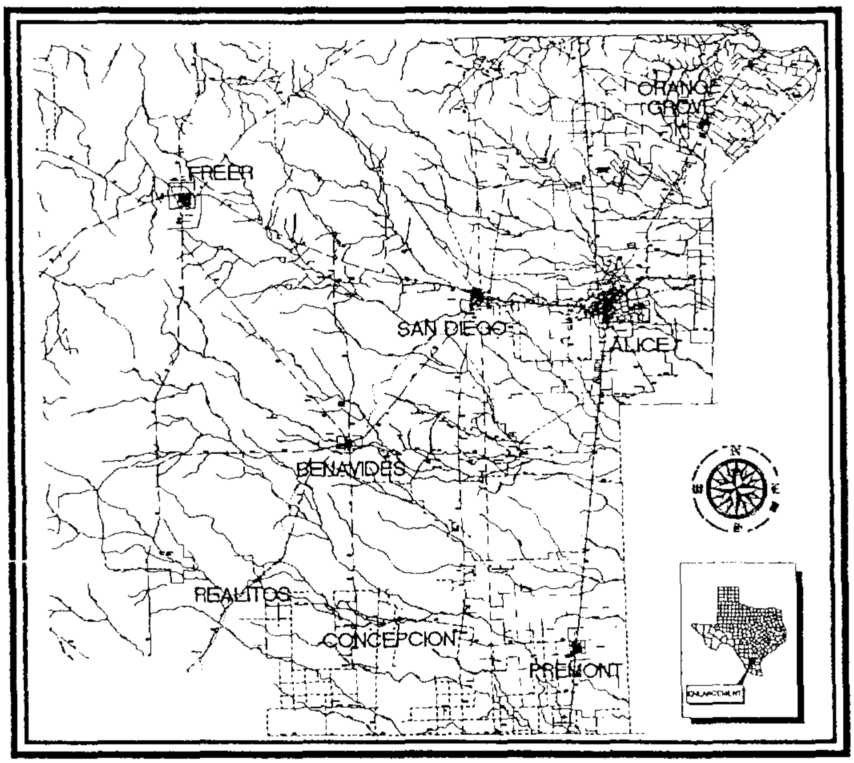
FINAL REPORT

REGIONAL WATER SUPPLY STUDY
DUVAL AND JIM WELLS COUNTIES, TEXAS

PREPARED FOR

NUECES RIVER AUTHORITY
AND
TEXAS WATER DEVELOPMENT BOARD



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ACKNOWLEDGMENT

This study was authorized and administered by the Nueces River Authority and funded by a grant from the Texas Water Development Board, with contributions from the following entities:

Alice Water Authority
City of Alice
Duval County
Duval County Conservation and Reclamation District
Freer Water Control and Improvement District
Jim Wells County

TABLE OF CONTENTS

TABLE OF CONTENTS - CONTINUED

TABLE OF CONTENTS - CONTINUED

TABLE OF CONTENTS - CONTINUED

LIST OF TABLES

LIST OF FIGURES

DUVAL AND JIM WELLS COUNTIES
REGIONAL WATER SUPPLY STUDY
OCTOBER, 1996

EXECUTIVE SUMMARY

ES 1.0. INTRODUCTION

With the exception of the City of Alice, all cities and public water suppliers located within Duval and Jim Wells Counties have historically relied on locally available groundwaters to satisfy the water needs of the region. For the planning period through year 2050, it is reasonable to assume that increased system demands will reduce groundwater quality and quantity, which in some cases is already marginal. The primary objective of this study is to determine the engineering and economic feasibility of extending a surface water supply system to the region. The Choke Canyon/Lake Corpus Christi Reservoir System (CC/LCC System) will be the source of surface water for the regional system and the City of Alice will be the water supplier.

ES 2.0. INVENTORY OF EXISTING WATER SUPPLY SYSTEMS

In addition to the City of Alice, existing water suppliers in Duval and Jim Wells Counties include: Orange Grove; Premont; Duval County Conservation and Reclamation District (DCCRD), which supplies San Diego, Benavides, Realitos and Concepcion; and Freer Water Control and Improvement District (Freer WCID). Fresh to moderately saline groundwaters are supplied to portions of the study area from three aquifers: the Catahoula Tuff, Oakville Formation and Goliad Formation.

Duval and Jim Wells Counties are also included in the 12-county region supplied by the (CC/LCC) System. Water supply facilities owned by the City of Alice include a raw water intake on Lake Corpus Christi, 20" and 30" raw water transmission lines and a 12 MGD water treatment plant. Groundwater facilities serving the other municipalities in the study area were inventoried, including their supply wells, ground storage tanks, booster pump stations and elevated storage tanks. Existing wastewater treatment plants which discharge into receiving waters in the study area include the Alice Northside and Southside plants, the Orange Grove plant and the San Diego plant. Existing wastewater treatment facilities that do not discharge include those at Premont, Benavides, Realitos, Concepcion and Freer.

ES 3.0. ADEQUACY OF EXISTING WATER SUPPLY AND TRANSMISSION CAPABILITIES TO SATISFY CURRENT STATE AND FEDERAL RULES AND REGULATIONS

Chlorides and total dissolved solids levels in existing groundwater supplies are shown in Table ES-1.

TABLE ES-1
CONTAMINANT LEVELS OF EXISTING GROUNDWATER SUPPLY

Constituent	Max. Permissible Level (mg/L)		Approximate Existing Average Constituent Level (mg/L)							
	TNRCC	USEPA	Alice	Orange Grove	Premont	San Diego	Benavides	Realitos	Concepcion	Freer
Total Dissolved Solids	1000	500	1150 - 1230	1000 - 1100	750±	800 - 1000	1350 - 1425	1021	1104	1292
Chloride	300	250	310 - 418	250±	250±	180 - 250	425 - 450	399	466	396

Several water suppliers in the study area have received correspondence from the Texas Natural Resource Conservation Commission (TNRCC) stating that the maximum permissible levels for these constituents have been exceeded, and that should an alternate source of water become available, they must utilize the alternate source to remediate or replace the existing water supply.

Alice has existing raw water pump capacity, treatment capacity and high service pump capacity to meet a 12-million gallon per day (mgd) demand. The projected average daily demands for all cities in the study area at year 2050 is approximately 7 mdg, with projected peak day demands of 12 mgd. Other municipalities in the study area generally have adequate capacities in wells, pumping and storage to meet their existing needs.

ES 4.0. POTENTIAL REGIONAL WATER SUPPLY AND TRANSMISSION FACILITIES

Study area population and water demand projections were based on the 1996 Consensus Texas Water Plan. The most likely series population projections with below normal rainfall were used. Table ES-2 shows population projections for the study area.

Nine (9) regional surface water service area alternatives were evaluated. Alternative 1 (San Diego, Benavides, Realitos, Concepcion and Freer), Alternative 2 (San Diego, Benavides and Freer), Alternative 3 (San Diego and Benavides), Alternative 4 (San Diego and Freer), and Alternative 5 (San Diego), Alternative 6 (Freer), and Alternative 9 (Orange Grove) assume connection to the City of Alice water treatment plant high service pump station. Alternative 7 assumes water supply directly from Choke Canyon Reservoir to Freer. Alternative 8 assumes connection to the City of Alice distribution system near the southern city limits and extension to Orange Grove. Proposed regional facilities include transmission lines ranging in size from 6" to 16" in diameter, and intermediate storage and booster pump stations (required by the relatively high static heads and long pumping distances). Total capital cost and annual costs (debt service, power cost, O&M cost, and treated water cost) were estimated for each alternative and are summarized in Table ES-3. In addition, costs associated with continued use of groundwater were used in evaluating the feasibility of the various surface water alternatives. The required number of wells were determined for the planning period, and capital, operation and maintenance (O&M) and power costs were estimated per 1000 gallons of water produced at the wellhead. Estimated costs for continued use of groundwater are summarized in Table ES-4. Estimated costs for desalination of brackish groundwater were estimated to range up to $3.50/ 1000 gallons.

TABLE ES-2
STUDY AREA POPULATION PROJECTIONS [1]

City	YEAR					
	2000	2010	2020	2030	2040	2050
Alice	22,123	23,649	24,910	25,105	24,982	24,860
Orange Grove	1,333	1,430	1,505	1,521	1,525	1,529
Premont	3,105	3,607	4,239	4,752	4,984	5,227
San Diego	5,336	5,962	6,423	7,068	7,553	8,076
Benavides	1,910	2,087	2,257	2,376	2,456	2,539
Realitos	508	541	590	586	581	552
Concepcion	198	210	229	227	226	215
Freer	4,276	4,888	5,451	6,031	6,597	7,216
TOTAL STUDY AREA	38,789	42,374	45,604	47,666	48,904	50,214

(1) Based on TWDB most likely series.

TABLE ES-3
SUMMARY OF COSTS FOR SURFACE WATER ALTERNATIVES[1]

Alternative No.	Total Project Capital Cost (millions of dollars)	Total Cost/1000 Gallons (dollars)[2]
1. San Diego, Freer, Benavides, Realitos, Concepcion (See Table 4-8)	$13.862	$3.09
2. San Diego, Freer, Benavides (See Table 4-9)	$10.605	$2.84
3. San Diego, Benavides (See Table 4-10)	$5.207	$2.31
4. San Diego, Freer (See Table 4-11)	$8.08	$2.80
5. San Diego (See Table 4-12)	$2.466	$2.05
6. Freer (supplied by Alice) (See Table 4-13)	$7.685	$4.49
7. Freer (supplied by Corpus Christi) (See Table 4-14)	$13.217	$5.08
8. Premont (See Table 4-15)	$5.267	$2.80
9. Orange Grove (See Table 4-16)	$1.773	$3.02

(1) Includes costs for transmission of surface water to storage facilities. Does not include costs for distribution from storage facilities to user.

(2) Includes: Debt service for total project capital cost (assumes 4.5%, 40 years)
Power Cost
O&M cost
Treated water cost (assumes $1.40/1000 gallons)

TABLE ES-4

COST/1000 GALLONS PRODUCED AND DELIVERED TO TREATED WATER STORAGE FACILITIES (1996 DOLLARS)

Cost	2000	2010	2020	2030	2040	2050
ORANGE GROVE						
Capital Cost	---	---	---	0.41	0.41	0.41
Operation & Maintenance Cost	0.29	0.29	0.29	0.29	0.29	0.29
Energy Cost	0.13	0.14	0.15	0.16	0.17	0.18
Total Cost	0.42	0.43	0.44	0.86	0.87	0.88
PREMONT						
Capital Cost	---	---	---	0.07	0.07	0.06
Operation & Maintenance Cost	0.14	0.12	0.11	0.10	0.09	0.09
Energy Cost	0.17	0.18	0.19	0.20	0.21	0.22
Total Cost	0.31	0.30	0.30	0.37	0.37	0.37
SAN DIEGO						
Capital Cost	---	0.35	0.34	0.15	0.15	0.14
Operation & Maintenance Cost	0.17	0.16	0.16	0.15	0.15	0.14
Energy Cost	0.22	0.23	0.24	0.25	0.26	0.27
Total Cost	0.39	0.74	0.74	0.55	0.56	0.55
BENAVIDES						
Capital Cost	0.20	0.19	0.18	0.28	0.27	0.27
Operation & Maintenance Cost	0.27	0.27	0.26	0.25	0.25	0.24
Energy Cost	0.12	0.13	0.14	0.15	0.16	0.17
Total Cost	0.59	0.59	0.58	0.68	0.68	0.68
FREER						
Capital Cost	0.22	0.20	0.19	0.17	0.17	0.16
Operation & Maintenance Cost	0.21	0.19	0.18	0.17	0.16	0.15
Energy Cost	0.30	0.31	0.32	0.33	0.34	0.35
Total Cost	0.73	0.70	0.69	0.67	0.67	0.66

NOTE: This analysis is for economic purposes only and is not necessarily indicative of solutions to supply water which meets TNRCC and USEPA drinking water quality standards.

ES 5.0. INSTITUTIONAL ARRANGEMENTS FOR MANAGEMENT, FINANCING, AND OPERATIONS AND MAINTENANCE FOR RECOMMENDED REGIONAL WATER SUPPLY AND TRANSMISSION FACILITIES

Financial assistance available through the USDA - Rural Development (formerly the Farmers Home Administration), was determined to be the most attractive for the regional surface water supply system. The Rural Development loan rate at the present time is 4.5% and the payout period is 40 years.

ES 6.0. WATER CONSERVATION PLAN

The City of Alice Code of Ordinances requires all its water customers to abide by the water conservation plan detailed therein.

ES 7.0. RECOMMENDED PLAN

Based on the results of the study, the following conclusions are made:

- Orange Grove and Premont appear to be in the most favorable position to remain on groundwater for the near and long term.

- Although existing water qualities are poor, the cost to serve Concepcion and Realitos with surface water is generally prohibitive.

- The major problems with groundwater quantity and quality in the study area lie with the three largest cities in Duval County: San Diego, Benavides and Freer.

- San Diego has marginally acceptable water. Recent attempts to find locations for high volume wells with acceptable water quality have been unsuccessful. It is likely that in the long term the DCCRD must seek larger well fields some distance from the City or, alternately, convert to surface water.

- Benavides and Freer have water that falls substantially outside the TNRCC limits for total dissolved solids and chlorides. While Benavides appears to be in reasonably good condition with respect to well volume potential and water availability, there is concern about remaining life of the existing wells and future availability of water in Freer.

- It is evident that there will be a need for enhanced water supply for the three Duval cities in the future. The time frame will be dictated by several factors, including:
  - Deterioration of water quantity, water quality and pumping levels in existing wells.
  - Availability of new suitable potable groundwater resources.
  - More stringent enforcement of water quality standards by TNRCC and USEPA.

Cost estimates indicate that the existing water well systems presently have an economic advantage, when compared to regional surface water systems. However, there are other factors which may require future conversion to surface water.

It is recommended that surface water projects in Duval County be initiated, constructed and financed by the Duval County Conservation and Reclamation District. In addition, the system should be operated and maintained by DCCRD. Based on the investigation of possible funding sources, the best financing is through the USDA - Rural Development(RD). RD has a grant-loan program with up to a maximum of 75% of project cost being grant and with the loan portion having an interest rate of 4.5% for 40 years. However, it appears that, with the exception of the "Freer only" project (Alternative 6), which could be eligible for up to a 50% grant, no other project would be likely to receive grant funding from RD.

It is recommended that Duval County entities continue to maintain their groundwater systems in the short term until such time as events occur which may necessitate a change in water supply. These events could include:

- Requirement to change to surface water by TNRCC and/or USEPA due to water quality considerations.
- Possible large capital investment in new wells due to deterioration of quality or quantity of water in existing wells.
- Inability to find locations for new wells.

When any of these events occur, it is recommended that DCCRD utilize the preliminary engineering and cost estimates developed in this study to begin the process of converting cities in Duval County to surface water. Under the conditions at that time, an in-depth evaluation of the economic feasibility of "phasing" into the surface water system should be made.

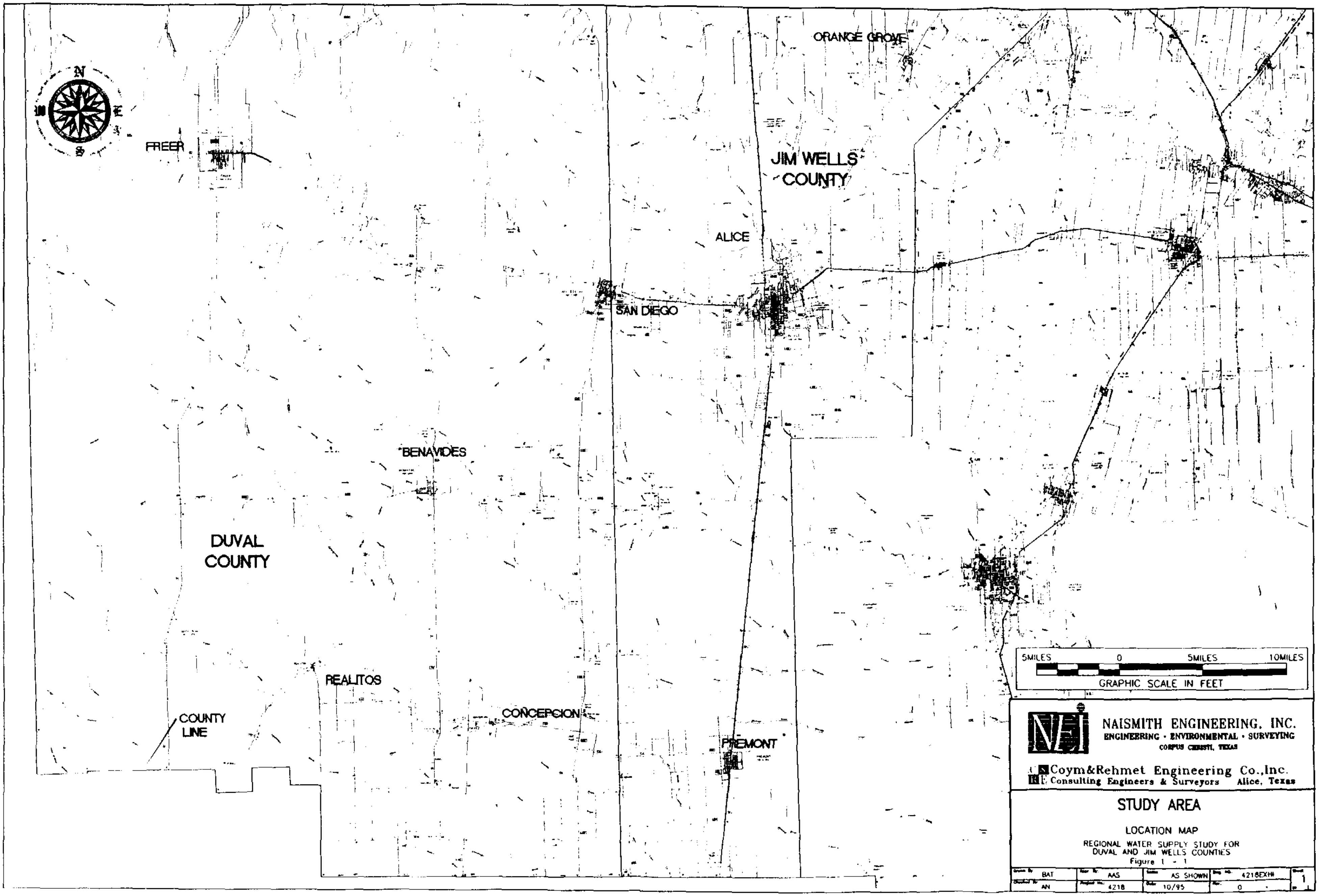
1.0. INTRODUCTION

1.1. Study Area Description

The planning area encompasses the entire geographical boundaries of Duval and Jim Wells Counties. The area is located within the Nueces River Basin and the Nueces-Rio Grande Basin. (See Figure 1-1).

1.2. Background

With the exception of the City of Alice, all cities and public water suppliers located within Duval and Jim Wells Counties have historically relied on locally available groundwaters to satisfy the water needs of the region. The City of Alice, which is currently treating surface waters from Lake Corpus Christi, converted from groundwater in 1965. Residents within Duval and Jim Wells Counties have relied primarily on groundwater supplies from wells drilled into the Goliad sand. The City of Freer, located in Duval County, is the only exception and draws its water from a deeper sand known as the Catahoula Tuff. Groundwater supplies from this region have historically experienced consistent difficulties meeting the Texas Natural Resource Conservation Commission's (TNRCC) Secondary Maximum Contaminant Levels established for Drinking Water Standards for total dissolved solids (TDS), chlorides and sulfates.



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FREER
ORANGE GROVE
JIM WELLS
COUNTY
ALICE
SAN DIEGO
BENAVIDES
DUVAL
COUNTY
REALITOS
CONCEPCION
COUNTY
LINE
PREMONT
5MILES
0
5MILES
10MILES
GRAPHIC SCALE IN FEET
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STUDY AREA
LOCATION MAP
REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES
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Existing groundwater pumping levels and water qualities have been diminishing with continual pumping of the fresh water aquifers serving this region. Increased system demands will further reduce groundwater quality and quantity, which will in turn reduce the region's ability to meet future water system demands. Well fields, which have provided water supply to this area, are for the most part, 20 -30 years of age and are reaching the end of their useful service life. Continual pumping to meet municipal, agricultural, and industrial demands have resulted in moderate to large drops in the pumping water levels in much of the region. As an example, the City of Freer has seen a considerable reduction in static water level over the past 30 years. Many water wells drilled in the early 1960s have had significant drops in static water levels, several which have resulted in the abandonment of water wells serving the public water supply system.

The following table from the City of Freer's water system typifies problems with pumping waters from the Catahoula Tuff sands for public water supply.

City of Freer Water Supply

Well Number	Year Drilled	Original Static Water Level	1992 Static Water Level
6	1961	225'	542'
8	1961	230'	Dry/Abandoned
4	1961	172'	Dry/Abandoned

Moderate to large declines in water levels have also occurred in the Goliad sands. These declines are mainly attributed to pumpage by irrigation, public supply, and industrial wells that tapped Goliad sands in the East, Central, and Southeast part of the Duval County. In some places in Duval County, saline or moderately saline water overlies fresh and slightly saline water. This condition, coupled with the corrosive nature of the area's soils, may have resulted in contributing to the loss of water quality. From review of the Texas Water Development Board's Report 181, Ground Water Resources of Duval County, Texas, March, 1974, it becomes apparent that reliability of groundwater resources within the Duval/Jim Wells County area, is marginal at best. In the abstract of this report, the following statement is made:

> "THE GROUNDWATER IS CHARACTERISTICALLY HIGH IN DISSOLVED SOLIDS, CHLORIDE, AND HARDNESS. MOST OF THE WATER SAMPLED DOES NOT MEET THE QUALITY STANDARDS OF THE U.S. PUBLIC HEALTH SERVICE FOR DRINKING WATER, ALTHOUGH WATER HAVING CHEMICAL CONSTITUENTS IN EXCESS OF THE STANDARDS IS USED IN THE COUNTY FOR DRINKING. WATER FROM THE GOLIAD SAND IS MORE SUITABLE FOR IRRIGATION THAN WATER FROM THE OAKVILLE SAND STONE AND CATAHOULA TUFF; HOWEVER, WATER FROM ANY OF THE THREE AQUIFERS SHOULD BE USED WITH CAREFUL MANAGEMENT AND AS A SUPPLEMENT TO RAINFALL."

Copies of recent groundwater analyses are included in Appendix A, and show that, in many cases, water produced from existing municipal water supply systems, do not currently meet TNRCC Secondary Maximum Contaminant Levels for public water supply wells. As with many South Texas communities, the residents of Duval and Jim Wells Counties must begin to investigate alternatives available to meet fresh water system demands. Over the past 40 years, 24 public water suppliers located within the Choke Canyon/Lake Corpus Christi service area, have converted from groundwaters to surface water supply to meet their water system requirements.

Many of these communities made the conversion as regional surface water supplies and transmission facilities were developed. In 1965, the City of Alice developed a fresh water supply system from Lake Corpus Christi to meet their water supply needs. Since that period of time, additional transmission facilities and an upgrade of the Alice water treatment plant have been constructed to meet existing and future proposed demands.

1.3. Objectives

The rural communities of Jim Wells and Duval Counties are faced with a rapidly deteriorating water supply infrastructure and must begin to investigate development of future alternative water supply and transmission facilities. While each city and rural community would, more than likely, not be able to convert to surface water supplies on their own, the feasibility of a regional supply and transmission system might provide an economical solution to satisfying future water needs. A potential supplier of surface water is the Alice Water Authority, which takes water from Lake Corpus Christi under a water supply contract with the City of Corpus Christi and has capacity to serve the Duval County communities with treated surface waters.

The primary objective of this study is to determine the engineering and economic feasibility of a regional surface water conveyance system to serve some or all areas in Jim Wells and Duval Counties that currently depend on groundwater supplies.

In addition, this study will evaluate the potential for enhancement of the existing groundwater supply. Finally, the study will evaluate the potentials for wastewater reuse and water conservation to maximize the area's water resources.

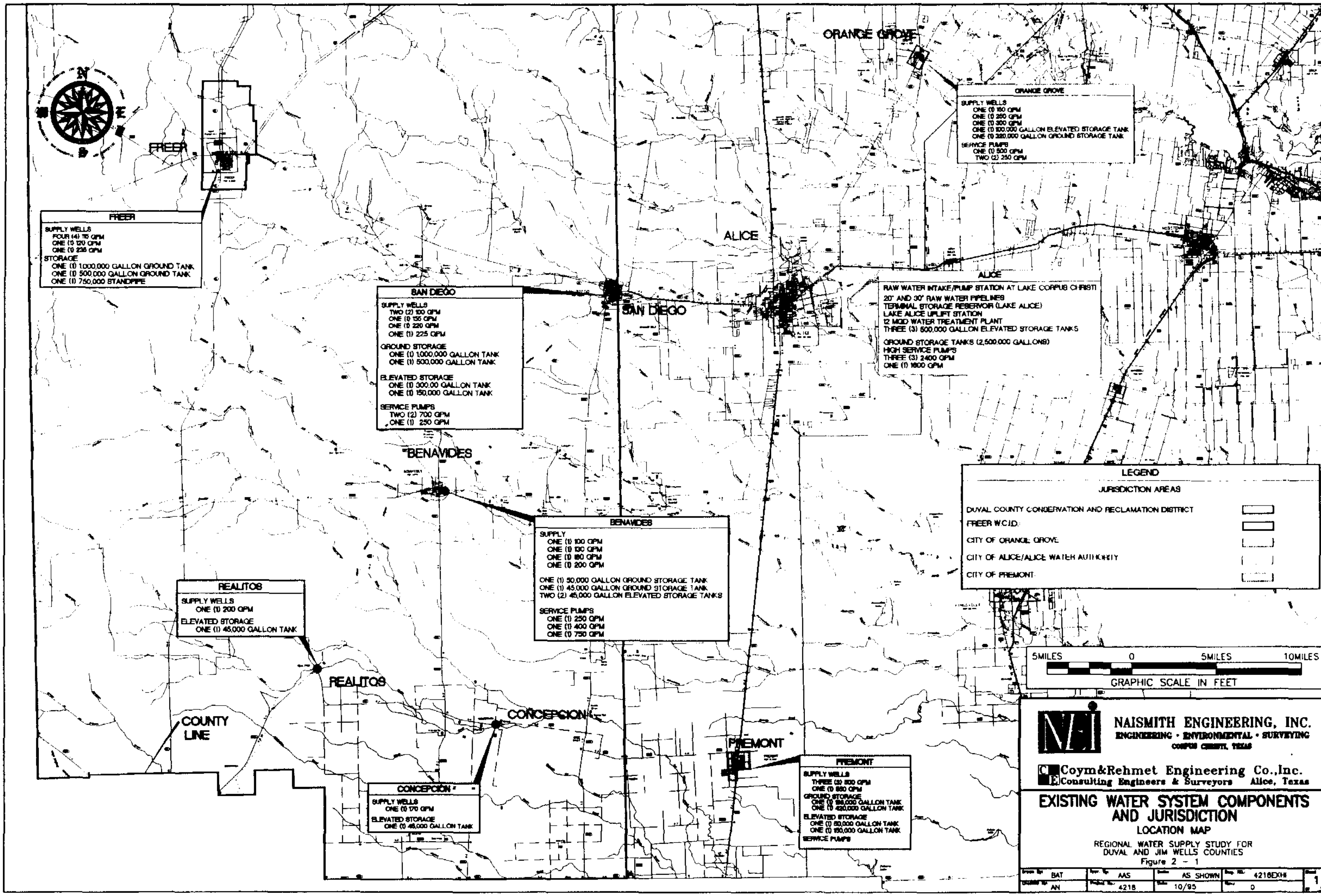
2.0. INVENTORY OF EXISTING WATER SUPPLY SYSTEMS FOR DUVAL AND JIM WELLS COUNTIES

2.1. Areas of Jurisdiction Within The Planning Area

There are five major entities with jurisdictional responsibility for water and wastewater services in Duval and Jim Wells Counties (See Figure 2-1).

2.1.1. City of Alice and the Alice Water Authority (AWA)

The City of Alice and the Alice Water Authority (AWA) effectively act as one entity. The Board of the AWA is appointed by the Alice City Council and the Executive Director of the AWA is the Alice City Manager. The area of jurisdiction of the City of Alice and the Alice Water Authority is the city limits of Alice.



ORANGE GROVE
FREER
ALICE
SAN DIEGO
BENAVIDES
REALITOS
CONCEPCION
FREMONT
COUNTY LINE
N
E
S
W
ORANGE GROVE
SUPPLY WELLS
ONE (1) 160 GPM
ONE (1) 250 GPM
ONE (1) 300 GPM
ONE (1) 100,000 GALLON ELEVATED STORAGE TANK
ONE (1) 320,000 GALLON GROUND STORAGE TANK
SERVICE PUMPS
ONE (1) 500 GPM
TWO (2) 250 GPM
FREER
SUPPLY WELLS
ONE (1) 120 GPM
ONE (1) 235 GPM
STORAGE
ONE (1) 1,000,000 GALLON GROUND TANK
ONE (1) 500,000 GALLON GROUND TANK
ONE (1) 750,000 STANDPIPE
SAN DIEGO
SUPPLY WELLS
TWO (2) 100 GPM
ONE (1) 155 GPM
ONE (1) 220 GPM
ONE (1) 225 GPM
GROUND STORAGE
ONE (1) 1,000,000 GALLON TANK
ONE (1) 500,000 GALLON TANK
ELEVATED STORAGE
ONE (1) 300,00 GALLON TANK
ONE (1) 150,000 GALLON TANK
SERVICE PUMPS
TWO (2) 700 GPM
ONE (1) 250 GPM
ALICE
RAW WATER INTAKE/PUMP STATION AT LAKE CORPUS CHRISTI
20" AND 30" RAW WATER PIPELINES
TERMINAL STORAGE RESERVOIR (LAKE ALICE)
LAKE ALICE UPLIFT STATION
12 MGD WATER TREATMENT PLANT
THREE (3) 500,000 GALLON ELEVATED STORAGE TANKS
GROUND STORAGE TANKS (2,500,000 GALLONS)
HIGH SERVICE PUMPS
THREE (3) 2400 GPM
ONE (1) 1600 GPM
BENAVIDES
SUPPLY
ONE (1) 100 GPM
ONE (1) 130 GPM
ONE (1) 180 GPM
ONE (1) 200 GPM
ONE (1) 50,000 GALLON GROUND STORAGE TANK
ONE (1) 45,000 GALLON GROUND STORAGE TANK
TWO (2) 45,000 GALLON ELEVATED STORAGE TANKS
SERVICE PUMPS
ONE (1) 250 GPM
ONE (1) 400 GPM
ONE (1) 750 GPM
REALITOS
SUPPLY WELLS
ONE (1) 200 GPM
ELEVATED STORAGE
ONE (1) 45,000 GALLON TANK
CONCEPCION
SUPPLY WELLS
ONE (1) 170 GPM
ELEVATED STORAGE
ONE (1) 45,000 GALLON TANK
FREMONT
SUPPLY WELLS
THREE (3) 500 GPM
GROUND STORAGE
ONE (1) 420,000 GALLON TANK
ELEVATED STORAGE
ONE (1) 50,000 GALLON TANK
ONE (1) 150,000 GALLON TANK
SERVICE PUMPS
LEGEND
JURISDICTION AREAS
DUVAL COUNTY CONSERVATION AND RECLAMATION DISTRICT
FREER W.C.I.D.
CITY OF ORANGE GROVE
CITY OF ALICE/ALICE WATER AUTHORITY
CITY OF FREMONT
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EXISTING WATER SYSTEM COMPONENTS
AND JURISDICTION
LOCATION MAP
REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES
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2.1.2. Orange Grove

The area of jurisdiction includes the city limits and is generally a two-mile square centered on the intersection of S.H. 359 and F.M. Road 624 with the North-South axis generally parallel to S.H. 359.

2.1.3. Premont

The area of jurisdiction is the city limits of the City of Premont.

2.1.4. Duval County Conservation And Reclamation District (DCCRD

The area of jurisdiction is the entirety of Duval County with the exception of approximately 11,900 acres encompassed by the Freer Water Control and Improvement District (Freer WCID).

2.1.5. Freer Water Control And Improvement District (Freer WCID)

The area of jurisdiction is an approximate 11,900 acres which encompasses the city limits of the City of Freer and from the intersection of State Highway 44 and State Highway 16 extends approximately four miles to the North, two miles to the South, two miles to the East and one mile to the West.

2.2. Groundwater And Surface Water Resources for the Planning Area

2.2.1. Groundwater Resources

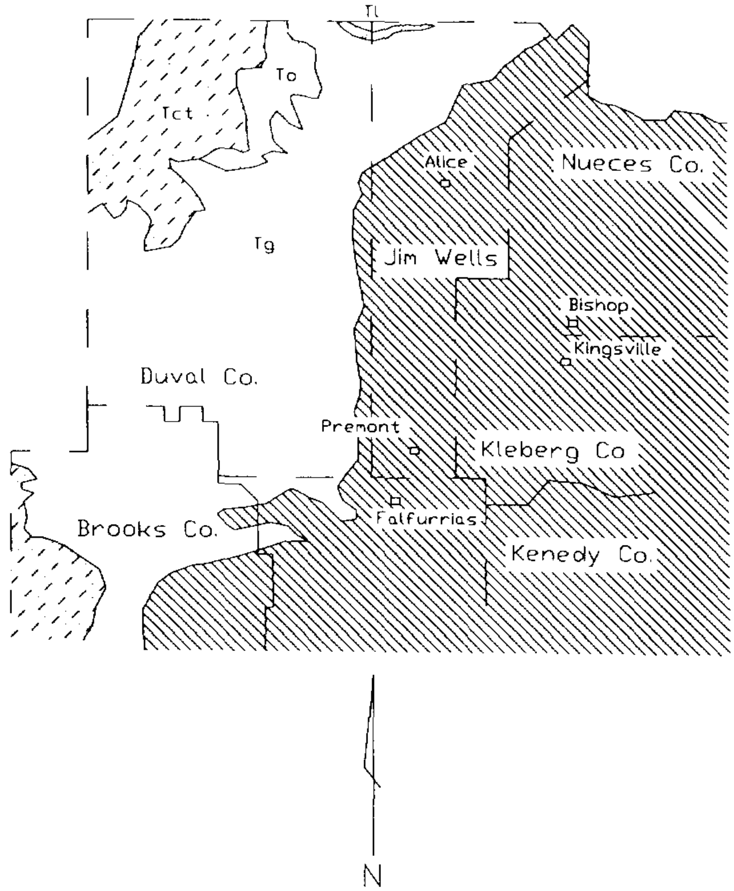
The groundwater resources of Duval and Jim Wells Counties are detailed in several publications by the State of Texas[1,2,3] and private consultants.[4,5] These reports indicate that, with the exception of Alice, the cities, towns and small rural communities in the study area are all supplied by groundwater from one of three aquifers/geologic formations. The three aquifers from oldest to youngest are: Catahoula Tuff, Oakville Formation and Goliad Formation. Each of these aquifer units supplies fresh to moderately saline groundwater in portions of the study area. Table 2-1 lists and briefly describes the groundwater resources in the study area. Figures 2-2 and 2-3 describe the general geologic characteristics of Jim Wells and Duval Counties.

In the Western third of Duval County, the Catahoula Tuff consists of a tuffaceous clay and volcanic tuffs with interbedded lenticular sandy clays and thick to thin beds of sand and conglomerates. This formation contains water that ranges from fresh to moderately saline. One particular lens of this formation, termed a "Frio Sand" by consulting petroleum engineers, located approximately six to eight miles south of Freer and found at a depth of 400± to 600±, yields water that is utilized as the main source of public water supply for that City.

The Oakville Formation, overlying the Catahoula Formation, is recognized in outcrops as a predominately sandy sequence forming an irregular belt from one to ten miles wide in the north-west central portion of the study area. This sand is from 0 to about 600 feet in thickness and yields small to moderate quantities of fresh to slightly saline waters. This aquifer may be utilized in a few areas of the study area that require very limited water supplies but is currently used in limited areas due to a better water supply obtained from the overlying Goliad sand.

The Goliad Formation is the primary source of potable groundwater supply for the study area. The Goliad Formation consists of fine to coarse, mostly gray calcareous sand interbedded with gravel and calcareous clay. Caliche is common throughout the outcrop area. In the subsurface, the Goliad approaches a thickness of 1,100 feet and dips to the east at a rate of between 20 to 40 feet per mile. In the study area, the top of the Goliad occurs from ground surface to 600_ below the land surface. Recharge to the Goliad results from precipitation on the outcrop area in Duval, Jim Wells, and Jim Hogg Counties with the groundwater constantly moving to discharge areas in the east.

QUATERNARY		Deposits younger than the Goliad (Eolian deposits, Barrier island deposits Beach deposits Beaumont and Lissle Formations) Sands, gravels, silts and caly.
TERTIARY	Pliocene	Tg Goliad Sand Fine to coarse sand interbedded with sandstone and clay
	Miocene	Tl Lagarto Clay Calcareous clay and some thin beds of lenticular sand
		To Oakville Sandstone Very fine to coarse sand and sandstone interbedded with silt and clay
		Tct Catahoula Tuff Tuffaceous clay, sandstone and conglomerate
	Oligocene and Eocene	Rocks older than Catahoula Tuff



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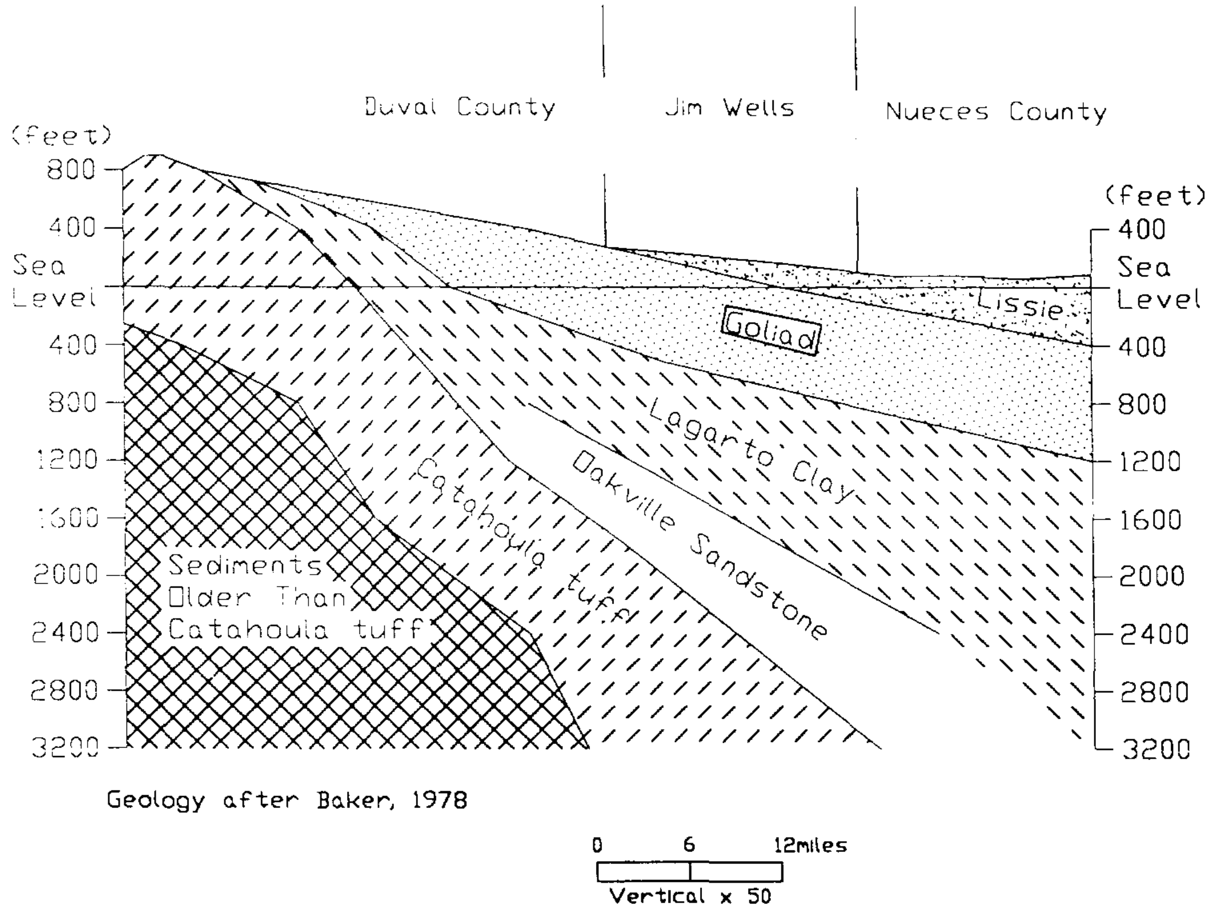
GENERALIZED GEOLOGIC MAP OF DUVAL AND JIM WELLS COUNTIES, TEXAS

REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES
Figure 2 2

Drawn By:	Appr By: GAB	Scale: 1"=25'	Dwg. NO.: GEOMAP01	Sheet 1
Checked By: GAB	Project No.: 4218	Date: 9-96	Rev.: 0	of 1



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GENERALIZED GEOLOGIC CROSS-SECTION DUVAL AND JIM WELLS COUNTIES, TEXAS

REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES
Figure 2-3

Drawn By: AN	Appr. By: GAB	Scale: 1"=1"	Dwg. No.: GEOLOC	Sheet 1 of 1
Checked By: GAB	Project No.: 4218	Date: 9-96	Rev.: 0	

TABLE 2-1

EXISTING GROUNDWATER RESOURCES IN STUDY AREA

System	Series	Geologic Formation	Maximum Thickness (Ft)	Lithology	Water Bearing Characteristics
QUATENARY	Pleistocene	Lissie Formation	1.400	Lissie Formation mostly very calcareous, slightly carbonaceous, blue and yellow clay and a few lenticular beds of sand.	Lissie Formation yields small quantities of fresh to moderately saline water to a few domestic and stock wells in eastern Jim Wells County.
TERTIARY	Pliocene	Goliad Sand	1,100	Fine to coarse, mostly gray calcareous sand interbedded with sandstone and vari-colored calcareous clay. Sand beds or sandstone compose from 40 to 60 percent of the formation.	Principal aquifer. Yields small to large quantities of fresh to slightly saline water to public supplies, industrial, irrigation, rural domestic, and stock wells.
		Lagarto Clay	1,200+	Mostly stiff, compact, gray calcareous clay and some thin lenticular beds of gray sand.	Generally not used, but capable of yielding small quantities of slightly saline water in Kenedy, Jim Wells and Brooks Counties.
		Oakville Sandstone	600	Very fine to coarse, brown to gray sand and sandstone interbedded with silt and a considerable amount of clay.	Yields small to moderate quantities of fresh to slightly saline water to industrial, rural domestic and stock wells in Duval, Jim Wells and Brooks Counties.
		Catahoula Tuff	1,400	Tuffaceous clay and volcanic tuffs with interbedded lenticular sandy clays and thick to thin beds of sand and conglomerates.	Yields small to moderate quantities of fresh to slightly saline water to the City of Freer, rural domestic and stock wells in Western Duval County.

2.2.2. Surface Water Resources

The 12-County Coastal Bend area of Texas depends upon the CC/LCC System for its surface water requirements. In the study area, only the City of Alice utilizes surface water from this system for its public water supply.

Choke Canyon Reservoir and Lake Corpus Christi are the largest existing reservoirs in the Nueces River Basin. The City of Corpus Christi owns and operates Lake Corpus Christi. Choke Canyon Reservoir is jointly owned by the Nueces River Authority (20%), the City of Corpus Christi (78%) and the City of Three Rivers (2%) and is operated by the City of Corpus Christi.

The City of Corpus Christi is the largest diverter of raw water from the CC/LCC System. Water released from the reservoir for the Corpus Christi area is treated, settled, filtered, and pumped from the river at Calallen, some 35 miles downstream from Lake Corpus Christi. The city also delivers both treated and untreated water to the San Patricio Municipal Utility District. The San Patricio Municipal Water District supplies water to industries and to the cities of Odem, Taft, Gregory, Portland, Ingleside, Rockport, and Port Aransas, all located in the adjacent San Antonio-Nueces Coastal Basin. In addition, the city sells treated water to the South Texas Water Authority which supplies water to Kingsville, Bishop, Banquete, Agua Dulce and other small communities and water districts in Nueces and Kleberg Counties. The Alice Water Authority, the City of Mathis, and the Beeville Water Supply District purchase water from the City at Lake Corpus Christi for municipal use.

The water demands placed on the CC/LCC System are rapidly approaching the annual dependable supply which the reservoir system will yield. The City of Corpus Christi has recently contracted for additional water from the Lavaca-Navidad River Authority and holds an option for additional water rights from the Garwood Irrigation Company. Plans are under way to construct a pipeline from Lake Texana to bring water to meet future needs of Corpus Christi and the region, including the entities in the study area.

2.3. Inventory of Existing Water System Components

2.3.1. Alice

The City of Alice maintains an integrated surface water pumping, transmission, treatment and distribution system. A schematic diagram of the existing water system components is shown in Figure 2-4. The City's system consists of an offshore intake structure just upstream of Wesley Seale Dam at Lake Corpus Christi, parallel 20" diameter and 30" diameter raw water transmission lines, a large reservoir (Lake Alice), a 12 MGD water treatment plant and high service pumps. The system includes 1,500,000 gallons of ground storage capacity and 1,500,000 gallons of elevated storage capacity.

2.3.2. Orange Grove

Orange Grove's water system consists of three wells with a total capacity of 700 gpm, one 320,000 gallon ground storage tank and one 100,000 gallon elevated storage tank. A schematic diagram of the existing water system components is shown in Figure 2-5.

2.3.3. Premont

Premont's water system consists of four wells with a total capacity of 2,050 gpm, 420,000-gallon and 186,000-gallon ground storage tanks, one booster pump station and 150,000-gallon and 50,000-gallon elevated storage tanks. Two of the wells pump directly into the distribution system. A schematic diagram of the existing water system components is shown in Figure 2-6.

2.3.4. Duval County Conservation and Reclamation District

2.3.4.1. San Diego

San Diego's water system consists of five wells with a total capacity of 800 gpm, 1,000,000-gallon and 500,000-gallon ground storage tanks, one booster pump station and 150,000-gallon and 300,000-gallon elevated storage tanks. A schematic diagram of the existing water system components is shown in Figure 2-7.

2.3.4.2. Benavides

Benavides' water system consists of four wells with a total capacity of 610 gpm, 45,000-gallon and 50,000-gallon ground storage tanks, two booster pump stations and two 45,000-gallon elevated storage tanks. A schematic diagram of the existing water system components is shown in Figure 2-8.

2.3.4.3. Realitos

Realitos' water system consists of one 200 gpm well and a 45,000 gallon elevated storage tank. A schematic diagram of the existing water system components is shown in Figure 2-9.

2.3.4.4. Concepcion

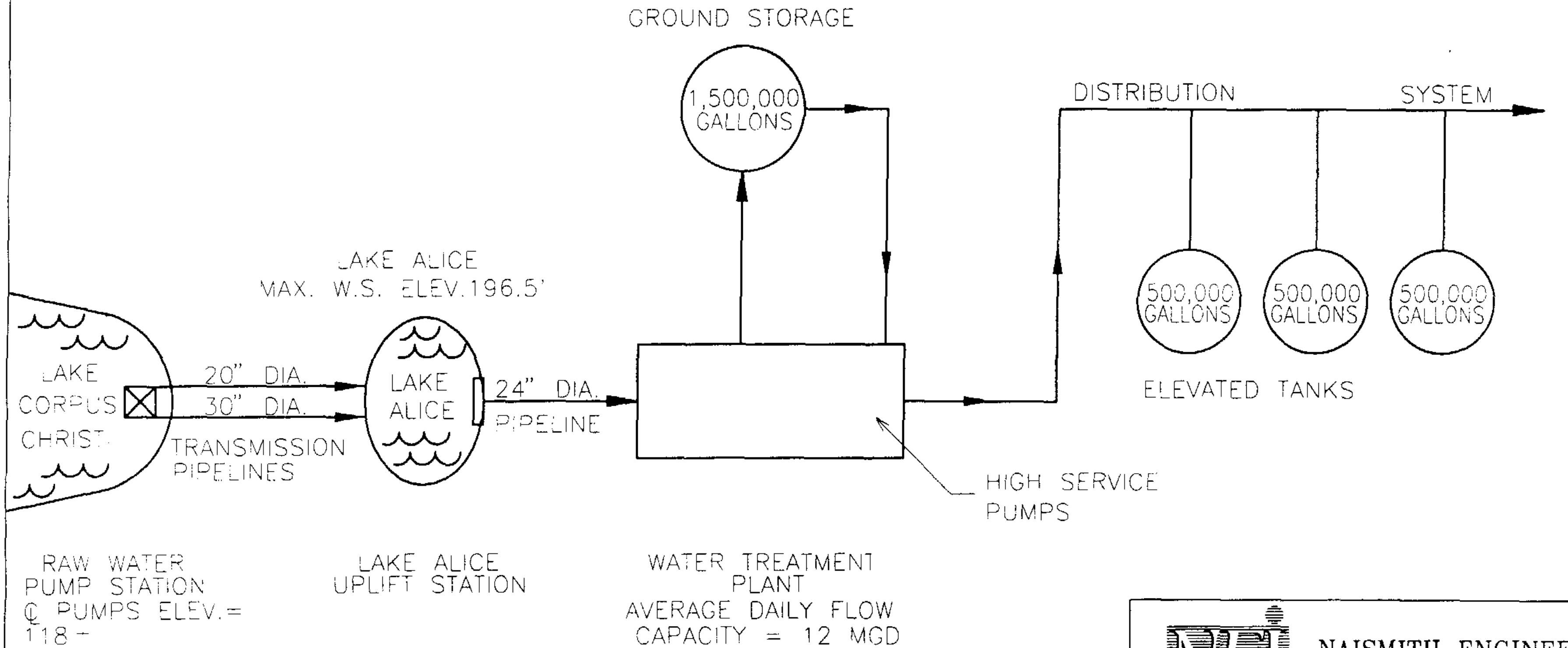
Concepcion's water system consists of one 170 gpm well and a 45,000-gallon elevated storage tank. A schematic diagram of the existing water system components is shown in Figure 2-9.

2.3.5. Freer

Freer's water system consists of six wells with a total capacity of 815 gpm, 1,000,000-gallon and 500,000-gallon ground storage tanks and a 750,000-gallon standpipe. A schematic diagram of the existing water system components is shown in Figure 2-10.

LAKE CORPUS CHRISTI PUMP STATION PUMP DATA			
PUMP NO.	H.P.	CAPACITY (GPM)	@ TDH (FT.)
1	400	4600	172
2	400	4600	265
3	125	1860	265

LAKE ALICE CAPACITY		
ELEV.	CAPACITY (MILLON GAL.)	DESCRIPTION
186	0	EMPTY
189	30 +	GENERAL OPERATING LEVEL
196.5	800 +	SPILLWAY ELEVATION



ALICE WATER TREATMENT PLANT HIGH SERVICE PUMP DATA			
PUMP NO.	H.P.	CAPACITY (GPM)	@ TDH (FT.)
1	125	2400	151
2	125	2400	151
3	100	1600	150
4	125	2400	151

PUMP STATION GENERAL PUMP DATA		
PUMP NO.	H.P.	CAPACITY (GPM)
1	150	8333
2	50	3200
3	50	3200

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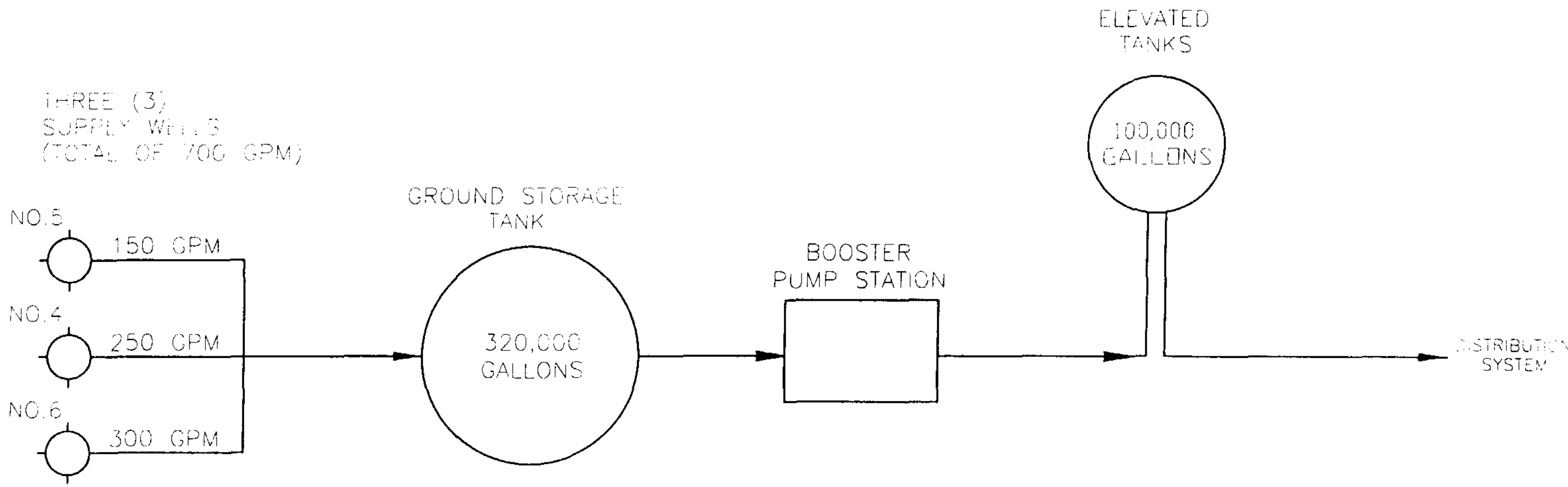
CITY OF ALICE

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 2 – 4

Drawn By:	R.C.	Appr. By:	G.A.B.	Scale:	N.T.S.	Dwg. No.:	4218–E1A	Sheet	
Checked By:	G.A.B.	Project No.:	4218	Date:	8-96	Rev.:	0	of	0



PUMP STATION GENERAL PUMP DATA	
PUMP NO	CAPACITY GPM
1	500
2	250
3	250

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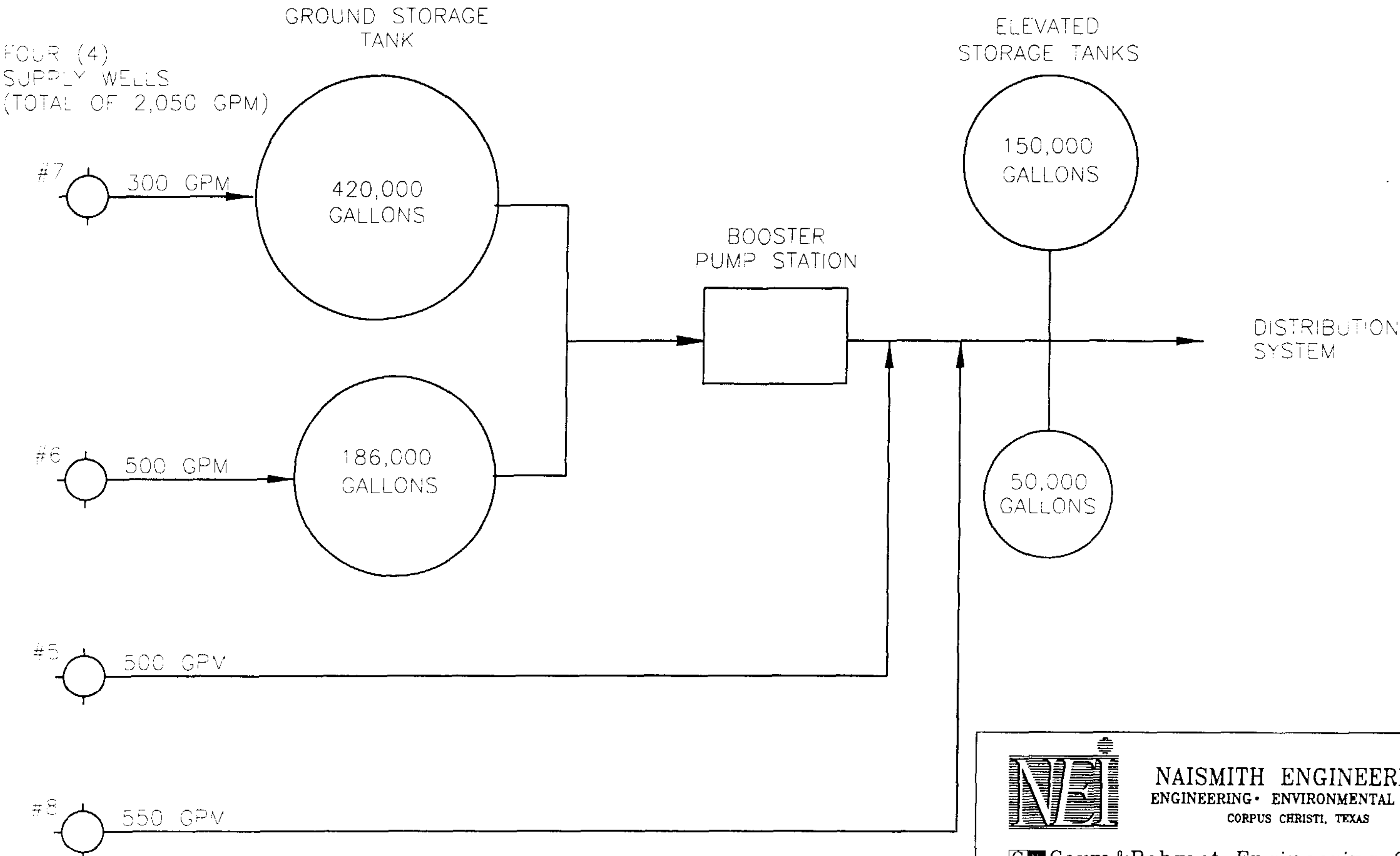
ORANGE GROVE

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM

REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES
Figure 2 – 5

Drawn By: R.C.	Appr. By: G.A.B.	Scale: N.T.S.	Dwg. NO: 4218–E9A	Sheet
Checked By: G.A.B.	Project No: 4218	Date: 8-96	Rev: 0	Of 0



PUMP STATION GENERAL PUMP DATA	
PUMP NO.	CAPACITY GPM
1	500
2	500

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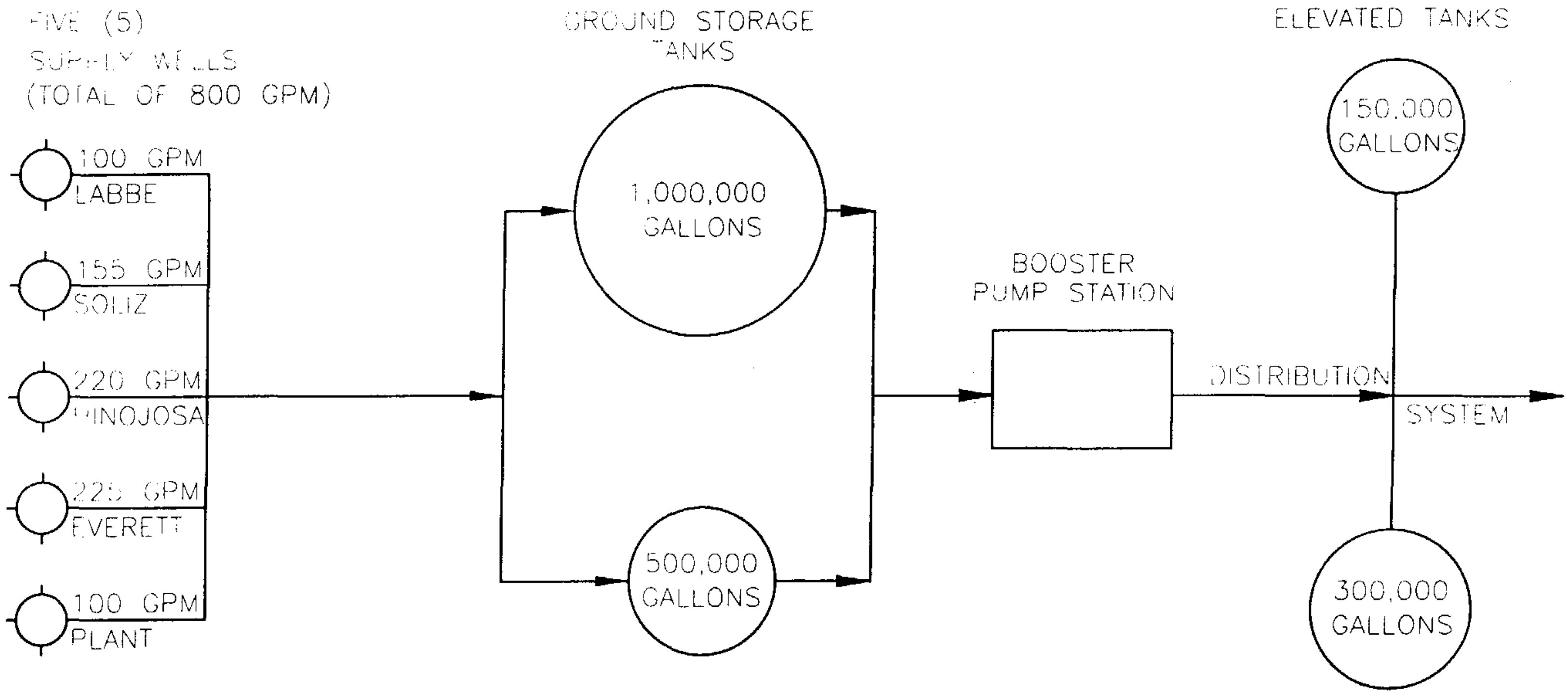
PREMONT

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 2 – 6

Drawn By: R.C.	Appr. By: G.A.B.	Scale: N.T.S.	Dwg. NO.: 4218-E68	Sheet
Checked By: G.A.B.	Project No: 4218	Date: 8-96	Rev: 0	of 0



PUMP STATION GENERAL PUMP DATA	
PUMP NO.	CAPACITY GPM
1	700
2	700
3	250

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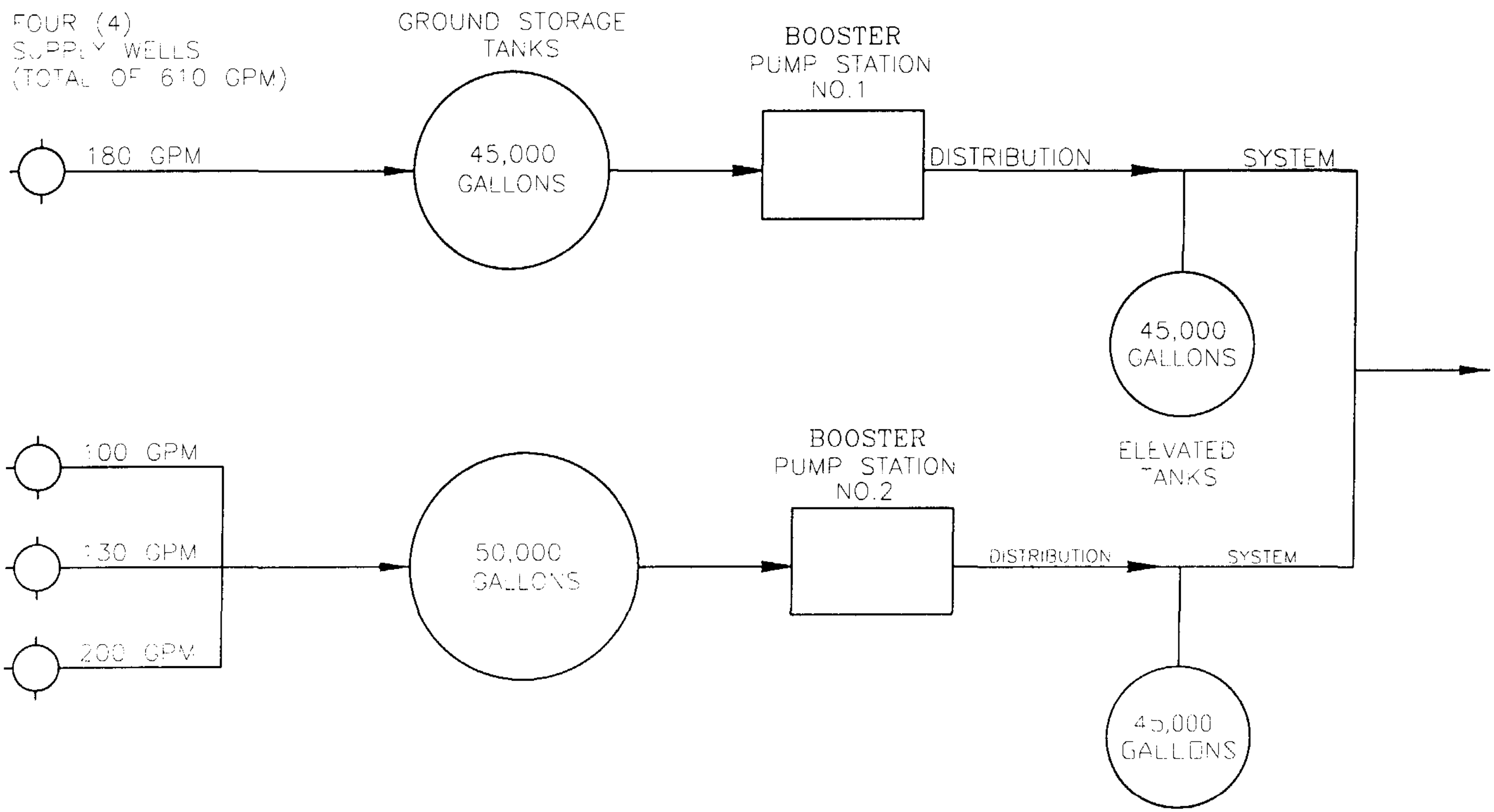
DUVAL COUNTY CONSERVATION AND RECLAMATION DISTRICT

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM – SAN DIEGO

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 2 – 7

Drawn By:	R.C.	Appr. By:	G.A.B.	Scale:	N.T.S.	Dwg. No.:	4218-E3A	Sheet	
Checked By:	G.A.B.	Project No:	4218	Date:	8-96	Rev:	0	of	0



PUMP STATION GENERAL PUMP DATA	
PUMP NO.	CAPACITY GPM
STA.1-P1	400
STA.2-P1	750
STA.2-P2	250

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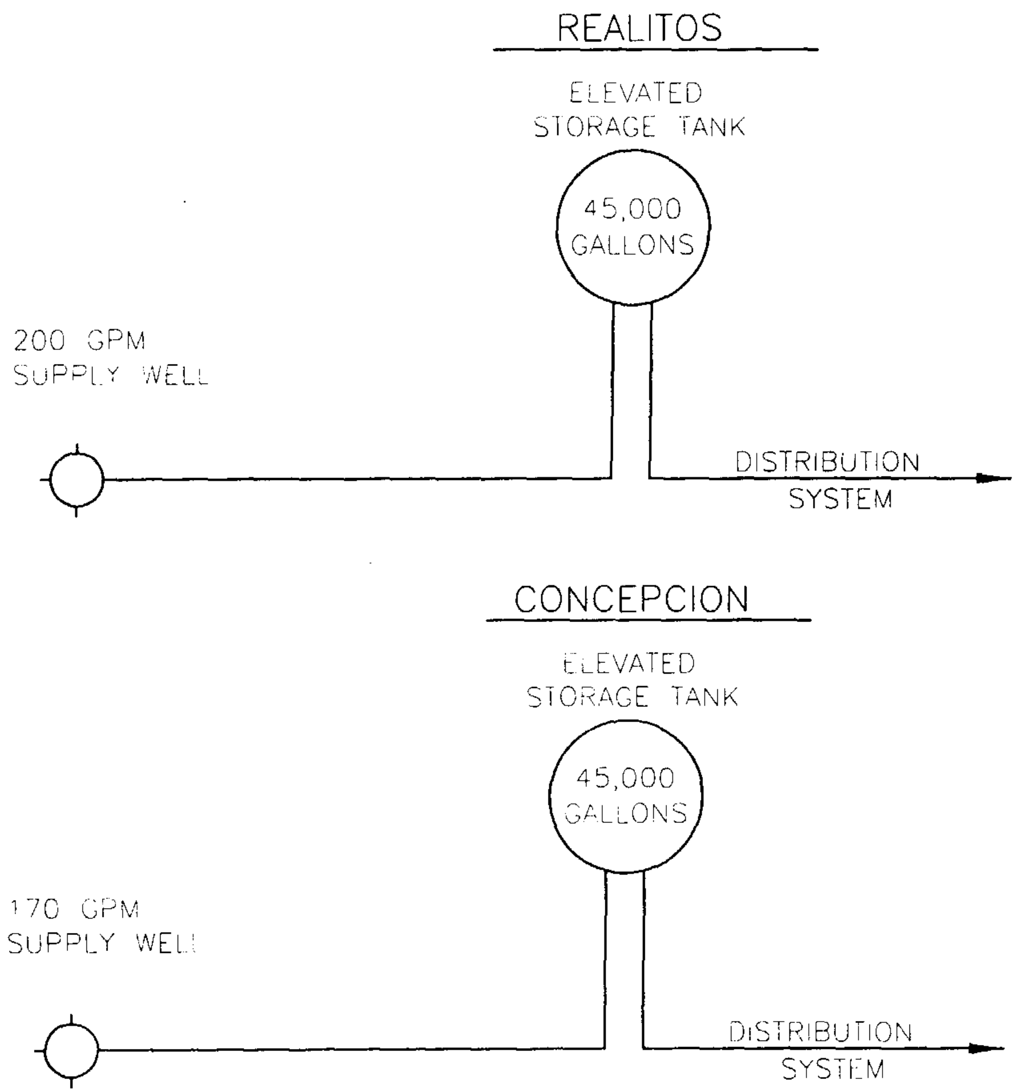
DUVAL COUNTY CONSERVATION AND RECLAMATION DISTRICT

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM – BENAVIDES

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 2 – 8

Drawn By:	R.C.	Appr. By:	G.A.B.	Scale:	N.T.S.	Dwg. No.:	4218-E7A	Sheet	
Checked By:	G.A.B.	Project No.:	4218	Date:	8-96	Rev.:	0	of	0



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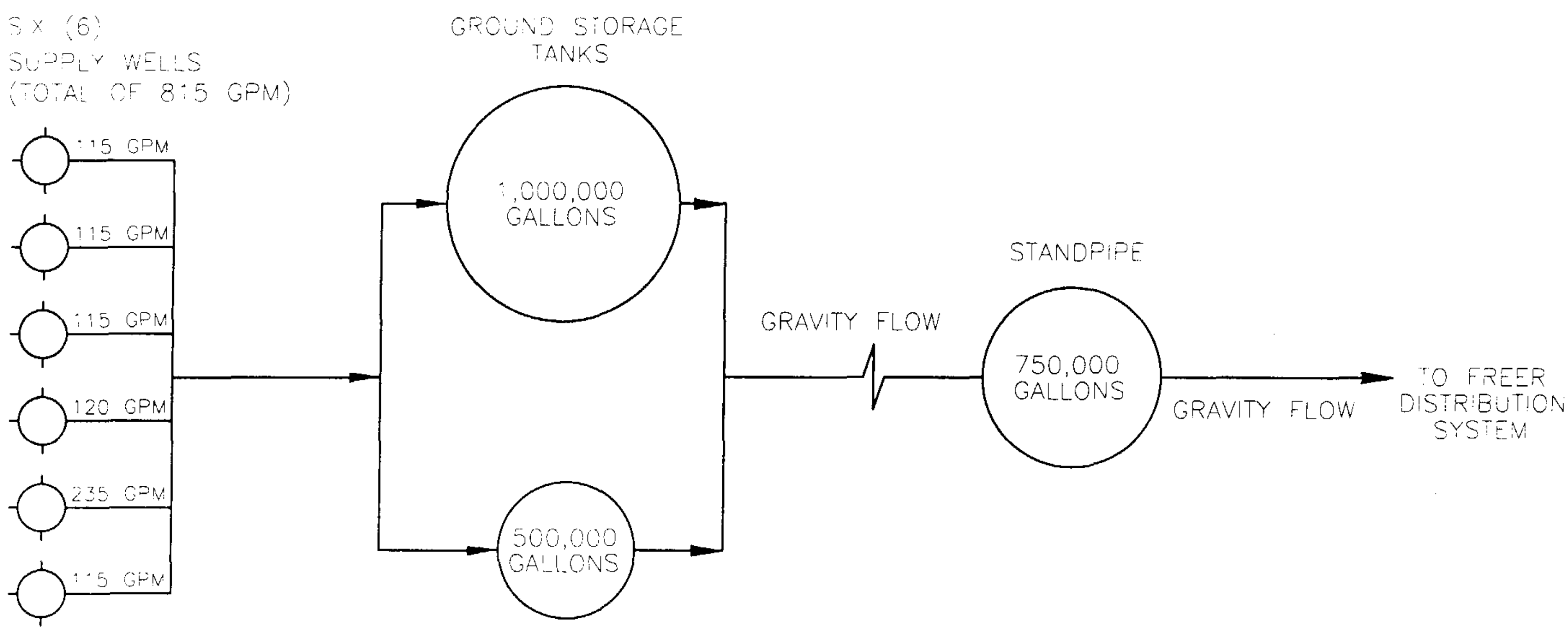
DUVAL COUNTY CONSERVATION AND RECLAMATION DISTRICT

SCHEMATIC DIAGRAM OF EXISTING WATER SUPPLY SYSTEM – REALITOS AND CONCEPCION

REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES

Figure 2 – 9

Drawn By:	R.C.	Appr. By:	G.A.B.	Scale:	N.T.S.	Dwg. No.:	4218–E4A	Sheet	4
Checked By:	G.A.B.	Project No.:	4218	Date:	8–96	Rev.:	0	of	9



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FREER WCID SUPPLY SYSTEM

SCHEMATIC DETAIL OF EXISTING WATER SUPPLY SYSTEM

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 2 – 10

Drawn By: R.C.	Appr. By: G.A.B.	Scale: N.T.S.	Dwg. No.: 4218–E2A	Sheet
Checked By: G.A.B.	Project No: 4218	Date: 8–96	Rev.: 0	Of 0

2.4. Existing Wastewater Treatment Plant Facilities

Figure 2-11 shows the locations of existing wastewater treatment plants in the study area. Brief descriptions of treatment facilities for each city are presented in the following sections.

2.4.1. Alice

The City's treatment facilities consists of two plants. The Northside Plant is an extended aeration system in oxidation ditch, followed by clarification, chlorination, dechlorination and discharge of effluent into the San Fernando Creek. The city presently reuses effluent water from the plant to irrigate the municipal golf course located northwest of the plant site. The plant discharges under the following permits:

EPA NPDES Wastewater Permit No. TX0091219

TNRCC Permit No. 1053604

Permit Limitations are as follows:

Effluent Characteristics	Discharge Limitations
Average Flow	2.02 mgd
BOD_5	10 mg/L
TSS	15 mg/L

The City's Southside Plant is an extended aeration activated sludge process followed by clarification and chlorination, dechlorination and discharge of effluent into Lattas Creek. The City presently reuses some of the effluent from the plant for plant washdown. The plant discharges under the following permits:

EPA NPDES Wastewater Permit No. TX0034002

TNRCC Permit No. 1053602

Permit Limitations are as follows:

Effluent Characteristics	Discharge Limitations
Average Flow	2.6
BOD_5	20 mg/L until 1997 then 10 mg/L
TSS	20 mg/L until 1997 then 15 mg/L

2.4.2. Orange Grove

The City's treatment plant is an extended aeration in oxidation ditch followed by clarification, chlorination and discharge into Leon Creek. The plant discharges under the following permits:

EPA NPDES Wastewater Permit No. TX0020397

TNRCC Permit No. 10592

Permit Limitations are as follows:

Effluent Characteristics	Discharge Limitations
Average Flow	0.2 mgd
BOD_5	20 mg/L
TSS	20 mg/L

2.4.3. Premont

The City's treatment of wastewater is accomplished by aerated lagoons located approximately one mile southeast of the City. No discharge from the facility occurs.

2.4.4. San Diego

The DCCRD's treatment plant in San Diego is an extended aeration in oxidation ditch followed by clarification, chlorination and discharge into the San Diego Creek. The plant discharges under the following permits:

EPA NPDES Wastewater Permit No. TX002361

TNRCC Permit No. W00010270

Permit limitations are as follows:

Effluent Characteristics	Discharge Limitations
Average Flow	0.75 mgd
BOD_5	10 mg/L
TSS	15mg/L

2.4.5. Benavides

The DCCRD's treatment facility in Benavides is an Imhoff tank discharging into facultative lagoons. No discharge from the facility occurs.

2.4.6. Realitos

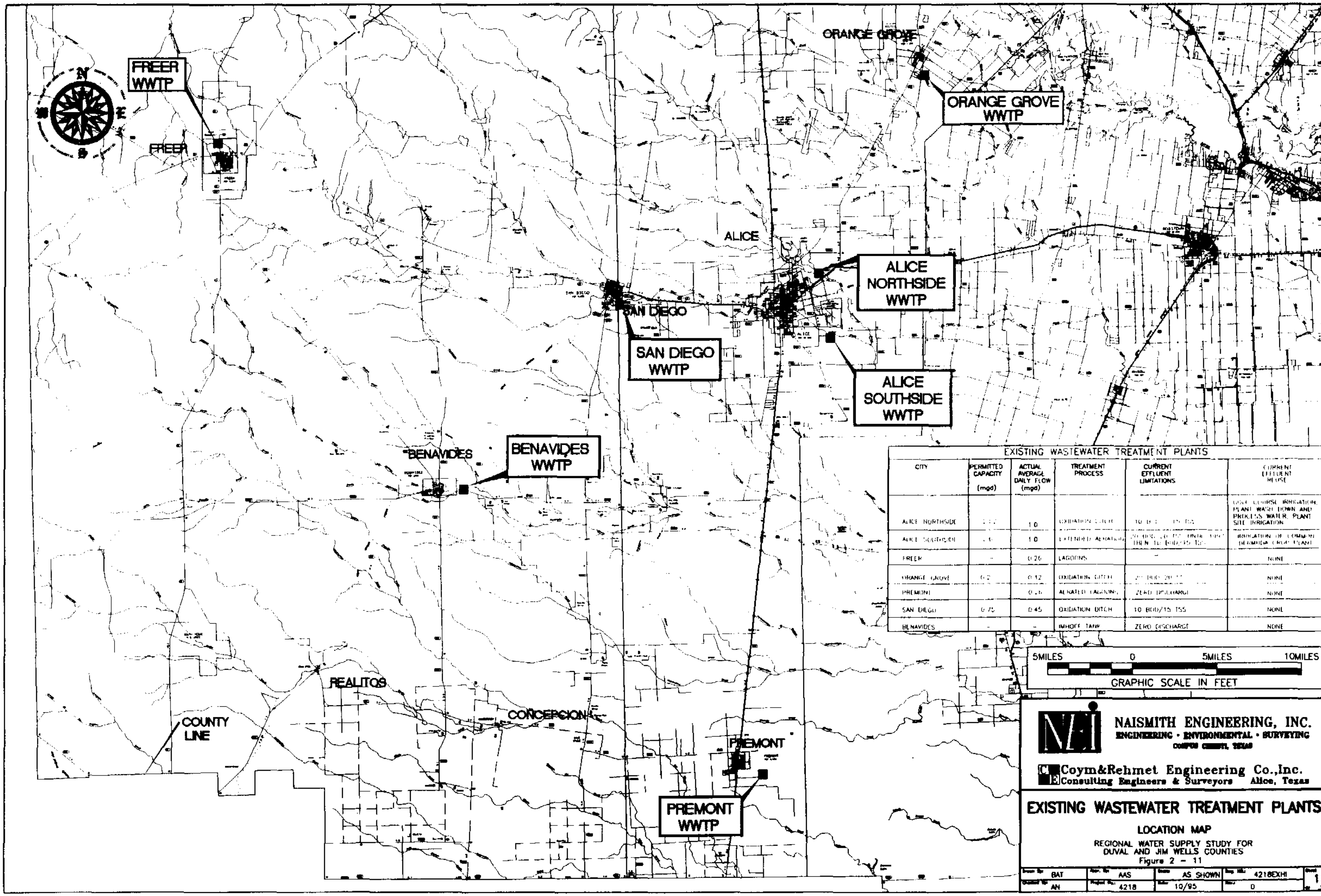
No wastewater treatment facility exists in Realitos.

2.4.7. Concepcion

No wastewater treatment facility exists in Concepcion.

2.4.8. Freer

The Freer WCID's wastewater treatment is by facultative lagoons located approximately one-half mile north of the city. No discharge from the facility occurs.



EXISTING WASTEWATER TREATMENT PLANTS

CITY	PERMITTED CAPACITY (mgd)	ACTUAL AVERAGE DAILY FLOW (mgd)	TREATMENT PROCESS	CURRENT EFFLUENT LIMITATIONS	CURRENT EFFLUENT REUSE
ALICE NORTHSIDE	[illegible]	1.0	OXIDATION DITCH	[illegible]	GOLF COURSE IRRIGATION, PLANT WASH DOWN AND PROCESS WATER, PLANT SITE IRRIGATION
ALICE SOUTHSIDE	[illegible]	1.0	EXTENDED AERATION	[illegible]	IRRIGATION OF COMMON BERMUDA CROP PLANT
FREER	–	0.26	LAGOONS	–	NONE
ORANGE GROVE	0.2	0.12	OXIDATION DITCH	[illegible]	NONE
PREMONT		[illegible]	AERATED LAGOONS	ZERO DISCHARGE	NONE
SAN DIEGO	0.75	0.45	OXIDATION DITCH	10 BOD/15 TSS	NONE
BENAVIDES	–	–	IMHOFF TANK	ZERO DISCHARGE	NONE

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EXISTING WASTEWATER TREATMENT PLANTS

LOCATION MAP

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 2 – 11

Drawn By	BAT	Appr. By	AAS	Scale	AS SHOWN	Dwg. No.	4218EXHI	Sheet	1
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3.0. ADEQUACY OF EXISTING WATER SUPPLY AND TRANSMISSION CAPABILITIES TO SATISFY CURRENT STATE AND FEDERAL RULES AND REGULATIONS

3.1. Evaluation of Water Qualities and Quantities of Groundwater and Surface Water Resources

3.1.1. Resources - General

Groundwater for public water supply in Duval and Jim Wells Counties is obtained from wells in the Goliad Sand and the Catahoula Tuff. As a general rule, water levels in these aquifers in the study area rise or fall mainly in response to changes in the rates of recharge or discharge and rates of pumpage. During periods of drought, recharge to the aquifer is reduced and generally pumpage of water is increased thereby reducing the quantity of groundwater in storage and the water levels decline; during periods of above normal rainfall the process is reversed and the water levels rise. Water levels in the Goliad Sand have a long history of measurements while only relatively short records of measurements are available for wells tapping the Catahoula Tuff. It is generally safe to say that, since the cessation of pumping from the Goliad Sand by the City of Alice in the 1960's and the recent reductions in pumping by the City of Kingsville and nearby industry, the quantity of water available to the small communities utilizing the Goliad Sand should be adequate for the near term. However, groundwater levels in the communities of Freer and San Diego have generally declined over the past years and with increased water demand from the small communities may continue to decline. With continued pumping and gradually increasing demand, the overall quality of the available groundwater is anticipated to deteriorate with increasing levels of dissolved solids. Because the level of natural recharge to the water-bearing formations is low, the continued lowering of the piezometric surface induces leakage of higher salinity groundwater from the overlying and underlying clays. The continued reliance of the cities and towns in the study area on existing groundwater supplies will result in many cases in the following:

- Gradual deterioration of water quality
- Continued decline in groundwater levels
- Continued decline in well yields
- Increased pumping costs
- Increased need for potential treatment to reduce dissolved salt

While it is impossible to predict time frames for the above occurrences, it is reasonable to say that they will occur at some juncture, that time depending primarily on water withdrawal rate.

3.1.2. Quality and Quantity of Groundwater Resources

This report is not a comprehensive study of groundwater conditions in Duval and Jim Wells Counties, rather a planning tool to evaluate the costs of a regional water supply system. It is reasonable to assume that given feasible economic factors, all cities in the study area should eventually convert to surface water. However, since economic factors are not always feasible from a customer's standpoint, groundwater will probably continue to be the primary source of potable water for some cities and towns in the study area. Table 3-1 lists the general water quality of each community in the study area compared to the TNRCC and USEPA maximum levels. The quality of groundwater in the study area is generally evaluated, and mostly limited by, two primary constituents; chlorides and total dissolved solids. The standards for these constituents by the TNRCC and the USEPA are:

Constituent	Maximum Allowable Level (mg/L)	
	TNRCC	USEPA
Total Dissolved Solids	1000	500
Chloride	300	250

TABLE 3-1

CONTAMINANT LEVELS OF EXISTING GROUNDWATER SUPPLY

Constituent	Max. Permissible Level (mg/L)		Approximate Existing Average Constituent Level (mg/L)							
	TNRCC	USEPA	Alice	Orange Grove	Premont	San Diego	Benavides	Realitos	Concepcion	Freer
Total Dissolved Solids	1000	500	1150 - 1230	1000 - 1100	750±	800 - 1000	1350 - 1425	1021	1104	1292
Chloride	300	250	310 - 418	250±	250±	180 - 250	425 - 450	399	466	396

Since the conditions of the various aquifers vary widely between cities and towns in the study area, following is a brief overview, by City or town, of the most basic quantity and quality characteristics of the aquifer(s) in each City or town's vicinity.

3.1.2.1. Alice

General

Since the City has been utilizing surface water since 1965 and has discontinued use of its wells it is doubtful that Alice will make use of groundwater in the future.

Aquifer and Quantity of Water

The aquifer for the City is the Goliad Sand. Wells in the Goliad in this area typically produce 250 - 350 gpm. The recharge to the Goliad in the Alice area was estimated in a 1963 study to be approximately 3 mgd.

Quality of Water

Old records of samples from the City of Alice wells previously in operation indicate that the water in the wells was in the 310 - 420 mg/l range for chlorides and in the 1150 - 1230 mg/l range for total dissolved solids.

3.1.2.2. Orange Grove

Aquifer and Quantity of Water

The aquifer for the City's water supply is the Goliad Sand. Wells in the Goliad in this area typically produce 150 - 350 gpm. It is reasonable to assume that the amount of water in storage in the Goliad Sand in the Orange Grove area is large enough to sustain projected demands for an extended period of time.

Quality of Water

Test results on samples from existing City wells indicate that the water is in the 250 mg/L range for chlorides and in the 1000 - 1100 mg/L range for total dissolved solids. Comparing these with results of testing on old wells, it appears that the values have remained unchanged or have become slightly higher over the years.

3.1.2.3. Premont

Aquifer and Quantity of Water

The aquifer for the City's water supply is the Goliad Sand. The Goliad in this area is quite prolific with some wells attaining yields of 1000± gpm. Previous studies indicate that the "strongest" parts of the Goliad Sand lie in the Southeastern portion of Duval County and into Southern Jim Wells County. Therefore, it is reasonable to assume that water in storage in the Goliad Sand in the Premont is large enough to sustain projected demands for an extended period of time.

Quality of Water

Test results on samples from existing city wells indicate that the water is in the 250 mg/L range for chlorides and in the 750 mg/L range for total dissolved solids.

3.1.2.4. San Diego

Aquifer and Quantity of Water

The aquifer for San Diego's water supply is the Goliad Sand. Typical yields of wells containing suitable water are in the 100 - 250 gpm range. Previous studies indicate that water available in the Goliad Sand is sufficient for an extended period of time; however, declines in pumping levels over recent years is a concern. Recent test holes indicate that thicknesses of the sand in areas which might be developed for groundwater are not sufficient to warrant completion of higher volume wells. Previous studies further indicate that long term development for larger quantities of water should take place in a well field located approximately three miles Southeast of the City.

Quality of Water

Test results on samples from existing wells serving the City indicate that the water is in the 180 - 250 mg/L range for chlorides and is in the 800 - 1000 mg/L range for total dissolved solids. However, water sample tests from two recent test holes located South and Southeast, respectively, of the DCCRD's most southerly well, indicate water high in chlorides (480± mg/L) and total dissolved solids (1475 - 1600 mg/L). Test results from both sites were reviewed by the TNRCC and rejected for municipal water supply purposes.

3.1.2.5. Benavides

Aquifer and Quantity of Water

The aquifer for Benavides' water supply is the Goliad Sand. Typical yields of municipal-type wells in the area are in the 150 - 350 gpm range. The quantity of water in the Goliad Sand is adequate for projected future demands. Some of the thickest accumulations of the Goliad Sand are located in an area a few miles Southeast of the City and are as yet untapped by a municipal water well.

Quality of Water

Test results on samples from existing wells serving the City indicate that the water is in the 425 - 450 mg/L range for chlorides and in the 1350 - 1425 mg/L range for total dissolved solids. The DCCRD has received correspondence from the TNRCC stating that the maximum permissible levels for these constituents have been exceeded and that should an alternate source of water become available, the District must utilize the alternate source to remediate or replace the existing water supply.

3.1.2.6. Realitos

Aquifer and Quantity of Water

The aquifer for Realitos' water supply is the Goliad Sand. Typical yields of municipal-type wells in the area are 150 - 250 gpm. It is judged that the quantity of water in the Goliad Sand is adequate for future demands in the area.

Quality of Water

Test results on samples from the existing well serving the community indicate that the concentration of chlorides and total dissolved solids are 399 mg/L and 1021 mg/L respectively. The DCCRD has received correspondence from the TNRCC stating the maximum permissible levels for these constituents have been exceeded and that, should an alternate source of water become available, the District must utilize the alternate source to remediate or replace the existing water supply.

3.1.2.7. Concepcion

Aquifer and Quantity of Water

The aquifer for Concepcion's water supply is the Goliad Sand. Typical yields of municipal-type wells in the area are 150 - 250 gpm. It is judged that the quantity of water in the Goliad Sand is adequate for future demands in the area.

Quality of Water

Test results on samples from the existing well serving the community indicate that the concentration of chlorides and total dissolved solids are 466 mg/L and 1104 mg/L respectively. The DCCRD has received correspondence from the TNRCC stating that maximum permissible levels for the constituents have been exceeded and that, should an alternate source of water become available, the District must utilize the alternate source to remediate or replace the existing water supply.

3.1.2.8. Freer

Aquifer and Quantity of Water

The aquifer for Freer's water supply is the Catahoula Tuff. The amount of water available from the Catahoula Tuff is difficult to determine because of a lack of appropriate data on the aquifer. A study conducted in 1974 stated that approximately 6 mgd may be available from the Catahoula Tuff in its entirety. The areas deemed most favorable for development are along a line extending from the Southwest corner of the County north-northeastward through Freer. This line may be considered to be the axis of thick accumulations of sand containing fresh to slightly saline water. From 5 to 20 miles East of this line the thickness of sand containing fresh to slightly saline water decreases to zero. The thickest accumulations of sand in the vicinity of Freer are in a 12-square mile area along State Highway 16 from 4 to 10 miles South of Freer and in a similarly sized area about 20 miles West of Benavides. The former area is the location of the existing well field for Freer where concentrated pumping has lowered water levels (as evidenced by several municipal wells going dry) and created an extensive core of depression in the potentiometric surface. The most recent well (1982) however, has maintained a 235 gpm flow rate with only a small drop in pumping level since its construction, according to the Freer WCID, which may indicate a new zone in the Catahoula Tuff.

Quality of Water

Test results on samples from the existing wells serving the City indicate that the concentration of chlorides and total dissolved solids are 396 mg/L and 1292 mg/L respectively.

The Freer WCID has received correspondence from the TNRCC stating that maximum permissible levels for these constituents has been exceeded and that, should an alternate source of water become available, the District must utilize the alternate source to remediate or replace the existing water supply.

3.1.3. Quality and Quantity of Surface Water Resources

Quality of Water

The surface water supply for the study area consists of the firm yield of the CC/LCC System. It is apparent that the most feasible method of surface water conversion in the study area is through the City of Alice/Alice Water Authority System. The raw water intake for this system is just upstream of Wesley Seale Dam at Lake Corpus Christi. Studies[6] over the years have shown that water quality at this point is generally considered to be good. Chloride concentrations at this part of the basin have been measured between the years 1967-1993 to have a median value of 73 mg/L. Total dissolved solids measured over the same period show a median value of 341 mg/L Hardness, which, although an unregulated constituent, can be problematic to both industrial and residential users in terms of the scaling of precipitants on equipment as well as home plumbing fixtures, was measured with a median value of 180 mg/L (measured as $CaCO_3$). Table 3-2 lists general statistics of the water quality at Wesley Seale Dam.

TABLE 3-2

**WATER QUALITY STATISTICS NEAR CITY OF ALICE INTAKE STRUCTURE
LAKE CORPUS CHRISTI**

	CHLORIDE	HARDNESS	SULFATE	TDS
MAX	370	360	100	859
MED	73	180	43	341
MIN	11	93	12	164

Quantity of Water

The CC/LCC System is presently strained due to a prolonged drought. However, alternate water supply plans[6] have been developed by the City of Corpus Christi to acquire sufficient water supplies to meet the projected demands of the area through the year 2050. The projected demands of Jim Wells and Duval Counties are included in these plans. After exhaustive studies of various alternatives, it was judged that the most feasible method of obtaining additional water to meet future demands is by the purchase of additional water from the Lavaca-Navidad River Authority through Lake Texana and obtaining an option for additional water rights from the Garwood Irrigation District. The City of Corpus Christi is proceeding with implementation of this plan. Contracts have been executed with the Lavaca-Navidad River Authority and an option has been signed with the Garwood Irrigation Company for the additional water supply. Design engineering is currently underway on the project.

The City of Alice raw water pumping, transmission and treatment facilities are presently designed for average daily flows of 12 mgd. The projected average daily demand for all cities in the study area at year 2050 is approximately 7 mgd, with a projected peak day demand of 12 mgd. Therefore, it appears that the present system can adequately accommodate the demands of the study area for the planning period.

3.2. Analysis of System Capabilities to Meet Existing Service Area Demands

Appendix B, Tables 1 through 6 show that system capacities for cities in the study area generally exceed TNRCC minimum requirements for wells, total storage, service pumps and elevated storage. The only exception is well capacity in San Diego. It should be noted however, that TNRCC storage requirements do not include fire rating or "worst case" scenarios usually included in water system planning.

3.3. Existing Water Supply and Treatment Capabilities

3.3.1 Raw Water Pump Capacity

The TNRCC minimum requirement for raw water pump capacity for a surface water system is 0.6 gpm/connection with the largest pump out of service. Table 3-10 shows that Alice has raw water pumping capacity of 6,400 gpm, with the largest pump out of service. Based on the TNRCC requirement, the City has existing raw water pump capacity for 10,667 connections (6,400 gpm divided by 0.6 gpm/connection).

3.3.2. Treatment Plant Capacity

The City of Alice a water treatment capacity of 12 MGD. TNRCC Rules and Regulations for Public Water Systems requires all surface water supplies to have a treatment plant capacity of 0.6 gpm per connection. Based on this requirement, the City has existing treatment plant capacity for 13,889 connections (12 MGD divided by 0.00144 gpm/MGD divided by 0.6 gpm/connection).

3.3.3. High Service Pump Capacity

TNRCC Rules and Regulations for Public Water Systems requires all surface water supplies to have two or more service pumps with a combined capacity of 0.6 gpm/connection. Appendix B, Table 7 shows that Alice has high service pumping capacity of 6,400 gpm, with the largest unit out of service. Based on the TNRCC requirement, the City has existing service pump capacity for 10,667 connections (6,400 gpm divided by 0.6 gpm/connection).

3.4. Evaluation of Available Quantities and Qualities of Treated Wastewater for Potential Reuse

Regulatory requirements that govern municipal wastewater effluent reuse (reclaimed water) in the State of Texas are found in Chapter 310 of the 31 Texas Administrative Code (30 TAC Chapter 310), Use of Reclaimed Water. Repeal of 30 TAC Chapter 310, and enactment of new 30 TAC Chapter 210, concerning use of reclaimed water, is proposed by TNRCC. Therefore, any future reclaimed water projects in the study area will be governed by the requirements of 30 TAC Chapter 210. These regulations specify reclaimed water quality requirements, depending on the specific end use of the reclaimed water. The reuse categories and effluent requirements (30-day average values) that are applicable to the study area are:

- Irrigation of restricted landscape areas (defined as land which has had its plant cover modified and access to which may be controlled in some manner). Examples of such areas are: golf courses; cemeteries; roadway right-of-ways; median dividers.

  BOD^5 - 20 mg/L (system other than pond system)
  BOD^5 - 30 mg/L (pond system)
  Fecal coliform - not to exceed 800 CFU/100 mL (requires additional disinfection at the storage site if it is stored for a period of 24 hours or longer, based on daily average flow rates).

- Commercial and industrial use

  BOD^5 - 20 mg/L (system other than pond system)
  BOD^5 - 30 mg/L (pond system)
  Fecal coliform - not to exceed 200 CFU/100 mL

An inventory of existing wastewater treatment plant facilities in the study area is presented in Section 2.4. Summaries of average daily flows and discharge permit limitations for Alice, Orange Grove and San Diego are shown in Table 3-3.

TABLE 3-3

SUMMARY OF EXISTING WWTP AVERAGE DAILY FLOWS AND DISCHARGE PERMIT LIMITATIONS

City	Existing Average Daily Flow (ADF)	Discharge Permit Limitations
Alice Northside	1.0 mgd	BOD_5 = 10 mg/L TSS = 15 mg/L ADF = 2.02 mgd
Alice Southside	1.0 mgd	Until 1997: BOD_5 = 20 mg/L TSS = 20 mg/L ADF = 2.6 mgd After 1997: BOD_5 = 10 mg/L TSS = 15 mg/L ADF = 2.6 mgd
Orange Grove	0.12 mgd	BOD_5 = 20 mg/L TSS = 20 mg/L ADF = 0.2 mgd
San Diego	0.4 mgd	BOD_5 = 10 mg/L TSS = 15 mg/L ADF = 0.75 mgd

4.0. POTENTIAL REGIONAL WATER SUPPLY AND TRANSMISSION FACILITIES

4.1. Future Water System Requirements

Future water system requirements were determined by estimating the anticipated population growth and water demands of the Study area for the planning period. 1996 Consensus Texas Water Plan projections were provided by TWDB planning staff for this purpose.

Population projections included in this study are based on the most likely series, which is the population scenario selected by the consensus planning staffs of the TWDB, the TNRCC and the Texas Parks and Wildlife Department (TP&WD) as the growth pattern most likely to occur. The most likely municipal water use scenario incorporates the most likely population projection, with the per capita water use estimate that reflects below normal rainfall conditions and the expected level of conservation. These water use projections are developed by the TWDB for long-term water supply planning. Sizing of water supply facilities for this study is based on peaking factors applied to average condition per capita water use.

Population and average day water demand projections for each city are presented in Appendix C, Tables 1 through 8. Peak day demands are also shown in the tables. Peak factors are based on actual flow records obtained from the various water supply entities.

4.2. Delineation of Future Service Areas

Future service area alternatives evaluated in this study are listed in Table 4-1.

TABLE 4-1

FUTURE SERVICE AREA ALTERNATIVES

Alternative Number	Water Supplier	Water Customer
1	City of Alice	DCCRD (San Diego, Benavides, Realitos, Concepcion); Freer WCID
2	City of Alice	DCCRD (San Diego and Benavides); Freer WCID
3	City of Alice	DCCRD (San Diego and Benavides); Freer WCID
4	City of Alice	DCCRD (San Diego); Freer WCID
5	City of Alice	DCCRD (San Diego)
6	City of Alice	Freer WCID
7	City of Corpus Christi	Freer WCID
8	City of Alice	City of Premont
9	City of Alice	City of Orange Grove

Alternatives 1-6 and 8-9 assume water supply from the Alice Water Authority. Alternative 7 (supply to Freer WCID from the City of Corpus Christi directly out of Choke Canyon Reservoir) was evaluated for comparison to Alternative 6.

Summaries of total peak day water demand projections for Service Area Alternatives 1-4 (various combinations of cities currently served by groundwater from DCCRD and Freer WCID).

4.3. Potential Conversion from Groundwater Supply to Surface Water

As stated in Section 3.1.3, the City of Alice surface water pumping, transmission and treatment facilities can adequately accommodate the demands of the entire study area for the planning period. Facilities required for conversion from groundwater supply to surface water via the City of Alice system are summarized below.

4.3.1. Service Area Alternatives 1 through 6 (Various combinations of DCCRD and Freer WCID

Conversion from existing groundwater supply to surface water for service area Alternatives 1 through 6 could be implemented by:

- Connection to the high service pump station discharge line at the existing 12 MGD City of Alice Water Treatment Plant or to the existing 16" diameter line located in the southwest quadrant of the City of Alice,
- Extension of new transmission lines to the various customer cities,
- Construction of intermediate storage and booster pump stations along the transmission lines, as required, and
- Connection of the new surface water transmission lines to existing storage facilities at the point of service for each customer city.

4.3.2. Service Area Alternative 7 (Freer WCID)

Conversion to surface water supply for service area alternative 7 would require:

- Construction of a new raw water intake and pump station at Choke Canyon Reservoir,
- Extension of new transmission line to Freer,

- Construction of two (2) intermediate storage and booster pump stations along the transmission line, and

- Connection to Freer WCID's existing 750,000 gallon standpipe.

In addition, a new water treatment plant would be required for Alternative 7. Options for location of the treatment plant include the Choke Canyon Reservoir area, in conjunction with a treated water transmission line, or near Freer, preceded by a raw water transmission line. For purposes of this study, the treatment plant location is not relevant, as the cost of facilities will be approximately the same regardless of location.

4.3.3. Service Area Alternative 8 (Premont)

Conversion to surface water supply for service area alternative 8 would require the following facilities:

- Connection to the existing City of Alice distribution system near its southern limit,

- Extension of a new transmission line to Premont, and

- Connection to Premont's existing ground storage tanks.

4.3.4. Service Area Alternative 9 (Orange Grove)

Conversion to surface water supply for service area Alternative 9 would require the following facilities:

- Connection to the high service pump station discharge line at the existing City of Alice Water Treatment Plant,

- Extension of a new transmission line to Orange Grove, and

- Connection to Orange Grove's existing ground storage tank.

Hydraulic analyses required for sizing of new surface water supply and transmission facilities are summarized in Section 4.5. Cost estimates for the facilities are presented in Section 4.6.

4.4. Evaluation and Costs For Enhancement of Existing Groundwater Supply

The costs associated with continued use and future development of groundwater supplies is an important factor in evaluating the economics of future water supply alternatives. The costs of developing and pumping groundwater in existing and proposed well fields within the study area for the major communities presently utilizing groundwater are discussed in the following paragraphs. These sections are followed by a section describing processes and costs associated with desalination of water high in chloride and dissolved solids.

4.4.1. Groundwater Development Plan

To arrive at costs for groundwater development, an analysis was performed to determine the number of wells required in the planning period. Future water requirements are shown in Section 4.1 and are utilized in this analysis. Additionally, predictions of pumping levels were made. This analysis for each City is shown in the following tabulations:

TABLE 4-2

FUTURE WATER REQUIREMENTS
CITY OF ORANGE GROVE
GROUNDWATER SUPPLY

Category	Year					
	2000	2010	2020	2030	2040	2050
Water Requirement Avg. Daily flow (mgd)	0.22	0.22	0.22	0.22	0.22	0.22
Water Requirement Avg. Summer Mos. Flow (mgd)	0.28	0.28	0.28	0.28	0.28	0.28
Average Pump Rate/Well (gpm)	233	233	233	233	233	233
Number of Wells Required	2	2	2	2	2	2
Pumping Level (ft.)	270	280	290	300	310	320

TABLE 4-3
FUTURE WATER REQUIREMENTS
CITY OF PREMONT
GROUNDWATER SUPPLY

Category	Year					
	2000	2010	2020	2030	2040	2050
Water Requirement Avg. Daily flow (mgd)	0.92	1.03	1.15	1.29	1.32	1.39
Water Requirement Avg. Summer Mos. Flow (mgd)	1.15	1.29	1.44	1.61	1.65	1.74
Average Pump Rate/Well (gpm)	513	513	513	513	513	513
Number of Wells Required	3	3	3	3	3	4
Pumping Level (ft.)	320	360	400	440	480	520

**TABLE 4-4
FUTURE WATER REQUIREMENTS
CITY OF SAN DIEGO
GROUNDWATER SUPPLY**

Category	Year					
	2000	2010	2020	2030	2040	2050
Water Requirement Avg. Daily flow (mgd)	0.78	0.79	0.81	0.88	0.91	0.96
Water Requirement Avg. Summer Mos. Flow (mgd)	0.98	0.99	1.01	1.10	1.14	1.20
Average Pump Rate/Well (gpm)	160	160	160	160	160	160
Number of Wells Required	6	6	6	7	7	7
Pumping Level (ft.)	480	490	500	510	520	530

**TABLE 4-5
FUTURE WATER REQUIREMENTS
CITY OF BENAVIDES
GROUNDWATER SUPPLY**

Category	Year					
	2000	2010	2020	2030	2040	2050
Water Requirement Avg. Daily flow (mgd)	0.45	0.47	0.49	0.50	0.51	0.52
Water Requirement Avg. Summer Mos. Flow (mgd)	0.56	0.58	0.61	0.63	0.64	0.65
Average Pump Rate/Well (gpm)	153	153	153	153	153	153
Number of Wells Required	4	4	4	4	4	4
Pumping Level (ft.)	310	320	330	340	350	360

TABLE 4-6
FUTURE WATER REQUIREMENTS
CITY OF FREER
GROUNDWATER SUPPLY

Category	Year					
	2000	**2010**	**2020**	**2030**	**2040**	**2050**
Water Requirement Avg. Daily flow (mgd)	0.64	0.40	0.74	0.80	0.83	0.86
Water Requirement Avg. Summer Mos. Flow (mgd)	0.80	0.88	0.93	1.00	1.04	1.08
Average Pump Rate/Well (gpm)	136	136	136	136	136	136
Number of Wells Required	6	6	7	7	8	8
Pumping Level (ft.)	590	630	670	710	750	790

Although the analysis indicates very few additional new well requirements, it is reasonable to assume that new well development will occur as replacement wells and for additional capacity required. For purposes of this study, ground water development scenarios for each City are as follows:

Orange Grove

- New well drilled to replace one existing well in year 2030.

Premont

- New well drilled to replace one existing well in year 2030.

San Diego

- New well drilled in new well field southeast of the City in year 2010.
- New well drilled in new well field in year 2030.

Benavides

- New well drilled at water plant site in year 2000.
- New well drilled in year 2030.

Freer

- New well drilled in year 2000.
- New well drilled in year 2030.

4.4.2. Groundwater Development Costs

In order to determine the various costs to arrive at a cost per thousand gallons over the planning period, the following methodology and definitions were used:

Capital costs were determined for new wells necessary to provide the projected daily supply and replacement wells for those no longer serviceable. Also included in well costs are pipelines necessary to transport the water to ground storage. Annual capital costs were determined by dividing the annual debt service for a 40 year period at 4.5% interest by the total water produced (in thousands) which yields capital costs per thousand.

Operation and maintenance costs were predicted from labor, contract services and pump costs. These included costs for pump repair, pump replacement, pump lowering, well reworking, and labor and materials for routine well operation and maintenance. The total estimated annual cost was divided by the total water produced (in thousands) which yields operation and maintenance costs per thousand.

Energy costs were computed using the following formula:

$$\text{Cost/1000 gals} = \frac{16.67 \times \text{tdh} \times 0.746 \times \text{kwh cost}}{3960 \times \text{efficiency}}$$

Where:

16.67 = a constant to convert from cost/hr to cost/1000 gals pumped

tdh = total dynamic head which includes pumping level in well to discharge at ground storage

Kwh = cost per kilowatt-hour for electricity in cents.

3960 = a constant for conversion of units.

efficiency = wire-to-water efficiency which is the overall pump efficiency multiplied by the efficiency of the motor (0.70 used as average).

Total cost/1000 gallons is the sum of the above three costs. Following is a tabulation of these total costs for each City through the fifty year planning period, in terms of 1996 base dollars (inflation and escalation rates were not applied).

TABLE 4-7

COST/1000 GALLONS PRODUCED AND DELIVERED TO TREATED WATER STORAGE FACILITIES 1996 DOLLARS)

Cost	2000	2010	2020	2030	2040	2050
ORANGE GROVE						
Capital Cost	---	---	---	0.41	0.41	0.41
Operation & Maintenance Cost	0.29	0.29	0.29	0.29	0.29	0.29
Energy Cost	0.13	0.14	0.15	0.16	0.17	0.18
Total Cost	0.42	0.43	0.44	0.86	0.87	0.88
PREMONT						
Capital Cost	---	---	---	0.07	0.07	0.06
Operation & Maintenance Cost	0.14	0.12	0.11	0.10	0.09	0.09
Energy Cost	0.17	0.18	0.19	0.20	0.21	0.22
Total Cost	0.31	0.30	0.30	0.37	0.37	0.37
SAN DIEGO						
Capital Cost	---	0.35	0.34	0.15	0.15	0.14
Operation & Maintenance Cost	0.17	0.16	0.16	0.15	0.15	0.14
Energy Cost	0.22	0.23	0.24	0.25	0.26	0.27
Total Cost	0.39	0.74	0.74	0.55	0.56	0.55
BENAVIDES						
Capital Cost	0.20	0.19	0.18	0.28	0.27	0.27
Operation & Maintenance Cost	0.27	0.27	0.26	0.25	0.25	0.24
Energy Cost	0.12	0.13	0.14	0.15	0.16	0.17
Total Cost	0.59	0.59	0.58	0.68	0.68	0.68
FREER						
Capital Cost	0.22	0.20	0.19	0.17	0.17	0.16
Operation & Maintenance Cost	0.21	0.19	0.18	0.17	0.16	0.15
Energy Cost	0.30	0.31	0.32	0.33	0.34	0.35
Total Cost	0.73	0.70	0.69	0.67	0.67	0.66

NOTE: This analysis is for economic purposes only and is not necessarily indicative of solutions to supply water which meet TNRCC and USEPA drinking water quality standards.

4.4.3. Desalination

The most commonly utilized processes for enhancement of groundwater by desalination are:

- Distillation (thermal) Processes; and
- Membrane (non-thermal) Processes.

4.4.3.1. Distillation (Thermal) Processes

Distillation processes produce purified water by vaporizing a portion of the saline feedstock to form steam. Since the salts dissolved in the feedstock are nonvolatile, they remain unvaporized and the steam formed is captured as a pure condensate. Distillation processes are normally very energy-intensive, quite expensive, and are generally used for large-scale desalination of sea water. Heat is usually supplied by steam produced by boilers or from a turbine power cycle used for electric power generation. Distillation plants are commonly dual purpose facilities which produce purified water and electricity.

In general, for a specific plant capacity, the equipment in distillation plants tends to be much larger than membrane desalination equipment. However, distillation plants do not have the stringent feedwater quality requirements of membrane plants. Due to the relatively high temperatures required to evaporate water, distillation plants have high energy requirements, making energy a large factor in their overall water cost. Their high operating temperatures can result in scaling (precipitation of minerals from the feedwater), which reduces the efficiency of the evaporator processes, because once an evaporator system is constructed, the size of the exchange area and the operating profile are fixed, leaving energy transfer as a function of only the heat transfer coefficient. Therefore, any scale that forms on heat exchanger surfaces reduces heat transfer coefficients. Under normal circumstances, scale can be controlled by chemical inhibitors, which inhibit but do not eliminate scale, and by operating at temperatures of less than 200° F.

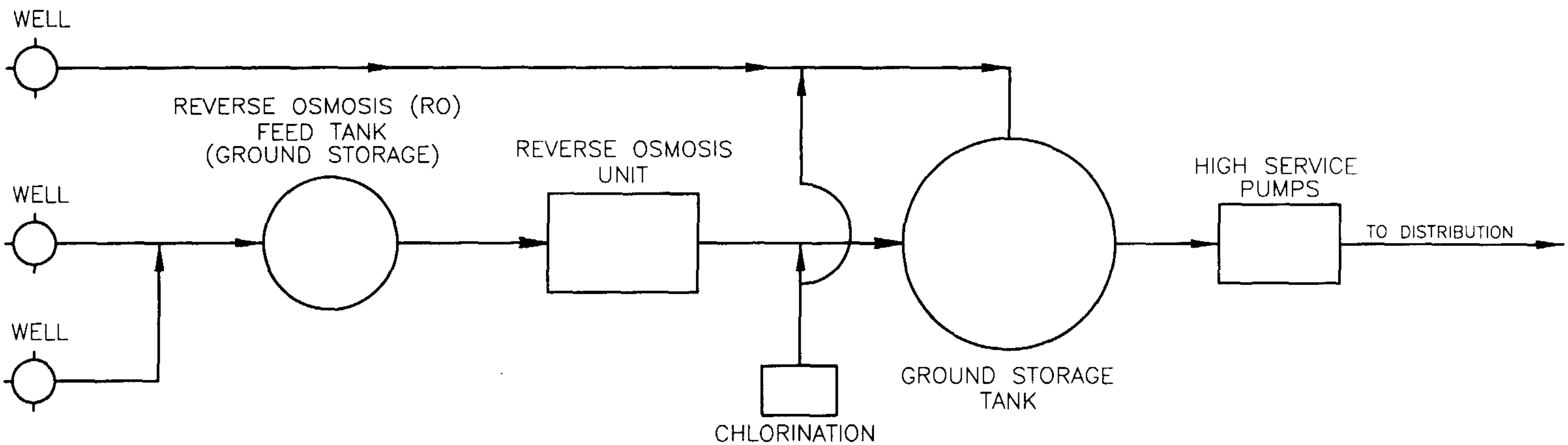
Distillation product water recoveries normally range from 15% to 45%, depending on the process. The product water from these processes is nearly mineral free, with very low TDS (less than 25 mg/L). However, this product water is extremely aggressive and is too corrosive to meet the Safe Drinking Water Act (SDWA) corrosivity standards without post-treatment. Product water can be stabilized by chemical treatment or be blending with other potable water.

The three main distillation processes in use today are: Multistage Flash Evaporation (MSF), Multiple Effect Distillation (MED), and Vapor Compression (VC). All three of these processes utilize an evaporator vessel which vaporizes and condenses the feedstock. The three processes differ in the design of the heat exchangers in the vessels and in the method of heat introduction into the process.

4.4.3.2. Membrane (Non-thermal) Processes

The two types of membrane processes use either pressure, as in reverse osmosis, or electrical charge, as in electrodialysis reversal, to reduce the mineral content of water. Both processes use semipermeable membranes which allow selected ions to pass through while other ions are blocked. Electrodialysis reversal (EDR) uses direct electrical current applied across a vessel to attract the dissolved salt ions to their opposite electrical charges. EDR can desalinate brackish water with TDS up to several thousand mg/L, but energy requirements tend to make it economically uncompetitive when compared with reverse osmosis (RO) processes.

RO utilizes a semi-permeable membrane which limits the passage of salts from the brackish water side to the fresh water side of the membrane. Electric motor drive pumps or steam turbines (in dual purpose installations) provide the 800 to 1,200 PSIG pressure to overcome the osmotic pressure and drive the fresh water through the membrane, leaving a waste stream of brine/concentrate. Recovery rates up to 75% are common for a brackish water RO facility. A typical schematic diagram for a RO facility utilized to enhance groundwater is shown on Figure 4-1. In groundwater situations like those in most areas of Duval County, it is reasonable to assume that "blending" may be allowed by the regulatory agencies. This would involve RO treatment of that quantity of well water which would bring the water in the distribution system within regulatory limits. A reasonable assumption is that two-thirds to three-fourths of the water going into the ground storage would be subjected to the RO process. The basic components of an RO plant include high pressure pumps, membrane assemblies, and post-treatment (chlorination).



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SCHEMATIC DIAGRAM OF TYPICAL REVERSE OSMOSIS (RO) FACILITY FOR GROUNDWATER ENHANCEMENT (WITH BLENDING)

REGIONAL WATER SUPPLY STUDY FOR
DUVAL AND JIM WELLS COUNTIES

Figure 4–1

Drawn By: R.C.	Appr. By: G.A.B.	Scale: N.T.S.	Dwg. No.: 4218–EBA	Sheet
Checked By: G.A.B.	Project No.: 4218	Date: 8–96	Rev.: 0	of 0

4.4.3.3. Cost Estimates

While the engineering feasibility of desalination has been clearly demonstrated with a number of technologies, it is essentially the economic feasibility of desalination that has hindered its widespread use. Costs will vary based on a number of factors including:

- Siting
- Plant capacity
- Water source quality
- Product water quality goal
- Recovery rate
- Concentrate discharge system
- Transmission, storage and distribution system
- Regulatory issues
- Power costs

An analysis of RO operations for water with chemical constituents typically found in the Duval County communities indicates that the estimated cost for desalination ranges between $2.50 to $3.50 per 1000 gallons. These figures include capital recovery, O & M costs and power costs for the well and RO operation only. A typical breakdown of costs for a water well/RO system is shown below:

COST/1000 GALLONS - PRODUCED AT GROUND STORAGE FOR WATER WELL/RO SYSTEM

Capital costs	$1.42
O&M Costs	$1.27
Power Costs	$0.41
TOTAL	**$3.10**

4.5. Evaluation and Hydraulic System Analyses of Alternative Surface Water Supply Facilities

Hydraulics of alternative surface water supply and transmission facilities were modeled using the KYPIPE2 computer program. Design criteria used in the hydraulic analyses are summarized below:

- A minimum of 65 psi pressure was assumed to be available at the City of Alice Water Treatment plant high service pump station discharge line or the 16" diameter line located in the Southwest quadrant of the City.
- Intermediate storage and booster pump stations were assumed to consist of three (3) horizontal split case pumps of equal capacity, sized to meet year 2020 peak day demands with 2 units operating and one unit as standby.
- Two (2) ground storage tanks (approximately 40' height), with a total capacity of approximately 6 hours of average day demand, were assumed to be operated in parallel at each booster pump station site.
- Transmission pipelines were sized to provide booster pump stations with a maximum total dynamic head (TDH) of approximately 250-300 feet, based on year 2050 peak day demands. PVC pipe, meeting the requirements of AWWA Standard C900, was assumed for sizes up to 12". AWWA C905 PVC pipe was assumed for sizes greater than 12".

4.5.1. Alternative 1

Alternative 1 provides surface water supply from the City of Alice to San Diego, Freer, Benavides, Realitos and Concepcion.

Figure 4-3 shows a plot of the natural ground elevations and hydraulic grade line for a portion of the Alternative 1 routing from Alice to Freer. This plot demonstrates the long distances required by the proposed regional system, as well as the relatively high static heads along most of the pipeline routings.

Facilities include four (4) storage and booster pump stations and a total of approximately 85.4 miles of pipelines, ranging in size from 6" through 16" diameter. Locations of proposed regional facilities for Alternative 1 are shown on Figure 4-2 and are listed below.

- Approximately three (3) miles of 16" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 Bypass) to the intersection with US Highway 44 (US 44).

- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 125 horsepower (HP) pumps.

- Approximately 7.4 miles of 16" diameter transmission line (paralleling US 44) from Pump Station #1 to a junction node in San Diego.

- Approximately 3.8 miles of 16" diameter transmission line from the junction node to Pump Station #2.

- Booster Pump Station #2, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.

- Approximately eight (8) miles of 16" diameter transmission line (along the US 44) from Pump Station #2 to Pump station #3.

- Booster Pump Station #3, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.

- Approximately fifteen (15) miles of 12" diameter transmission line from Pump Station #3 to the existing 750,000 gallon standpipe in Freer.

- Approximately one (1) mile of 16" diameter transmission line (located within existing city streets) from the junction node in San Diego to a pressure reducing station.

- Approximately 300 feet of 10" diameter line from the pressure reducing station to the 500,000 gallon or 1 million gallon DCCRD ground storage tank in San Diego.

- Approximately 2.0 miles of 16" diameter transmission line from upstream of the pressure reducing station in a southerly direction (parallel to Highway 359) to Pump Station #4.

- Booster Pump Station #4, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 40 HP pumps.

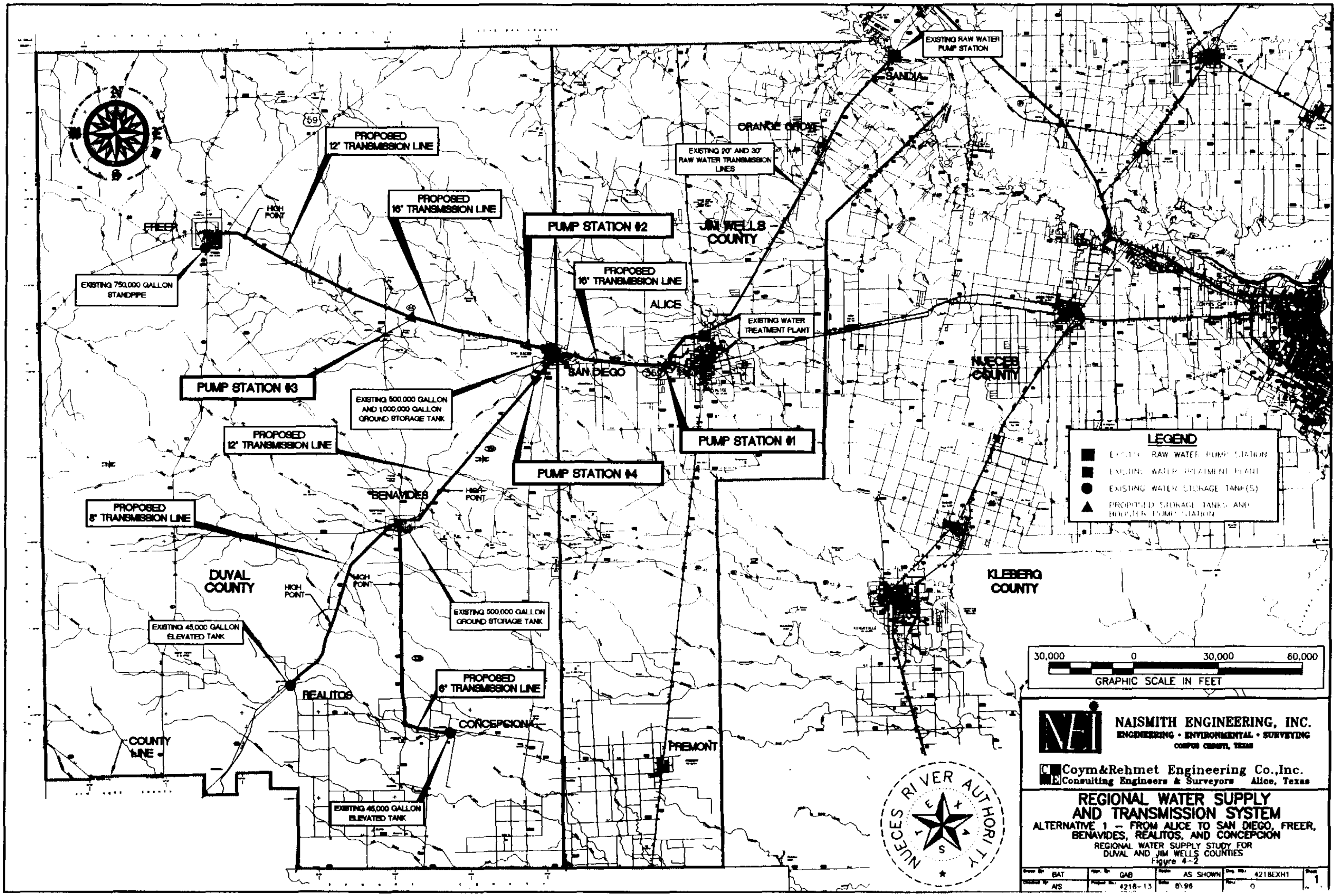
- Approximately 13 miles of 12" diameter transmission line from Pump Station #4 to a junction node in Benavides.

- Approximately 4,000 feet of 8" diameter transmission line from the junction node in a southerly direction to the 500,000 gallon DCCRD ground storage tank in Benavides.

- Approximately 2,000 feet of 8" diameter transmission line to a second junction node.

- Approximately 13.6 miles of 8" diameter transmission line from the above mentioned second node in a southwesterly direction (parallel to Highway 359) to the 45,000 gallon DCCRD elevated tank in Realitos.

- Approximately 16.6 miles of 6" diameter transmission line from the above mentioned second node in a southerly direction (parallel to Highways 339 and 716) to the 45,000 gallon DCCRD elevated tank in Concepcion.


EXISTING RAW WATER PUMP STATION
SANDIA
ORANGE GROVE
EXISTING 20" AND 30" RAW WATER TRANSMISSION LINES
PROPOSED 12" TRANSMISSION LINE
PROPOSED 16" TRANSMISSION LINE
PUMP STATION #2
JIM WELLS COUNTY
FREER
HIGH POINT
EXISTING 750,000 GALLON STANDPIPE
PROPOSED 16" TRANSMISSION LINE
ALICE
EXISTING WATER TREATMENT PLANT
SAN DIEGO
NUECES COUNTY
PUMP STATION #3
EXISTING 500,000 GALLON AND 1,000,000 GALLON GROUND STORAGE TANK
PROPOSED 12" TRANSMISSION LINE
PUMP STATION #1
PUMP STATION #4
LEGEND
EXISTING RAW WATER PUMP STATION
EXISTING WATER TREATMENT PLANT
EXISTING WATER STORAGE TANK(S)
PROPOSED STORAGE TANKS AND BOOSTER PUMP STATION
PROPOSED 8" TRANSMISSION LINE
BENAVIDES
HIGH POINT
DUVAL COUNTY
HIGH POINT
KLEBERG COUNTY
EXISTING 500,000 GALLON GROUND STORAGE TANK
EXISTING 45,000 GALLON ELEVATED TANK
30,000 0 30,000 60,000
GRAPHIC SCALE IN FEET
PROPOSED 6" TRANSMISSION LINE
REALITOS
CONCEPCION
COUNTY LINE
PREMONT
EXISTING 45,000 GALLON ELEVATED TANK
NUECES RIVER AUTHORITY
TEXAS
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Consulting Engineers & Surveyors Alice, Texas
REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM
ALTERNATIVE 1 -- FROM ALICE TO SAN DIEGO, FREER, BENAVIDES, REALITOS, AND CONCEPCION
REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 4-2
BAT
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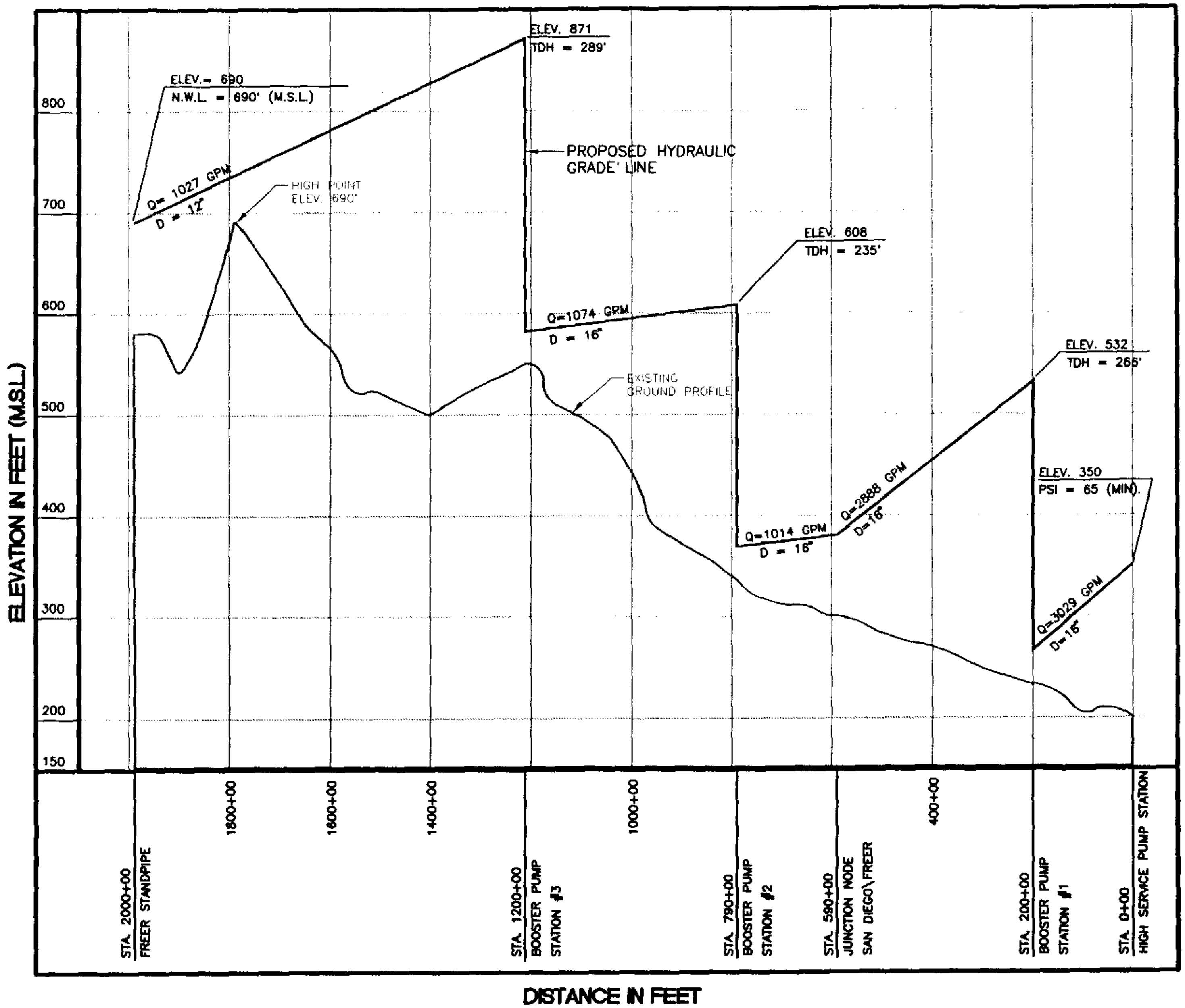

NOTES:

1. HYDRAULIC GRADE LINE REPRESENTS YEAR 2050 PEAK DAY DEMANDS FOR SAN DIEGO, FREER, BENAVIDES, REALITOS AND CONCEPCION
2. EXISTING GROUND PROFILE REPRESENTS THE TRANSMISSION LINE ROUTING FROM ALICE TO FREER.

VERT. SCALE IN FEET 0 100

20000 10000 0 20000

HORZ. GRAPHIC SCALE IN FEET

NUECES RIVER AUTHORITY

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REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM

ALTERNATIVE 1 – HYDRAULIC GRADE LINE

REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES

Figure 4-3

BAT/DC	GAB	AS SHOWN	4218-FRE	1
A/S	4218-13	8/-96	0	

4.5.2. Alternative 2

Alternative 2 provides surface water supply from the City of Alice to San Diego, Freer and Benavides. Facilities include four (4) storage and booster pump stations and a total of approximately 54.6 miles of pipelines, ranging in size from 6" through 16" diameter. Locations of proposed regional facilities for Alternative 2 are shown on Figure 4-4 and are listed below.

- Approximately three (3) miles of 16" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 Bypass) to the intersection with US Highway 44 (US 44).
- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 125 horsepower (HP) pumps.
- Approximately 7.4 miles of 16" diameter transmission line (paralleling US 44) from Pump Station #1 to a junction node in San Diego.
- Approximately 3.8 miles of 16" diameter transmission line from the junction node to Pump Station #2.
- Booster Pump Station #2, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.
- Approximately eight (8) miles of 16" diameter transmission line (along the US 44) from Pump Station #2 to Pump station #3.
- Booster Pump Station #3, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.
- Approximately fifteen (15) miles of 12" diameter transmission line from Pump Station #3 to the existing 750,000 gallon standpipe in Freer.
- Approximately one (1) mile of 16" diameter transmission line (located within existing city streets) from the junction node in San Diego to a pressure reducing station.
- Approximately 300 feet of 10" diameter line from the pressure reducing station to the DCCRD ground storage tank in San Diego.
- Approximately 2.0 miles of 16" diameter transmission line from upstream of the pressure reducing station in a southerly direction (parallel to Highway 359) to Pump Station #4.

- Booster Pump Station #4, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 30 HP pumps.
- Approximately 13 miles of 12" diameter transmission line from Pump Station #4 to a junction node in Benavides.
- Approximately 4,000 feet of 10" diameter transmission line from the junction node in a southerly direction to the 500,000 gallon DCCRD ground storage tank in Benavides.

4.5.3. Alternative 3

Alternative 3 provides surface water supply from the City of Alice to San Diego and Benavides. Facilities include two (2) storage and booster pump stations and a total of approximately 28 miles of pipelines, ranging in size from 6" through 16" diameter. Locations of proposed regional facilities for Alternative 3 are shown on Figure 4-5 and are listed below.

- Approximately three (3) miles of 16" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 bypass) to the intersection with US Highway 44 (US 44).
- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 75 horsepower (HP) pumps.
- Approximately 7.4 miles of 16" diameter transmission line (paralleling US 44) from Pump Station #1 to a junction node in San Diego.
- Approximately one (1) mile of 12" diameter transmission line (located within existing city streets) from the junction node in San Diego to a pressure reducing station.
- Approximately 300 feet of 10" diameter line from the pressure reducing station to the DCCRD ground storage tank in San Diego.
- Approximately 2.0 miles of 8" diameter transmission line from upstream of the pressure reducing station in a southerly direction (parallel to Highway 359) to Pump Station #2.
- Booster Pump Station #2, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 30 HP pumps.

- Approximately 13 miles of 10" diameter transmission line from Pump Station #2 to a junction node in Benavides.

- Approximately 4,000 feet of 10" diameter transmission line from the junction node in a southerly direction to the 500,000 gallon DCCRD ground storage tank in Benavides.

4.5.4 Alternative 4

Alternative 4 provides surface water supply from the City of Alice to San Diego and Freer. Facilities include three (3) storage and booster pump stations and a total of approximately 38.8 miles of pipelines, ranging in size from 12" through 16" diameter. Locations of proposed regional facilities for Alternative 4 are shown on Figure 4-6 and are listed below.

- Approximately three (3) miles of 16" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 bypass) to the intersection with US Highway 44 (US 44).

- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 75 horsepower (HP) pumps.

- Approximately 7.4 miles of 16" diameter transmission line (paralleling US 44) from Pump Station #1 to a junction node in San Diego.

- Approximately 3.8 miles of 16" diameter transmission line from the junction node to Pump Station #2.

- Booster Pump Station #2, consisting of two (2) 100,000 gallon ground storage tanks and three (3) 50 HP pumps.

- Approximately eight (8) miles of 16" diameter transmission line (along U.S. 44) from Pump Station #2 to Pump Station #3.

- Booster Pump Station #3, consisting of two (2) 100,000 gallon ground storage tanks and three (3) 50 HP pumps.

- Approximately fifteen (15) miles of 12" diameter transmission line from Pump Station #3 to the existing 750,000 gallon standpipe in Freer.

- Approximately one (1) mile of 10" diameter transmission line (located within existing city streets) from the junction node in San Diego to a pressure reducing station.

- Approximately 300 feet of 10" diameter line from the pressure reducing station to the 500,000 gallon or 1 million gallon DCCRD ground storage tank in San Diego.

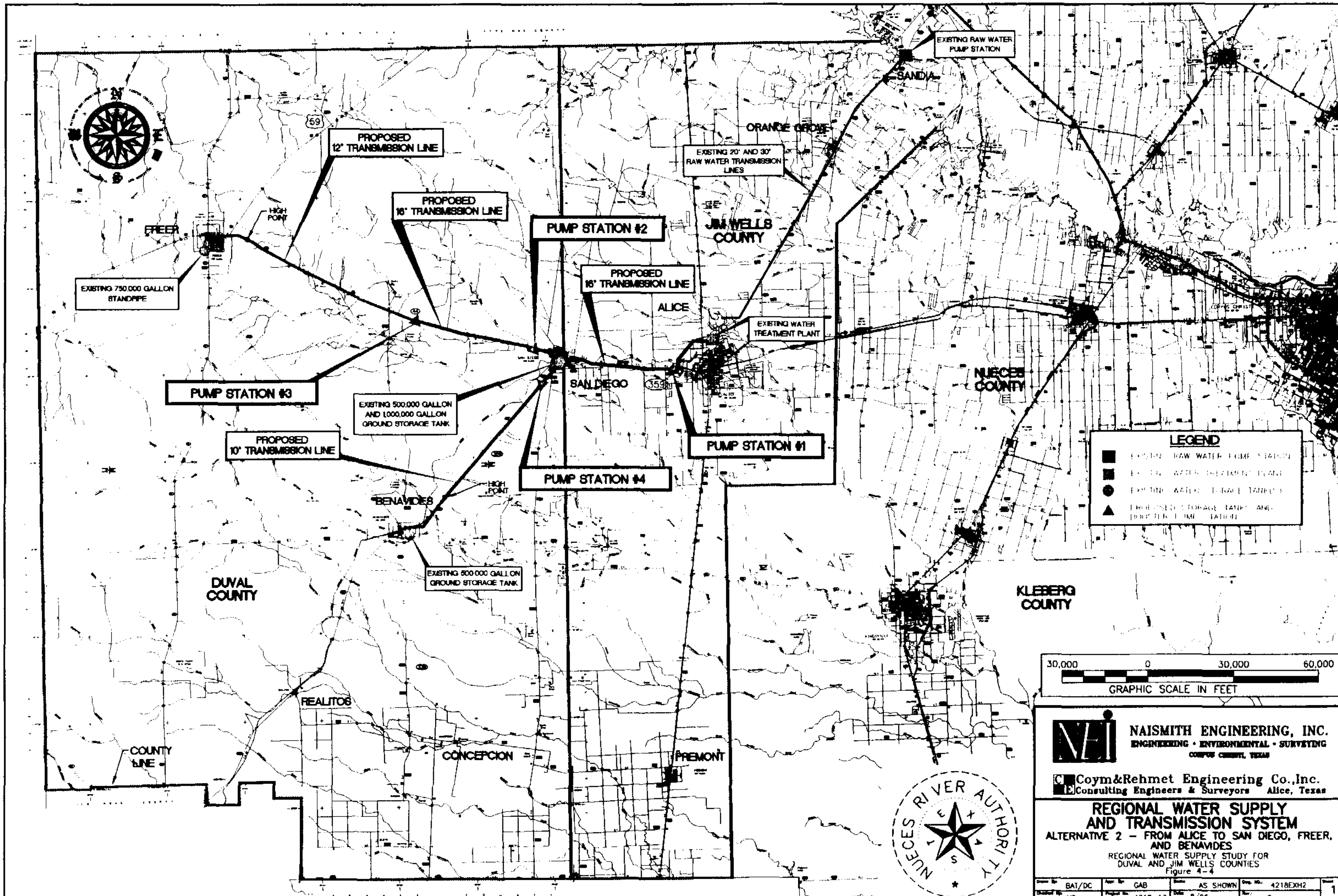
4.5.5. Alternative 5

Alternative 5 provides surface water supply from the City of Alice to San Diego. Facilities include one (1) storage and booster pump stations and a total of approximately 12.5 miles of 12" diameter pipeline. Locations of proposed regional facilities for Alternative 5 are shown on Figure 4-7 and are listed below.

- Approximately three (3) miles of 12" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 Bypass) to the intersection with US Highway 44 (US 44).

- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 40 horsepower (HP) pumps.

- Approximately 8.4 miles of 16" diameter transmission line (paralleling US 44) from Pump Station #1 to the 500,000 gallon or 1 million gallon DCCRD ground storage tank in San Diego.


EXISTING RAW WATER PUMP STATION
SANDIA
ORANGE GROVE
EXISTING 20" AND 30" RAW WATER TRANSMISSION LINES
PROPOSED 12" TRANSMISSION LINE
PROPOSED 16" TRANSMISSION LINE
PUMP STATION #2
JIM WELLS COUNTY
FREER
HIGH POINT
EXISTING 750,000 GALLON STANDPIPE
PROPOSED 16" TRANSMISSION LINE
ALICE
EXISTING WATER TREATMENT PLANT
PUMP STATION #3
SAN DIEGO
359
EXISTING 500,000 GALLON AND 1,000,000 GALLON GROUND STORAGE TANK
NUECES COUNTY
PROPOSED 10" TRANSMISSION LINE
PUMP STATION #1
PUMP STATION #4
HIGH POINT
BENAVIDES
LEGEND
EXISTING 500,000 GALLON GROUND STORAGE TANK
DUVAL COUNTY
KLEBERG COUNTY
30,000
0
30,000
60,000
GRAPHIC SCALE IN FEET
REALITOS
COUNTY LINE
CONCEPCION
PREMONT
NUECES RIVER AUTHORITY
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REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM
ALTERNATIVE 2 - FROM ALICE TO SAN DIEGO, FREER, AND BENAVIDES
REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 4-4
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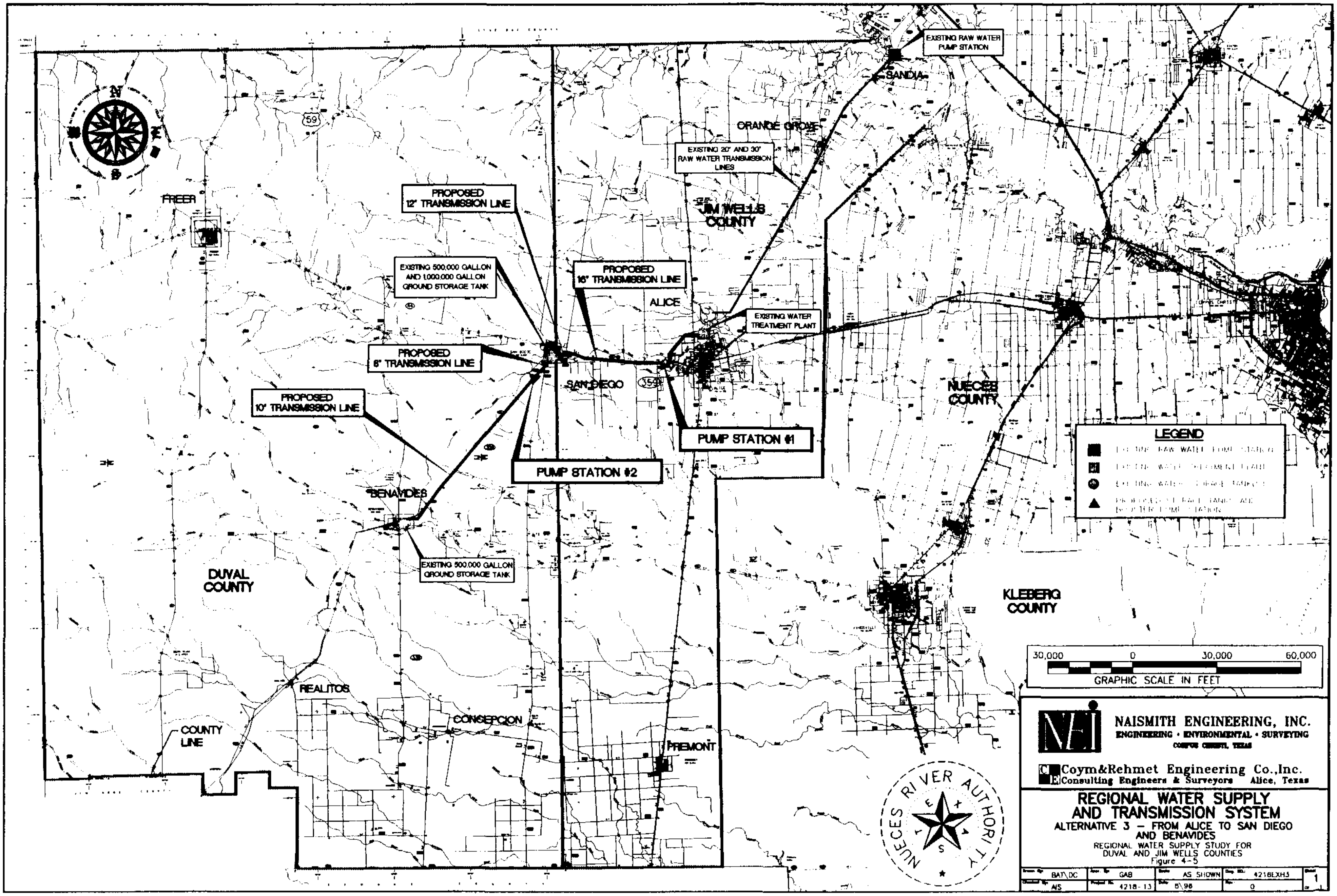
EXISTING RAW WATER PUMP STATION
SANDIA
ORANGE GROVE
EXISTING 20" AND 30" RAW WATER TRANSMISSION LINES
59
FREER
PROPOSED 12" TRANSMISSION LINE
JIM WELLS COUNTY
EXISTING 500,000 GALLON AND 1,000,000 GALLON GROUND STORAGE TANK
PROPOSED 16" TRANSMISSION LINE
ALICE
EXISTING WATER TREATMENT PLANT
PROPOSED 8" TRANSMISSION LINE
SAN DIEGO
359
PROPOSED 10" TRANSMISSION LINE
NUECES COUNTY
PUMP STATION #1
PUMP STATION #2
LEGEND
BENAVIDES
EXISTING 500,000 GALLON GROUND STORAGE TANK
DUVAL COUNTY
KLEBERG COUNTY
30,000 0 30,000 60,000
GRAPHIC SCALE IN FEET
REALITOS
CONCEPCION
COUNTY LINE
PREMONT
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NUECES RIVER AUTHORITY
TEXAS
REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM
ALTERNATIVE 3 – FROM ALICE TO SAN DIEGO AND BENAVIDES
REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 4-5
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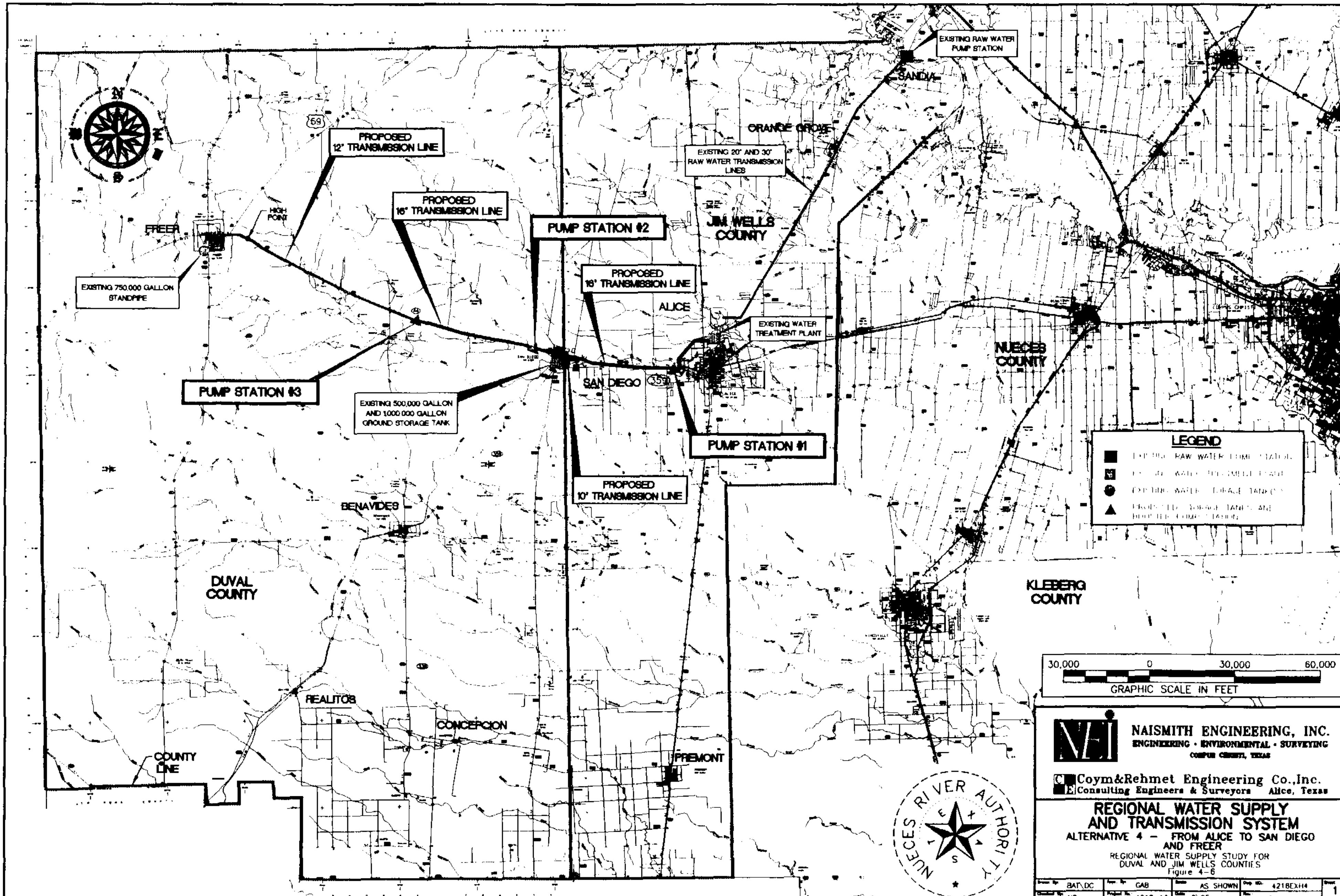

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REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM
ALTERNATIVE 4 – FROM ALICE TO SAN DIEGO AND FREER
REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 4-6

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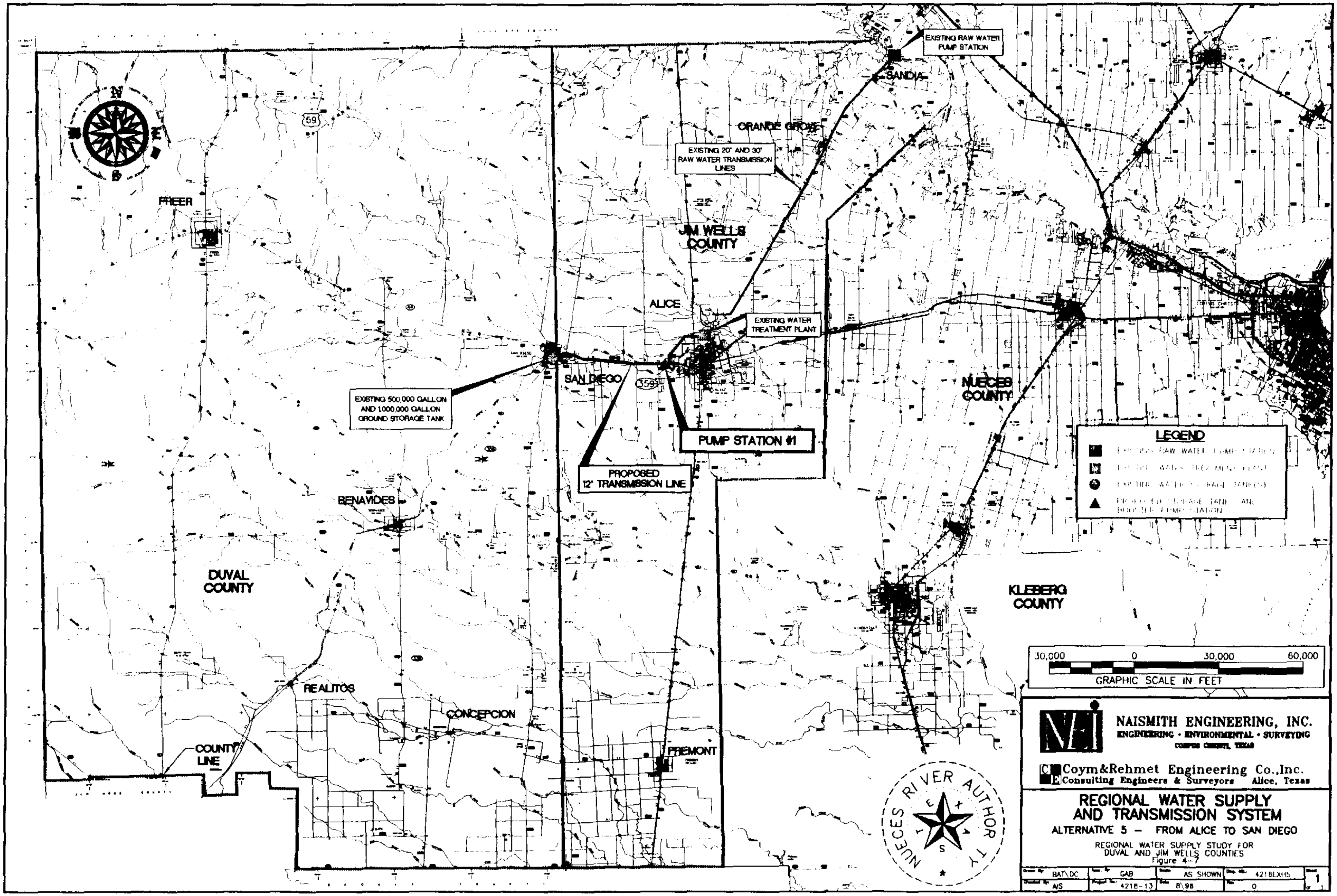
EXISTING RAW WATER PUMP STATION
SANDIA
ORANGE GROVE
EXISTING 20" AND 30" RAW WATER TRANSMISSION LINES
FREER
59
JIM WELLS COUNTY
ALICE
EXISTING WATER TREATMENT PLANT
SAN DIEGO
359
EXISTING 500,000 GALLON AND 1,000,000 GALLON GROUND STORAGE TANK
PUMP STATION #1
PROPOSED 12" TRANSMISSION LINE
NUECES COUNTY
LEGEND
BENAVIDES
DUVAL COUNTY
KLEBERG COUNTY
30,000 0 30,000 60,000
GRAPHIC SCALE IN FEET
REALITOS
CONCEPCION
COUNTY LINE
PREMONT
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NUECES RIVER AUTHORITY
REGIONAL WATER SUPPLY AND TRANSMISSION SYSTEM
ALTERNATIVE 5 – FROM ALICE TO SAN DIEGO
REGIONAL WATER SUPPLY STUDY FOR DUVAL AND JIM WELLS COUNTIES
Figure 4-7
BAT\DC
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4.5.6. Alternative 6

Alternative 6 provides surface water supply from the City of Alice to Freer. Facilities include three (3) storage and booster pump stations and a total of approximately 37.8 miles of pipelines, ranging in size from 12" through 16" diameter. Locations of proposed regional facilities for Alternative 6 are shown on Figure 4-8 and are listed below.

- Approximately three (3) miles of 12" diameter transmission line from the City of Alice high service pump station (parallel to the US Highway 281 Bypass) to the intersection with US Highway 44 (US 44).
- Booster Pump Station #1, consisting of two (2) - 250,000 gallon ground storage tanks and three (3) 50 horsepower (HP) pumps.
- Approximately 11.2 miles of 12" diameter transmission line (paralleling US 44) from Pump Station #1 to Pump Station #2.
- Booster Pump Station #2, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.
- Approximately eight (8) miles of 12" diameter transmission line (along the US 44) from Pump Station #2 to Pump Station #3.
- Booster Pump Station #3, consisting of two (2) - 100,000 gallon ground storage tanks and three (3) 50 HP pumps.
- Approximately fifteen (15) miles of 12" diameter transmission line from Pump Station #3 to the existing 750,000 gallon standpipe in Freer.

4.5.7. Alternative 7

Alternative 7 provides surface water supply directly from the City of Corpus Christi to Freer via Choke Canyon Reservoir. Facilities include a raw water intake and pump station, two (2) additional storage and booster pump stations and a total of approximately 61 miles of 12" and 16" diameter pipeline. The conceptual pipeline routing generally parallels existing highway right-of-ways from Choke Canyon to Freer. Locations of proposed facilities from Alternative 7 are shown on Figure 4-9 and listed below:

- Raw water intake and pump station at Choke Canyon Reservoir, consisting of three (3) 50 HP pumps.
- Approximately 28.4 miles of 16" diameter transmission line from the raw water pump station to Pump Station #2.
- Booster Pump Station #2, consisting of two (2) 100,000 gallon ground storage tanks and three (3) 50 HP pumps.
- Approximately 11.4 miles of 12" diameter transmission line from Pump Station #2 to Pump Station #3.
- Booster Pump Station #3, consisting of two (2) 100,000 gallon ground storage tanks and three (3) 40 HP pumps.
- Approximately 18.5 miles of 16" and approximately 3.0 miles of 12" diameter transmission line from Pump Station #3 to the existing 750,000 gallon standpipe in Freer.

4.5.8. Alternative 8

Alternative 8 provides surface water supply from the City of Alice to Premont. Connection would be made to the existing Alice distribution system in the southern part of the city. The conceptual pipeline routing parallels existing Highway 281 ROW from Alice to Premont. The hydraulic analysis assumed a minimum pressure at the point of connection of 40 psi. Locations of proposed facilities for Alternative 8 are shown on Figure 4-10 and listed below:

- Approximately 25.9 miles of 18" and approximately 1 mile of 16" diameter transmission lines from the Alice distribution system to Premont's existing ground storage tanks.

4.5.9. Alternative 9

Alternative 9 provides surface water supply from the Alice Water Treatment Plant to Orange Grove. The conceptual pipeline routing generally parallels existing highway right-of-ways. Locations of proposed facilities for Alternative 9 are shown on Figure 4-11 and listed below:

- Approximately 6.6 miles of 10" and approximately 12.5 miles of 8" diameter transmission line from the City of Alice high service pump station to the existing ground storage tank in Orange Grove.