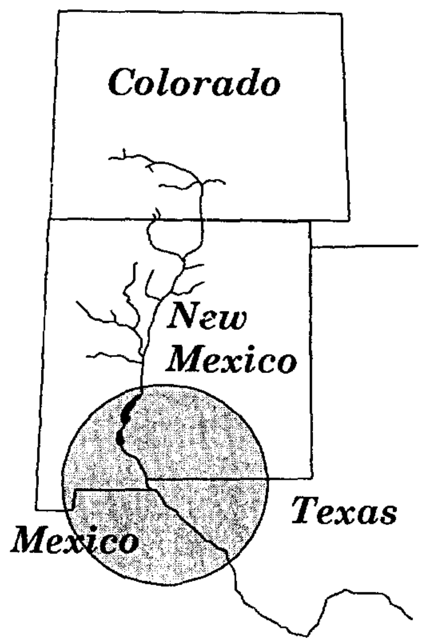
Conjunctive Water Resource Management Technical Data Report—Volume I



Prepared for the New Mexico/Texas Water Commission

94-483-017

June 1994

BOYLE **Engineering-Science, Inc.**

Conjunctive Water Resource Management and Aquifer Restoration Study for New Mexico/Texas Water Commission

Revised - 1/16/95

Table of Contents

List of Figures

Tables

Acronyms and Definitions

af - acre feet

af/yr - acre feet per year

Aquifer/Basin/Bolson used interchangeably

acequias - irrigation canals, laterals, ditches.

cfs - cubic feet per second

New Mexico/Texas Water Commission (Commission)

EBID - Elephant Butte Irrigation District

EDR - Electric Dialysis Reversal

EPCWID#1 - El Paso County Water Improvement District No. 1

EPWU - El Paso Water Utilities/Public Service Board

gpcd - gallons per capita per day

IBWC - International Boundary and Water Commission

M&I - Municipal and Industrial

mCi/day - micro-Couries per day

MCL - maximum contaminant level

MCLg - maximum contaminant level goal

MG - million gallons

mg/L - milligrams per liter

MGD - million gallons per day

NTU - nephelometric turbidity unit

RGP - Rio Grande Project

RO - Reverse Osmosis

SDWA - Safe Drinking Water Act

TDS - total dissolved solids

TOC - total organic carbon

USBR - United States Department of the Interior, Bureau of Reclamation

USGS - United States Geologic Survey

WTP - Water Treatment Plant

Executive Summary

This report describes progress to date on an effort by the New Mexico-Texas Water Commission (Commission) to improve use of water resources in the Rio Grande Project area. The history of water resource development is discussed and the basic philosophy of the Commission, "conjunctive or complementary use of both surface and ground water for the region-wide needs," is described. The recognition that the two major ground water aquifers of the region, the Hueco and Mesilla Basins, are finite and depletable resources is an important part of the motivation for optimizing conjunctive use. Current over pumping, particularly of the Hueco Basin, is rapidly depleting these aquifers, which are an essential element of the environmental quality of the Region.

The Commission recognizes that the best solution to the water resource problems of the Region is to optimize the use of renewable surface water. In order to assist in the implementation of this solution, several alternative objectives for a surface water conveyance have been identified. A surface water conveyance will allow year round delivery to municipal and industrial(M&I) users. It will also preserve the raw water quality which exists in the Rio Grande Project reservoirs in deliveries to both agricultural and M&I users.

Three conveyance alternatives have been identified. These differing conveyances are "alternative objectives" because they do not serve all of the same end users and, therefore, do not accomplish the same objective. The Commission has directed its engineering consultants to do a reconnaissance level study of these alternatives which are described below:

- *Alternative 1- will convey the Rio Grande Project surface water allocation of the Texas and Mexican entities and a small amount for M&I uses in Southern Dona Ana County, from the Percha Diversion Dam, along the Rio Grande in a lined canal, without commingling with other irrigation or storm water, to the American Dam in El Paso.*

- *Alternative 2 - will convey all of the surface water allocation of the Rio Grande Project from the Percha Diversion Dam in lined and upgraded canals to the American Dam in El Paso. All historic irrigation supplies would be served by diversion from the canal with an option to re-divert instream flows in the Rio Grande for blending with water that has been diverted from the canal. Additionally, provisions would accommodate two new diversions from the upgraded canal to supply surface water to two new regional water treatment plants for distribution to M&I users.*

- *Alternative 3 - will divert the surface water allocation attributable to the EPWU and the Republic of Mexico from the outlet works of Caballo Dam through a closed conduit to a termination at the Jonathan Rogers Water Treatment Plant located near the Riverside*

Diversion Dam in El Paso. Provisions will be made to divert flows at a point between the communities of Anthony and Canutillo, Texas, to serve a future water treatment plant. Provisions will also be made to divert flows at the Robertson-Umbenhauer Water Treatment Plant in El Paso.

The purpose of this study is to provide information to assist the Commission in deciding on a common objective. In addition to the three conveyance objectives outlined above, the study will consider other factors which might influence construction and operation of a successful conveyance project. These factors include:

- *layouts for two regional water treatment plants,*
- *consideration of possible means for blending the conveyance supply with agricultural return flows and storm water runoff,*
- *locations for and benefits of canal and drain storage,*
- *consideration of agricultural return flow treatment,*
- *initial consideration of aquifer storage and recovery,*
- *consideration of drought contingency,*
- *consideration of means to improve the regional aquatic and riparian environment and recreational opportunities as part of project implementation.*

The study also included a water budget analysis for each alternative. These analyses provide the Commission an indication of the water quality and quantity changes which would result from implementation of the three conveyance alternatives. The water budget model also provides a useful tool for the conceptualization and discussion of the numerous hydrologic and operational factors involved.

Layouts of the three conveyance alternatives are shown on Figure 3 in the map pocket at the back of the report. Details of various proposed canal structures are shown in Figures 4 through 8 in the "Alternative Objectives" section. The capital costs of the three alternatives, as well as alternative 2a, which would allow blending, are as follows:

- *Alternative 1 - $332 - million*
- *Alternative 2 - $377 - million*
- *Alternative 2a - $541 million*
- *Alternative 3 - $398 million*

All of the costs presented in this report are estimated for the year 2000, as discussed in the Cost Criteria Memorandum in Appendix B. Further detail on alternative costs is included in Tables 1 through 4 in the "Alternative Objectives" and in the cost tabulations in the Summary of Study Results section of the report.

Layouts of the Regional Water Treatment Plants are shown in Figure 23 and Figure 24. The first regional plant is located south of Dona Ana, near Las Cruces and would serve down to Santo Tomas. The second is located between Anthony and Canutillo, Texas and would serve Southern Dona Ana County and the west side of El Paso. It would also provide 54 MGD of treatment capacity for possible use by

Ciudad Juarez, Mexico. Estimated capital costs of these plants and associated treated water transmission facilities are as follows:

- *Las Cruces Plant facilities for 2015 demand - $130 million*
- *Las Cruces Plant facilities for 2035 demand - $242 million*
- *Anthony Plant facilities for 2015 - $310 million*
- *Anthony Plant facilities for 2035 demand - $466 million*

These costs are based on the uninflated figure for construction costs of $1.15 per gallon per day of treatment plant capacity in the Cost Basis Memorandum. The treatment plant processes chosen as appropriate for the water quality expected from Caballo Reservoir are shown in Figure 26. Lime softening and carbon adsorption will not be necessary. The construction cost figure used is based on the Jonathan W. Rogers Water Treatment Plant, which includes both of these processes. Therefore, these estimates of water treatment plant construction costs are conservatively high.

The final section, "Summary of Study Results," pulls together the important aspects of the alternative conveyance objectives to assist the Commission in selecting the common objective with the greatest net benefit to all parties concerned. Costs, surface water quality impacts, pros and cons, and impacts on the sustainability of the Hueco and Mesilla Basins are all considered. In keeping with the philosophy of the Commission to protect these aquifers, the effect of the alternatives on net aquifer balance may be one of the most important considerations. All of the alternatives greatly improve on the consequences of the baseline (no *action) condition, which provides major support to the viability of the surface water conveyance concept.*

The findings of the Phase II/III study are numerous; however, five issues are revealed which will greatly affect the selection by the Commission of the preferred alternatives:

1. *The Hueco Basin is in serious jeopardy of continued depletion which will not be eliminated by any of the alternatives. Additional measures will be required.*

2. *Restoration of the Hueco Basin requires stabilization of pumping withdrawals by both El Paso and Juarez and implementation of aquifer storage and recovery program.*

3. *Aquifer storage and recovery is key to economical sizing and operation of regional water treatment plants because most summer peak demands can be met from ground water without depletion of the aquifer.*

4. *Under all of the alternatives, there will be significant deficits in supply from surface water sources unless there is reuse of return flows by rediversion .*

5. *Creative use of return flows could offer not only the possibility of augmenting the canal supply but also an opportunity for providing positive environmental benefits through enhancement of riparian habitat and recreational opportunities.*

Introduction

Purpose of the Study

During the hundreds of years that man has inhabited the Rio Grande Valley, social and economic changes have altered water demand patterns in the region. However, water suppliers have been reluctant to change the source and distribution of the water due to the high costs and relative permanence of water supply facilities.

The purpose of this study is to evaluate the total water resources available to supply the needs of the population in the study area to the year 2035. Further, the study aims to remedy current imbalances of resource distribution which are consuming the ground water element of the total supply beyond its sustainable capacity.

Study Area

The study region encompasses the Rio Grande floodway starting upstream near Truth or Consequences, New Mexico, and extending southeasterly to Fort Quitman, Texas, located on the international boundary with the Republic of Mexico. This area includes three major cities: Las Cruces, New Mexico; El Paso, Texas; and Ciudad Juarez, Chihuahua, Mexico. There are numerous small farming communities throughout the valley in this area, and one Indian Pueblo—Ysleta, Texas. Recently, extemporaneous small communities called "Colonias" are being constructed without planning, municipal services, or zoning and subdivision restrictions.

Historic Perspective

The development of water resources in the region that is now defined by the Rio Grande Project has a history dating back to the pre-Columbian period. During the Spanish Colonial period, the Camino Real trade route developed between the cities of Chihuahua and Santa Fe through El Paso. The Texas Republic was established in 1836, followed by the Mexican-American War of 1846-1848. The war ended with the Treaty of Guadalupe Hidalgo by which Mexico ceded a large area of the Southwest to the United States, including the New Mexico Territory. In 1853, the United States and Mexico executed the Gadsden Treaty that purchased lands for the United States along the frontier that established the current international boundary.

Before the annexation of the project area into the United States, agriculture thrived in the valley floodway of the Rio Grande. Aboriginal Indians inhabiting pueblos along the waterway were the first farmers in the region, followed by the Spanish colonists who introduced advanced European irrigation methods involving a network of acequias (community irrigation ditches) to distribute the intermittent flows of the Rio Grande (and other streams) to the lands in the valley floor.

With the change of sovereignty of the region, American colonization took place. This influx of settlers was fed first by the establishment of the Santa Fe Trail from Missouri, and later in the nineteenth century by the Butterfield Stage line through Texas and New Mexico, via El Paso. The railroads followed, with both the Southern Pacific and the Santa Fe serving the region. Increased accessibility fostered further development, most notably international commerce with Mexico at El Paso, agriculture in the fertile valleys, and mining in the mountains.

The Rio Grande valley floor was characterized by a shallow water table. Phreatophytic vegetation such as Tamarisk (Salt Cedar) and Cottonwood trees thrived in the area. Crop watering was accomplished by diverting the intermittent flows of the Rio Grande through the acequia system, by pumping from shallow wells, and from natural rainfall. The high desert climate at these latitudes provided a relatively long growing season with a sub-freezing dormant period each year.

The Rio Grande Project

The Reclamation Act of June 17, 1902, addressed the settlement of the West and the national concern over the use of America's resources. The Rio Grande Project was one of the original projects authorized by Congress on February 25, 1905, and by the Secretary of the Interior on December 2, 1905 to develop water resources in the Rio Grande Valley. The construction of Elephant Butte Dam and Reservoir, keystones to the development of the Rio Grande Project, was completed in 1916. Downstream of the dam, this project extended through two states and encompassed over 230,000 acres. The project was composed of river diversion dams, conveyance canals, drain ditches, distribution laterals which generally followed the old community ditches, river levees, and channel improvements along the Rio Grande. A few years later, the Reclamation Act of June 12, 1906, extended to the State of Texas the benefits of the Act of June 17, 1902.

The Republic of Mexico was included as a beneficiary of the Rio Grande Project by the Convention of 1906. Mexico has an entitlement of 60,000 af/yr in a normal year's allocation. This water is now delivered to the International Dam at Ciudad Juarez, where it is diverted into the heading of the Acequia Madre for agricultural use.

The Reclamation Act of March 4, 1907, appropriated $1 million toward the construction of a dam (Elephant Butte) to store water and to deliver the 60,000 af per year to the Republic of Mexico.

Before the Rio Grande Project improvements, flows in the Rio Grande were entirely dependent upon the spring snow-melt in the high mountains of Northern New Mexico and Southern Colorado. Old community ditches (acequias) were used to deliver water to the fields. The river was often dry for long periods most years. The municipalities in the region developed community water supply systems by tapping the ground water aquifers with wells. This was the only potable water source available on a year-round basis at that time.

Even with the advent of the Rio Grande Project, reliance on ground water continued. The U.S. Department of the Interior, Bureau of Reclamation (USBR), designed the project facilities for agricultural irrigation and electric power generation. While there were provisions in the enabling legislation to address the municipal needs, there were no incentives or facilities to use the surface waters of the Rio Grande because of the seasonal availability and relatively low water quality without treatment.

Caballo Dam and Reservoir were constructed on the Rio Grande downstream of Elephant Butte in 1936 to 1938. The Caballo facility served as a buffer to regulate the different release requirements between power generation and irrigation demands. In addition, it was sized to provide flood storage (100,000 af) to justify substantial cost reductions in the Rio Grande Rectification Project (1933) which channelized the Rio Grande along the international boundary from the American Dam to Fort Quitman.

El Paso's Water Supply

As early as 1940, El Paso, Texas, determined the ground water aquifers were being overdrafted due to well pumping by water users. In response to that concern, the city constructed the Canal Street Water Treatment Plants, the first of which came on line in 1943 to partially meet the water demands of the community. In 1963 a second Water Treatment Plant was added at the same location to increase surface water treatment capacity. The water supply for these plants was derived from the Rio Grande Project annual allocation of surface water to the EPCWID#1. The district enacted restrictions in its operational regulations to limit the amount of water that could be converted to municipal use. In subsequent years, EPWU further expanded its surface water treatment capacity; however, the plants could only be operated during the irrigation season because of water availability.

Litigation

In 1980, the EPWU filed applications with the Office of the State Engineer of New Mexico to drill water wells in Dona Ana County, New Mexico. This action resulted in extended litigation between El Paso, the EPWU and several public entities in New Mexico. While the litigation process fostered regulatory changes, statutory changes, and a Supreme Court ruling, it did not allow EPWU to obtain well permits. The discovery process and hearings during the litigation elicited the awareness and concern of the parties involved for protection of regional water resources and the lack of quantitative analyses.

Litigation Settlement

As a result of these concerns, El Paso along with EPCWID#1, EBID and the New Mexico public entities separately conducted major planning studies to evaluate their present and future circumstances. The two studies, The Water Resource Management Plan, prepared by Boyle Engineering Corporation for EPWU and EPCWID#1, and Surface Water Supply Alternatives for the City of El Paso and Southern New Mexico Water Users, prepared by Engineering-Science, Inc., for the New Mexico public entities, provided valuable information to negotiate a litigation settlement agreement. A settlement of litigation was achieved, resulting in an agreement dated March 6, 1991.

Key conditions in the settlement are summarized below:

1. Formation of a Joint Commission.
2. Conservation of water is first priority.
3. Use of the surface water of the region for all purposes.
4. Perform water resource studies applicable to the entire project area.

The Commission

In compliance with the litigation settlement agreement, the Joint Commission (now the New Mexico-Texas Water Commission) was formed, and now includes participation by entities who were not parties to the litigation but have a vital interest in the long-term water resources of the region.

This Commission has also proceeded with the stipulated planning effort by hiring Boyle Engineering Corporation and Engineering-Science, Inc., to combine the information and data previously gathered through the individual studies and to perform further studies to formulate a plan that will best serve the water resource interests of all the parties. This report presents the findings of certain elements of that study, which is proceeding by distinct phases. Phase I, which was completed and previously reportéd, dealt with identification of alternative methods to more fully use surface water supplies for M&I purposes and to quantify increased resource utilization through water loss mitigation.

The Commission has sought to include all parties of interest in the region, including local and county officials, officials from the states of Texas and New Mexico, the International Boundary and Water Commission, The Bureau of Reclamation, the Rio Grande Compact Commission, and officials of Ciudad Juarez.

The driving force of the planning effort is to tap renewable water sources to serve people in both the urban and rural areas of the region, with the provision that both the riparian and instream ecosystems be preserved, enhanced, and restored. Since the high Chihuahua Desert macrocosm of the region is fragile in nature, future water resources must be based on sustainable and renewable surface water sources in areas where ground water is being rapidly depleted. The areas of depleted ground water resources must also be restored, held in reserve and perpetually maintained. There is also an awareness that the region's attractive climatic will foster future immigration and population growth.

Given these parameters, the Commission is committed to preserving and restoring the Hueco and Mesilla Basins (or Bolsons) and the Rio Grande River, all of which are essential elements in this environmental stability and quality of the region. The word "Bolson" is Spanish for "water pocket" and has evolved into a technical term describing a type of valley fill aquifer. These aquifers will be referred to as basins, for clarity to the general reader, in the remainder of the report.

The Commission has specifically directed that the water resource limitations be identified and that a conservation program be included as an element of this study.

This report presents a Phase II/III study that evaluates the feasibility of each of three alternative objectives for conveyance of surface water. These alternatives all offer possibilities for facilitation of Commission goals.

Subject of the Study for Phases II and III

The focus of the overall study is to evaluate the potential efficacy of a protected surface water conveyance to various entities. This conveyance might decrease system losses, make better use of the project water, preserve water quality, restore over-stressed ground water aquifers, and provide sustainable water resources to meet the needs of the region, in accord with achievable environmental improvements. This focus is intended to meet the goals identified in the Study Criteria Memorandum in Appendix A.

By general consent of the Commission, the consultant has been directed to study the feasibility and effects of constructing surface water conveyance facilities from the appropriate upstream location to meet three distinctly different purposes or alternative objectives.

Alternative Objective 1

Alternative Objective 1 will convey the Rio Grande Project surface water allocation of the Texas and Mexican entities and a small portion of the Elephant Butte Irrigation District (EBID) allotment for M&I uses in Southern Dona Ana County, from the Percha Diversion Dam, through the EBID in a lined canal, without commingling with other irrigation or storm water, to the American Dam in El Paso.

Alternative Objective 2

Alternative Objective 2 will convey all of the surface water allocation of the Rio Grande Project from the Percha Diversion Dam in lined and upgraded canals to the American Dam in El Paso. All historic irrigation supplies would be served by diversion from the canal with an option to re-divert instream flows in the Rio Grande for blending with the water that has been diverted from the canal. Additionally, provisions would accommodate two new diversions to supply surface water to two new regional water treatment plants for distribution to M&I users.

Alternative Objective 3

Alternative Objective 3 will divert the surface water allocation attributable to the EPWU and the Republic of Mexico from the outlet works of Caballo Dam through a closed conduit to a termination at the Jonathan Rogers Water Treatment Plant located near the Riverside Diversion Dam in El Paso. Provisions will be made to divert flows at a point between the communities of

Anthony and Canutillo, Texas, to serve a future water treatment plant. Provisions will also be made to divert flows at the Robertson-Umbenhauer Water Treatment Plant.

Additional Options

In addition to the three basic conveyance alternatives and associated regional water treatment facilities, other possible enhancements to the project have been considered. These include additional facilities, modes of operation and possible environmental improvements which could be implemented with construction of a project. These options may help to accomplish the primary goal of preserving of the Hueco and Mesilla Basins, increase the efficiency of surface water use, and promote positive environmental benefits. They are discussed under the section *Additional Considerations* near the end of this report.

General Methods Applied

Data used for this study were those which were generally available from records existing in the user agencies, and state and federal agencies. No field investigations, surveys, or other data generation have been performed. The data that are applicable to the purposes of this study have been collected, compiled, and evaluated.

Subsequent phases of the project development will require substantial field investigations.

The approach of this study was to analyze the holistic effects on the entire water system (surface and ground water) of implementing any of the three objectives. A water budget analysis method was applied. The baseline water budget is representative of the status quo against which each of the alternatives can be compared.

Concurrently with the water budget analyses, conceptual engineering of each of the three alternatives was developed to a degree which allows evaluation of the physical feasibility and the project construction cost.

The planning horizons used in these studies are:

- Facilities come into service—2005
- Facilities in service to expanded population—2015
- Study Horizon—2035

Approach

The approach taken in this study was to consider the conjunctive or complementary use of both surface and ground water for the region-wide needs, and also to identify means by which the overdrafted ground water resource can be stabilized.

If the Commission determines that sufficient benefits are identified by these analyses, it will select one of the alternative objectives to be refined by an environmental assessment and preliminary engineering toward the end of funding improvements that will be required to best use the water resources of the region.

Data Collection

The data collection for the study consisted of compiling readily available information to develop a base map, to prepare a water budget, and to locate and size two regional water treatment plants and their associated conveyance and distribution systems. The study relied upon existing information, and no new data were developed. Existing data were obtained from a large variety of sources and compiled and evaluated for use in the study. Due to the large study area, and the many entities within the study area, there were many cases where information was available in varying detail and quality. The purpose of this section is to report the information sources used to complete the study.

Base Map

Maps were developed as a part of the planning effort. The data used for the Rio Grande Project base maps included data from the U.S. Census Bureau, the EBID, and the U.S. Geological Survey (USGS).

The base data (roads, railroads, river, hydrology, and political boundaries) were acquired from the U.S. Census Bureau in the form of Tiger files. The Tiger files included all of Sierra County, Dona Ana County and El Paso County. It was decided that the quality of these data was adequate for planning purposes.

The irrigation district boundary within the Mesilla Valley was provided by the EBID. This information was required to determine acreage within the valley served by surface water.

In critical locations within the project area (valley constrictions, possible raw water conveyance routes and possible treatment facility and distribution line locations), topographic information was required. All available 1:24,000 topographic, public land survey, and boundary information was obtained from the USGS. The topography was constructed from three dimensional digital elevation models (DEMs) where available. The public land survey and boundary information was used to provide additional reference points and a common coordinate system.

Water Budget

A water budget was developed for nine selected years (three dry, three average, and three normal) to provide an assessment of the effects of alternatives on the hydrologic system. The years studied were 1951, 1967, and 1971; 1970, 1980, and 1984; and 1988, 1989, and 1993 for dry, average and normal years respectively. Data were collected for the Rincon Valley, the Mesilla Valley, and the El Paso Valley. The following is a listing of the sources for all readily available data used in the water budget:

Precipitation

Data for the Rincon and Mesilla Valleys were compiled from three stations (Caballo Dam, New Mexico State University and El Paso). The data were obtained from USBR Rio Grande Project historical records and USBR Annual Operating Plan reports.

Agricultural River Diversion

Data were available at each of the three diversion dams (Percha Dam - including Percha and Bonita Laterals, Leasburg Dam, and Mesilla Dam) in the USBR Rio Grande Project historical records and the USBR Annual Operating Plan reports.

Drain Flow

Data were available on a monthly basis from USBR drain flow gaging records.

M&I Ground Water Pumping

Data for the Mesilla Valley were taken from Frenzel and Kaehler (Reference 7) and from Hamilton and Maddock (Reference 9).

Lateral and Canal Seepage

Data for 1951 through 1971 were based on monthly USBR estimates of canal seepage and farm deliveries available in USBR project files. These estimates are also reported on an annual basis in New Mexico State Engineer Technical Report 43 (Reference 23).

Vertical Hydraulic Conductivity

Data for estimating deep percolation were available for the Mesilla Valley from the Wright Water Engineers groundwater study (Reference 12).

Irrigation Return Flow & Canal Waste Return Flow

Data for 1951 through 1971 were based on monthly USBR estimates of canal waste and return flow available in USBR project files. These estimates are also reported on an annual basis in New Mexico State Engineer Technical Report 43 (Reference 23).

River Flow

Data were available from the USGS, the USBR, and the International Boundary and Water Commission (IBWC) which maintain gaging stations at points along the river for both the Rincon Valley, the Mesilla Valley and El Paso Valley.

River Seepage

Data were available from New Mexico State Engineer Technical Report 43 (Reference 23), Wright Water Engineers (Reference 12), Hamilton and Maddock (Reference 9) and Frenzel and Kaehler (Reference 7).

Ground Water Boundary Flux

Estimates of the ground water boundary flux for the Mesilla Valley were available from the Frenzel and Kaehler (Reference 7) and Hamilton and Maddock (Reference 9).

River TDS

Data were obtained from the IBWC for both the Rincon Valley and the Mesilla Valley.

M&I Return Flow TDS

Data were taken from the New Mexico Water Resources Research Institute Report No. 064 (Reference 15).

Drain Inflow TDS

Data were available from the USBR and the IBWC for both the Rincon Valley and the Mesilla Valley.

Agricultural Ground Water Pumping

Estimates for the Mesilla Valley were available from groundwater modeling studies of the Mesilla Valley by Wright Water Engineers (Reference 12), Frenzel and Kaehler (Reference 7) and Hamilton and Maddock (Reference 9). Groundwater pumping estimates for the years of 1975 and 1980 for the Rincon Valley were available from New Mexico State Engineer Technical Reports 43 and 44 (References 23 and 19) respectively.

Water Demand

The data compiled to size the two proposed regional water treatment plants included population projections, per capita daily uses, and projected peaking factors. The population data for New Mexico were obtained from the Dona Ana County Planning Department and the City of Las Cruces. These data included the 1990 Census figures for Dona Ana County. Population figures for the Texas area served by the regional water treatment plants were calculated based on estimated water requirements from Boyle Engineering Corporation for that area for the year 2015.

Conveyance, Treatment and Distribution

Data compiled for the three alternative conveyance and distribution systems included existing canal capacities, alignments, and lengths and topographic mapping. Maps and reports describing existing water systems in the study area were obtained to determine pressure zones, and locations and capacities of treated water storage reservoirs and main transmission lines. Existing water treatment plant design information was also obtained from the City of El Paso's Jonathan Rogers Water Treatment Plant report.

Alternative Objectives

The alternative conveyance systems named and briefly discussed in the introduction to this report are not conceived to meet a single common objective. Different portions of the total Rio Grande Project supply are conveyed to different end users in each of the three alternatives considered. In addition, Alternative 2a considers a dual system which allows controlled blending of the protected contents of the Alternative 2 canal with return flow and runoff in a separate canal system. For this reason, the alternatives investigated are "alternative objectives" rather than alternative means of meeting a common objective. This study is, therefore, not a conventional engineering feasibility study. It is a reconnaissance level study to assist the Commission in selecting a suitable common objective.

Alternative Objective 1

The objective of this alternative is to supply water on a year-round basis to the Texas entities of the EPCWID#1 and EPWU, to the Republic of Mexico, and possibly for relatively small M&I uses in Southern Dona Ana County, independent of other New Mexico entities. The necessity to provide some New Mexico water in this alternative is required only if the Anthony Regional Water Treatment Plant, discussed later, supplies southern Dona Ana County.

The Texas/Mexico allotment of the annual Rio Grande Project surface water allocation, and a small portion of the EBID allotment as required by Southern Dona Ana County for M&I uses, would be diverted at the Percha Diversion Dam on the Rio Grande, conveyed in a lined canal and delivered in part to a proposed water treatment plant in the Anthony area, and the rest to the American Canal headworks at the American Dam on the Rio Grande in El Paso. The portion of the flow allocated to Mexico may be released to the Rio Grande at the American Dam, or alternatively, be diverted for treatment at the Anthony water treatment facility and delivery to a point on the international boundary near Anapra, NM. This would provide for Mexico's allocation of project water to be converted to M&I purposes for Ciudad Juarez, as determined by authorities in Mexico.

The water would be conveyed in a lined canal that would provide for a diversion at the Anthony water treatment plant and prevent all other inflow/outflow between the termini. The terminus at the American Dam would allow for the American Canal, and its extension to Riverside Canal, to be used as the conveyance system below American Dam.

Alternative Objective 2

The objective of this alternative is to provide Rio Grande Project system-wide improvements to meet the needs of all regional water agencies. This alternative is conceived to upgrade the Rio Grande Project facilities to serve a modern mission of preserving and protecting the ground water resources of the region by the improved uses and year-round delivery of the renewable and sustainable surface water resource.

The concept of this alternative is to construct a lined canal along existing main canals from the Percha Diversion Dam on the Rio Grande to a terminus at the American Dam on the Rio Grande in El Paso. The full annual allocation of the Rio Grande Project would be diverted to this conveyance less a constant instream release determined to be sufficient for riparian purposes. The conveyance canal would utilize existing alignments and rights-of-way to the greatest extent practical. A new segment of canal will be required to connect the Rincon Valley and the Mesilla Valley through Selden Canyon on the Rio Grande.

The objective is to maintain all existing agricultural water interests of the region through more efficient distribution systems. From the water savings derived from modern facilities, surface water can become available for application to M&I needs. The municipalities presently are overdrafting the ground water aquifers in the United States and the Republic of Mexico. The City of El Paso and Ciudad Juarez will exhaust the Hueco Basin (aquifer) by around the year 2023 if present trends continue (see Figure 1). Both cities are heavily dependent upon the Hueco source for their supplies. The city of Las Cruces has created a major cone of depression in the Mesilla Basin. Inasmuch as there is hydraulic connectivity between the area aquifers and the Rio Grande, the water table of the underlying aquifers will impact the surface water flow rate as shown in the water budget analyses.

Alternative Objective 2a

The objective of Alternative 2a is identical with Alternative 2, with the addition of optional facilities to reuse and blend instream flows in the Rio Grande with the diversions to agricultural irrigation. As described above for Alternative 2, the conveyed surface water in the main canal is protected from inflow of storm runoff, drain discharges, spills (wasteway releases), and return flows. Alternative 2a provides for facilities to divert these instream flows at Leasburg Diversion Dam and Mesilla Diversion Dam into lateral feeders for purposes of reuse for agricultural irrigation. At those points of diversion, surface water from the main canal can be blended with the reuse diversion in a blended water canal to attain quality and quantity of flow desirable by the user.

These facilities will involve parallel conveyance laterals which cannot backflow into the spine conveyance channel. Substantial additional cost is

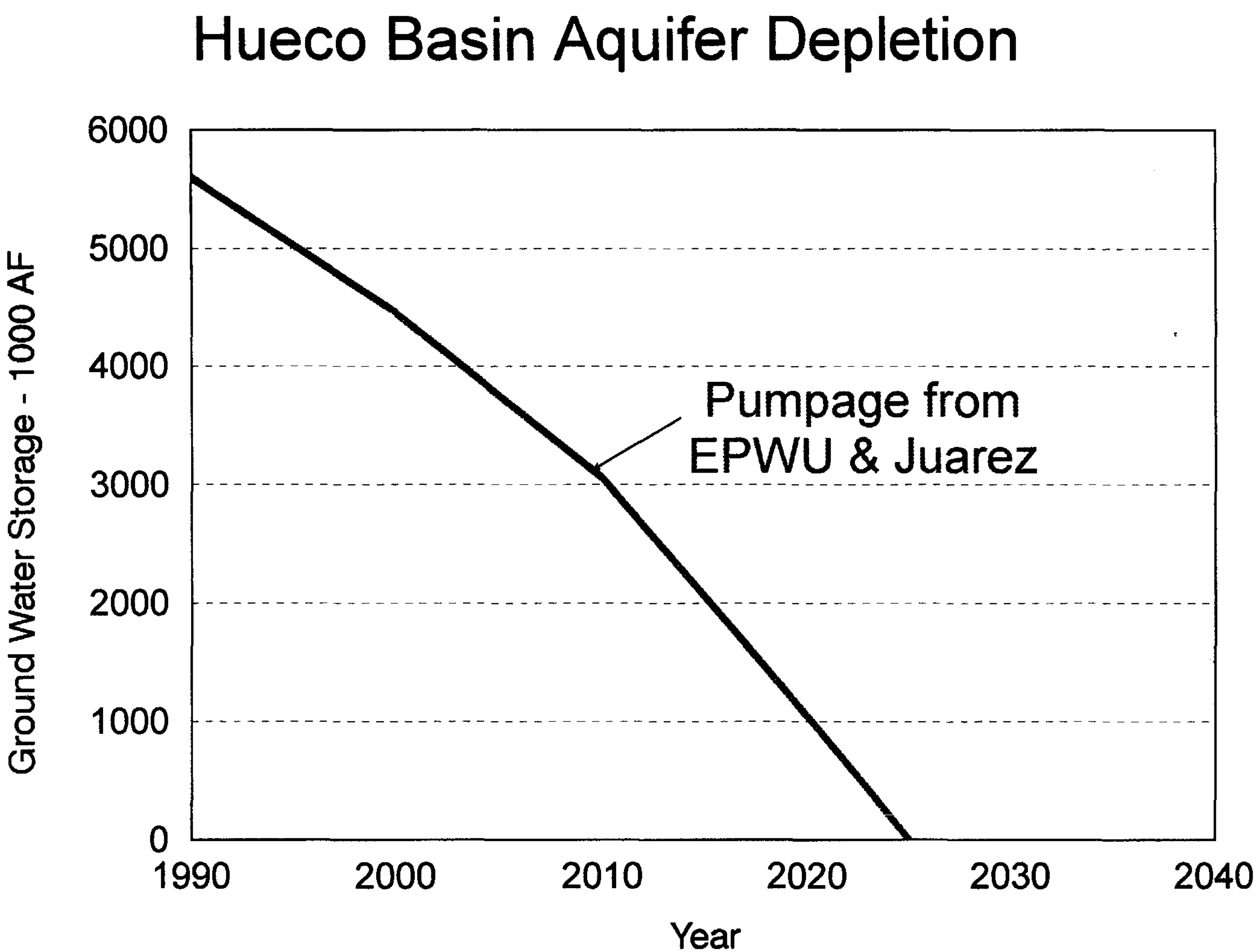

Hueco Basin Aquifer Depletion
Ground Water Storage - 1000 AF
6000
5000
4000
3000
2000
1000
0
1990
2000
2010
2020
2030
2040
Year
Pumpage from
EPWU & Juarez

Figure 1

involved as shown on the cost analyses below. In addition, as illustrated by the results of the water budget discussed later in the report, available supplies for blending may at times be poorer in quality than the protected canal flow. However, the costs and quality impacts should be evaluated against the benefit of the additional total surface water which will be available for agricultural uses.

Alternative Objective 3

The objective of this alternative is to convey surface water from the outlet works of Caballo Dam, through a closed conduit (pipe), to the City of El Paso. The facility would provide capacity to convey the full annual allocation of Mexican Rio Grande Project water on a uniform year-round basis, and the portion of the EPCWID#1 allocation attributable to EPWU on a basis of daily demand by EPWU.

This alternative will convey raw water from Caballo Reservoir directly to water treatment facilities owned and operated by EPWU for treatment and distribution to El Paso County customers, and for treatment and delivery to Ciudad Juarez on a wholesale basis.

Physical Attributes of Conceptual Alternatives

Alternative 1.

Conveyance:
Open-channel with trapezoidal cross-section, concrete lined.
(See Figure 2)

Length and termini:
Point of beginning: Percha Diversion Dam.
Point of termination: American Diversion Dam.
Length of main channel: 103.7 statute miles.

Route: (See Figure 3) in pocket
Parallel to, and adjacent to the Rio Grande.

Ancillary structures: (See Figures 4, 5, 6)
Three river crossings (inverted siphons).
Flumes and siphons at stream and arroyo crossings.
Wasteway structures.
Check dams and drop structures as determined by hydraulics.

Diversions (turnouts See Figures 7, 8):
Only one intermediate diversion point to supply Anthony WTP.

Schematic Flow Diagrams for Alternative 1 for years 2005, 2015, and 2035 are presented in Figures 9, 10, and 11 respectively.

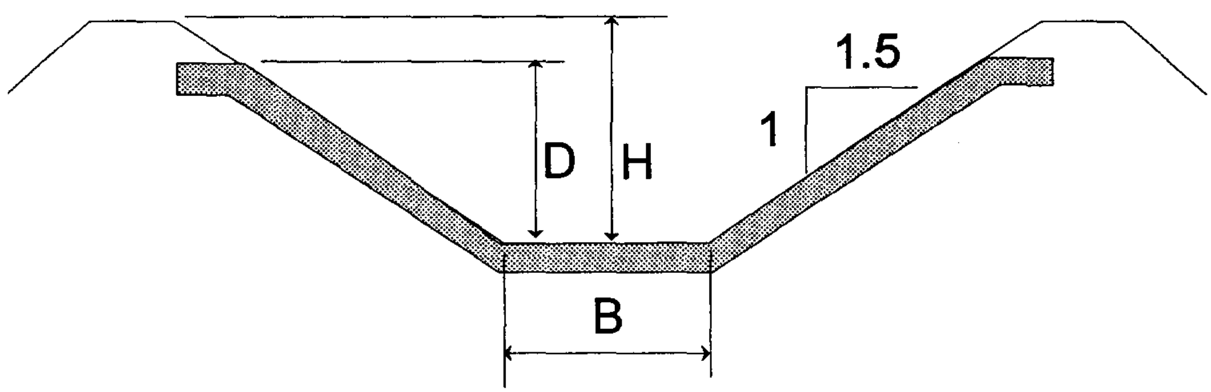
Alternative No. 2.

Conveyance:
An open-channel with trapezoidal cross-section, concrete lined. (See Figure 12)

Length and termini:
Point of beginning: Percha Diversion Dam.
Point of termination: American Diversion Dam.
Length of main channel: 102.4 statute miles.

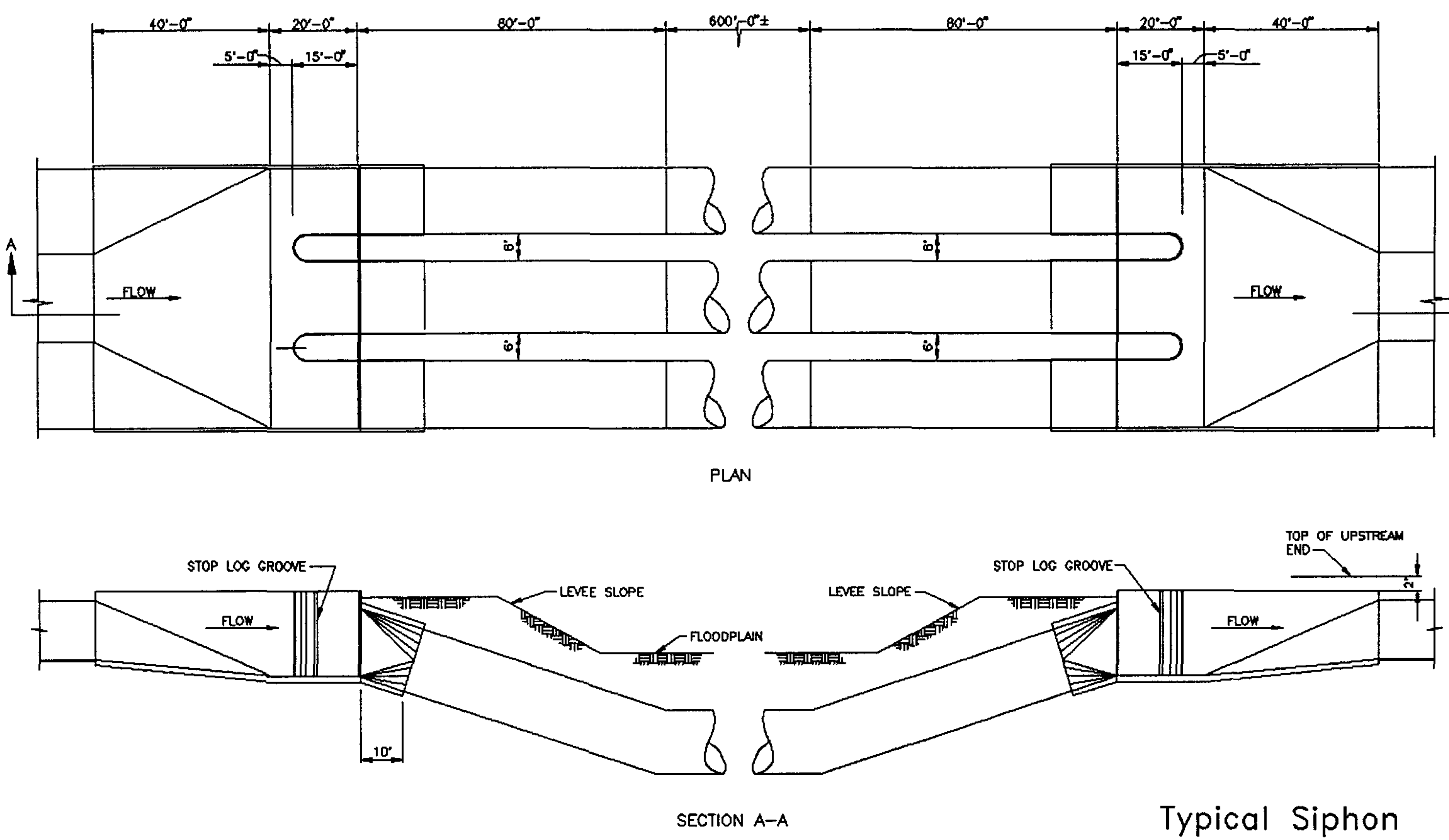
Route: (See Figure 3) in pocket

Canal Cross Section for Alternative 1

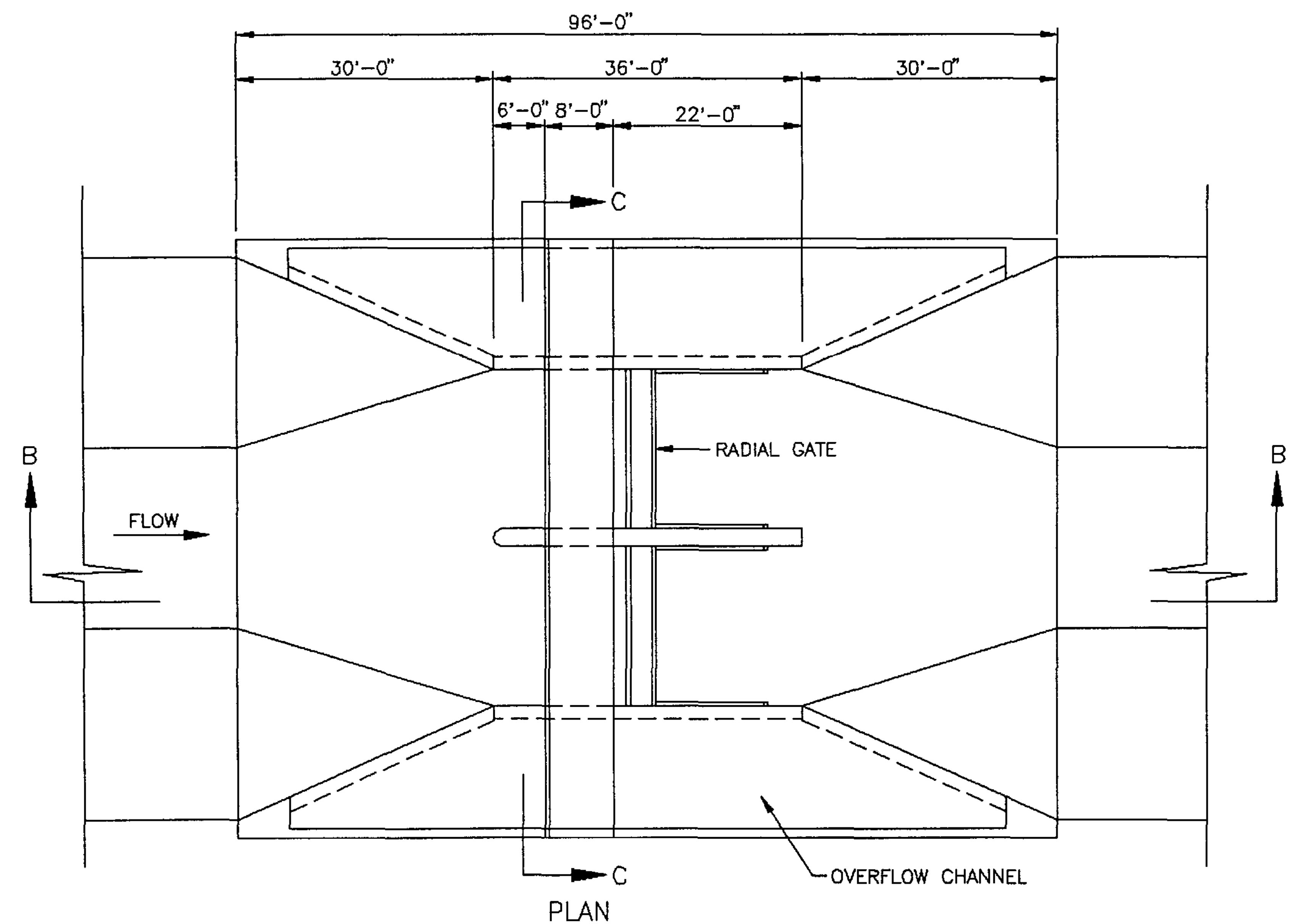


Reach	Length, miles	B, feet	D, feet	H, feet
Percha Dam to Anthony WTP	88.0	12.0	9.0	11.0
Anthony WTP to Closed Conduit	13.7	12.0	9.0	11.0
Closed Conduit to American Dam	2.0	2-10 ft x 10 ft Barrels		

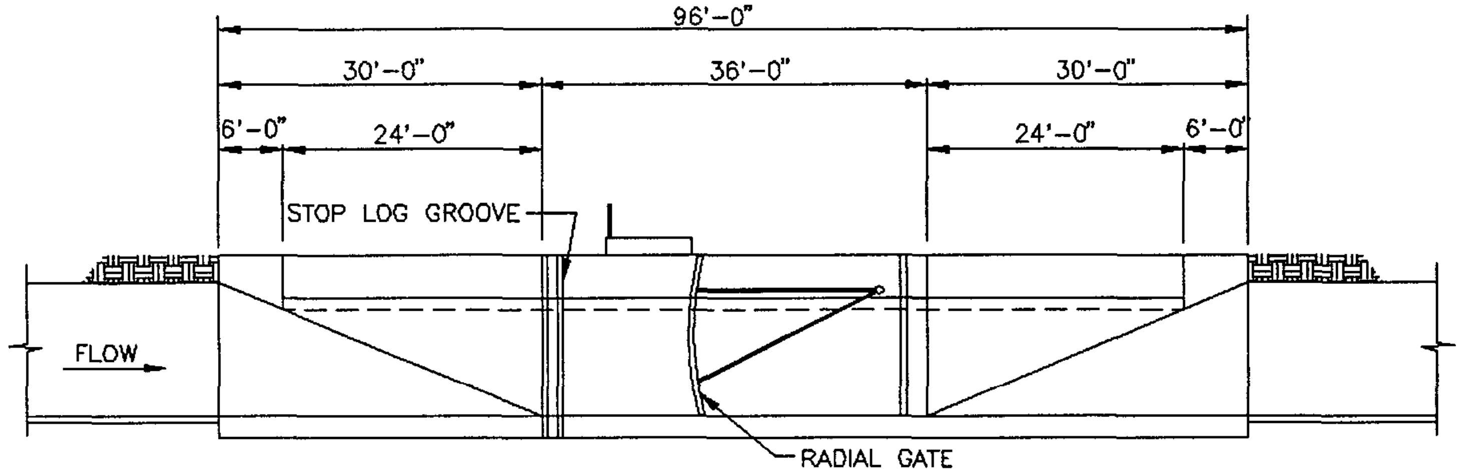
Figure 2



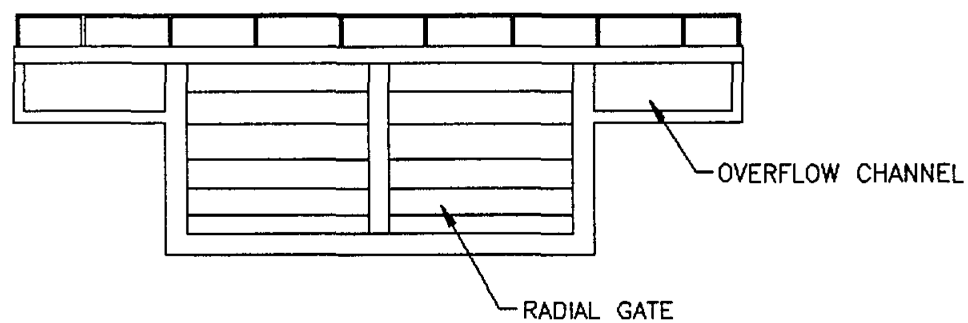
Typical Siphon
River Crossing
Figure 4



Typical Check Structure
Figure 5

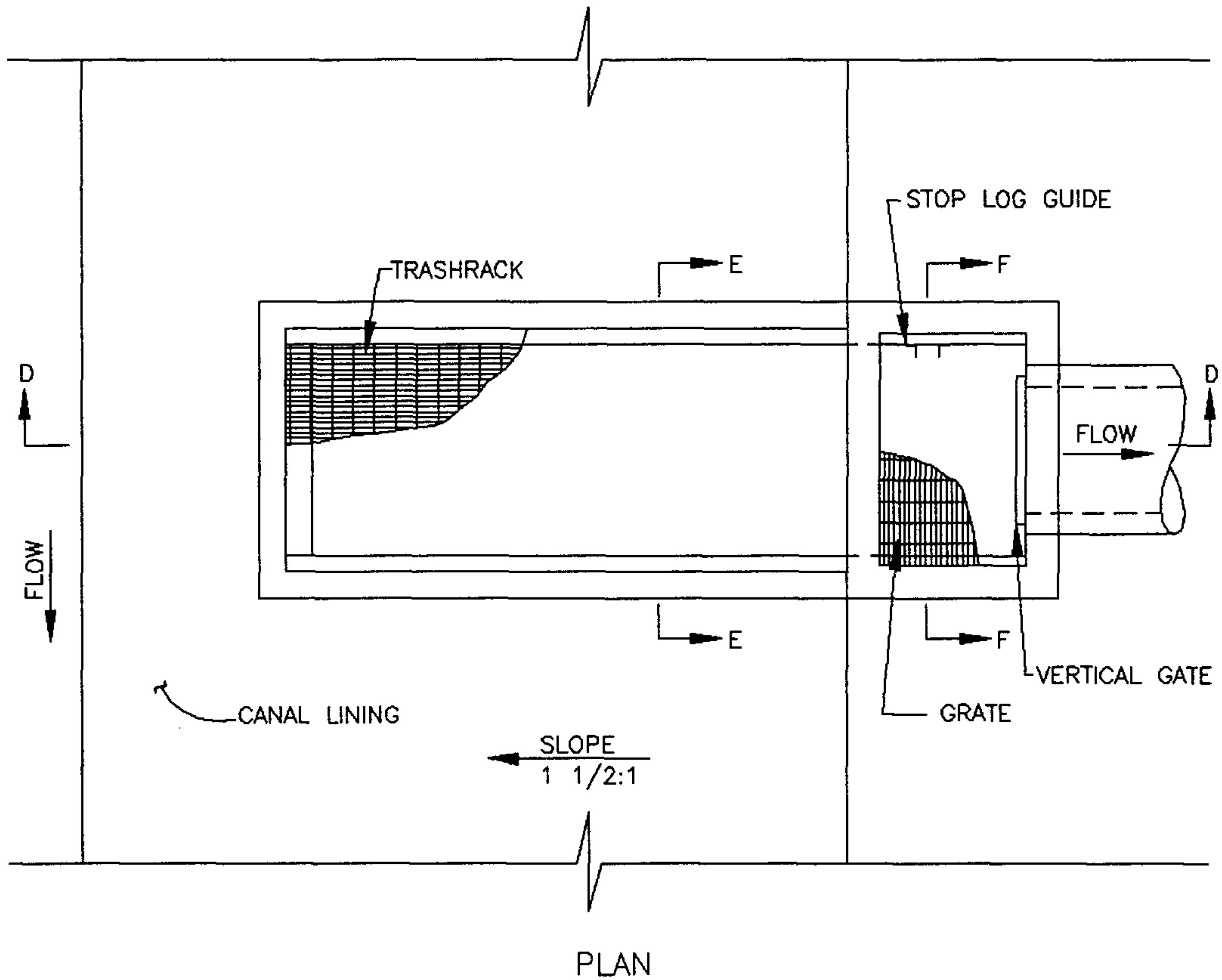


SECTION B–B

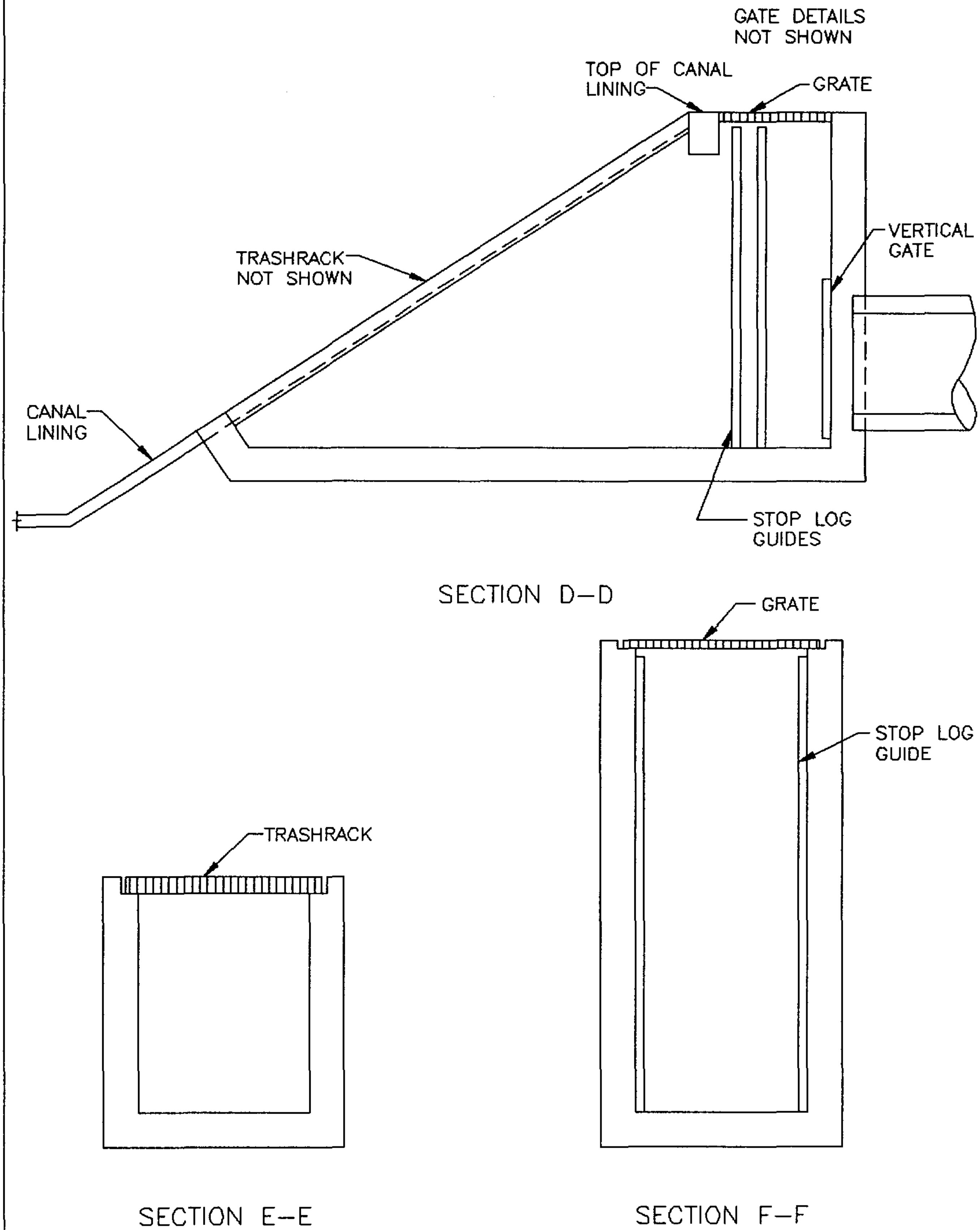


SECTION C–C

Typical Check Structure Sections
Figure 6



Typical Turnout
Figure 7



Typical Turnout Sections
Figure 8

Alternative 1
Texas/Mexico Canal
Year 2005

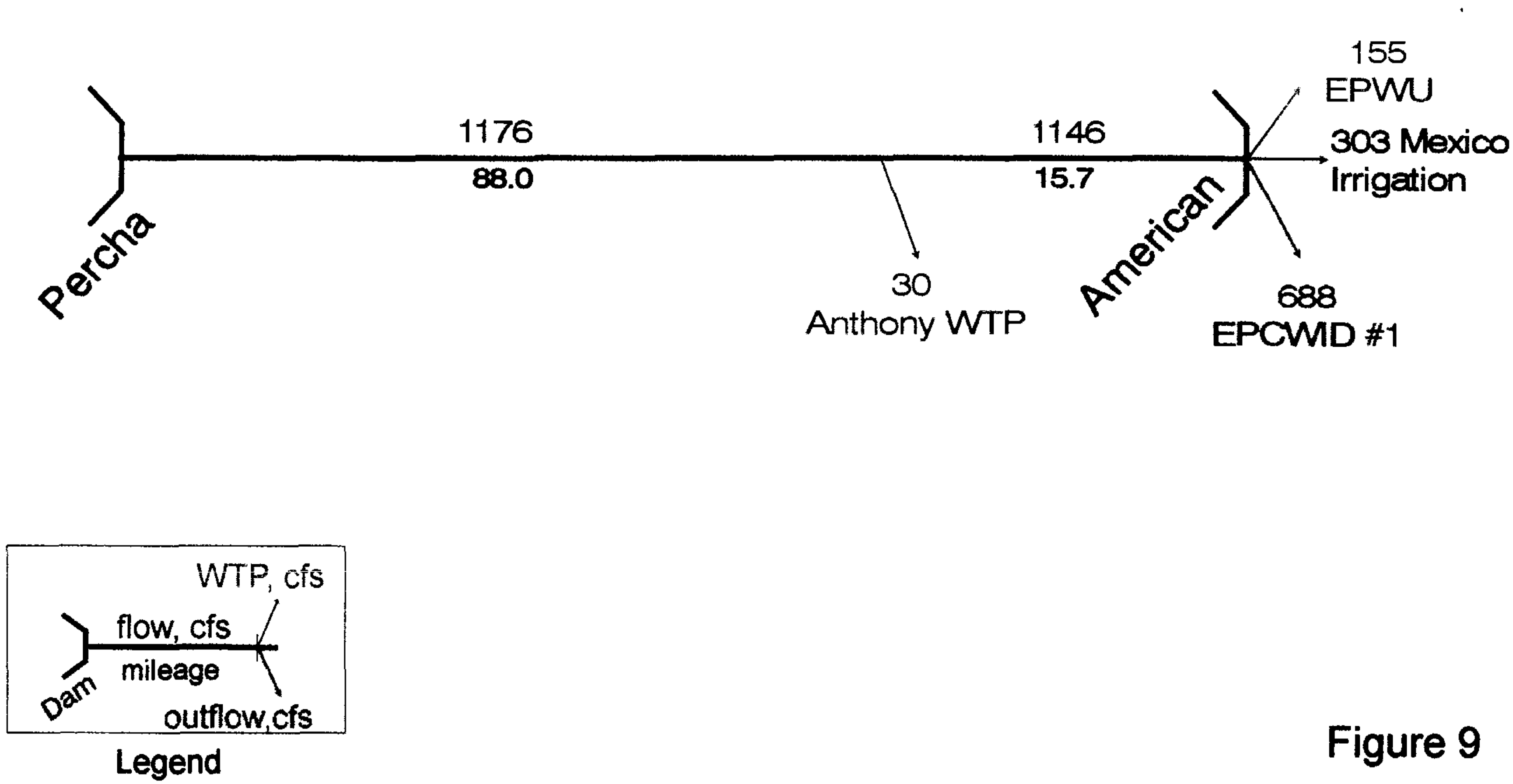
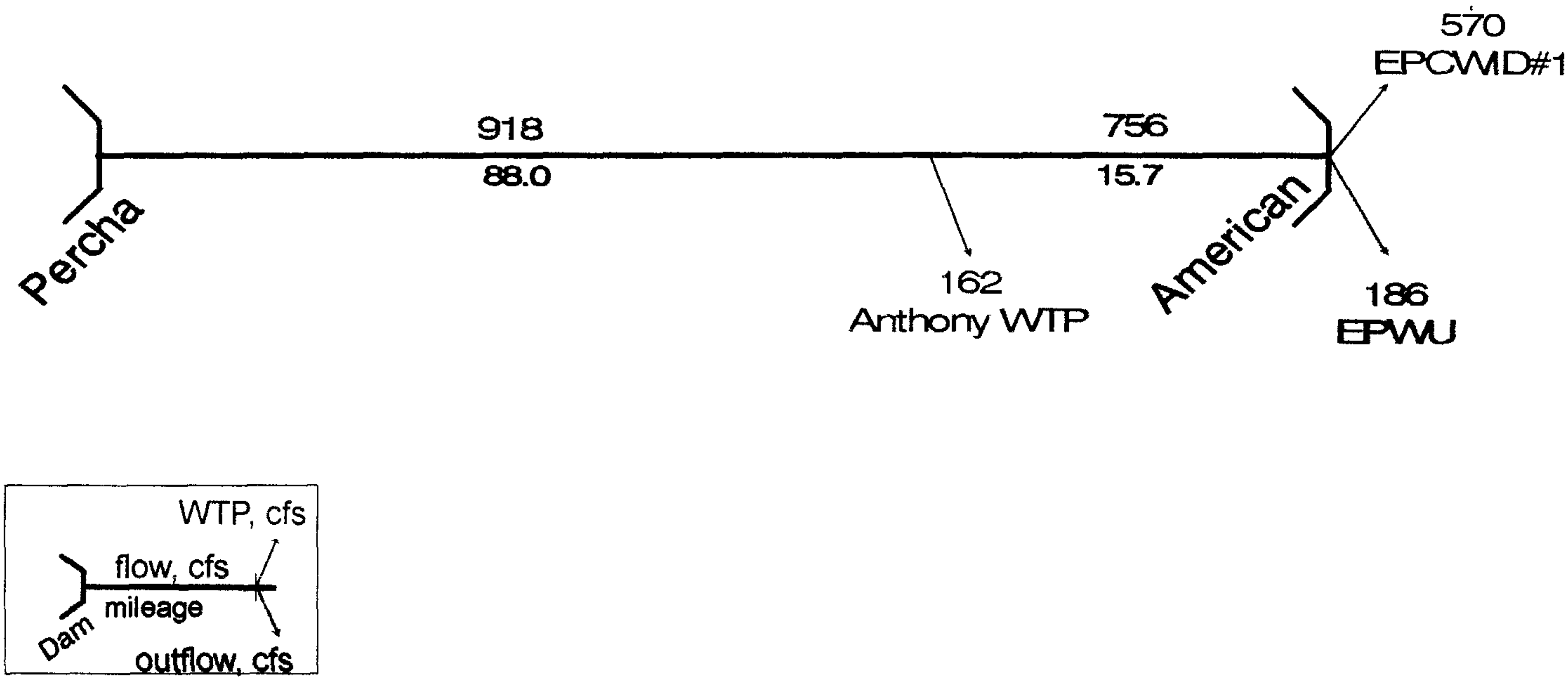


Figure 9

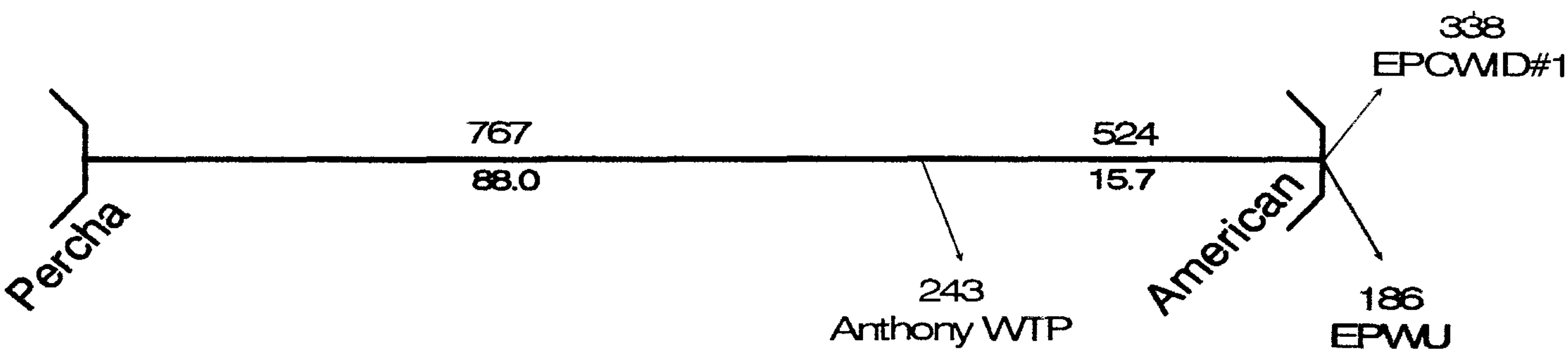
Alternative 1
Texas/Mexico Canal
Year 2015

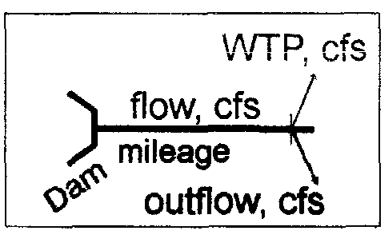


Legend

Figure 10

Alternative 1
Texas/Mexico Canal
Year 2035

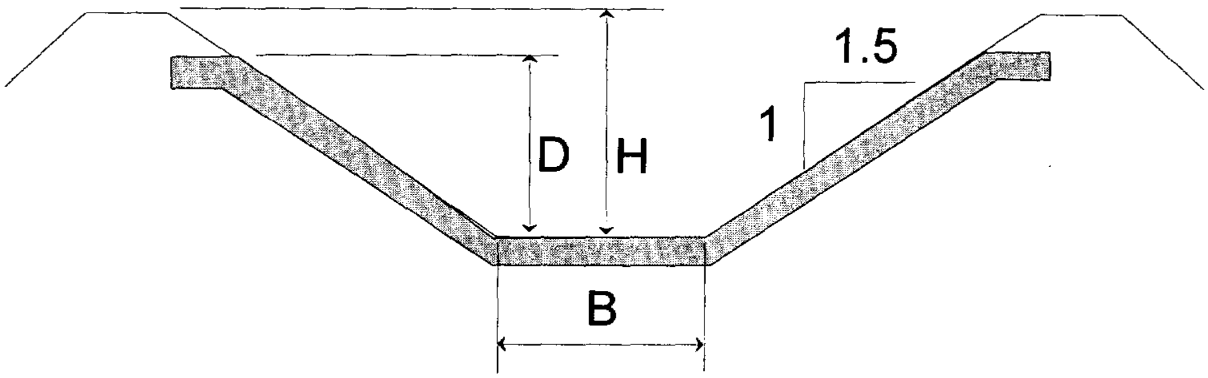




Legend

Figure 11

Canal Cross Section for Alternative 2



Reach	Length, miles	B, feet	D, feet	H, feet
Arrey Canal	4.75	20.0	12.5	14.5
Garfield Canal	9.33	20.0	12.5	14.5
Hatch Canal	8.33	20.0	12.5	14.5
Selden Canyon	20.08	18.0	12.5	14.5
Leasburg Canal	13.03	16.0	12.5	14.5
Mesilla Lateral	9.09	14.0	12.0	14.0
West Side Canal	13.79	12.0	11.0	13.0
La Union Main	4.28	12.0	10.5	12.5
La Union East	10.6	10.0	10.0	12.0
New	7.33	10.0	9.5	11.5
Closed Conduit	1.80	2-10 ft x 10 ft Barrels		

Figure 12

The main channel will consist of reconstruction of the existing canal (Arrey, Garfield, Hatch, Angostura, Leasburg, and West Side). Through the Selden Canyon of the Rio Grande there will be a new alignment required for a distance of approximately 23 miles.

Ancillary structures: (See Figures 4, 5, 6)
- River crossings, new and rehabilitated.
- Flumes and siphons for arroyo crossings
- Check dams
- Drop structures.
- Metering facilities.

Diversions (turnouts Figure 7, 8):

All existing points of diversion and turnouts will be maintained and serviced from the improved canal. There will be two additional points of diversion in the reaches between the termini to provide raw surface water to each of two new water treatment plants (Las Cruces and Anthony).

Schematic Flow Diagrams for Alternative 2 for years 2005, 2015, and 2035 are presented in Figures 13,14, and 15 respectively.

Alternative 2a

The physical features of Alternative 2a are identical with Alternative 2 with the addition of the blending facilities at Leasburg and Mesilla Diversion Dams, and the extension of the blended water parallel laterals. A schematic of the features is shown in Figure 16. Schematic Flow Diagrams for Alternative 2a for years 2005, 2015, and 2035 are presented in Figures 17, 18, and 19 respectively.

Alternative 3

Conveyance:

A closed conduit will be conceived to be a 120 inch diameter circular pipe connected to the outlet works of Caballo Dam. The inlet pressure will be that provided by the Caballo Reservoir surface elevation. No booster pumping will be required. The pipe will be designed to withstand static hydraulic pressure when shut-off at the lowest terminus. Pressure-reducing stations and maintenance valves will be used.

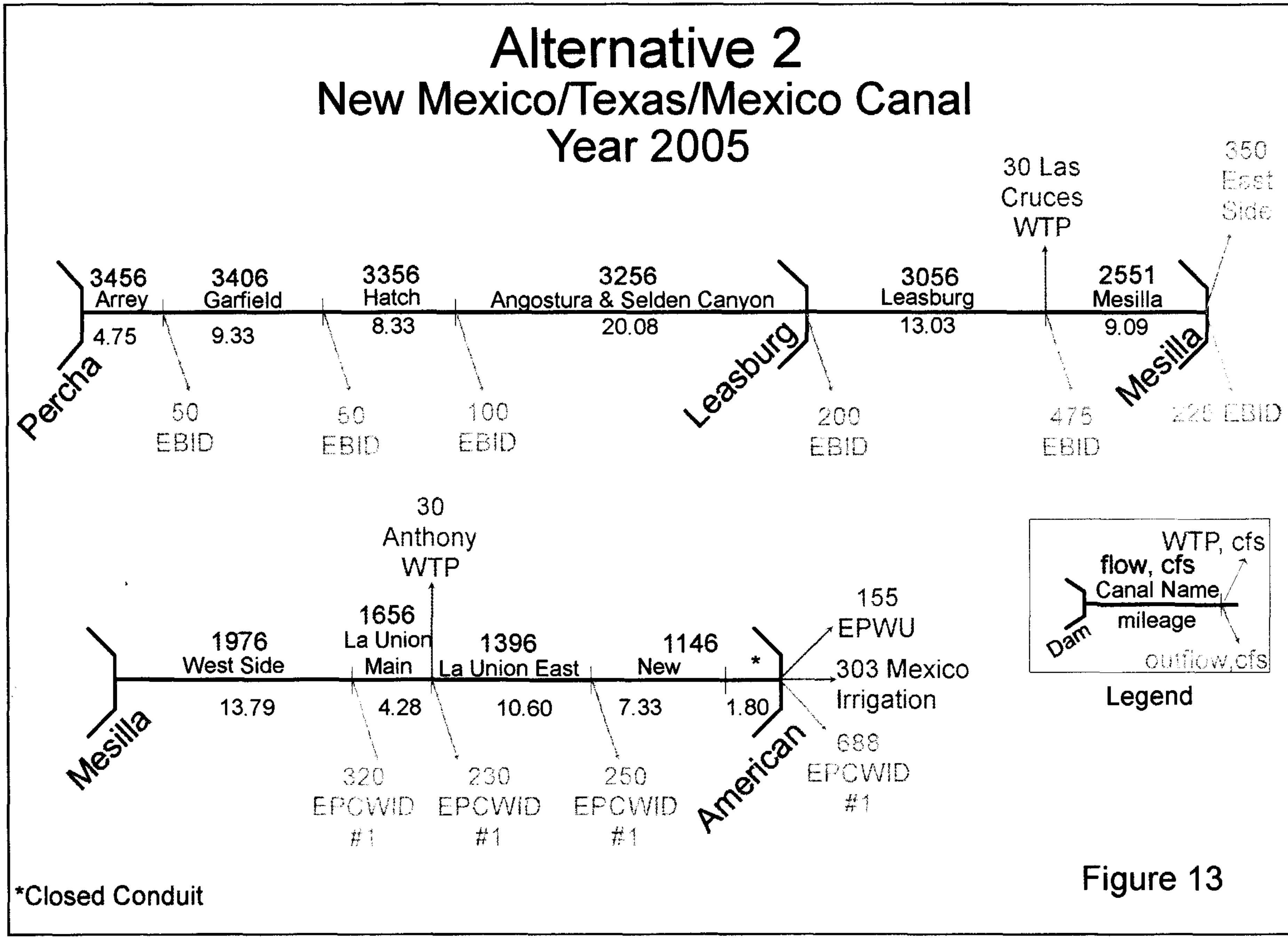
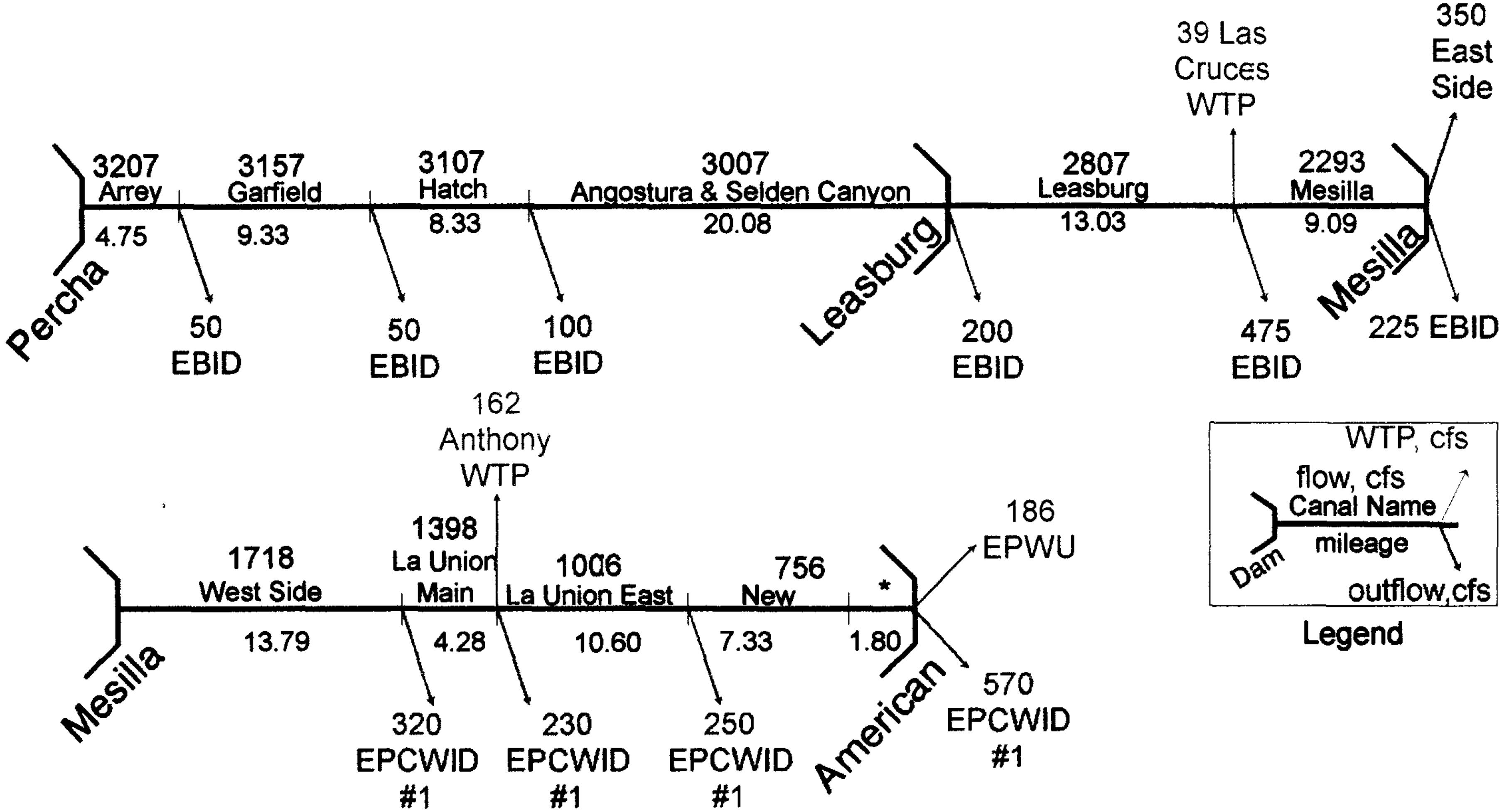

Alternative 2
New Mexico/Texas/Mexico Canal
Year 2005
Percha
3456
Arrey
4.75
50 EBID
3406
Garfield
9.33
50 EBID
3356
Hatch
8.33
100 EBID
3256
Angostura & Selden Canyon
20.08
Leasburg
200 EBID
3056
Leasburg
13.03
30 Las Cruces WTP
475 EBID
2551
Mesilla
9.09
350 East Side
225 EBID
Mesilla
1976
West Side
13.79
320 EPCWID #1
1656
La Union Main
4.28
30 Anthony WTP
230 EPCWID #1
1396
La Union East
10.60
250 EPCWID #1
1146
New
7.33
*
1.80
American
155 EPWU
303 Mexico Irrigation
688 EPCWID #1
WTP, cfs
flow, cfs
Canal Name
mileage
Dam
outflow,cfs
Legend
*Closed Conduit

Figure 13

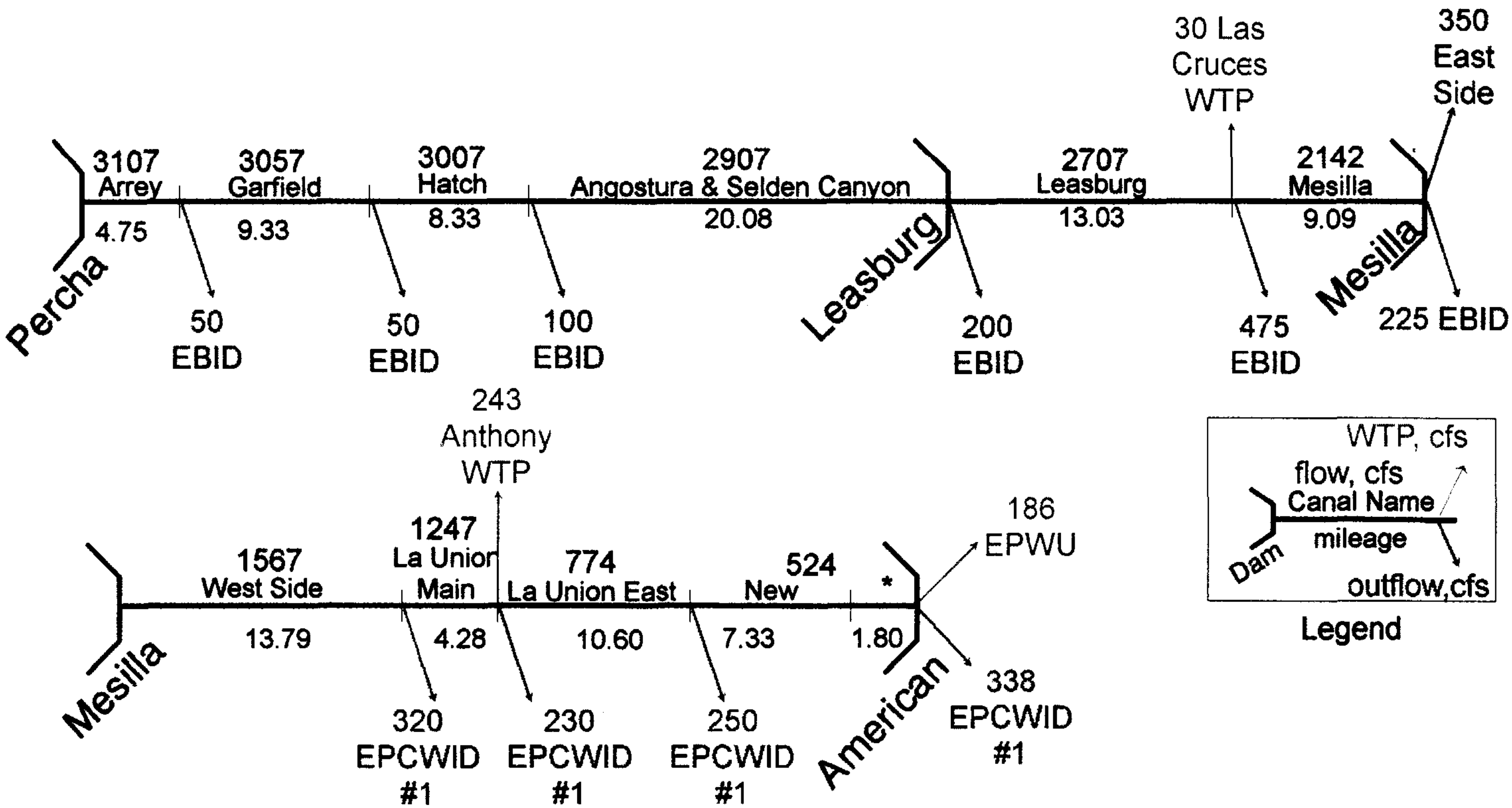
Alternative 2
New Mexico/Texas/Mexico Canal
Year 2015



*Closed Conduit

Figure 14

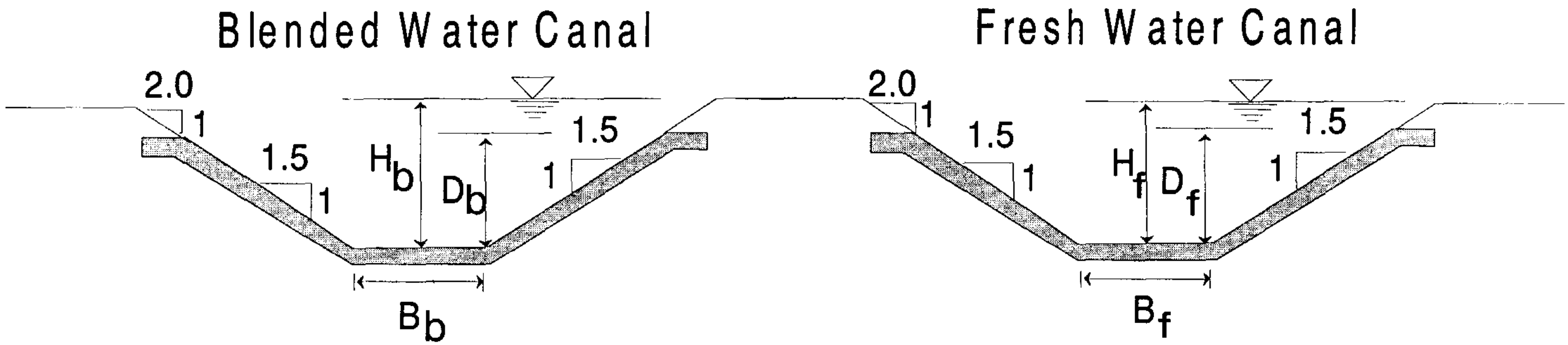
Alternative 2
New Mexico/Texas/Mexico Canal
Year 2035



*Closed Conduit

Figure 15

Dual Canal Section
Alternative 2a



Blended Water Canal

Reach	Length, mi	B, feet	D, feet	H, feet
to Las Cruces	13.7	8.0	7.5	9.5
to Mesilla Dam	11.9	6.0	5.0	6.5
West Side Canal - 1	14.4	8.0	8.0	10.0
West Side Canal - 2	3.6	7.0	6.5	8.0
West Side Canal - 3	11.0	6.0	5.0	6.5
West Side Canal - 4	5.0	4.0	3.5	5.0

Fresh Water Canal

Reach	Length, mi	B, feet	D, feet	H, feet
Percha Dam				
to Selden Canyon	22.4	16.0	12.5	14.5
to Leasburg Dam	20.1	15.0	12.5	14.5
to Las Cruces WTP	13.7	14.0	11.0	13.0
to Mesilla Dam	11.9	14.0	11.0	13.0
to Anthony WTP	18.0	10.0	9.0	11.0
to American Dam	18.0	10.0	9.0	11.0

Figure 16

Alternative 2a - Blending Option

Year 2005

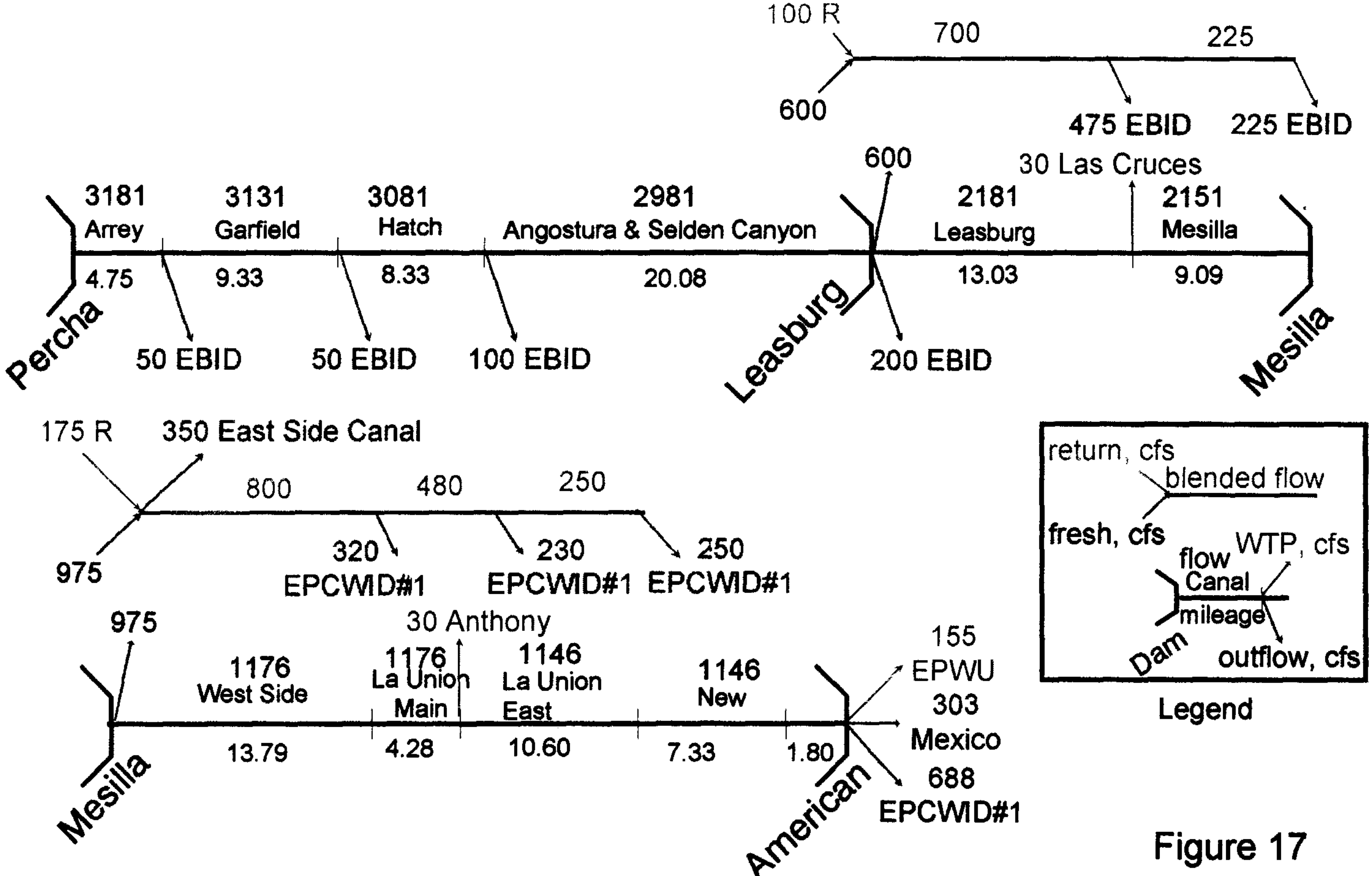


Figure 17

Alternative 2a - Blending Option

Year 2015

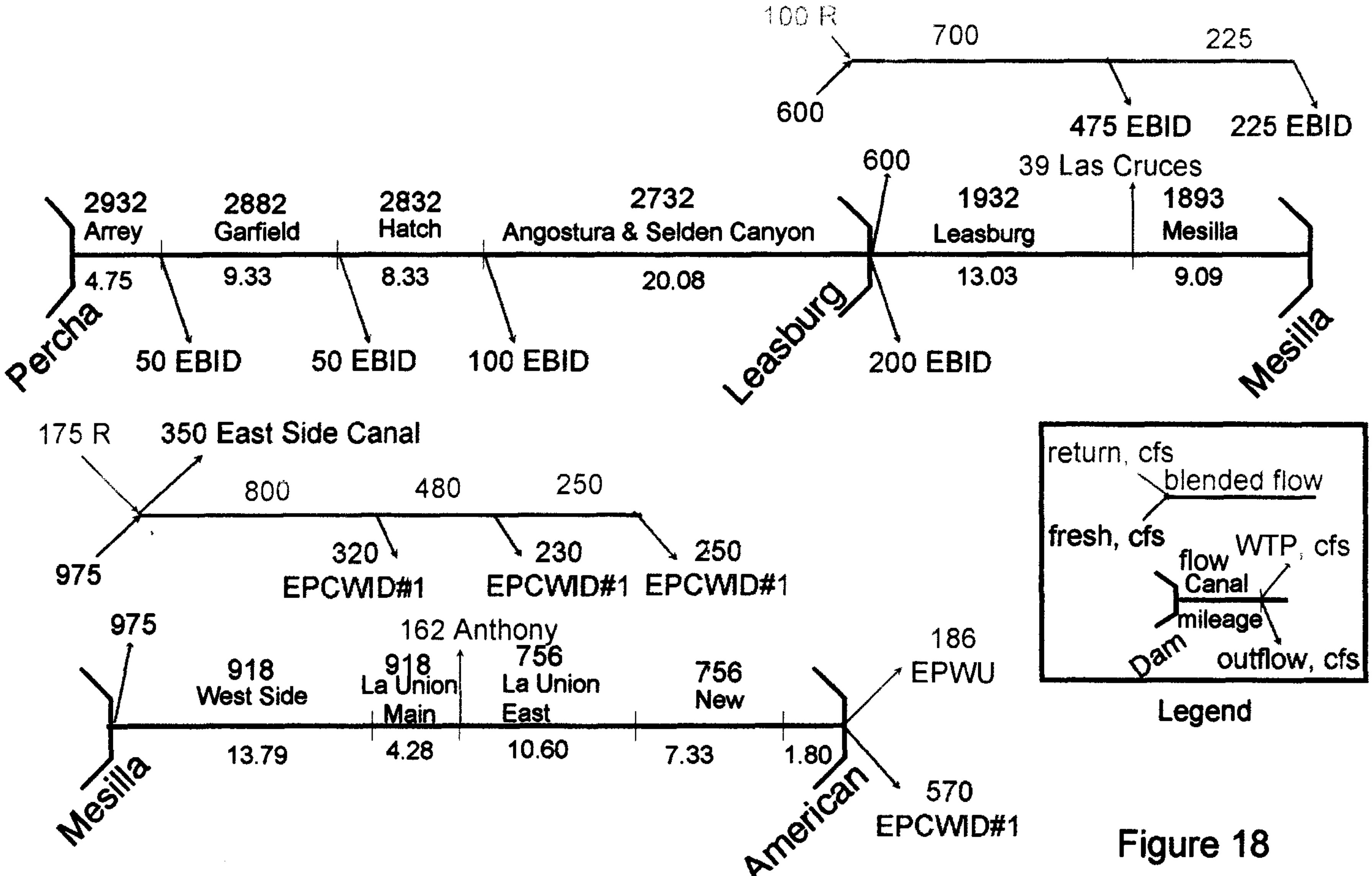
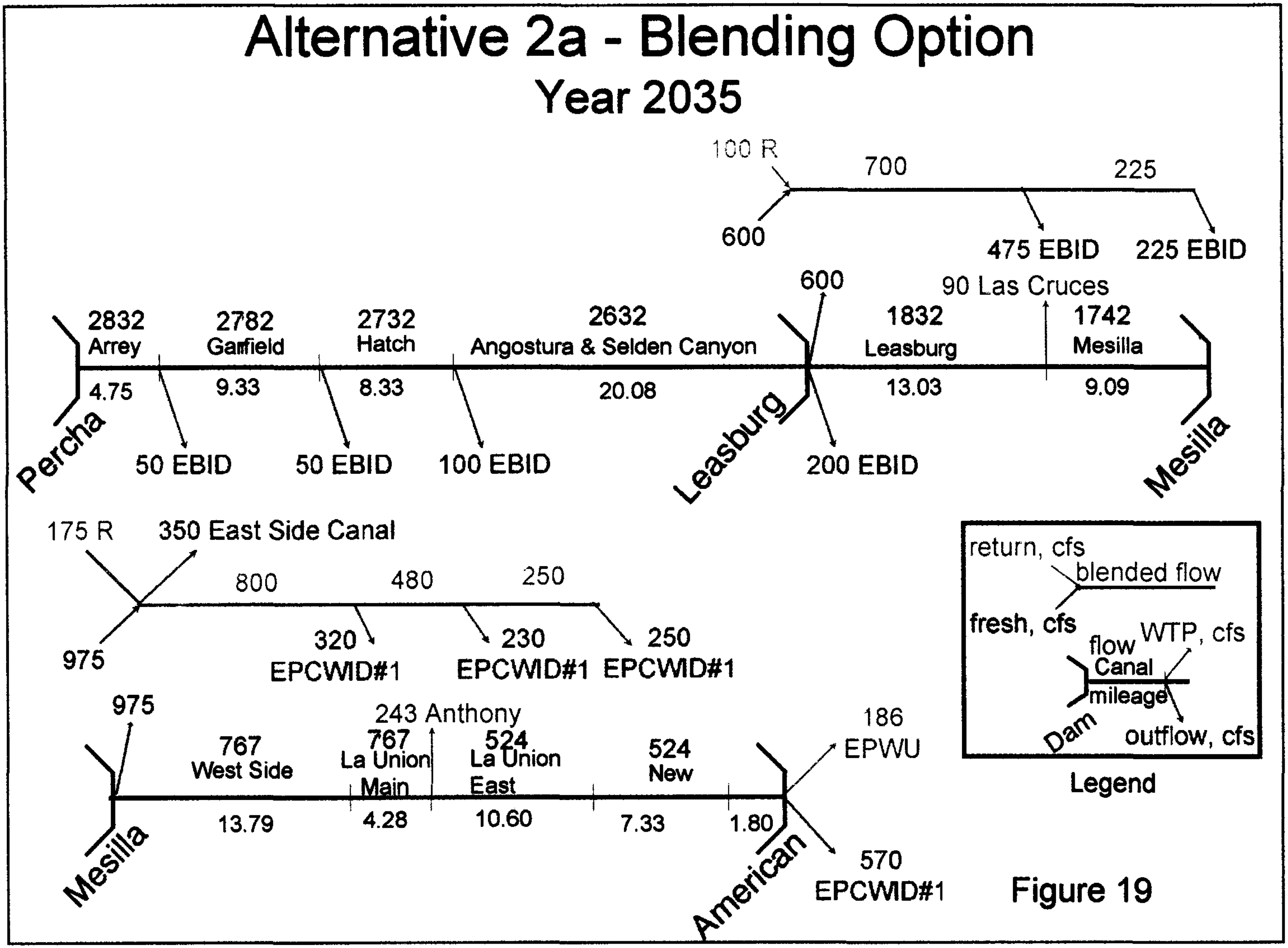


Figure 18



Alternative 2a - Blending Option
Year 2035
100 R
700
225
600
475 EBID
225 EBID
600
90 Las Cruces
2832
Arrey
2782
Garfield
2732
Hatch
2632
Angostura & Selden Canyon
1832
Leasburg
1742
Mesilla
4.75
9.33
8.33
20.08
13.03
9.09
Percha
50 EBID
50 EBID
100 EBID
Leasburg
200 EBID
Mesilla
175 R
350 East Side Canal
800
480
250
975
320
EPCWID#1
230
EPCWID#1
250
EPCWID#1
975
243 Anthony
767
West Side
767
La Union
Main
524
La Union
East
524
New
186
EPWU
13.79
4.28
10.60
7.33
1.80
Mesilla
American
570
EPCWID#1
return, cfs
blended flow
fresh, cfs
flow
WTP, cfs
Canal
mileage
Dam
outflow, cfs
Legend

Figure 19

Length and Termini:

- Point of beginning: Caballo Dam Outlet Works.
- Point of termination: Jonathan Rogers Water Treatment Plant.

Length of Conduit: 113.0 Statute miles.

Route: (See Figure 3) in pocket

The alignment of the pipeline will follow public rights-of-way where possible, paralleling US 85 highway where hydraulically feasible.

Ancillary Structures:

- Air and vacuum relief stations as dictated by profile requirements.
- Metering Station.
- Maintenance valve stations.

Diversions (turnouts):

- Wasteways to the river.
- Feed line to Anthony WTP.
- Feed line to Robertson-Umbenhauer WTP.
- Feed line to Jonathan W. Rogers WTP.

Schematic Flow Diagrams for Alternative 3 for years 2005, 2015, and 2035 are presented in Figures 20, 21, and 22 respectively.

Capital Cost Estimates

Estimates of capital costs for Alternatives 1, 2, 2a, and 3 are presented in Tables 1, 2, 3, and 4 respectively. Estimates have been based on the Cost Basis Memorandum (see Appendix B) for items included in the Memorandum, with some modifications where these appeared reasonable. Detailed quantity and characteristic breakdowns for canal construction for Alternatives 1, 2, and 2a, and for pipe construction for Alternative 3 are presented in Appendix C.

Alternative 3
Texas/Mexico Pipeline
Year 2005

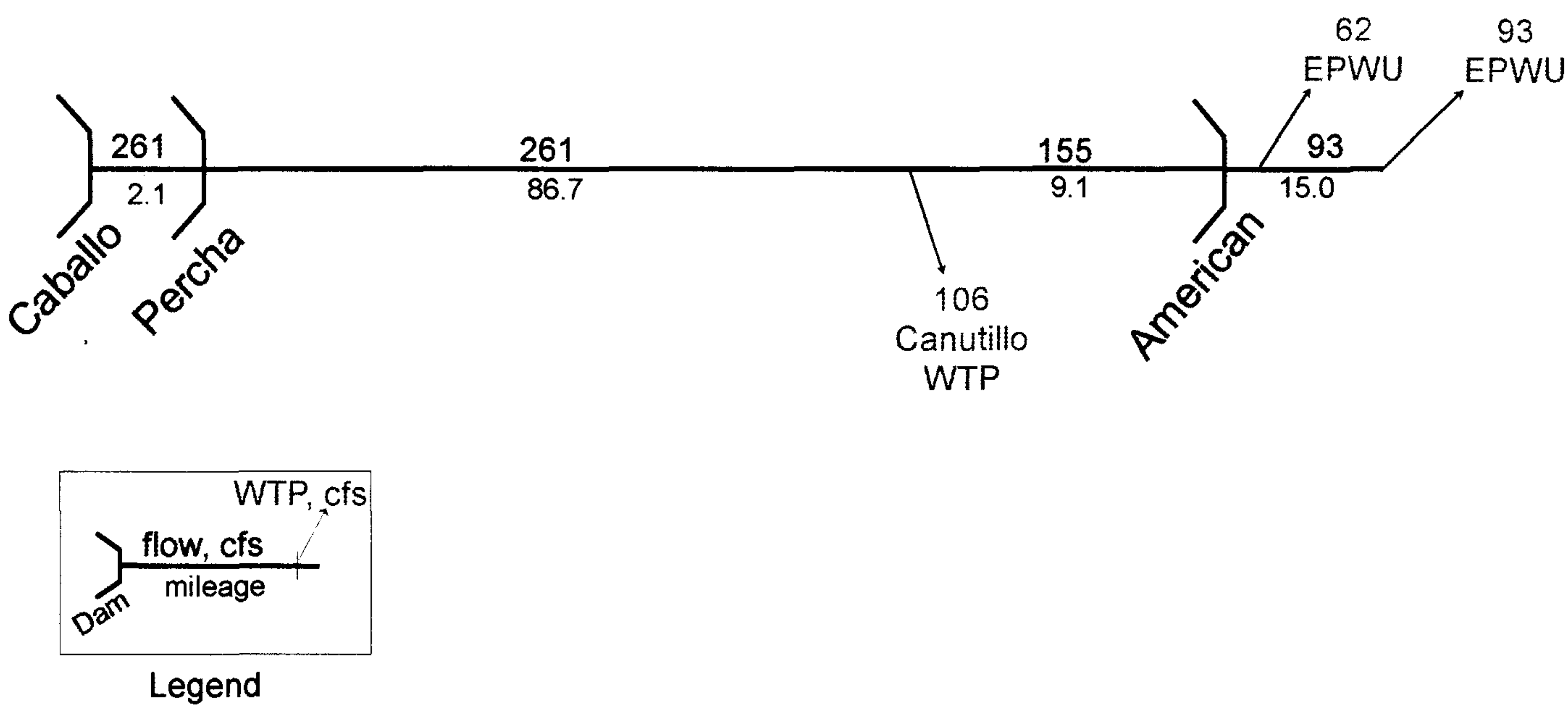


Figure 20

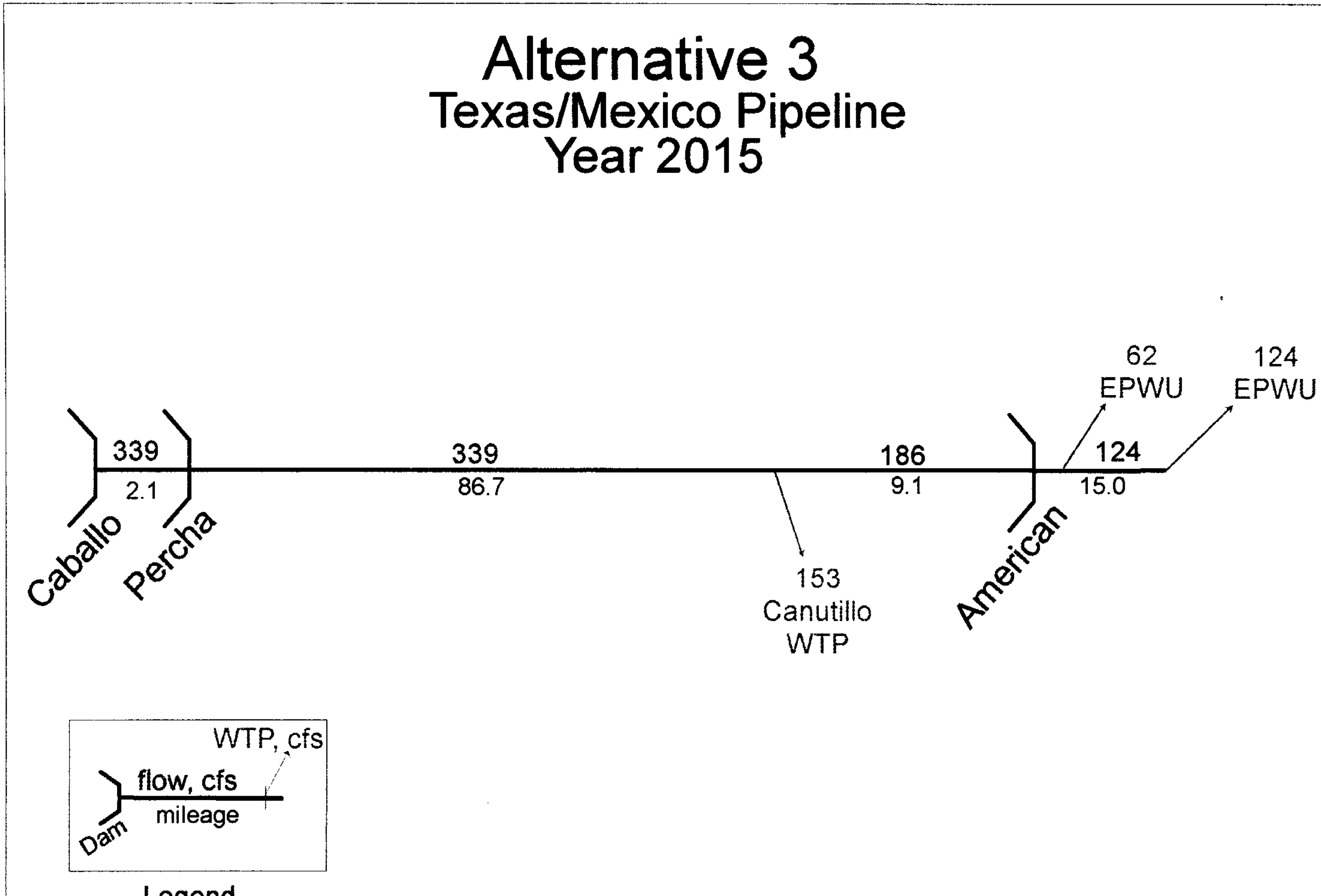
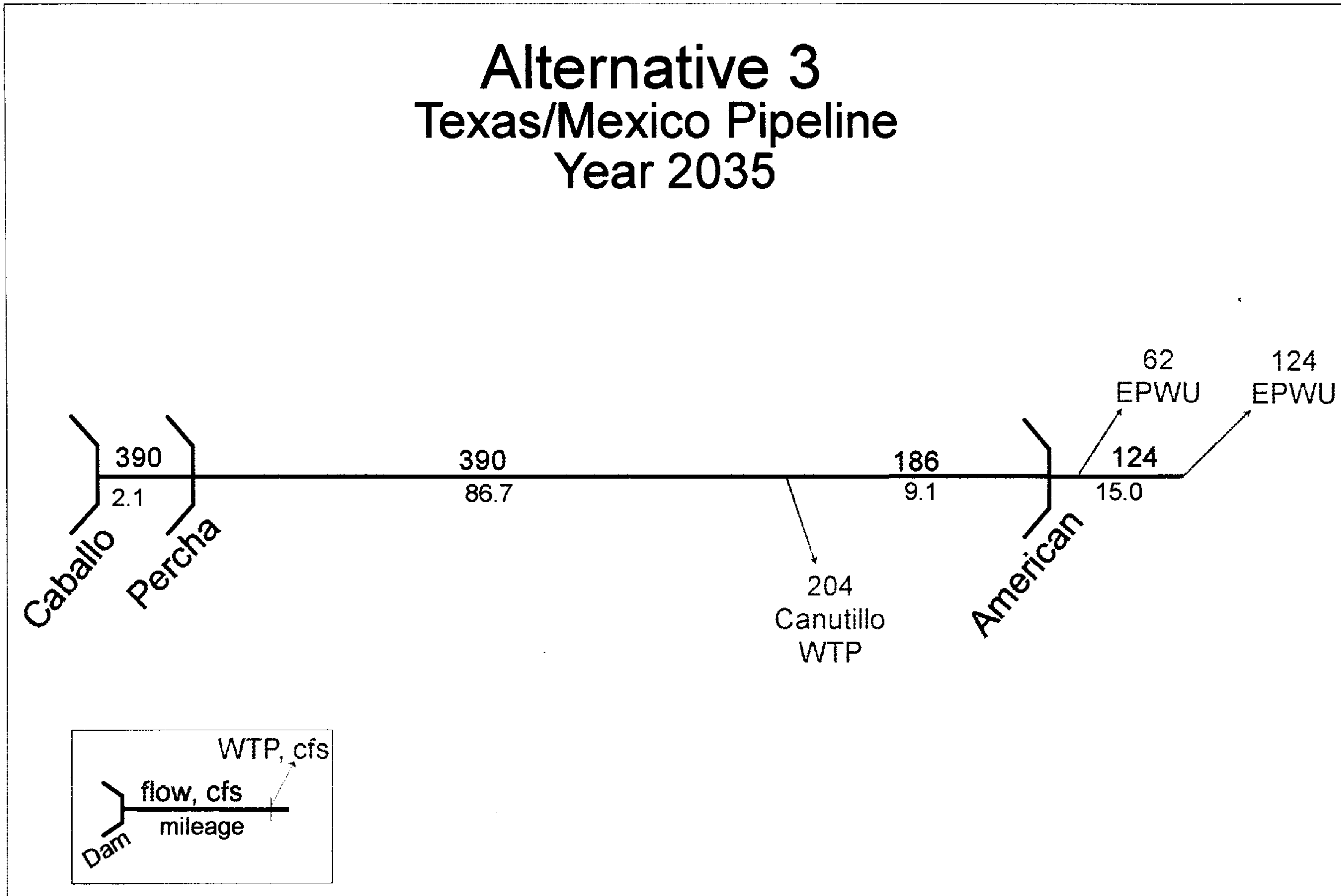

Alternative 3
Texas/Mexico Pipeline
Year 2015
62
EPWU
124
EPWU
339
2.1
339
86.7
186
9.1
124
15.0
Caballo
Percha
153
Canutillo
WTP
American
WTP, cfs
flow, cfs
mileage
Dam
Legend

Figure 21



Alternative 3
Texas/Mexico Pipeline
Year 2035
62
EPWU
124
EPWU
390
2.1
390
86.7
186
9.1
124
15.0
Caballo
Percha
204
Canutillo
WTP
American
WTP, cfs
flow, cfs
mileage
Dam
Legend

Figure 22

Table 1
Capital Costs for Alternative No. 1

Item		Unit Price $	Unit	Quantity		Cost
Canal, concrete lined with maintenance road and fence		280	foot	537,900	ft	$150,612,000
Concrete Pipe		3.25	in dia-ft	2,622,000	in dia-ft	$8,521,500
Special Excavation		10.50	Cy	62,963	Cy	$661,112
Major Headgates (Anthony)		150,000	each	1	each	$150,000
Check Structures		300,000	each	1	each	$300,000
River Crossing		750,000	each	3	each	$2,250,000
Bridge Crossings		100,000	each	91	each	$9,100,000
Rights-of-way	Non Orchard	10,000	acre	1,275.9	acres	$12,759,493
	Orchard	20,000	acre	82.6	acres	$1,651,515
				Sub-total		$186,005,619
	Adjusted Subtotal to Year 2000			119%		$221,346,687
	Construction Contingency			20%		$44,269,337
	Subtotal Construction Cost					$265,616,024
	Contractors Profit and Overhead			11%		$29,217,763
	Engineering and Administrative			14%		$37,186,243
				TOTAL		$332,020,030

6/21/94

Table 2
Capital Costs - Alternative 2

Item		Unit Price $	Unit	Quantity		Cost
Canal, concrete lined with maintenance road and fence		320	foot	224,400	ft	$71,808,000
Canal, concrete lined with maintenance road and fence		310	foot	68,800	ft	$21,328,000
Canal, concrete lined with maintenance road and fence		300	foot	48,000	ft	$14,400,000
Canal, concrete lined with maintenance road and fence		290	foot	95,400	ft	$27,666,000
Canal, concrete lined with maintenance road and fence		280	foot	94,700	ft	$26,516,000
Special Excavation		10.50	CY	62,963	CY	$661,111
Concrete Pipe		3.25	in dia-ft	2,622,000	in dia-ft	$8,521,500
Major Headgates		150,000	each	12	each	$1,800,000
Minor Headgates		15,000	each	90	each	$1,350,000
Check Structures		375,000	each	36	each	$13,500,000
River Crossing		750,000	each	5	each	$3,750,000
Bridge Crossings		100,000	each	117	each	$11,700,000
Connection to Wasteways		75,000	each	10	each	$750,000
Rights-of-way	Non Orchard	10,000	acre	435.0	acres	$4,349,773
	Orchard	20,000	acre	142.4	acres	$2,847,670
				Sub-total		$210,948,054
	Adjusted Subtotal to Year 2000			119%		$251,028,185
	Construction Contingency			20%		$50,205,637
	Subtotal Construction Cost					$301,233,821
	Contractors Profit and Overhead			11%		$33,135,720
	Engineering and Administrative			14%		$42,172,735
6/21/94				TOTAL		$376,542,277

Table 3
Capital Costs for Alternative 2a

Item		Unit Price $	Unit	Quantity			Cost
Canal, concrete lined with maintenance road and fence		310	foot	224,400	ft	15' to 16' width	$69,564,000
Canal, concrete lined with maintenance road and fence		300	foot	126,500	ft	14' width	$37,950,000
Canal, concrete lined with maintenance road and fence		280	foot	362,100	ft	8' to 10' width	$101,388,000
Canal, concrete lined with maintenance road and fence		270	foot	142,700	ft	width < 8'	$38,529,000
Special Excavation		10.50	CY	62,963	CY		$661,111
Concrete Pipe		3.25	in dia-ft	2,622,000	in dia-ft		$8,521,500
Major Headgates		150,000	each	12.00	each		$1,800,000
Minor Headgates		15,000	each	90.00	each		$1,350,000
Check Structures		375,000	each	36.00	each		$13,500,000
River Crossing		750,000	each	5.00	each		$3,750,000
Bridge Crossings		100,000	each	117.00	each		$11,700,000
Rights-of-way	Non Orchard	10,000	acre	1,045.4	acres		$10,453,963
	Orchard	20,000	acre	193.9	acres		$3,878,787
				Sub-total			$303,046,361
	Adjusted Subtotal to Year 2000			119%			$360,625,170
	Construction Contingency			20%			$72,125,034
	Subtotal Construction Cost						$432,750,204
	Contractors Profit and Overhead			11%			$47,602,522
	Engineering and Administrative			14%			$60,585,029
				TOTAL			$540,937,755

6/21/94

Table 4
Capital Costs for Alternative No. 3

Item	Unit Price $	Unit	Quantity		Cost
Concrete Pipe	3.25	in-dia-ft	66,320,400	in-dia-ft	$215,541,300
Trench Dewatering	5,000	miles	33.9	miles	$169,697
Connection to Caballo Reservoir	1,000,000	each	1	each	$1,000,000
Plant Connections	300,000	each	5	each	$1,500,000
River Crossing	350,000	each	3	each	$1,050,000
Rights-of-way					
Non Orchard	10,000	acres	371.4	acres	$3,714,414
Orchard	20,000	acres	9.2	acres	$183,707
			Sub-total		$223,159,118
	Adjusted Subtotal to Year 2000		119%		$265,559,350
	Construction Contingency		20%		$53,111,870
	Subtotal Construction Cost				$318,671,220
	Contractors Profit and Overhead		11%		$35,053,834
	Engineering and Administrative		14%		$44,613,971
		TOTAL			$398,339,025

For quick reference, the total capital costs for the different alternatives are summarized below:

	Capital Cost
Alternative 1	$332,020,030
Alternative 2	$376,542,277
Alternative 2a	$540,937,755
Alternative 3	$398,339,025

Water Conveyance Costs

In order to assist in evaluating project alternatives, the cost that may be assigned to the conveyance of water was determined in the form of a cost per unit volume of water delivered. In the determination of this cost, a total release to the Rio Grande Project of 650,000 ac-ft, which corresponds to an "average" year, was used as the basis for the unit conveyance cost calculations. This total volume was distributed among Elephant Butte Irrigation District (EBID), El Paso County Water Improvement District #1 (EPCWID#1), and Mexico. From the total annual amount, 60,000 ac-ft were allowed for Mexico's entitlement, and of the remainder, 57 percent was used as EBID's allotment and 43 percent as EPCWID#1's. Conveyance costs were determined for each one of the alternative conveyance objectives under study. Capital costs were uniformly distributed over an assigned useful life of the project of 50 years, with zero salvage at the end of this period. Annual O&M costs were used as specified in the Cost Basis Memorandum.

In order to take into account variations in demands during the life of the project, the study was divided into three periods of operation: 2005 to 2014, 2015 to 2034, and 2035 to 2054. Alternative 1 delivers the constant volume corresponding to EPCWID#1 and a small and varying amount during each period for M&I uses in Southern Dona Ana County, New Mexico. This is necessary to conform with the service area of the Anthony Regional plant as currently conceived. Alternative 2 delivers a constant annual volume through the life of the project, and Alternative 3 delivers a varying amount for treatment by EPWU, determined on the basis of projected production requirements from the existing and proposed water treatment plants. Results of average-year deliveries and unit cost calculations are presented in Table 5.

Deliveries to both EBID and EPCWID#1 were divided into agricultural and M&I uses for the purpose of determining the annual costs for each particular use. For M&I uses, EBID was considered to supply New Mexico users and EPCWID#1 Texas users, including EPWU. Deliveries to each agency and for each use, and the conveyance costs for each annual volume delivered are presented in Table 6.

In Alternative 1, the annual volumes delivered for Mexico and for EPCWID#1 are constant through the 50 year life of the project, and there is a variation only in the volume delivered for M&I uses in Southern New Mexico. Of the constant annual volume delivered for EPCWID#1, a portion that varies with time is delivered to EPWU for M&I water supply, and the complement is distributed by EPCWID#1 for agricultural uses. As mentioned previously, volumes for EPWU were determined on the basis of maximum production of the existing and proposed water treatment plants. For the years 2005 and 2015, daily demand hydrographs, with a maximum limit equal to the available treatment plant capacity for each year, were integrated to determine the annual volume required. For 2035, it was considered that supply would occur at a rate equal to average demand minus a small calculated amount drawn from natural aquifer recharge throughout the year, with excess water during periods of low demand being stored through water banking in the area aquifers. The volumes thus determined for each year were used to estimate average required deliveries during each of the periods considered.

In Alternative 2, the volume delivered is the total of the Rio Grande Project water. Deliveries to EBID, Mexico, and EPCWID#1 are constant through the life of the project. Water for M&I uses from the EBID delivery varies in volume for each period as demand in Las Cruces and Southern New Mexico increases. Total deliveries to EPCWID#1 are the same as for Alternative 1, and the amounts for M&I uses delivered to EPWU are determined on the same basis as for Alternative 1.

In Alternative 3, all the water conveyed is for EPCWID#1 to be delivered to EPWU for M&I uses, and for Mexico. The volumes required by EPWU are determined on the same basis as and are thus identical with those determined for Alternatives 1 and 2.

Table 5
Water Conveyance Unit Cost

Alternative No. / Operation Period	Total Capital Cost	Annual Capital Cost	Annual O&M Cost	Annual Total Cost	Average Annual Delivery, AC-FT	Unit Cost per AC-FT
1	$332,020,030					
2005 TO 2014		$21,064,774	$415,000	$21,479,774	318,850	$67.37
2015 TO 2034		$21,064,774	$415,000	$21,479,774	320,530	$67.01
2035 TO 2054		$21,064,774	$415,000	$21,479,774	342,155	$62.78
2	$376,542,277					
2005 TO 2054		$23,889,456	$415,000	$24,304,456	650,000	$37.39
2a	$540,937,755					
2005 TO 2054		$34,319,410	$640,000	$34,959,410	650,000	$53.78
3	$398,339,025					
2005 TO 2014		$25,272,335	$283,000	$25,555,335	196,220	$130.24
2015 TO 2034		$25,272,335	$283,000	$25,555,335	248,535	$102.82
2035 TO 2054		$25,272,335	$283,000	$25,555,335	281,805	$90.68

Notes:

Annual Interest Rate: 6.00 Percent

Amortization Period: 50 Years

Table 6
Annual Water Conveyance Cost

Alternative No. / Operation Period	Average Year Unit Cost Per AC-FT	Average-Year Deliveries, AC-FT					Annual Conveyance Costs				
		EBID		MEXICO	EPCWID#1		EBID		MEXICO	EPCWID#1	
		Agriculture	M&I	AG./M&I	Agriculture	M&I	Agriculture	M&I	AG./M&I	Agriculture	M&I
1											
2005 TO 2014	$67.37	N/A	5,150	60,000	117,480	136,220	N/A	$346,937	$4,041,984	$7,914,204	$9,176,650
2015 TO 2034	$67.01	N/A	6,830	60,000	65,165	188,535	N/A	$457,701	$4,020,798	$4,366,922	$12,634,353
2035 TO 2054	$62.78	N/A	28,455	60,000	31,895	221,805	N/A	$1,786,345	$3,766,674	$2,002,301	$13,924,453
2											
2005 TO 2014	$37.39	309,300	27,000	60,000	117,480	136,220	$11,565,182	$1,009,570	$2,243,488	$4,392,750	$5,093,466
2015 TO 2034	$37.39	301,350	34,950	60,000	65,165	188,535	$11,267,920	$1,306,832	$2,243,488	$2,436,615	$7,049,601
2035 TO 2054	$37.39	242,875	93,425	60,000	31,895	221,805	$9,081,453	$3,493,298	$2,243,488	$1,192,601	$8,293,615
2a											
2005 TO 2014	$53.78	309,300	27,000	60,000	117,480	136,220	$16,635,301	$1,452,160	$3,227,022	$6,318,510	$7,326,417
2015 TO 2034	$53.78	301,350	34,950	60,000	65,165	188,535	$16,207,720	$1,879,741	$3,227,022	$3,504,815	$10,140,111
2035 TO 2054	$53.78	242,875	93,425	60,000	31,895	221,805	$13,062,718	$5,024,743	$3,227,022	$1,715,431	$11,929,495
3											
2005 TO 2014	$130.24	N/A	N/A	60,000	N/A	136,220	N/A	N/A	$7,814,291	N/A	$17,741,044
2015 TO 2034	$102.82	N/A	N/A	60,000	N/A	188,535	N/A	N/A	$6,169,433	N/A	$19,385,902
2035 TO 2054	$90.68	N/A	N/A	60,000	N/A	221,805	N/A	N/A	$5,441,068	N/A	$20,114,267

Notes:

Annual Interest Rate: 6.00 Percent
Amortization Period: 50 Years

Regional Water Treatment Plants

Treatment of surface water and the necessary major treated water transmission lines were evaluated for both the New Mexico and Texas portions of the Mesilla Valley. It was determined that two regional water treatment plants should be analyzed. The first, hereafter referred to as the Las Cruces Regional Treatment Plant, would serve the northern portion of the Mesilla Valley from Leasburg Dam to a service boundary between Santo Tomas and Mesquite as shown in Figure 23. The other, hereafter referred to as the Anthony Regional Treatment Plant, would serve the southern portion of the Mesilla Valley both in New Mexico and Texas as shown in Figure 24.

Rio Grande Project Water Supply

The Rio Grande Project water supply is governed by the Rio Grande Compact, an interstate compact that allocates the waters of the Rio Grande above Fort Quitman, Texas, between the states of Colorado, New Mexico, and Texas. The Compact specifies a normal release of 790,000 af annually from the Rio Grande Project. However, reservoir operation studies (Reference 5) show that the project can currently supply an average of between 600,000 and 650,000 af annually with maximum supplies exceeding 790,000 af annually and minimum supplies not less than 315,000 af annually. A more detailed analysis of the Rio Grande Project water supply is contained in the Phase I report (Reference 4).

The Rio Grande Project is a federal reclamation project and its water supply is also governed by federal contracts between the United States and two irrigation districts, the EBID and the EPCWID#1. The EBID holds the contract water rights for water delivered in New Mexico while the EPCWD#1 holds the contract water rights for water delivered in Texas. These two districts are the contractors and managers of the Rio Grande surface water supply and will play an important role in the development of the M&I surface water supply.

Future Population and Water Demand

Water demand projections were based on projected demand per capita and population projections. The population projections for the Mesilla Valley, from the Leasburg Dam to the New Mexico - Texas border, were derived from 1990 census data. The 1990 Census divided Dona Ana County into seven census divisions (Figure 25). It was assumed that the population of the census divisions that include the Mesilla Valley were concentrated within the

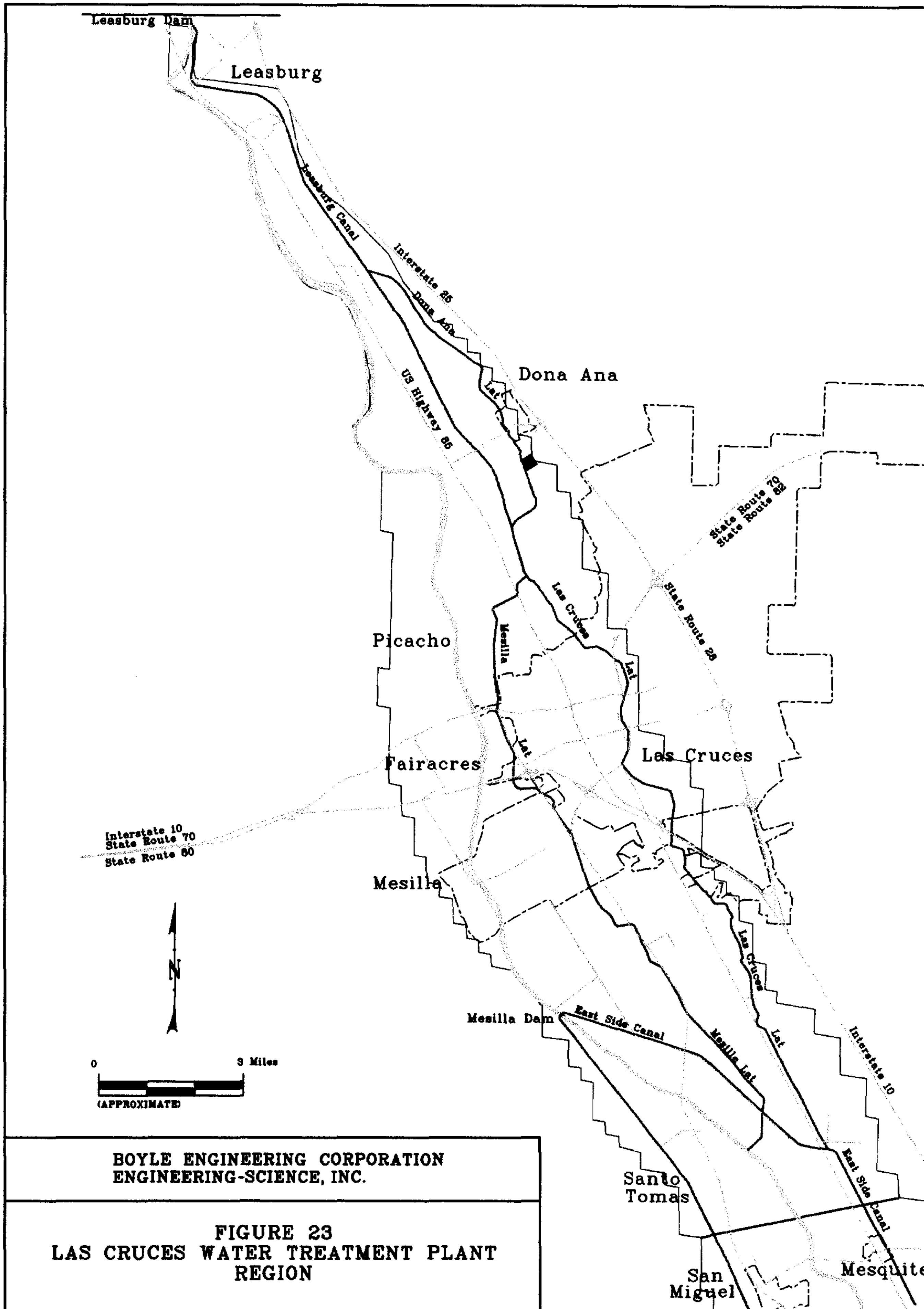


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FIGURE 23
LAS CRUCES WATER TREATMENT PLANT
REGION

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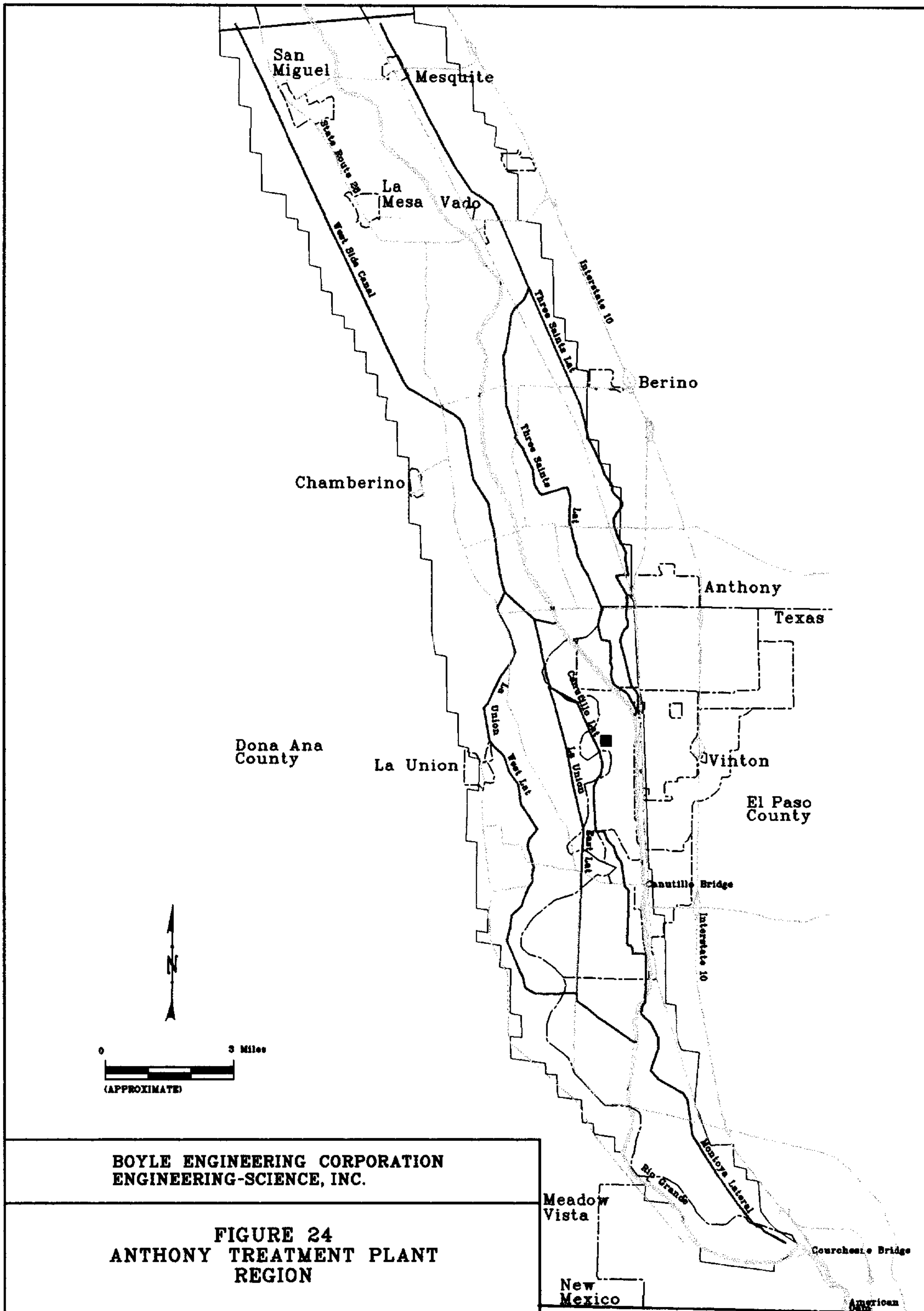

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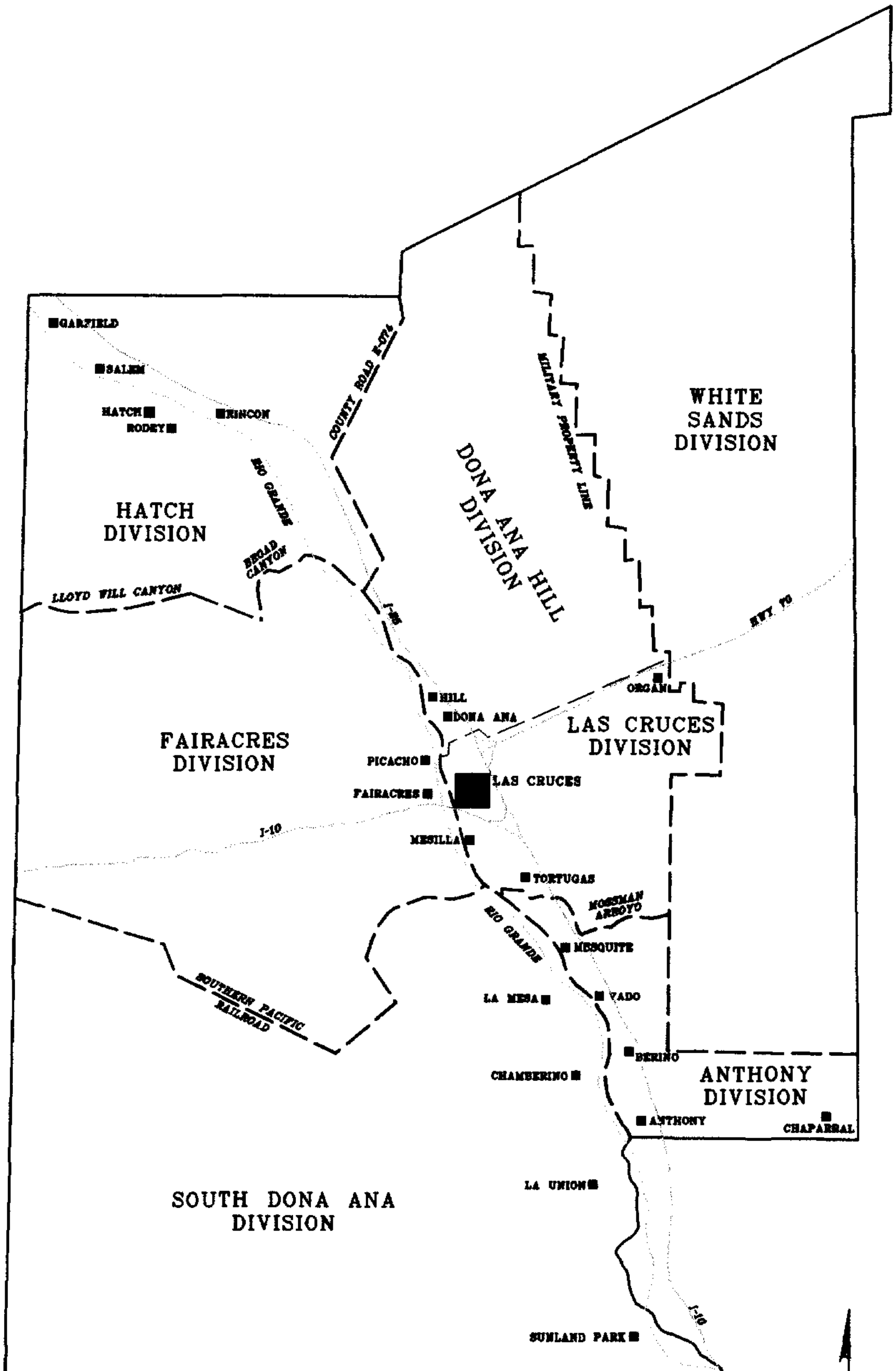
FIGURE 24
ANTHONY TREATMENT PLANT
REGION

D:\724046\ANTHREGN.DGN R03 06.20.94



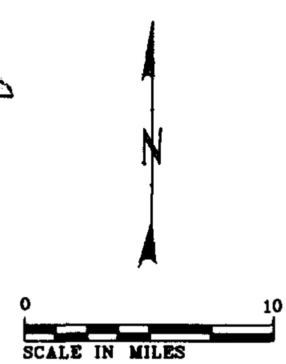


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FIGURE 25
DONA ANA COUNTY
CENSUS DIVISIONS

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EBID boundary. The 1990 Census also provided population figures for the "incorporated areas" in Dona Ana County. Incorporated areas outside of the EBID boundary were not included in the projections. Average annual growth rates of 2.5 percent for the City of Las Cruces and 2.8 percent for the rest of the EBID area were assumed through the year 2035. The two planning horizons used for this study were the years 2015 and 2035. Using the above assumed growth rates, the following population projections for New Mexico south of the Leasburg Dam were calculated.

Table 7
Mesilla Valley Population, New Mexico

Year	Population
2015	242,738
2035	410,337

The population projections for the Mesilla Valley, from the Texas - New Mexico border to the American Dam, were calculated based on information from Boyle Engineering Corporation. Boyle predicted that the Texas population in the Mesilla Valley would require 90 million gallons per day (MGD) (40 MGD from a water treatment plant and 50 MGD from wells) in the year 2015. A population was calculated for 2015 using the 90 MGD, a 2.0 peaking factor, and a 160 gallons per capita per day (gpcd) daily use. Although the expected annual growth rate for the City of El Paso is 2.1 percent, as specified in the Criteria Memorandum (Appendix A), the population served from the Anthony plant will probably grow at a faster rate. This assumption is based on available land area and planned future capacity at the existing Canal Street and Jonathan W. Rogers Water treatment plants and expected rapid growth on the west side of El Paso. The 2035 capacity expected at the two existing plants was subtracted from the expected overall growth in El Paso. The Anthony Plant capacity for El Paso is assumed to be equal to the amount of water necessary to supply this demand deficit. It turns out that a service area growth rate of 2.8 percent for that portion of demand to be supplied from the Anthony plant corresponds to these assumptions. Using this growth rate, the following population projections for the Texas portion of the Anthony Plant were calculated.

Table 8
Mesilla Valley Population, Texas

Year	Population
2015	281,250
2035	488,602

The projected populations were divided into two areas, the area to be served by the proposed Las Cruces regional water treatment plant and the area to be served by the proposed Anthony regional water plant. It was decided that the service boundary between the two regional water treatment plants would be between Santo Tomas and Mesquite. Based on this boundary, the projected populations that the proposed regional water treatment plants would serve in the years 2015 and 2035 are:

Table 9
Water Treatment Plant Region Populations

Water Treatment Plant	Year	Population Served
Las Cruces	2015	181,881
Las Cruces	2035	304,613
Anthony	2015	342,107
Anthony	2035	594,326

The above population projections were used to develop water demand projections. The study assumed the following daily per capita use rates for the region for the years 2015 and 2035:

Table 10
Mesilla Valley Projected Daily Per Capita Water Use

Location	Year	Daily Use (gpcd)
City of Las Cruces	2015	160
Rest of New Mexico	2015	100
Texas	2015	160
City of Las Cruces	2035	160
Rest of New Mexico	2035	160
Texas	2035	160

The study anticipates, for the sizing of treatment plants, that the ratio of the maximum-day water supply capacity to the average-day demand will be 1.0 for the entire Mesilla Valley in 2015. Maximum day demands above the average demand rate are assumed to be met by pumping ground water from wells. By the year 2035, the peaking factor on the water treatment plant capacity will be increased to 1.5 for New Mexico outside of the City of Las Cruces. This assumption was made to assure that surface water treatment capacity will be adequate if groundwater production capacity for peaking is limited. Las Cruces surface water treatment capacity will remain at 1.0 times average demand. It was assumed that the City of Las Cruces would have sufficient water rights, and well capacity, to meet its maximum demand with ground water. The assumption that Texas would also have sufficient well capacity to meet maximum demands was made; thus, Texas was also assumed to have a maximum surface water production to demand factor of 1.0 through 2035. In order to maintain long term capacity in the Hueco Basin and overdrafted parts of the Mesilla Basin, aquifer storage and recovery, discussed later in the report, will be necessary. In addition to meeting the New Mexico/Texas population demands, the Anthony regional water treatment plant was also sized to provide Mexico with its allotted 60,000 af per year (53.5 MGD) of Rio Grande water as treated water. Based on this criteria, the sizes of the water treatment plants required to meet these water demands for the years 2015 and 2035 are as follows:

Table 11
Regional Water Treatment Plant Capacities

Water Treatment Plant	Year	Size (MGD)
Las Cruces	2015	25
Las Cruces	2035	60
Anthony	2015	105
Anthony	2035	160

Estimation of Ultimate Demand

In regional water supply planning, it is important to consider and evaluate the ultimate water supply delivery which might be needed with total municipal development of all lands in the study area. Evaluation of the ultimate system provides the planner a perspective as to the water treatment and delivery facilities that might eventually be needed as an area develops. With this perspective, the interim plan for water supply facility needs anticipated within a shorter planning horizon will be more easily updated to meet the ultimate demand that may eventually be placed on the system.

The largest possible surface water supply system would deliver all surface water as treated water for M&I uses within past or present irrigated areas of the Rio Grande Project in the Mesilla Valley and other adjoining lands. Thus, for the ultimate system, it is assumed that all Rio Grande Project lands in the Mesilla will be developed for M&I use and the entire water supply could eventually be converted from irrigation to domestic use and supplied to the developed project lands. This is not to say that over the foreseeable future this will actually happen. The production of food and fiber could eventually be considered more beneficial than municipal developments. It is useful, however, to ponder the ultimate water treatment demands which would result from total conversion to domestic use.

It was assumed that the ultimate demand on the surface water supply system will be constrained by the surface water supply available from the Rio Grande Project. The lands that can be supplied include all Rio Grande Project lands within the study area and additional lands assumed to be located along the fringes of the presently irrigated area. The available surface water supply from the Rio Grande Project varies from year to year, but can be depended upon to deliver a base supply each year and can be supplemented with recharge of surface water into the groundwater system in wet years and subsequent groundwater withdrawals in low water years. This will provide a sustainable and renewable water resource for the area without mining the ground water aquifers.

The Rio Grande Compact provides for a normal release of 790,000 af annually from the Rio Grande Project. For the purposes of evaluating the design of the ultimate system, a 790,000 acre-foot release was used as a basis for estimation of the ultimate demand on the water supply system since this supply is the amount provided for the project by the Compact. The Bureau of Reclamation reports that there are 177,992 irrigated acres in the Rio Grande Project (Water and Power Resources Service, 1981). The Project must deliver 60,000 af to the country of Mexico as part of an international treaty leaving a supply of 730,000 af annually for the project or 4.101 af per acre. This water supply was used for facilities sizing at ultimate buildout.

Treatment Processes

The purposes of this section are to present preliminary recommended treatment processes and to describe the basic information, criteria, and guidelines that were used in developing the flow processes for the Las Cruces and Anthony Water Treatment Plant Alternatives. The treatment processes selected were based upon the information found in the Jonathan W. Rogers Water Treatment Plant Predesign (JWRWTP) Report (Reference 24), water quality data reported in the New Mexico State Bulletin No. 064, New Mexico State University (Reference 15) as "water quality from the Rio Grande at Caballo Reservoir," criteria of the American Water Works Association Water Treatment Guidelines (Reference 25), the Texas Natural Resource Conservation Commission Rules and Regulations (Reference 26) for public water systems, and engineering experience gained on similar designs for similar types of water. A description of the expected raw water quality, the treatment water quality goals, and the treatment process selection follows.

Raw Water Quality

The sole source of raw water for the Las Cruces, New Mexico, and the Anthony, Texas Regional Water Treatment Plants is surface water from the Rio Grande Project as diverted into an open lined canal or a closed conduit conveyance system at or near Caballo Reservoir in New Mexico. In contrast, the JWRWTP was designed to treat water, 50 percent of which comes from the Rio Grande as diverted from the Riverside Canal and 50 percent of which comes from the effluent of the Haskell Wastewater Treatment Plant. A very conservative treatment process train would result if the complete treatment criteria for the JWRWTP were used for the Las Cruces and Anthony regional plants. It does not appear that such a conservative approach is necessary for water that is released directly from Caballo Reservoir. Therefore, the flow processes have been modified to reflect the expected better quality of water released from Caballo Reservoir. Certain specific assumptions were made based upon the limited information on water quality that was available. The available water quality information is summarized in Table 12. None of the water quality parameters shown in Table 12 exceeds the current National Primary Drinking Water Regulations.

The raw water conveyed to the treatment plants in lined conveyance facilities will be isolated from the Rio Grande and will not contain flood flows or return flows from irrigation. Thus, the raw water will contain very little sediment and the water delivered to the treatment plants should have quality similar to historical releases from Caballo Reservoir. In fact, the water quality of releases from Caballo Reservoir is expected to be somewhat improved over historical conditions due to recent changes in reservoir operations. A water conservation program has been implemented by the Bureau of Reclamation and the Irrigation Districts. The storage in Caballo Reservoir is now limited to about 60,000 af during the hot summer months. This decreases the evaporation loss from that which has historically occurred. This reduction from 200,000 af to 60,000 af of storage in the summer is expected to result in less concentration of salts and a general improvement in the water quality of Caballo Reservoir releases as compared to that of historical releases.

On the basis of the data in Table 12 it appears that the treatment processes at the Las Cruces and the Anthony regional water treatment plants can be largely conventional processes for removal of turbidity, tri-halomethane precursors, and other pollutants expected in a fairly high quality raw water supply The information that is shown in Table 12 with regard to organics is all that was available in the existing data. Much more study is needed on this issue to fully determine how much removal of organics will be required.

Table 12
Water Quality in Caballo Reservoir Releases

Item		Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calcium														
	High	mg/L	85.40	79.40	126.00	132.40	110.40	102.00	94.40	93.20	92.20	99.20	91.60	94.20
	Low	mg/L	44.40	37.80	58.40	59.60	55.80	49.80	38.00	49.60	53.80	48.00	52.80	58.00
	Average	mg/L	64.90	58.60	92.20	96.00	83.10	75.90	66.20	71.40	73.00	73.60	72.20	76.10
Magnesium														
	High	mg/L	38.60	11.30	26.90	28.10	30.20	25.40	22.50	21.50	26.40	35.40	33.70	35.10
	Low	mg/L	11.90	11.30	11.20	11.10	11.10	10.70	10.60	9.60	10.60	9.60	11.30	11.70
	Average	mg/L	25.20	21.30	19.00	19.60	20.60	18.10	16.60	15.60	18.50	22.50	22.50	23.40
Sodium														
	High	mg/L	252.50	259.00	212.80	177.80	235.50	175.00	162.40	175.00	223.10	265.20	274.90	263.40
	Low	mg/L	69.90	62.30	58.20	55.70	56.60	50.10	39.30	39.10	46.50	57.00	59.80	64.20
	Average	mg/L	161.20	160.70	135.50	116.80	116.10	112.60	100.90	107.10	134.80	161.10	167.40	163.80
Bi-Carbonate														
	High	mg/L	234.00	219.90	96.00	96.30	118.50	99.00	93.00	95.10	202.80	216.30	235.50	220.50
	Low	mg/L	69.30	72.90	74.10	74.10	66.00	66.00	52.50	71.40	40.50	66.30	77.10	75.30
	Average	mg/L	151.70	146.40	85.10	85.20	92.30	82.50	72.80	83.30	121.70	141.30	156.30	147.90
Nitrate														
	High	mg/L	2.48	1.24	2.48	1.86	2.48	1.86	1.86	1.24	2.48	4.34	1.86	0.62
	Low	mg/L	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
	Average	mg/L	1.55	0.93	1.55	1.24	1.55	1.24	1.24	0.93	1.55	2.48	1.24	0.62
Cloride														
	High	mg/L	193.47	197.02	239.63	172.89	227.20	142.00	131.35	195.25	174.66	209.45	207.68	204.13
	Low	mg/L	41.53	38.70	31.95	30.17	35.85	30.53	28.40	30.17	33.72	39.05	42.60	44.02
	Average	mg/L	117.50	117.86	135.79	101.53	131.53	86.27	79.88	112.71	104.19	124.25	125.14	124.08
Sulfate														
	High	mg/L	237.12	261.60	394.56	459.84	425.76	417.12	360.48	291.36	426.72	373.44	320.64	275.52
	Low	mg/L	149.28	125.76	120.48	122.88	126.24	124.32	122.88	123.36	114.72	129.60	126.24	136.80
	Average	mg/L	193.20	193.68	257.52	291.36	276.00	270.72	241.68	207.36	270.72	251.52	223.44	206.16
Boron														
	High	mg/L	0.31	0.29	0.28	0.25	0.26	0.21	0.20	0.22	0.26	0.36	0.30	0.28
	Low	mg/L	0.05	0.09	0.08	0.08	0.06	0.05	0.08	0.03	0.05	0.08	0.09	0.09
	Average	mg/L	0.18	0.19	0.18	0.17	0.16	0.13	0.14	0.13	0.16	0.22	0.20	0.19
Arsenic														
	Average	mg/L	-----	-----	0.00	-----	-----	0.01	-----	-----	0.01	0.00	-----	0.01
Cadmium														
	Average	mg/L	-----	-----	<.006	-----	-----	<.006	-----	-----	<.006	<.006	-----	<.006
Zinc														
	Average	mg/L	-----	-----	0.03	-----	-----	<.02	-----	-----	0.03	<.02	-----	<.02
Mercury														
	Average	mg/L	-----	-----	<.0002	-----	-----	0.00	-----	-----	0.00	0.00	-----	0.00
Copper														
	Average	mg/L	-----	-----	<.10	-----	-----	<.10	-----	-----	<.10	<.10	-----	<.10
Carbonate														
	Average	mg/L	-----	-----	4.80	-----	-----	0.00	-----	-----	0.00	0.00	-----	0.00
Total Phosphorus														
	Average	mg/L	-----	-----	0.03	-----	-----	0.02	-----	-----	0.11	0.01	-----	0.07
Potassium														
	Average	mg/L	-----	-----	6.30	-----	-----	6.20	-----	-----	5.50	5.10	-----	6.60
Coliform														
	Average	Avg cnt / 100 ml	-----	-----	83.00	-----	-----	210.00	-----	-----	340.00	600.00	-----	1,400.00
Fecal Coliform														
	Average	Avg cnt / 100 ml	-----	-----	17.00	-----	-----	0.00	-----	-----	1,520.00	67.00	-----	200.00
Chemical Oxygen Demand	Average	mg/L	-----	-----	16.00	-----	-----	36.00	-----	-----	44.00	87.00	-----	28.00
PH														
	High		8.30	8.00	8.10	8.20	8.20	8.30	8.20	8.30	8.30	8.10	8.20	8.20
	Low		7.80	7.70	7.70	7.90	7.90	7.80	7.40	7.70	7.80	7.70	7.80	7.90
	Average		8.05	7.85	7.90	8.05	8.05	8.05	7.80	8.00	8.05	7.90	8.00	8.05
EC														
	High	E-6 mmhos	1,610.00	1,590.00	1,650.00	1,550.00	1,630.00	1,440.00	1,310.00	1,440.00	1,300.00	1,730.00	1,710.00	1,670.00
	Low	E-6 mmhos	701.00	658.00	647.00	639.00	637.00	562.00	482.00	503.00	573.00	617.00	108.00	681.00
	Average	E-6 mmhos	1,155.50	1,124.00	1,148.50	1,094.50	1,133.50	1,001.00	896.00	971.50	936.50	1,173.50	909.00	1,175.50
TDS														
	High	mg/L	981.00	974.00	1,069.00	1,099.00	1,040.00	981.00	885.00	914.00	1,010.00	1,062.00	1,062.00	1,040.00
	Low	mg/L	457.00	428.00	406.00	406.00	406.00	369.00	325.00	325.00	384.00	406.00	428.00	443.00
	Average	mg/L	719.00	701.00	737.50	752.50	723.00	675.00	605.00	619.50	697.00	734.00	745.00	741.50

The available information listed in the above table did not include any data on ammonia levels that might be expected in the raw water. Ammonia is a source of concern relative to effective final disinfection. Therefore, the JWRWTP plant design criteria for disinfection were used as a guide. This would meet the goals of the EPWU with regard to residual chlorine in the complete system.

Treatment Water Quality Goals

The water quality goals of JWRWTP Treatment Predesign Report were adopted for this study. Consideration was also given to changes in existing and expected Safe Drinking Water Act (SDWA) requirements which have developed since 1990. The treatment processes must produce potable water which complies with the current SDWA including current regulations regarding maximum contaminant levels (MCLs). In addition, the plant processes should be sized and designed to handle future more stringent requirements expected under Safe Drinking Water Act regulations, where it is possible to anticipate such requirements. Table 13 presents a summary of information regarding existing and anticipated requirements of the SDWA.

The treated water design goals of JWRWTP were developed on the basis of the current and proposed state and federal regulations and on non-regulated water quality concerns. These goals have been reviewed and found to be very applicable for the Las Cruces and the Anthony regional water treatment plants. Therefore, they were adopted for this study.

Regulatory Objectives

The following is a brief discussion of regulatory objectives for water quality parameters that are currently anticipated to be regulated under the SDWA and subsequent amendments. Some of the proposed regulations are expected to change before being adopted since they are in the process of development at the present time. The water quality objectives presented here are based on the best information that is available at the present time. The following sections summarize the anticipated treatment objectives.

Turbidity

The current SDWA regulations require water turbidity coming from the filter effluent to be less than 1 nephelometric turbidity unit (NTU). This standard is proposed to be reduced to approximately 0.5 NTU. The new plants should be designed to comply with the more stringent 0.5 NTU standard.

Tri-halomethanes

The MCL standard for tri-halomethanes (THMs) is currently 0.10 milligrams per liter (mg/l). This standard is presently under consideration and will probably be reduced to 0.04 mg/l. El Paso City's older plants have previously treated Rio Grande water with resulting THM levels exceeding 0.10 mg/l at times. Although THM precursors should be much lower in the Caballo supply, prudence would indicate that THM control should be considered. Ozonation is recommended to remove some of the organics and tri-halomethane precursors that may be in the water released from Caballo Reservoir.

Pathogens

The SDWA disinfection requirements call for a 3-log removal and/or inactivation of Giardia cysts. A 2-log cyst removal credit is given for a water treatment plant that includes filtration and produces a filtered water less than 0.5 NTU in 95% of the monthly measurements. The remaining 1-log Giardia cyst reduction would need to be obtained through disinfection. This level of removal is expected to be required for the Las Cruces and Anthony Treatment Plants.

Lead and Corrosion Control

The control of lead was adopted under the reference 56 FR 26460 dated June 7, 1991. This rule specifies that the water supply must not be corrosive to lead and copper in consumer plumbing. Levels in the higher 10 percent of consumer tap samples above 0.015 mg/l trigger public notification and corrosion control requirements. As one of the means of controlling this problem, a minimum pH of 8.0 is suggested for the water in the distribution

Table 13
Current and Expected SDWA Requirements

Parameters	MCL[a]	MCLG[b]	Proposed MCL	Proposed MCLG
Inorganic Compounds				
Aluminum				
Antimony	0.006	0.006		
Arsenic	0.050	0.050		.002 to 0.020
Asbestos				7.1E+06 Fibers/l
Barium	2.0	2.0		
Beryllium	0.004	0.004		
Cadmium	0.005	0.005		
Chromium	0.01	0.01		
Copper	1.30 [c]			
Cyanide	0.2	0.2		
Fluoride	4.000	4.000		
Lead	0.015 [c]			
Mercury	0.002	.002		
Molybdenum				
Nickel	0.1	0.1		
Nitrate	10.000	10.000		
Nitrite	1.000	1.000		
Selenium	0.050	0.05		
Silver	0.050			
Sodium				
Sulfate	400/500	400/500		
Thallium	0.002	0.0005		
Vanadium				
Zinc				
Microbiological				
Coliform	1-4 Clfm/ 100 ml			0
Giardia Lamblia				0
Legionella				
Standard Plate Count				
Viruses				0

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[a] MCL as defined by the SDWA

[b] Maximum Contaminent Level Goal (MCLG), nonenforceable health goal, as defined by the SDWA

[c] Lead and Copper have "action levels" requiring public information and corrosion control, which are not actual MCLs.

Notes: All values are milligrams per liter (mg/l) unless otherwise stated.
Under 1/22/88 changes column, + indicates adition to the list, - indicates deletion
pCi/l = pico-Curie per liter, mrem/year = millirem per year, NTU = nephelometric turbiduity unit.

Table 13 (continued)
Current and Expected SDWA Requirements

Parameters	MCL[a]	MCLG[b]	Proposed MCL	Proposed MCLG
Synthetic Organic Compounds				
1,2-Dichloropropane	0.005	0		0.006
2,3,7,8-TCDD (Dioxin)				
2,4,5-TP Silvex	0.05	0.05		0.052
2,4-D	0.1			0.07
Acrylamide		0		
Adipates	0.4	0.4		
Alachlor	0.002	0		0
Aldicarb	0.003	0.001		
Aldicarb Sulfone	0.002	0.001		
Aldicarb Sulfoxide	0.004	0.001		
Atrazine	0.003	0.003		
Carbofuran	0.04	0.04		
Chlordane	0.002	0		
Dalapon	0.2	0.2		
Dibromochloropropane	0.002	0		
Dibromomethane				
Dinoseb				
Diquat				
Endothall				
Endrin	2.0E-04			
Epichlorohydrin		0		
Ethylbenzene	0.7	0.7		
Ethylene Dibromide	0.00005	0		
Glyphosate				
Heptaclor	0.0004	0		
Heptaclor Epoxide	0.002	0		
Hexachlorocyclopentadiene				
Lindane	0.0002	0.0002		
Methoxyclor	0.04	0.04		
Pentachlorophenol	0.001	0		
Phthalates	0.006	0		
Pichloram	0.5	0.5		
Polychlorinated Biphenyls				0
Polynuclear Aromatic Hydrocarbons				

[a]MCL as defined by the SDWA
[b]Maximum Contaminent Level Goal (MCLG), nonenforceable health goal, as defined by the SDWA

Notes: All values are milligrams per liter (mg/l) unless otherwise stated.
Under 1/22/88 changes column, + indicates addition to the list, - indicates deletion
pCi/l = pico-Curie per liter, mrem/year = millirem per year, NTU = nephelometric turbidity unit

Table 13 (continued)
Current and Expected SDWA Requirements

Parameters	MCL[a]	MCLG[b]	Proposed MCL	Proposed MCLG
Simazine				
Styrene	0.1	0.1		
Toluene	1.0	1.0		
Total Trihalomethanes	0.100	0		
Toxaphene	0.003	0		
Vydate				
Xylenes	10	10		
Volatile Organic Compounds				
1,1,1-Trichloroethane	0.200	0.200		
1,2-Dichloroethane	0.005	0.000		
1,1-Dichloroethylene	0.007	0.007		
Benzene	0.005	0.000		
Carbon Tetrachloride	0.005	0.000		
Chlorobenzene				
CIS 1,2-Dichloroethylene				0.070
Methylene Chloride				
P-Dichlorobenzene	0.750	0.750		
Tetrachloroethylene				0.000
Trans 1,2-Dichloroethylene				0.070
Thichlorobenzene (s)				
Trichloroethylene	0.005	0.000		
Vinyl Chloride	0.002	0.000		
Radionuclides				
Radon	300. pCi/l	0		
Uranium	0.02	0		
Gross Alpha Particle Activity	15 pCi/l	0		
Radium-266 & Radium-228	20 pCi/l	0		
B Particles & Photon Radioactivity	4 mrem/yr	0		
Other				
Turbidity	1.0 NTU	0.5 NTU	0.1 NTU	

[a]MCL as defined by the SDWA
[b]Maximum Contaminent Level Goal (MCLG), nonenforceable health goal, as defined by the SDWA

Notes: All values are milligrams per liter (mg/l) unless otherwise stated.
Under 1/22/88 changes column, + indicates addition to the list, - indicates deletion
pCi/l = pico-Curie per liter, mrem/year = millirem per year, NTU = nephelometric turbidity unit

Table 13 (continued)
Current and Expected SDWA Requirements

Maximum Secondary Contaminants	National SMCL[c]	Texas SMCL[d]
Chloride	250	300
Color (color units)	15	15
Copper	1	1
Corrosivity	noncorrosive	noncorrosive
Fluoride	2	2
Foaming Agents	0.5	0.5
Hydrogen Sulfide	--	0.05
Iron	0.3	0.3
Manganese	0.05	0.05
Odor (threshold odor number)	3	3
pH	6.5-8.5	6.5-8.5
Sulfate	250	300
Total Dissolved Solids	500	1000
Zinc	5	5

[c]SMCL as defined by the SDWA

[d]Secondary Maximum Contaminent Level Goal (MCLG), nonenforceable health goal, as defined by the SDWA

Notes: All values are milligrams per liter (mg/l) unless otherwise stated.
Under 1/22/88 changes column, + indicates addition to the list, - indicates deletion
pCi/l = pico-Curie per liter, mrem/year = millirem per year, NTU = nephelometric turbidity unit

system. Therefore, provisions to achieve this pH goal should be included in the Las Cruces and Anthony plants.

Synthetic Organic Compounds

MCLs currently exist for several synthetic organic compounds. The plants as proposed would not be susceptible to synthetic organic compounds from pesticides from agricultural lands or from secondary effluent discharges. It was assumed that crop dusting from the air near the open conveyance channel would be curtailed. With this assumption, synthetic organic compounds do not appear to be a problem. The use of activated carbon for the removal of synthetic organic contaminants is therefore not recommended and is not included in the proposed flow process.

Disinfection Byproducts

New regulations for disinfection byproducts are expected. The compounds to be regulated will include chlorinated organics produced as a byproduct of disinfection with chlorine. The formation of these compounds could be reduced at the proposed treatment plants by using ozonation. However, ozonation also produces disinfection byproducts which may be regulated in the future. For that reason, only pre-filtration ozone is suggested at the present time for the new plants. This would allow chemical coagulation and sedimentation to remove some of the organics prior to ozonation. Post ozonation filtration should help to control some of the ozonation byproducts.

Policy Objectives

The JWRWTP Predesign Report included Public Service Board objectives and concerns for the quality of the El Paso drinking water not mandated by EPA regulations. These include softening, taste and odor control, and total dissolved solid concentrations, and are discussed below.

Finished Water Hardness

The EPWU's policy is to remove hardness that exceeds 150 mg/l as CaCO3 through lime softening, as long as it does not raise the pH of the water above 9.3. The Caballo supply has total hardness in the 150 mg/l range. Therefore, it is assumed that lime softening will not be necessary in the treatment processes to be designed for the two regional plants.

Taste and Odors

As the JWRWTP Predesign report states: "All waters have some tastes and odors from minerals present in the raw water or from disinfection. There are two common philosophies for taste and odor control. One is to maintain a minimum level of taste and odor below a threshold concentration; the other is to have no detectable objectionable tastes and odors." The EPWU has requested that the latter policy be used as the basis for design where possible. It is anticipated that this policy would be used in the Las Cruces and Anthony Treatment Plant alternatives. Although taste and odor may be less prevalent in the Caballo supply than further down river, it would be wise to plan for chemical addition facilities for taste and odor control if necessary and for other unforeseen raw water conditions.

Total Dissolved Solids

The total dissolved solids (TDS), as shown in the available data from Table 12 above, showed an average of between 500 and 600 mg/l. Only under severe periods of drought does the TDS get above 1000 mg/l for water out of Caballo Reservoir. The upper limit set by the State Health Departments for both New Mexico and Texas is 1000 mg/l. Therefore, it does not appear that removal of TDS will be needed in the treatment processes.

Final Disinfection

In order to assure the safety of the potable water, it is wise to maintain a free chlorine secondary disinfectant residual. Therefore, this has been included in the design for the new treatment plants.

Process Selection

Based upon the information available for the raw water quality expected for the plants and the previous discussions, it is suggested that the treatment plant processes include the following:

- Presedimentation
- Ferric Sulfate and Polymer Coagulation
- Clarification
- Ozonation
- Tri-media Filtration

- Facilities for Chemical Addition at Several Locations

A suggested process diagram is shown in Figure 26 for these treatment plants. It is anticipated that the pre-sedimentation process can be achieved in a raw water reservoir just ahead of the plant. This raw water reservoir may be constructed as part the existing conveyance facilities as described in the regulating reservoirs section of this report. It is also anticipated that there would be no pre-ozonation, but pre-filtration ozonation would be used.

Estimation of Treated Storage Capacity

Municipal water demands typically are at a minimum at night, increase to a peak some time in the afternoon, and decrease again toward nighttime. It is usually most economical to design treatment facilities for the peak daily demand and to provide storage sufficient to supply the diurnal fluctuations during the peak day. A storage requirement of 30 percent of peak day demand was assumed to supply the increased demand during the daylight hours of the peak day. Storage is also used to provide fire protection flows, which are assumed to use 30 percent of total storage. Storage for each reservoir was increased by an additional one million gallons (1 MG) for fire storage.

Distribution System Development

The distribution systems were developed using commercial computer models. The alignments of the pipelines were held constant for the alternatives to allow a more direct comparison of the levels of development for decision purposes concerning future system improvements. The results in this report are based upon available data and are to be used as guide in making decisions concerning the future of regional water development. This study was accomplished assuming that the water distribution system will deliver both treated surface water and groundwater from the existing wells. In this level of study, no information was available concerning where the wells will connect to the main distribution system. It was assumed that the wells would deliver water to the same supply location as the water treatment plant, or potentially to the reservoirs.

Las Cruces Regional Treatment Plant and Distribution System

This section discusses treatment of surface water and treated water transmission lines in the northern portion of the Mesilla Valley. The City of Las Cruces is the major municipality and lies within the central portion of the study area. Potable water systems are associated with the communities within the valley. All of the communities in the study area currently depend

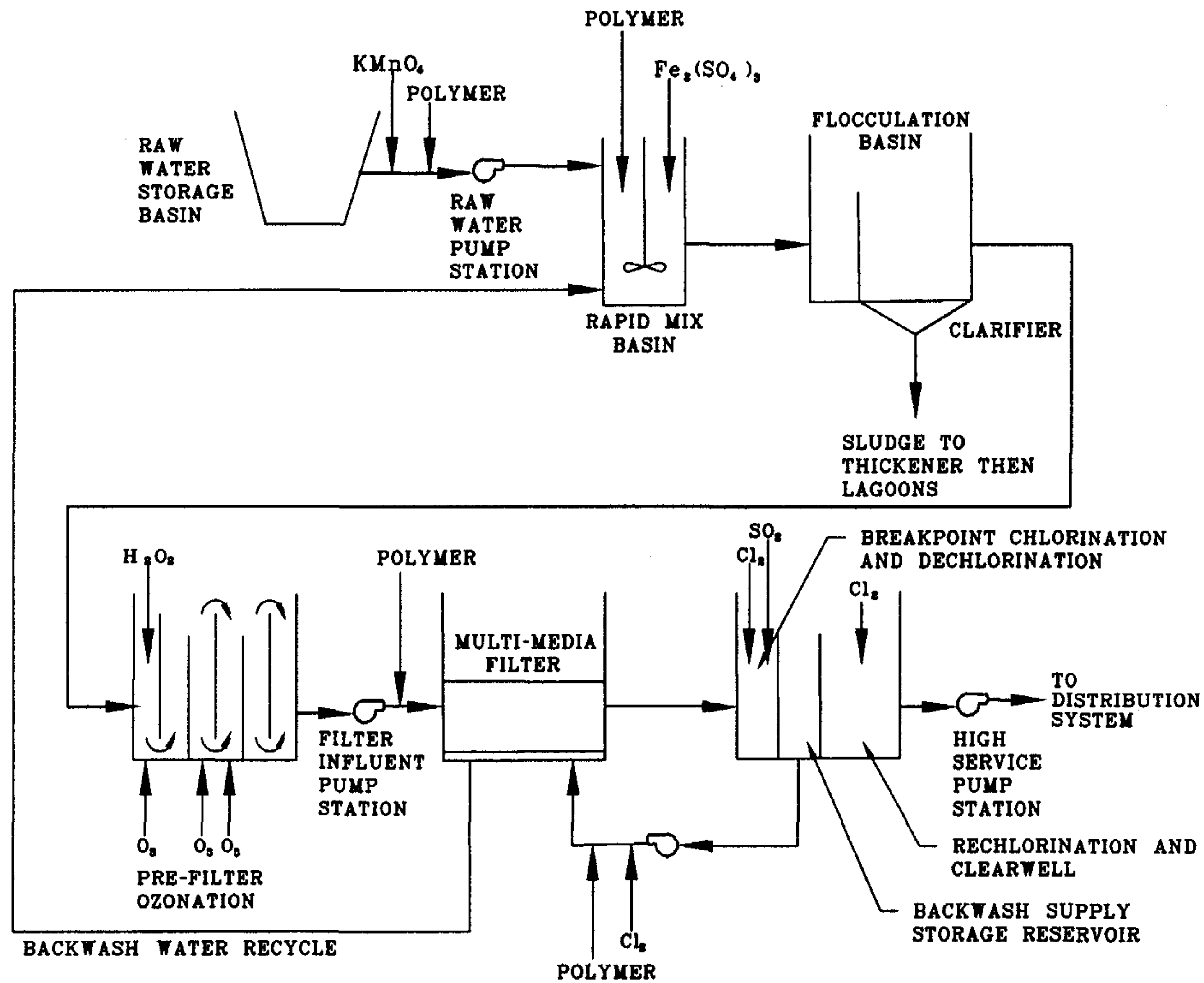

FIGURE 26
TREATMENT PLANT
PROCESS FLOW DIAGRAM

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exclusively on a limited groundwater supply. The City of Las Cruces is by far the largest supplier of municipal water in the area. Other municipal water suppliers in the study area include, but are not necessarily limited to the following:

- Jornada Water Company
- Moongate Water Company
- New Mexico State University
- Mountain View Water and Sewer Association
- Mountain View Mutual Domestic Water Consumer Association
- Picacho Mutual Domestic Water Consumer Association
- Dona Ana Mutual Domestic Water Consumer Association
- Valley View Water Users Association
- Alameda Mobile Home Park Associates
- Holly Gardens Mobile Home Park
- Leasburg Mutual Domestic Water Consumer Association
- Silver Spur Mobile Home Park
- Shangri-La Trailer Park
- St. John's Mobile Home Park
- Mesa Development
- Brazito Mutual Domestic Water Consumer Association
- Raasaf Hills Mutual Domestic Water Consumer Association
- Vista Real Mobile Home Park
- Alto De Las Flores Mutual Domestic Water Consumer Association

These smaller water systems generally consist of one or two wells, one or two small storage reservoirs, and a limited network of smaller diameter pipelines for distribution.

The City of Las Cruces currently has a population of approximately 62,000 people and draws its water supply from 21 active wells located throughout the city. Its distribution system consists of smaller diameter pipelines, mostly 12 inches in diameter or less, leading from each well and generally serving the lands in the vicinity of the well. Trunk lines no larger than 24-inches in diameter distribute water from six storage reservoirs that provide pressure head stabilization and storage for periods of peak use and fire suppression.

The distribution system is divided into six pressure zones the largest of which is called the Low Zone. All of the lands in the Elephant Butte Irrigation District in vicinity of Las Cruces would fall within this Low Zone. The Low Zone is currently served by three reservoirs with a total capacity of approximately 8.0 million gallons (MG) and a maximum water surface elevation of approximately 4,124 feet.

Water Treatment Plant

Surface water from the Rio Grande will require treatment before it can be used for municipal purposes. The location of a water treatment plant is influenced by a number of factors including, but not limited to:

- the central proximity to the entire service area,
- land development patterns,
- proximity to flood plains and other geologic hazards,
- topography,
- land area requirements,
- cost and availability of land,
- ability to return water to the river when needed,
- pumping requirements,
- preservation of water quality,
- size and length of raw water conveyance facilities,
- size and length of finished water main lines,
- and politics.

After careful consideration of these factors, it is recommended that the location for the Las Cruces Regional Treatment plant be south of Dona Ana alongside the Dona Ana Lateral just downstream of the Dona Ana Arroyo. This site offers the advantage of being centrally located within the service area while preserving much of the available head or elevation. Water can be spilled to the river down the Dona Ana Arroyo when required. This site is also close to the foothills where storage facilities can be located to provide pressure head for the delivery system. The plant can be supplied from the Dona Ana Lateral of the Leasburg Canal system which diverts from the river at the Leasburg Diversion Dam. However, this lateral will need to be lined and enlarged for raw water delivery.

The plant would be located sufficiently far outside of the Dona Ana Arroyo floodplain to prevent flooding of the facility. A large flood detention basin on the arroyo upstream of the site provides added flood protection. The land is relatively flat and suitable for the layout of a large facility.

Distribution System

The study area was divided into subareas for estimation of required pipeline conveyance and reservoir treated water storage capacities (see Figure 27). The average day and maximum day demands were computed as shown in Table 14. Maximum hour demands were assumed to be 1.75 times maximum daily demands.

Table 14
Average and Maximum Daily Demands for Las Cruces

	2035		Ultimate	
Reservoir Sub-Area	Average Demand MGD	Maximum Demand MGD	Average Demand MGD	Maximum Demand MGD
1	18	36	51	101
2	5	10	16	32
3	24	48	53	106
4	7	14	52	104

Main distribution lines were designed to deliver maximum hour demands within the reservoir service area and maximum day demands from the water treatment plant to the storage reservoirs.

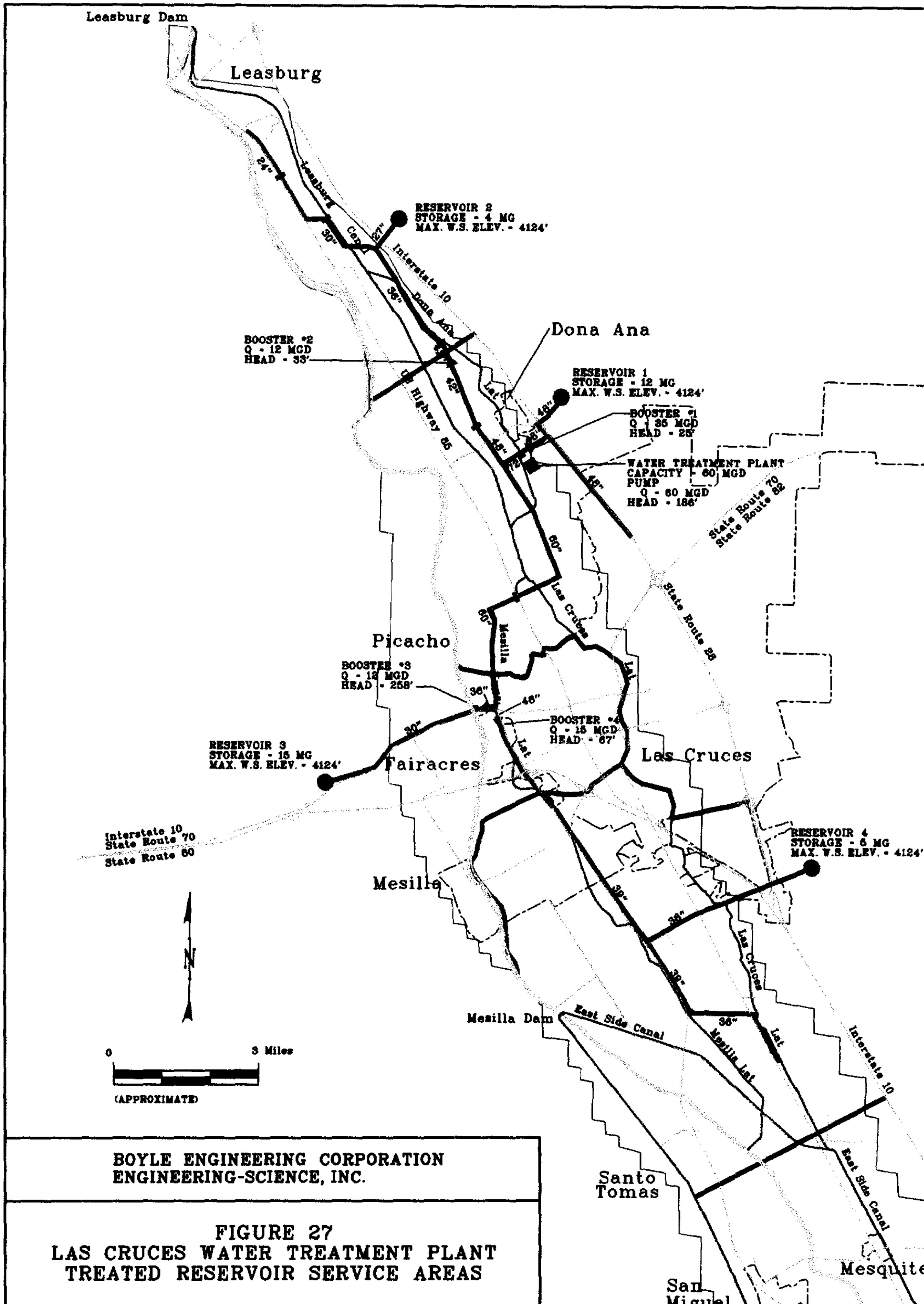

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FIGURE 27
LAS CRUCES WATER TREATMENT PLANT
TREATED RESERVOIR SERVICE AREAS

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Phased Development Plan for Las Cruces

A goal of this study was to develop a plan for providing surface water for municipal development that would be as compatible as possible with the current and anticipated future water system of the City of Las Cruces. The phased development plan presented here can deliver treated surface water to the City of Las Cruces at points designated by the 1988 Water System Master Plan (Leedshill-Herkenhoff, Inc., 1988) for development of well fields. This treated surface water can be delivered at pressures compatible with the existing.

The delivery system could be constructed in phases as the need for facilities arises. This also allows for modification of alignments, sizing, and phases of development as data becomes available and as the future becomes more clearly defined. Three main development phases are identified in this section. Within each phase, construction of many of the facilities can be deferred until they are actually needed. The estimated construction costs presented must be viewed as reconnaissance level only.

2015 Facilities

This phase will provide treated surface water to meet the increased demand expected in the Las Cruces area by the year 2015. The facilities to be constructed in this phase include a 25 MGD water treatment plant, 22 MG of treated water storage in reservoirs, and main lines as shown in Figure 28. The treatment plant should be planned for the ultimate capacity and the necessary land purchased to accommodate plant improvements and future expansion. The figure shows the estimated finished water storage elevation for the reservoirs constructed in this phase. Booster pump stations will be required at the water treatment plant and at other locations (as shown) to deliver water to the storage reservoirs during off peak hours. In addition, the Dona Ana Lateral would be concrete lined and enlarged slightly to carry the ultimate capacity of 300 cfs.

The 2015 facilities can provide treated surface water directly to the City of Las Cruces and Dona Ana. The communities of Mesilla, Mesilla Park, and Tortugas can be served indirectly through the Las Cruces water system; however, the amount of water that can be supplied to these communities will be constrained by the conveyance capacity of the Las Cruces system. The 2015 system would have a capacity to serve approximately 103,000 people at the current per capita use for Las Cruces of 242 gal/day or 156,000 people at the 160 gal/day expected target consumption. The estimated cost for the construction of the 2015 facilities is approximately $130.1 million as detailed in Table 15.

These costs, as well as the other costs presented in the following discussions of water treatment and transmission facilities, are based on unit cost values from the Cost Basis Memorandum in Appendix B. The unit cost for water treatment plant construction in the memorandum was based on projections of costs for facilities similar to the JWRWTP in El Paso. It is, therefore, conservatively high. Actual construction cost for the slightly simpler process train required for the softer Caballo Reservoir supply may be somewhat less, and the water treatment plant costs in Table 15, 16, 18, and 19 are probably conservatively high.

It is expected that the water treatment plant will need to be brought on line before 2015 to provide the demands projected in the 2005 planning horizon of the 1988 Las Cruces Water System Master Plan. The recommended development for the water treatment plant and the distribution system for the year 2005 are shown in Figure 29. The estimated cost for this development is included in the cost estimate for the 2015 phase.

Table 15
Construction Costs for Las Cruces, 2015

Facilities	Incremental Cost $(Millions)	Total Cost $(Millions)
Land	1.0	1.0
Water Treatment Plant	34.3	34.3
Distribution System	28.2	28.2
Pumps	10.8	10.8
Reservoirs	8.0	8.0
Subtotal	82.3	82.3
Construction Contingency (20%)	16.3	16.3
Construction Cost Total	98.5	98.5
Contractor Profit (12%)	11.8	11.8
Unknown Field Conditions (5%)	4.9	4.9
Engineering and Admin. (15%)	14.8	14.8
Total	**130.1**	**130.1**

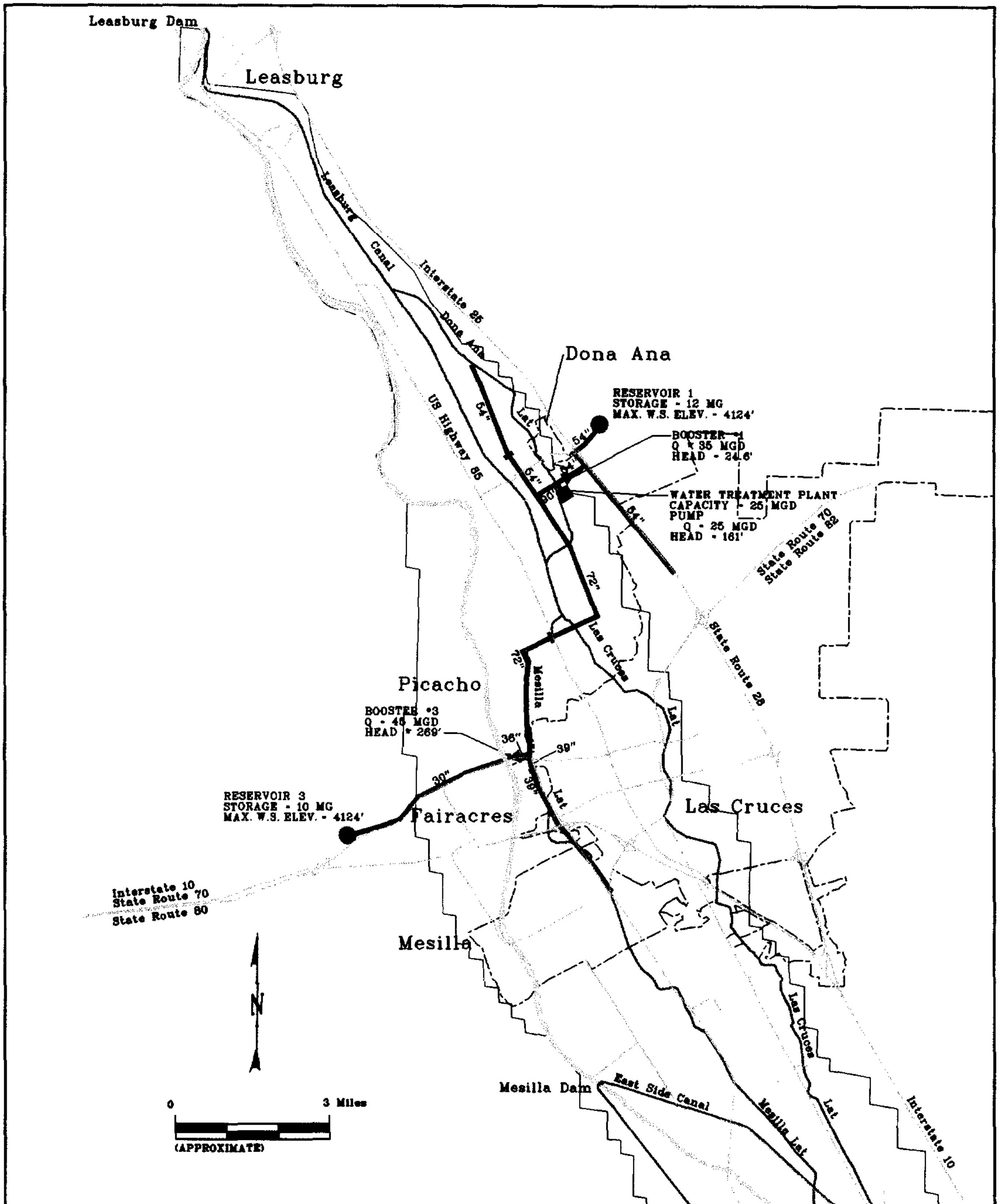

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FIGURE 28
LAS CRUCES WATER TREATMENT PLANT AND 2015 DISTRIBUTION SYSTEM

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2035 Facilities

Phase II facilities would provide mainlines for service to the balance of the northern half of the Mesilla Valley from Santo Tomas to Leasburg as shown in Figure 30. The water treatment plant would be upgraded to 60 MGD capacity. This could be done more efficiently and more cost effectively if the plant is planned for expansion and the necessary land is purchased as indicated in the 2015 facilities. The figure shows the location of the storage reservoirs, their elevations, and their necessary capacities. Additional storage of 14 MG would also be needed to meet peak hour demands. Booster pump stations will be required at the water treatment plant and at other locations as shown in the figure. These facilities would have a capacity to serve approximately 375,000 people, assuming 160 gal/day/person demands. Total cost of the 2035 facilities is estimated at approximately $242.1 million as detailed in Table 16. This will require an additional $112.0 million additional expenditure upon the completion of the 2015 facilities.

Table 16
Construction Costs for Las Cruces, 2035

Facilities	Incremental Cost Millions	Total Cost Millions
Land	0.0	1.0
Water Treatment Plant	47.8	82.1
Distribution System	12.9	41.1
Pumps	6.6	17.4
Reservoirs	3.6	11.6
Subtotal	70.9	153.2
Construction Contingency (20%)	14.2	30.4
Construction Cost Total	85.1	183.6
Contractor Profit (12%)	10.1	21.9
Unknown Field Conditions (5%)	4.2	9.1
Engineering and Admin. (15%)	12.6	27.4
Total	**112.0**	**242.1**

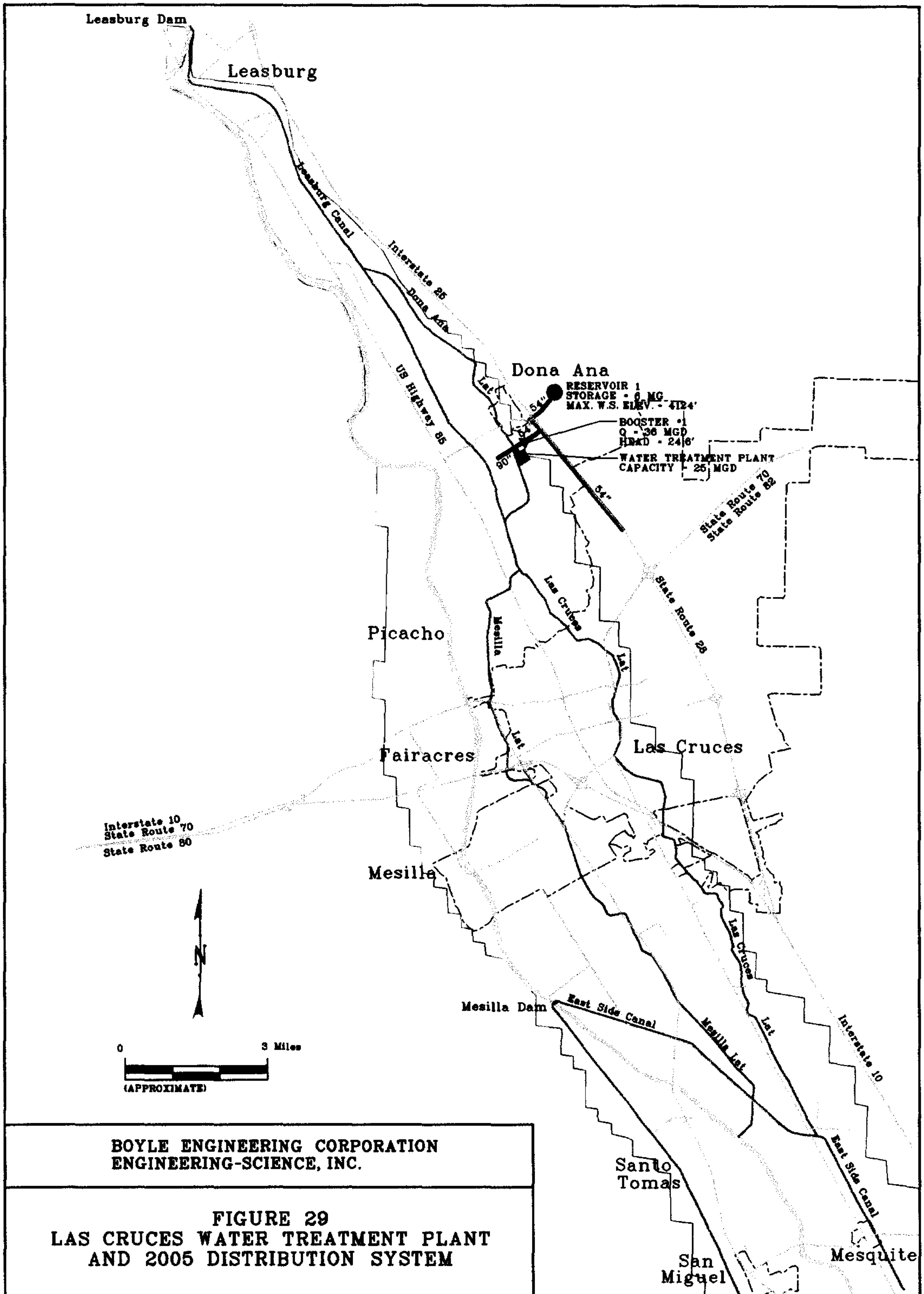

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FIGURE 29
LAS CRUCES WATER TREATMENT PLANT
AND 2005 DISTRIBUTION SYSTEM

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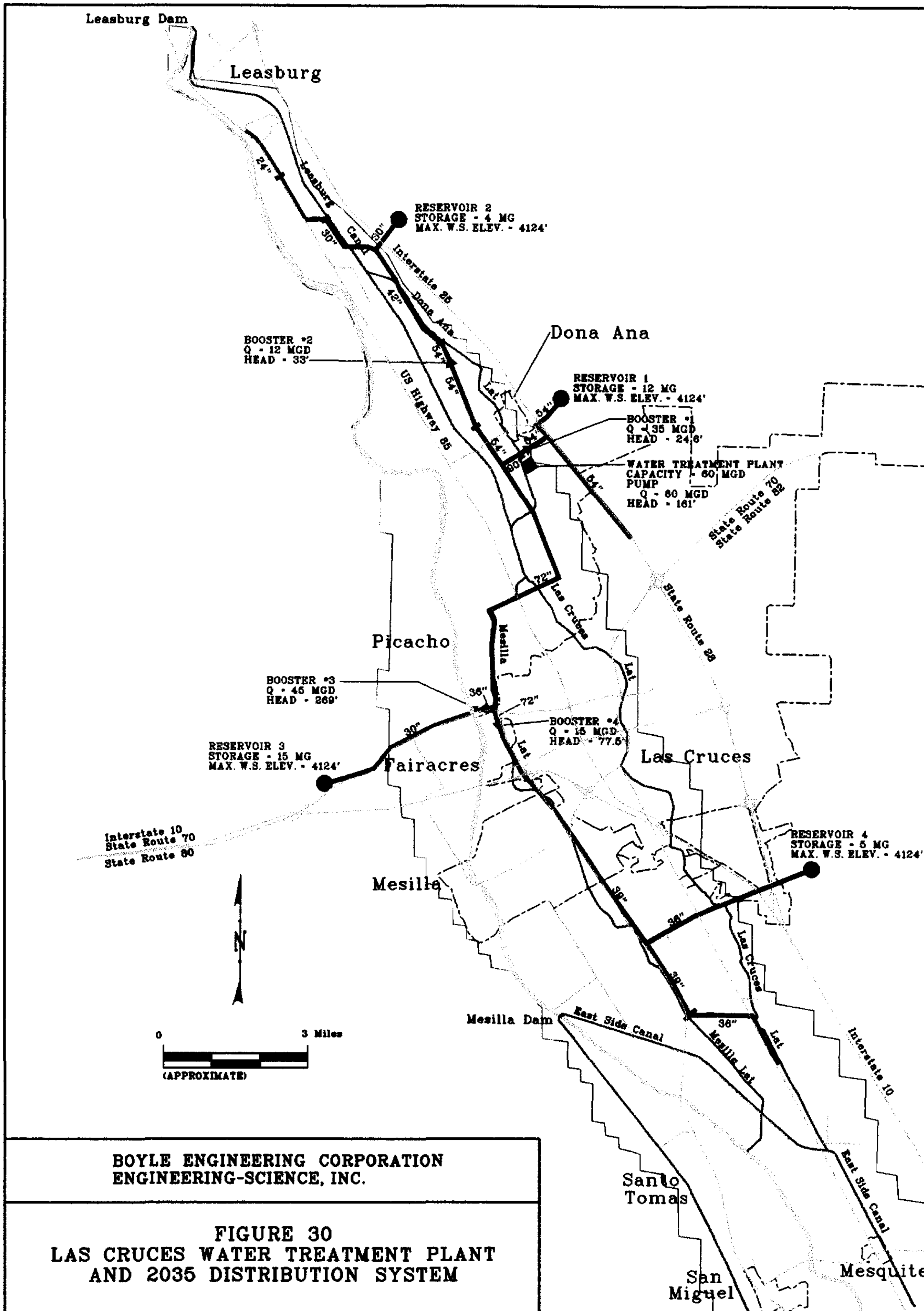

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FIGURE 30
LAS CRUCES WATER TREATMENT PLANT
AND 2035 DISTRIBUTION SYSTEM

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Ultimate Facilities

Much larger or ultimate facilities may become necessary when demands begin to exceed the capacity of the previous phase delivery system. Conversion to total M&I demand would increase the size of the water treatment plant to roughly 190 MGD, increase the size of the storage reservoirs to a total of 107 MG, and require that either the pipelines be replaced to the ultimate capacity requirements, or that parallel lines be run to meet the demand. Figure 31 shows the locations, elevations, and capacities of the storage reservoirs, the diameters of the pipelines should single pipelines be built, and the locations and sizes of the booster pumps necessary to deliver water to the storage reservoirs. These facilities would have the capacity to serve a population up to 1,200,000 people depending upon the actual per capita use.

Anthony Regional Treatment Plant and Distribution System

This section discusses treatment of surface water and treated water transmission lines for the southern portion of the Mesilla Valley including areas from La Mesa and Mesquite to the American Dam. The City of El Paso is the major municipality and extends northward into the southern portion of the Mesilla Valley. Potable water systems are associated with other smaller communities within the valley. All of the smaller communities in the study area currently depend exclusively on a groundwater supply. The City of El Paso is by far the largest supplier of municipal water in the area and currently treats surface water taken from the Rio Grande during irrigation season at two treatment plants, the JWRWTP and the Robertson-Umbenhauer Water Treatment Plant. Other municipal water suppliers in the southern Mesilla Valley include, but are not necessarily limited to the following:

- Anthony City
- Las Mesa Mutual Domestic Water Consumers Association
- Mesquite Mutual Domestic Water Consumer Association
- Westway Water Control and Improvement District
- Great Southwest Water Company
- Vinton Mobile Home Park
- Mayfair No. 5 Subdivision
- La Tuna Correctional

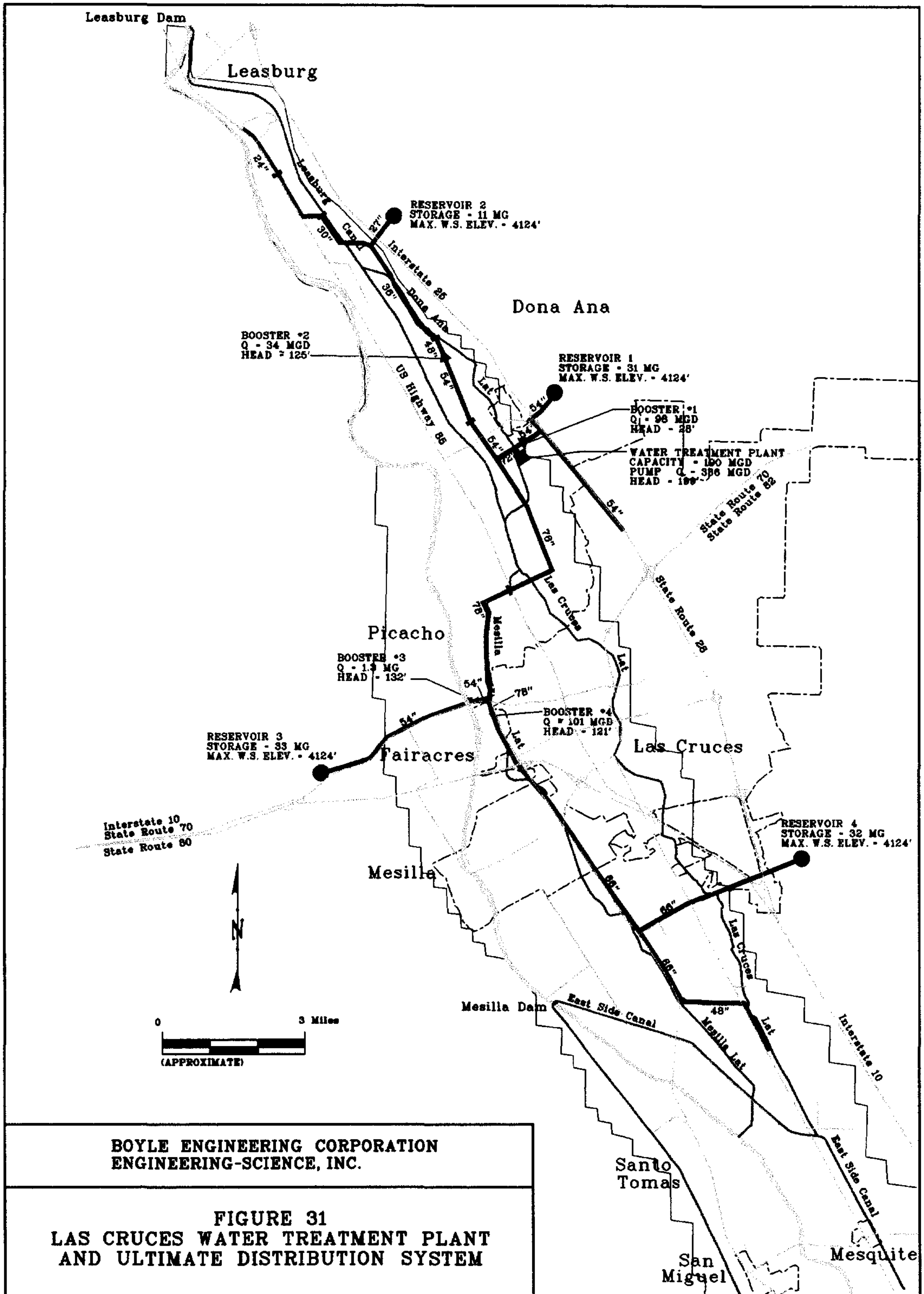

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FIGURE 31
LAS CRUCES WATER TREATMENT PLANT
AND ULTIMATE DISTRIBUTION SYSTEM

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- Hillside Mobile Home Park
- Gaslight Square Mobile Home Park

These smaller water systems generally consist of one or two wells, one or two small storage reservoirs, and a limited network of smaller diameter pipelines for distribution.

The City of El Paso's water supply lines extend northward into the study area, with a 60 inch pipeline extending along the Vinton Lateral just south of the water treatment plant.

Water Treatment Plant

As indicated above, surface water from the Rio Grande will require treatment before it can be used for M&I purposes. After careful consideration of siting factors, the recommended location for the Anthony Regional Treatment plant is on the Vinton Lateral at the junction with the Nemexas Drain. This location is relatively flat agricultural land centrally located within the region as shown in Figure 32. Water can be returned to the river down the Nemexas Drain when required. This site is also close to Vinton Bridge for delivery to a storage reservoir in the foothills east of the river to stabilize pressure head for the delivery system. The plant can be supplied from the Vinton Lateral served by the La Union East Lateral of the West Side Canal. However, these laterals will need to be lined and enlarged for delivery of the ultimate raw water demand.

The plant would be located sufficiently far outside of the Rio Grande floodplain to prevent flooding of the facility. The land is relatively flat and suitable for the layout of a large facility.

Distribution System

The study area was divided into three reservoir service areas for estimation of required pipeline conveyance and reservoir storage capacities (see Figure 32). The average day and maximum day demands were computed as shown in Table 17. Maximum hour demands were assumed to be met totally by the connecting systems.

Main distribution lines were designed to deliver maximum day demands from the water treatment plant and nearby wells to the connection nodes. The storage reservoirs are intended for flow and pressure regulation only.

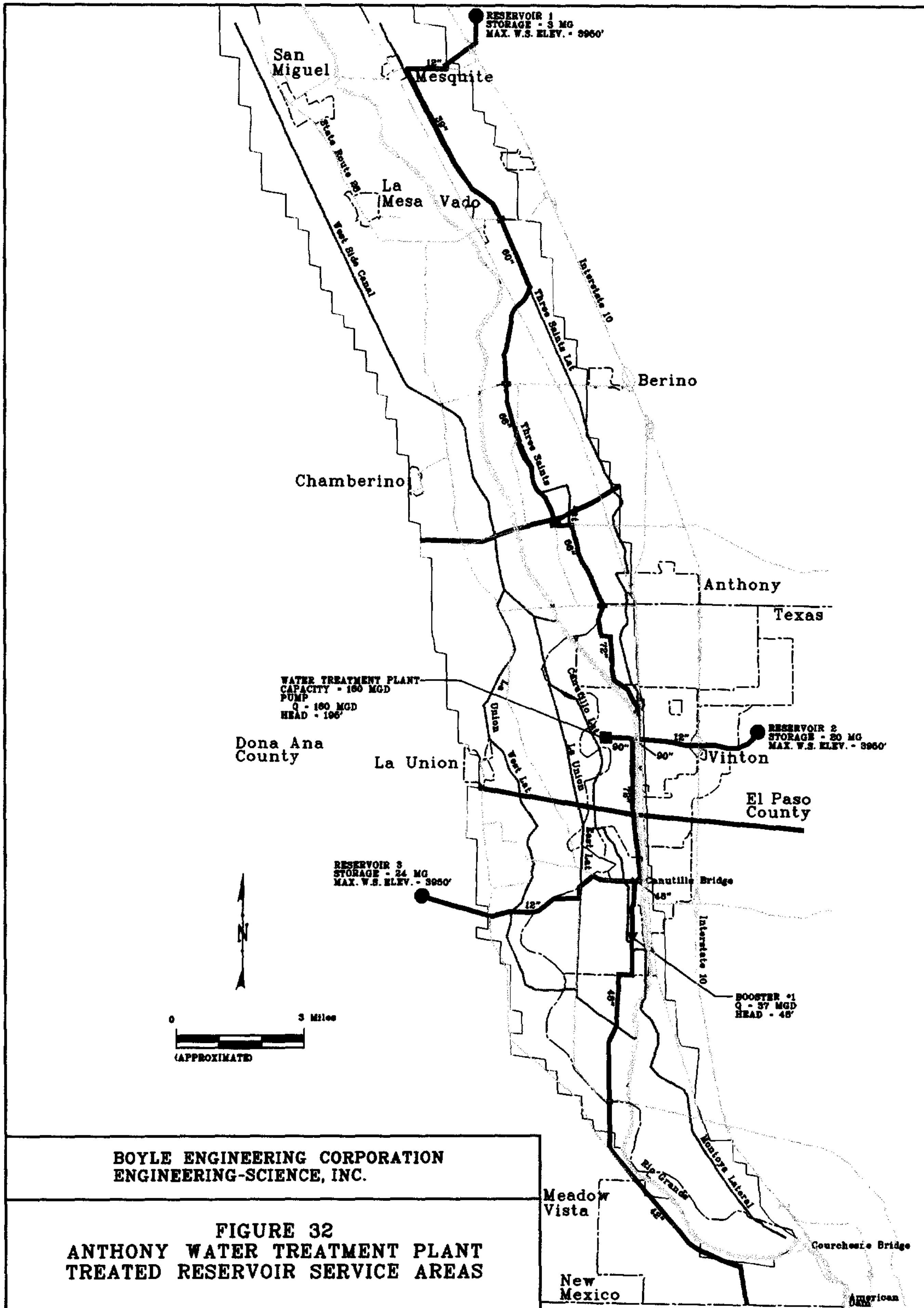

FIGURE 32
ANTHONY WATER TREATMENT PLANT
TREATED RESERVOIR SERVICE AREAS

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Maximum hour demands would not be met by these reservoirs. Providing for peak-hour demands will be the responsibility of the connecting entities.

Table 17
Average and Maximum Daily Demands for Anthony Plant

	2035		Ultimate	
Reservoir Sub-Area	Average Demand MGD	Maximum Demand MGD	Average Demand MGD	Maximum Demand MGD
1	4	7	75	150
2	32	63	77	153
3	59	117	59	117

Phased Development Plan for Anthony

A goal of this study was to develop a plan for providing surface water for municipal development that would be as compatible as possible with the current and anticipated future water system of the New Mexico and Texas entities. The phased development plan presented here can deliver treated surface water to the existing and planned delivery systems in the region. This treated surface water can be delivered at pressures compatible with the existing system.

The delivery system could be constructed in phases as the need for facilities arises. This also allows for modification of the alignments, sizing, and phases of development as data become available and as the future becomes more clearly defined. Three main development phases are identified in this section. Within each phase, construction of many of the facilities can be deferred until they are actually needed. The estimated construction costs presented must be viewed as reconnaissance level only.

2015 Facilities

This phase will provide treated surface water to meet the increased demand expected in the Anthony, Texas and Anthony, New Mexico areas by the year 2015. The facilities to be constructed in this phase include a 105 MGD water treatment plant, 44 MG of treated water storage in reservoirs, and main distribution lines as shown in Figure 33. The storage reservoirs shown in the figure for 2015 are the same size as for 2035. This storage will be needed to stabilize the pressure and flows to Mexico and meet the expected Texas and

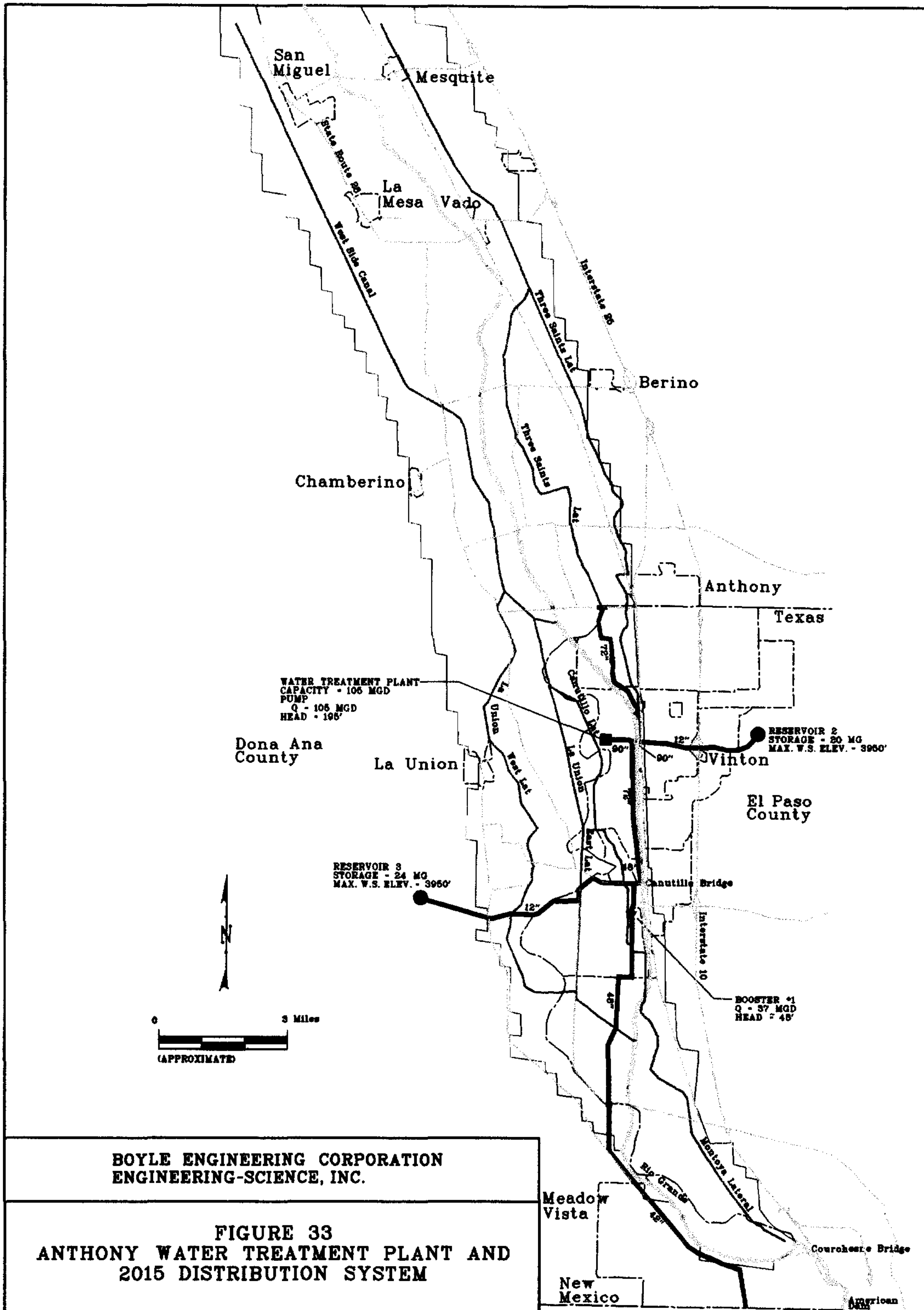

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FIGURE 33
ANTHONY WATER TREATMENT PLANT AND 2015 DISTRIBUTION SYSTEM

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New Mexico demands. The treatment plant should be planned for the ultimate capacity and the necessary land purchased to accommodate plant improvements and future expansion. The figure shows the estimated water storage elevation for the reservoirs constructed in this phase. Booster pump stations will be required at the water treatment plant and at other locations (as shown) to deliver water to the storage reservoirs during off peak hours. In addition, the Vinton Lateral should be concrete lined and enlarged slightly to carry the ultimate capacity of 480 cfs or 305 MGD.

The 2015 facilities can provide treated surface water directly to the existing Texas mainlines, provide treated water for the southern end of this region within New Mexico, and deliver the 60,000 af of treated water at a constant rate of 53.6 MGD to Ciudad Juarez at the new border crossing near Anapra. The 2015 system would have a capacity to serve approximately 321,000 people in Texas and New Mexico at the 160 gal/day expected consumption. The estimated cost for the construction of the 2015 facilities is approximately $310.1 million as detailed in Table 18.

Table 18
Construction Costs for Anthony, 2015

Facilities	Incremental Cost $(Millions)	Total Cost $(Millions)
Land	2.0	2.0
Water Treatment Plant	143.6	143.6
Distribution System	23.7	23.7
Pumps	14.7	14.7
Reservoirs	12.1	12.1
Subtotal	196.1	196.1
Construction Contingency (20%)	38.8	38.8
Construction Cost Total	234.9	234.9
Contractor Profit (12%)	28.2	28.2
Unknown Field Conditions (5%)	11.7	11.7
Engineering and Admin. (15%)	35.2	35.2
Total	**310.1**	**310.1**

It is expected that the water treatment plant will need to be brought on line before 2015 to provide the demands projected in the 2005 planning horizon. The recommended development for the water treatment plant and the distribution system for the year 2005 is shown in Figure 34. The estimated cost for this development is included in the cost estimate for the 2015 phase.

2035 Facilities

The 2035 facilities would provide main distribution lines for service to the balance of the southern half of the Mesilla Valley from the New Mexico-Texas border to Mesquite as shown in Figure 35. The water treatment plant would be upgraded to a 160 MGD capacity. This could be done more efficiently and more cost effectively if the plant is planned for expansion and the necessary land is purchased as indicated in the 2015 facilities. The figure shows the location of the storage reservoirs, their elevations, and their necessary capacities. Additional storage of 3 MG would also be needed to meet peak hour demands. Booster pump stations will be required at the water treatment plant and at other locations as shown in the Figure 35. These facilities would have a capacity to serve approximately 665,000 people in Texas and New Mexico, assuming 160 gal/day/person demand. Total cost of the 2035 facilities is estimated at approximately $466 million as detailed in Table 19. This will require an additional $155.9 million additional expenditure upon the completion of the 2015 facilities.

Table 19
Construction Costs for Anthony, 2035

Facilities	Incremental Cost $Millions	Total Cost $Millions
Land	0.0	2.0
Water Treatment Plant	75.4	219.0
Distribution System	16.2	39.9
Pumps	5.6	20.3
Reservoirs	1.4	13.5
Subtotal	98.6	294.7
Construction Contingency (20%)	19.7	58.5
Construction Cost Total	118.3	353.2
Contractor Profit (12%)	14.1	42.3
Unknown Field Conditions (5%)	5.9	17.6
Engineering and Admin. (15%)	17.6	52.8
Total	**155.9**	**466.0**

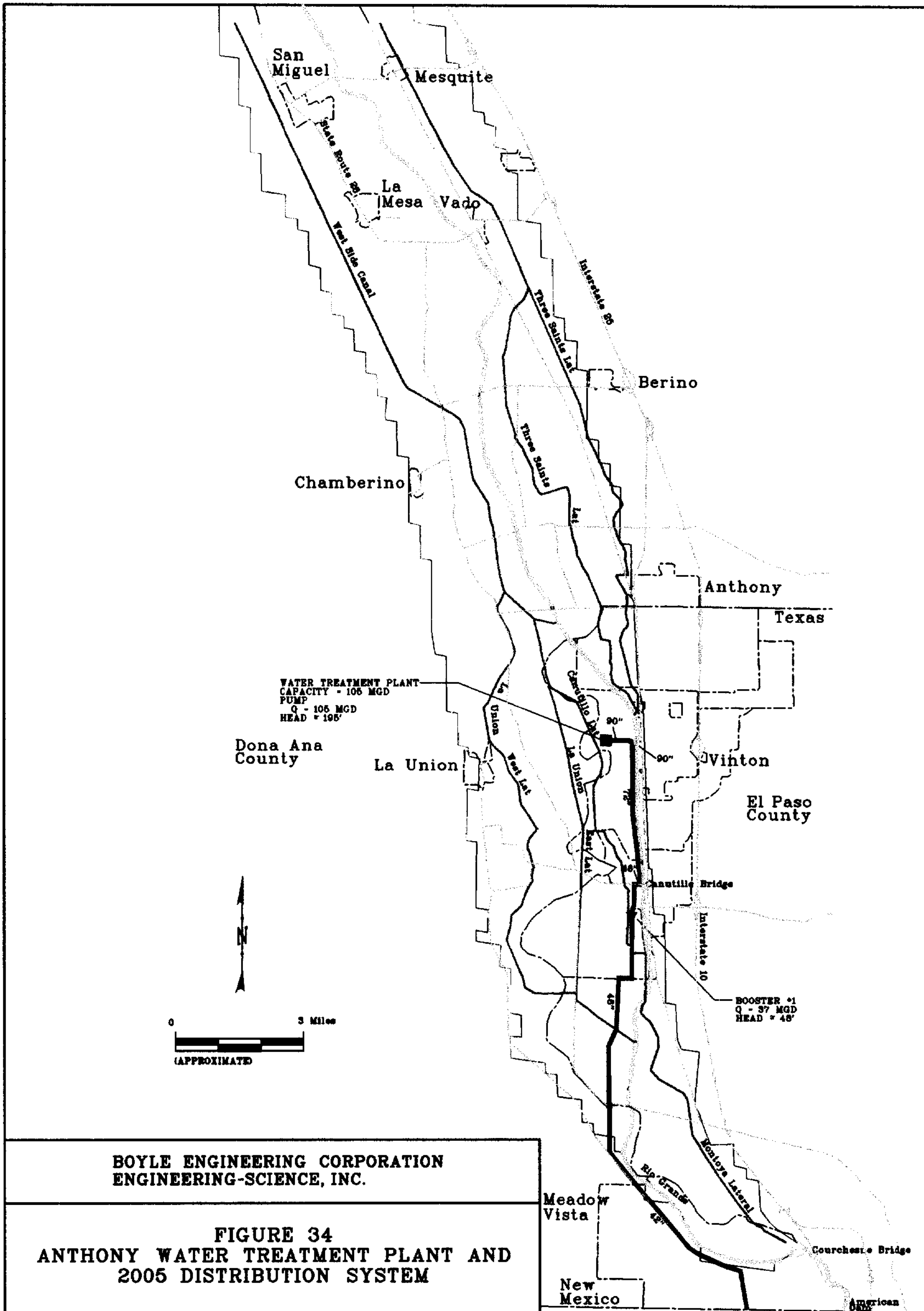

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FIGURE 34
ANTHONY WATER TREATMENT PLANT AND
2005 DISTRIBUTION SYSTEM

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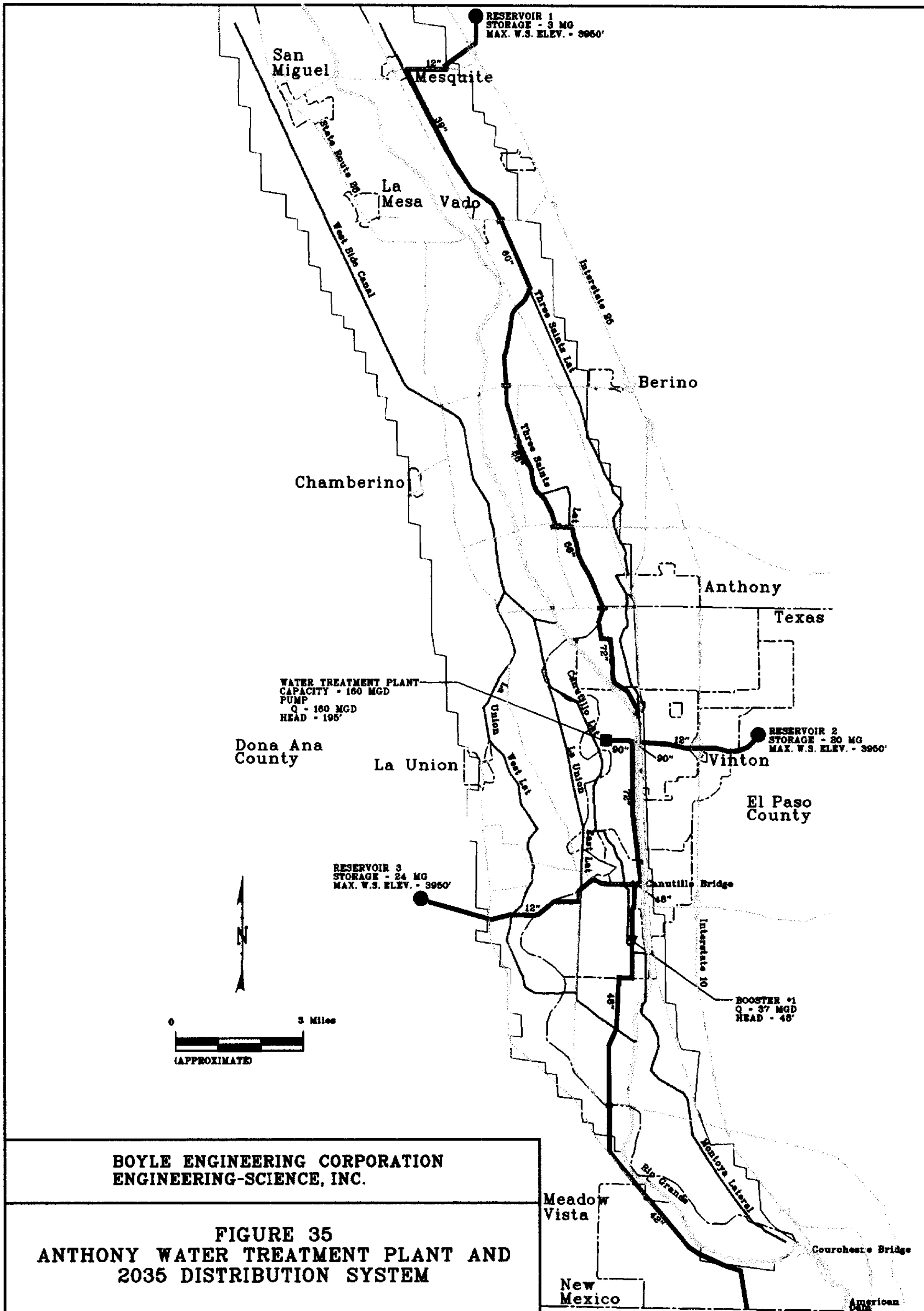

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FIGURE 35
ANTHONY WATER TREATMENT PLANT AND
2035 DISTRIBUTION SYSTEM

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Ultimate Facilities

Larger or ultimate facilities may eventually become necessary if demands begin to exceed the capacity of the 2035 phase delivery system. This phase would increase the size of the water treatment plant to roughly 305 MGD, would increase the size of the storage reservoirs to a total of 82 MG, and would require that either the pipelines be replaced to the ultimate capacity requirements, or that parallel lines be installed to meet the demand. Figure 36 shows the locations, elevations, and capacities of the storage reservoirs, the diameters of the pipelines should single pipelines be built, and the locations and sizes of the booster pumps necessary to deliver water to the storage reservoirs. These facilities would have the capacity to serve a population up to 1,570,000 people in New Mexico and Texas depending upon the actual per capita use.

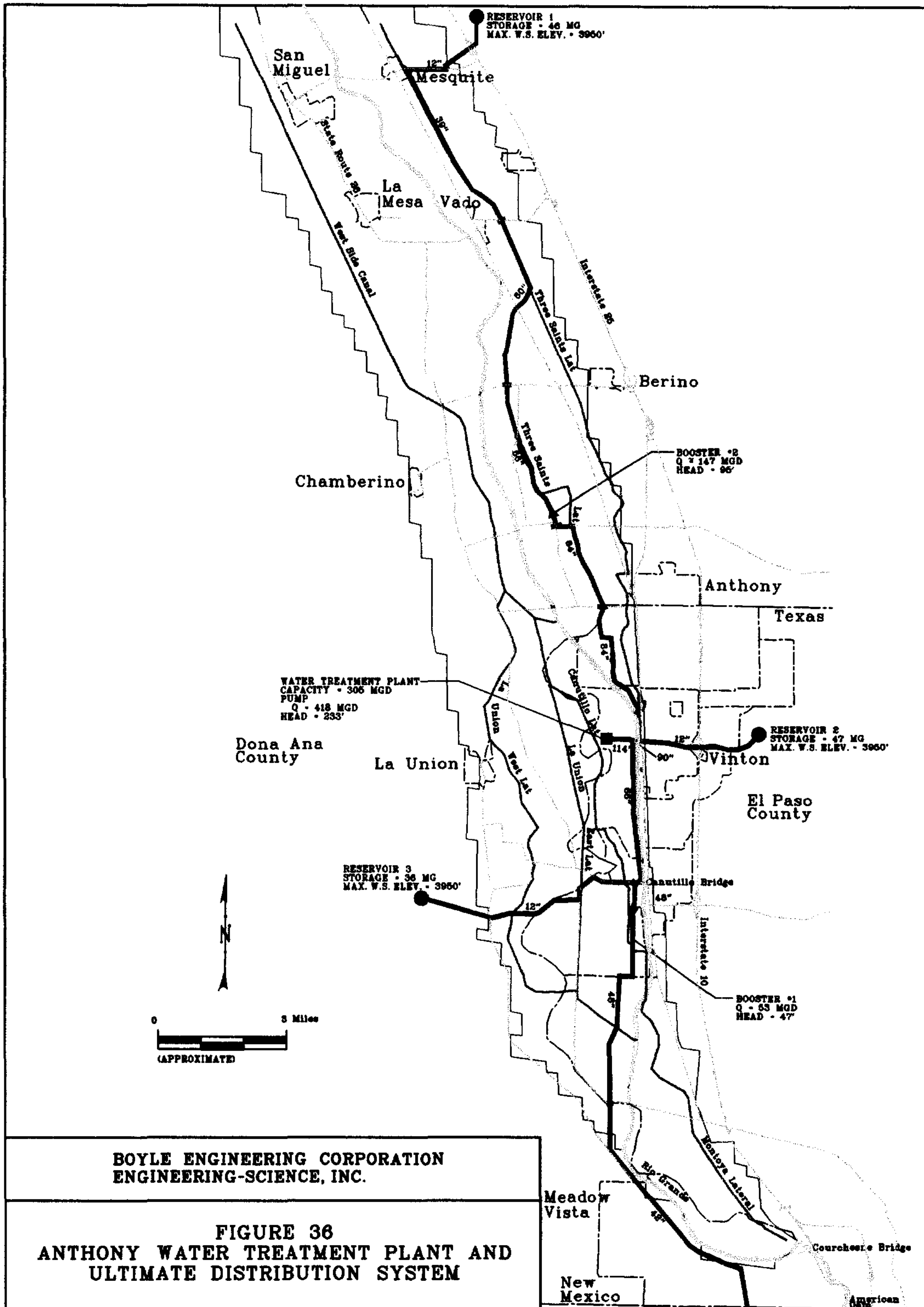

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FIGURE 36
ANTHONY WATER TREATMENT PLANT AND ULTIMATE DISTRIBUTION SYSTEM

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Water Budget Analysis

Introduction

In order to assess the impacts of the three proposed alternatives on the Rio Grande hydrologic system, water budgets were developed from just downstream of the Caballo Dam to upstream of the American Dam. Since it is desired to investigate the impacts of the alternatives on water quality, the balances are also used to perform mass budgets of total dissolved solids (TDS).

The study area is divided into two reaches—the Rincon Valley and the Mesilla Valley. The Rincon Valley reach (or Reach 1) extends from below Caballo Dam to upstream of the Leasburg Dam, and the Mesilla Valley reach (Reach 2) includes the Leasburg Dam and runs to upstream of the American Dam. For each of the reaches, spreadsheets are used to perform the water balances.

Three water supply scenarios representing historical hydrologic conditions were developed for each of the balances. This was accomplished by arranging releases from Caballo Reservoir for the years 1938 through 1993 in increasing order. The years with the lowest releases from Caballo Reservoir were classified as "Dry" years. The years with the highest releases were termed "Normal" years, and the years between the "Dry" and "Normal" years were labeled the "Average" years. Each of the periods, "Dry," "Average," and "Normal" contained one-third of the years from 1938 to 1993. Three representative years were then selected from within each range as follows: 1951, 1967 and 1971 as "Dry" years; 1970, 1980, and 1984 as "Average" years; and 1988, 1989, and 1993 as "Normal" years. Using three years for each water supply scenario reduces the effect of any data anomalies one year might contain and produces a more representative estimate of hydrologic conditions.

The water supply scenarios reflect only different hydrologic conditions. In order to eliminate time-varying characteristics, such as population and demand growth in the comparison between alternatives, representative values for these time-variant parameters were used for each year. For example, to eliminate the effect of an increasing population over time, a constant M&I demand is used for all years.

Four cases were simulated for each of the three hydrologic scenarios: Baseline, Alternative 1, Alternative 2, and Alternative 3. The Baseline case simulated "Dry," "Average," and "Normal" years under existing operating conditions, while the simulations for each of the alternatives represented conditions with the corresponding alternatives in place.

The water budget analysis provides a means of comparing system wide impacts of the various alternatives. In order to construct the water and mass balances, many assumptions were made on the hydrologic characteristics and operations within the study area. While the results of this analysis provide a useful and valid method of comparison for the alternatives, the results should not be extended beyond the scope of their intent. The results should not be used to make design or operating decisions. Since some variables were modified to provide a consistent comparison among the water supply scenarios and the alternatives and, further, only a relatively short period of time was used in the analysis, the results do not represent an historic water and mass balance of the system.

Methodology

For each reach and each water supply scenario ("type" of year), there are water balances which address the alluvial aquifer, the river, and the land and TDS mass balances for the river.

Since each alternative is compared with the Baseline case in order to assess its impacts, it is necessary to assume that historical conditions in the Rincon and Mesilla Valleys do not change with the implementation of the alternatives. Thus, historical irrigation and municipal and industrial demands will continue to be applied and be satisfied through the facilities available in the Baseline case.

However, each alternative will be able to satisfy additional demands downstream of American Dam. The water demands estimated in the year 2015 are used for each of the alternatives. These demands were supplied by the EPWU and found in the *El Paso Water Resources Management Plan Study, Phase I Completion Report (Reference 1) Facilities Master Plan (Reference 27).*

The estimated 2015 agricultural water demands downstream of American Dam are assumed to be the demands for the "Average" water supply scenario. To obtain the agricultural demands for the "Dry" scenarios, the "Average" annual demand is multiplied by the ratio of the "Dry" year agricultural water demand and the "Average" year demand in Reach 2. To obtain the agricultural demands for the "Normal" scenarios, the ratio of the "Normal" year agricultural water demand and the "Average" year demand is multiplied by the "Average" annual demand. These ratios were determined to be 0.8 and 1.12, respectively. It is assumed that M&I demands would not change for different hydrologic conditions.

Baseline

The Baseline case is developed using data from historical records for each water supply scenario. Where complete data are not available, estimates of missing data are made using existing data or information from studies. The Baseline case is compared to each alternative to assess the impacts of implementing the alternatives on river flow, return flows, diversions, water quality, etc. The Baseline case also provides the foundation for each of the alternatives. Changes are made to the Baseline case in order to reflect the operation of the alternatives.

Once values have been input and the calculations performed for each of the balances and for each of the study years, the results from the three years forming each water supply scenario are averaged. Thus, balances representing average "Dry", "Average", and "Normal" periods are produced. The mass balances and water budgets are balanced based on these average balances.

In order to balance the Baseline case, certain assumptions were made as follows:

- There is no change in water storage in the land spreadsheet. Thus, total inflow to the land equals total outflow from the land in each reach.
- There is no change in water storage in the river. Total inflow into the river in a reach equals the total outflow from the river in the same reach. The net river seepage is adjusted so that this assumption is satisfied. Thus, a positive net river seepage indicates a river loss to the alluvial aquifer, while a negative river seepage corresponds with a river gain from the alluvial aquifer.
- There is no change in the TDS mass of the Rio Grande. The total mass inflow into the river in a reach equals the total mass outflow from the river in the same reach. In the alternatives, the outflow of mass from each reach is unknown, and the balances are adjusted to solve for it.
- There is no change in water storage in the alluvial aquifer in the Mesilla Valley (Reach 2). In this case, the net leakage to the Mesilla Basin was adjusted to solve the balance. Due to the alluvial aquifer's hydraulic connection to the Mesilla Basin, the ground water level of the alluvial aquifer is assumed not to change in the Mesilla Valley. Any changes in flow to or from the alluvial aquifer is reflected in a similar change in the flow to or from the Mesilla Basin.

- A change in storage in the alluvial aquifer occurs in Reach 1 since it is not connected to another aquifer.

Once the Baseline case is balanced, the "Dry," "Average," and "Normal" year spreadsheets are used to develop the balances for the proposed alternatives. Many of the quantities and assumptions made in balancing the Baseline case are also used in balancing the alternatives. The following discussions will focus primarily on differences from approaches and assumptions used in balancing the Baseline case.

Alternative 1

This alternative consists of a new open conveyance channel that would transport water for the EPCWID#1, Mexico, and the City of El Paso. The conveyance canal will extend from the Percha Diversion Dam to its downstream terminus at the American Dam in El Paso.

The conveyance structure for this alternative is a concrete-lined, trapezoidal canal designed for gravity flow. It will be isolated from the Rio Grande flows, return flows from agricultural lands, municipal and industrial wastewater discharges, and storm water runoff inflows within each reach.

Within the Rincon Valley, there are assumed to be no changes in municipal and industrial use or agricultural use. A new water treatment plant would be constructed at Anthony in the Mesilla Valley reach and would take water from the new conveyance channel for M&I use by El Paso Water Utilities, Mexico, and southern New Mexico. The conveyance channel would also carry water to the American Canal for use by El Paso Water Utility (EPWU) and for irrigation downstream of the American Dam.

The amount of water to be diverted into the new conveyance channel is determined by the estimated 2015 demands for agricultural and M&I uses downstream of American Dam and M&I uses in Reach 2. At times, the historical flows available in the river are not adequate to meet projected demands. If there is a lack of available water to meet the full demand, the water released into the new conveyance canal is adjusted in several ways.

1. Caballo Dam is "operated" so more water is released in one month and less in another, but the total annual release is the same as the historical or Baseline case for each type of year. This allows the available water to be used efficiently by retaining water in months when there is a sufficient supply to meet demands and releasing a similar quantity of water in months when the historical supply will not meet demand.

2. If the reservoir operation can not provide the users with a full supply of water, the amount of water delivered to the entities is reduced. Ground water pumping would be used to provide water necessary to meet the unfilled demand.

3. In some months the available water supply may be so little that all water could be used to meet demands, leaving no water in the river. To prevent the river from "drying up," the canal releases were adjusted so that a minimum of 1000 af/month of flow would remain in the river.

In all cases the available water is used to its maximum efficiency, but due to its scarcity, it may not be able to provide a full supply to all users in all months and years. When the Rio Grande is unable to fulfill the complete water demand, the quantity of water delivered to the various entities using the water is reduced. This deficit in surface water supply was distributed above and below American Dam using 58 and 42 percent, respectively. The deficit in supply above American Dam was distributed among surface water demands in proportion to the amount of water delivered to these demands in the baseline.

Alternative 2

This alternative involves the development of an open conveyance channel to convey flows by gravity from the Percha Diversion Dam to the historic agricultural turnouts located within the Rio Grande Project, to M&I sources in Reach 2, and to agricultural and M&I users downstream of American Dam. Since existing canals will be concrete lined, and seepage losses should be reduced. Inflows to the canal from agricultural return flows, storm runoff inflows, and municipal wastewater discharges will be prevented

Alternative 2 is assumed to operate in a manner similar to Alternative 1.

Alternative 2a, which includes blending of return flows and runoff with the canal supply was not directly addressed in the water budget.

Alternative 3

A new pipeline would be constructed under this alternative to convey water from the outlet works at Caballo Dam to the proposed Anthony water treatment plant and to El Paso. The pipeline would carry water only for M&I use in Reach 2 and downstream of American Dam. As in Alternative 1, there would be no changes in M&I or agricultural uses in Reach 1 and Reach 2.

The same procedures and assumptions were used for this alternative as for Alternative 1.

Results

The results of the water budget analysis are presented in this section. The Baseline case provides a means to estimate the effect each potential project may have on the hydrologic system in the Mesilla and Rincon Valleys. In the description of the Baseline results, the trends in each balance from one "type" of year to the next will be discussed. In the description of the alternatives, the results of the "Composite" year for each alternative will be compared to the Baseline and to each other.

The "Composite" year is the average of the "Dry," "Average," and "Normal" years. Each parameter for each of the three water supply scenarios is averaged to yield a composite parameter value and create a "Composite" year balance.

Baseline

As the availability of water from the Rio Grande increases, river flow to agriculture increases, agricultural ground water pumping decreases, drain flow increases slightly, canal and lateral seepage increases, and canal waste return increases. Tributary inflow to the river, and M&I return flow and consumptive use are assumed to remain constant for all year types. These relationships remain consistent for all the reaches and alternatives.

Deep percolation of water from the soil zone to the alluvial aquifer increases from the "Dry" to the "Average" year because more water is applied to the land in an "Average" year, but from an "Average" to a "Normal" year deep percolation decreases. It appears that more water is actually applied to the crops in an "Average" year because more ground water is used and is delivered more efficiently than water delivery via canals. Although there is more water available in a "Normal" year, more of the transported water is lost to seepage and evaporation.

There is a large increase in seepage from the river from the "Dry" year to the "Average" year, but the "Average" and "Normal" years' river seepage values are about the same. This might be explained by an increase in the wetted perimeter of the Rio Grande. A larger wetted perimeter means that there is more area for water to flow through to the alluvial aquifer. The wetted perimeter probably increases from the "Dry" to the "Average" year due to increased flow in the river, but due to the large width and flatness of the channel, the wetted perimeter increases only slightly from the "Average" to the "Normal" year. In Reach 1 water flows from the alluvial aquifer into the river (a negative river seepage), and in Reach 2 the river loses flow to the aquifer (a positive river seepage).

In Reach 1 there is a slight decrease in the amount of water stored in the alluvial aquifer in the "Dry" year because more water is withdrawn due to ground water pumping than flows into the aquifer. In the "Average" year, there is essentially no change in storage - inflows equal outflows, and in the "Normal" year when there is little ground water pumping and more seepage from the river and canals, the ground water storage increases in the alluvial aquifer. In Reach 2 it is assumed that since the alluvial aquifer is in hydraulic connection with the Mesilla Basin, any increase of flow into the alluvial aquifer would increase the flow into the Mesilla Basin and the storage in the alluvial aquifer would remain relatively constant.

In Reach 1 the total mass of TDS in the river inflow and outflow of the "Average" and "Dry" years is about the same. The "Average" year has greater flow, but the concentration of TDS is less. The "Normal" year contains a greater mass of TDS because the flow is greater and the concentration of the TDS in the water is about the same. In Reach 2 the TDS concentration in the river increases due to the inflow from drains and canal waste returns, and the mass of TDS increases as the water flow increases.

Figures 37 and 38 show the composite results of the water and mass balances for the Baseline case. The spreadsheets for each balance for each water supply scenario can be found in Appendix D.

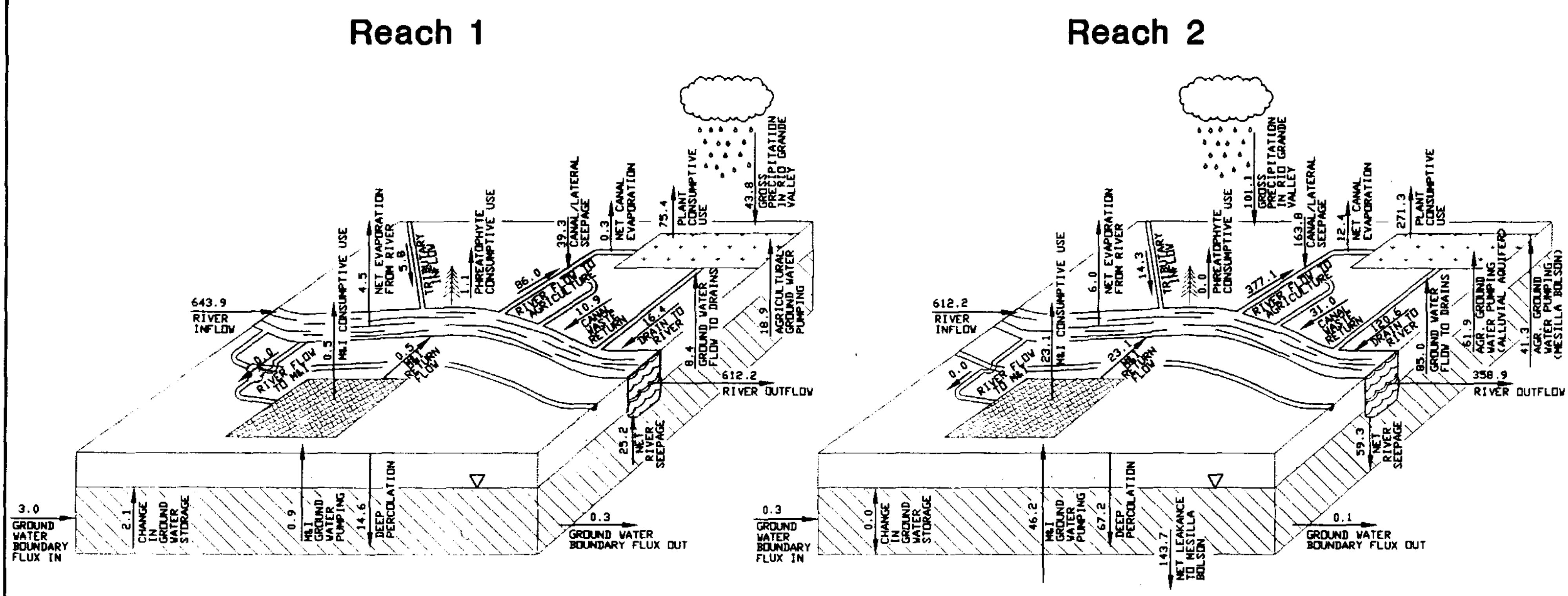
Alternative 1

Due to the proposed diversion at Percha Dam, Alternative 1 reduces river flows at Leasburg Dam from 612,200 af/year (Baseline) to 286,000 af/yr (Alternative 1), and the flow at American Dam decreases from 358,900 af/yr (Baseline) to 58,000 af/year (Alternative 1).

There is a higher concentration of TDS flowing through American Dam, but due to the low flows, the total mass of TDS is much less. The TDS concentration (600 mg/l) at Leasburg Dam is about the same for the Baseline and Alternative 1, but the TDS concentration is higher at American Dam for both cases. Alternative 1's TDS concentration increases to about 2000 mg/l whereas in the Baseline TDS concentrations increase to about 800 mg/l.

Alternative 1 supplies a full allocation of water in the "Normal" year, but not in the "Dry" and "Average" years. An additional 16,000 af/yr is needed in the "Average" year, and 158,600 af is required in the "Dry" year. It is assumed that additional water would be acquired from ground water pumping.

Water Budget - Baseline

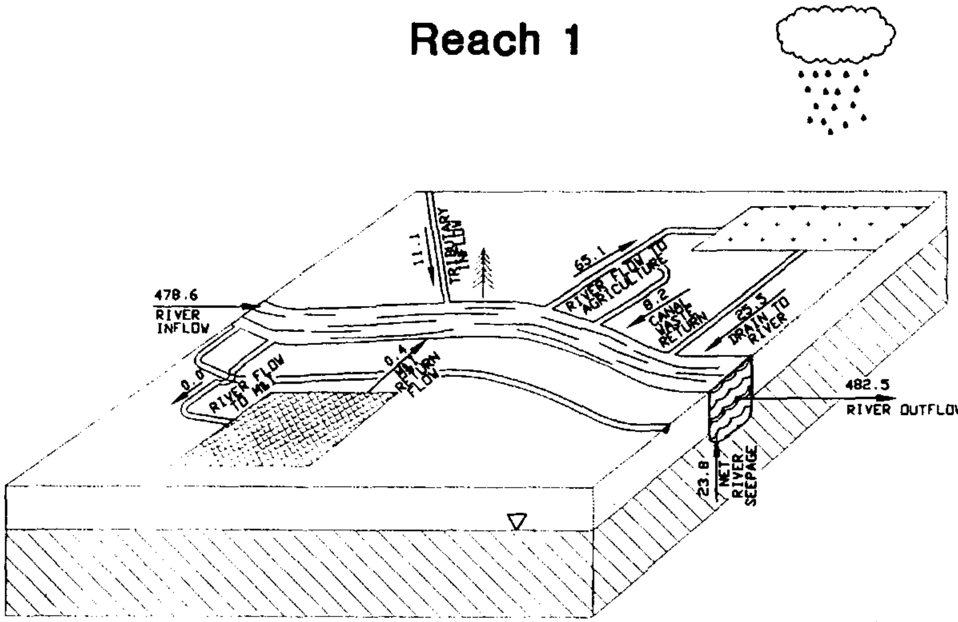


Note: All quantities are in 1000 acre-feet unless otherwise noted.

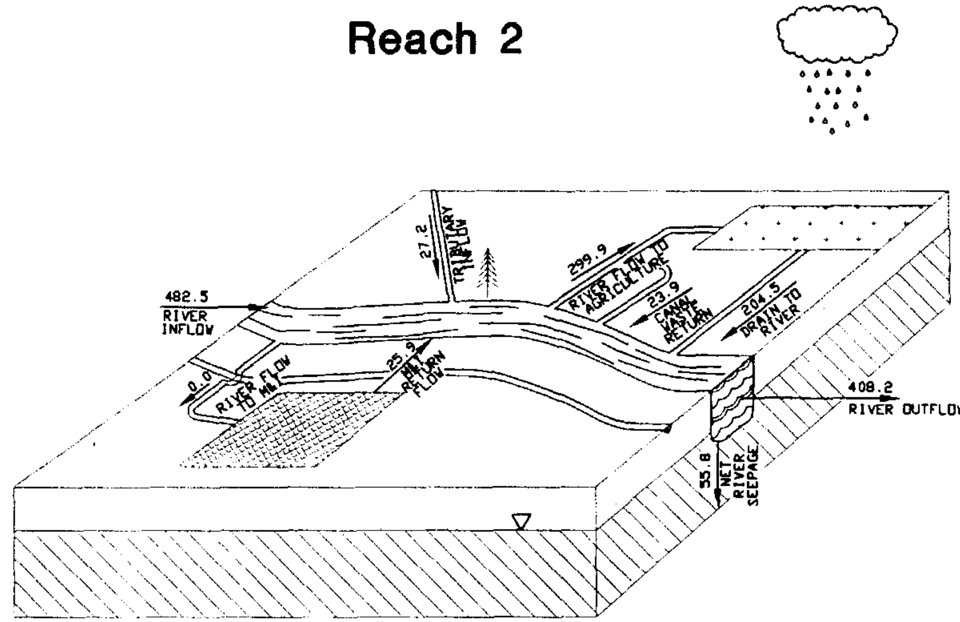
Figure 37

Total Dissolved Solids (TDS) Mass Budget - Baseline

Reach 1



Reach 2



Reach 1:

Estimated River Inflow TDS Concentration (mg/l) = 500
Estimated River Outflow TDS Concentration (mg/l) = 600

Reach 2:

Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 800

All quantities are in 1000-tons unless otherwise noted.

Figure 38

In Reach 2 ground water pumping for M&I decreases to 6,500 af/yr (Alternative 1) from 46,200 af/yr (Baseline). Corresponding to this decrease in M&I ground water pumping, canal flow to M&I increases from 0 af/yr to 39,700 af/yr.

Figures 39 and 40 show the composite results of the water and mass balances for Alternative 1. The spreadsheets for each balance for each water supply scenario can be found in Appendix D.

Alternative 2

On the average, less water flows past the headgate to agriculture in Alternative 2 compared to the Baseline. Alternative 2 lines the main canal which reduces canal seepage. Since there are less losses, less water needs to be sent to agriculture. Essentially Alternative 2 "saves" water. On the average, Alternative 2 reduces canal losses by about 13,500 af/yr in Reach 1, and in Reach 2 it reduces losses by about 20,000 af/yr.

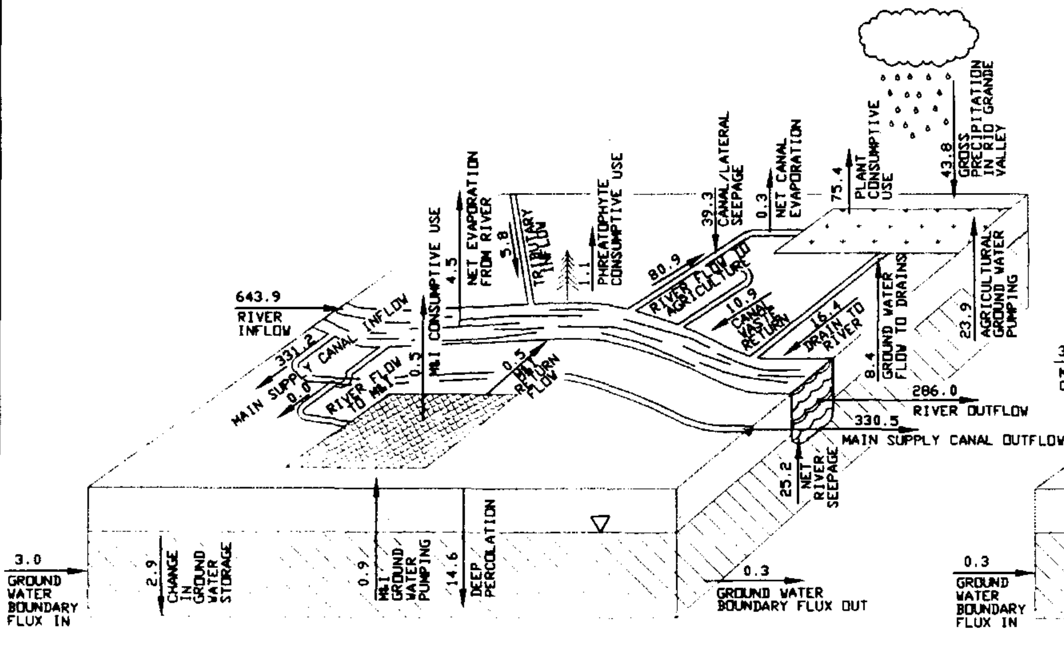
In Reach 1, due to the reduction in canal seepage and an increase in ground water pumping, there is a net loss in storage in the alluvial aquifer. The storage decreases by about 35,600 af/yr for Alternative 2 compared with an average increase in the Baseline case of 2,100 af/yr. In Reach 2, the leakage from the alluvial aquifer to the Mesilla Basin decreases by about 55,700 af/yr due to Alternative 2.

Since much of the Rio Grande flow is diverted to the new canal at Percha Dam, the composite annual flow at Leasburg is 11,900 af/yr for Alternative 2 compared to 612,200 af/yr in the Baseline case. Due to the influx of canal waste return and drain flow in Reach 2, the Rio Grande flow increases to 135,700 af/yr at American Dam for Alternative 2. Due to the consumption of river water by agriculture in Reach 2, the Rio Grande flow decreases to 358,900 af/yr in the Baseline case.

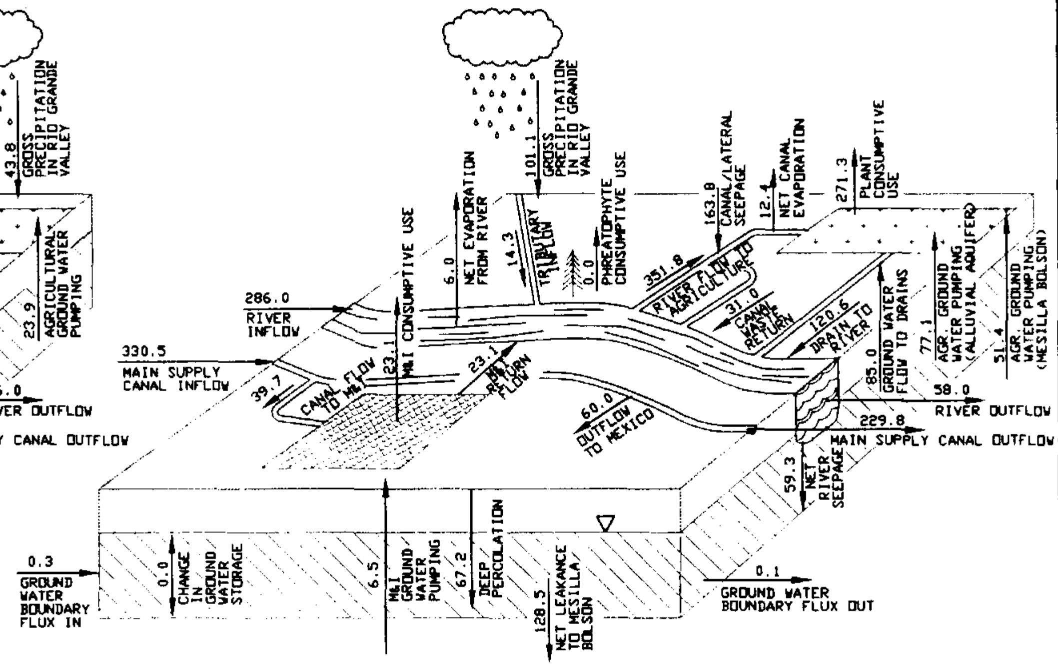
In the "Normal," "Average," and "Dry" years, it cannot supply enough water to meet demand, and there is a 48,200, 135,700, and 222,300 af/yr deficit, respectively. The composite deficit in providing a full supply of water is 135,400 af/yr. It is assumed that additional water would be acquired from ground water pumping.

Water Budget - Alternative 1

Reach 1



Reach 2



Deficit in full supply from surface water = 58.2

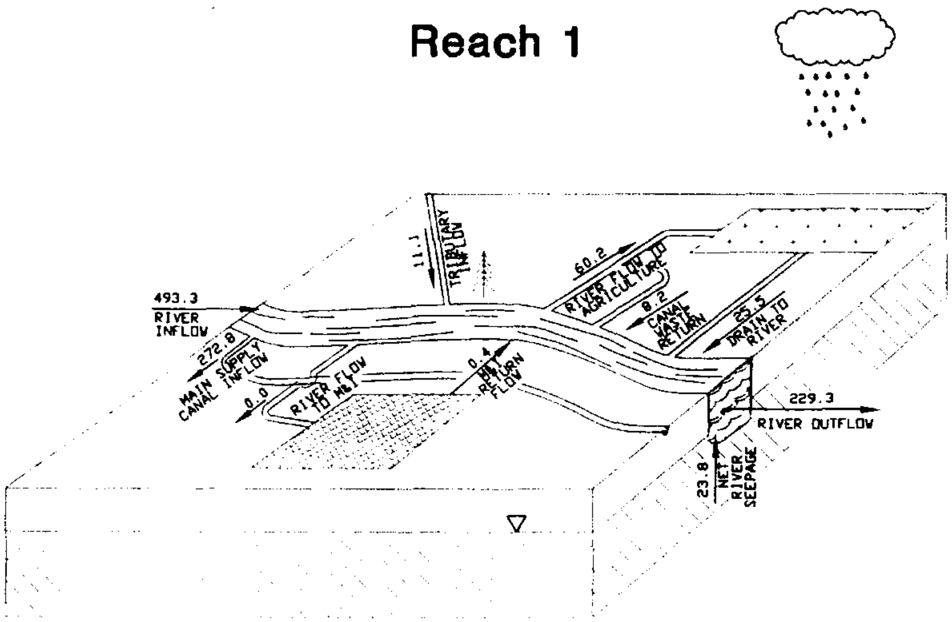
Notes: All quantities are in 1000 acre-feet unless otherwise noted.

Deficit in full supply from surface water is satisfied by increased ground water pumping.

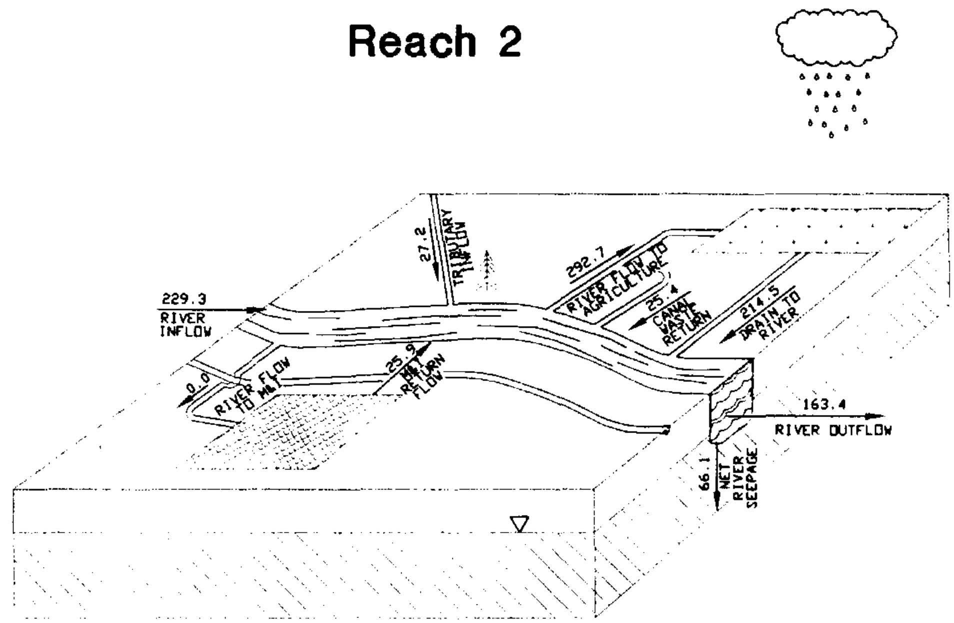
Figure 39

Total Dissolved Solids (TDS) Mass Budget - Alternative 1

Reach 1



Reach 2



Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 600

Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 2000

All quantities are in 1000-tons unless otherwise noted.

Figure 40

Since the rate of flow in the Rio Grande is much less at Leasburg Dam and American Dam in Alternative 2, the amount of TDS mass transported by the river is less, but the concentration of TDS is higher in Alternative 2. The TDS concentration at Leasburg Dam increases from about 600 mg/l (Baseline) to approximately 2000 mg/l (Alternative 2), and the TDS concentration at American Dam rises from 800 mg/l (Baseline) to 1000 mg/l (Alternative 2).

Figures 41 and 42 show the composite results of the water and mass balances for Alternative 2. The spreadsheet for each balance for each water supply scenario can be found in Appendix D.

Alternative 3

Since the pipeline provides water to M&I users in Reach 2, M&I ground water pumping is reduced from 46,200 af/yr (Baseline) to 4,500 af/yr (Alternative 3). It is assumed that M&I ground water pumping withdraws water from the Mesilla Basin and not the alluvial aquifer.

Alternative 3 reduces river flow at Leasburg Dam from an average of 612,200 af/yr (Baseline) to 351,800 af/yr (Alternative 3), and at American Dam the flow decreases from 358,900 af/yr (Baseline) to 108,600 af/yr (Alternative 3)

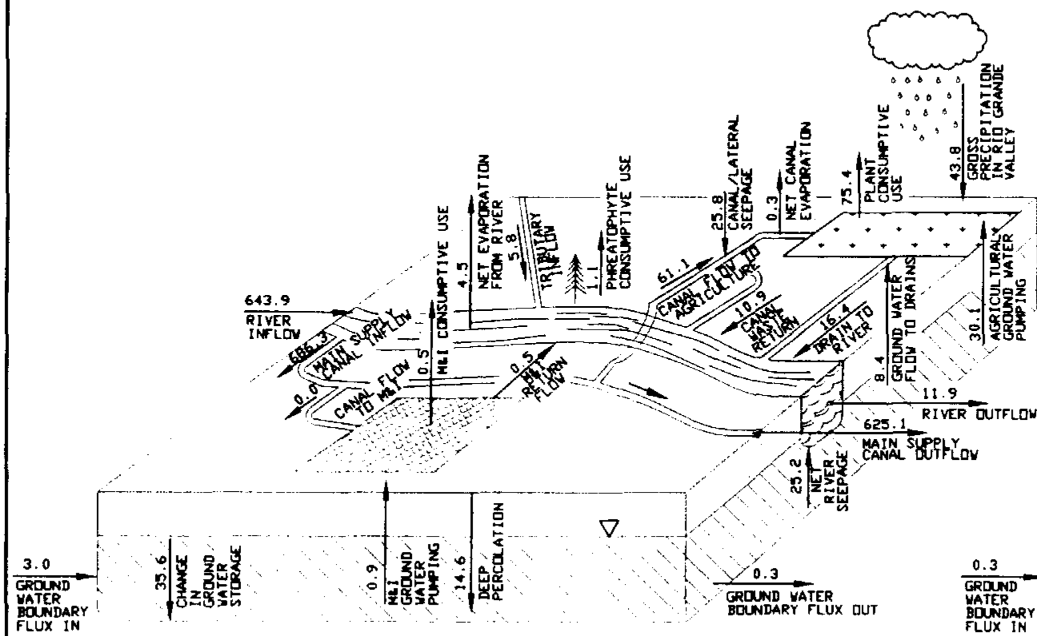
By rearranging releases from Caballo Dam, Alternative 3 is able to provide a full supply of water to its intended users in the "Average" and "Normal" years. In the "Dry" year there is a 70,000 af/yr deficit in the full supply of water delivered by the project. Ground water pumping is assumed to provide the water needed to eliminate this deficit.

Although the TDS concentration of the Rio Grande is higher in Alternative 3, less TDS mass is moved through the river because there is less flow in the river. The Baseline case and Alternative 3 have an estimated TDS concentration at Leasburg Dam of 600 mg/l, and the TDS concentration for both scenarios is about 800 mg/l to 1000 mg/l at American Dam.

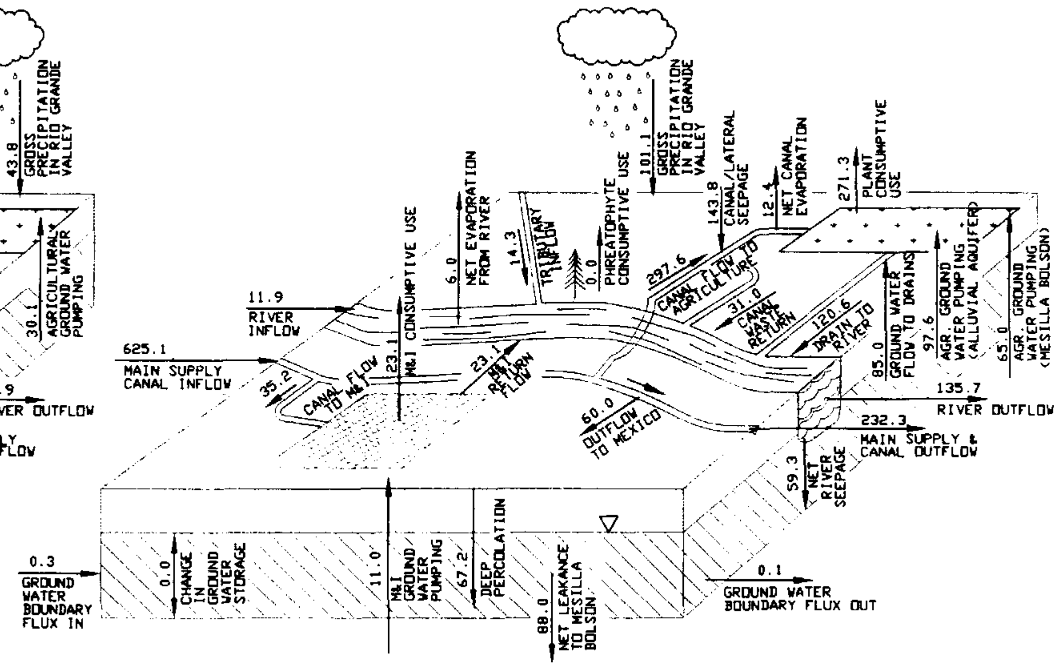
Figures 43 and 44 show the composite results of the water and mass balances for Alternative 3. The spreadsheet for each balance for each water supply scenario can be found in Appendix D.

Water Budget - Alternative 2

Reach 1



Reach 2



Deficit in full supply from surface water = 135.4

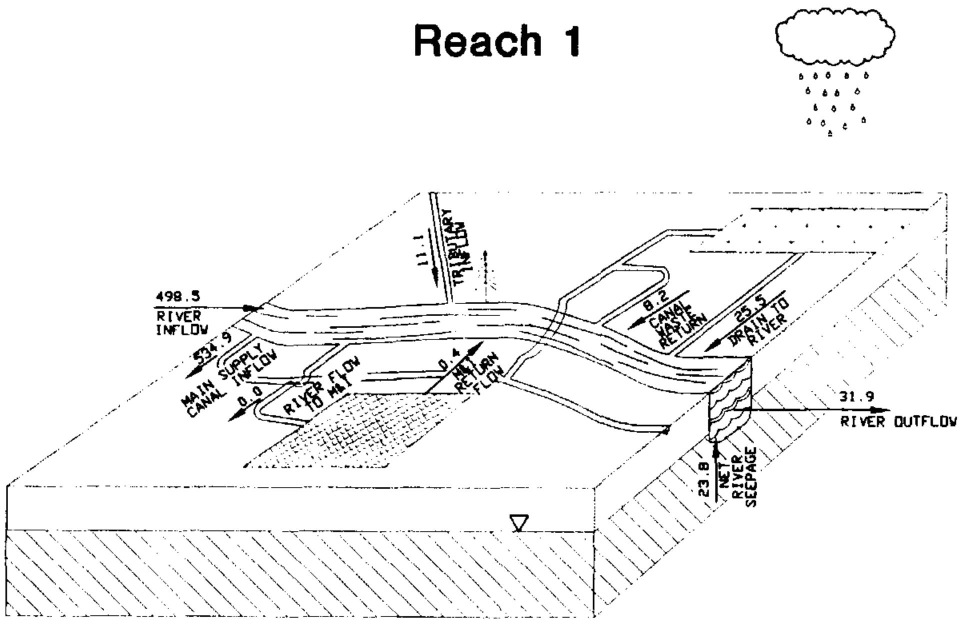
Notes: All quantities are in 1000 acre-feet unless otherwise noted.

Deficit in full supply from surface water is satisfied by increased ground water pumping.

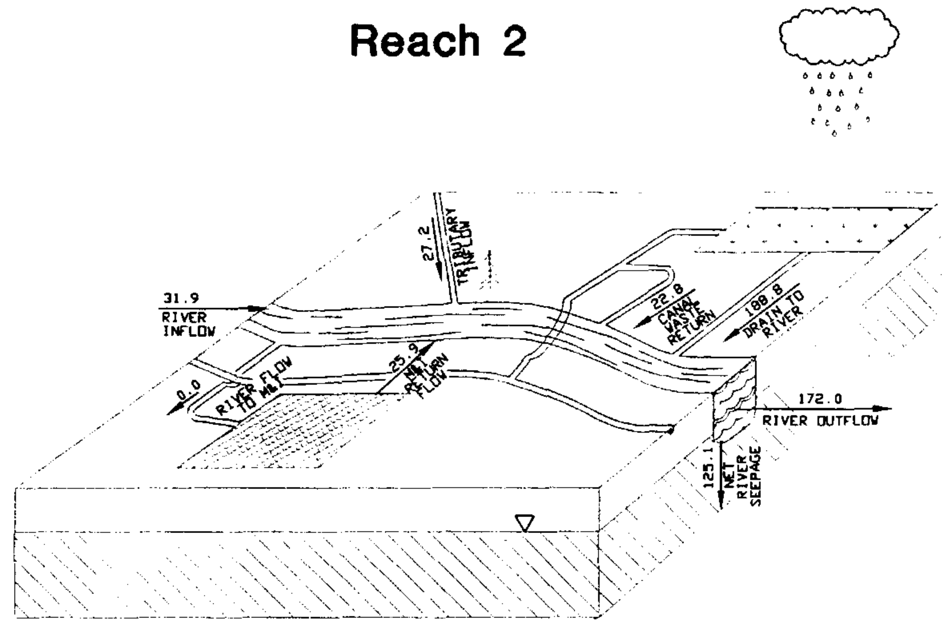
Figure 41

Total Dissolved Solids (TDS) Mass Budget - Alternative 2

Reach 1



Reach 2



Reach 1:

Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 2000

Reach 2:

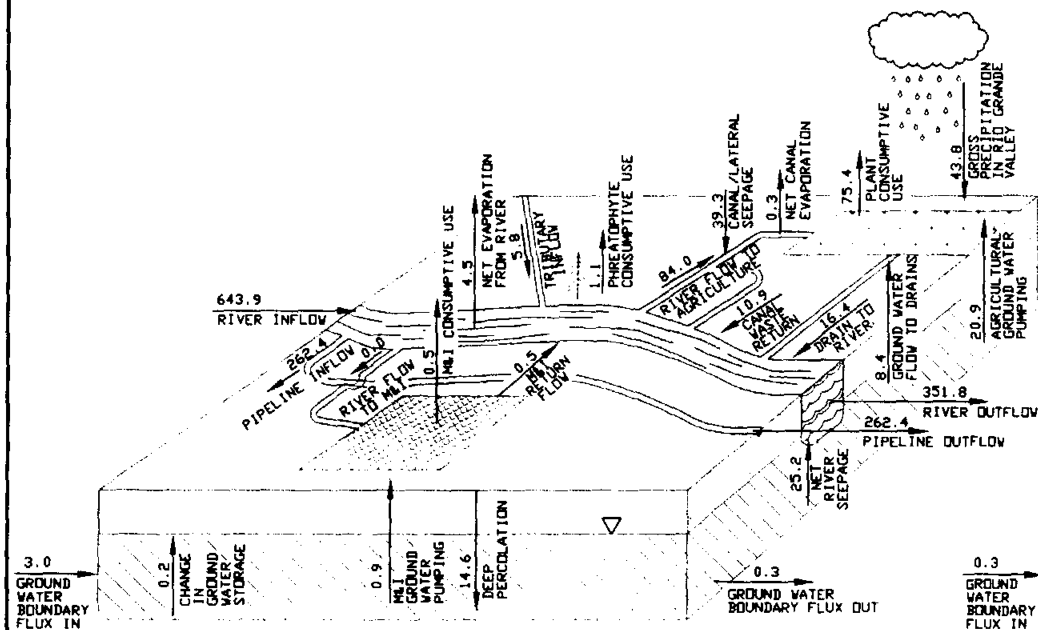
Estimated River Inflow TDS Concentration (mg/l) = 2000
Estimated River Outflow TDS Concentration (mg/l) = 1000

All quantities are in 1000-tons unless otherwise noted.

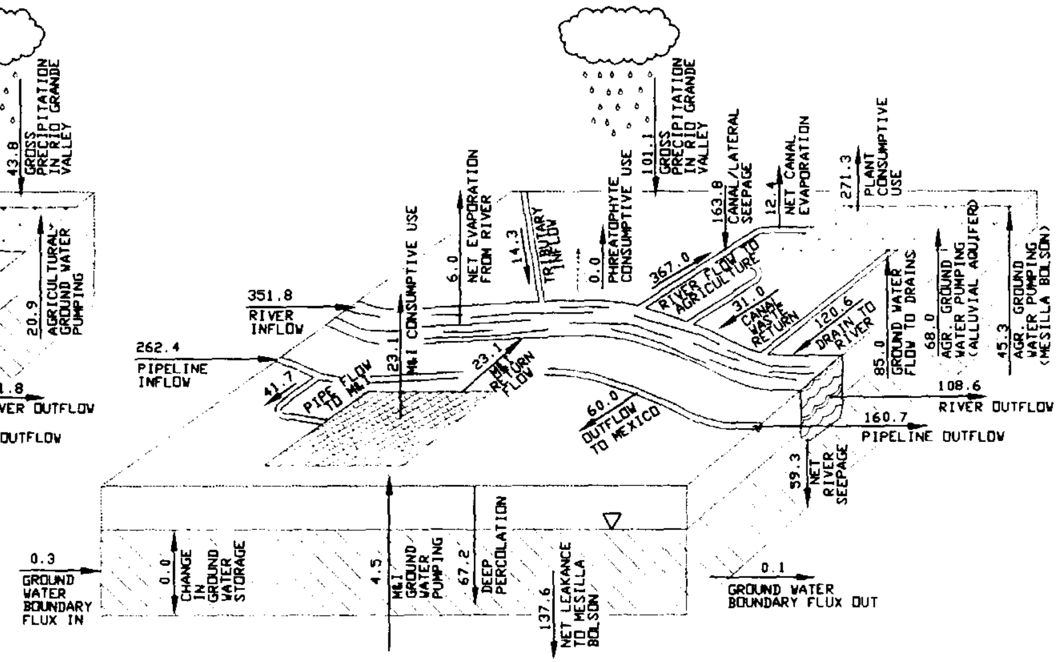
Figure 42

Water Budget - Alternative 3

Reach 1



Reach 2



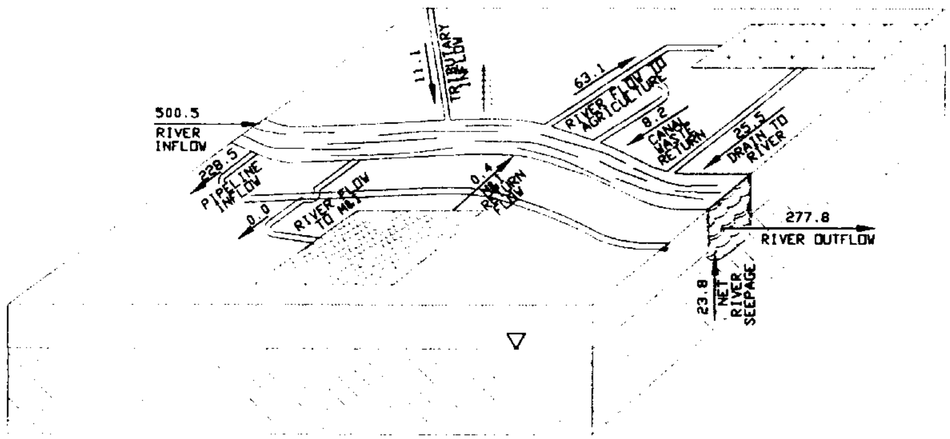
Deficit in full supply from surface water = 23.3

Notes: All quantities are in 1000 acre-feet unless otherwise noted.
Deficit in full supply from surface water is satisfied by increased ground water pumping.

Figure 43

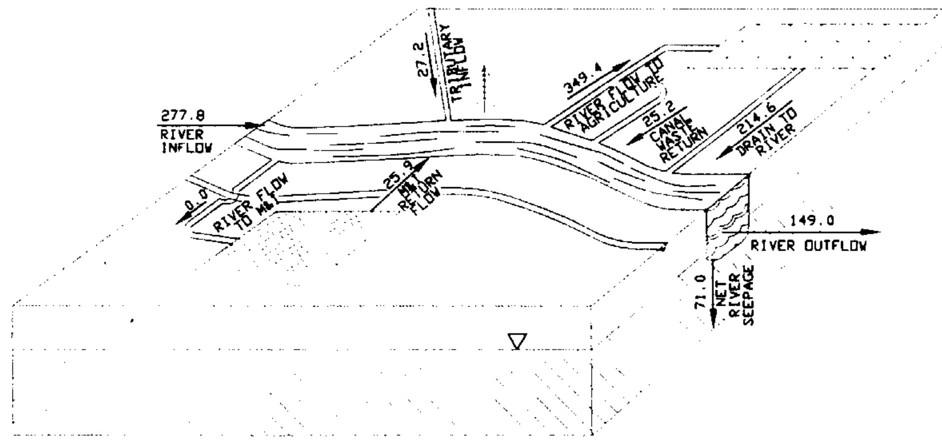
Total Dissolved Solids (TDS) Mass Budget - Alternative 3

Reach 1



Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 600

Reach 2



Estimated River Inflow TDS Concentration (mg/l) = 600
Estimated River Outflow TDS Concentration (mg/l) = 1000

All quantities are in 1000-tons unless otherwise noted.

Figure 44

Additional Considerations

Canal and Drain Storage

Regulating reservoirs could be designed and included in the raw water conveyance systems for three primary purposes. First, the reservoirs could be used to stabilize the flow in the canal downstream of the thereby reducing spills. Specially designed gates would be installed on the reservoir outlet to maintain a nearly constant outflow. The regulating reservoir would need to be large enough to store water from short term peak flow periods to provide constant outflow during short term low flow periods in the canal. Secondly, the regulating reservoirs could be used to deliver water to users on demand and to compensate for the time of travel of water from Caballo Dam to the turnout location. This regulation improves the efficiency of delivery and provides water conservation by catching and storing water that would normally be lost to canal spillage (operation waste). Boyle estimated that the average canal spillage was 16 percent in 1990 for the EPWCID#1 and 9 percent for EBID (Reference 1). They also estimated that the operation spillage could be reduced to 5 percent with regulating reservoirs. The regulating reservoirs were then expected to save up to 27,000 af of water (average) annually from the EPWCID#1 and 17,700 af annually from EBID. Third, the reservoirs could be used for recreation and environmental enhancement of the surrounding areas.

Raw water storage will also be needed near each of the possible water treatment plants near Dona Ana, New Mexico and Anthony, Texas. The raw water storage reservoirs for these plants were located and sized to provide a stable flow of water to the water treatment plants and to regulate the flow in the conveyance system downstream of the treatment plant diversion. Additional regulating reservoirs were located solely for the purpose of flow regulation along the conveyance systems. These additional reservoirs would remove some hydraulic transients from the system, stabilize flows in the canals, provide short term storage of peak flows that are in excess of the demand, develop recreational areas, and provide environmental enhancements and mitigation. The efforts in this report focused on defining where the reservoirs could be placed (potentially), how much water they could store for flow regulation, and how much raw water storage would be needed for the water treatment plants.

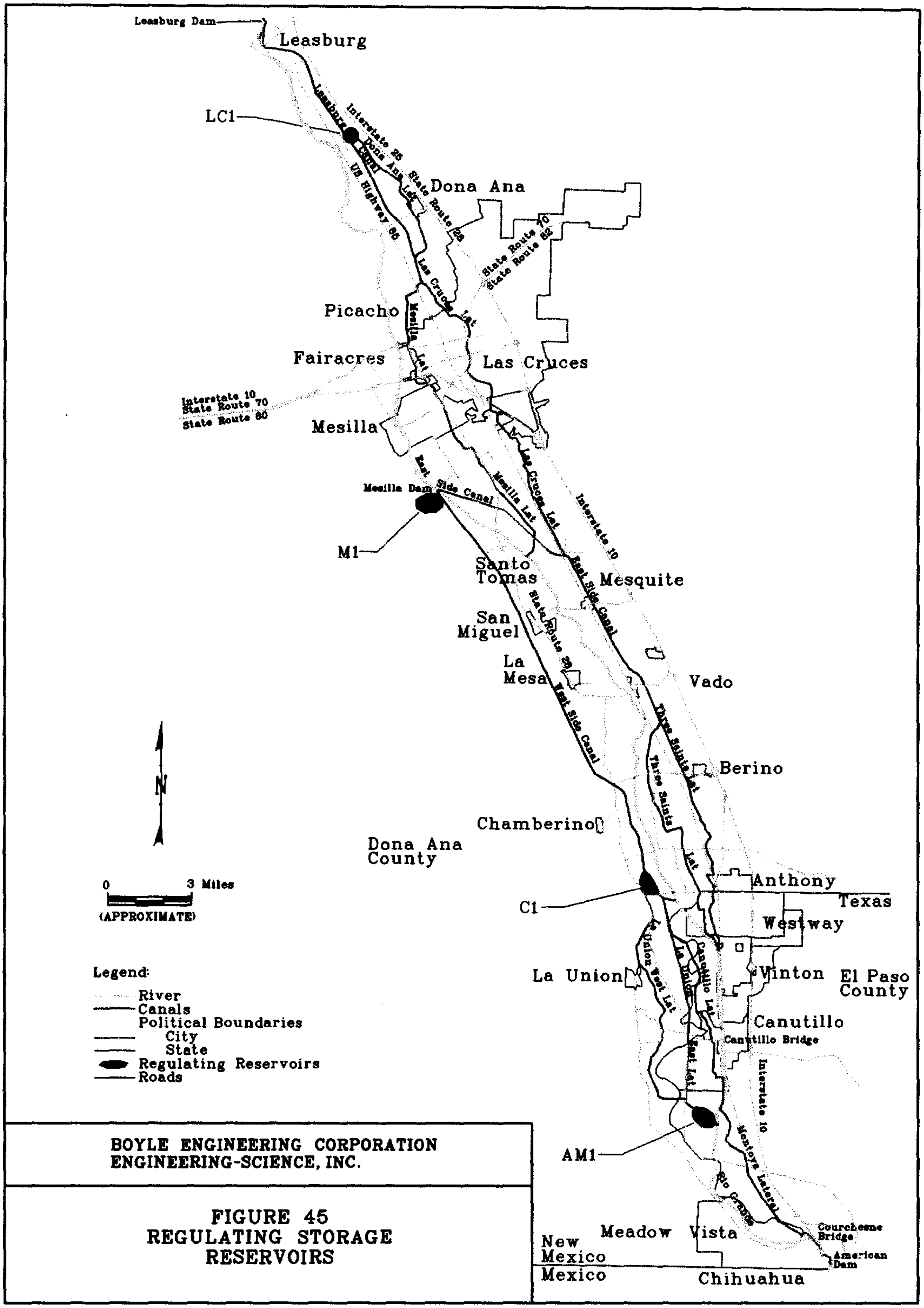
Four regulating storage reservoirs were identified in New Mexico to help improve the operating efficiencies of the conveyance alternatives, conserve water, and provide raw water storage for the water treatment plants. The potential locations of the regulating reservoirs are shown in Figure 45. Table 20 includes an estimate of the regulating capacity, the total storage, the surface area, and a listing of which conveyance alternatives are applicable for each reservoir. For cost estimate purposes, the channel expansion reservoirs were assumed to follow the channel. Other reservoir shapes may be economically, technically, and environmentally more feasible and should be addressed in further studies.

Table 20
Regulating Reservoirs Description

Reservoir Label Name	Surface Area Acres	Average Depth (feet)	Storage Total (af)	Storage Regulating (af)	24 Hour Outflow (cfs)	Alternative Number Applicable
AM1	40	10.1	400	100	50	1,2,2a
C1	50	10.7	500	125	63	2,2a
M1	40	10	400	200	100	2,2a
LC1	50	12.7	600	125	63	2,2a
Totals	**180**		**1900**	**550**	**276**	

Reservoir "AM1" (regulating water delivery to American Dam) could be built by widening the main conveyance channel to 200 feet, and raising the water depth to a maximum depth of 12.6 feet, with the canal design depth being 7.6 feet. The dikes along this reservoir would need to be 4 feet above the maximum water surface (above the canal dikes) to provide the necessary freeboard for a distance of nearly 7,700 feet upstream of the regulating structure. The reservoir could be lined with an impermeable geotechnical lining to eliminate seepage.

Reservoir "C1" (regulating water delivery to the Anthony Treatment Plant near Canutillo) could be constructed by widening the main conveyance channel to 250 feet, and increasing the water depth to a maximum depth of 13.2 feet, with the canal design depth being 8.2 feet. The dikes along this reservoir would need to be 4 feet above the maximum water surface (above the canal dikes) to provide the necessary freeboard for a distance of nearly 7,700 feet upstream of the regulating structure. This reservoir would stabilize flows and would be used to provide storage of raw water for the water treatment plant at Anthony. Its design would provide for by-passing most of the flow through the main canal, along with most of the sediments and debris, and would divert the raw water for the water treatment plant through a side diversion. The reservoir could be lined with an impermeable geotechnical lining to eliminate seepage.



BOYLE ENGINEERING CORPORATION
ENGINEERING-SCIENCE, INC.

FIGURE 45
REGULATING STORAGE
RESERVOIRS

D:\724046\REGTANKS.DGN R01 06.20.94

Reservoir "M1" (regulating water delivery to the West Side of EBID) could be constructed by diking the inlet and east dike of the west side canal to an elevation of nearly 3870 feet, and diking the outlet of the reservoir just south of the rodeo grounds and just below the West Side Canal Inlet. The average depth of the water in this reservoir could be expected to be roughly 12 feet. The dikes along this reservoir would need to be 4 feet above the maximum water surface elevation in the area shown on Figure 3.x. The reservoir could be lined with an impermeable geotechnical lining to eliminate seepage.

Reservoir "LC1" (regulating water delivery to the Las Cruces Water Treatment Plant) could be built by widening the main conveyance channel to 250 feet, and increasing the water depth to a maximum depth of 15.2 feet, with the canal design depth being 10.2 feet. The dikes along this reservoir would need to be 4 feet above the maximum water surface to provide the necessary freeboard for a distance of nearly 7,700 feet upstream of the outlet structure. This reservoir would stabilize flows in the canal and would be used to provide storage of raw water for the water treatment plant at Las Cruces. Its design would by-pass the majority of flow through the main canal, along with most of the sediments and debris, and divert the raw water for the water treatment plant through a side diversion. The reservoir could be lined with an impermeable geotechnical lining to eliminate seepage.

Regulation storage downstream from these locations can probably be handled by the regulating reservoir planned for construction along with the American Canal Extension.

Several other regulating reservoirs could be recommended along the main delivery canals for regulation purposes within the individual irrigation districts. However, the location of these regulating reservoirs, their costs, and feasibility will not be addressed in this report. These additional reservoirs would improve the operating efficiency of the existing canals and conserve water to supplement deliveries.

Other regulating storage reservoirs could be constructed along some of the major drains in the Mesilla, Rincon, and El Paso Valleys. These drain regulating reservoirs could be used to conserve water, manage water quality, develop recreational parks, and enhance environmental mitigation. By using regulating reservoirs to capture drain flow and surface runoff, the drain water can be used to recharge the alluvial aquifer, irrigate (when water quality will allow) agricultural crops, supplement (when blended) diversions, and/or enhance environmental mitigation. At present, the State of New Mexico may not recognize environmental enhancements as a beneficial use, but the mitigative potential may be used to meet National Environmental Protection Act compliance requirements. Environmental enhancements through the development of recreational parks, wetlands, riparian habitat, bridal trails, bike and hiking paths, fisheries, and other potential improvements would benefit the entire Rio Grande Project. These improvements would assist in improving the standard of living in the area, as well as increase the economic value of the surrounding areas as residential and municipal development continues.

Another significant beneficial use of regulated drain flows is to manage water quality in the Rio Grande River. Drain flow salinity tends to peak in the winter months and reach a minimum during periods of high irrigation in the summer. The winter peaks reflect the impacts of the alluvial aquifer flows through areas of highly saline soils to the drains. By installing regulating reservoirs, the peak salinity levels could be significantly lowered by blending the higher quality summer flows from small storage reservoirs. The quality of these flows would require periodic monitoring and review to maintain the salt balance, and to optimize the operations of these reservoirs.

It would be beneficial to identify remotely the soils that contribute the highest salinity, then zone these areas for industrial development. This would allow a reasonable economic return to the present land owners, help protect high quality agricultural lands from municipal development, and provide the irrigation districts the option to reassign the water to other project lands for industrial purposes. By isolating highly saline areas, and potentially installing interceptor drains to reduce ground water inflow through the saline soils, the drain water quality to the river could be significantly improved. Other potential management improvements could include isolating the highly saline drains (TDS>1000 mg/l) and using this water to sprinkle riparian areas while diverting or piping higher quality drain water to the canals or the river for other uses.

The placement of these regulating reservoirs would require careful consideration of the drainage patterns, the quality of the drainage inflows to the reservoirs, the quality of the outflow from the reservoirs, and the overall impacts on the entire hydrologic system. The future development of these ideas will require careful consideration to prevent salting out of agricultural lands and to maintain the purpose of the drains. The drains must continue to carry away the leached salts and prevent the soil from souring or becoming anaerobic.

Return Flow Treatment

Opportunities for blending of return flows with canal water and for storing return flows to optimize their use have been discussed in a previous section of the report. These return flows would normally be higher in TDS than the main conveyance supply, as the water budget data indicate. For some uses, such as aquatic and riparian wildlife habitat, industrial cooling water, etc., this may not be a severe problem. For use as an agricultural water source, the return flows could be blended or used as is, depending on the location and crop. As long as irrigated agriculture remains the predominant RGP water use, especially when considering return flows in areas below Leasburg and in dry years, drain flow salinity may be too high for some M&I uses. The return flows may also contain traces of pesticides, nitrogen compounds, higher levels of total organic carbon (TOC) than the canal water, tastes and odors from algae, turbidity or color and many other possible contaminants. For many uses, especially potable water, treatment would be necessary.

The type of treatment required would depend on the time of year and location, but is likely to be more expensive than the processes already discussed for treatment of canal water. Additional unit processes such as adsorption of organics on activated carbon and more storage for raw water pre-sedimentation may be required. In order to meet SDWA requirements for municipal water supply, desalination would probably be necessary. Both reverse osmosis (RO) and electrodialysis reversal (EDR) could be used. The most practical and economical choice would depend on the water quality at the time and location. A combination of advanced conventional water treatment, followed by RO membrane treatment, may be the most feasible scheme for potable water production. As with any desalination planned in the vicinity, handling of the reject brine waste from the membrane process, as well as the conventional chemical treatment waste sludge, must be considered.

It is important to realize that the irrigation waste and drain flows will change in quality and decline in volume along with reductions in the quantity of RGP water used in agriculture. However, as M&I water use increases the volume of treated wastewater flowing into the river will also increase. This treated wastewater may be reused in place, but will eventually be released to the Rio Grande and become agricultural return flow or ground water. Extensive reuse of wastewater effluent for irrigation should maintain some return flows in the system.

It is unlikely that desalination of return flows will be a large scale use in the near future. It is quite possible, however, that treatment can be used to produce potable water and fill other high quality water supply needs in local areas. This might prove practical under certain conditions such as:

- remoteness from a regional water treatment plant
- small demands at, for example, a state park at an area of enhanced wildlife habitat

- complete allocation of the canal water supply
- specialized use for boiler feed or other high purity water needs at an industrial facility which might use untreated return flows for its other nonpotable requirements

The Commission should keep an open mind about specific uses for treated return flow, although it does not appear to be a practical large scale regional water source.

In order to evaluate the practicality of treatment at a particular location, the value of untreated return flow at that location must be added to the canal supply costs and compared to the return flow treatment cost before a valid decision on the best water source choice can be made.

As demonstrated by the results of the water budget, the TDS concentration at American Dam will average approximately 1000 mg/l for Alternatives 2 and 3. For Alternative 1 the TDS at American Dam is 2000 mg/l due to the lower availability of dilution flows. TDS in the Montoya and East Side Drains would, of course, be higher. If drain sources in this area are to be used as a potable supply, desalination would obviously be necessary. If the Rio Grande is conveyed to the drains through the water blending system, TDS may drop dramatically for short periods during the thunder storm season, making for variable TDS in the treatment feed water.

Aquifer Storage and Recovery

Aquifer Storage and Recovery is the storage of surface water in a ground water aquifer for later retrieval. Aquifer storage offers significant possibilities for augmenting supplies and reducing surface water treatment plant capacities. Treated surface water is already being used for part of the municipal supply in El Paso during the irrigation season, because of the ongoing depletion of ground water in the Hueco Basin. However, ground water has been, and continues to be the primary source of M&I water for El Paso and other communities in the Commission planning region. With a ground water production system in place, aquifer storage of surface water may greatly reduce necessary peak water treatment plant capacities. Aquifer storage also provides a means to insure long term stability of water quantities in the aquifers. If a net surplus of water is used, which would not be difficult once a recharge program is implemented, the depleted aquifer could eventually be restored to near the original capacity.

Conveyance to provide year-round water offers the opportunity to consume less groundwater for M&I uses by providing surface water at average consumption rates, less other sources of supply or recharge. This will result in availability of excess surface water in the winter and would allow storing of surface water in the aquifers. Water can then be withdrawn to meet peak summer demands without resulting in net depletion of the ground water supply.

The two ground water aquifers in the area, the Hueco Basin and the Mesilla Basin, will be studied for their suitability for aquifer storage and recovery in an upcoming, follow-on study to the phase II/III work. The Hueco Basin currently has suffered the largest depletion with resulting intrusion of brackish water at the margins and large draw downs requiring deeper pumping equipment submergence. As the El Paso and Juarez areas continue to grow, production from the Hueco Basin will become impractical unless a rapid switch to surface water avoids further overpumping. Although the overall capacity of the Mesilla Basin is greater, its capacity is also finite, especially when considering the capacity available to El Paso and Juarez without importing ground water from New Mexico. By the end of the study period in 2035, water banking in both the Hueco Basin and the Mesilla Basin, which will probably prove to be feasible, would greatly reduce required surface water treatment capacity and help preserve both of the aquifers.

M&I water usage in southern New Mexico and El Paso County area varies during the year with low use in the winter increasing to the highest usage during late June or early July. Winter use can be as low as 40 percent of the average increasing to as high as two times the average during the summer. Although summer peak use spans only two or three months, supply facilities need to be large enough to meet this peak demand. Consequently, water treatment plants have unused capacity during the winter months, when demand is low, if they are designed to meet the high summer peak.

Currently, water treatment plants operate only during the irrigation season, when surface water of acceptable quality is available. With the introduction of conveyance facilities, surface water of higher quality will be available year round. During winter months when water usage is less than the yearly average, extra treatment capacity and water supply would be available. Aquifer storage takes advantage of this situation to provide optimum year round surface water use. During the winter months, when water use is low, the excess of surface water production over demand could be pumped from the treatment plants, through the distribution system and into the underground aquifer. During the summer high water usage months, the stored water would be pumped by the existing ground water production system to meet the peak in usage, allowing the surface water treatment plants to treat at a more or less constant rate year round. Some excess surface water capacity above net average demand would still be necessary to allow down time for service of process and pumping equipment in the treatment plants.

Two methods can be used to introduce water into an aquifer. One method is to use injection wells, either specially constructed injection wells or existing production wells operated in reverse. Another method is by spreading water into an infiltration basin at the surface. Use of injection wells requires that the surface water be treated to drinking water standards prior to introduction into the aquifer. It also requires attention to corrosion control and the chemical compatibility of the injected water with that already present in the aquifer. The water is injected at points where it can be retrieved by ground water wells during periods of peak use. Because of possible contamination by peripheral or overlying brackish water, the potential for injected ground water to migrate laterally to a location where it may be unavailable for production and the possibility of other users of ground water producing water injected by Commission entity, the location at which the water is injected, both above and below ground, is very important for the practicality of future retrieval. The best locations may be in areas where the water quality remains suitable but where there is a cone of depression due to over pumping. The cone of depression can be partially refilled and will hold the water near the point of injection. The use of injection wells allows control of the water quality and relatively precise location of recharge. However, surface water treatment and possible additional corrosion control treatment may be necessary.

The second method, spreading in an infiltration basin, may allow use of untreated or partially treated surface water. Depending on the quality of the raw water, pre-sedimentation may still be necessary. The spreading is conducted in an area which allows transport of the water by percolation through the ground down to the aquifer. Selected spreading locations are used and dikes may be necessary to hold the water over the infiltration bed. The soil acts as a filter to remove sediment and organic contaminants before they reach the aquifer.

Surface spreading provides an economical way to recharge an aquifer; however, some potential problems can result. The feasibility of surface spreading is highly dependent on the permeability and chemical characteristics of the underlying sediments. Build up of total dissolved solids and/or specific cations or anions of concern can occur. An area of fairly high permeability (large uncemented sediment particles above and within the zone of saturation) must be used to allow practical rates of infiltration. Subsurface layers of caliche or clay may retard infiltration or produce perching at depths above the ground water table. Some lateral movement may also occur prior to reaching the primary production aquifer.

In general, coarse sediments and shallow depths to groundwater make surface spreading more practical. Surface spreading requires a good knowledge of the geology above the ground water table and would probably require pilot studies prior to investments in a large scale operation. During the time the water is at the surface it is subject to evaporation which can consume a significant portion of the applied volume and concentrate the total dissolved solids. The evaporation problem increases if infiltration rates are slow.

Either method of aquifer storage would hold water for retrieval at a later time and provide a means of recharging the depleting aquifers. Aquifer storage would also provide long term storage for retrieval during drought periods, as discussed later in this report.

To determine the feasibility of underground storage and the most effective recharge method, further study is necessary. Additional study should identify potential sites based on surface and subsurface attributes, evaluate the feasibility of the two recharge methods at that location and predict the water quality effects that might result. Determination of the overall feasibility of aquifer storage should be based on cost comparisons, retrievable storage capacity and sustainable recharge rates. Information from the water budget developed for this report will be used in the upcoming aquifer storage study.

The planned follow-on study will evaluate aquifer storage and recovery at four sites:

- In the Las Cruces area
- West of La Union in Southern Dona Ana County
- In the Canutillo Wellfield area north of El Paso
- In the Northeast Hueco Basin area of El Paso

Both spreading and injection will be considered. The results of this study should provide the Commission with insight into the feasibility of aquifer storage and recovery as part of overall regional conjunctive use. Aquifer storage offers tremendous potential to protect and restore depleted aquifers, while optimizing water use efficiency.

Drought Contingency

Although surface water originating from the storage facilities on the Rio Grande may be considered a permanent source of supply, in the particular case of the Rio Grande Project, the actual amount available each year varies according to operating policies based on the amounts in storage in Elephant

Butte and Caballo Reservoirs, and on climatic occurrences and forecasts. Annual allotments of water available to the Rio Grande Project lands are thus variable, and water supply for M&I uses based on acquisition of water from these lands would be subject to similar variations.

The reliability of the Rio Grande Project as a source of water supply has been studied through use of return-frequency analysis on annual net supplies to the EPCWID#1 (Reference 1). From this approach, it has been determined that the probability of the annual net supply in any given year being equal to or greater than the long-term average annual net supply is 56 percent.

During extended periods of drought, Rio Grande Project allotments are decreased in accordance to the severity of the drought. Historically, allotments have fallen as low as 0.5 af per acre from a normal of 3 af per acre. When only reduced amounts of Rio Grande Project water are available, farmers may opt to reduce their farmed acreage to an amount compatible with the water supply; they may pump ground water and thus limit the reduction in their farmed acreage; or, if feasible, they may forego farming during the drought period. Operators of treated water supply facilities for M&I uses do not have this flexibility to adjust their demand to available supply.

For the City of El Paso, EPWU is committed to supply the normal demand, decreased only by possible emergency conservation measures. One possible arrangement that would help to satisfy the expectations for water supply of both the farmers and EPWU could be for both parties to enter into long-term drought contingency agreements. Such agreements could provide that in years when the initial water allotments are below a certain set amount, farmers would commit to lease their water allotment for that year to EPWU for M&I water supply, and in return, EPWU would pay farmers a certain pre-specified fee per acre foot of water ceded to EPWU. In this process, farmers would be guaranteed an income, even if limited, and EPWU would help alleviate a shortage in their water supply operations during drought periods. When Mexico, Las Cruces and Dona Ana County become users of treated surface water, they may wish to make similar arrangements with EPCWID#1 and EBID farmers to address dry years.

Another solution for dry years is conjunctive use of ground water. Ground water can be pumped to supplement available surface water in dry years, in similar fashion to its planned use to meet peak summertime demands for M&I water. If large amounts of water are available in storage, or in areas where demand is relatively low and natural recharge is able to replenish the periodic withdrawals, this practice can continue more or less indefinitely. In high demand areas like El Paso and Juarez, aquifer storage and recovery would be a necessary part of using groundwater as a source for drought contingency.

With a good program of aquifer storage, the aquifers can be used as a drought contingency bank, and perpetually protected from depletion. Use of groundwater as a drought contingency supply mandates that a system of groundwater production wells and collector lines be maintained. It also requires a system and plan for aquifer recharge in those areas where significant draw downs have occurred or will occur from future demands.

Environmental Considerations

The Legal Advisory Committee of the New Mexico-Texas Water Commission has considered environmental issues. The Legal Advisory Committee and Management Advisory Committee also conducted a presentation to interested government agencies on April 28, 1994. Follow up discussions were held with specific members of state and federal agencies, interested citizens and environmental groups. From these initial discussions and from the previous experience of the Commission members and the legal and engineering consultants, some expectations as to the environmental issues which will result from consideration of a large scale surface water conveyance, and an initial plan for addressing them have been developed.

The first reaction to diversion of all or a major portion of the reservoir releases from the river to a lined canal is likely to be negative. It will be assumed that such a diversion will have negative impact on aquatic life and on the viability and aesthetic appeal of the Rio Grande and associated wildlife and recreational uses. An environmental assessment will be necessary, particularly if any federal funds are to be used on the project, and an environmental impact statement may be required.

Prior to any environmental assessment work, the Commission should use the information provided in this Phase II/III report to decide on a common set of objectives. One major common objective which is already identified is the need to preserve and restore the Hueco and Mesilla ground water aquifers. In order to establish this and other common objectives, the parties who are to make use of the conveyance must be defined. These parties can then develop a set of common objectives for conveyance and use of the renewable surface water supply. Once a common set of objectives is determined, two or three variations on the appropriate means to satisfy the objectives (conveyance/treatment alternatives) can be identified. The relative feasibility of these alternatives will then be evaluated from both an environmental and economic viewpoint and compared to the "no action" alternative. A lead federal agency, the agency that will be in charge if an environmental impact statement is necessary, should be identified. Environmental assessment work should start by compiling existing data and proceed to new field studies if necessary.

The environmental assessment will involve extensive public involvement. It will be the first time many local citizens, environmental groups and other public and private organizations become aware of the project. It is important that they be made aware of the following facts.

- The existing river below Caballo Reservoir is basically an irrigation canal and floodway. The natural riparian vegetation has been cleared and the non irrigation season flow is made up of irrigation and wastewater return flows and occasional storm water runoff.

- Year round delivery of surface water of high quality and adequate quantity will allow major municipalities in the area, including Las Cruces, El Paso, and Juarez, to discontinue overdraft of the Mesilla and Hueco Basins, thus preserving the important regional ground water aquifers.

- Water banking of the year round surface water supply will allow summer peak municipal water demands to be met while preserving and restoring the ground water aquifers.

- Well thought out use of return flows and storm water runoff may actually enhance the aquatic and riparian habitat and recreational value of the Rio Grande Project system to a level above the "no action alternative."

- Moving from use of depletable ground water to a sustainable surface water supply is necessary to supply even the present population in the area and will allow improvement of environmental conditions and the quality of life of many of the area's residents.

- Minimum stream flows can be maintained, marshes and wildlife management areas can be developed with managed use of return flows, and any environmental losses can be more than mitigated by a well thought out project.

The Commission should adopt a pro-active and cooperative approach in explaining the project and design it to accommodate the public interest. The project can be used to restore aquifers, enhance the local environment and provide a dependable and permanent water supply. Interested parties must be made to understand that the project is a plus, not a minus, to all of the interests of the region.

Summary of Study Results

This section summarizes the results determined from analysis of the alternative objectives. It is included to assist the members of the Commission in selecting an appropriate conveyance system. Issues such as regional socio-economic impacts, specific environmental impacts, and legal-institutional constraints are not addressed in the study.

The evaluation parameters are those dealing with water resource management from an engineering perspective, including:

- Advantage/disadvantage of alternatives.
- Unit conveyance and treatment cost determination including estimates of construction cost and operations/maintenance costs.
- System impacts on the Rincon and Mesilla Valleys as indicated by the water budget analysis.
- Surface water "losses" comparison.
- Future effects on the Mesilla and Hueco Basins.

The following Figure 46 illustrates the agency service objective of each of the alternatives for referral during evaluations by the Commission. It should be noted that the consultants (Boyle, E-S) have not included an evaluation or a recommendation for a preferred alternative.

An initial objective perception regarding environmental issues to be addressed is that the major favorable impact of the project is stabilization of the two (2) major aquifers. Any of these three alternatives can adequately address the aquatic and riparian environmental impacts, particularly if public and professional participation is included in the next phase of project development.

Certain advantages and disadvantages are exclusive to a particular Alternative Objective. An understanding of the specific advantages and disadvantages of each alternative will help in evaluating the best alternative to meet the evaluation parameters listed earlier. A compendium of advantages and disadvantages follows.

Service Fields of Alternatives

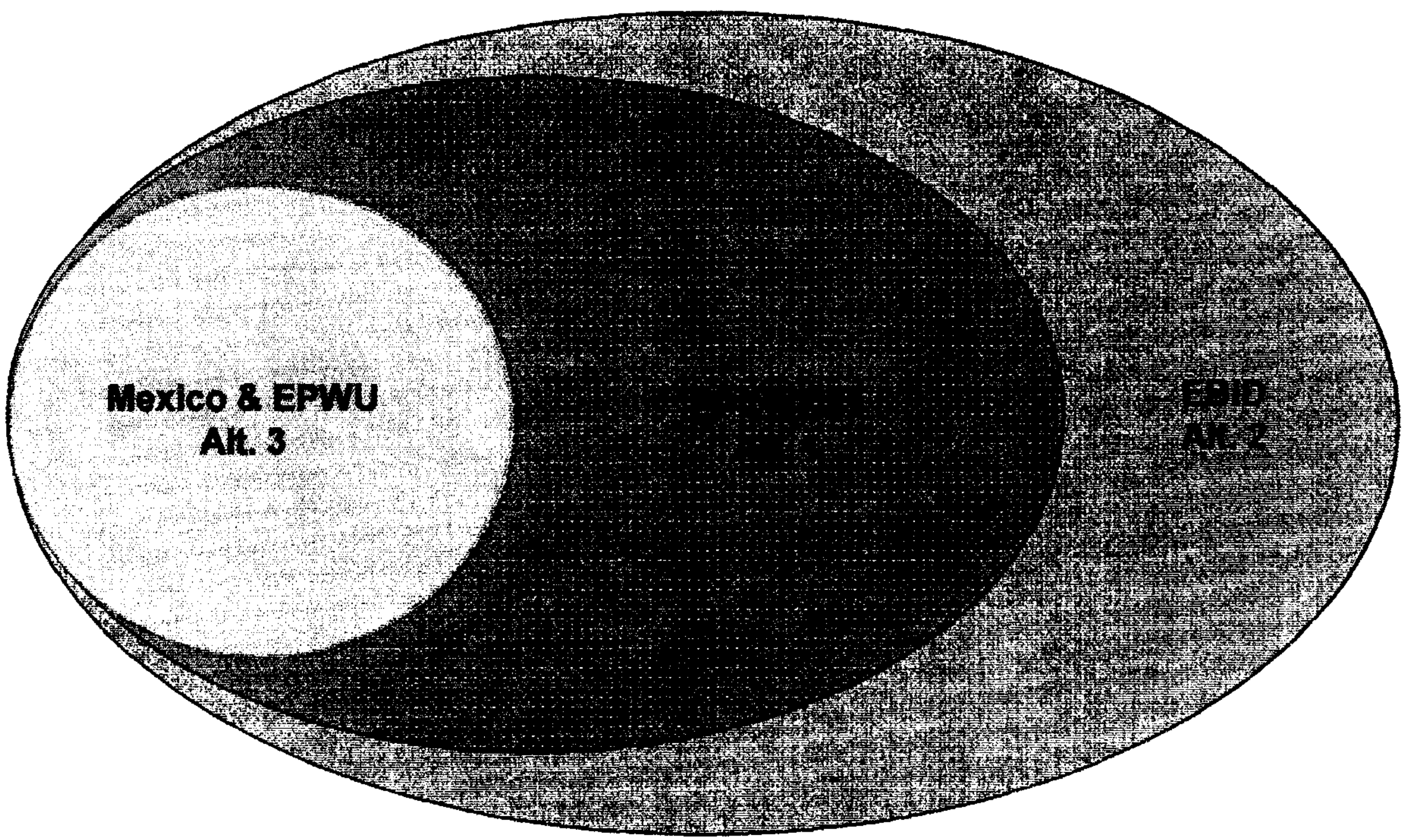


Figure 46

Alternative Objective No. 1

Advantages of Alternative 1:

1. The water quality delivered at El Paso would be the same as that existing in Caballo Reservoir. The quality would be maintained and protected from contamination and degradation by prohibiting intermediate inflows of drain, return, and storm waters.

2. The availability of water would be year-round, and flow requirements would be more controllable to meet demands.

3. Water conveyance losses due to seepage and evaporation would be significantly reduced. The transportation time would be reduced from three days to less than one day.

Disadvantages of Alternative 1:

1. The upstream entities would not have available to them the downstream allocation flow for purposes of using it for "carrier" water.

2. The downstream entities would receive their full allocation at a point above significant storm water, drain, waste, and return inflows, which are considered to be Project water.

3. Not all of the regional entities would directly benefit from the project. To provide equitable benefits to all regional entities, construction of a companion project would be required.

Alternative Objective No. 2

Advantages of Alternative 2:

1. All water agencies and water users of the region will benefit from system-wide improvements to the water conveyance system.

2. Regulatory control of system-wide operations of the Rio Grande Project will be centralized. That is, the physical allocation of flows will be in parallel rather than in series.

3. All beneficiary agencies will receive water of similar quality, with the option to blend agricultural diversions with "reuse" water from the Rio Grande.

4. The project construction cost per unit volume of water delivered is the lowest of the alternatives considered (see Cost subsection below).

5. Local agencies can be more responsive to the future shifts of the water needs of the region than can state or federal officials.

Disadvantages of Alternative 2:

1. Implementation of system-wide conveyance improvements with the attendant inclusion of all water agencies in the region requires a more general consensus on equitable water resource allocation than has occurred historically.

2. Implementation of Alternative Objective 2 may require statutory changes in the states of Texas and New Mexico to provide the necessary authority for the regional water commission to operate the improved system and to manage the water resource.

Alternative Objective No. 3

Advantages of Alternative 3:

1. Provides EPWU water for treatment and distribution that is not degraded in quality by prior use within the Rio Grande Project.

2. Provides security against contamination during conveyance.

3. Provides a high degree of flow control.

Disadvantages of Alternative 3:

1. This alternative does not provide region-wide surface water resource improvements.

2. The project construction cost per unit volume of water delivered is the highest of the alternatives considered.

Costs

Capital costs and the costs of conveyance per unit volume of water are parameters which will certainly be of assistance in the evaluation of the different alternatives. These costs were discussed previously, and several tables were presented showing their detailed calculation. A summary of these costs is shown in Table 21:

Table 21

Capital and Conveyance Costs

Alternative No./Period of Operation	Capital Cost	Conveyance Cost per acre-foot
1	$332,020,000	
2005 to 2014		$67.37
2015 to 2034		$67.01
2035 to 2054		$62.78
2	$376,542,000	
2005 to 2054		$37.39
2a	$540,937,000	
2005 to 2054		$53.78
3	$398,339,000	
2005 to 2014		$130.24
2015 to 2034		$102.82
2035 to 2054		$90.68

As noted previously, although not the lowest in capital cost, Alternative 2 yields the lowest cost per unit volume of water conveyed.

On the basis of water treatment plant capital costs and treatment capacities discussed earlier for water treatment plants in Las Cruces and Anthony, capital costs per unit volume of treated water were determined. The costs found are shown in Table 22.

Table 22

Water Treatment Plant Cost

Plant/Facility	Capital Cost	Unit Cost per Acre Foot
Las Cruces		
2015 Facilities	$130,100,000	$295
2035 Upgrade	$268,400,000*	$282
Anthony		
2015 Facilities	$310,100,000	$167
2035 Upgrade	$373,900,000*	$250

*The 2035 upgrades reflect costs based on a 2015 investment with inflation of 3%.

Water Budget Analysis

Estimated impacts to the Rio Grande hydrologic system from just downstream of Caballo Dam to upstream of American Dam resulting from the three proposed alternatives were developed from water budget analyses. Associated with quantitative impacts are impacts to water quality resulting from the alternatives. These impacts were estimated using mass budgets for TDS. The water and mass budgets were constructed in two reaches. Reach 1 represents the Rincon Valley and Reach 2 represents the Mesilla Valley upstream of American Dam. Impacts are assessed by comparing the water and mass budget for each of the alternatives at 2015 demand levels against the Baseline representing existing conditions.

Analysis of the system behavior was performed for "Normal," "Average," and "Dry" water supply conditions. The results from these analyses were combined to develop a "Composite" scenario. Results for only the composite scenario are presented. Key terms from the water budget analyses for the Baseline, Alternative 1, Alternative 2, and Alternative 3 by reach are presented in Table 23. Also shown for each term are the differences between each alternative and the Baseline. A similar table, Table 24, presents the results of the mass budget analyses and the difference between each alternative and the Baseline.

Shown in the last row of Table 23 is the estimated deficit in full supply for 2015 demands from surface water sources for each alternative. The deficit was divided between the New Mexico and Texas water users on a 58 percent, 42 percent basis. Upstream of American Dam, the analyses assumed that the deficit would be made up by ground water pumping. Downstream of American Dam, the deficit could also be made up by ground water pumping. Both upstream and downstream of American Dam, depending on the alternative, additional supply could be developed through capturing and blending return flows in the river. Reduction in demand through, for example , retirement of agricultural land would also be a means of reducing the deficit in surface water supply.

A further distillation of the results for the Baseline and each Alternative is provided in Table 25. This table specifically focuses on the flow in the river and the water quality, expressed as a concentration, at key locations in the system. As shown by these results, each alternative has significantly different impacts on the Rio Grande both from a quantity and quality stand point.

Table 23
Water Budget Summary

Composite Water Supply Scenario PARAMETER	BASELINE Estimated Amount (1000 af)	ALTERNATIVE 1 Estimated Amount (1000 af)	ALTERNATIVE 1 Change from Baseline (1000 af)	ALTERNATIVE 2 Estimated Amount (1000 af)	ALTERNATIVE 2 Change from Baseline (1000 af)	ALTERNATIVE 3 Estimated Amount (1000 af)	ALTERNATIVE 3 Change from Baseline (1000 af)
Reach 1 (Rincon Valley)							
Ground water boundary flux in	3.0	3.0	0.0	3.0	0.0	3.0	0.0
Ground water boundary flux out	0.3	0.3	0.0	0.3	0.0	0.3	0.0
M&I ground water pumping	0.9	0.9	0.0	0.9	0.0	0.9	0.0
Agricultural ground water pumping	18.9	23.9	5.0	30.1	11.2	20.9	2.0
Deep percolation	14.6	14.6	0.0	14.6	0.0	14.6	0.0
Ground water flow to drains	8.4	8.4	0.0	8.4	0.0	8.4	0.0
Canal/lateral seepage	39.3	39.3	0.0	25.8	-13.5	39.3	0.0
Net river seepage (into alluvial aquifer)	-25.2	-25.2	0.0	-25.2	0.0	-25.2	0.0
Change in ground water storage	2.1	-2.9	-5.0	-35.6	-37.7	0.2	-1.9
River inflow	643.9	643.9	0.0	643.9	0.0	643.9	0.0
River outflow	612.2	286.0	-326.2	11.9	-600.3	351.8	-260.4
Main supply canal/pipeline inflow	0.0	331.2	331.2	686.3	686.3	262.4	262.4
Main supply canal/pipeline outflow	0.0	330.5	330.5	625.1	625.1	262.4	262.4
River flow to M&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Main supply canal/pipeline flow to M&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River flow to agriculture	86.0	80.9	-5.1	0.0	-86.0	84.0	-2.0
Main supply canal/pipeline flow to agriculture	0.0	0.0	0.0	61.1	61.1	0.0	0.0
Reach 2 (Mesilla Valley)							
Ground water boundary flux in	0.3	0.3	0.0	0.3	0.0	0.3	0.0
Ground water boundary flux out	0.1	0.1	0.0	0.1	0.0	0.1	0.0
M&I ground water pumping	46.2	6.5	-39.7	11.0	-35.2	4.5	-41.7
Agr. ground water pumping from alluvial aquifer	61.9	77.1	15.2	97.6	35.7	68.0	6.1
Agr. ground water pumping from Mesilla Bolson	41.3	51.4	10.1	62.6	21.3	45.3	4.0
Deep percolation	67.2	67.2	0.0	67.2	0.0	67.2	0.0
Ground water flow to drains	85.0	85.0	0.0	85.0	0.0	85.0	0.0
Canal/lateral seepage	163.8	163.8	0.0	143.8	-20.0	163.8	0.0
Net river seepage (into alluvial aquifer)	59.3	59.3	0.0	59.3	0.0	59.3	0.0
Change in ground water storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net leakance to Mesilla Bolson	143.7	128.5	-15.2	88.0	-55.7	137.6	-6.1
River inflow	612.2	286.0	-326.2	11.9	-600.3	351.8	-260.4
River outflow	358.9	58.0	-300.9	135.7	-223.2	108.6	-250.3
Main supply canal/pipeline inflow	0.0	330.5	330.5	625.1	625.1	262.4	262.4
Main supply canal/pipeline outflow	0.0	229.8	229.8	232.3	232.3	160.7	160.7
River flow to M&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Main supply canal/pipeline flow to M&I	0.0	39.7	39.7	35.2	35.2	41.7	41.7
River flow to agriculture	377.1	351.8	-25.3	0.0	-377.1	367.0	-10.1
Main supply canal/pipeline flow to agriculture	0.0	0.0	0.0	297.6	297.6	0.0	0.0
Deficit in full supply from surface water supply	0.0	58.2	58.2	135.4	135.4	23.3	23.3

Table 24
Mass Budget Summary

Composite Water Supply Scenario PARAMETER	BASELINE Estimated Amount (1000 tons)	ALTERNATIVE 1 Estimated Amount (1000 tons)	ALTERNATIVE 1 Change from Baseline (1000 tons)	ALTERNATIVE 2 Estimated Amount (1000 tons)	ALTERNATIVE 2 Change from Baseline (1000 tons)	ALTERNATIVE 3 Estimated Amount (1000 tons)	ALTERNATIVE 3 Change from Baseline (1000 tons)
Reach 1 (Rincon Valley)							
River inflow	478.6	493.3	14.7	498.5	19.9	500.5	21.9
Canal waste return	8.2	8.2	0.0	8.2	0.0	8.2	0.0
M&I return flow	0.4	0.4	0.0	0.4	0.0	0.4	0.0
Drain flow to river	25.5	25.5	0.0	25.5	0.0	25.5	0.0
Tributary inflow	11.1	11.1	0.0	11.1	0.0	11.1	0.0
River flow to M&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River flow to agriculture	65.1	60.2	-4.9	0.0	-65.1	63.1	-2.0
Main supply canal/pipeline inflow	0.0	272.8	272.8	534.9	534.9	228.5	228.5
Net river seepage (into alluvial aquifer)	-23.8	-23.8	0.0	-23.8	0.0	-23.8	0.0
River outflow	482.5	229.3	-253.2	31.9	-450.6	277.8	-204.7
Reach 2 (Mesilla Valley)							
River inflow	482.5	229.3	-253.2	31.9	-450.6	277.8	-204.7
Canal waste return	23.9	25.4	1.5	22.8	-1.1	28.0	4.1
M&I return flow	25.9	25.9	0.0	25.9	0.0	25.9	0.0
Drain flow to river	204.5	214.5	10.0	25.9	-178.6	261.9	57.4
Tributary inflow	27.2	27.2	0.0	27.2	0.0	27.2	0.0
River flow to M&I	0.0	0.0	0.0	0.0	0.0	0.0	0.0
River flow to agriculture	299.9	292.7	-7.2	0.0	-299.9	349.4	49.5
Net river seepage (into alluvial aquifer)	55.8	66.1	10.3	125.1	69.3	78.8	23.0
River outflow	408.2	163.4	-244.8	172.0	-236.2	149.0	-259.2

Table 25

River Flow and Quality at Key Locations for Composite Water Supply Scenario

Location	River Flow (1000 af)				TDS (mg/l)			
	Baseline	Alt 1	Alt 2	Alt 3	Baseline	Alt 1	Alt 2	Alt 3
Downstream of Caballo	643.9	643.9	643.9	643.9	500	600 1)	600 1)	600 1)
Leasburg	612.2	286.0	11.9	351.8	600	600	2000	600
Upstream of American	358.9	58.0	135.7	108.6	800	2000	1000	1000

1) Revised release pattern from Caballo Reservoir simulated in alternative analyses resulted in increase in estimated TDS concentration below Caballo.

Surface Water Loss Evaluation

The single surface water impact analysis is presented as Table 26. These results tabulate the losses to the usable surface water due to seepage and evaporation. The seepage loss element of surface water losses is not necessarily a system loss, but is presented for evaluation as surface water that will be unavailable for application to irrigation or M&I uses.

The analysis in Table 26 is presented for the purpose of illustrating the comparative values of "loss" for the baseline (no action) and the three alternatives. As applied here, the term "loss" means surface water that is unavailable for surface water applications. The actual loss is that water which evaporates since the seepage quantities become ground water.

Summary of Aquifer Effects

The water budget analysis shows the effect of the baseline and three alternative objectives operating scenarios on the surface water and shallow ground water in the Mesilla Valley. This information is key to the determination of the system-wide effects of the alternatives on the three resource elements of the project: the Mesilla Basin, the Hueco Basin, and the Rio Grande. By extrapolation, the impacts of stream flow in the river and canals, and the long-term gain/loss storage in the aquifers can be determined.

Table 26
Surface Water Loss Analysis
for Average Year
All values in acre-feet x 1000 per year

Water Budget Scenario	Reach	Rio Grande Seepage	Canal Seepage	Rio Grande Evap.-Precip.	Canal Evaporation	Total Loss Seep./Evap.
Baseline	One	-32.6	41.2	4.1	0.3	13.0
	Two	71.4	161.2	5.6	11.8	250.0
	Total	38.8	202.4	9.7	12.1	**263.0**
Alternative 1	One	-32.6	41.2	4.1	0.3	13.0
	Two	71.4	161.2	5.6	11.8	250.0
	Total	38.8	202.4	9.7	12.1	**263.0**
Alternative 2	One	-32.6	27.0	4.1	0.3	-1.2
	Two	71.4	141.5	5.6	11.8	230.3
	Total	38.8	168.5	9.7	12.1	**229.1**
Alternative 3	One	-32.6	41.2	4.1	0.3	13.0
	Two	71.4	161.2	5.6	11.8	250.0
	Total	38.8	202.4	9.7	12.1	**263.0**

The two aquifer analyses are presented as summary diagrams (Figures 47 and Figure 48) to illustrate the effects on the supply resources. The results for each aquifer are presented as a plot of a spreadsheet analysis of the annual gain/loss of storage in that aquifer resulting from "no action" (baseline) and the three alternatives.

The Mesilla Basin

This aquifer is located within the Rio Grande Rift in the reach of the river starting immediately below Caballo Dam. It extends down the river valley to "the pass" at El Paso near the American Dam where the boundaries of New Mexico, Texas, and Chihuahua meet. This aquifer is stream-related inasmuch as flows of surface water in the river channel freely recharge the aquifer and vice-versa, depending on hydraulic gradients. If ground water is withdrawn from the aquifer, causing a surface differential with the river, water will tend to recharge the aquifer. Conversely, if the surface of the aquifer rises above the stream bed of the river, ground water will tend to flow to the surface of the river bed.

Figure 47 shows a plot of net losses in the aquifer storage of the Mesilla Basin vs. time for each alternative and the baseline (no action). The assumptions in making these projections are:

1. The present state of the aquifer is stable. That is, all withdrawals are in balance with the recharge rate, and withdrawals in excess of mountain front recharge are replenished by seepage from the stream beds of the river and canals.

2. The mountain front recharge is presented as a constant representing the estimated average recharge due to watershed precipitation.

3. All M&I well pumpage of ground water is from the Mesilla.

4. Forty percent of all agricultural well pumpage is from the Mesilla, 60 percent is from shallow aquifers.

5. The water required to maintain and protect the aquifer will naturally flow from seepage sources of surface water if available.

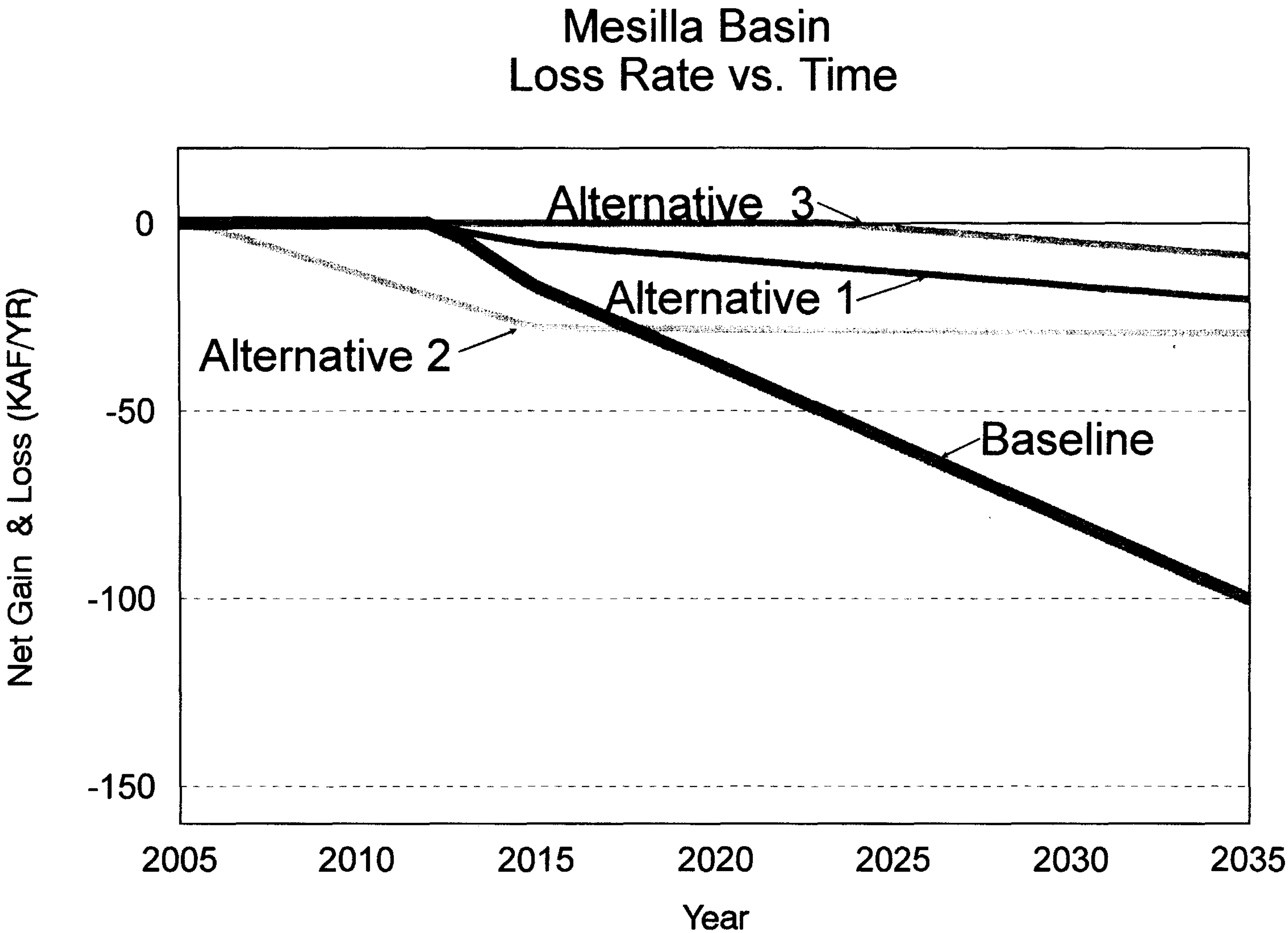

Mesilla Basin
Loss Rate vs. Time
Net Gain & Loss (KAF/YR)
0
-50
-100
-150
Alternative 3
Alternative 1
Alternative 2
Baseline
2005
2010
2015
2020
2025
2030
2035
Year

Figure 47

The Hueco Basin

The Hueco Basin is markedly different from the Mesilla. It is a closed basin on three sides, and it crosses below the flood plain of the Rio Grande, terminating in the Republic of Mexico on the fourth (southern) side. The bulk of the basin lies east of the Hueco Tanks outcropping. The northern end is in Dona Ana County, New Mexico. At present, approximately 60 percent of the municipal water supply of the City of El Paso is extracted by wells from this aquifer. This aquifer is in serious jeopardy of total depletion if actions are not taken to stop and reverse present trends.

The extrapolations of the results of the water budget analysis are applied by assuming the surface water availability to EPWU/PSB identified in the alternatives will be applied against the base demand requirements of the utility, and the existing well fields will be utilized to provide the peak requirements during the summer months when water demands exceed the base capacity of the water treatment plants. This strategy will reduce the aquifer withdrawal by more than two-thirds.

The assumptions of this analysis are:

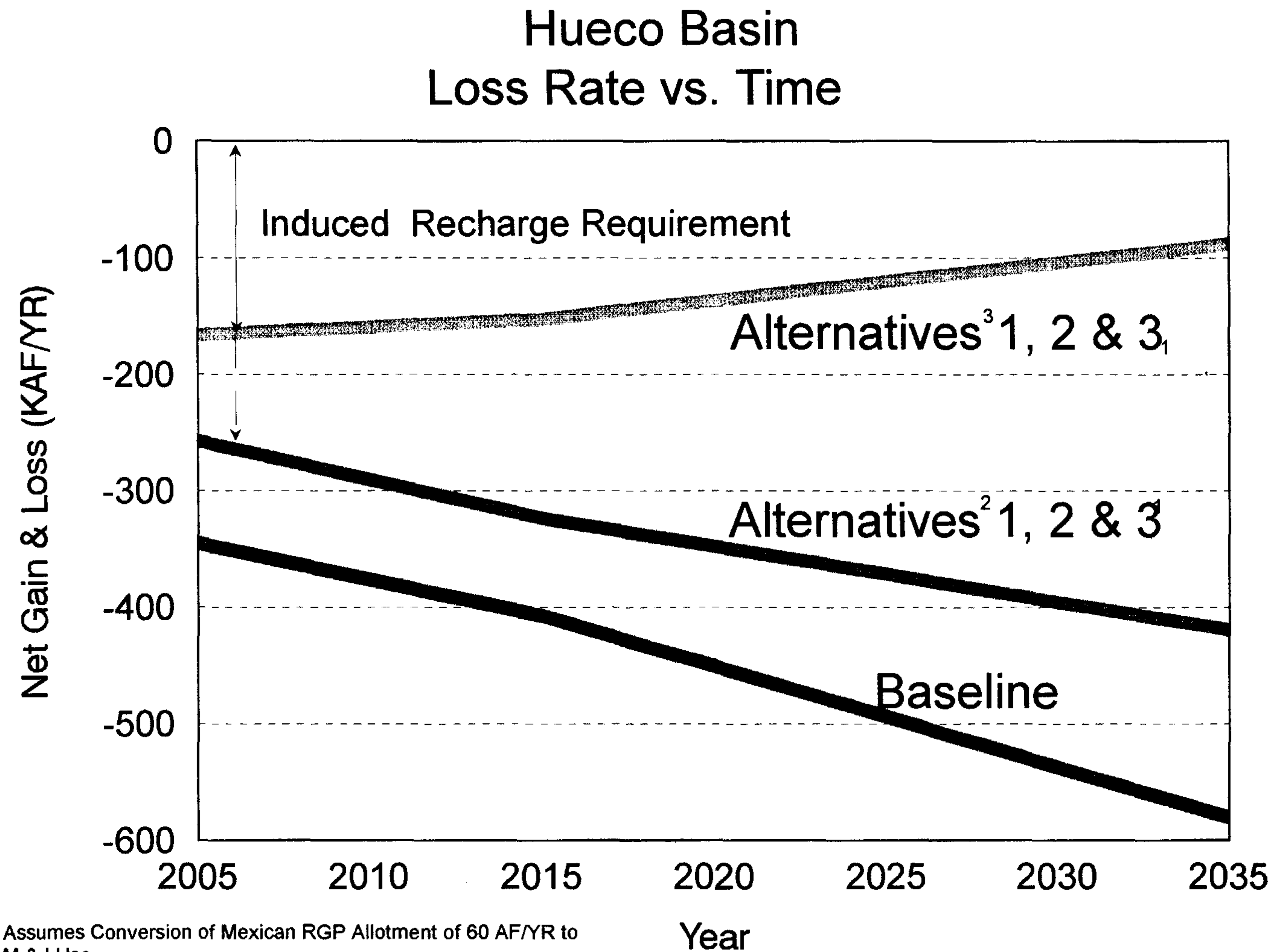
1. The natural mountain front recharge is represented as a constant representing the average annual recharge due to precipitation on the watershed.

2. The recharge attributable to the injection of tertiary treated waste water from the Fred Hervey Water Reclamation plant will continue at the present capacity.

3. The out-flux of the aquifer is assumed to be the projected well pumpage by Ciudad Juarez for its municipal water supply. The baseline Juarez water demand from the aquifer is modified for the alternative analyses by a reduction equivalent to applying the full 1906 Convention allotment for Mexico (60,000 af/yr) to municipal purposes.

The plot shown on Figure 48 represents the Hueco Basin storage impacts. To be noted is that even with the most rigorous application of surface water to municipal purposes by the City of El Paso (EPWU), full stability of reservoir storage is not achieved.

The extraction of ground water from the Hueco Basin by Juarez is not within the jurisdiction of the United States entities. This fact would indicate that continued cooperative ground water conservation planning efforts with the Republic of Mexico should be pursued.



1. Assumes Conversion of Mexican RGP Allotment of 60 AF/YR to M & I Use.
2. Alternatives impact if Mexico continues present trends of ground water for M & I.
3. Alternatives impact if Mexico converts growth demand beyond year 2000 to surface water supply.

Figure 48

Restoration or stabilization of the Hueco Basin will be dependent on induced recharge by means of spreading or well injection of surface water. The quantity, or rate of recharge required to attain stability is indicated in Figure 48 as the difference between the selected alternative and zero loss.

Water banking and aquifer storage are addressed under the Additional Considerations section of this report.

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Conjunctive Water Resource Management Technical Data Report-Volume I

Contract No. 94-483-017

The following maps are not attached to this report. Due to their size, they could not be copied. They are located in the official file and may be copied upon request.

Conjunctive Water Resource Management and Aquifer Restoration Study—Northern Half Figure 3

Conjunctive Water Resource Management and Aquifer Restoration Study—Southern Half Figure 3

Please contact Research and Planning Fund Grants Management Division at (512) 463-7926 for copies.