered by the same discount rate (5.375% in this report), and dividing the first by the second. Table 1 shows how the levelized rate to repay capital costs is calculated.

Table 1
NAVAJO-GALLUP WATER SUPPLY PROJECT
LEVELIZED CAPITAL COST / THOUSAND GALLONS
50 year Project Life, Federal Financing at 5.375%, 2005$

	Navajo	Gallup	Jicarilla	Project Total
Present Value of Capital Costs	$790,000,000	$176,000,000	$37,000,000	$1,003,000,000
Annual Amortization of Capital Costs	$45,804,685	$10,204,588	$2,145,283	$58,154,556
Annual Equivalent Water Deliveries (1,000 gal.)	8,950,913	2,443,890	641,777	12,036,580
Levelized Cost/ Thousand Gallons	$5.12	$4.18	$3.34	$4.83

2. Operation, Maintenance and Replacement (OM&R) costs

Following its construction, the Project will incur both fixed and variable OM&R costs. The fixed costs include staff salaries, intake dredging, annual maintenance and equipment replacement. Variable costs include energy and chemical costs. The distinction is important because while the fixed costs are assumed constant (in 2005$) over time, the variable costs will increase in conjunction with increases in water use. We calculate the total present value of the Project's OM&R costs to be $283 million (2005$), using a 5.375% discount rate and energy rates provided by the Navajo Tribal Utility Authority.

[1] Levelized cost is calculated by dividing the present value of costs by the levelized annual water delivery. The levelized annual water delivery is that constant annual delivery of water that over the 50 year project life has the same present value as the anticipated actual water deliveries (which may change over time and in some cases begin before the 50 year project period).

Table 2 shows how this OM&R cost is allocated among project participants and calculates the levelized rate needed to pay this cost.

Table 2 NAVAJO-GALLUP WATER SUPPLY PROJECT LEVELIZED O,M&R COST / THOUSAND GALLONS NTUA Rates for Energy, 50 year Project Life, 5.375%, 2005$	Navajo	Gallup	Jicarilla	Project Total
Present Value of O,M&R Costs	$209,799,000	$52,951,000	$20,967,000	$283,717,000
Annual Amortization of O,M&R Costs	$12,164,275	$3,070,132	$1,215,680	$16,450,086
Annual Equivalent Water Deliveries (1,000 gal.)	8,950,913	2,443,890	641,777	12,036,580
Levelized Cost/ Thousand Gallons	$1.36	$1.26	$1.89	$1.37

3. Cost of water

Both the Navajo Nation and the Jicarilla Apache Nation presently have rights to water they intend to use in the Project. The terms of the Jicarilla Water Rights Settlement Act exempt the Jicarillas from paying any cash cost for water from Navajo Reservoir, the source for Project water. In the absence of a similar settlement the Navajo Nation will pay a levelized cost to the Bureau of Reclamation estimated to be $4.12 per acre-foot. The City of Gallup will have to pay for obtaining water from a water rights owner. The present value of a tentative purchase arrangement is $20 million (2005$). Table 3 shows how this cost translates to the levelized rate needed to cover the projected payments for water.

Table 3 NAVAJO-GALLUP WATER SUPPLY PROJECT LEVELIZED WATER COST / THOUSAND GALLONS 50 year Project Life, Federal Financing at 5.375%, 2005$	Navajo	Gallup	Jicarilla	Project Total
Present Value of Water Costs	$2,950,140	$19,758,536	$0	$22,708,677
Annual Amortization of Water Costs	$171,051	$1,145,612	$0	$1,316,663
Annual Equivalent Water Deliveries (1,000 gal.)	8,950,913	2,443,890	641,777	12,036,580
Levelized Cost/ Thousand Gallons	$0.02	$0.47	$0.00	$0.11

4. Continuing utility costs

The Navajo Nation, the City of Gallup and the Jicarilla Apache Nation will all incur costs separate from the Project to build distribution systems and/or operate their water systems. These costs will presumably be paid by the customers of each utility, and the costs are therefore appropriate to include in future rate calculations. The Navajo costs include the amortized cost of constructing distribution lines to deliver the Project water to various Navajo Chapters. Gallup costs are those costs to operate the City system that will continue even after the Project is constructed. These Gallup costs do not include the cost of operating wells that will be shut down when the Project begins delivering water. The Jicarilla costs included here are those needed to construct and operate a distribution system serving on the commercial and residential (not industrial) users of their water allocation. Table 4 summarized these other costs and calculates the levelized rate needed to pay them.

Table 4
NAVAJO-GALLUP WATER SUPPLY PROJECT
LEVELIZED OTHER COST / THOUSAND GALLONS
50 year Project Life, Federal Financing at 5.375%, 2005$

	Navajo	Gallup	Jicarilla	Project Total
Annual Amount of Other Costs - Capital	$2,203,000		$290,000	$2,493,000
Annual Amount of Other Costs - O&M		$5,183,284	$150,000	$5,333,284
Annual Equivalent Water Deliveries (1,000 gal.)	8,950,913	2,443,890	162,926	11,557,729
Levelized Cost/ TG - Capital	$0.25		$1.78	$0.22
Levelized Cost/ TG - O&M		$2.12	$0.92	$0.46

Note: Jicarilla other costs are for commercial and residential users only

5. Summary of levelized rate

Table 5 summarizes the various cost components for each participant and for the Project as a whole, and shows the levelized rate per thousand gallons needed to pay all the financial costs.

Table 5 NAVAJO-GALLUP WATER SUPPLY PROJECT SUMMARY OF LEVELIZED COST / THOUSAND GALLONS 50 year Project life, Federal Financing at 5.375% and NTUA Rates for Energy, 2005$				
	Navajo	**Gallup**	**Jicarilla**	**Project Total**
Capital Cost	$5.12	$4.18	$3.34	$4.83
OM&R Cost	$1.36	$1.26	$1.89	$1.37
Water Cost	$0.02	$0.47	$0.00	$0.11
Other Cost - Capital	$0.25	$0.00	$1.78	$0.22
Other Cost - O&M	$0.00	$2.12	$0.92	$0.46
Total Cost	**$6.74**	**$8.02**	**$7.94**	**$6.98**

IV. Federal and State Programs Available to Assist in Project Financing

Many water projects in the rural West have been funded through government programs, both federal and state. The eligibility criteria for Indian tribes generally differ from those for non-Indian projects, so the two cases will be discussed separately.

A. Non-Tribal Water Supply Projects

The United States Department of Agriculture (USDA), Environmental Protection Agency (EPA), and Bureau of Reclamation (BOR) are the primary federal agencies responsible for funding water supply projects in small towns and rural areas. While the BOR builds or supervises construction of water projects at the direction of Congress, USDA and EPA have programs that fund water project construction in communities that meet program criteria.

The USDA's Rural Utility Service (RUS) provides rural communities with loans and grants for water project construction. The RUS distributes funds in direct loans, guaranteed loans, and grants through the Water and Waste Disposal for Rural Communities program. Total program funding has declined from the $2.1 billion in FY 2002 to about $1.5 billion in FY 2003, 2004 and 2005 [USDA, 2005a and 2005b]. These funds are allocated to each state using a formula that takes into account each state's share of national rural population, national rural population with incomes below the poverty level, and national nonmetropolitan unemployment [USDA, 1999]. In FY 2003 New Mexico was allocated $830,000 in funds for guaranteed loans, $7,416,000 in funds for direct loans and $3,947,000 in funds for grants [USDA, 2005b]. USDA criteria for participation include economic feasibility, population limits, and need. Except in the case of grants awarded to low-income[2] communities, all USDA funds must be repaid [USDA, 1999, Section 1780.10(b)(2)].

The EPA's Drinking Water State Revolving Fund (DWSRF) provides states with capitalization grant funds for loans. These funds are loaned by states to public and non-profit water systems

[2] Grant funds cannot be used to pay any costs of a project when the median household income exceeds the non-metropolitan median household income of the State.

within their respective states. The DWSRF funding for FY 2005 was $843 million and is expected to be $835 million in FY 2006 [EPA, April, 2005 and 2005b]. New Mexico's share was $8,285,000 in FY 2005 and is tentatively $8,352,500 in FY 2006 [USEPA, 2005a and 2005b]. New Mexico adds 20% of the federal contributions as matching funds, so the total available funding is slightly in excess of $10 million annually. Each state develops its own criteria for participation in the DWSRF program. The criteria for New Mexico are based on public health risk, environmental factors, affordability and capacity development factors [New Mexico Finance Authority, "Fund"]. With the exception of grants awarded based on need, all DWSRF funds must be repaid. Interest rates are applied in three tiers: (1) communities not qualifying as "disadvantaged"[3] pay 3% annual interest; (2) communities with median household income (MHI) less than 90% of State MHI and with an affordability ratio between 1.0% and 1.5% pay 0% interest, and (3) communities with MHI less than 90% of State MHI and an affordability ratio greater than 1.5% receive assistance in planning, design and engineering services, extension of loan repayment period, or forgiveness of principal sufficient to bring their affordability ratio down to 1.5%. New Mexico treats 1.5% as the maximum affordability ratio that a disadvantage community should bear [New Mexico Finance Authority, "Program"].

The BOR does not presently have a program for funding water projects. On the other hand, BOR is often delegated authority by Congress to construct or oversee projects. Because BOR has no ongoing program, it has not established any formal eligibility criteria. However, long-standing BOR policy supports full-reimbursement plus interest. Section 9 of the 1939 Reclamation Project Act requires that projects authorized or built pursuant to Federal reclamation laws repay at least their annual operation and maintenance cost [U.S.Congress]. Legislation pending before the current Congress would establish some criteria for BOR review of rural water projects and recommendation by the Secretary of the Interior for Congressional funding [U.S. Senate, 109 S. 895]. The legislation, as proposed, would allow up to 75% federal cost sharing of construction costs. This legislation, however, would not establish any separate funding mechanism for water projects – any recommended projects would still need Congressional authorization and appropriations.

The Non-Tribal assistance criteria for the USDA, EPA, and BOR are summarized in Table 7. The Table shows that the Navajo Gallup Water Supply Pipeline is not a good fit for any of the programs. The USDA's RUS program requires that a project serve only communities of fewer than 10,000 people, while Gallup alone has a population approximately double this size. BOR does not have an ongoing program to fund water projects, so Project participants would have to secure Congressional authorization to obtain BOR sponsorship – they cannot apply directly to the BOR. Most significantly, both the RUS program and the EPA's DWSRF program are inadequate in scale to use as principal funding sources for the Project. The Project's initial capital cost of $715 million far exceeds the recent program funds that have been made available for water projects in New Mexico.

[3] "Disadvantaged" is defined as having median household income less than 90% of the State average and having an affordability ratio of at least 1.0%, where the affordability ratio is calculated as the ratio of the cost of water service to the median household income.

Table 7

Federal Assistance Funding Criteria For Non-Tribal Water Supply Projects

Agency	USDA	EPA	BOR (1)
Population	Population of town cannot exceed 10,000	At least 15% of state fund must be used yearly for projects serving no more than 10,000	Population of community not more than 50,000
Project Type	Construction, enlargement, extension or improvement of water supplies	Drinking water infrastructure project that bring existing water systems in compliance with the Safe Drinking Water Act or address public health problems	Planning, evaluation and construction of rural water supply projects
Applicant Type	Public entity; not-for-profit organization, or Indian tribe	Community water systems and publicly or privately owned or nonprofit community water systems	State, regional or local authority, including Indian tribes and public districts
Applicant Eligibility	Applicant must have legal authority and responsibility to undertake the project, operate and maintain the proposed facility, and meet the financial terms of the project.	Applicant must be able to repay the loan.	
Cost Sharing Criteria	Project must be economically feasible with regard to repayment, 75% maximum federal cost share.	100% repayment with interest, although States can allow subsidized interest and/or principal forgiveness to disadvantaged communities.	Project must be economically feasible with regard to repayment, 75% maximum federal cost share, based on capability to pay. Locals must pay 100% OM&R.
Growth Considerations	Designed to meet the needs of present or projected population	Project cannot be intended primarily for growth, but may meet needs for reasonable growth over its life.	Project can address future water supply needs
State Requirements		States must prioritize projects on basis of health risk, clean water standards, and need.	
Recent annual funding in N.M	$12 million	$10 million (including State contribution)	NA
Service Area	National	National	17 Western States

(1) BOR Program is proposed in 109 S. 895. BOR does not currently have a formal program.

Sources: General Accounting Office. Federal Assistance Criteria Related to the Fort Peck Reservation Rural Water Project, June 1998; 109 S. 895.

B. Tribal Water Supply Projects

USDA does not have special criteria for tribal water projects.

EPA and BOR criteria for funding tribal water supply projects differ significantly from criteria for non-tribal water supply projects. Whereas both the EPA and the BOR historically have expected full repayment for non-tribal projects, tribal projects are not expected to repay funds. The primary EPA program for funding tribal water supply projects is the DWSRF Tribal Set Aside. The BOR presently does not have a formal policy regarding funding or cost share. However, as with non-tribal projects, there has been an informal funding policy, which in the case of tribal water projects has been full federal funding. Legislation pending in the current Congress would allow the Secretary of the Interior to consider deferring all tribal construction costs if warranted based on an assessment of tribal capability to repay costs [109 S. 895].

Tribal assistance criteria for the USDA, EPA, and BOR are summarized in the Table 8, below. While both the Navajo Nation and Jicarilla Apache Nation would apparently qualify for both EPA and BOR funding, the EPA funds are inadequate to contribute substantially to the Navajo Gallup Project, and BOR funding is obtained only through specific Congressional authorization, as discussed in the next section.

Table 8

Federal Assistance Funding Criteria For Tribal Water Supply Projects

Agency	USDA	EPA	BOR (1)
Special Tribal Criteria	None	1.5% Tribal set-aside	Repayment of construction costs may be deferred.
Project Type	Construction, enlargement, extension or improvement of water supplies	Drinking water infrastructure project that bring existing water systems in compliance with the Safe Drinking Water Act or address public health problems	Planning, evaluation and construction of rural water supply projects
Applicant Type	Indian tribes are eligible	Indian tribes are eligible	Indian tribes are eligible
Applicant Eligibility	Applicant must have legal authority and responsibility to undertake the project, operate and maintain the proposed facility, and meet the financial terms of the project.	Applicant must be able to repay the loan.	
Cost Sharing Criteria	Project must be economically feasible with regard to repayment, 75% maximum federal cost share.	100% federal funding	Up to 100% federal funding

Table 9 - Western Municipal Water Projects Funded by Congressional Authorization

	General		Demographics		Capital Cost (2005$)					OM&R Cost		Bill or Statute (a)	
Project	**State**	**Water Delivered (afy)**	**Pop Served**	**% Indian**	**per pers. served**	**per af**	**total (million $)**	**cost share split fed/non-fed**	**Interest During Construction**	**OM&R Cost share fed/non-fed**	**Preference Power authorized**	**introduced**	**enacted**
Lewis and Clark Rural Water System (b)	SD, MN, IA	25,763	200,000	0%	$2,115	$16,419	$423	80/20, with the exception of Sioux Falls, Sioux Falls - 50/50 split of incremental cost		0/100			PL106-246
Mid Dakota (c)	SD	4,481	32,000	4%	$4,938	$35,263	$158	$100 million federal funding of $147 million project, up to 85% grant	forgiven		yes		PL102-575 Title XIX
Mni Wiconi (d)	SD	14,563	50,000	75%	$8,616	$29,581	$431	non tribal - 80/20 tribal - 100			yes		PL103-434
Rocky Boy North Central Montana Water System (e)	MO	8,000	31,000	10%	$8,913	$34,538	$276	non tribal - 80/20 tribal - 100		all (core) 100/0 non-tribal 0/100 (non-core)	yes		PL106-163 PL107-331
WEB Rural Water Development Project (f)	SD	4,604	14,763	0%	$12,057	$38,664	$178	80/20					PL100-490
Animas La Plata (g)	CO, NM	57,100	70,190	2%	$7,437	$9,142	$522	non-tribal - 0/100 tribal - 100 feds pay 100% of design and env.		all 0/100			PL106-554
Southwest Pipeline Project (h)	ND	3,109	35,000	0%	$5,286	$59,503	$185	75/25				99 HR 1116 106 S 623	
Perkins County (i)	SD	460	2,500	0%	$12,000	$65,164	$30	75/25			yes		PL106-136
Fort Peck Reservation Rural Water System (j)	MO	6,000	28,000	36%	$7,536	$35,167	$211	non-tribal 76/24 tribal - 100		non-tribal 0/100 tribal 100/0	yes.		PL104-300 PL106-382
Fall River Water Users District Rural Water System (k)	SD	118	660	0%	$7,493	$41,810	$5	70/30			yes.		PL105-352
Jicarilla Apache Reservation Rural Water System (l)	NM			100%			$45 mil. (federal)	specific items allocated to feds and tribe					PL107-331

Notes:

(c) There is no Indian component in authorization, but Crow Creek reservation is inside service boundaries,
Maximum federal funding for project is a dollar amount ceiling, not a percentage. Maximum grant for federal share is 15%.

(f) WEB Water was unable to provide Population Served. Population Served calculated using number of hook-ups provided by WEB Water and number of persons per household provided by 1990 U.S. Census

(g) Population served has not been formally determined. Population numbers are estimated based on population of prospective service area and USBR informal estimates.
Tribal Population is based on number of Ute Indians.

Source:

(a) www.thomas.gov

(b) Pam Bonrud, Lewis and Clark Rural Water System

(c) Tribal Population from Department. Of Commerce, Economic Development Administration, all other information from Kurt Pheifle, Mid Dakota Rural Water District

(d) Mike Curly, Lyman Jones Rural Water System

(e) Tribal Population from Chippewa Creek Tribal Council, all other information from Anne-Marie Robinson, Bear Paw Development

(f) Laurie Swallow, WEB Water

(g) Pat Shumacher, USBR; Rege Leach, USBR

(h) Pinkie Evanscurry, Southwest Pipeline

(i) Dave Ryan, State of South Dakota Department of Environment and Natural Resources

(j) Clint Jacobs, Dry Prairie Rural Water Authority

(k) PL105-352

(l) PL107-331

Capital cost and population served updated from Federal Reserve Bank of Minneapolis, "Fedgazette," Sept., 2005, www.minneapolisfed.org/pub/fedgaz/05-09/table.cfm.

Table 10 - Proposed Western Municipal Water Projects

Title	General		Demographics		Capital Cost (2005$)					OM&R Cost		Bill or Statute (a)	
Title	State	Water Delivered (afy)	Pop Served	% Indian	per pers. served	per af	total (million $)	cost share split fed/non-fed	Interest During Construction	OM&R Cost share fed/non-fed	Preference Power authorized	introduced	enacted
Lake Powell - St. George Pipeline (a)	UT	100,000	200,000	0%	$2,500	$5,000	$500						
Southern Delivery System (b)	CO	87,000	32,000	0%	$31,575	$11,614	$1,010						
Northern Integrated Supply Project ©	CO	35,700	50,000	0%	$7,904	$11,070	$395						
St. Mary Canal (d)	MT	2,509	14,000	NA	$8,571	$47,825	$120						
Southern Black Hills Water System (e)	SD	3,405	19,000	NA	$4,211	$23,493	$80						
South Central Regional Water System (f)	ND	2,420	13,500	NA	$5,481	$30,585	$74						
Fort Berthold Rural Water Supply System (g)	ND	3,307	9,866	100%	$12,099	$36,095	$119						
Eastern New Mexico Rural Water System (h)	NM	24,000	133,911	0%	$2,009	$11,209	$269	80/20		0/100		108 S. 2513	
Red River Valley Water Supply Project (i)	ND	NA	480,000 to 566,000	NA	$972 to $4,583	NA	550 to 2,200					106 S. 623	PL106-541
Navajo Gallup Water Supply Project (j)	NM - AZ	37,600	209,794	80%	$3,482	$19,431	$731						

Notes:
(h) population served estimated from water deliveries based on 160 gpcd
(d)(e)(f) water use estimated from population based on 160 gpcd

Source:
(a) "Water Strategist," July/August, 2005
(b) Colorado Springs Utilities, "Southern Delivery System Fact Sheet," May, 2005.
(c) MWH Americas, Inc., "Northern Integrated Supply Project, Phase II Alternative Evaluation," Jan., 2004.
(d) Federal Reserve Bank of Minneapolis, "Fedgazette," Sept., 2005, www.minneapolisfed.org/pub/fedgaz/05-09/table.cfm.
(e) Federal Reserve Bank of Minneapolis, "Fedgazette," Sept., 2005, www.minneapolisfed.org/pub/fedgaz/05-09/table.cfm.
(f) Federal Reserve Bank of Minneapolis, "Fedgazette," Sept., 2005, www.minneapolisfed.org/pub/fedgaz/05-09/table.cfm.
(g) MSE-HKM, Inc., "Discussion of recent Large Scale Municipal, Rural and Industrial (MR&I) Water Projects," Dec. 8, 1999.
(h) 108 S. 2513
(i) Federal Reserve Bank of Minneapolis, "Fedgazette," Sept., 2005, www.minneapolisfed.org/pub/fedgaz/05-09/table.cfm.
(j) James P. Merchant, "Navajo-Gallup Water Supply Project, Allocation of Capital and O,M&R Costs Among Project Participants, San Juan River - PNM Alternative," Sept. 26, 2005.
Project costs indexed from Jan., 2005$ ($715 million) to July, 2005$ ($731 million) to match period for costs for other projects.

Growth Considerations	Designed to meet the needs of present or projected population	Project cannot be intended primarily for growth, but may meet needs for reasonable growth over its life.	Project can address future water supply needs
Recent annual national funding	$16 million	$13 million	NA
Service Area	National	National	17 Western States

(1) BOR Program is proposed in 109 S. 895. BOR does not currently have a formal program.

Sources: General Accounting Office. Federal Assistance Criteria Related to the Fort Peck Reservation Rural Water Project, June 1998; 109 S. 895.

C. Congressional Project Authorization

Projects that do not meet the criteria of established funding programs can seek Congressional authorization. Because the authorization is project-specific there are no formal guidelines on determining whether a project qualifies or the terms of funding once awarded. However, many of the recent Western rural water projects funded by Congress have some similar characteristics. Table 9 shows that the federal share of construction costs for non-Indian projects has typically ranged from 70 to 80 percent, while the federal share of construction costs for Indian projects has normally been 100 percent. While all non-Indian projects have been expected to pay 100 percent of OM&R costs, the Indian projects sometimes pay zero percent and sometimes pay 100 percent.

Table 10 shows how the Navajo-Gallup Water Supply Project compares to other water projects being proposed in the West. None of these projects has received Congressional approval for construction, so the terms of any approval are still pending. However, the table does show the relative size of the projects in terms of population served, water supply developed and cost. Figures 1 and 2 compare these proposed projects on a cost per person served and a cost per acre-foot of capacity basis.

Tables 9 and 10, and Figures 1 and 2, compare only the capital costs of various water projects. Operation and maintenance (O&M) costs are not readily available for most of these projects. Table 11 shows the total levelized cost per thousand gallons ($/TG) for some western projects for which O&M costs were available.

Table 11
Western Municipal Water Projects
Total Cost per Thousand Gallons

Project	Capacity (afy)	Cost / TG
Albuquerque	97,000	$1.32
Lewis & Clark	25,760	$5.56
Navajo-Gallup Water Supply Project	37,550	$6.98
Rocky Boys/North Central Montana Regional Water System	8,802	$8.32
Santa Fe	8,730	$5.58

Sources: Stomp, Carpenter, HKM, Banner, Dornbusch Associates.

Figure 1
Western United States Water Projects
Capital Cost per Person Served (2005$)

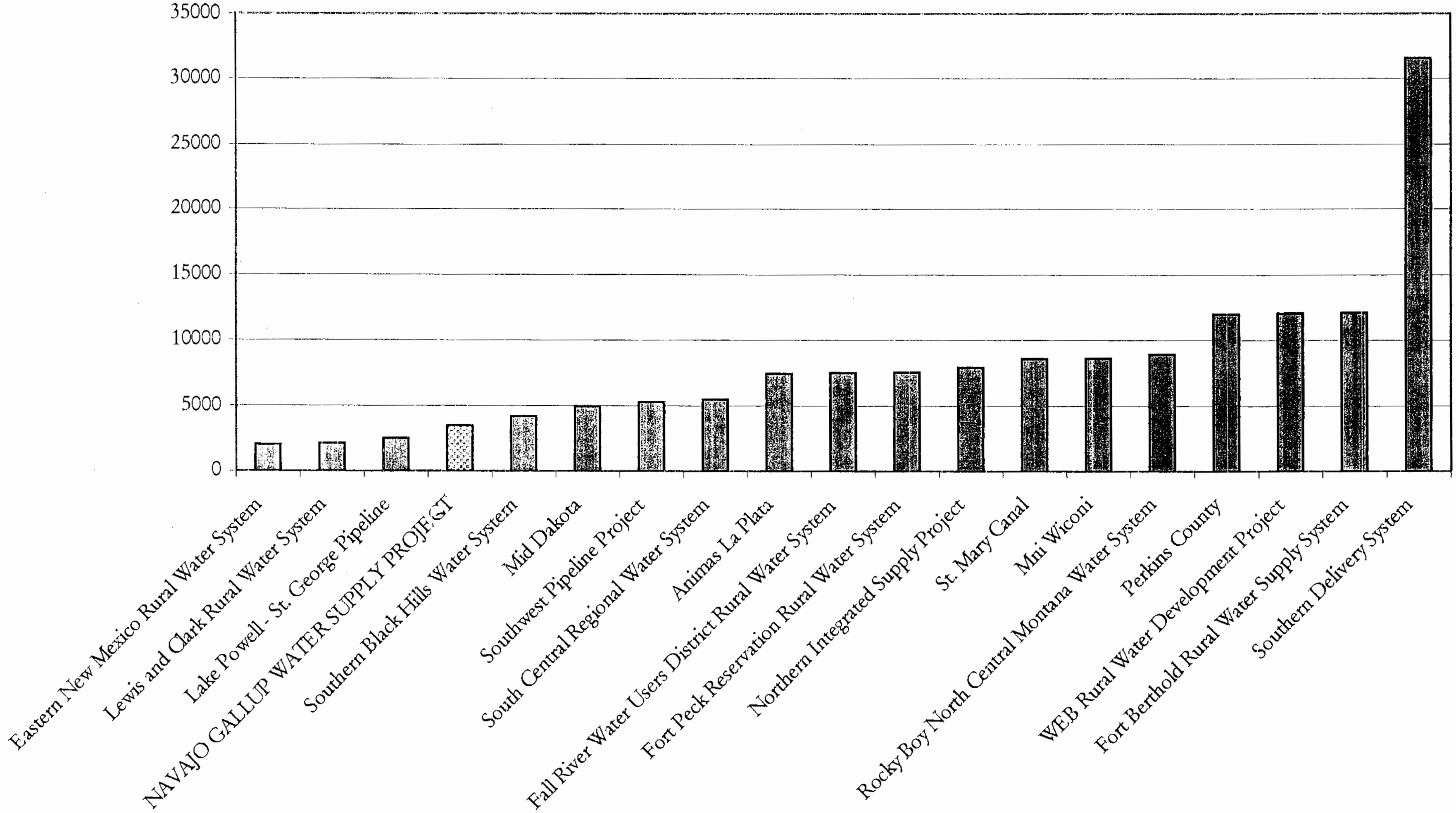
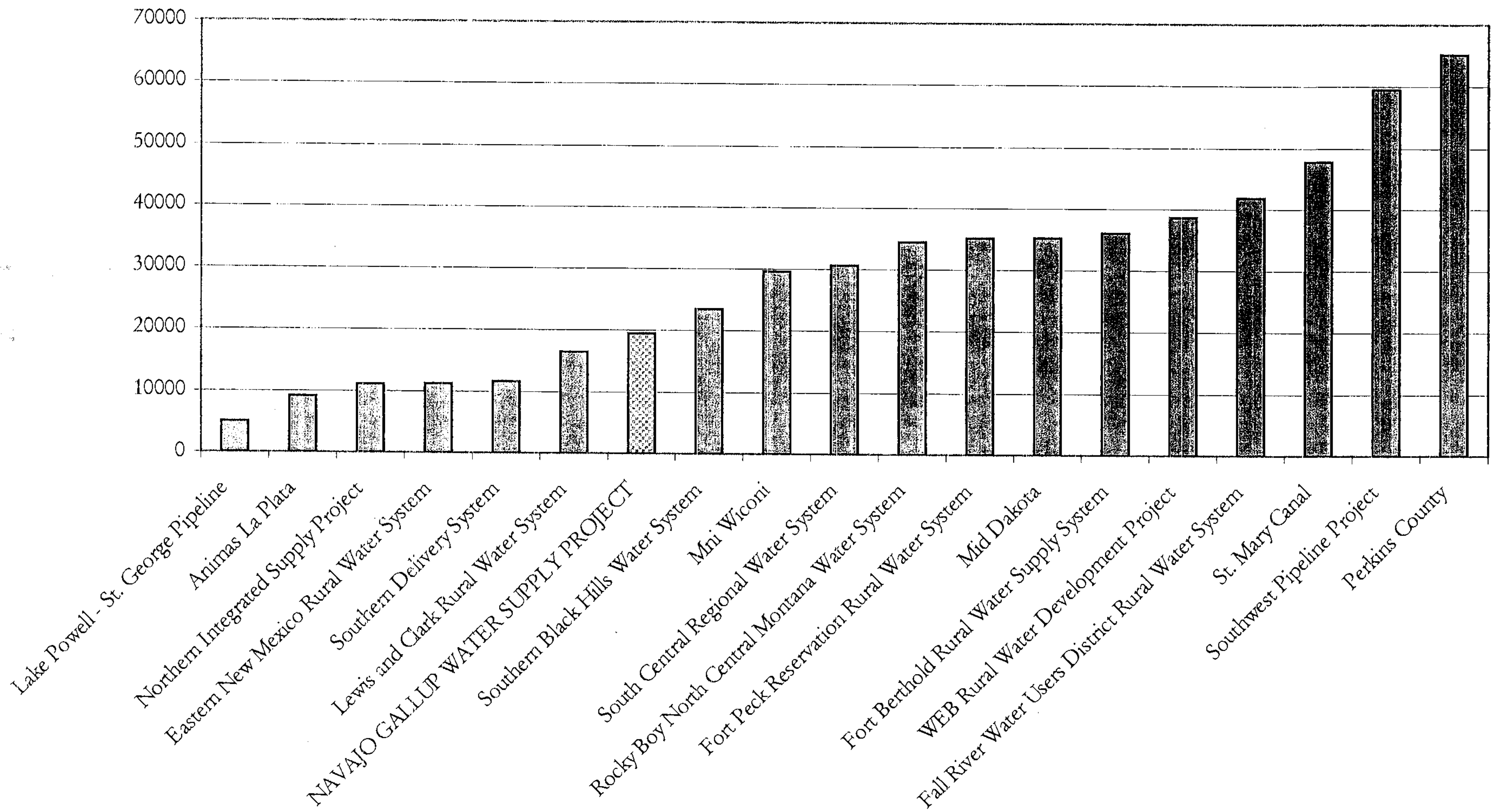


Figure 2
Western United States Water Projects
Capital Cost per Acre-Foot of Capacity (2005$)



V. Ability to Pay

Some of the funding programs discussed above use "affordability ratios" [NMFA] or "capability to pay" measures [109 S. 895]. These concepts are commonly referred to as the ability of water users to pay for their water service, or in short, the "ability to pay" issue.

Ability to pay in a water supply context refers to the affordability of a water system. The Asian Development Bank, for example, explains "ability-to-pay" as "[t]he affordability or the ability of the users to pay for the water services, as expressed by the ratio of the monthly household water consumption expenditure to the monthly household income." [ADB, p. 362] This ability to pay concept is used by some programs as a threshold which once surpassed triggers additional assistance or as a limit on how much of project's costs a beneficiary should pay. Although it appears that the available funding programs are either inadequately funded or inappropriate for the Navajo Gallup Water Supply Project, it may be useful to review how the ability to pay is used by these programs and by other agencies. If the Project participants seek Congressional funding, for example, Congress may be interested in knowing the affordability of the Project costs.

The most common measure of ability to pay for water services is utility payments as a percent of median household income. [EPA, 1999(b), p. 93] EPA, for example, uses 2.5% of median household income (MHI) in determining whether water treatment options to comply with clean water standards are affordable and should be required. EPA selected 2.5% of median household income as an affordability threshold based on their analysis of consumer spending on discretionary goods (alcohol and tobacco = 1.5% of MHI), on other utilities (telephone = 1.9% of income, and energy and fuels = 3.3% of MHI), and on the cost of bottled water (about 2.1% of MHI). [EPA, 1998(b), p. 45]

Individual states are free to develop their own criteria for determining an affordability threshold in their drinking water programs. Some states use a ratio of water charges to MHI but set the affordability threshold at a lower level than the EPA's 2.5%. New York State, for example, sets their threshold at 1.0% to 1.5% depending on the level of income. Pennsylvania uses a sliding threshold of 1.0% to 2.0% of MHI depending on the socioeconomic condition of the community. The State of Washington uses an affordability range of 1.25% to 1.75%. [EPA, 1998(b), Appendix F] New Mexico designates 1.5% of MHI as the maximum amount that any disadvantaged community (MHI less than 90% of statewide average) should pay. [NM Finance Authority, "Program"]

The USDA Rural Utilities Service uses a different approach in determining the extent to which a project can qualify for federal funds under the Water and Waste Water Loan and Grant Program. Projects can qualify for 75% federal funding when the median household income is below the higher of the poverty line or 80% of the state nonmetropolitan median income, or 45% federal funding if the MHI is above 80% but below 100% of the statewide nonmetropolitan household income. [USDA, 1999]

Legislation proposed in the 109th Congress allows the Secretary of Interior to determine the Federal share of construction costs based on an analysis of per capita income, median household income, poverty rate, ability to raise revenues, the strength of the balance sheet and the existing cost of water, all relative to regional averages. [109 S. 897, Section 106(f)(2)] However, the bill does not specify any threshold for these measures.

The Asian Development Bank and the World Bank use a rule of thumb that water costs should not exceed 5% of household income. [See Churchill, p. 102; ADB, p. 58; IRC, p. 17 (3% to 5%)]. For example, in the China Rural Water Supply Project costs of 3.6% to 3.7% of household income are characterized as appearing to be "affordable." [World Bank, pp. 5-6] Similarly, in a Chilean water supply project subsidies are provided to limit the maximum household payments for water and sewer to 5% of monthly household income. [Kessides, p. 28]

The variety of MHI thresholds used to determine affordability, as well as the application of alternative approaches in defining affordability, highlight the fact that affordability is not an objective economic concept. Rather, affordability is a social or equity concept based on the premise that safe drinking water is a right that all citizens should enjoy, and that no one should have to pay more than some limited percentage of their income to obtain that water supply. This threshold percentage cannot be objectively determined but is based on a subjective judgment of fairness and equity. [See EPA, pp. 7 and 11; CBO, Appendix C; Churchill, p. 102; Bieder, p. 8]

Given this lack of an objective basis for determining affordability it may be useful to show the average percentage of MHI that the Project participants would pay for water. Table 12 shows the Project costs, by component, as a percent of MHI. These percentages are calculated by dividing the average monthly household costs for each component (from Table 6), by the MHI shown in Table 13.

Table 12
NAVAJO-GALLUP WATER SUPPLY PROJECT
TOTAL ANNUAL COST (FULL REPAYMENT) / MEDIAN HOUSEHOLD INCOME
50 year Project life, Federal Financing at 5.375% and NTUA Rates for Energy, 2005$

	Navajo	Gallup	Jicarilla
Project Capital Cost	4.6%	1.4%	2.1%
Project OM&R Cost	1.2%	0.4%	1.2%
Project Water Cost	0.0%	0.2%	0.0%
Other Facility Capital Cost	0.2%	0.0%	1.1%
Other Facility O&M Cost	0.0%	0.7%	0.6%
Total Cost	**6.1%**	**2.8%**	**5.0%**

Table 13 NAVAJO-GALLUP WATER SUPPLY PROJECT MEDIAN HOUSEHOLD INCOME			
	NAVAJO NATION	**CITY OF GALLUP**	**JICARILLA APACHE NATION**
1999 MEDIAN HOUSEHOLD INCOME (1999$)	**$20,005**	**$34,868**	**$26,750**
2005 MEDIAN HOUSEHOLD INCOME (2005$)	**$23,807**	**$41,247**	**$30,620**

Source: 1999 MHI from U.S. Census Bureau, "2000 Census of Population and Housing;" indexed to 2005$ with U.S. Bureau of Labor Statistics, "Consumer Price Index;" annual growth rates from U.S. Census Bureau, "1990 Census of Housing" and "2000 Census of Population and Housing;" Dornbusch Associates.

The affordability percentages for different Project cost components are shown in Figure 3. Figure 3 also compares these cost percentages to the EPA benchmark 2.5% of MHI. This benchmark is based on the EPA judgment of the affordable portion of household income used to pay for a water supply. Figure 3 shows that the O&M and water costs for all three Project participants are within the EPA threshold of 2.5%, but once full capital cost repayment is added the percentage income needed exceeds the EPA threshold for all three participants.

Other measures of Ability to Pay. Although water cost as a percent of median household income is a common way for programs to measure ability to pay, it is not the only way. Proposed federal legislation, for example, requires the Secretary of the Interior to devise a measure of "capability to pay" by including factors such as per capita income, poverty rate, ability to raise tax revenues, strength of the community balance sheet and existing cost of water, in addition to median household income. While many of these additional measures should be highly correlated to median household income some may not be, and the resulting analysis could provide a more nuanced assessment of affordability, particularly in borderline cases.

Income Disparity. Regardless of how water costs compare to median household income in a community, by definition costs are a greater percentage of household income for one-half of the households and a lesser percentage of household income for the other one-half. This means that even if community-wide water costs are below some threshold of affordability, there may be many individual households within that community for which water costs exceed that threshold. This disparity can be addressed within a community by implementing a progressive rate structure such that a certain basic water supply is available at a relatively low rate and additional amounts of water are available at progressively higher rates. The *average* rate for water can remain the same, but low water users not only pay for less water but also a lower rate for that water, and higher water users not only pay for more water but also a higher rate. This type of price structure encourages water conservation while also addressing the income disparity issue.

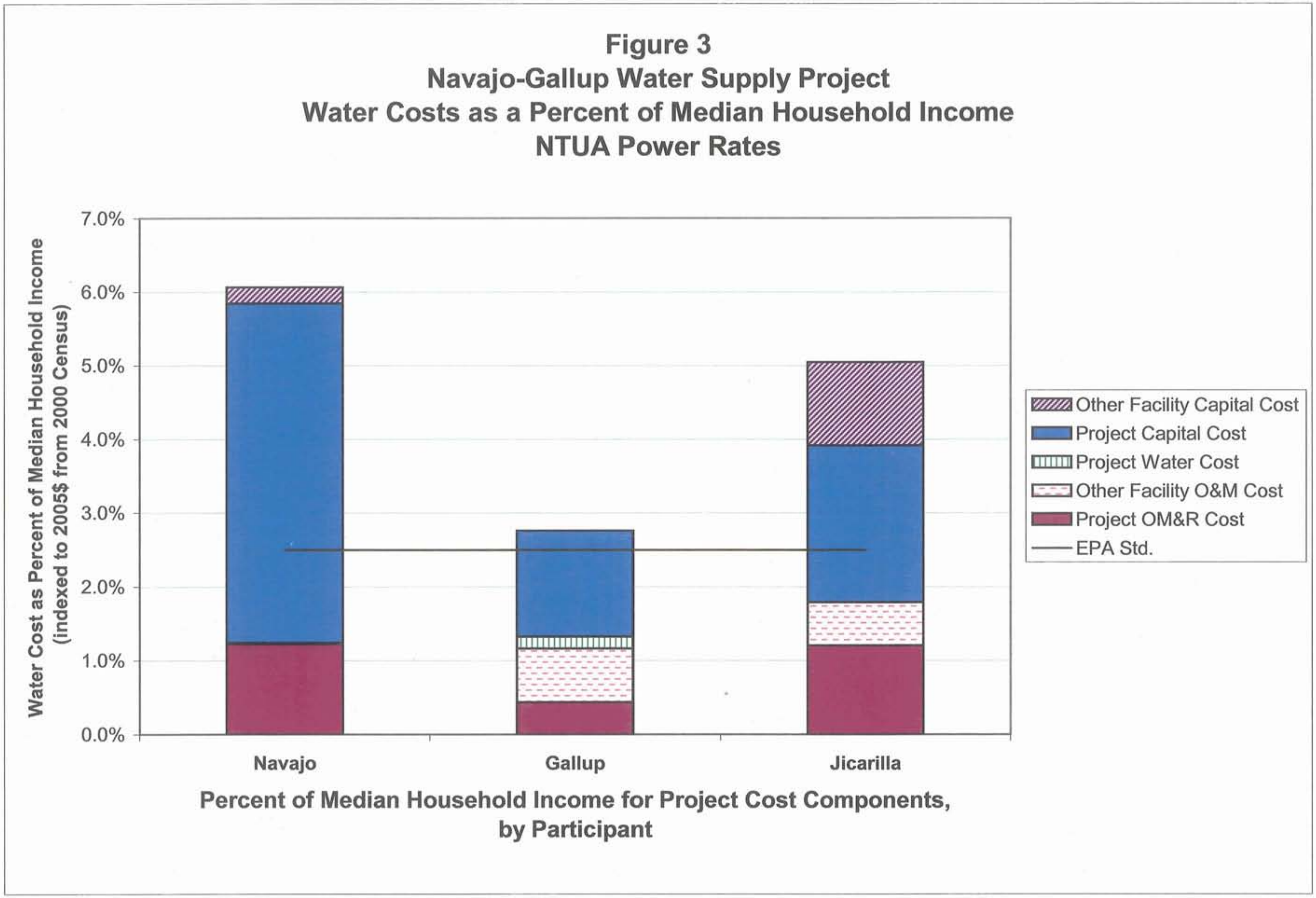


Figure 3
Navajo-Gallup Water Supply Project
Water Costs as a Percent of Median Household Income
NTUA Power Rates
Water Cost as Percent of Median Household Income (indexed to 2005$ from 2000 Census)
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
Navajo
Gallup
Jicarilla
Percent of Median Household Income for Project Cost Components, by Participant
Other Facility Capital Cost
Project Capital Cost
Project Water Cost
Other Facility O&M Cost
Project OM&R Cost
EPA Std.

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APPENDIX D

Part IV
Social Impacts from the Navajo-Gallup Water Supply Project

SOCIAL IMPACTS FROM THE NAVAJO – GALLUP WATER SUPPLY PROJECT

Prepared by James P. Merchant

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Berkeley, CA

April 11, 2006

TABLE OF CONTENTS

A. EXECUTIVE SUMMARY

This report discusses the social impacts associated with the Navajo-Gallup Water Supply Project. The report addresses impacts on three groups of people, the Navajo Nation, the City of Gallup and the Jicarilla Apache Nation. The types of social impacts addressed include (1) Community cohesion, (2) Accessibility to water, (3) Public health, (4) Employment impacts, (5) Demand for local services, and (6) Environmental Justice issues.

The Project should have strong positive effects on the Accessibility to water and Public health categories, and positive effects on Employment and Environmental Justice categories. If Project jobs are filled predominantly by new arrivals to the area there may be a minor negative impact on the Demand for local services. Project employment may increase construction sector employment by somewhat more (168%) than the standard deviation in that sector, but total Project-related employment (including secondary employment) will not represent an unusual fluctuation in the area's year-to-year total employment. We did not identify any significant impact on Community Cohesion.

B. COMMUNITY COHESION

For purposes of this report "Community Cohesion" refers to interactions among people and groups within a community[1] and may be affected to the extent that a project interferes with those interactions or introduces stress into the social patterns within a community. A project could interfere with community interactions by physically displacing people, by creating physical or aesthetic barriers that disrupt established patterns, or by creating a divisive debate about the advisability of the project.

The Navajo-Gallup Water Supply Project will consist primarily of buried pipelines, community storage tanks and two water treatment plants. While the pipeline route will

[1] US Department of Transportation, 1996.

transit some privately held property, most of that route is in rural areas and no residences will be displaced. Undergrounding the pipeline should preclude any barrier effect from that project aspect. The storage tanks and treatment plants are tentatively sited outside any community and should also not create barriers to community interaction.

The Project has enjoyed very strong local support among all its constituents. The Northwest New Mexico Council of Governments in conjunction with the U.S. Bureau of Reclamation held public scoping meetings early in the Project design stage at which numerous people spoke about the Project's desirability. The meetings were held in St. Michaels, AZ, and Crownpoint, Farmington, Shiprock and Gallup, New Mexico[2]. Of the 36 speakers, 19 people specifically expressed support for the Project, 3 expressed qualified support, and 3 others supported the concept of an increased water supply but did not express an opinion on the Project. Of the 36 speakers only 2 did not support the Project in some way.

All three local government bodies also have expressed their support for the Project. The Resources Committee of the Navajo Nation Council adopted a resolution supporting the PNM alignment of the Project, and the Navajo President and Vice-President have repeatedly written letters expressing the Navajo Nation's support for the Project.[3] The City of Gallup … The Legislative Council of the Jicarilla Apache Nation has cited their significant development plans for the southeast portion of their Reservation and has formally endorsed the planning effort to participate in the Navajo-Gallup Water Supply Project.[4]

Finally, the Upper Colorado River Commission, representing the Upper Basin states of Colorado, New Mexico, Utah and Wyoming, also adopted a resolution supporting the Navajo-Gallup Water Supply Project.[5]

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[2] Northwest New Mexico Council of Governments, 2000.
[3] Navajo Nation Council, Resources Committee.
[4] Jicarilla Apache Nation, 2001.
[5] Upper Colorado River Commission.

C. ACCESSIBILITY TO WATER

Accessibility to a clean, reliable water supply is considered so important that the United Nations Millennium Project cites water infrastructure as one of the key requirements to help people break out of the "poverty trap." [6] Providing a water supply is also cited as the basis for Congressional legislation in the United States. For example, the first Congressional finding in the 1996 Amendments to the Clean Water Act states that "safe drinking water is essential to the protection of public health." [7]

Some 40% of the Navajo people living in the Project service area presently have no access to piped water, and consequently haul water from sometimes distant sources.[8] Some of the water they do consume is from non-potable sources intended for stock watering and not compliant with EPA water quality standards.[9] The Project is planned to deliver a reliable supply of treated water to many of the Navajo homes that are presently without a piped water supply. Although Project plans assume that 10% of the Navajo homes presently without a piped water supply will not be served by the Project, the remainder will be.

In addition, many of the Navajo communities in the Project service area that presently do have a piped water supply rely on wells with a limited water supply. The Project will allow these communities to provide an adequate water supply to their future population and commercial needs.

The City of Gallup currently relies on groundwater pumping to supply water to its residents. The water level in Gallup wells has been falling by 7 to 29 feet per year over an extended period, and at some point the production capacity of the current well system is expected to diminish. Absent the Project, therefore, Gallup would be faced with some combination of the following scenarios: (1) development of alternative water supply

[6] UN Millennium Project, 2005, p. 39.
[7] PL 104-182, 1996, Section 3.
[8] Navajo Nation Department of Water Resources, p. ES-3.
[9] Ecosystem Management, Inc., 2004.

projects, (2) diminishing per capita water supply, and/or (3) curtailment of population growth. Gallup has not been able to identify any other water supply project that is as cost-effective as the Navajo Gallup Water Supply Project. Without new water it is estimated that the available water per capita would fall to less than one-half of existing water use by the year 2033. Thus without the Project, Gallup would have to make major changes in water use patterns, with consequential negative implications for the city's economic well-being. Accordingly, one Project impact is to prevent the overall economic losses to the City that would occur if future water shortages caused residents and businesses to locate elsewhere.

The Jicarilla Apache Nation has established a policy of developing the southwest portion of its Reservation. In order to attract the housing and commercial enterprises to that area they must develop a reliable, sustainable water supply. The Nation has no adequate local water sources capable of providing such a water supply, so they have investigated various alternatives for importing water from non-local sources. Of the alternatives investigated the Navajo Gallup Water Supply Project offers the best combination of reliability and cost-effectiveness. The effect, then, of the Project would be to facilitate the Jicarilla Nation's plans to diversify their Reservation, both residentially and economically.

D. PUBLIC HEALTH

A primary rationale for the public policy of providing clean and reliable water to all people in the United States is the resulting health benefit. As noted in the "Accessibility to Water" section, above, the 1996 Amendments to the Clean Water Act explicitly link public health to safe drinking water.[10] In addition, Congress has found specifically for Indians that a "major national goal of the United States is to provide the quantity and quality of health services which will permit the health status of Indians to be raised to the highest possible level ...,"[11] and that "the provision of safe water supply systems and sanitary sewage and solid waste disposal systems is primarily a health consideration and

[10] PL 104-182, Section 3.
[11] 25 USC 1601

function," and that "it is in the interest of the United States, and it is the policy of the United States, that all Indian communities and Indian homes, new and existing, be provided with safe and adequate water supply systems… as soon as possible."[12]

There is a clear connection between sanitation facilities (water & sewerage) and Indian health. The Indian Health Service considers the availability of essential sanitation facilities to be "critical to breaking the chain of waterborne communicable disease episodes… In addition, many other communicable diseases, including hepatitis A, shigella, and impetigo are associated with the limited hand washing and bathing practices often found in households lacking adequate water supplies. This is particularly true for families that haul water."[13] The Indian Health Service reports that American Indian families living in homes with satisfactory environmental conditions required about one-fourth the medical services as those with unsatisfactory environmental conditions.[14]

The Navajo Gallup Water Supply Project will provide a safe water supply to many households who would otherwise not have it, particularly on the Navajo Reservation. As mentioned in the previous section, approximately 40% of Navajo households presently must haul water, sometimes from non-potable water sources. The Project is designed to deliver a safe, reliable water supply to most of these households, and this water supply should have a direct beneficial effect on the health of the people receiving it.

E. EMPLOYMENT IMPACTS

Project-induced change in employment opportunities could represent either a positive or negative social impact. To the extent that a project provides opportunities for employment in an area with high unemployment rates, the project can relieve social stress due to the lack of jobs. On the other hand, a project that attracts a large number of employees from outside the local area could create social tension. The degree to which

[12] 25 USC 1632
[13] Indian Health Service, 2004
[14] Ibid.

Project employment could attract a substantial influx of workers, stressing both community infrastructure and community cohesion, is addressed in the next section.

The Navajo-Gallup Water Supply Project will create jobs for both the construction and operation phases. The construction phase is expected to last some 13 years, and construction will occur in San Juan and McKinley counties in two main corridors: the western branch from the PNM diversion on the San Juan River to Gallup, with east and west branches; and the eastern branch from the Cutter diversion on the NAPI canal south to Torreon. The construction employment is estimated to average about 600 workers and peak at about 650 workers during the 3rd through 12th years of construction. The operational phase will employ about 22 full-time equivalent workers on a long term basis. The jobs for these workers will be located primarily at the water treatment plants and pumping plants, with crews monitoring and repairing the pipelines and electric transmission lines.

The San Juan – McKinley county area has experienced long-term unemployment problems, particularly among the Navajo and Jicarilla people. In recent years the overall unemployment rate in the area has exceeded the national rate by approximately 10% to 70%, while the unemployment rate among Navajo and Jicarilla people has been six to ten times the national rate. Table 1 shows the most recently available unemployment rates for the area.

Table 1

Unemployment Rates in United States and Vicinity of Navajo Gallup Water Supply Project

Year	United States	San Juan County, NM	McKinley County, NM	Navajo Reservation	Jicarilla Apache Reservation
1999	4.2%	7.5%	7.1%	34%	40%
2000	4.0%	5.8%	6.6%		
2001	4.7%	6.2%	6.2%	52%	33%
2002	5.8%	6.9%	6.2%		
2003	6.0%	7.6%	7.4%		
2004	5.5%	6.1%	7.6%		

Sources: National and county unemployment rates from U.S. Bureau of Labor Statistics, "Local Area Unemployment Statistics;" Reservation unemployment rates from U.S. Bureau of Indian Affairs, "American Indian Population and Labor Force Report," 1999 and 2001.

To the extent that the construction and operation jobs can be filled by currently unemployed local people, the Project should represent an important benefit to the local area's socioeconomic condition. The Water Resources Council's Principles and Guidelines conclude that in an area of substantial and persistent unemployment a local hire rule can increase the percent of jobs going to otherwise unemployed people from 30% to 43% in the case of skilled workers, and from 47% to 58% in the case of unskilled workers.[15] In either event the Project should result in a significant number of jobs for otherwise unemployed people.

F. DEMAND FOR LOCAL SERVICES

Although many Project workers may be hired from the local population base, some other workers may be attracted from outside the area. If the number of immigrants is sufficiently large, it may have negative effects on both community infrastructure and on community social fabric.

During the construction phase the Project will support two types of additional employment in the region. First, the Project will require several hundred construction workers to build the water treatment plants, pipeline, storage tanks, pumping plants and electrical transmission lines. Second, the income earned by Project construction workers will stimulate local spending on goods and services, adding more jobs primarily to the retail and service sectors. Table 2 shows an estimate of the jobs added in the construction sector and in all sectors (including construction) during each year of construction. The numbers of new construction and new total jobs were estimated using an IMPLAN input-output model that links a change in employment to an initial change in spending (in this case, Project construction spending).[16] Table 2 also shows an estimate of the baseline construction and overall employment that would exist in the absence of the Project. Future overall employment was estimated by extending the 1999-2003 trend in overall employment into the future. Construction employment has been declining over the 1999-

[15] U.S. Water Resources Council, p. 94.
[16] IMPLAN

2003 period. For purposes of this analysis we assumed that the decline will halt and in the absence of the Project, future construction employment would stabilize at the 2003 level.

Table 2

Baseline and Project-Related Additional Employment

McKinley and San Juan Counties, New Mexico

Year	Baseline Construction Employment	Additional Project-Related Construction Employment	Baseline Total Employment	Additional Project-Related Total Employment
1999	5,124		62,261	
2000	4,554		62,097	
2001	4,477		64,377	
2002	4,142		65,441	
2003	4,187		66,000	
2004	4,187		67,282	
2005	4,187		68,364	
2006	4,187		69,446	
2007	4,187		70,528	
2008	4,187	268	71,611	511
2009	4,187	432	72,693	825
2010	4,187	659	73,775	1,258
2011	4,187	650	74,857	1,240
2012	4,187	653	75,939	1,245
2013	4,187	653	77,022	1,246
2014	4,187	650	78,104	1,241
2015	4,187	661	79,186	1,261
2016	4,187	653	80,268	1,245
2017	4,187	653	81,350	1,245
2018	4,187	653	82,433	1,245
2019	4,187	652	83,515	1,244
2020	4,187	544	84,597	1,038

Source: U.S. Bureau of Labor Statistics, "State and County Employment and Wages from the Quarterly Census of Employment and Wages;" IMPLAN; Dornbusch Associates.

Table 2 shows the future estimated baseline (without Project) employment and the Project-related increase in employment for the construction sector and for total employment. The significance of these increases is a remaining question. As the actual employment data for 1999-2003 in Table 2 show, employment can vary considerably from year to year. Using the data for 1999-2003 we calculate standard deviations for both construction and total employment. This measure indicates the expected variability in employment from year to year. So long as the annual employment numbers are "normally" distributed, we would expect the annual numbers to be within one standard deviation of the mean about two-thirds of the time. Table 3 shows the annual Project-related employment as a percent of one standard deviation.

Table 3

Project-Related Construction and Total Employment as a Percent of One Standard Deviation, McKinley and San Juan Counties, New Mexico

Year	Project-Related Construction Employment / Standard Deviation	Project-Related Total Employment / Standard Deviation
2008	68%	29%
2009	110%	46%
2010	168%	70%
2011	165%	69%
2012	166%	69%
2013	166%	69%
2014	165%	69%
2015	168%	70%
2016	166%	69%
2017	166%	69%
2018	166%	69%
2019	166%	69%
2020	138%	58%

Table 3 shows that the Project-related total employment change is estimated to be within one standard deviation of the baseline employment. On the other hand, the Project-related construction employment is estimated to exceed one standard deviation from the baseline employment. If the distribution of annual construction employment follows a normal distribution, an increase the magnitude of Project-related construction employment would only be expected to occur in about one year in ten. However, the Project-related construction employment does not reach this peak level until the third year of construction; the biggest year-to-year change in Project-related construction employment is well within the one standard deviation benchmark. Figures 1 and 2 show graphically how the Project-related construction and total employment, respectively, compare to expected baseline employment during the construction phase. The error bars around the baseline employment numbers represent plus and minus one standard deviation from the mean number.

Figure 1
Project Construction Employment Impact
Navajo Gallup Water Supply Project
San Juan and McKinley Counties, NM

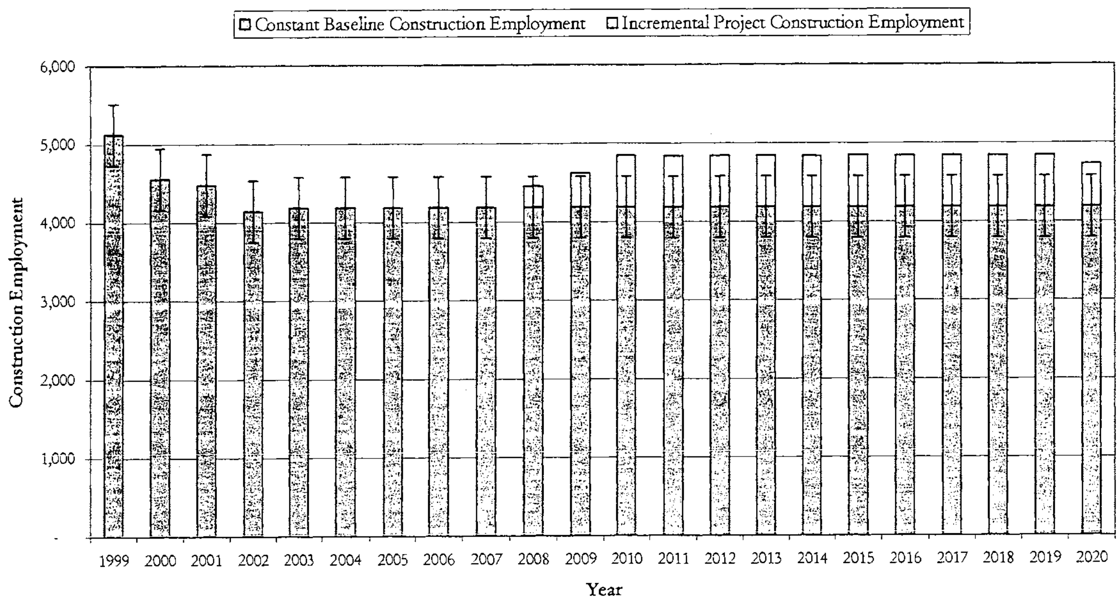
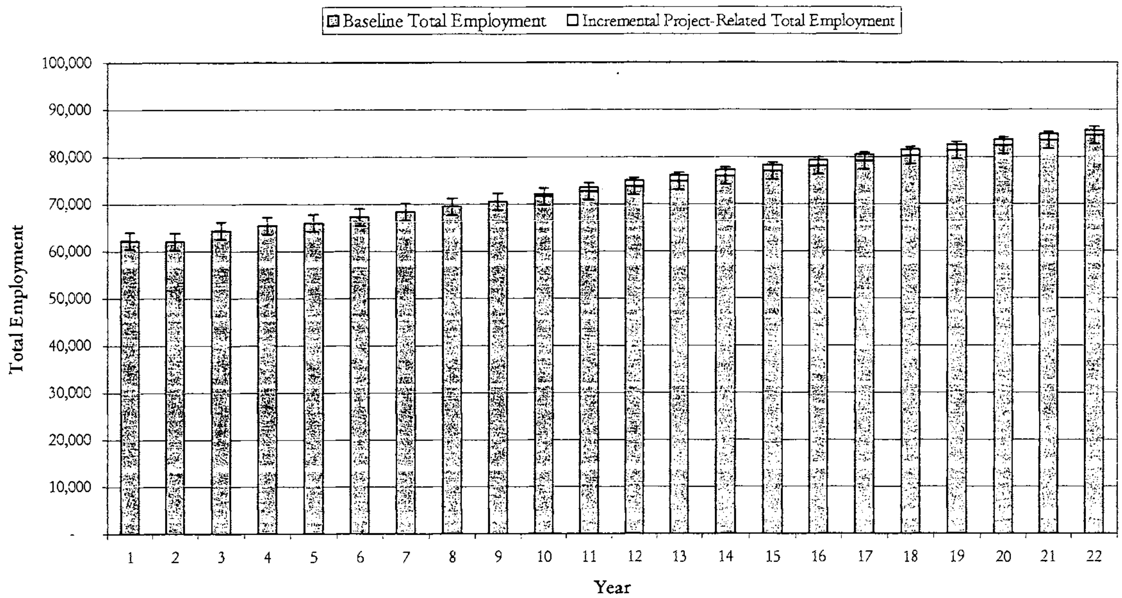


Figure 2
Project-Related Total Employment Impact
Navajo-Gallup Water Supply Project
San Juan and McKinley Counties, NM



The changes shown in Table 3 represent a worst case possibility. To the extent that the construction industry and other sectors hire local people who were otherwise unemployed these jobs will be filled by people who will not add substantially to the demand for local services and infrastructure. For example, these local people may already have housing and their children may already attend local schools. As discussed in the previous section, the U.S. Water Resources Council suggests that in an area with persistent and substantial unemployment some 30% to 58% of the construction workforce will come from the pool of unemployed workers. The number depends partially on whether the jobs are skilled or unskilled and on the presence of a local hire rule.[17]

The Project operation will require operators and maintenance personnel. Based on the IMPLAN model we estimate that about 66 workers will be needed, of which about one-third will be directly working on the Project, one-third working for businesses that supply goods and services to the Project, and the remaining one-third working for businesses that provide goods and services to Project employees and employees of the businesses

[17] U.S. Water Resources Council, p. 94.

supplying the Project. Sixty-six employees represents about one-tenth of one percent of total area employment. This level of employment should not have more than a minor impact on the area's infrastructure and services.

G. ENVIRONMENTAL JUSTICE

The Environmental Justice issue is essentially one of discrimination against specific subpopulations. Executive Order 12898 directs that federal programs, policies and activities not have a disproportionately high and adverse human health and environmental effect on minority and low-income populations.[18]

Substantial populations in the Project area clearly qualify as minority and low-income. The 2000 Census of Population reports that 74.7% of the 74,798 people in McKinley County and 36.9% of the 113,801 people in San Juan County are American Indians.[19] The 2000 Census also shows that both the Navajo people ($21,830) and Jicarilla Apache people ($26,667) in New Mexico earn median incomes far below the New Mexico state average ($34,133).[20]

No major adverse impacts from the Project have been identified, and there is no indication that any adverse impacts would have a disproportionate effect on the minority and low-income populations.

Conversely, the beneficial effects from providing water to those who would otherwise have to haul water will accrue *primarily* to the minority and low-income populations. This access to water benefit and the related health improvements are discussed in earlier sections of this report. These important positive Project impacts will assist rather than harm the minority and low-income populations.

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[18] Presidential Executive Order 12898.
[19] US Census Bureau, Quick Facts McKinley County and US Census Bureau, Quick Facts San Juan County.
[20] US Census Bureau, Characteristics of American Indians.

In addition to the positive water accessibility and related health benefits to the minority and low-income populations, the Project will have an additional beneficial impact by increasing the attractiveness of the area for economic development. The Project will provide a water infrastructure essential for many businesses. The water provided by the Project will assist the City of Gallup in retaining existing businesses and attracting new ones, and will assist the Navajo Chapters and the Jicarilla Apache Nation in attracting businesses that would not otherwise be interested in investing in the area.

Finally, the Project may indirectly help reduce the outmigration of Navajo people. The improved economic climate facilitated by the Project will provide more employment opportunities for the minority and low-income populations. This increased employment opportunity, together with an improved water infrastructure, will make the area more attractive for young adults who might otherwise consider moving outside the area.

According to Census Bureau data the population of the Navajo Nation grew by 32.4% between 1990 and 2000, from 225,298 to 298,197 people [U.S. Census Bureau, 1995; U.S. Census Bureau, 2002]. In contrast, the number of Navajo people residing on the Navajo Reservation or Trust Lands increased only 21.6% [U.S. Census Bureau, "American Factfinder;" U.S. Census Bureau, "American Indian Reservations and Trust Lands"]. This disparity indicates that the number of Navajo people residing off-Reservation increased by 53.2%, or over 40,000 people.

The Navajo tribal statistician noted this trend of Navajo outmigration in the 1996 "Chapter Images" profile of Navajo communities [Navajo Division of Community Development, 1997, p. vii]. The statistician attributed the trend to "development stagnation" on the Reservation [Ibid.]. Another factor contributing to the outmigration, however, may be the low standard of living due to primitive water supply conditions. About 40% of Navajo families have no piped water supply and must haul water from a central source to their dwellings. As noted in the section discussing health benefits, above, water hauling is not only expensive and inconvenient but also contributes to health problems for families who haul water.

Section E, above, discussed the likelihood that the Navajo Gallup Water Supply Project would stimulate the regional economy. This increased economic activity should provide additional long-term employment opportunities for all people in the Project service area, including those on the Navajo Reservation. In addition, the provision of a piped water supply will raise the standard of living in the Project area, providing clean, reliable water at a price much less than the cost of water hauling. The increased opportunity for increased economic well-being, in addition to the convenience afforded by a reliable source of clean piped water, should substantially reduce the outmigration of Navajo people.

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