South Central Texas Regional Water Planning Area

Regional Water Plan

Volume III — Technical Evaluations of Water Supply Options

Prepared by:

South Central Texas Regional Water Planning Group

With administration by:

San Antonio River Authority

With technical assistance by:

HDR Engineering, Inc.
Moorhouse Associates, Inc.
Open Forum

In association with:

Paul Price Associates, Inc.
LBG-Guyton Associates
R.J. Brandes Company
The Wellspec Company

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Volume I: Executive Summary and Regional Water Plan

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Introduction

Planning Process

The South Central Texas Regional Water Planning Group (SCTRWPG) has employed a planning process (Figure 1) focused on the development of a Regional Water Plan to meet the needs of every water user group in the region for a period of fifty years. Given the history of sharp and divisive conflict concerning water planning in this region, the planning process has provided extraordinary opportunities for participation by water user groups in providing input to achieve the goal of a plan that will "provide for the orderly development, management, and conservation of water resources…" 31 TAC 357.5(a). To build consensus among the constituencies represented by the members of the SCTRWPG, the planning process has emphasized the coordination and careful integration of technical information with information provided through public participation.

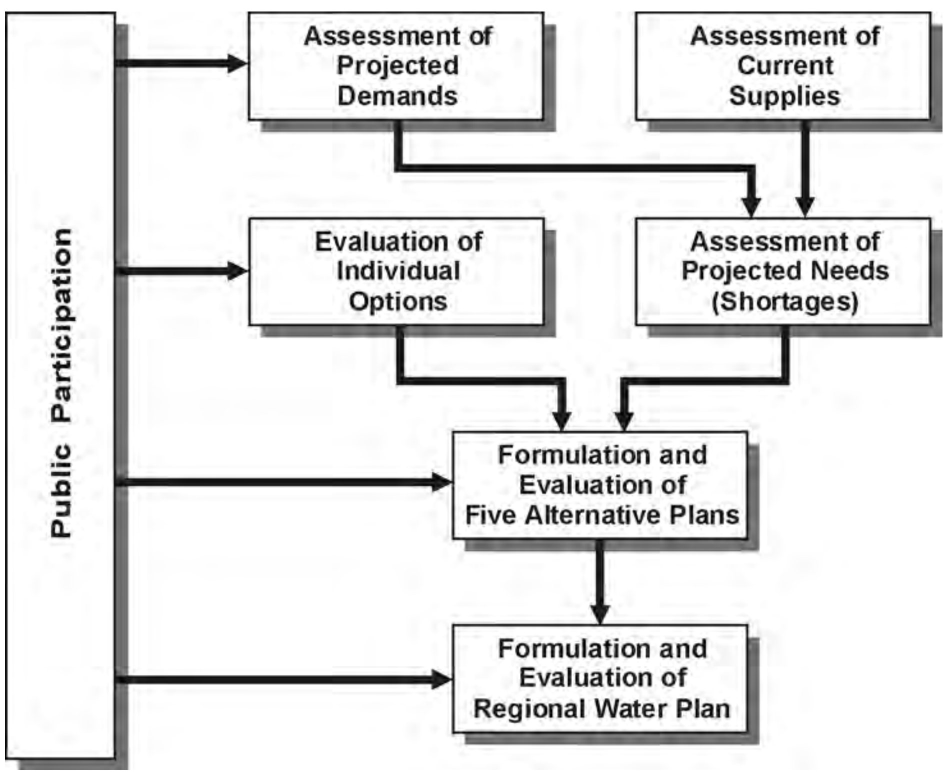


Figure 1. Planning Process

Conflict over the past several decades in this region has focused on how to manage the Edwards Aquifer so as to meet the needs of many water user groups. Central to progress in resolving this conflict, and thus in achieving the formulation of a water plan acceptable to all constituencies represented in the SCTRWPG, is the assurance that all of the different competing strategies for meeting water needs will be given consideration. It has thus been central to the viability of the planning process itself that the evaluation of water supply options and combinations of these options in the context of a regional plan receive extraordinary attention.

To this end, the SCTRWPG has employed a planning process that ensures evaluation of virtually all the water supply options or management strategies that have been proposed or discussed in the past, together with several new ones that have never before been subjected to technical evaluation. To achieve confidence by all constituencies in the planning process, it has been necessary to evaluate the options both on a stand-alone basis (Volume III – Technical Evaluations of Water Supply Options) and in various combinations in the context of alternative plans (Volume II – Technical Evaluations of Alternative Regional Water Plans). Given the fact that some of the proposed strategies for regional management are at odds with one another, it has been important to look at a series of alternative regional water plans. By formulating five alternative regional water plans, the SCTRWPG has carefully considered many diverse management strategies. In keeping with logical and acceptable planning methods, the SCTRWPG has taken the best components of these alternative plans and developed a Regional Water Plan (Volume I – Executive Summary and Regional Water Plan).

This volume of the Initially Prepared Regional Water Plan for the South Central Texas Regional Planning Area includes the technical evaluations of water supply options and strategies selected by the SCTRWPG for consideration. The methods whereby options and strategies were selected for consideration are summarized below. The technical evaluations of each water supply option are presented in the following sections of this volume. These technical evaluations are based on the stand-alone consideration of each water supply option. Cumulative effects of the implementation of multiple options, particularly with respect to environmental factors and water availability, are addressed in the technical evaluation of the Regional Water Plan (Volume I) and alternative regional water plans (Volume II).

Selection of Options and Strategies

In its scope of work, the SCTRWPG defined a Regional Water Management Alternative Plan as a combination of Options and Strategies that will meet the water needs of the entire South Central Texas Region. However, in order to formulate meaningful Regional Water Management Alternative Plans for consideration, it is necessary to evaluate, in comparable terms, the known and available Options and Strategies with respect to feasibility and potentials to contribute to a Regional Water Management Alternative Plan. The SCTRWPG's scope of work provided that up to 60 potentially feasible regional Options and Strategies would be identified for evaluation, using criteria to be established by the SCTRWPG. The scope of work specified that the 60 regional water management Options and Strategies would be evaluated according to the criteria of TWDB Rules, Section 357.7 (a)(7). For purposes of this task, the scope of work provided that the evaluations of 122 options identified in the West Central Trans-Texas "Summary Report of Water Supply Alternatives," San Antonio River Authority, et al., March 1998, would be used to the extent possible, and that up to 40 of the options listed in this reference would be selected for evaluation. In addition, the scope of work provided that up to 20 new Options and Strategies identified through public input would also be included in the list from which Options and Strategies would be selected for evaluation.

At its facilitated workshop of January 29-30, 1999, the SCTRWPG developed a screening process that enabled them to make an initial selection of nine Options and Strategies for evaluation by the Technical Consultant, HDR Engineering, Inc.[1] For this initial selection, the RWPG applied screens to exclude options for which:

- Source is outside the region;
- Per acre-foot cost greater than $800; and
- Yield less than 20,000 acre-feet.

For selection of additional options, the RWPG identified the following additional factors for consideration:

- Options with an established record of strong public controversy should be excluded;
- Options suggested in Senate Bill 1, but never studied under Trans-Texas, could be considered for inclusion as "new" options;
- Options included in existing local water plans should be included;

[1] "South Central Texas Regional Water Planning Group, Phase 1 – Project Planning and Initial Workshop," Folk-Williams, John, Open Forum Facilitation Team, November 20, 1998 through February 5, 1999, San Antonio, Texas.

- Options mentioned in regional media as under consideration by local water agencies should be reviewed for inclusion; and
- Options and strategies on the Trans-Texas list that are "variations on a theme" could be consolidated.

The RWPG directed the SCT Staff Workgroup to perform preliminary screening of the Options and Strategies and report the results to the RWPG.

On February 3, 1999, the Staff Workgroup reviewed the complete West Central Trans-Texas list of 122 items and reduced the list to 46 (55 including the nine chosen at the January 30, 1999 workshop) from which the RWPG could pick up to 31 additional options (bringing the total from the West Central Trans-Texas group up to 40) for further evaluation. The screening process used to reduce the list successively eliminated options that fell into one or more of the following categories:

- Already committed or otherwise viewed as no longer available;
- Already built;
- In a group with many variations; other options of the group remain for further consideration;
- Insufficient information to be "existing option," but may become "new option;"
- Listed and developed for information purposes only;
- Cost greater than $2,000 per acre-foot; and/or
- Two groups of similar options from one of which three are to be chosen and from the other two are to be chosen.

On February 9, 1999, the results of the Staff Workgroup's screening efforts were presented to the SCTRWPG, together with its recommendation that the SCTRWPG hold a workshop to select options for further consideration at the March 9, 1999 meeting. The SCTRWPG accepted by consensus the results of applying the technical screens and scheduled a workshop, as recommended.

At the March 9, 1999 workshop, the SCTRWPG reviewed the results of a survey of the public, technical factors for selection of options, and the list of options—as grouped by the Staff Workgroup at its February 9, 1999 meeting—including suggested new options. The results of this facilitated review was a list of 58 options and strategies, for which the SCTRWPG directed the Staff Workgroup to work with the Technical Consultant to develop a scope, budget, and schedule for evaluation of each option. The SCTRWPG further specified that the sum of the budgets for evaluation of the 58 options should not exceed 80 percent of the total funds budgeted for this purpose.

The Staff Workgroup met on March 23, April 1, and April 6, 1999 and reviewed drafts of the scopes of work for evaluation of each option provided by the Technical Consultant. Upon completion of this series of reviews and modifications of the scopes, a document entitled, "South Central Texas Regional Water Plan Water Supply Options" was prepared for presentation to the SCTRWPG at its April 13, 1999 meeting. The document presented the scope of work for an evaluation of each option, with the view that upon approval of the specific scope of work, then the Technical Consultant could provide a cost estimate to perform the work. Following the approval of the draft scopes, the SCTRWPG scheduled a workshop for April 27, 1999 to consider the proposed scopes, budgets, and schedules to perform the evaluations of each of the 58 options.

At the beginning of the April 27, 1999 workshop, the facilitator reported that the Staff Workgroup had met to review the scopes of work, budgets, and assumptions of the water supply options selected by the SCTRWPG. The facilitator also stated that the SCTRWPG had given HDR Engineering, Inc. and the Staff Workgroup the goal to reserve 20 percent of the available budget so new or additional options could be studied, and further stated that the Staff Workgroup has recommended a balanced study program, but that it was not able to reserve 20 percent of the budget.

The facilitator suggested four options for the SCTRWPG to consider in order to initiate the analyses of the water supply options. They were:

1. Accept the Staff Workgroup recommendation;
2. Depend on other agencies to conduct some of the analyses;
3. Ask, if needed, the local water agencies to provide funding for any additional studies; and
4. Select options to cut or delay.

The facilitator suggested that the SCTRWPG keep these options in mind as HDR Engineering, Inc. explained each water supply option and for the SCTRWPG to discuss and decide how to proceed after HDR's explanation.

Representatives of HDR Engineering, Inc. explained the scope of work, budget, and general assumptions associated with each water supply option.

The SCTRWPG discussed the four options of how to provide adequate funds to evaluate new or additional water supply options in addition to the 58 water supply options recommended by the Staff Workgroup. By consensus, the SCTRWPG adopted a motion to approve the scopes of work, budgets, and assumptions of the 58 water supply options recommended by the Staff Workgroup; to raise, from the local water agencies, any funds needed to study water supply options that are in addition to the 58 approved water supply options; and to continue discussions to coordinate concurrent studies with the Edwards Aquifer Authority that may result in reduced costs.

During its meeting of March 2, 2000 in Carrizo Springs, the SCTRWPG engaged in extended discussions of potential additional water supply options for technical evaluation. As a result, scopes of work for two additional water supply options were prepared and presented to the SCTRWPG during its meeting of April 6, 2000 in Gonzales. Technical evaluations of the Cotulla Reservoir (SCTN-18) and Nueces Reservoir/Smyth Crossing Site (SCTN-19) were authorized by the SCTRWPG at this meeting. Technical evaluation of an additional group of water supply options, Lower Colorado River Diversions (SCTN-20) was authorized by the SCTRWPG during a June 1, 2000 meeting in Port Lavaca. Although the inclusion of SCTN-20 brought the official total of water supply options for consideration to 61, variations of options for which technical evaluations have been completed actually total 79.

The list of 61 options and strategies approved by the SCTRWPG for evaluation is as follows:

Local/Conservation/Reuse/Exchange Water Supply Options

01 Demand Reduction (Water Conservation) (L-10)
02 Exchange Reclaimed Water for Edwards Irrigation Water (L-11)
03 Purchase or Lease of Edwards Irrigation Water for Municipal and Industrial Use (L-15)
04 Transfer of SAWS Reclaimed Water to Coleto Creek Reservoir (Exchange for CP&L Rights and GBRA Canyon Contract) (L-20)
05 Transfer of Unappropriated and/or Reclaimed Water to Corpus Christi via Choke Canyon Reservoir (for Water Exchange or Mitigation) (L-14)
06 Brush Management (SCTN-4)
07 Weather Modification (SCTN-5)
08 Rainwater Harvesting (SCTN-9)
09 Gulf Coast Aquifer — Exchange for Irrigation Surface Water Rights (SCTN-12)
10 Desalination (SCTN-17)
11 Off-Channel Local Storage (SCTN-10)

Edwards Aquifer Recharge Water Supply Options

12 Edwards Aquifer Recharge from Natural Drainage — Type 1 Projects (L-17)
13 Edwards Aquifer Recharge from Natural Drainage — Type 2 Projects (L-18)
14 Medina Lake — Existing Rights and Contracts with Irrigation Use Reduction for Recharge Enhancement (S-13B)
15 Guadalupe River Diversion near Comfort to Recharge Zone via Medina Lake (G-30)
16 Diversion of Canyon Reservoir Flood Storage to Recharge Zone via Cibolo Creek (G-32)
17 Edwards Aquifer Recharge Enhancement with Guadalupe River Diversions (SCTN-6)

River Diversion with Storage Water Supply Options

18 Guadalupe River Diversions at Gonzales to Mid-Cities and/or Major Water Providers with Regional Water Treatment Plant with Uniform Delivery to Mid-Cities, CRWA, and SAWS (G-38C)
19 Lower Guadalupe River Diversion — Firm Yield (Sources of Supply are Existing Water Rights at the Guadalupe River Saltwater Barrier and Stored Water from Canyon Reservoir) (SCTN-16a)
20 Lower Guadalupe River Diversion — Firm Yield (Sources of Supply are Unappropriated Streamflow, Existing Water Rights at the Guadalupe River Saltwater Barrier, and Stored Water from Canyon Reservoir) (SCTN-16b)
21 Lower Guadalupe River Diversion — Firm Yield (Sources of Supply are Unappropriated Streamflow, Existing Water Rights at the Guadalupe River Saltwater Barrier and Stored Water from Canyon Reservoir, and Groundwater from the Gulf Coast Aquifer) (SCTN-16c)
22 Colorado River in Colorado County — Buy Stored Water and Irrigation Rights; Firm Yield (C-17A)
23 Colorado River in Wharton County — Buy Irrigation Rights and Groundwater; Firm Yield (C-17B)
24 Purchase/Lease Surface Water Irrigation Rights for Municipal/Industrial Use (SCTN-11)
25 Lower Colorado River Diversions (SCTN-20)

Existing Reservoir Water Supply Options

26 Canyon Reservoir Released to Lake Nolte — Firm Yield (G-15C)
27 Wimberley and Woodcreek Water Supply from Canyon Reservoir, with G-23A and 2030 Demands (G-24)
28 Joint Development of Water Supply with Corpus Christi — Firm Yield (Sources of Supply are Guadalupe River at Saltwater Barrier and Groundwater from Gulf Coast Aquifer) (SCTN-14a)

29 Joint Development of Water Supply with Corpus Christi — Firm Yield (Sources of Supply are Guadalupe River at Saltwater Barrier and Groundwater from Gulf Coast Aquifer plus Diversions from the San Antonio River at Falls City) (SCTN-14b)
30 Colorado River at Bastrop — Purchase of Stored Water; Firm Yield (C-13C)

Potential New Reservoir Water Supply Options

31 Cibolo Reservoir; Firm Yield (S-15C)
32 Cibolo Reservoir with Imported Water from the San Antonio River; Firm Yield (S-15Da)
33 Cibolo Reservoir with Imported Water from the San Antonio and Guadalupe Rivers; Firm Yield (S-15Db)
34 Cibolo Reservoir with Imported Water from the San Antonio, Guadalupe, and Colorado Rivers; Firm Yield (S-15Dc)
35 Cibolo Reservoir with Imported Water from the Guadalupe River at the Saltwater Barrier; Firm Yield (S-15Ea)
36 Cibolo Reservoir with Imported Water from the Guadalupe River at the Saltwater Barrier and the Colorado River below Garwood (S-15Eb)
37 Goliad Reservoir — Firm Yield (S-16C)
38 Applewhite Reservoir — Firm Yield (S-14D)
39 Guadalupe River Dam No. 7 — Raw Water at Reservoir; Firm Yield (G-19)
40 Gonzales Reservoir — Raw Water at Reservoir; Firm Yield (G-20)
41 Lockhart Reservoir — Raw Water at Reservoir; Firm Yield (G-21)
42 Dilworth Reservoir — Raw Water at Reservoir; Firm Yield (G-22)
43 Cloptin Crossing Reservoir — Raw Water at Reservoir; Firm Yield (G-40)
44 Sandies Creek Reservoir — Firm Yield (G-17C1)
45 Cuero Reservoir — Firm Yield (G-16C1)
46 Palmetto Bend Stage II Reservoir (SCTN-13)
47 Shaws Bend Reservoir — Firm Yield (C-18)
48 Cummins Creek Reservoir (SCTN-15)
49 Allens Creek Reservoir — Firm Yield (B-10C)
50 Cotulla Reservoir (SCTN-18)
51 Nueces Reservoir / Smyth Crossing Site (SCTN-19)

Carrizo and Other Aquifer Water Supply Options

52 Carrizo Aquifer — Firm Yield (Source of water includes Carrizo Aquifer in Wilson, Atascosa, and/or Gonzales Counties South of the San Marcos River) (CZ-10C)
53 Carrizo Aquifer — Firm Yield (Source of water includes Carrizo Aquifer in Wilson, Atascosa, Gonzales, Caldwell, and/or Bastrop Counties south of the Colorado River) (CZ-10D)
54 Simsboro Aquifer — North of Colorado River in Milam, Lee, and Bastrop Counties (SCTN-3)

55 Wintergarden Carrizo Recharge Enhancement (Dimmit, Zavala, Frio, La Salle, and Atascosa Counties) (SCTN-7)
56 Local Groundwater Supply — Carrizo Aquifer (SCTN-2a)
57 Local Groundwater Supply — Gulf Coast Aquifer SCTN-2b)
58 Local Groundwater Supply — Trinity Aquifer (SCTN-2c)
59 Aquifer Storage and Recovery (ASR) — Regional Option (SCTN-1a)
60 Aquifer Storage and Recovery (ASR) — Local Option (SCTN-1b)
61 Aquifer Optimization (SCTN-8)

General Assumptions for Applications of Hydrologic Models

Following are general assumptions for applications of hydrologic models in the evaluations of water supply options for the South Central Texas Regional Water Planning Group. Pertinent exceptions to—or clarifications of—these general assumptions are enumerated in the technical evaluation of each option identified for study and included herein.

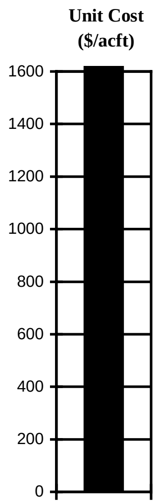
- Full exercise of surface water rights;
- Edwards Aquifer pumpage of 400,000 acft/yr with Critical Period Management rules;
- Subordination of all senior Guadalupe River hydropower permits to Canyon Reservoir;
- Annual effluent discharge/return flows reported for 1988 with SAWS direct reclaimed water use of 35,000 acft/yr;
- Operation of power plant reservoirs (Coleto Creek, Braunig, and Calaveras) subject to authorized consumptive uses at the reservoir, with makeup diversions as needed to maintain full conservation storage subject to instream flow constraints and/or applicable contractual provisions;
- Delivery of GBRA's full contractual obligations from Canyon Reservoir to point of diversion in all years. Uncommitted balance of Canyon Reservoir currently authorized annual diversions, and additional diversions proposed under an amendment presently before TNRCC, to be diverted near Lake Dunlap;
- Desired San Antonio River flows at Falls City gage of 55,000 acft/yr. Minimum desired instream flows under current SAWS/SARA/CPS agreement included;
- Application of Environmental Water Needs Criteria of the Consensus Planning Process (Appendix B) in consideration of water potentially available for diversion and/or impoundment as a part of a new water supply project (Appendix F);
- Operation of Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System subject to Phase 4 (maximum yield) policy and TNRCC Agreed Order regarding freshwater inflows to the Nueces Estuary;
- Historical Edwards Aquifer recharge estimates developed by HDR;
- Applicable rules of groundwater management districts will be included to the extent possible; and

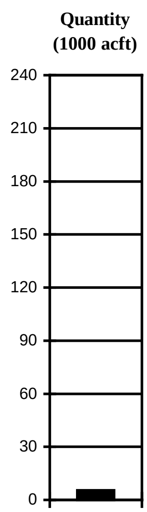
- Period of record for simulations: Guadalupe-San Antonio River Basin (1934-89, Critical Drought = 1950s), Nueces River Basin (1934-96, Critical Drought = 1990s), Colorado River Basin (1941-65, Critical Drought = 1950s).

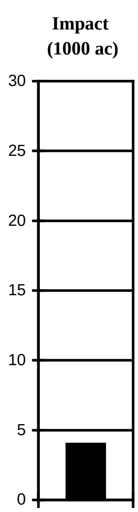
Hydrologic Models to be applied include, but are not limited to:

Guadalupe-San Antonio River Basin Model (HDR)
Nueces River Basin Model (HDR)
Lower Nueces River Basin & Estuary Model (HDR)
Guadalupe-San Antonio River Basin Water Availability Model (WRAP) (TNRCC/HDR)
Nueces River Basin Water Availability Model (WRAP) (TNRCC/HDR)
Colorado River Daily Allocation Program (RESPONSE) (LCRA)
Edwards Aquifer (Balcones Fault Zone) Model GWSIM4 (TWDB)
Carrizo-Wilcox Aquifer Model (TWDB/LBG-G/HDR)
SIMYLD, RESOP, & SIMDLY (TWDB/TDWR)

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/13/99







OPTION NUMBER: L-17
OPTION NAME: Edwards Aquifer Recharge from Natural Drainage – Type 1 Projects (Program 1A)

OPTION DESCRIPTION: *Type 1 recharge structures are located upstream of the Edwards Aquifer recharge zone. These structures capture flood flows and release water at the maximum recharge rate of the downstream channel across the outcrop.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	$3,309	per acft[1] Raw Water in Aquifer
QUANTITY OF WATER:	5,554	acft/yr[2]
LAND IMPACTED:	4,042	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Price of land for recharge reservoir sites, costs of dams and emergency spillways, and maintenance costs for recharge features such as trash control and removal.

[2]**QUANTITY OF WATER:** Quantity listed is for sustained yield increase computed using GWSIM-IV model of the Edwards Aquifer and recharge enhancement due to following projects: Montell, Upper Dry Frio, Concan, Upper Sabinal, Upper Hondo, Upper Verde, and Upper Blanco.

[3]**LAND IMPACTED:** Recharge structure sites. Area inundated by the reservoir at full recharge pool capacity. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

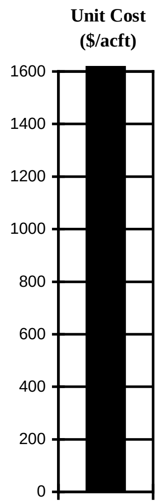
ENVIRONMENTAL ISSUES: Effects of periodic inundation lasting for several weeks or months of the recharge structure sites upon terrestrial habitat located within the recharge sites. Sites on the Nueces, Frio, Sabinal, and Blanco Rivers are located in areas recommended for designation as Ecologically Unique River Segments by TPWD.

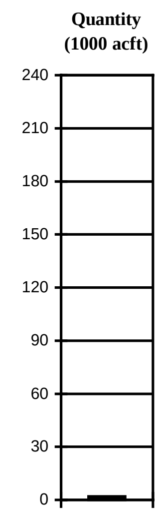
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain agreements with local landowners for recharge sites, water rights, and necessary construction permits. Mitigation of impacts to downstream water rights.

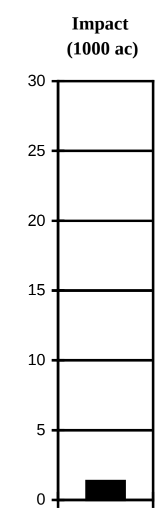
ADDITIONAL FACTORS: Ability of recharge sponsors to obtain recharge recovery permits and/or credits for quantities of water artificially recharged to the aquifer or discharged from springs.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, G-20, G-30, G-40, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-7, SCTN-14a, and/or SCTN-14b.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/13/99







OPTION NUMBER: L-17
OPTION NAME: Edwards Aquifer Recharge from Natural Drainage – Type 1 Projects (Program 1B)

OPTION DESCRIPTION: *Type 1 recharge structures are located upstream of the Edwards Aquifer recharge zone. These structures capture flood flows and release water at the maximum recharge rate of the downstream channel across the outcrop.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$2,557**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**1,958**	**acft/yr[2]**
LAND IMPACTED:	**1,340**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Price of land for recharge reservoir sites, costs of dams and emergency spillways, and maintenance costs for recharge features such as trash control and removal.

[2]**QUANTITY OF WATER:** Quantity listed is for sustained yield increase computed using GWSIM-IV model of the Edwards Aquifer and recharge enhancement due to following projects: Upper Dry Frio, Upper Sabinal, and Upper Verde.

[3]**LAND IMPACTED:** Recharge structure sites. Area inundated by the reservoir at full recharge pool capacity. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Effects of periodic inundation lasting for several weeks or months of the recharge structure sites upon terrestrial habitat located within the recharge sites. Site on the Sabinal River is located in an area recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain agreements with local landowners for recharge sites, water rights, and necessary construction permits. Mitigation of impacts to downstream water rights.

ADDITIONAL FACTORS: Ability of recharge sponsors to obtain recharge recovery permits and/or credits for quantities of water artificially recharged to the aquifer or discharged from springs.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, G-30, CZ-10D, SCTN-2a, SCTN-6, SCTN-14a, and/or SCTN-14b.

2.1 Edwards Aquifer Recharge from Natural Drainage — Type 1 Projects (L-17)

2.1.1 Description of Option

Two types of recharge enhancement reservoirs have been analyzed in a series of studies[1,2,3,4,5,6] sponsored by the Edwards Underground Water District beginning in 1990. Type 1 reservoirs are catch-and-release structures located upstream of the Edwards Aquifer recharge zone, and Type 2 reservoirs are immediate recharge structures located within the recharge zone. This option deals with the potential construction of Type 1 projects. Type 1 structures are generally operated to release water at the maximum recharge rate of the downstream channel across the outcrop. These structures release water as quickly as possible for recharge to the aquifer, thereby minimizing evaporation losses and maximizing long-term average recharge. Under this type of operation, reservoir levels will fluctuate more than might normally be expected, due to the large release rates.

The locations of each of the seven Type 1 recharge projects considered for development are shown in Figure 2.1-1. Six of the projects are located in the Nueces River Basin and affect inflows to the Choke Canyon Reservoir/Lake Corpus Christi Reservoir System (CCR/LCC System) and the Nueces Estuary. These six projects include Montell, Upper Dry Frio, Concan, Upper Sabinal, Upper Hondo, and Upper Verde. Other previously identified Type 1 sites in the Nueces River Basin are not included in this study because the quantity of enhanced recharge during the drought is extremely small and the associated unit costs are extremely high.

In the San Antonio and Guadalupe River Basins, one new recharge project is being considered—Upper Blanco. The Upper Blanco project includes a pipeline to divert water over

[1] HDR Engineering, Inc. (HDR) and Geraghty and Miller, Inc., "Nueces River Basin Regional Water Supply Planning Study, Phase I," Vols. 1, 2, and 3, Nueces River Authority (NRA), et al., May 1991.
[2] HDR, "Nueces River Basin Regional Water Supply Planning Study, Phase III – Recharge Enhancement," NRA, November 1991.
[3] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IV-A," Edwards Underground Water District (EUWD), June 1994.
[4] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IV-B — Technical Memorandum, Combined Impacts of Frio, Sabinal, Hondo, and Verde Recharge Enhancement Projects on Downstream Water Rights," December 12, 1995.
[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Vols. I, II, and III, EUWD, September 1993.
[6] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study Feasibility Assessment," Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses, San Antonio River Authority, et al., March 1998.

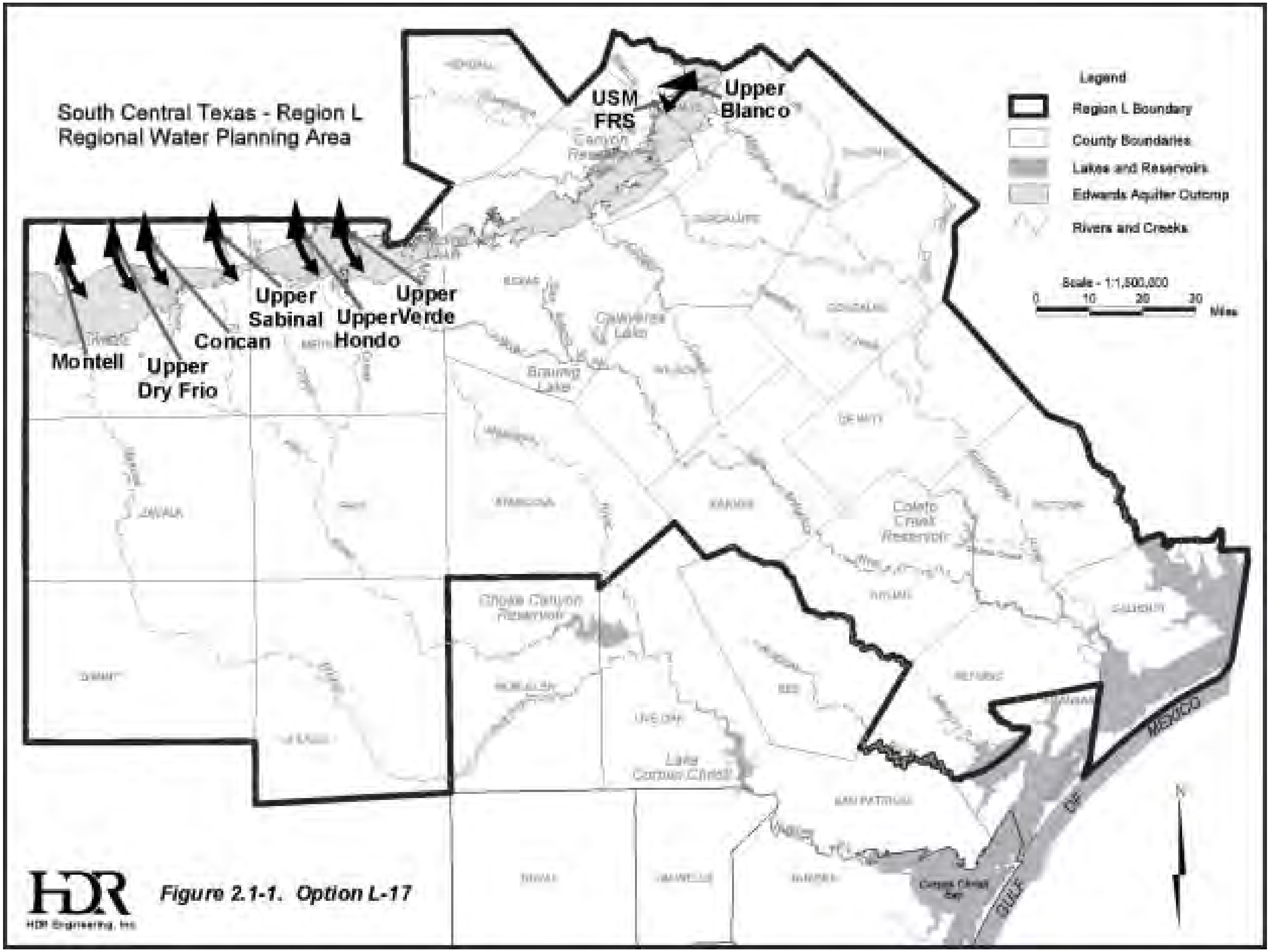


Figure 2.1-1. Option L-17

the basin divide and into three Soil Conservation Service (SCS) reservoirs in the Upper San Marcos River Basin. These three SCS reservoirs in turn recharge the Edwards Aquifer.

The Type 1 projects in the Nueces and Guadalupe-San Antonio River Basins have all been considered in previous studies.[7,8] As a result of these studies, an optimum size has previously been determined for each project. The optimum sizes for each project were used in this study. Two Type 1 programs consisting of up to 7 potential storage projects are presented in this study. The projects included in each of the two programs are identified below.

2.1.1.1 Program 1A

- Nueces River Basin
  - Montell
  - Upper Dry Frio
  - Concan
  - Upper Sabinal
  - Upper Hondo
  - Upper Verde
- Guadalupe-San Antonio River Basin
  - Upper Blanco (with recharge diversion to San Marcos FRS)

2.1.1.2 Program 1B

- Nueces River Basin
  - Upper Dry Frio
  - Upper Sabinal
  - Upper Verde

The projects in Program 1A would impound a combined maximum recharge pool storage of 68,910 acre-feet (acft) and periodically inundate 4,042 acres, as shown in Table 2.1-1. Program 1B would impound up to 21,080 acft in the combined recharge storage pools for projects in this program and periodically inundate about 1,340 acres.

2.1.2 Available Yield

Available yield or recharge enhancement volumes were calculated for the Type 1 structures using the Nueces River Basin Model and the Guadalupe-San Antonio River Basin Model, subject to average and drought conditions. Average conditions represent the average annual recharge enhancement rate for the entire 56-year simulation period (1934 to 1989).

[7] HDR, Op. Cit., November 1991.
[8] HDR, Op. Cit., March 1998.

Table 2.1-1.
Summary of Recharge Enhancement Potential
for Type 1 Reservoir Programs (L-17)

Type 1 Project Program	Capacity (acft)	Surface Area (acres)	Recharge Enhancement 1934 to 1989 Average Conditions (acft/yr)	Recharge Enhancement 1947 to 1956 Drought Conditions (acft/yr)	Reduction in Average Nueces Estuary Inflow (acft/yr)	Reduction in CCR/LCC System Yield (acft/yr)	Reduction in Drought Average Guadalupe Estuary Inflow (acft/yr)
Program 1A	68,910	4,042	27,882	16,029	4,674	1,235	2,917
Program 1B	21,080	1,340	5,615	2,955	1,465	1,235	—

[1] Computed using the Lower Nueces River Basin and Estuary Model assuming Phase IV Operating Policy, the Agreed Bay and Estuary Release Order, and 2010 sediment accumulation.

<u>Drought conditions</u> represent the average annual recharge enhancement rate for the 10-year period from 1947 through 1956, which is when the most severe drought on record occurred. Analyses of recharge enhancement projects presented in this study were performed honoring all existing water rights to the maximum extent possible, with one exception. This exception involved the water rights of the CCR/LCC System, in which case impacts were not mitigated by releases, but were assumed to be purchased. Other options may be available to mitigate the impact of the recharge projects on the CCR/LCC System, such as Option L-14, which considers the transfer of San Antonio River water into Choke Canyon Reservoir.

An improved methodology employing a daily computation timestep for the estimation of monthly Edwards Aquifer recharge enhancement associated with proposed Type 2 projects was developed in the Nueces River Basin Edwards Aquifer Recharge Enhancement Project, Phase IV-A[9] and modified for use in this study. The daily timestep was applied in the simulation of recharge reservoir contents, delivery of spills and releases to the next downstream control point located near the downstream edge of the recharge zone, and the computation of enhancement to natural recharge due to recharge releases from the Type 1 projects. For each day, recharge releases from the Type 1 reservoirs were compared to the channel loss rates over the outcrop,[10] and the portion of recharge release that becomes recharge is computed based on the difference between the natural recharge occurring in the reach and the measured channel loss rates.

[9] HDR, Op. Cit., June 1994.
[10] USGS, "Streamflow Losses Along the Balcones Fault Zone, Nueces River Basin, Texas," Water Resources Investigations Report, 83-4368, Austin, Texas, 1983.

For the Type 1 Recharge Program 1A, recharge could be enhanced by 27,882 acft/yr for average conditions and 16,029 acft/yr for drought conditions, as shown in Table 2.1-1. The impact on the CCR/LCC System totals 1,235 acft/yr for the Type 1 Program 1A, which represents about 0.6 percent of the system firm yield. Estimates indicate that Type 1 Recharge Program 1B could enhance recharge by 5,615 acft/yr for average conditions and 2,955 acft/yr during drought. Program 1B impacts CCR/LCC System yield by 1,235 acft/yr, or 0.6 percent.

Application of the Consensus Environmental Criteria (Appendix B) for reservoir pass-throughs for instream flows was included in this analysis for the Type 1 recharge projects. All seven recharge dams studied required reservoir pass-throughs. The maximum impact on the average inflow to the Nueces Estuary due to the six Nueces River Basin projects (Program 1A) is a reduction of about 4,674 acft/yr, or about 1 percent. The impact of the Upper Blanco site on the average inflow to the Guadalupe Estuary (as measured at the Guadalupe River Saltwater Barrier) would be a reduction of about 2,917 acft/yr, or about 0.5 percent under Program 1A during drought (1947 to 1956). The impact of Program 1B on average inflows to the Nueces Estuary is 1,465 acft/yr, or about 0.3 percent, and to the Guadalupe Estuary is 0 acft/yr because there are no projects in the Guadalupe-San Antonio River Basin in Program 1B.

Once monthly recharge enhancement amounts were computed for each potential project, they were added to the baseline recharge for the GWSIM-IV model of the Edwards Aquifer at the spatial locations representing the proposed recharge enhancement projects. Figure 2.1-2 shows the Edwards Aquifer GWSIM-IV aquifer model cell grid with an overlay of the streams and major reservoirs in the model area. Also shown in this figure are the approximate locations of the recharge enhancement projects modeled. Recharge enhancement estimates from the surface water models for Programs 1A and 1B were distributed into the appropriate recharge zone cells in the GWSIM-IV model. In general, the recharge enhancement was distributed into ground-water model cells downstream of the associated Type 1 project. Application of the GWSIM-IV Model provides a basis for determining additional groundwater that could potentially be withdrawn under a recharge recovery permit[11] (Appendix C) for each Type 1 Recharge Enhancement Program. It is noted, however, that rules governing recharge recovery have yet to be adopted by the Edwards Aquifer Authority. A summary of the sustained yield

[11] HDR, "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

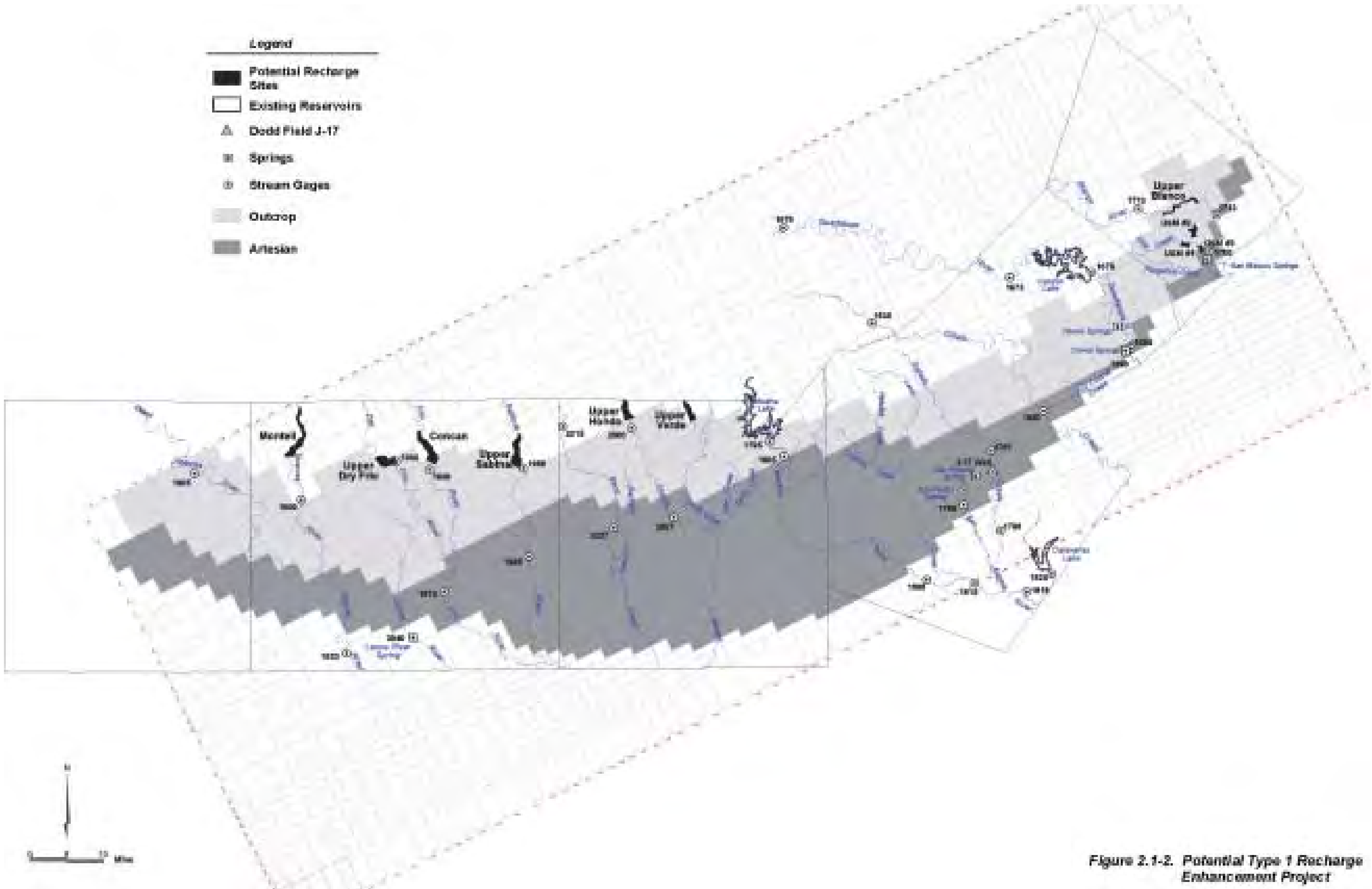


Figure 2.1-2. Potential Type 1 Recharge Enhancement Project

pumpage increase associated with each Type 1 Recharge Enhancement Program is presented in Table 2.1-2. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board (TWDB) rules for regional water supply planning.

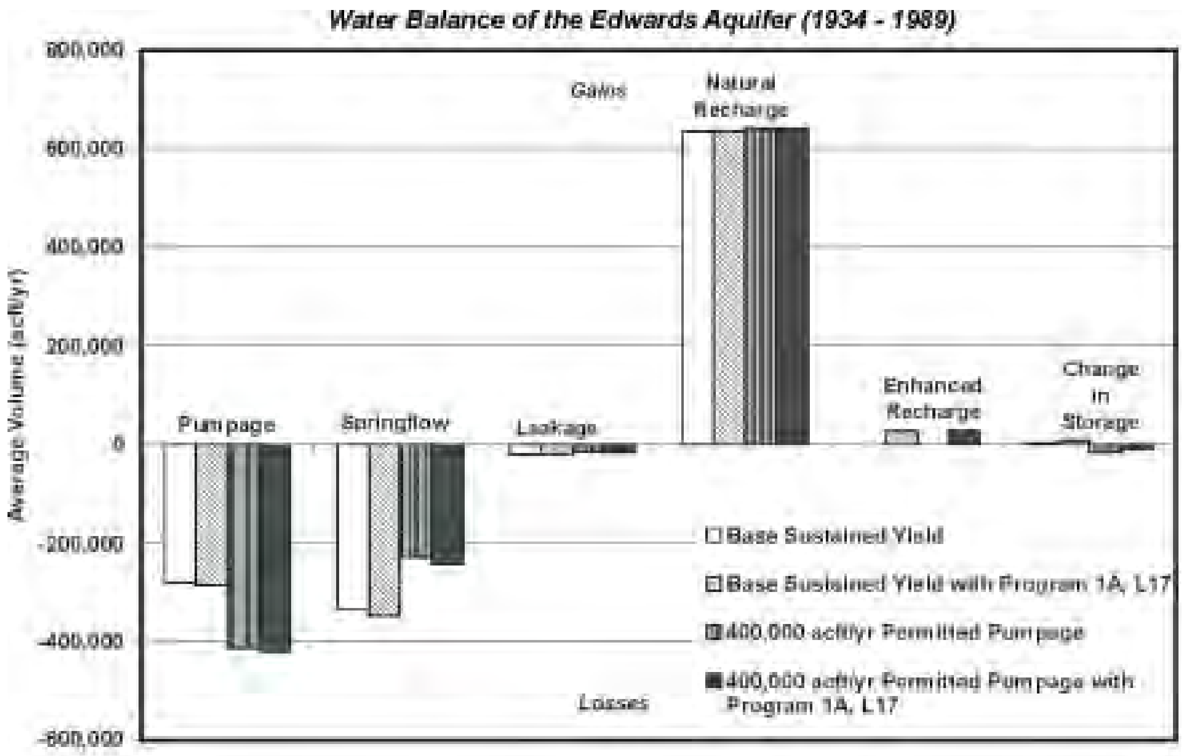
Table 2.1-2.
Summary of Sustained Yield Enhancement for Type 1 Reservoir Programs

Type 1 Project Program	*Recharge Enhancement*		*Sustained Yield Pumpage Increase (acft/yr)*	*Increase in Springflow (acft/yr)*
	1934 to 1989 Average Conditions (acft/yr)	*1947 to 1956 Drought Conditions (acft/yr)*		
Program 1A	27,882	16,029	5,554	14,188
Program 1B	5,615	2,955	1,958	1,616

1 Sustained yield increase based on comparison of GWSIM-IV Model runs in which aquifer pumpage was maximized while maintaining a minimum flow from Comal Springs of 60 cfs in one and only one month with and without recharge enhancement from the associated Type 1 Program.

Figure 2.1-3 summarizes the results of the GWSIM-IV Model runs used to determine the change in sustained yield associated with enhanced recharge for Program 1A. With long-term average enhancement recharge of 27,882 acft/yr, the sustained yield pumpage was found to increase by 5,554 acft/yr (20 percent of the average annual enhancement). The majority of the average annual recharge enhancement becomes springflow. As shown in Table 2.1-2, 14,188 acft/yr (51 percent) of the 27,882 acft/yr recharge enhancement becomes increased springflow. This increase in springflow is shown in the lower chart in Figure 2.1-3. This chart shows the Comal Springs flow patterns under the 400,000 acft/yr management plan pumpage with and without a recharge recovery permit pumpage of 5,554 acft/yr. As seen in this figure, the close proximity of the Upper Blanco recharge project to Comal and San Marcos Springs probably serves to enhance springflow more than increase dependable supply for municipal pumpage.

Program 1B was analyzed in a similar fashion and the results indicate larger increases, on a percentage basis, to increased sustained yield. Under Program 1B, 1,985 acft/yr (35 percent of the average annual enhancement) is potentially available for a recharge recovery permit, while 1,616 acft/yr (29 percent) becomes increased springflow. The differences between Programs 1A



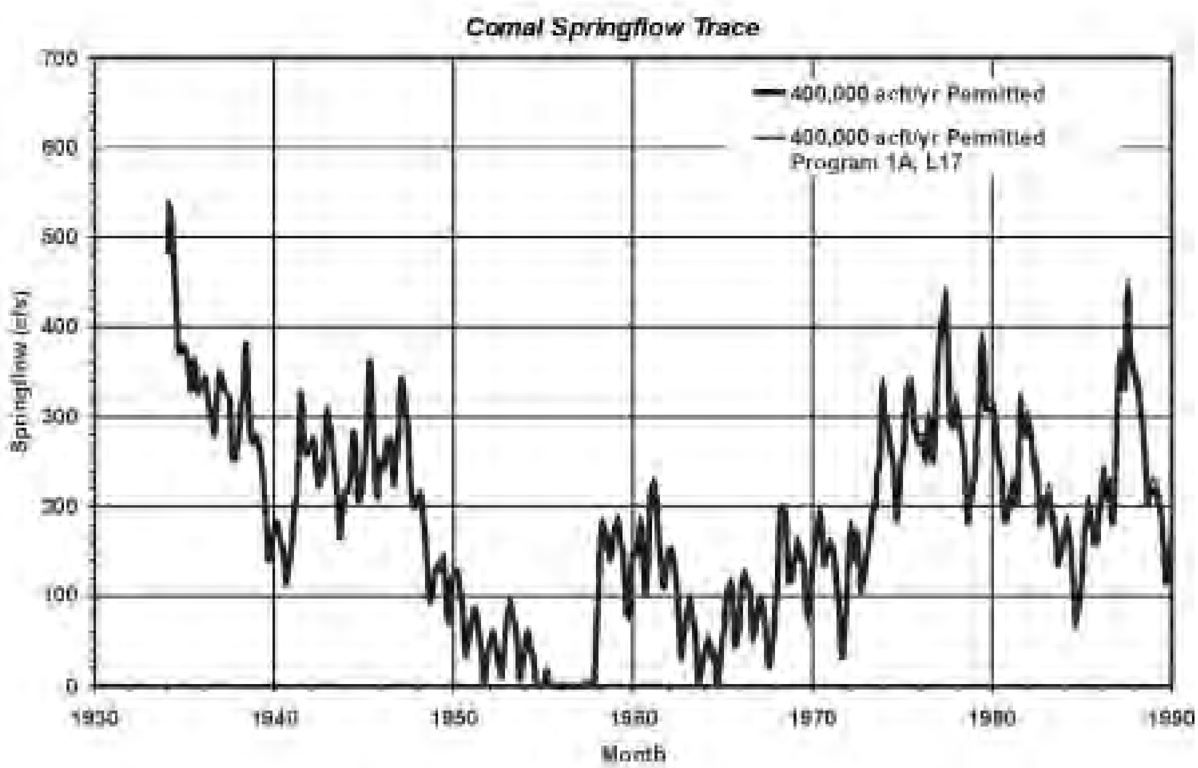


Figure 2.1-3. Enhanced Recharge from Type 1 Recharge Projects — Program 1A

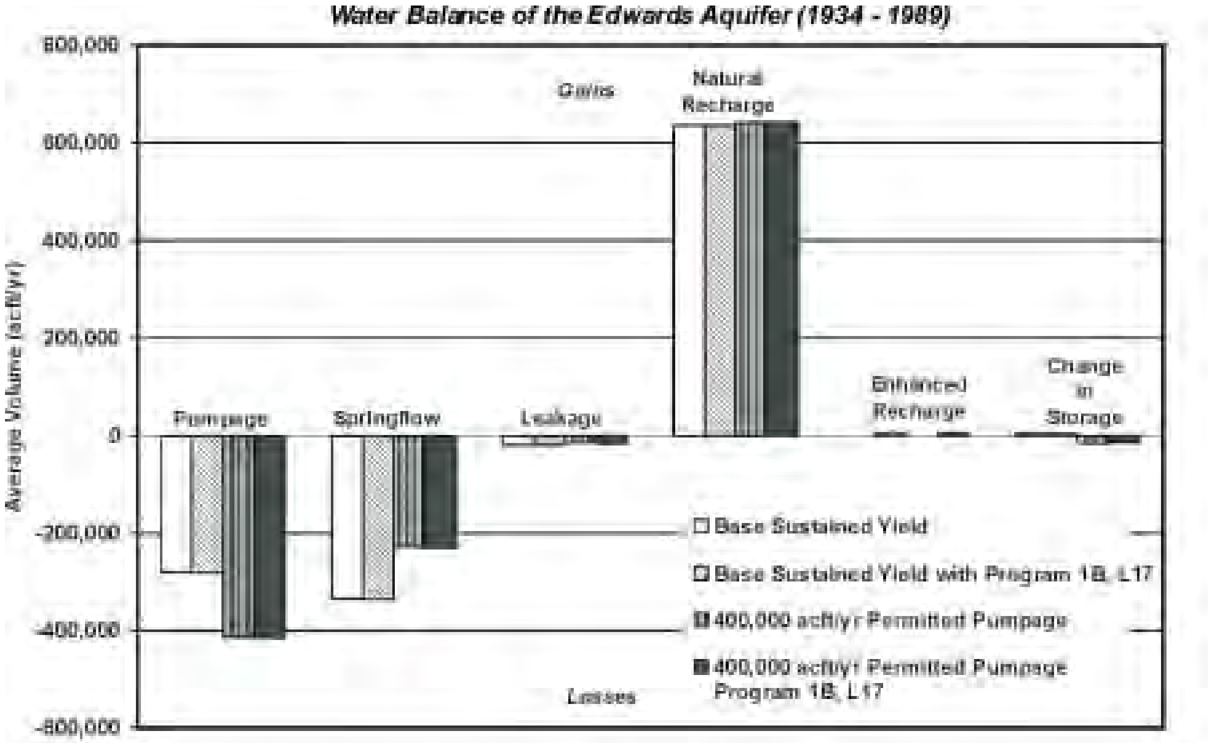
and 1B are the exclusion of the Montell, Concan, Upper Hondo, and Upper Blanco recharge projects in Program 1B. The results from Program 1B are shown in Figure 2.1-4.

Potential Edwards Aquifer recharge enhancement projects could negatively impact natural recharge of the Carrizo-Wilcox Aquifer. Previous studies[12] have estimated recharge to the Carrizo-Wilcox Aquifer by breaking recharge into three components: baseflow recharge in the stream, flood flow recharge in overbanks of the stream, and areal recharge in the tributaries and soils in the watershed outside the main channel. Of these three components, flood flow recharge is the component most likely to be negatively impacted by recharge dams on the Edwards Aquifer outcrop, upstream of the Carrizo-Wilcox outcrop. Flood flow recharge is defined as the recharge that occurs along the main channel during flood events due to the inundation of overbanks adjacent to the river. Previous estimates of total recharge in the Winter Garden Area[13] (the Carrizo-Wilcox from the Rio Grande to the San Marcos River) tabulated flood flow recharge to the Carrizo-Wilcox as approximately 25 percent (51,500 acft/yr) of the total average annual recharge to the aquifer. Total average annual recharge in the Winter Garden Area was estimated to be 207,700 acft/yr.

Average annual flood flow recharge in the area was estimated to be 51,500 acft/yr, of which 14,500 acft/yr occurs on streams which could potentially be impacted by Type 1 Edwards Aquifer recharge enhancement projects. Therefore, in the most extreme case (no flood flow recharge to the Carrizo-Wilcox downstream of potential Type 1 Edwards Projects) average annual Carrizo-Wilcox natural recharge could be reduced by approximately 7 percent (14,500/207,700) under Program 1A. Similarly, under Program 1B, the removal of Edwards Recharge Projects on the Nueces and Blanco Rivers would decrease the potential impact to Carrizo-Wilcox recharge to 2.5 percent of the total average annual recharge.

It should be noted that these estimates of impacts, while relatively small, are essentially the maximum attainable assuming the Edwards Aquifer recharge projects completely control all floods on their respective streams. The proposed Type 2 projects, however, are not large enough to control floods to this extent. Therefore, impacts to Carrizo-Wilcox recharge across the region will most certainly be considerably less than the potential impacts presented above. As water management plans are developed, if specific projects potentially impacting Carrizo-Wilcox

[12] LBG-Guyton Associates and HDR Engineering, Inc., "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," Texas Water Development Board, August 1998.
[13] Ibid.



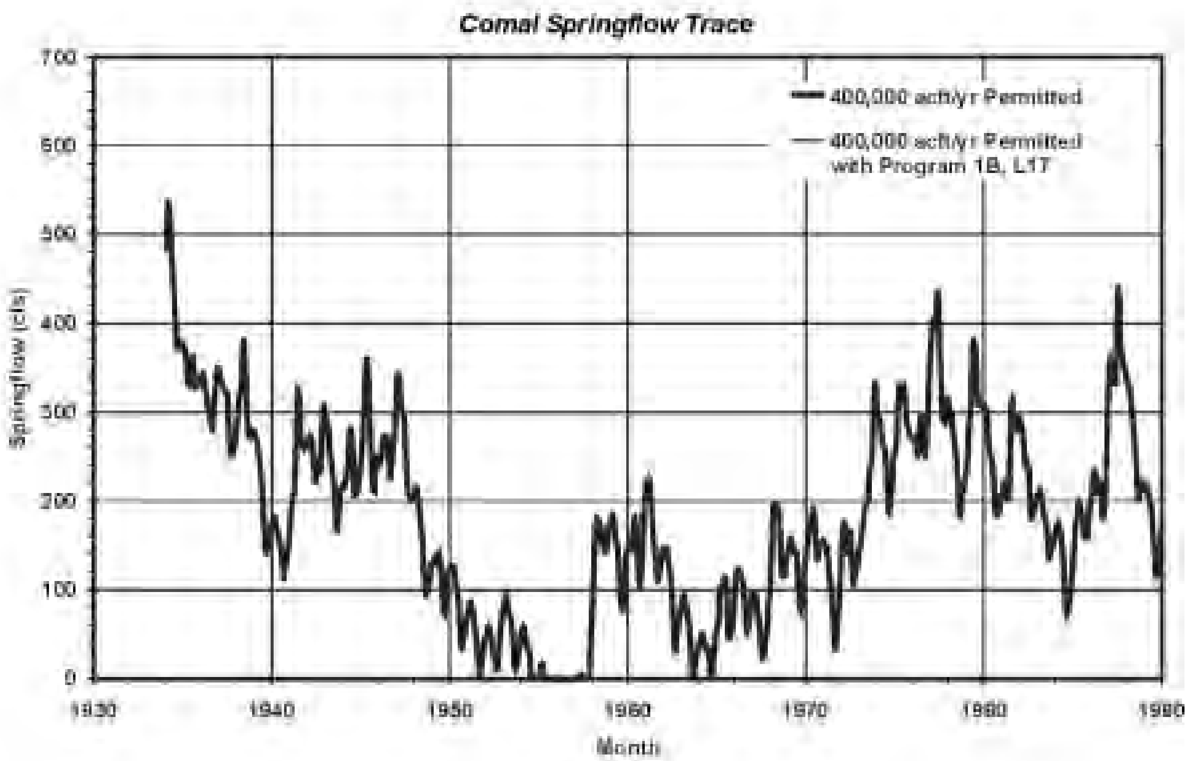


Figure 2.1-4. Enhanced Recharge from Type 1 Recharge Projects — Program 1B

recharge are included in a plan, more detailed analyses of the actual impacts of said projects on Carrizo-Wilcox recharge will be performed.

2.1.3 Environmental Issues

Type 1 Reservoirs are catch-and-release structures that would be located upstream of the Edwards Aquifer recharge zone. They would be operated to store water during period of surplus, while releases would be maintained at the maximum recharge rate in the downstream channel during periods when flow over the recharge zone would have been less under historical conditions. These structures would be located within the stream channel and may maintain storage contents for months or even years.

Suitable sites for the Type 1 Reservoirs are located in the area encompassing the headwaters of the Nueces River Basin along the southern margin of the Edwards Plateau in Medina and Uvalde Counties, and the Blanco River along the southeastern margin of the Edwards Plateau in Hays County. There are four Type 1 reservoir sites in Uvalde County (Montell, Upper Dry Frio, Concan, Upper Sabinal), two in Medina County (Upper Hondo, Upper Verde), and one in Hays County (Upper Blanco), as shown in Figure 2.1-1.

These proposed reservoirs are located in the southern and southeastern portion of Omernik's Central Texas Plateau, which is bordered by the Texas Blackland Prairies to the east and the Southern Texas Plains to the south.[14] Omernik describes the area as tablelands with moderate relief, plains with high hills, and open high hills dominated by juniper-mesquite-oak savannahs and bluestem grasses with dry mollisols. Correll and Johnston describe the vegetation of the Central Texas Plateau as dense strands of Ashe juniper, various scrub oaks, and mesquite.[15] The dominant climax grasses of the ecoregion include switchgrass, several species of bluestem and grama, Indian grass, Canada wild-rye, curly mesquite, and buffalo grass. The rocky limestone outcrops typically support a tall or mid-grass understory and a brush overstory complex of live oak, Texas oak, shinnery oak, junipers, and mesquite. Juniper and mesquite brush are generally though of as invaders into a presumed climax of largely grassland or savannah, except on the steeper slopes, which have continually supported dense cedar and oak thickets.

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[14] Omernik, James M. "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.

[15] Correll, D.S. and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.

Blair considered this area to be in the Balconian Biotic Province and characterized it as an intermixture of faunal elements of other major provinces.[16] The vertebrate fauna of the Balconian Province contains species from the Austroriparian, Tamaulipan, Chihuahuan, and Kansan Biotic Provinces. Blair's description of the vegetation of the area generally agrees with Omernik, Correl and Johnston, and Gould's descriptions. The flood plains of the stream consist of mesic forest of live oak, elm, hackberry, and pecan, with cypress lining some streams.[17] Gould described the climax grasses of the Edwards Plateau as a tall or mid-grass understory composed of switchgrasses and bluestems.[18]

Soils of Medina County are light colored, brownish to reddish, and well drained, with areas of dark loamy surfaces over clayey subsoils.[19] In the southeast portion of the county, the soils are deep, with light colored loam over mottled, clayey subsoils. The soils of northern Uvalde County are light to dark, well drained, loamy soils, with accumulations of lime.[20] The southern part of the county has soils that are light colored, well drained, gray to black cracking clayey soils with high shrink-swell potential. The soils of Hays County are slightly acidic with loamy surfaces over cracking, clayey subsoils and acidic cracking, clayey soils that have a high shrink-swell potential.[21]

Within the Nueces River Basin, the primary land use is agricultural. About 84 percent of the area of Medina and Uvalde Counties was estimated to be rangeland, 6 percent pasture, and 10 percent cropland.[22] Primary land use of Hays County is agricultural with 75 percent of the land in farms and ranches, 8 percent of this is in harvested cropland, and less than 1 percent irrigated.[23]

The conventional Type 1 Reservoirs will eliminate terrestrial habitat through dam construction and permanent inundation to the extent of their recharge pools. Because the Type 1 sites are located in perennial, typically spring-fed, reaches, aquatic habitat quality tends to be

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[16] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[17] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[18] Clements, John, "Texas Facts: A Comprehensive Look at Texas Today County by County," Clements Research II, Inc., Dallas, Texas, 1988.
[19] Ibid.
[20] Ibid.
[21] Ibid.
[22] HDR, "Regional Water Supply Planning Study — Phase III – Recharge Enhancement, Nueces River Basin," 1991.
[23] Clements, John, "Texas Facts: A Comprehensive Look at Texas Today County by County, Clements Research II, Inc., Dallas, Texas, 1988.

high and of particular importance in arid areas with a scarcity of permanent surface water. The regional gradients in precipitation and evaporation are such that aridity increases from east to west. Species diversity and productivity are both nearly always greater in perennially flowing streams and springs than in intermittent systems, even when permanent pools persist in the latter. Because perennial flow often occurs in isolated situations in the western half of Texas, unique (endemic) species may be present. For those reasons, and because perennial flow appears to be a diminishing resource there, the sensitivity of lotic habitats, including springs, may be considered high. Recharge pool levels and major types of habitat that would be inundated as a result of operation of these Type 1 reservoirs are listed in Table 2.1-3.

Table 2.1-3.
Habitats Affected by Operation of Type 1 Recharge Reservoirs

Reservoir	*Conservation Pool (acres)*	*Grasslands (percent)*	*Brushlands (percent)*	*Woodlands (percent)*	*Wetlands (acres)*
Montell	1,460	5%	20%	75%	1.2
Upper Dry Frio	440	75%	0%	25%	6.2
Concan	710	40%	40%	20%	1.8
Upper Verde	350	15%	0%	85%	14
Upper Sabinal	550	70%	0%	30%	26.8
Upper Hondo	350	20%	0%	80%	13.4
Upper Blanco	182	—	—	—	—

Operation of the Type 1 structures will affect streamflows below each reservoir, resulting in reduced flood peaks entering the recharge zone, and increased frequency and duration of low flows covering the recharge zone. All the streams considered in the Nueces River Basin are intermittent over the recharge zone, and aquatic communities there would benefit by increasing the periods during which lotic conditions are present.

Conversely, the Blanco River, although also intermittent over the recharge zone, is less so and retains very large perennial pool habitats that support productive and diverse communities comparable to perennial streams in the region. Blanco River recharge is believed to contribute to local springflows, which do rejoin surface flow at the San Marcos/Blanco River confluence.

Effects to the Nueces Estuary inflows, and on the yield of the CCR/LCC System, are presented in Section 2.1.2 and Table 2.2-1. CCR/LCC System yields would be reduced slightly

(1,235 acft/yr under Program 1A) and fully compensated for by users of the enhanced Edwards Aquifer recharge. Projected reductions in Nueces Estuary inflows would be similarly small (4,674 acft/yr under Program 1A) and at least partially offset by water imported to the system to replace the reduced yield. The absolute value of reductions in Guadalupe River flows at the Saltwater Barrier (2,917 acft/yr for the Upper Blanco site) is only about 0.5 percent of drought average annual gaged inflow to San Antonio Bay.

Substantial effects on the subterranean fauna of the Edwards Aquifer reservoir zone as a result of recharge projects appears unlikely so long as water quality of the recharge reservoir can be maintained. The characteristically constant temperature, chemical composition and clarity of the water in the reservoir portion of the aquifer which supplies the springs, is largely a function of storage in the cavernous limestones of the aquifer, and not of constant quality water entering the recharge zone.

The potentially long periods of impoundment in Type 1 reservoirs may alter water quality as suspended materials that would have been transported downstream settle out, and as a result of thermal stratification and subsequent dissolved oxygen (D.O.) depletion in isolated bottom waters. Since discharge of D.O. depleted waters would be adverse to both downstream aquatic communities and to the aquifer fauna (if re-aeration is not accomplished before recharge), the outlet works of the Type 1 structures could need to allow for discharge of water from various depths in the reservoirs.

Many rare and endemic species of plants exist as a result of the many canyons, rugged terrain, past geologic history and biogeographical location of the south and southeastern portions of the Edwards Plateau. The Texas snowbells (*Styrax texana*) is considered endangered by both the USFWS and TPWD. The bracted twist-flower (*Streptanthus bracteatus*) is recognized by TPWD and the Texas Organization of Endangered Species (TOES) as a species of concern. The basin bellflower (*Campanula reverchonii*), bearded mock-orange (*Philadelphus ernestii*), canyon mock-orange (*P. texensis*), *Anemone edwardsiana* and cliff bedstraw (*Galium correllii*) are also on the TOES watch list. Other rare and endemic plant species which do not have federal or state status and are not recognized on the TOES watchlist are lipferns (*Cheilanthes* spp.), cloakferns (*Notholaena* spp.), *Anemia mexicana*, halberd fern (*Tectaria heracleifolia*), hairy maidenhair fern (*Adiantum tricholepis*), cliff brakes (*Pellaea*), columbine (*Aquilegia canadensis*), wand butterfly-bush (*Buddleja racemosa*), american smoke-tree (*Cotinus americana*), spicebush

(*Benzoin aestivale*), silverbells (*Styrax platanifolia*), netleaf forestiera (*Forestiera reticulata*), plateau milkvine (*Matelea edwardsensis*), Lindheimer crownbeard (*Verbesina lindheimeri*), *Lythrum ovalifolium*, *Tridens buckleyanus*, twisted leaf yucca (*Yucca rupicola*), and sotol (*Dasylirion heteracanthium*).[21]

In addition to the rare and/or endemic species listed above there are numerous protected and candidate species in the study areas as well as in the Edwards Aquifer and in springs fed by the aquifer (Table 2.1-4). None of these species have been reported to occur directly within the proposed dam and impoundment locations, but some have been observed in the vicinity of several sites and suitable habitat for one or more protected species appears to be present at some of the sites. Both the biogeographical setting and present knowledge indicates that field surveys should be conducted at appropriate seasons to determine the presence or absence of protected species habitat and assess the probability of use of each site by protected species.

While each of these reservoir sites has some potential to affect private interests and recreation, the Concan site on the Frio River is the only location that would impact a popular recreational reach that has experienced substantial riparian resort and residential development. The Blanco River site may also have some impact on recreation and on riparian residential property.

Texas Archeological Research Laboratory files were examined and data on 231 archaeological sites determined to occur in the upper Nueces River Basin were compiled.[24] Known historic sites in the study area were compiled from the National Register of Historic Places. All site locations were plotted on 7.5-minute quadrangle maps and assessed for the probability that they would be affected by construction of one of the proposed recharge reservoirs. However, these statistics reflect strong sample bias and an absolute lack of information from some areas. This information has not been compiled for the Upper Blanco site, as its predictive utility is small. Burned rock middens are the most common archaeological site (130, 56 percent) in the Upper Nueces River Basin, with rock quarries (9), rock shelters (5), and caves (3) comprising the other 44 percent of the sites. Nine historic sites are recorded in the study area, and at 22 sites (9.5 percent), no information beyond the location is available.[25]

[24] HDR, "Regional Water Supply Planning Study Phase III Recharge Enhancement, Nueces River Basin," 1991
[25] Ibid.

Table 2.1-4.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Edwards Aquifer Recharge from Natural Drainage — Type 1 (L-17)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS	TPWD	TOES[1,2]	Potential Occurrence in County
BIRDS						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in Hays, Medina, Uvalde
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in Hays, Medina, Uvalde
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant in Uvalde
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in Hays
Wood Stork	*Mycteria americana*	forages in prairie ponds, ditches, and still shallow standing water formerly nested in Texas		T	T	Migrant in Uvalde
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant in Medina, Uvalde, Hays
Black-capped Vireo	*Vireo atricapillus*	oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces. Known occurrence in the upper Hondo, Upper Verde, and Concan Reservoir area	E	E	T	Nesting/Migrant in Medina, Uvalde, Hays
Golden-cheeked Warbler	*Dendroica chrysoparia*	ashe juniper-oak woodlands; dependent on mature ashe juniper (cedar) for nests. Known occurrence in the Upper Hondo, Upper Verde, Concan, Upper Blanco Reservoir area	E	E	E	Nesting/Migrant in Medina, Uvalde, Hays
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant in Medina, Hays
REPTILES						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges. Known occurrence in the Upper Blanco Reservoir area	C1		C1	Hays
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, open sparsely vegetated uplands, grass, cactus, brush; soil may vary in texture	C2	T	T	Medina, Uvalde, Hays
Spot-tailed earless Lizard	*Holbrookia lacerata*	Central & Southern Texas; oak-juniper woodlands and mesquite-prickly pear				Medina, Hays
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Medina, Uvalde
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush	C2	T	T	Uvalde
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Medina, Hays
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Medina, Uvalde
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Medina, Hays

Table 2.1-4 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS	Listing Agency TPWD	Listing Agency TOES[1,2]	Potential Occurrence in County
AMPHIBIANS						
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	Isolated, intermittent pools of a subterranean stream; sinkhole found in Medina Co.				Medina
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; subaquatic, springs and caves in Comal Co.		T	T	Comal
Comal Blind Salamander	*Eurycea tridentifera*	endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal Co	C2	T	T	Comal
Blanco River Springs Salamander	*Eurycea pterophila*	subaquatic, springs and caves in the Blanco River drainage in Blanco, Hays and Kendall				Hays
Texas Blind Salamander	*Eurycea rathbuni*	troglobitic, water-filled subterranean caverns, along San Marcos Spring Fault	E	E	T	Hays
San Marcos Salamander	*Eurycea nana*	headwaters of San Marcos River, downstream to 1/2 mile past IH-35	T	T	T	Hays
Blanco Blind Salamander	*Eurycea robusta*	troglobitic, water-filled subterranean caverns, may inhabit deep levels of Balcones Aquifer	C2	T	T	Hays
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	endemic; troglobitic; springs, seeps, cave streams, and creek headwaters. Known occurrence in the Upper Hondo, Montell, Upper Sabinal, Upper Blanco And Concan Reservoir area	C2			Medina, Uvalde, Hays
FISH						
Blue Sucker	*Clycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River	C2	T	WL	Uvalde, Hays
Guadalupe Bass	*Micropterus treculi*	Perennial streams of the Edward's plateau region. Known occurrence in the Montell Reservoir area	C2		WL	Uvalde, Hays
Headwater catfish	*Ictalurus lupus*	Clear streams. Known occurrence below the Montell Reservoir area				Historic in Uvalde
Toothless Blindcat	*Trogloglanis pattersoni*	troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer	C2	T	E	Bexar
Widemouth Blindcat	*Satan eurystomus*	troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer	C2	T	E	Bexar
Fountain Darter	*Etheostoma fonticola*	known only from the San Marcos and Comal rivers; springs and spring-fed streams in dense vegetation		T	E	Hays
ARTHROPODS						
Peck's Cave Amphipod	*Stygobromus pecki*	small, aquatic crustacean; lives underground in Edwards Aquifer	PE		WL	Comal
Ezell's Cave Amphipod	*Stygobromus flagellatus*	known only from artesian wells	C2		WL	Hays
Texas Cave Shrimp	*Palaemonetes antrorum*	Edwards Aquifer subterranean caverns and subterranean sluggish streams and pools	C2		WL	Hays
Flint's net-spinning caddisfly	*Cheumatopsyche flinti*	Honey Creek	C2		WL	Uvalde, Hays
San Marcos Saddle Case Caddisfly	*Protoptila arca*	known from an artesian well in Hays Co.; 1-2m deep water	C2		WL	Hays
Bifurcated Cave Amphipod	*Stygobromus bifurcatus*	Spring openings	C2		WL	
Balcones Cave Amphipod	*Stygobromus balconis*	Limestone caves	C2		WL	
Comal Springs Water Beetle	*Heterelmis comalensis*	Comal Springs	C2			Comal

Table 2.1-4 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS	TPWD	TOES[1,2]	
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Comal Springs	PE			Comal
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Edwards Aquifer subterranean caverns; known from an artesian well in Hays Co.	C2		WL	Hays
MOLLUSKS						
Mimic Cave Snail	*Phreatodrobia imitata*	Edwards Aquifer subterranean caverns	C2			
PLANTS						
Texas wild-rice	*Zizania texana*	perennial, emergent, aquatic grass known from San Marcos River	E	E	E	Hays
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes KNOWN OCCURANCE IN THE CONCAN RESERVOIR AREA				Medina, Uvalde
Sandhill woolywhite	*Hymenopappuscarrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Medina
Texas Greasebush	*Forsellesia texensis*	dry limestone ledges and chalk bluffs. Known occurrence in the Montell Reservoir area			WL	Uvalde
Hill Country Wild-mercury	*Argythamnia aphoroides*	shallow to deep clays and loams over limestone; grasslands and live oak woodlands. Known occurrence in the Concan Reservoir area			WL	Uvalde, Comal
Dark Noseburn	*Tragia nigricans*	mixed evergreen deciduous woodlands on clay or clay loam over limestone. Known occurrence in the Upper Blanco,Concan Reservoir area			WL	Uvalde, Hays, Comal
Texas Snowbells	*Styrax texana*	Known occurrence in the Upper Dry Frio Reservoir area	E	E	WL	Uvalde
Texas Mock-Orange	*Philadelphus texensis*	On limestone bluffs and among boulders on the Edwards Plateau. Known occurrence in the Upper Hondo, Concan Reservoir area	C2		WL	Uvalde, Medina
MAMMALS						
Cave Myotis Bat	*Myotis velifer*	colonial, and cave dwelling; hibernates in limestone caves of Edwards Plateau	C2			Uvalde, Hays
White-nosed coati	*Nasua narica*	woodlands, rocky and riparian areas		T	WL	Uvalde
Black Bear	*Usus americanus*	Mountains, broken country, woods, brushlands, forests	T	T	T	Uvalde
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, farmyards, forest edges			C2	Hays
Frio Pocket Gopher	*Geomys texensis bakeri*	Associated with nearly level Atoc soil, which is well drained and consists of sandy surface layers with loam extending to as deep as 2m.	C2			Medina, Uvalde
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas	E	E	E	Uvalde
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Uvalde

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[2] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Because none of these recharge reservoirs have been adequately surveyed, all areas to be disturbed during construction would have to be surveyed by qualified professionals for the presence of significant cultural resources. Measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

2.1.4 Engineering and Costing.

Preliminary cost estimates for all Type 1 recharge enhancement projects located in the Nueces River Basin were prepared in 1991 by HDR,[26] and preliminary cost estimates for the Type 1 recharge enhancement projects located in the Guadalupe-San Antonio River Basin were prepared in 1998 by HDR.[27] The costs presented in Table 2.1-5 have been adjusted to Second Quarter 1999 prices.

As seen in Table 2.1-5, the Type 1 Recharge Program 1A has a total cost of $232,420,000 and a total annual cost of $18,379,000. Under this Program, sustained yield is enhanced by about 5,554 acft/yr, which results in an estimated unit cost of water of $3,309 per acft.

The Program 1B total cost was computed as $66,519,000, with a total annual cost of $5,006,000. Sustained yield pumpage for Program 1B is 1,958 acft/yr, which results in an estimated unit cost of $2,557 per acft.

2.1.5 Implementation Issues

Implementation of Type 1 Recharge Programs could directly affect the feasibility of other water supply options under consideration, including L-18, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-20, G-30, G-40, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-7, SCTN-14a and/or SCTN-14b.

An institutional arrangement is needed to implement this project including financing on a regional basis.

1. Necessary permits could include:
    a. TNRCC Water Right and Storage permits.
    b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
    c. TWDB Sand, Gravel, and Marl Removal permits.
    d. GLO Easement for use of state-owned land.

[26] HDR, Op. Cit., November 1991.
[27] HDR, Op. Cit., March 1998.

Table 2.1-5.
Summary of Costs for
Recharge Enhancement Programs — Type 1 Reservoirs (L-17)
Second Quarter 1999 Prices

Item	Program 1A[1]	Program 1B[2]
Capital Costs		
Dams and Reservoirs	$102,245,000	$29,025,000
Total Capital Cost	**$102,245,000**	**$29,025,000**
Engineering, Legal Costs and Contingencies	$36,275,000	$10,159,000
Land Acquisition	33,805,000	10,213,000
Environmental & Archaeology Studies and Mitigation	30,854,000	10,213,000
Surveying	3,380,000	1,021,000
Interest During Construction	25,861,000	5,888,000
Total Project Cost	**$232,420,000**	**$66,519,000**
Annual Costs		
Debt Service (6 percent for 30 years)	$523,000	0
Reservoir Debt Service (6 percent for 40 years)	14,968,000	4,420,000
Operation and Maintenance	2,329,000	96,000
Water Rights Mitigation	559,000	490,000
Total Annual Cost	**$18,379,000**	**$5,006,000**
Available Project Yield (acft/yr)	**5,554**	**1,958**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[3]	**$3,309**	**$2,557**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[3]	**$10.15**	**$7.84**

[1] Program 1A includes Montell, Upper Dry Frio, Concan, Upper Sabinal, Upper Hondo, Upper Verde, and Upper Blanco.
[2] Program 1B includes Upper Dry Frio, Upper Sabinal, and Upper Verde.
[3] Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer.

   e. Edwards Aquifer Authority recharge recovery permit (rules governing such permits are presently under consideration).
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.

   d. Cultural resource studies.
   e. Study of impact on karst geology organisms.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations and crossings:
   a. Highways and railroad.
   b. Other utilities.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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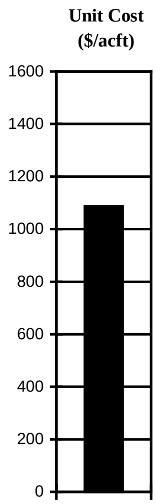

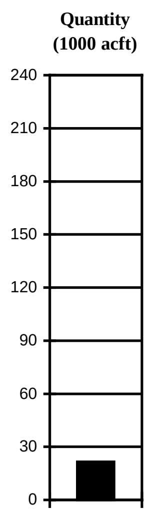

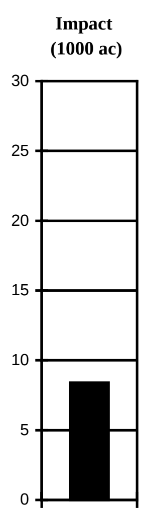

OPTION NUMBER: L-18

OPTION NAME: Edwards Aquifer Recharge from Natural Drainage – Type 2 Projects (Program 2A)

OPTION DESCRIPTION: *Type 2 recharge structures are located within or directly over the Edwards Aquifer Recharge Zone. These structures impound water for only a few days or weeks (as it percolates into the aquifer) and are normally dry.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$1,087**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**21,577**	**acft/yr[2]**
LAND IMPACTED:	**8,448**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Price of land for recharge reservoirs, costs of dams and emergency spillways, and maintenance costs for recharge features such as trash control and removal.

[2]**QUANTITY OF WATER:** Quantity listed is for sustained yield increase computed using GWSIM-IV model of the Edwards Aquifer and recharge enhancement due to following projects: Indian Creek, Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, Northern Bexar/Medina County Projects, Dry Comal, and Salado Creek FRS outlet modifications.

[3]**LAND IMPACTED:** Recharge structure sites. Area inundated by the reservoir at full recharge pool capacity. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Effects of periodic inundation lasting for a few days or weeks of the recharge structure sites upon terrestrial habitat located within the recharge sites. Sites on the Nueces, Frio, Sabinal, and Blanco Rivers are located in areas recommended for designation as Ecologically Unique River Segments by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain agreements with local landowners for recharge sites, water rights, and necessary construction permits. Mitigation of impacts to downstream water rights.

ADDITIONAL FACTORS: Ability of recharge sponsors to obtain recharge recovery permits and/or credits for quantities of water artificially recharged to the aquifer or discharged from springs. In combination with other water supply options, Option L-18 may be an economical interruptible (rather than firm or sustained yield) supply.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-20, G-30, G-40, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-7, SCTN-14a, and/or SCTN-14b.

SOUTH CENTRAL TEXAS REGION SUPPLY OPTIONS
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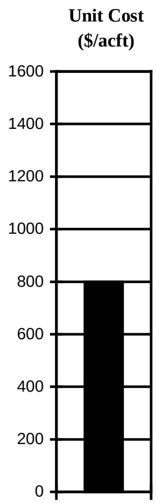
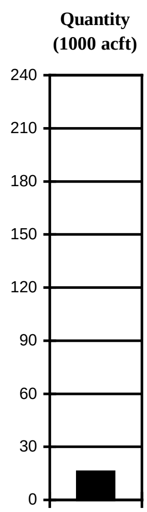
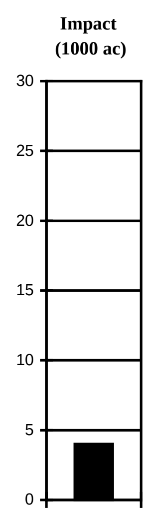






OPTION NUMBER: L-18
OPTION NAME: Edwards Aquifer Recharge from Natural Drainage – Type 2 Projects (Program 2B)

OPTION DESCRIPTION: *Type 2 recharge structures are located within or directly over the Edwards Aquifer Recharge Zone. These structures impound water for only a few days or weeks (as it percolates into the aquifer) and are normally dry.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$800**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**15,980**	**acft/yr[2]**
LAND IMPACTED:	**4,186**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Price of land for recharge reservoir sites, costs of dams and emergency spillways, and maintenance costs for recharge features such as trash control and removal.

[2]**QUANTITY OF WATER:** Quantity listed is for sustained yield increase computed using GWSIM-IV model of the Edwards Aquifer and recharge enhancement due to following projects: Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, and Salado Creek FRS outlet modifications.

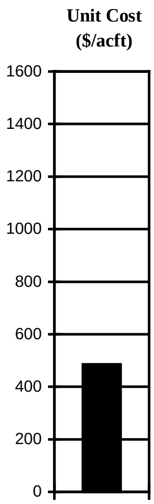
[3]**LAND IMPACTED:** Recharge structure sites. Area inundated by the reservoir at full recharge pool capacity. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

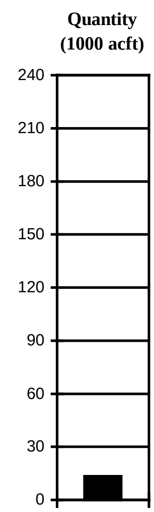
ENVIRONMENTAL ISSUES: Effects of periodic inundation lasting for a few days or weeks of the recharge structure sites upon terrestrial habitat located within the recharge sites. Sites on the Frio, Sabinal, and Blanco Rivers are located in areas recommended for designation as Ecologically Unique River Segments by TPWD.

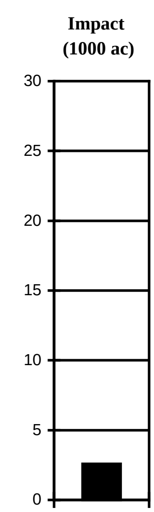
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain agreements with local landowners for recharge sites, water rights, and the necessary construction permits. Mitigation of impacts to downstream water rights.

ADDITIONAL FACTORS: Ability of recharge sponsors to obtain recharge recovery permits and/or credits for quantities of water artificially recharged to the aquifer or discharged from springs. In combination with other water supply options, Option L-18 may be an economical interruptible (rather than firm or sustained yield) supply.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-20, G-30, G-40, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-14a, and/or SCTN-14b.







SOUTH CENTRAL TEXAS REGION SUPPLY OPTIONS
OPTION DATA SHEET
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OPTION NUMBER: L-18
OPTION NAME: Edwards Aquifer Recharge from Natural Drainage – Type 2 Projects (Program 2C)

OPTION DESCRIPTION: *Type 2 recharge structures are located within or directly over the Edwards Aquifer Recharge Zone. These structures impound water for only a few days or weeks (as it percolates into the aquifer) and are normally dry.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$486**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**13,451**	**acft/yr[2]**
LAND IMPACTED:	**2,595**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Price of land for recharge reservoir sites, costs of dams and emergency spillways, and maintenance costs for recharge features such as trash control and removal.

[2]**QUANTITY OF WATER:** Quantity listed is for sustained yield increase computed using GWSIM-IV model of the Edwards Aquifer and recharge enhancement due to following projects: Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Cibolo Dam No. 1, and Salado Creek FRS outlet modifications.

[3]**LAND IMPACTED:** Recharge structure sites. Area inundated by the reservoir at full recharge pool capacity. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Effects of periodic inundation lasting for a few days or weeks of the recharge structure sites upon terrestrial habitat located within the recharge sites. Sites on the Frio and Sabinal Rivers are located in areas recommended for designation as Ecologically Unique River Segments by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain agreements with local landowners for recharge sites, water rights, and the necessary construction permits. Mitigation of impacts to downstream water rights.

ADDITIONAL FACTORS: Ability of recharge sponsors to obtain recharge recovery permits and/or credits for quantities of water artificially recharged to the aquifer or discharged from springs. In combination with other water supply options, Option L-18 may be an economical interruptible (rather than firm or sustained yield) supply.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-30, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-14a, and/or SCTN-14b.

2.2 Edwards Aquifer Recharge from Natural Drainage — Type 2 Projects (L-18)

2.2.1 Description of Option

Two types of recharge enhancement reservoirs have been analyzed in a series of studies[1,2,3,4,5,6] sponsored by the Edwards Underground Water District beginning in 1990. Type 1 reservoirs are described and evaluated in Section 2.1. This option deals with the potential construction of Type 2 projects, which are immediate recharge structures located within the Edwards Aquifer recharge zone. Type 2 structures are, generally speaking, normally dry and impound water only for a few days or weeks following storm events. These structures recharge water very quickly to the aquifer, typically draining at a rate of 2 to 3 feet per day. This large recharge rate minimizes evaporation losses and maximizes recharge.

The location of each of the Type 2 recharge projects most favorable for development is shown in Figure 2.2-1. Five of the projects are located in the Nueces River Basin and affect inflows to the Choke Canyon Reservoir/Lake Corpus Christi System (CCR/LCC System) and the Nueces Estuary. These five projects include Indian Creek, Lower Frio, Lower Sabinal, Lower Hondo, and Lower Verde. Other previously identified Type 2 sites in the Nueces River Basin are not included in this study because the quantity of enhanced recharge during the drought is extremely small and the associated unit costs are extremely high.

In the San Antonio and Guadalupe River Basins, up to nine new recharge projects are being considered. These include San Geronimo, Cibolo Dam No. 1, Dry Comal, Lower Blanco, and up to five small Soil Conservation Service (SCS) type reservoirs in northern Bexar and Medina Counties. Other previously identified recharge enhancement projects in the San Antonio and Guadalupe River Basins considered in this study include projects to modify the outlets on

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[1] HDR Engineering, Inc. and Geraghty and Miller, Inc., "Nueces River Basin Regional Water Supply Planning Study, Phase I," Vols. 1, 2, and 3, Nueces River Authority, et al., May 1991.
[2] HDR, "Nueces River Basin Regional Water Supply Planning Study, Phase III – Recharge Enhancement," Nueces River Authority, November 1991.
[3] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVA," Edwards Underground Water District, June 1994.
[4] HDR, "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVB, Technical Memorandum, Combined Impacts of Frio, Sabinal, Hondo, and Verde Recharge Enhancement Projects on Downstream Water Rights," December 12, 1995.
[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Vols. I, II, and III, Edwards Underground Water District, September 1993.
[6] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study Feasibility Assessment," Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses, San Antonio River Authority, et al., March 1998

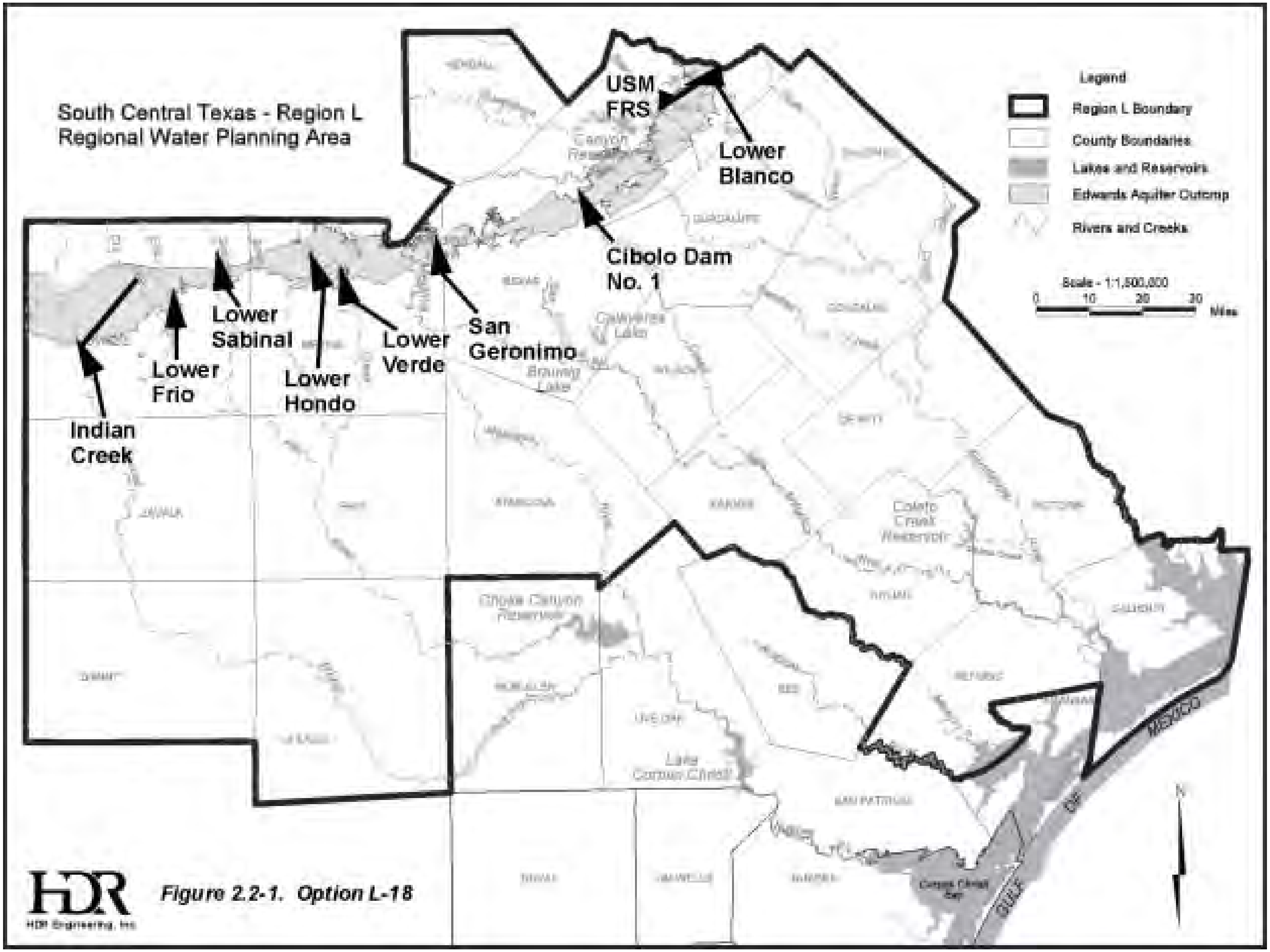


Figure 2.2-1. Option L-18

existing SCS Floodwater Retarding Structures (SCS-FRS) in the Salado Creek watershed. These modifications would either close or restrict the outlets on existing SCS-FRS dams resulting in additional recharge.

The Type 2 projects in the Nueces and Guadalupe-San Antonio River Basins have all been considered in previous studies that included cost analyses. For these projects, an optimum size has previously been determined for each project and is used in this study. Three Type 2 Programs consisting of up to 14 potential new storage projects and two modifications to existing dams to increase recharge are presented in this study. The projects included in each of the three programs are identified below.

2.2.1.1 Program 2A

- Nueces River Basin
- Indian Creek (with recharge diversions to Dry Frio River)
- Lower Frio
- Lower Sabinal
- Lower Hondo
- Lower Verde

- Guadalupe-San Antonio River Basin
  - Lower Blanco (with recharge diversions to San Marcos FRS)
  - Cibolo Dam No. 1
  - San Geronimo
  - Northern Bexar/Medina County Projects
    - Limekiln
    - Culebra
    - Government Canyon
    - Deep Creek
    - Salado Dam No. 3
  - Dry Comal
  - Salado Creek FRS
    - Modifications to spillways at existing dams 11 and 13B

2.2.1.2 Program 2B

- Nueces River Basin
  - Lower Frio
  - Lower Sabinal
  - Lower Hondo
  - Lower Verde

- Guadalupe-San Antonio River Basin
  - Lower Blanco (with recharge diversions to San Marcos FRS)
  - Cibolo Dam No. 1
  - San Geronimo
  - Salado Creek FRS
    - Modifications to spillways at existing dams 11 and 13B

2.2.1.2 Program 2C

- Nueces River Basin
  - Lower Frio
  - Lower Sabinal
  - Lower Hondo
  - Lower Verde

- Guadalupe-San Antonio River Basin
  - Cibolo Dam No. 1
  - Salado Creek FRS
    - Modifications to spillways at existing dams 11 and 13B

The projects in Program 2A would impound a combined maximum recharge pool storage of 170,309 acft and periodically inundate 8,448 acres, as shown in Table 2.2-1. At the other extreme, Program 2C would impound up to 42,650 acft in the combined recharge storage pools for projects in this program and periodically inundate about 2,595 acres.

Table 2.2-1. Summary of Recharge Enhancement Potential for Type 2 Reservoir Programs (L-18)

Type 2 Project Program	Capacity (acft)	Surface Area (acres)	Recharge Enhancement: 1934 to 1989 Average Conditions (acft/yr)	Recharge Enhancement: 1947 to 1956 Drought Conditions (acft/yr)	Reduction in Average Nueces Estuary Inflow (acft/yr)	Reduction in CCR/LCC System Yield (acft/yr)	Reduction in Drought Average Guadalupe Estuary Inflow (acft/yr)
Program 2A	170,309	8,448	134,434	50,032	14,590	4,308	13,269
Program 2B	96,150	4,186	108,003	34,788	11,592	1,355	13,026
Program 2C	42,650	2,595	54,471	10,034	11,592	1,355	500

1 Estuarine inflow reduction and CCR/LCC System yield reductions estimated by the addition of Indian Creek Project impacts from "Edwards Aquifer Recharge Enhancement Project, Phase IVA" and the analysis in footnote 2 below.

2 Estimates of estuarine inflow reduction and CCR/LCC System yield reduction quantities were taken from "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project, Phase IVB, Technical Memorandum, Combined Impacts of Frio, Sabinal, Hondo, and Verde Recharge Enhancement Projects on Downstream Water Rights," December 12, 1995, prepared by HDR Engineering, Inc.

3 Estimates of drought average (1947 to 1956) estuarine inflow reductions for all San Antonio and Guadalupe River Basin Projects were taken from "Guadalupe-San Antonio River Basin Recharge Enhancement Study Feasibility Assessment," West Central Study Area, Trans-Texas Water Program, Phase II, Edwards Aquifer Recharge Analysis.

2.2.2 Available Yield

Available yield or recharge enhancement volumes were calculated for the Type 2 structures using the Nueces River Basin Model and the Guadalupe-San Antonio River Basin Model, subject to average and drought conditions. Average conditions represent the average annual recharge enhancement rate for the entire 56-year simulation period (1934 to 1989). Drought conditions represent the average annual recharge enhancement rate for the 10-year period from 1947 through 1956, which is when the most severe drought on record occurred. Analyses of recharge enhancement projects presented in this study were performed honoring all existing water rights to the maximum extent possible, with one exception. This exception involves the water rights of the CCR/LCC System, in which case impacts were not mitigated by releases, but were assumed to be purchased. Other options may be available to mitigate the impact of the recharge projects on the CCR/LCC System, such as Option L-14, which considers the transfer of San Antonio River water into Choke Canyon Reservoir.

For the Type 2 Recharge Program 2A, recharge could be enhanced by 134,434 acft/yr for average conditions and 50,032 acft/yr for drought conditions as shown in Table 2.2-1. The impact on the CCR/LCC System totals 4,308 acft/yr for the Type 2 Program 2A, which represents about 2 percent of the system firm yield. Estimates indicate that Type 2 Recharge Program 2B could enhance recharge by 108,003 acft/yr for average conditions and 34,788 acft/yr during drought. Program 2B impacts CCR/LCC System yield by 1,355 acft/yr (less than 1 percent). Program 2C could enhance recharge in the Nueces and Guadalupe-San Antonio River Basins by 54,471 acft/yr and 10,034 acft/yr, during average and drought conditions, respectively. Impacts to CCR/LCC System yield under Program 2C are the same as under Program 2B.

Application of the Consensus Environmental Criteria (Appendix B) for reservoir pass-throughs for instream flows was included in this analysis for the Type 2 recharge projects. The only potential recharge dams that required reservoir pass-throughs were Indian Creek and Lower Blanco. The criteria were not significant at other sites because, under normal weather conditions, these sites do not contribute flows downstream of the recharge zone. The maximum impact on the average inflow to the Nueces Estuary due to the five Nueces River Basin projects (Program 2A) is a reduction of about 14,590 acft/yr, or about 6 percent. The impact of the remaining sites on the average inflow to the Guadalupe Estuary (as measured at the Guadalupe

River Saltwater Barrier) would be a reduction of about 13,300 acft/yr, or about 1 percent under Program 2A during drought (1947 to 1956). The impact of Program 2C on average inflows to the Nueces Estuary is about 11,590 acft/yr, or about 4.5 percent, and to the Guadalupe Estuary, is 500 acft/yr.

Once monthly recharge enhancement amounts were computed for each potential project, they were added to the baseline recharge for the GWSIM-IV Model of the Edwards Aquifer at the spatial locations representing the proposed recharge enhancement projects. Figure 2.2-2 shows the Edwards Aquifer GWSIM-IV aquifer model cell grid with an overlay of the streams and major reservoirs in the model area. Also shown in this figure are the approximate locations of the recharge enhancement projects modeled. Recharge enhancement estimates from the surface water models for Program 2A, Program 2B, and Program 2C were distributed into the appropriate recharge zone cells in the GWSIM-IV Model. Application of the GWSIM-IV Model provides a basis for determining additional groundwater that could potentially be withdrawn under a recharge recovery permit[7] for each Type 2 Recharge Enhancement Program (Appendix C). It is noted, however, that rules governing recharge recovery have yet to be adopted by the Edwards Aquifer Authority. A summary of the sustained yield pumpage increase associated with each Type 2 Recharge Enhancement Program is presented in Table 2.2-2. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board rules for regional water supply planning.

Figure 2.2-3 summarizes the results of the GWSIM-IV Model runs used to determine the change in sustained yield associated with enhanced recharge for Program 2A. With long-term average enhance recharge of 134,434 acft/yr, the sustained yield pumpage was found to increase by 21,577 acft/yr (16 percent of the average annual enhancement). The majority of the average annual recharge enhancement becomes springflow. As shown in Table 2.2-2, 80,189 acft/yr (60 percent) of the 134,434 acft/yr recharge enhancement becomes increased springflow. This increase in springflow is shown in the lower chart in Figure 2.2-3. This chart shows the Comal Springs flow patterns under the 400,000 acft/yr management plan pumpage with and without a

[7] HDR, "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

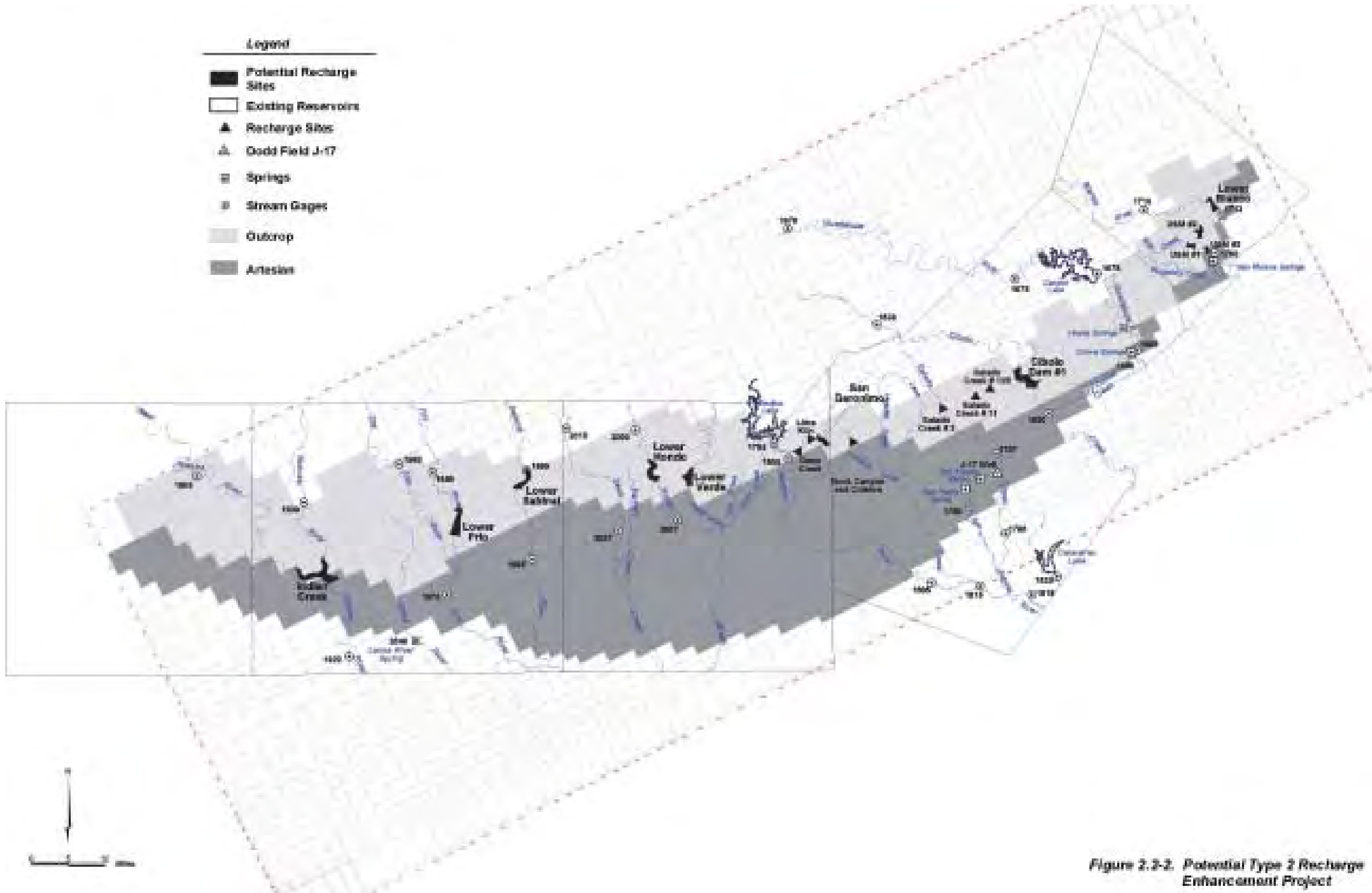


Figure 2.2-2. Potential Type 2 Recharge Enhancement Project

Table 2.2-2.
Summary of Sustained Yield Enhancement for Type 2 Reservoir Programs

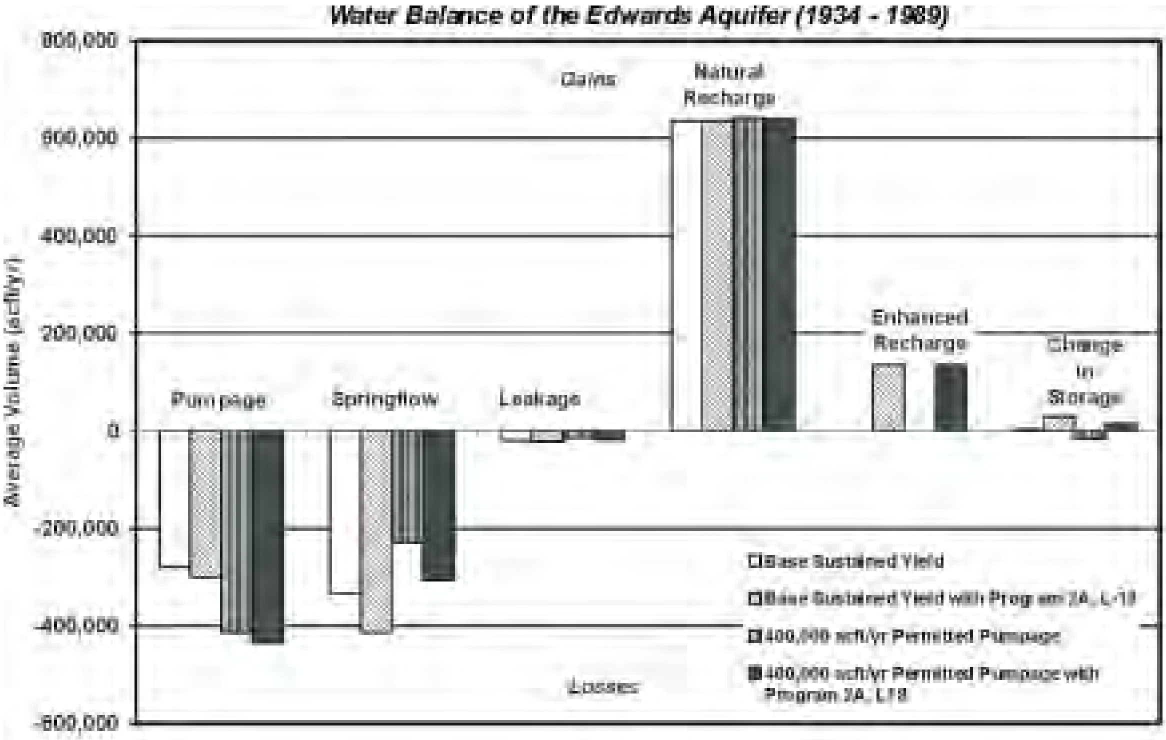
Type 2 Project Program	Recharge Enhancement		Sustained Yield Pumpage Increase (acft/yr)	Increase in Springflow (acft/yr)
	1934 to 1989 Average Conditions	1947 to 1956 Drought Conditions		
Program 2A	134,434	50,032	21,577	80,189
Program 2B	108,003	34,788	15,980	69,971
Program 2C	54,471	10,034	13,451	24,401

[1] Sustained yield increase based on comparison of GWSIM-IV Model runs in which aquifer pumpage was maximized while maintaining a minimum flow from Comal Springs of 60 cfs in one and only one month with and without recharge enhancement from the associated Type 2 Program.

recharge recovery permit pumpage of 21,577 acft/yr. As seen in this figure, the close proximity of the Lower Blanco and Cibolo Dam No. 1 recharge projects to Comal and San Marcos Springs serve to enhance springflow more than increase dependable supply for municipal pumpage.

Program 2B was analyzed in a similar fashion and the results indicate similar increases, on a percentage basis, to increased sustained yield and springflow. Under Program 2B, 15,980 acft/yr (15 percent) of the 108,003 acft/yr average annual recharge enhancement is potentially available for a recharge recovery permit, while 69,971 acft/yr (65 percent) becomes increased springflow. The primary difference between Programs 2A and 2B is the exclusion of the Indian Creek recharge project in Program 2B. The Lower Blanco and Cibolo Dam No. 1 projects remain and thus Comal and San Marcos springflow enhancement remains high. The results for Program 2B are shown in Figure 2.2-4.

In the last option, Program 2C, Indian Creek, Lower Blanco, and San Geronimo recharge enhancement projects were removed from the program. As shown in Table 2.2-2 and Figure 2.2-5, the increase in sustained yield pumpage of the aquifer is 13,451 acft/yr, approximately 25 percent of the average annual recharge enhancement. This is the only program considered herein with a sustained yield greater than the drought average recharge enhancement. Figure 2.2-5 and Table 2.2-2 also indicate that the removal of the Lower Blanco project from the Program 2C analysis decreased the percentage of average annual enhancement that became increased springflow. For Program 2C, 24,401 acft/yr (or 45 percent) of the annual average



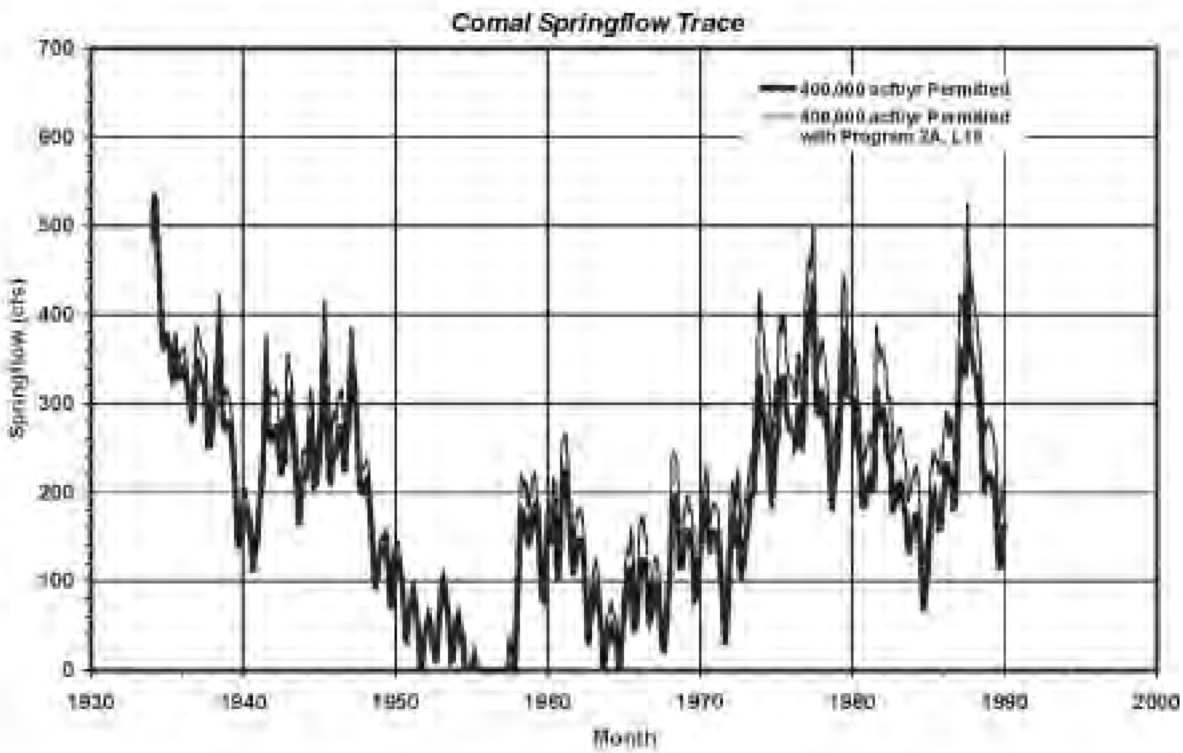


Figure 2.2-3. Enhanced Recharge from Type 2 Recharge Projects — Program 2A

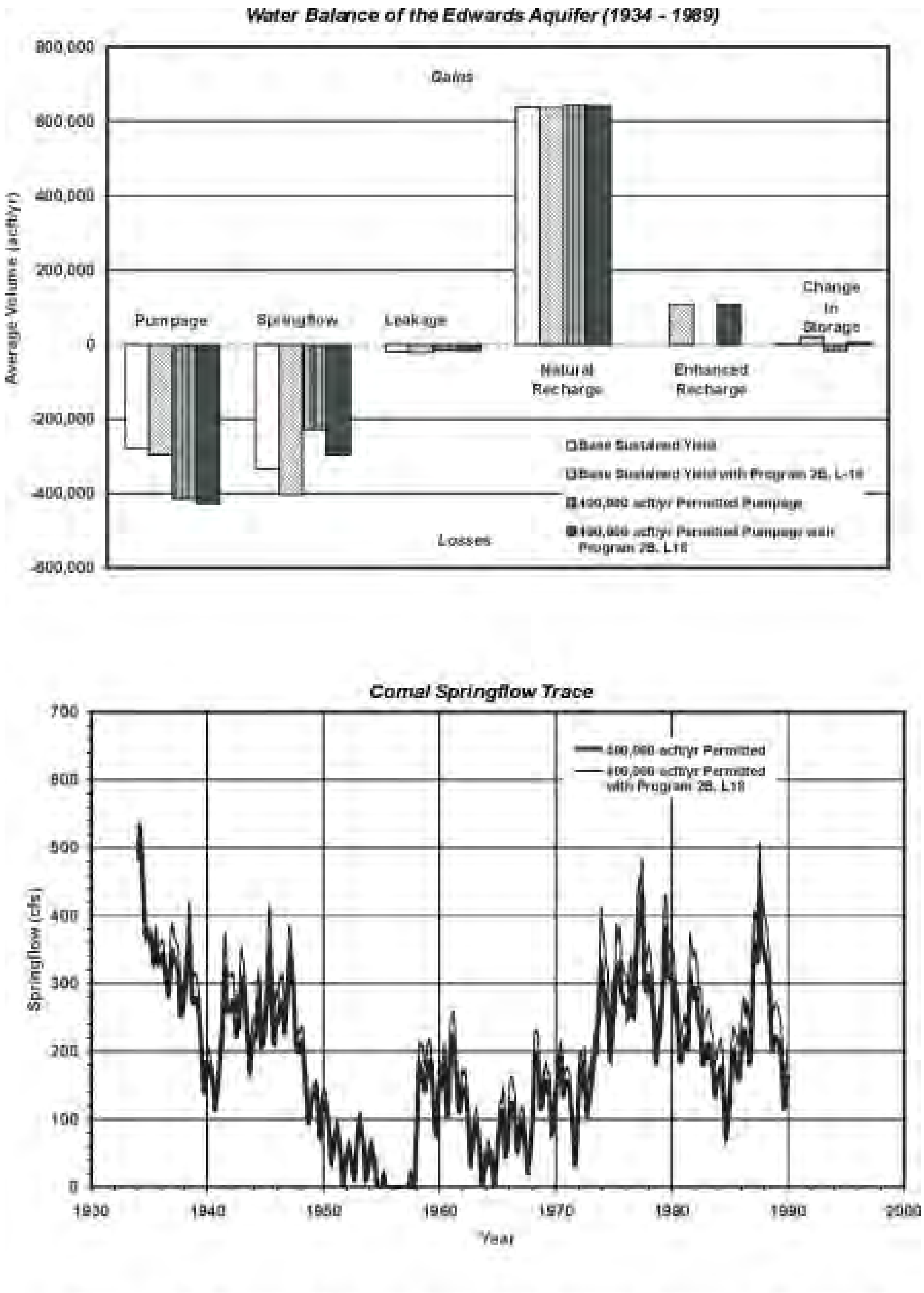


Figure 2.2-4. Enhanced Recharge from Type 2 Recharge Projects — Program 2B

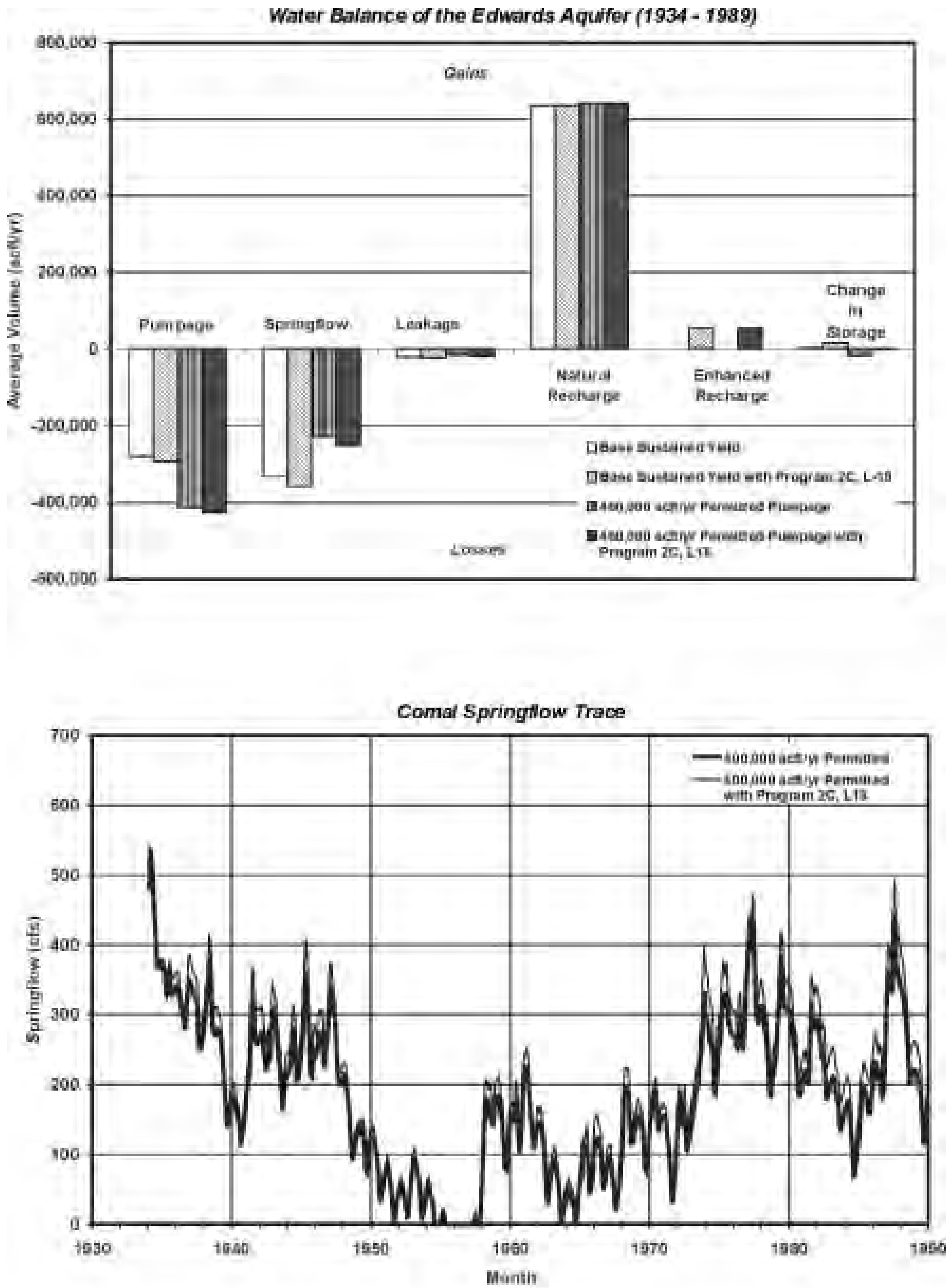


Figure 2.2-5. Enhanced Recharge from Type 2 Recharge Projects — Program 2C

recharge enhancement becomes springflow. For these reasons, Program 2C appears to be, in a hydrologic sense, the most efficient Type 2 recharge project enhancement program.

Potential Edwards Aquifer recharge enhancement projects could negatively impact natural recharge of the Carrizo-Wilcox Aquifer. Previous studies[8] have estimated recharge to the Carrizo-Wilcox Aquifer by breaking recharge into three components: baseflow recharge in the stream, flood flow recharge in overbanks of the stream, and areal recharge in the tributaries and soils in the watershed outside the main channel. Of these three components, flood flow recharge is the component most likely to be negatively impacted by recharge dams on the Edwards Aquifer outcrop, upstream of the Carrizo-Wilcox outcrop. Flood flow recharge is defined as the recharge that occurs along the main channel during flood events due to the inundation of overbanks adjacent to the river. Previous estimates of total recharge in the Winter Garden Area[9] (the Carrizo-Wilcox from the Rio Grande to the San Marcos River) tabulated flood flow recharge to the Carrizo-Wilcox as approximately 25 percent (51,500 acft/yr) of the total average annual recharge to the aquifer. Total average annual recharge in the Winter Garden Area was estimated to be 207,700 acft/yr.

Average annual flood flow recharge in the area was estimated to be 51,500 acft/yr, of which 17,700 acft/yr occurs on streams which could potentially be impacted by Type 2 Edwards Aquifer recharge enhancement projects. Therefore, in the most extreme case (no flood flow recharge to the Carrizo-Wilcox downstream of potential Type 2 projects) average annual Carrizo-Wilcox natural recharge could be reduced by approximately 8.5 percent (17,700/207,700) under Program 2A. Similarly, under Program 2B, the removal of an Edwards Project on the Nueces River would decrease the potential impact to Carrizo-Wilcox recharge down to 5 percent of the total average annual recharge. Likewise, Program 2C could cause a decrease in Carrizo-Wilcox average annual recharge of at most 4 percent.

It should be noted that these estimates of impacts, while relatively small, are essentially the maximum attainable assuming the Edwards Aquifer Recharge projects completely control all floods on their respective streams. The proposed Type 2 projects, however, are not large enough to control floods to this extent. Therefore, impacts to Carrizo-Wilcox recharge across the region will most certainly be considerably less than the potential impacts presented above. As water

[8] LBG-Guyton Associates and HDR Engineering, Inc., "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," Texas Water Development Board, August 1998.
[9] Ibid

management plans are developed, if specific projects potentially impacting Carrizo-Wilcox recharge are included in a plan, more detailed analyses of the actual impacts of said projects on Carrizo-Wilcox recharge will be performed.

2.2.3 Environmental Issues

Type 2 reservoirs are immediate recharge (direct percolation) structures that drain from the bottom of the reservoir into the recharge zone until the entire volume is exhausted, usually within a period of less than 1 month. Type 2 reservoirs are intended to impound flows that would have otherwise passed across the recharge zone.

Suitable sites for the Type 2 reservoirs are located in the area encompassing the headwaters of the Nueces River Basin along the southern margin of the Edwards Plateau in Medina and Uvalde Counties, and the headwaters of the San Antonio and Guadalupe rivers along the southeastern margin of the Edwards Plateau in Bexar and Comal Counties, respectively (Figure 2.2-1). There are three Type 2 reservoir sites in Uvalde County (Indian Creek, Lower Frio and Lower Sabinal), five Type 2 reservoir sites in Medina County (Lower Hondo, Lower Verde, San Geronimo, Deep Creek, and Limekiln), four Type 2 reservoir sites in Bexar County (Culebra, Government Creek, Salado Creek Site #3, and Cibolo Dam #1), one Type 2 reservoir site in Comal County (Dry Comal), and one Type 2 reservoir site in Hays County (Lower Blanco).

As in the case for Type 1 projects, all of the Type 2 recharge project sites are located in Omernik's Central Texas Plateau Ecoregion and the corresponding ecotones of Gould, Blair and Correll and Johnston.[10,11,12,13]

The soils in the area of Cibolo Creek, on the edge of Bexar and Comal Counties are composed of Tarrant, rolling (TaC) and Tarrant, hilly (TaD) associations[14,15] The Tarrant associations are very dark grayish-brown calcareous clay loam with an underlying layer of

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[10] Omernik, James M., “Ecoregions of the Conterminous United States,” Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[11] Correll, D.S., and M.C. Johnston, “Manual of the Vascular Plants of Texas,” Texas Research Foundation, Renner, Texas, 1979.
[12] Blair, W. F., “The Biotic Provinces of Texas,” Texas Journal of Science 2(1): pp. 93-117, 1950.
[13] Gould, F.W., “The Grasses of Texas,” Texas A & M University Press, College Station, Texas, 1975.
[14] United States Department of Agriculture, Soil Conservation Service, and Texas Agricultural Experiment Station, “Soil Survey of Comal and Hays Counties, Texas,” USDA, 1984.
[15] United States Department of Agriculture, Soil Conservation Service, and Texas Agricultural Experiment Station, “Soil Survey of Bexar County, Texas,” USDA, 1984.

fractured limestone. Tarrant soils have rapid surface drainage, low water retention capabilities and water erosion is a hazard. Soils in the area of Dry Comal Creek, Comal County, are primarily of the Rumple-Comfort (RUD), Eckrant-Rock outcrop and Comfort-Rock outcrop associations.[16] The RUD association consists of shallow and moderately deep soils made up of approximately 60 percent Rumple soils, 20 percent Comfort soils and 20 percent other soils. Rumple soil is dark reddish brown very cherty clay loam about 10 inches thick with the subsoils being dark reddish brown very cherty clay and dark reddish brown extremely stony clay that is about 75 percent limestone fragments with an underlying layer of indurated fractured limestone. The RUD association is noncalcareous, permeability is moderately slow to slow, available water capacity is very low and water erosion is a moderate hazard. The Eckrant-Rock outcrop consists of barren exposures of indurated limestone with dark gray extremely stony clay and an underlying layer of indurated fractured limestone. ErG associations are moderately alkaline and noncalcareous, permeability is moderately slow, available water holding capacity is very low and water erosion is a severe hazard. The Comfort-Rock outcrop consists of dark brown extremely stony clay with an underlying layer of indurated fractured limestone. CrD associations are mildly alkaline and noncalcareous, permeability is slow, available water capacity is very low and water erosion is a slight hazard.

The terrestrial habitat impacts of the Type 2 reservoirs will depend on the amount of clearing done, frequency of inundation, and the rapidity of pool drainage following capture of run-off. Operation of a Type 2 recharge structure on Parker's Creek in Medina County for 20 years has resulted in little or no impact to terrestrial vegetation beyond an approximately 20 acre cleared area immediately upstream of the dam. Conservation (recharge) pool levels and major types of habitat that would be inundated as a result of operation of the Type 2 reservoirs being studied here are listed in Table 2.2-3.

The types of dissolved and suspended materials entering the recharge zone is not expected to be altered by the Type 2 reservoirs. As only brief impoundment and immediate recharge will take place there will be no opportunity for thermal stratification to set up or for oxidation of entrained organic material to deplete dissolved oxygen levels. The presence of the

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[16] United States Department of Agriculture, Soil Conservation Service. and Texas Agricultural Experiment Station, “Soil Survey of Comal and Hays Counties, Texas,” USDA, 1984.

Table 2.2-3.
Habitats Affected by Operation of Type 2 Recharge Reservoirs (L-18)

Reservoir	*Recharge Pool[1] (acres)*	*Grassland (%)*	*Brush (%)*	*Developed (%)*	*Crops (%)*	*Woodlands (%)*	*Wetland (acres)*
Indian Creek	3,657	20%	80%				10.4
Lower Frio	1,099	20%	80%				7.4
Lower Sabinal	454						
Lower Hondo	232	70%				30%	5.5
Lower Verde	334	3%				97%	8.2
San Geronimo Creek	183		45%			40%	5
Government Creek	216	No information available					
Cibolo Dam #1	476	10%				40%	50
Dry Comal Creek	265[E]	5%	10%	5%	50%	20%	10

[1] Corresponds to conservation pool of a conventional reservoir.
E = estimated

dams will increase sediment deposition in the upstream channel, and extend the duration of recharge events.

Because Type 2 reservoirs are immediate recharge (direct percolation) structures that drain directly into karst features (fractures, holes, and/or caves) present below the stream channel, disturbance of the local karst system and its fauna is a possibility. The fauna inhabiting these caves are usually small in both species diversity and population size, and are adapted to relatively stable physical habitats, which presumably makes them particularly sensitive to disturbances outside of the natural regime. The results of the investigation of the karst fauna in northern Bexar County, however, seem to indicate that caves with biological communities have not been encountered in streambeds there.[17] Streambed openings in the recharge zone are subject to sedimentation during flow events. Openings in the streambed itself would tend to fill most rapidly since they are exposed to bed load movements. Openings in the stream bank would be exposed to successively smaller sediment loads and particle size at successively higher elevations. The interiors of all such openings however, would be exposed to the erosive force of flowing water, lessening the likelihood that an organized "terrestrial" community would be able to develop and persist in such a location.

[17] Elliot, William R., "Cave Fauna Conservation in Texas", Proceedings of the 1991 National Cave Management Symposium, Bowling Green Kentucky, American Cave Conservation Association, Horse Cave Kentucky, 1993.

Karst openings in the vicinity of the recharge structures that presently experience periodic flooding may be inundated for longer periods, or experience an increase in the maximum elevation to which the water rises following a runoff event, causing flow across the recharge zone. Both terrestrial and aquatic communities are extensive in the karst openings associated with the Edwards limestone, and significant threats to these habitats presently exist as a result of human activities in many areas, including northern Bexar County.[18,19] The extent of intermittently flooded karst zones that would be affected hydrologically by the proposed Type 2 structures is unknown, as is the extent to which these zones are inhabited, and how hydrologic changes might affect resident communities.

Two caves in the vicinity of the proposed Type 2 recharge sites in northern Bexar County, Government Creek Bat Cave and Surprise Cave have been explored and the faunas have been inventoried.[20] (Table 2.2-4). There are also caves in the vicinity of San Geronimo Creek, but none have been explored. In the vicinity of Culebra Creek, lack of access to the property has prevented a search for caves. No caves have been identified in the vicinity of Deep or Limekiln Creeks.

A petition to the United States Fish and Wildlife Service to list as endangered or threatened nine new species of invertebrates with limited distributions in caves of northern Bexar County has been filed (Table 2.2-4). The petition identifies specific inhabited caves, and a study is underway to identify additional habitat areas. The USFWS has recently performed a study having to do with the petition, but it has not yet been released. All of the Type 2 recharge sites are in areas that have potential for caves containing endangered species.[21]

Government Creek Bat Cave (Table 2.2-4) is located in the immediate vicinity of the potential recharge site on that stream. Although the known opening of this cave is located well above the impoundment elevation, the depth to which *Cicurina* n.s. 3, habitat extends is not known, and additional site surveys would be required to determine whether it might be affected by an increase in the duration of inundation events, or by an increase in the maximum inundation elevation within the cave. On-site surveys of the reservoir and surrounding areas and mitigation

[18] Ibid.
[19] Longley, G., "The Edwards Aquifer: Earth's Most Diverse Ground Water Ecosystem?" International. J. Speleol. 11:123-128, 1981.
[20] George Veni, Personal Communication, April 22, 1994.
[21] Ibid.

Table 2.2-4
Anthropods Listed for Protection on Petition to USFWS

Common Name	***Scientific Name***	***Summary of Habitat Preference***	***Cave Location Known to Exist***	***County***
Government Cave Spider	*Neoleptoneta microps*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Government Canyon Bat Cave	Bexar
Robber Baron Cave Harvestman	*Texella Cokendolpheri*	Small, eyeless or essentially eyeless troglobitic harvestman; karst features in N and NW Bexar Co.	Robber Baron Cave	Bexar
Madla's Cave Spider	*Cicurina madla*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Madla's Cave	Bexar
Vesper Cave Spider	*Cicurina vespera*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Bracken Bat Cave	Bexar
Robber Baron Cave Spider	*Cicurina baronia*	Small, eyeless or essentially eyeless troglobitic spider; karst features in N and NW Bexar Co.	Robber Baron Cave	Bexar
Veni's Cave Spider	*Cicurina venii*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co. troglobitic	Government Canyon Bat Cave	Bexar
Ground Beetle	*Rhadine exilius*	Small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	John Wagner Ranch Cave No. 3 (Marnock Cave)	Bexar
Ground Beetle	*Rhadine infernalis*	Small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	Government Canyon Bat Cave, Cave of the Woods, Genesis Cave, Helotes Blowhole, Isopit, Kamikaze Cricket Cave, Poison Ivy Pit, and Wurzbach Cave	Bexar
Helotes Mold Beetle	*Bastrisodes venyivi*	Small, essentially eyeless mold beetle; karst features in N and NW Bexar Co.	Helotes Hilltop Cave	Bexar

or relocation of the project may be required if caves with protected species are found and will be affected by project development. Government Canyon, including the Government Canyon Bat Cave site, is the location of a new state park. The Government Canyon State Park plan includes environmental resource preservation, a preserve for nesting Golden-Cheeked Warblers and Black-Capped Vireos, and some recreational facilities. Natural recharge in the canyon may not conflict with preserving the area's environmental resources and the park development plan, although extensive dam construction may conflict. Protected and candidate species known or thought to occur in the study areas of Uvalde, Bexar, Hays, Comal, and Medina Counties are listed in Table 2.2-5.

Table 2.2-5.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Edwards Aquifer Recharge from Natural Drainage – Type 2 Projects (L-18)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
BIRDS						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in HaysBexar, Medina, Uvalde, Comal
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in HaysBexar, Medina, Uvalde, Comal
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant inUvalde
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in Bexar, Comal, Hays
Wood Stork	*Mycteria americana*	forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	T	Migrant in Bexar, Uvalde
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant in Bexar, Medina, Uvalde, Comal, Hays
Black-capped Vireo	*Vireo atricapillus*	oak-juniper woolands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces	E	E	T	Nesting/Migrant in Bexar, Medina, Uvalde, Comal, Hays
Golden-cheeked Warbler	*Dendrpoica chrysoparia*	juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar, Medina, Uvalde, Comal, Hays
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields	C2	T	T	Migrant inBexar
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant inBexar
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant inBexar, Medina, Comal, Hays
REPTILES						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges	C1		C1	Bexar, Comal, Hays
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush	C2	T	T	Bexar, Medina, Uvalde, Comal, Hays
Spot-tailed earless Lizard	*Holbrookia lacerata*	Central & Southern Texas; oak-juniper woodlands and mesquite-prickly pear				Bexar, Medina, Comal, Hays

Table 2.2-5 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Bexar, Medina, Uvalde
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush	C2	T	T	Uvalde
Timber Rattlesnake	*Crotalus horridus*	floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Bexar
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Bexar, Medina, Comal, Hays
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquie savannah of coastal plain		T	wl	Bexar, Medina, Uvalde
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Bexar, Medina, Hays
AMPHIBIANS						
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	isolated, intermittent pools of a subterranean stream; sinkhole found in Medina Co.				Medina
Black Spotted Newt	*Notophthalmus meridionalis*	can be found in wet or sometimes wet areas, such as arroyos, canals, ditches, or shallow depressions; Gulf Coastal Plain of the San Antonio River	C2	T	E	Bexar
Cascade Caverns Salamander	*Eurycea latitans*	endemic; subaquatic, springs and caves in Comal Co.		T	T	Comal
Comal Springs Salamander	*Eurycea sp.8*	endemic to Comal Springs				Comal
Comal Blind Salamander	*Eurycea tridentifera*	endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal Co	C2	T	T	Bexar, Comal
Blanco River Springs Salamander	*Eurycea pterophila*	subaquatic, springs and caves in the Blanco River drainage in Blanco, Hays and Kendall				Hays
Texas Blind Salamander	*Eurycea rathbuni*	troglobitic, water-filled subterranean caverns, along San Marcos Spring Fault	E	E	T	Hays
San Marcos Salamander	*Eurycea nana*	headwaters of San Marcos River, downstream to 1/2 mile past IH-35	T	T	T	Hays
Blanco Blind Salamander	*Eurycea robusta*	troglobitic, water-filled subterranean caverns, may inhabit deep levels of Balcones Aquifer	C2	T	T	Hays
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	endemic; troglobitic; springs, seeps, cave streams, and creek headwaters	C2			Bexar, Medina, Uvalde, Comal, Hays
FISH						
Blue Sucker	*Clycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River	C2	T	wl	Uvalde, Hays
Guadalupe Bass	*Micropterus treculi*	Perennial streams of the Edward's plateau region	C2		wl	Bexar, Uvalde, Comal, Hays
Headwater catfish	*Ictalurus lupus*	Clear Streams				Historic in Uvalde
Toothless Blindcat	*Trogloglanis pattersoni*	troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer	C2	T	E	Bexar

Table 2.2-5 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Widemouth Blindcat	*Satan eurystomus*	troglobitic, blind catfish endemic to the San Antonio pool of the Edward's Aquifer	C2	T	E	Bexar
Fountain Darter	*Etheostoma fonticola*	known only from the San Marcos and Comal rivers; springs and spring-fed streams in dense vegitation		T	E	Comal, Hays
ARTHROPODS						
Peck's Cave Amphipod	*Stygobromus pecki*	small, aquatic crustacean; lives underground in Edwards Aquifer	E			Comal
Ezell's Cave Amphipod	*Stygobromus flagellatus*	known only from artesian wells	C2		wl	Hays
Texas Cave Shrimp	*Palaemonetes antrorum*	subterranean sluggish streams and pools	C2		wl	Hays
Government Cave Spider	*Neoleptoneta microps*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	PE			Bexar
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Small, eyeless or essentially eyeless harvestman; karst features in N and NW Bexar Co.	PE			Bexar
Madla's Cave Spider	*Cicurina madla*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	PE			Bexar
Vesper Cave Spider	*Cicurina vespera*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	PE			Bexar
Robber Baron Cave Spider	*Cicurina baronia*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	PE			Bexar
Veni's Cave Spider	*Cicurina venii*	Small, eyeless or essentially eyeless spider; karst features in N and NW Bexar Co.	PE			Bexar
Flint's net-spinning caddisfly	*Cheumatopsyche flinti*		C2		wl	Uvalde, Hays
Exilis ground beetle	*Rhadine exilis*	small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	PE			Bexar
Infernalis ground beetle	*Rhadine infernalis*	small, essentially eyeless ground beetle; karst features in N and NW Bexar Co.	PE			Bexar
Helotes Mold Beetle	*Bastrisodes venyivi*	small, essentially eyeless mold beetle; karst features in N and NW Bexar Co.	PE			Bexar
San Marcos Saddle Case Caddisfly	*Protoptila arca*	known from an artesian well in Hays Co.; 1-2m deep water	C2		wl	Hays
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	known from an artesian well in Hays Co.	E			Comal, Hays
PLANTS						
Texas wild-rice	*Zizania texana*	perennial, emergent, aquatic grass known from San Marcos River	E	E	E	Hays
Big Red Sage	*Salvia penstemonoides*	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade	C2		wl	Bexar
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			wl	Bexar
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			wl	Bexar

Table 2.2-5 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Bexar, Medina, Uvalde, Comal
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tarnaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			wl	Bexar
Correll's false dragon-head	*Physostegiacorrellii*	wet soils including roadside ditches, irrigation channels			wl	Bexar
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Bexar, Medina, Uvalde, Comal
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tarnaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			wl	Bexar
Correll's false dragon-head	*Physostegiacorrellii*	wet soils including roadside ditches, irrigation channels			wl	Bexar
Glass Mountain coral root	*Hexalectrisnitida*	mesic woodlands in canyons, lower elevations, under oaks				Bexar
Sandhill woolywhite	*Hymenopappuscarrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Bexar, Medina
Texas Mock-Orange	*Philadelphus texensis*	On limestone bluffs and among boulders on the Edwards Plateau	C2		wl	Uvalde, Comal , Medina
MAMMALS						
Cave Myotis Bat	*Myotis velifer*	colonial, and cave dwelling; hibernates in limestone caves of Edwards Plateau	C2			Bexar, Uvalde, Comal, Hays
White-nosed coati	*Nasua narica*	woodlands, rocky and riparian areas		T	wl	Uvalde
Black Bear	*Usus americanus*	Mountains, broken country, woods, brushlands, forests	T	T	T	Uvalde
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, farmyards, forest edges			C2	Bexar, Comal, Hays
Frio Pocket Gopher	*Geomys texensis bakeri*	associated with nearly level Atoc soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as 2m.	C2			Medina, Uvalde
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas	E	E	E	Uvalde
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Uvalde

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

The Government Creek area is known to contain numerous prehistoric sites and a 17th century Spanish colonial trail. Other recharge sites may contain similar cultural resources. Cultural resources protection on public lands in Texas, or lands affected by projects regulated under Department of the Army permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

2.2.4 Engineering and Costing.

Preliminary cost estimates for all Type 2 recharge enhancement projects located in the Nueces River Basin were prepared in 1994 by HDR,[22] and preliminary cost estimates for the Type 2 recharge enhancement projects located in the Guadalupe-San Antonio River Basin were prepared in 1998 by HDR.[23,24] The costs presented in Table 2.2-6 have been adjusted to Second Quarter 1999 prices.

As seen in Table 2.2-6, the Type 2 Recharge Program 2A has a total cost of $287,183,000 and a total annual cost of $23,455,000. Under this Program, sustained yield pumpage is enhanced by about 21,577 acft/yr, which results in an estimated unit cost of water of $1,087 per acft.

The Program 2B total cost was computed as $165,145,000 with a total annual cost of $12,785,000. Sustained yield pumpage for Program 2B is 15,980 acft/yr, which results in an estimated unit cost of $800 per acft.

Table 2.2-6 shows that Program 2C appears to be the most efficient program from both a hydrologic and a unit cost standpoint. Its total project cost of $84,239,000 equates to an annual cost of $6,536,000 per year. With a sustained yield increase of 13,451 acft/yr, the resulting annual unit cost of water under Program 2C is $486 per acft.

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[22] HDR Engineering, Inc., "Nueces River Basin Edwards Aquifer Recharge Study, Phase IVA," Edwards Underground Water District, May 1994.

[23] HDR, Op. Cit., March 1998.

[24] HDR, "Modification of Principal Spillways at Existing Flood Control Projects for Recharge Enhancement," Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses, San Antonio River Authority, et al., March 1998.

Table 2.2-6.
Summary of Costs for
Recharge Enhancement Programs — Type 2 Reservoirs (L-18)
Second Quarter 1999 Prices

Item	Program 2A[1]	Program 2B[2]	Program 2C[3]
Capital Costs			
Dams and Reservoirs	$178,168,000	$92,377,000	$55,899,000
Outlet Modifications	31,000	20,000	20,000
Total Capital Cost	**$178,199,000**	**$92,398,000**	**$55,920,000**
Engineering, Legal Costs and Contingencies	$44,822,000	$25,525,000	$12,548,000
Land Acquisition	32,016,000	23,505,000	6,220,000
Environmental & Archaeology Studies and Mitigation	11,872,000	9,706,000	589,000
Surveying	3,202,000	2,351,000	622,000
Interest During Construction	17,073,000	11,661,000	8,342,000
Total Project Cost	**$287,183,000**	**$165,145,000**	**$84,239,000**
Annual Costs			
Debt Service (6 percent for 30 years)	$2,612,000	$497,000	$2,000
Reservoir Debt Service (6 percent for 40 years)	16,696,000	10,521,000	5,596,000
Operation and Maintenance	2,219,000	1,001,000	210,000
Water Rights Mitigation	1,928,000	766,000	729,000
Total Annual Cost	**$23,455,000**	**$12,785,000**	**$6,536,000**
Available Project Yield (acft/yr)	**21,577**	**15,980**	**13,451**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[4]	**$1,087**	**$800**	**$486**
Annual Cost of Water ($ per 1,000 gallons)	**$3.34**	**$2.43**	**$1.69**

1 Program 2A includes Indian Creek, Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, Northern Bexar/Medina County Projects, Dry Comal, and Salado Creek FRS outlet modifications.

2 Program 2B includes Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Lower Blanco, Cibolo Dam No. 1, San Geronimo, and Salado Creek FRS outlet modifications.

3 Program 2C includes Lower Frio, Lower Sabinal, Lower Hondo, Lower Verde, Cibolo Dam No. 1, and Salado Creek FRS outlet modifications.

4 Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer.

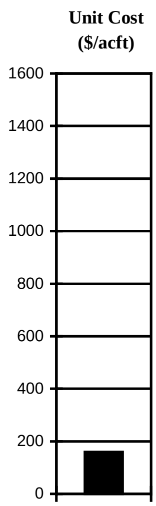
2.2.6 Implementation Issues

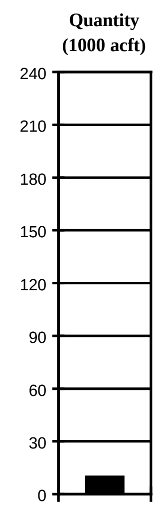
Implementation of Type 2 Recharge Programs could directly affect the feasibility of other water supply options under consideration, including L-17, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-20, G-30, G-40, CZ-10C, CZ-10D, SCTN-2a, SCTN-6, SCTN-7, SCTN-14a and SCTN-14b.

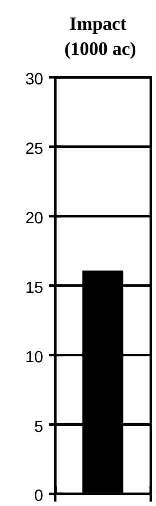
An institutional arrangement is needed to implement this project including financing on a regional basis.

1. Necessary permits could include:
a. TNRCC Water Right and Storage permits;
b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines;
   c. TWDB Sand, Gravel, and Marl Removal permits; and
   d. GLO Easement for use of state-owned land.
   e. Edwards Aquifer Authority recharge recovery permit (rules governing such permits are presently under consideration).
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries;
   b. Habitat mitigation plan;
   c. Environmental studies; and
   d. Cultural resource studies.
   e. Study of impact on karst geology organisms.
3. Land and/or easements must be acquired through either negotiations or condemnation.
4. Relocations and crossings:
   a. Highways and railroad; and
   b. Other utilities.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 11/02/99







OPTION NUMBER: **S-13B**

OPTION NAME: **Medina Lake System — Existing Rights and Contracts with Irrigation Use Reduction for Recharge Enhancement**

OPTION DESCRIPTION: *Operate the Medina Lake System subject to existing municipal water rights and contracts with irrigation use reduction resulting in Edwards Aquifer recharge enhancement.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$159**	**per acft**[1]	**Raw Water in Aquifer**
QUANTITY OF WATER:	**9,873**	**acft/yr**[2]	
LAND IMPACTED:	**16,000**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Purchase and/or retirement of irrigated acreage.

[2]**QUANTITY OF WATER:** Enhanced recharge through the Medina Lake System provides for potential recharge recovery of 9,873 acft/yr.

[3]**LAND IMPACTED:** Removal/conversion of approximately 16,000 acres of irrigated farmland from production or to dryland farming.

ENVIRONMENTAL ISSUES: Limited, if any, adverse effects.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Impact on local economy of removal/conversion of irrigated acreage. TNRCC water right amendment potentially needed. Edwards Aquifer Authority recharge recovery permit required.

ADDITIONAL FACTORS: Ability of sponsors to obtain permits and/or other protection of the security and ownership or credits for enhanced quantities of water recharged to the Edwards Aquifer. Structural and operational integrity of Medina Dam and appurtenant water control gates.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-30, and/or SCTN-6.

2.3 Medina Lake System — Existing Rights and Contracts with Irrigation Use Reduction for Recharge Enhancement (S-13B)

2.3.1 Description of Option

The Medina Lake System is located on the Medina River in Medina and Bandera Counties, about 25 miles northwest of San Antonio (Figure 2.3-1). The project was constructed between 1911 and 1913 and is presently owned and operated by the Bexar-Medina-Atascosa Counties Water Control and Improvement District No. 1 (BMA). Medina Lake has a conservation storage capacity of approximately 254,000 acft, controls 634 square miles of the Medina River watershed, and inundates approximately 5,575 acres at conservation pool level. Immediately below Medina Lake is the much smaller Diversion Lake, from which an extensive system of distribution canals and laterals extends for the delivery of water for irrigation purposes.

Medina and Diversion Lakes are both located on various geologic formations of the Edwards Aquifer and recharge water into the aquifer and leak water around the dams into the Medina River. Recent field observations by the U.S. Geological Survey (USGS)[1] are summarized as follows:

> "Field observations in the Medina Lake area confirm the findings of previous investigators that Medina Lake mostly overlies rocks of the upper member of the Glen Rose Limestone. The channel downstream of Medina Dam to the upper end of Diversion Lake also overlies the upper member of the Glen Rose Limestone. Most of Diversion Lake overlies a thin section of the Edwards Aquifer hydrogeologic division VIII (basal nodular member) and the basal part of hydrogeologic division VII (dolomitic member). Hydrogeologic subdivisions VIII and VII might be hydraulically connected to Medina Lake at high lake stages."

During the period of 1934 to 1989, Edwards Aquifer recharge associated with the Medina Lake System was estimated to average 41,830 acft/yr, ranging from 10,250 acft in 1951 to 53,270 acft in 1936.[2]

In this option, recharge to the Edwards Aquifer is increased by holding more water in the lakes. The additional water for storage and recharge would come through the purchase and/or

[1] Lambert, Rebecca B. and Roger W. Lee, "Assessment of Hydrogeology, Hydrologic Budget, and Water Chemistry of the Medina Lake Area, Medina and Bandera Counties, Texas, Draft," U.S. Geological Survey, 1998.
[2] HDR Engineering, Inc. (HDR), "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September 1993.

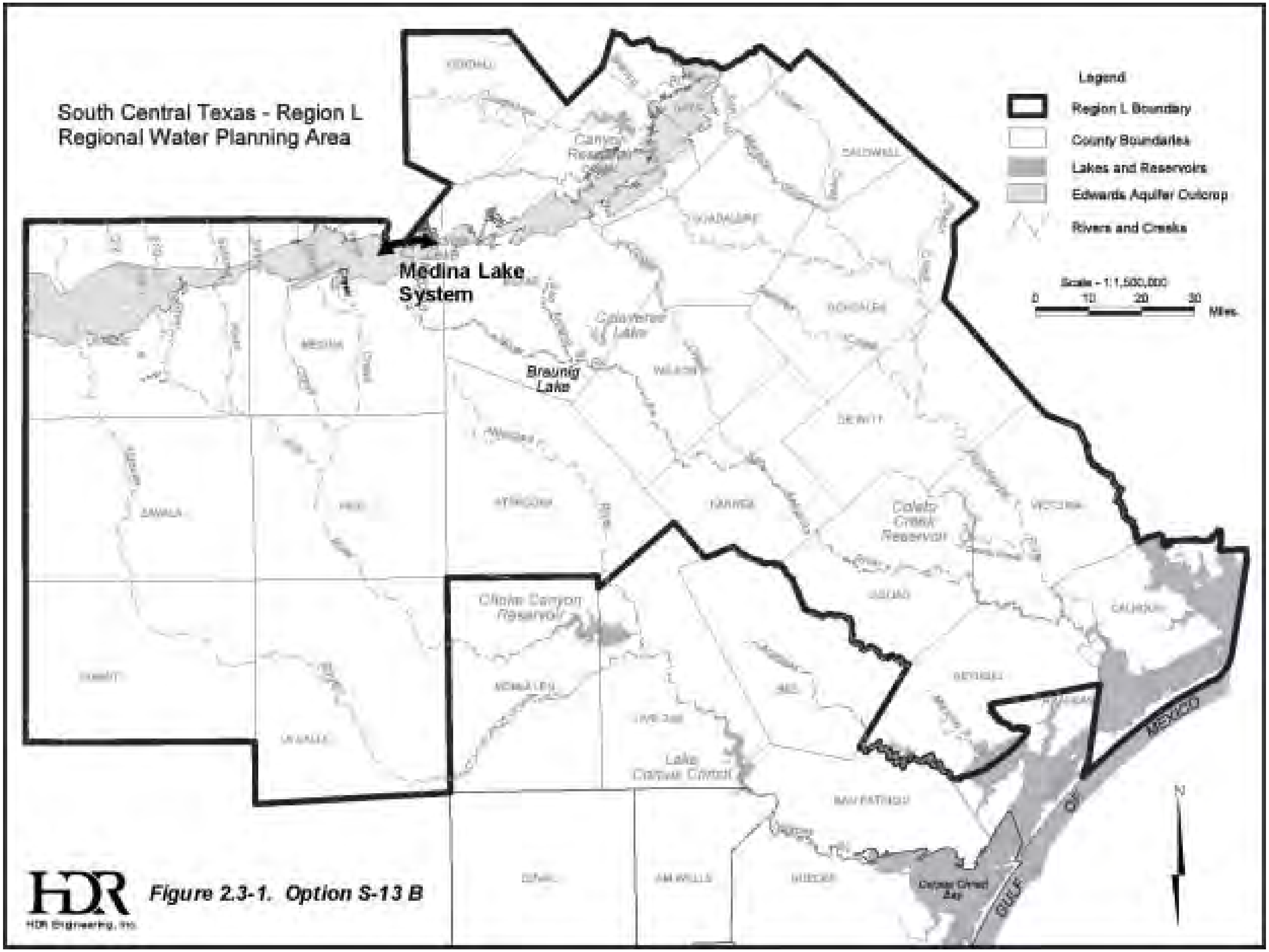


Figure 2.3-1. Option S-13 B

retirement of presently irrigated acreage, thereby minimizing diversions for irrigation. The enhanced recharge might be recaptured through a recharge recovery permit,[3] which could be obtained through the Edwards Aquifer Authority (EAA). It is important to note that the conceptual basis, statutory authority, and administrative procedures associated with recharge recovery permits are issues under consideration in the EAA's ongoing development of rules.

2.3.2 Enhanced Recharge and Groundwater Availability

To evaluate the potential for enhanced recharge, two scenarios were evaluated. In each, the Guadalupe-San Antonio River Basin Model (GSA Model)[4] was used to calculate recharge. The GSA Model includes specific relationships for Medina and Diversion Lakes, developed by Espey, Huston & Associates, Inc. (EH&A),[5] for estimating monthly recharge to the aquifer and leakage through the geologic formations near the dams based on the respective volumes of water stored in each lake. These recharge and leakage relationships are based on mass balance analyses using many years of gaged hydrologic data. Recent studies by the USGS,[6] based on 9 months of intensive hydrologic data collection, indicate recharge rates at lower lake levels that are somewhat less than those based on the EH&A study. The GSA Model tracks values of monthly recharge to the Edwards Aquifer and leakage through the geologic formations at the dams that show up as additional streamflow in the Medina River below the Diversion Lake Dam and other points downstream.

First, the GSA Model was used to establish baseline recharge conditions with full diversion of existing water rights for irrigation and municipal supply. Next, an additional simulation was performed assuming elimination of diversions for irrigation up to 45,856 acft/yr and inclusion of existing water supply contracts and commitments from the Medina Lake System. With curtailed demands, more water would remain in storage and the elevation of the lake would be higher, as shown in Figure 2.3-2. Increased storage results in increased Edwards Aquifer recharge and losses to evaporation and leakage. Figure 2.3-3 shows the enhanced recharge values, summarized on a yearly basis, for the 1934 to 1989 simulation period. The

[3] HDR, "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.
[4] HDR, Op. Cit., September 1993.
[5] Espey, Huston & Associates, Inc., "Medina Lake Hydrology Study," Edwards Underground Water District, March 1989.
[6] Lambert, Rebecca B. and Roger W. Lee, Op. Cit., 1998.

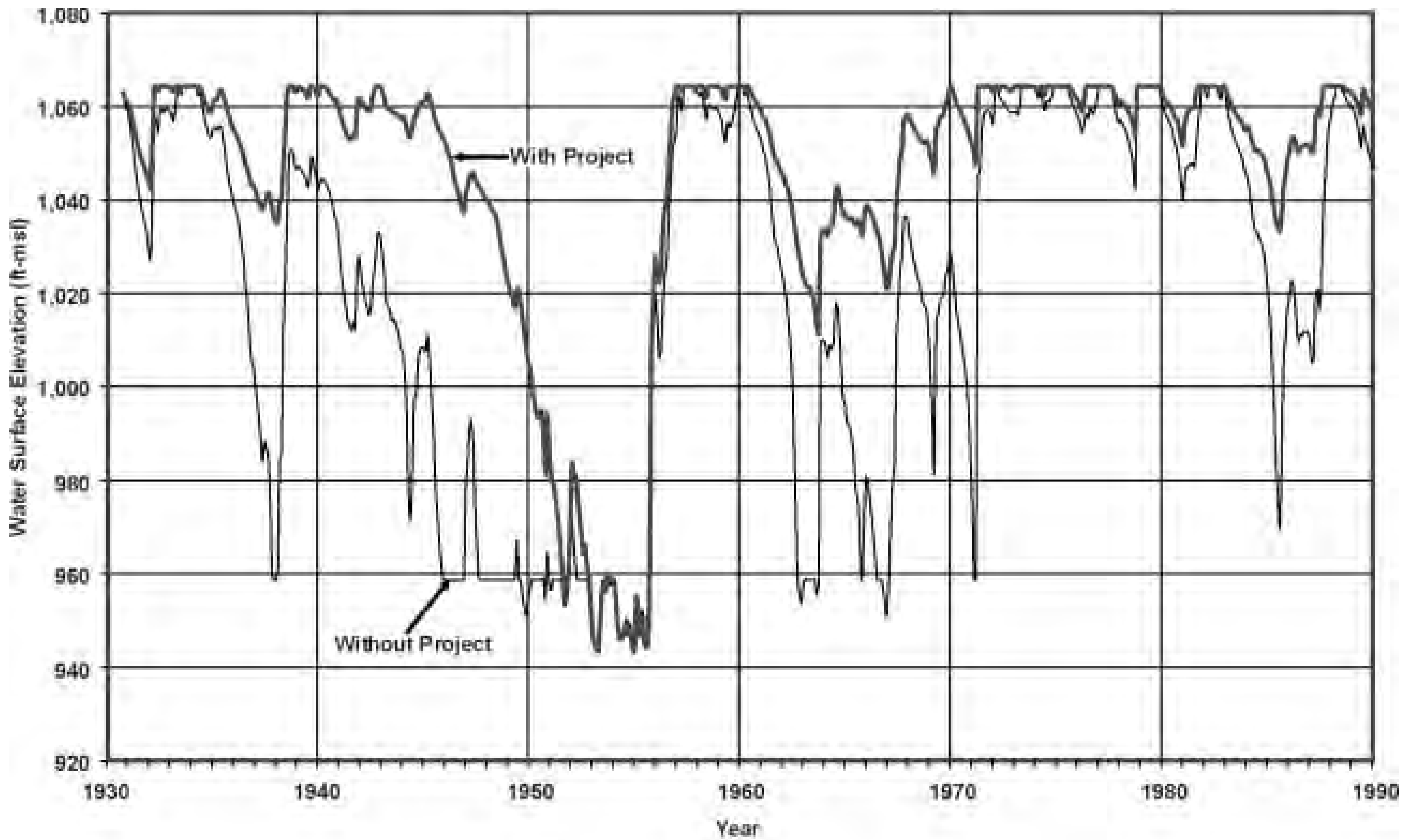


Figure 2.3-2. Medina Lake Water Surface Elevation

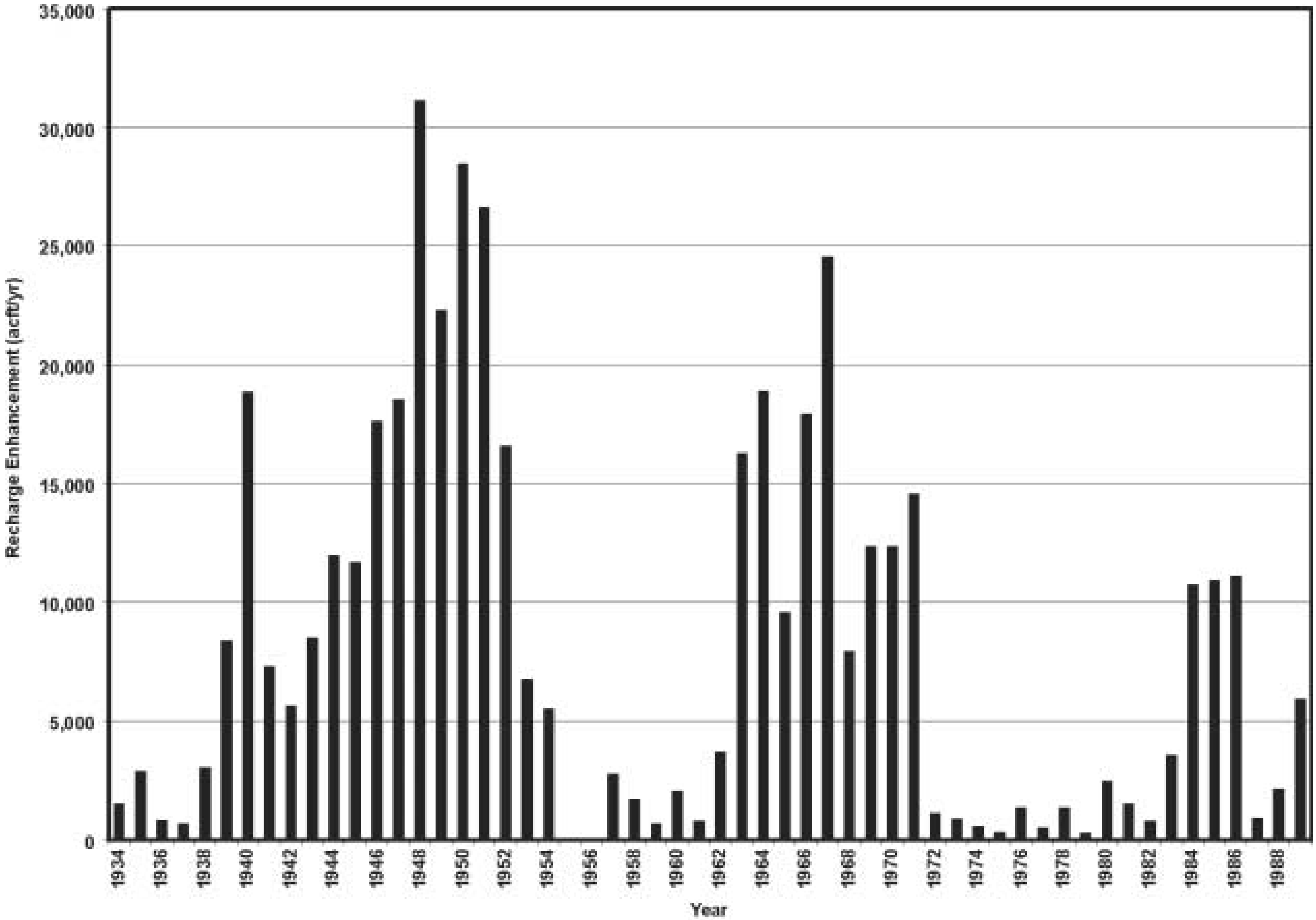


Figure 2.3-3. Enhanced Recharge for Medina Lake System (Option S-13B)

average over the entire 56-year period was 8,136 acft/yr, with a maximum of 31,083 in 1948. Importantly, there was a period of 7 years (1946 to 1952) with substantially enhanced recharge values (16,000 to 31,000 acft) immediately preceding the worst years of the critical drought period (1954 to 1956).

Once the monthly enhanced recharge values were generated, they were added to the recharge in the GWSIM-IV[7] Model of the Edwards Aquifer at spatial locations representing Medina and Diversion Lakes. The GWSIM-IV Model provides the basis for determining the additional groundwater that could be made available for a recharge recovery permit from EAA (Appendix C). The upper panel of Figure 2.3-4 summarizes results of the GWSIM-IV Model, including the change in sustained yield of the aquifer associated with the enhanced recharge of this option. With the enhanced recharge as shown in Figure 2.3-3 entering via Medina and Diversion Lakes, the sustained yield pumpage could be increased by an estimated 9,873 acft/yr. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board rules for regional water supply planning. At this time, the concept of sustained yield enhancement as a basis for recharge recovery permitting has not been adopted by the EAA.

The final step in the groundwater evaluation was to move from the sustained yield calculations to examine the effects of this enhanced recharge on 400,000-acft/yr permitted pumpage management plan of the Edwards Aquifer. Assuming that the change in sustained yield might form the basis for a recharge recovery permit of 9,873 acft/yr, the GWSIM-IV Model was applied with the additional 9,873 acft/yr included as distributed municipal pumpage. The lower panel of Figure 2.3-4 shows that the Comal Springs flow patterns under the 400,000-acft/yr management plan and with the additional pumpage of the recharge recovery permit are almost identical.

Figure 2.3-5 presents several plots that allow for comparisons of the impact of this option on streamflows. Monthly median streamflows and streamflow frequency plots with and without this option are presented for the Medina River near Riomedina (USGS #08180500) and the Guadalupe River at the Saltwater Barrier near Tivoli (USGS #08188800). Median monthly

[7] Texas Water Development Board (TWDB), "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," Report 340, July 1992.

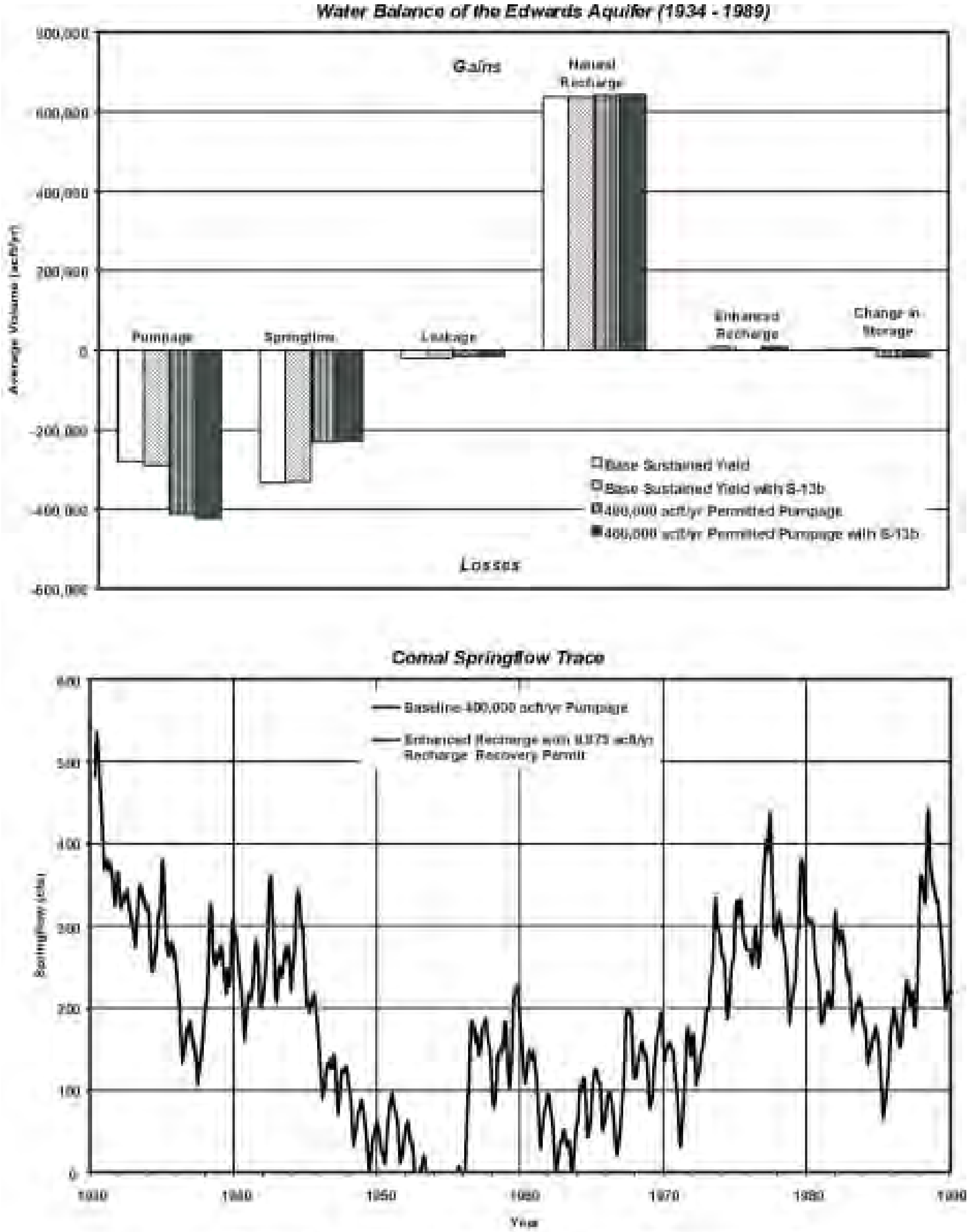


Figure 2.3-4. Medina Lake System Recharge Enhancement Water Balance and Springflow Considerations

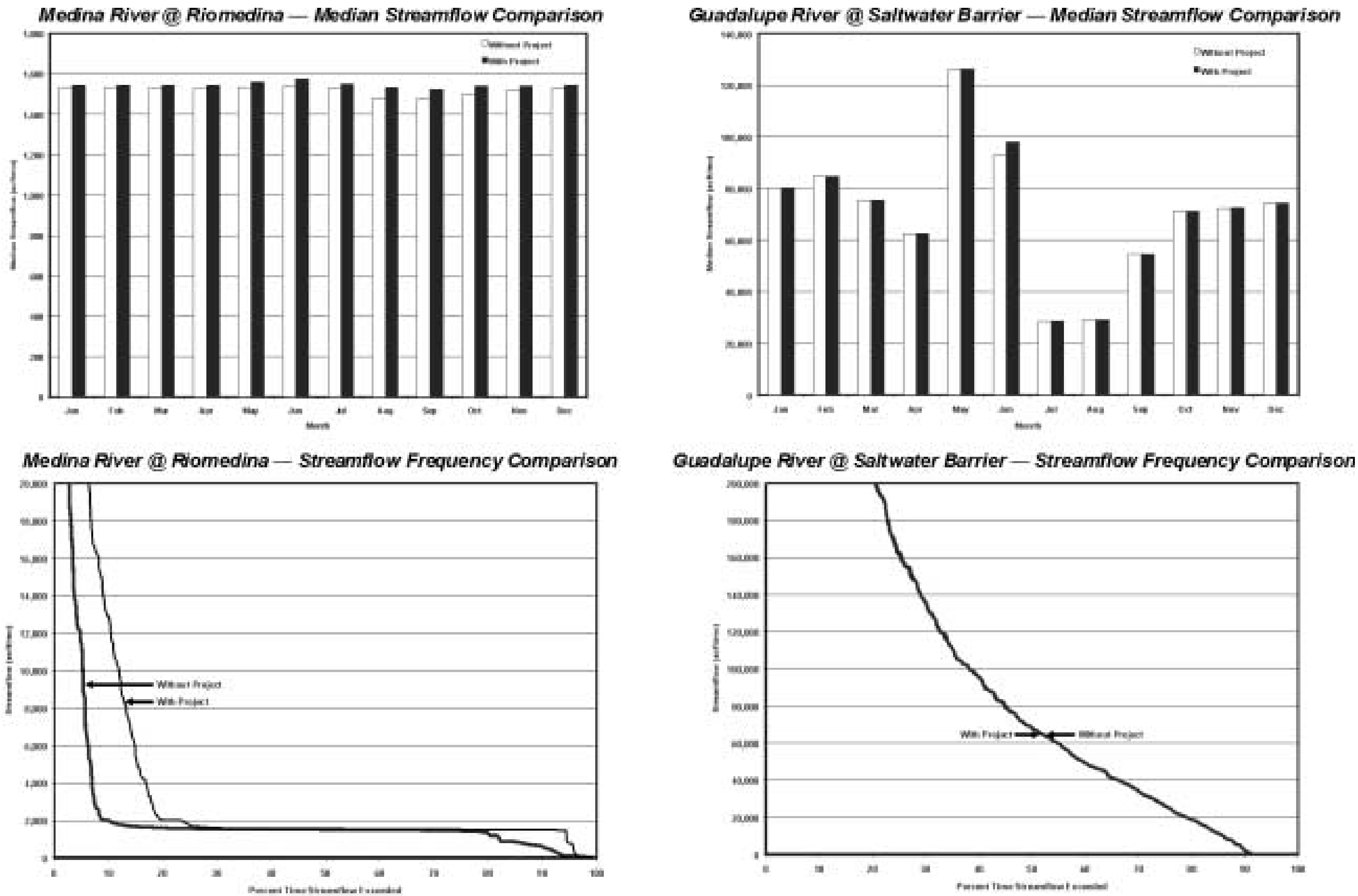


Figure 2.3-5. Medina Lake System Recharge Enhancement Streamflow Comparisons

streamflows in the Medina River at Riomedina, below the Diversion Lake Dam, and in the Guadalupe River at the Saltwater Barrier would be increased with this option. These increases in median streamflow are brought about because of the changes that this option would cause in the stored water at any given time, primarily in Medina Lake and to a lesser degree in Diversion Lake. With the removal of the irrigation diversions, the amount of water in storage would always be greater than with that irrigation. This would cause Medina Lake and Diversion Lake to spill excess water more frequently, due to large storm runoff events. On the streamflow frequency plot for the Medina River at Riomedina, there is a greater frequency of higher flows, associated largely with storm events, and also of lower flows on the right end of the plot. The increase in flows in this low-flow portion of the curve is caused by increased leakage through the geologic formations near the dams due to the higher elevations of water in storage. This leakage contributes to maintaining flows in the river during drier times.

Monthly median and streamflow frequency for the Guadalupe River at the Saltwater Barrier would also be positively affected by the change in Medina Lake System operations of this option. Freshwater inflows to the Guadalupe Estuary as measured at the Saltwater Barrier would be increased by an average of 12,129 acft/yr (about 0.74 percent) under this option.

2.3.3 Environmental Issues

The primary environmental concerns associated with Option S-13B includes in-lake effects of maintaining a higher water level, the potential for impact to the Edwards Aquifer recharge quantity, possible effects associated with the retirement of farm acreage, and the potential for impacts to downstream flows and bay and estuary inflows.

Under current operations, Medina Lake would be drafted to very low levels during drought conditions, leaving little water for recharge. Under this option, water surface elevations in Medina Lake would continue to fluctuate, but would, on average, be higher than current lake levels, resulting in potential recreational benefits. Because Medina Lake is an existing reservoir, this option would not have direct impacts on existing land uses within the reservoir boundaries.

The basis of this option is, of course, the fact that the quantity of recharge to the Edwards Aquifer would increase. Recharge to the Edwards Aquifer from Medina and Diversion Lakes would increase 19 percent over the present condition (by an estimated 8,136 acft/yr) based on long-term average. During the 10-year critical drought years (i.e., 1947 to 1956), additional recharge is estimated to average 15,569 acft/yr.

Streamflow in the Medina River below Diversion Lake would be increased, as shown in Figure 2.3-5, by between 0.6 and 3.6 percent, based on monthly median flows at Riomedina and increases in low-flow frequency. Maintenance of higher average water surface elevations of Medina Lake results in an increase in the frequency and magnitude of uncontrolled spills, which increases average annual flows in the Medina River below Diversion Lake. Figure 2.3-5 shows positive effects on inflows to the Guadalupe Estuary from operation of this alternative, with annual average inflows increasing by about 12,129 acft/yr.

Table 2.3-1 summarizes important species having habitat or known to occur in counties surrounding the Medina Lake System. The Bracted Twistflower (*Streptanthus bracteatus*) has been recorded near the reservoir and is listed as one of concern by TPWD and endangered by TOES. Because no inundation will occur outside the existing reservoir, this species will be unaffected by this alternative. Other mapped species of possible concern around the reservoir system are Texas Amorpha (*Amorpha roemeriana*) and Buckley Triodia (*Tridens buckleyanus*), which are both vascular plants. The Widemouth Blindcat (*Satan eurystomus*) and the Toothless Blindcat (*Trogloglanis pattersoni*), both candidates for federal listing and listed as threatened by the Texas Parks and Wildlife Department, are troglobitic species known only from deep wells in the Edwards Aquifer beneath the City of San Antonio. Because Option S-13B is expected to increase recharge and not affect recharge water quality, adverse impacts on these species are not anticipated.

No impacts to cultural resources are anticipated as a result of modified Medina Reservoir operations. Because the Medina Lake System is an existing resource, no mitigation requirements are anticipated for the reservoir itself.

Farmland retirement issues would be associated with the conversion of an estimated 16,000 acres of irrigated farmland along the Medina Canal System in southern Bexar, Medina, and Atascosa Counties to either dryland farming or rangeland. Currently, the Edwards Aquifer Authority is proposing to use a federal program, funded through the U.S. Department of Agriculture, in Bexar County that would pay up to 80 percent of costs to voluntarily set aside irrigated lands and plant native grasses on enrolled land. The specific program being considered is for lands retired for 15 years or more in areas with sensitive environments. While the irrigated farmland itself is not over sensitive lands, the water use is certainly related to pumping the

Table 2.3-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Medina Lake System Recharge Enhancement (S-13B)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	E	Nesting/Migrant
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Buckley Triodia	*Tridens buckleyanus*				NL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	T	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Amorpha	*Amorpha roemeriana*				NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Resident

Table 2.3-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	Intermittent pools of subterranean streams			NL	NL
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL Potentially Endangered/Threatened Blank = Rare, but no regulatory listing status

sensitive Edwards water and could potentially be considered for such programs. Option S-13B could permanently retire the water rights so that loss of irrigation could also be permanent.

Fallow farmland with no native grass plantings could become infested with opportunistic weeds, followed by slower growing native thornbrush plants characteristic of the surrounding unimproved rangelands. Recovery of the land could take two decades or more, depending on use for cattle grazing and brush management practices. These lands, along with lands converted to improved rangeland, would eventually provide additional native species habitat. A program of converting cropland to native grasses would speed the process of reaching a mature native plant community and reduce the opportunity for soil erosion through water and winds. Such a program could provide habitat for native Texas wildlife, including the horned toad, tortoises, deer, hawks, and other dessert grassland species.

2.3.4 Water Quality and Treatability

No change is expected in water quality in either the Medina Lake System or the Edwards Aquifer.

2.3.5 Engineering and Costing

For this option, water currently diverted for irrigation would be retained in the Medina Lake System and a portion of this would recharge the Edwards Aquifer. This water could provide the basis for a recharge recovery permit from the EAA and an increase in dependable municipal supply of 9,873 acft/yr. Implementation of this option would require institution of financial arrangements with BMA and/or the owners of irrigated farmland served by the Medina Canal System. For this analysis, it has been assumed that financial compensation could be based on purchase and/or retirement of about 16,000 acres of irrigated land at a unit cost of $1,000 per acre. No new facilities would be required to implement this option; however, historical concerns regarding the structural and operational integrity of Medina Dam and appurtenant water control gates could lead to substantial additional (contingency) costs. The annual cost for this option was based on debt service over 30 years at a 6 percent annual interest rate for the purchase and/or retirement of irrigation lands. This results in an annual expense of $1,279,000 (Table 2.3-2). With an additional municipal water supply of 9,873 acft/yr provided by this option, the annual unit cost is $159 per acft, or $0.49 per 1,000 gallons.

2.3.6 Implementation Issues

Implementation of Edwards Aquifer recharge enhancement and recovery through reduction/elimination of irrigation demands on the Medina Lake System could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-30, and/or SCTN-6.

An institutional arrangement is needed to implement this project, including financing on a regional basis.

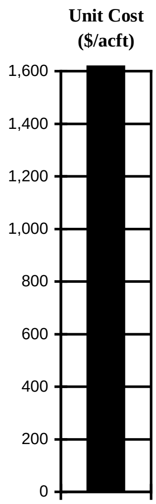
1. Implementation, at a minimum, will require:
    a. Determination of impact on local economy from retirement and/or purchase of irrigated lands.
    b. Texas Natural Resource Conservation Commission Water Rights Permit Amendment.
    c. EAA Recharge Recovery Permit.
    d. Other environmental studies.

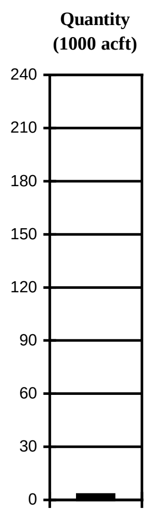
Table 2.3-2.
Cost Estimate Summary for
Medina Lake — Existing Rights and Contracts with
Irrigation Use Reduction for Recharge Enhancement (S-13B)
Second Quarter 1999 Prices

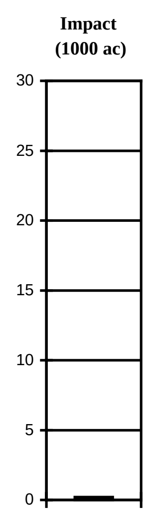
Item	***Estimated Cost***
Capital Costs	
Irrigated Acreage Retirement (16,000 acres @$1,000 per acre)	$16,000,000
Total Capital Cost	**$16,000,000**
Engineering, Legal Costs, and Contingencies	5,600,000
Total Project Cost	**$21,600,000**
Annual Costs	
Debt Service (6 percent for 30 years)	1,569,000
Total Annual Cost	**$1,569,000**
Available Project Yield (acft/yr)	9,873
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	$159
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	$0.49

[1] Reported Annual Cost is for additional water supply in the Edwards Aquifer.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft – 12/06/99







OPTION NUMBER: G-30
OPTION NAME: Guadalupe River Diversion near Comfort to Recharge Zone via Medina Lake

OPTION DESCRIPTION: *Water would be diverted from the Guadalupe River in the reach between Comfort and Center Point and pumped to the watershed divide where it would flow via Mason Creek and the Medina River to the Medina Lake System. Water would then be pumped to the Edwards Aquifer recharge zone in northeastern Medina and northern Bexar Counties to increase Edwards Aquifer recharge and the reliable quantity of water available for pumpage.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$2,079**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**3,902**	**acft/yr[2]**
LAND IMPACTED:	**256**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Guadalupe River intake and pump station, raw water pipeline to Medina River tributary, reservoir intake and pump stations, raw water pipeline to recharge zone, and recharge structures.

[2]**QUANTITY OF WATER:** Downstream water rights, instream flow requirements, level of Edwards Aquifer pumpage affecting downstream supplies to meet downstream needs, and instream flow requirements. With 72-inch diameter diversion pipeline, average available would be 28,443 acft/yr, with 5,962 acft/yr available during the 1947 to 1956 drought. This diversion would reduce firm yield of Canyon Lake by about 2,725 acft/yr and the cost of this yield reduction is included in the cost of water for this option. The recharge enhancement quantity to the Edwards Aquifer is net of channel and evaporative losses during transfer.

[3]**LAND IMPACTED:** Pipeline right-of-way and recharge structure sites.

ENVIRONMENTAL ISSUES: Guadalupe River instream flows and effects of pipeline routes and recharge structures upon terrestrial habitat. Resource conflicts can be avoided by careful selection of pipeline routes. Construction can be scheduled to avoid nesting schedules of any threatened or endangered species.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water and ability of sponsors to obtain credits for recharge that can be expressed in quantities of additional Edwards Aquifer pumping rights.

ADDITIONAL FACTORS: Ability to obtain permits and Canyon Lake water for this purpose.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, S-13B, G-15C, G-24, G-32, G-38C, SCTN-6, SCTN-8, SCTN-10, SCTN-16a, SCTN-16b, and/or SCTN-16c.

2.4 Guadalupe River Diversion near Comfort to Recharge Zone via Medina Lake (G-30)

2.4.1 Description of Option

Option G-30 includes the diversion of water from the Guadalupe River near Comfort and importation of this water to the San Antonio River Basin for enhancement of Edwards Aquifer recharge. With respect to water potentially available for diversion, this option includes two primary sources: 1) unappropriated streamflow; and 2) flows that would otherwise have been impounded in Canyon Lake. Water available from both of these sources was computed subject to senior water rights (excluding storage rights in Canyon Lake) and Consensus Environmental Criteria. Impacts to storage rights in Canyon Lake were quantified as a reduction in firm yield and costs for the purchase of this volume of water from the Guadalupe-Blanco River Authority (GBRA) were included in the cost estimate. The enhanced recharge might be recaptured through a recharge recovery permit,[1] which could be obtained through the Edwards Aquifer Authority (EAA). It is important to note that the conceptual basis, statutory authority, and administrative procedures associated with recharge recovery permits are issues under consideration in the EAA's ongoing development of rules.

As shown in Figure 2.4-1, the major facilities associated with this option include a channel dam, intake structure, and pump station on the Guadalupe River; a pipeline to a tributary of the Medina River; an intake structure and pump station at Diversion Lake (located just downstream of Medina Lake); a transmission pipeline from Diversion Lake to the selected recharge areas; and a series of small recharge enhancement dams located primarily in northwestern Bexar County.

2.4.2 Available Yield

The available yield for Option G-30 would be realized through enhanced Edwards Aquifer recharge and recovery of the associated increase in reliable supply from the Edwards Aquifer resulting from the importation of water from the Guadalupe River and its delivery to the recharge zone via the Medina Lake System. The procedures and assumptions pertinent to the computation of water potentially available are described in the following paragraphs.

[1] HDR Engineering, Inc. (HDR), "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

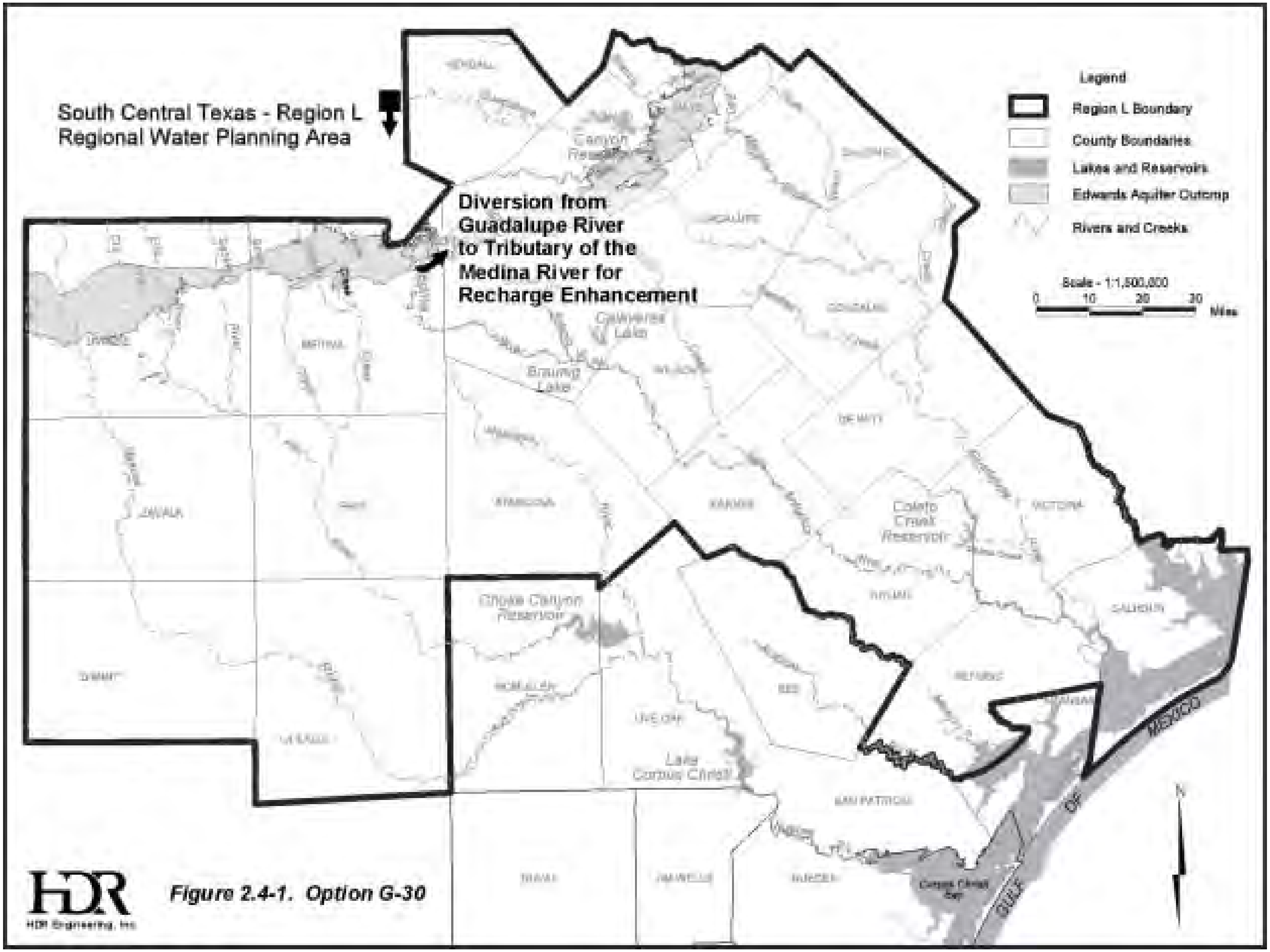


Figure 2.4-1. Option G-30

In order to quantify unappropriated streamflow potentially available for diversion, it was first necessary to estimate the portion of the total streamflow passing Comfort that is dedicated to downstream diversion rights and required to be passed through Canyon Lake. This task was accomplished using the Guadalupe-San Antonio River Basin Model[2] (GSA Model) assuming full subordination of hydropower water rights to Canyon Lake, fixed Edwards Aquifer pumpage of 400,000 acft/yr, treated effluent discharge at rates reported in 1988, and diversion of the uncommitted firm yield of Canyon Lake at Lake Dunlap after honoring GBRA contractual commitments from Canyon Lake totaling 53,606 acft/yr. These general assumptions were used in all water availability analyses for Option G-30. Water potentially available for diversion was computed on a daily basis as the total streamflow at Comfort less the greater of the minimum desired monthly instream flow under Consensus Environmental Criteria (Appendix B) or the flow to be passed for downstream water rights excluding storage rights in Canyon Lake. Effects of diversions of Guadalupe River water on storage rights in Canyon Lake were subsequently quantified by computing the resulting impact on firm yield.

Optimization analyses performed in previous studies[3] resulted in the selection of a 72-inch diameter import pipeline from the Guadalupe River. Water potentially available for diversion via a 72-inch diameter pipeline would average 28,443 acft/yr over the long-term (1934 to 1989) and 5,962 acft/yr during drought conditions (1947 to 1956). As is apparent in Figure 2.4-2, water availability would be highly variable from year to year and severely limited or non-existent during some drought years.

Information presented in Figure 2.4-2 represents water potentially available at the point of diversion on the Guadalupe River. The water ultimately available for Edwards Aquifer recharge enhancement, however, would be somewhat less, considering channel losses in delivery via the Medina River and evaporation losses in Medina Lake. For the purposes of this study, it was estimated that 90 percent of the water imported from the Guadalupe River would be available for recharge enhancement.

[2] (HDR), "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[3] HDR, "West Central Study Area – Phase I Interim Report," Vol. IV, Trans-Texas Water Program, San Antonio River Authority, January 1996.

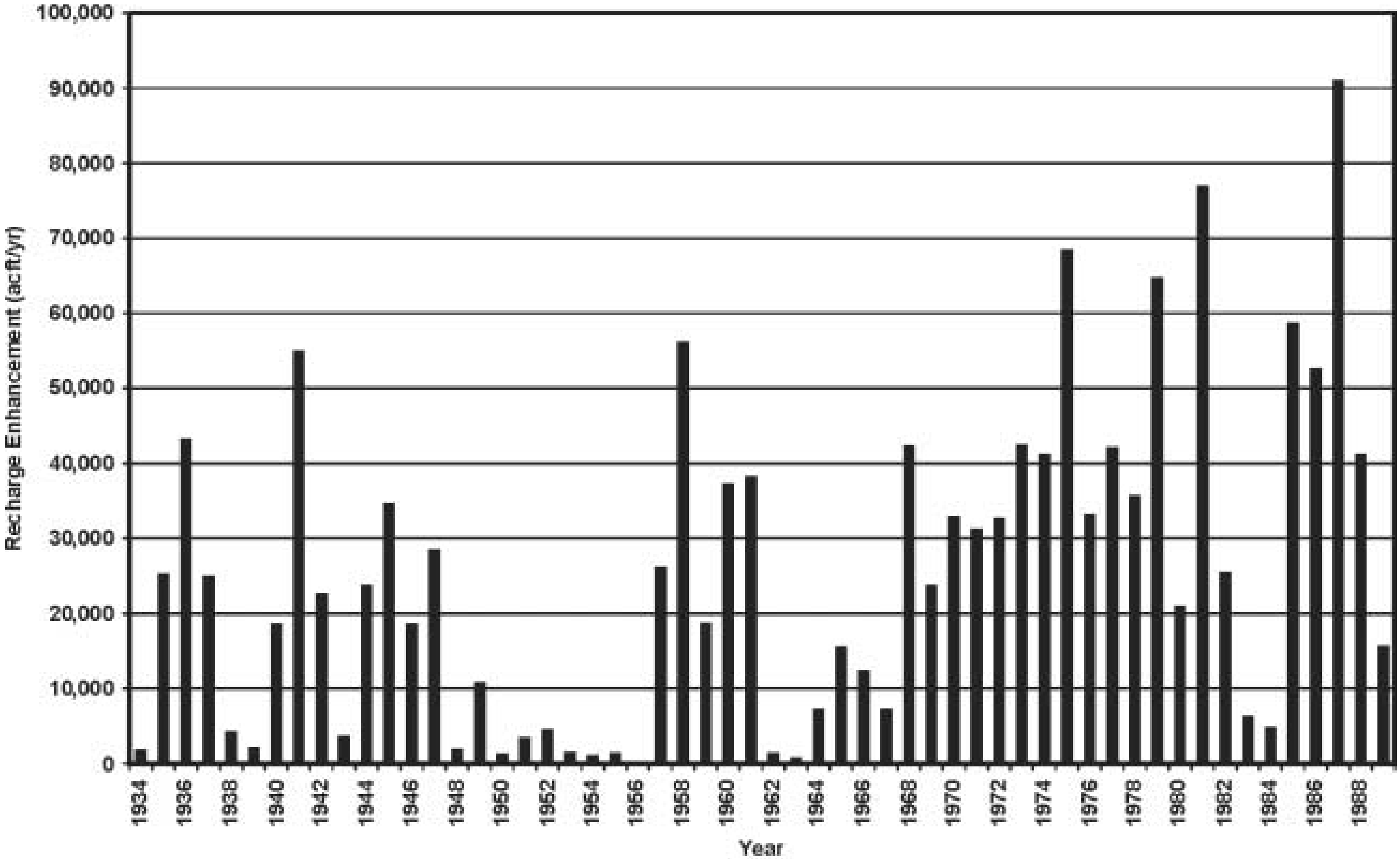


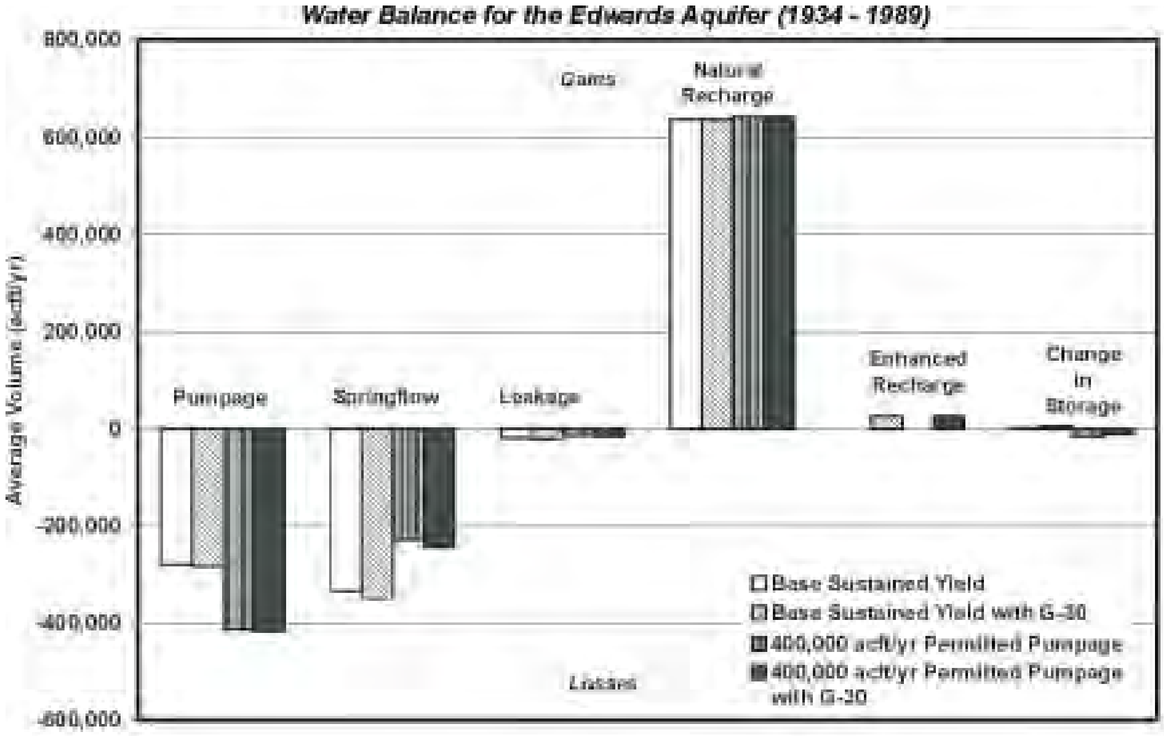
Figure 2.4-2. Enhanced Recharge for Guadalupe River Diversions above Comfort

Once the monthly enhanced recharge values were computed, they were added to the recharge in the GWSIM-IV[4] Model of the Edwards Aquifer at spatial locations representing recharge dams east of Medina and Diversion Lakes. The GWSIM-IV Model may provide the basis for determining additional groundwater that could be made available for a recharge recovery permit from EAA (Appendix C). The upper panel of Figure 2.4-3 summarizes results from application of the GWSIM-IV Model, including the increase in sustained yield of the aquifer associated with the enhanced recharge. With the enhanced recharge as shown in Figure 2.4-2 entering the recharge dam sites, via a pipeline from Medina and Diversion Lakes, the sustained yield aquifer pumpage could be increased by an estimated 3,902 acft/yr. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board rules for regional water supply planning. At this time, the concept of sustained yield enhancement as a basis for recharge recovery permitting has not been adopted by the EAA.

The final step in the groundwater evaluation was to move from the sustained yield calculations to examine the effects of this enhanced recharge on a 400,000 acft/yr permitted pumpage management plan for the Edwards Aquifer. Assuming that the change in sustained yield might form the basis for a recharge recovery permit of 3,902 acft/yr, the GWSIM-IV Model was applied with the additional 3,902 acft/yr included as distributed municipal pumpage. The lower panel of Figure 2.4-3 shows that the Comal Springs flow patterns under the 400,000 acft/yr management plan and with the additional pumpage of the recharge recovery permit are almost identical.

Although water available for upstream diversion under this option was initially computed without consideration of storage rights in Canyon Lake, resultant impacts to the firm yield were subsequently quantified using the GSA Model. Diversion of water potentially available from the Guadalupe River near Comfort, subject to the maximum diversion rate associated with a 72-inch transmission pipeline, would impact the firm yield of Canyon Lake by about 2,725 acft/yr, or about 3.5 percent. Annual costs for the purchase of this water from GBRA are included in the cost estimate for Option G-30 presented in Section 2.4.4.

[4] Texas Water Development Board, "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," Report 340, July 1992.



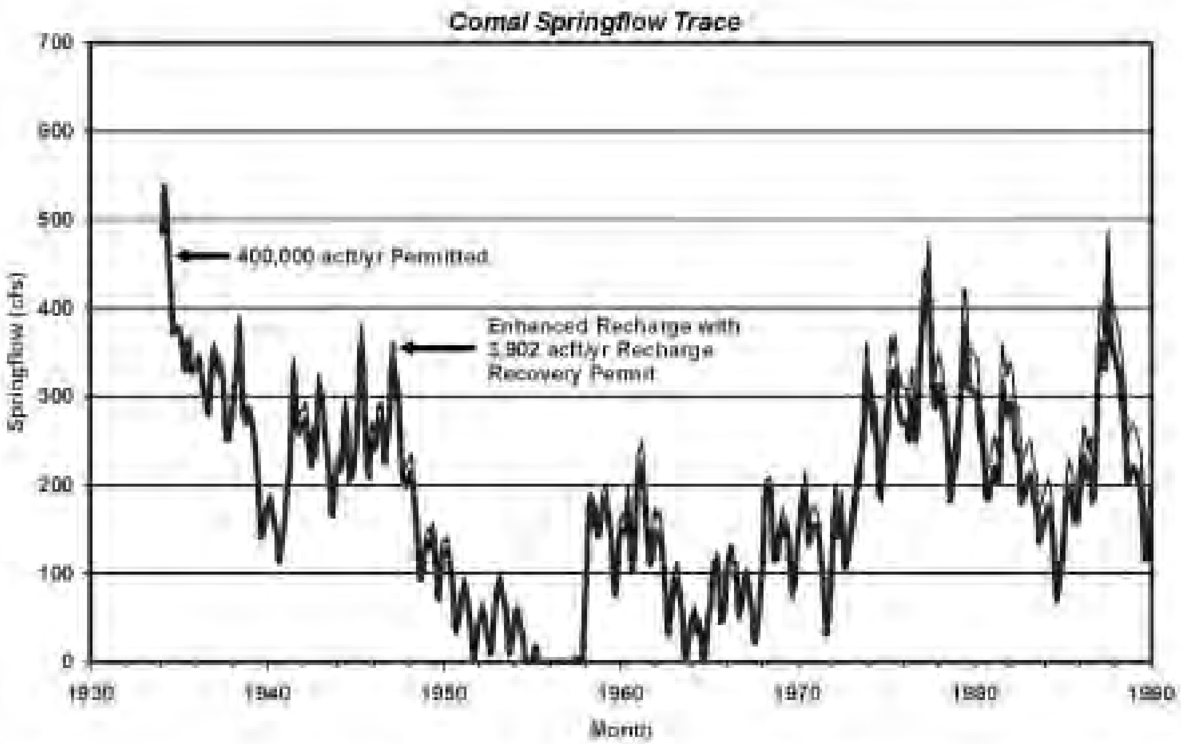


Figure 2.4-3. Guadalupe River Diversions near Comfort for Recharge Enhancement Water Balance and Springflow Considerations

2.4.3 Environmental Issues

Option G-30 involves diverting water from the Guadalupe River upstream of the City of Comfort (Kendall County) and downstream of the City of Center Point (Kerr County) to the Medina Lake System via Mason Creek and the Medina River (Figure 2.4-1). Water would then be diverted from Diversion Lake to the Edwards Aquifer recharge zone in northeastern Medina County and northern Bexar County. Option G-30 includes water transmission pipelines between the Guadalupe River and Elm Pass near Mason Creek, and between Diversion Lake and the recharge zone. The pipeline between the Guadalupe River and Elm Pass will follow the alignment of an existing cross-country pipeline.

The pipeline between the Guadalupe River and Mason Creek lies within Kerr County. Water delivered to Mason Creek would flow through Kerr, Bandera and Medina Counties in Mason Creek, a short segment of Bandera Creek, the Medina River, Medina Lake, and Diversion Lake. The pipeline from Diversion Lake to the recharge zone lies within Medina and Bexar Counties and the Edwards Plateau Vegetational Area.

The Edwards Plateau is a deeply dissected, rapidly drained rocky plain with broad, flat to undulating divides. Historically, the vegetation was grassland or open savannah-type plains with tree or brushy species found along rocky slopes and stream bottoms. In Medina and Bexar Counties, the Balcones Escarpment forms a distinct border of the plateau on its southern boundary with the South Texas Plains. Streams and rivers fed by numerous springs have cut canyons through the plateau, especially near its margins, forming unique niches for a variety of plant species. The ferns as well as many of the flowering plants are primarily lithophilous ("rock-loving"), and are represented primarily by various species of lipferns (*Cheilanthes spp.)*, cloak-ferns *(Notholaena spp.)* and cliff brakes *(Pellaea spp.).* Columbine *(Aquilegia canadensis)* and endemics such as *Anemone edwardsensis* and wand butterfly-bush *(Buddlega racemosa)* are sometimes found together with other species on large boulders in shaded ravines along with such species as mock-orange *(Philadelphus spp.),* American smoke-tree *(Cotinus americana),* spicebush *(Benzoin aestivale),* and the endemic silver bells *(Styrax platanifolia and S. texana).*

The most important climax grasses of the Plateau include switchgrass, several species of bluestems and gramas, Indian grass (*Sorghastrum nutans),* Canada wild-rye *(Elymus canadensis),* curly mesquite *(Hilaria berlangeri),* and buffalograss *(Buchloe dactyloides).* The rough, rocky areas typically support a tall or mid-grass understory and a brush overstory complex consisting primarily of live oak *(Quercus virginiana),* Texas oak *(Q. buckleyi),* shinnery oak *(Q. havardii),* juniper species *(Juniperus)* and mesquite *(Prosopis glandulosa).* Throughout the region, the brush species are generally considered as "invaders" with the climax stages composed of grassland or open savannah. The steeper canyon slopes historically supported a dense oak-Ashe juniper thicket.

The Balcones Escarpment is characterized by a complex of porous, faulted limestones in stream beds, sinkholes and fractures which allow substantial volumes of water to flow into the Edwards Aquifer.[5] The Edwards recharge zone has a surface area of about 1,500 square miles in Uvalde, Kinney, Medina, Bexar, Hays and Comal Counties. Streamflows contribute significantly to recharge of the Edwards Aquifer,[6] which supplies water to numerous agricultural and municipal entities in the region. Additionally, the Edwards Aquifer feeds springs that provide habitat for several endemic, endangered species.

The proposed water line from the Guadalupe River to Mason Creek is about 5.15 miles long. It would cross vegetative habitats classified as live oak-Ashe juniper park, live oak-mesquite-Ashe juniper park, and live oak Ashe juniper wood.[7] Acreage affected during construction would total 87.4 acres based on a right-of-way 140 feet in width. This acreage would include 3.4 acres (3.6 percent) of riparian scrub bordering the Guadalupe River, 2.3 acres (2.6 percent) of brush, 7.7 acres (8.8 percent) of crop, 1.9 acres (2.2 percent) of riparian woodland (Verde Creek), 28 acres (32 percent) of grass, and 44.4 acres (50.8 percent) of park. A right-of-way 40 feet wide maintained for the life of the project would affect a total of 25 acres.

Important species in Kerr, Bandera, Medina and Bexar Counties are listed Table 2.4-1. Habitat for several endangered species could be encountered along the pipeline route. The Golden-cheeked Warbler (*Dendroica chrysoparia)* requires mature Ashe juniper in dense oak-Ashe juniper stands for nesting. The Black-capped Vireo *(Vireo atricapillus)* nests in semi-open woods with a dense brushy understory. The U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD) list the Golden-cheeked Warbler and the Black-capped Vireo as endangered species. However, habitat for these birds can be avoided by carefully

[5] Caran, C.S., "Lineament Analysis and Inference of Geologic Structure, 1982.
[6] United States Geological Survey, "Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1988, with 1934-1988 Summary," Bulletin 48, November 1989.
[7] McMahan, C.A., R.G. Frye and K.L. Brown, "The Vegetation Types of Texas Including Cropland, Texas Parks and Wildlife Department, Austin, Texas, 1984.

Table 2.4-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Guadalupe River Diversion near Comfort to Recharge Zone via Medina Lake (G-30)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Basin Bellflower	*Campanula reverchonii*	Dry gravels and shallow sandy soils; open slopes			WL	Resident
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA	T	T	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River			NL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Buckley Triodia	*Tridens buckleyanus*	Margins of the Edwards plateau			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edge Falls Anemone	*Anemone edwardsiana var petraea*	Woodlands in mesic canyons			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Frio Pocket Gopher	*Geomys texensis bakeri*	Sandy surfaces with loam up to 2 meters deep			NL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident

Table 2.4-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	Listing Agency: TPWD[1]	Listing Agency: TOES[2,3,4]	Potential Occurrence in County
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Headwater Catfish	*Ictalurus lupus*	Clear streams			WL	Resident
Heller's Marbleseed	*Onosmodium helleri*	Juniper-oak woodlands			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mexican Blackhead Snake	*Tantilla atriceps*	Predominately Tamaulipan range[6]			NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Peregrine Falcon	*Falco peregrinus*	Open country, cliffs, occasionally cities[5]	E	T	NL	Nesting/Migrant
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spreading Leastdaisy	*Chaetopappa effusa*	Calcareous soils[7]			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Sonora Fleabane	*Erigeron mimegletes*	Edwards Plateau[7]			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Amorpha	*Amorpha roemeriana*				NL	Resident
Texas Fescue	*Festuca versuta*	Margins of Edwards Plateau[7]			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident

Table 2.4-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Texas Mock-Orange	*Philadelphus texensis*	Mesic stream bottoms and canyons			WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Tobusch Fishhook Cactus	*Anicistrocactus tobuschii*	Live oak-juniper woodlands, gravelly soil, shortgrass grasslands	E	E	E	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	Pools of subterranean streams; sinkhole in Medina County			NL	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-Nosed Coati	*Nasua narica*	Woodlands and riparian areas		T	WL	Resident
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17pp.
5 Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. pg 86.
6 Tennant, Alan. 1985. A Field Guide to Texas Snakes. Texas Monthly Press. Austin, Texas. pg 110.
7 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL Potentially Endangered/Threatened
PE/PT = Potential to be Listed as Endangered/Threatened Blank = Rare, but no regulatory listing status NL = Not Listed

routing the pipeline in the early planning stages. Other important species with potential habitat along the pipeline corridor include the Texas Horned Lizard *(Phrynosoma cornutum),* Texas Tortoise *(Gopherus berlandieri),* and Indigo Snake *(Drymarchon corais erebennus).* The Texas Tortoise is a federal candidate species and all three of these reptile species are listed as threatened in Texas.

Within north and northwest Bexar County, karst features are prominent along and adjacent to the pipeline corridor. Numerous species have been mapped by the Texas Natural

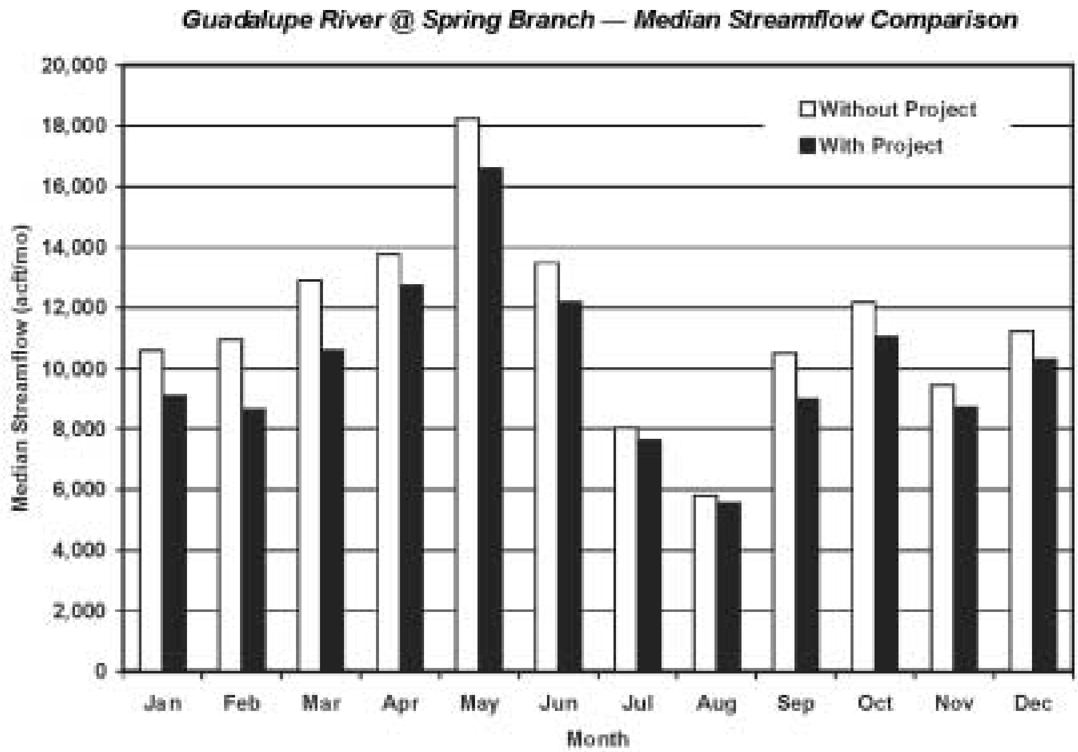
Heritage Program, including Madla's Cave Spider (*Cicurina madla*), two species of ground beetles (*Rhadine exilis* and *R. infernalis*), Helotes Mold Beetle (*Batrisodes venyivi*), Government Canyon Cave Spider (*Neoleptoneta microps*), and Vesper Cave Spider (*Cicurina vespera*). The aforementioned species and others that may possibly reside in the project area are presented in Table 2.4-1. These arachnids and insects are listed by the USFWS as potentially endangered. Habitat and endangered species surveys of the proposed pipeline corridor should be conducted in a later phase of the study if this option continues to be developed.

Mason Creek is an intermittent stream that flows into Bandera Creek about 2000 feet upstream of its confluence with the Medina River. Implementation of Option G-30 would increase the frequency of flows in Mason Creek and about 2000 feet of Bandera Creek. Flow studies (including environmental analyses) of Mason Creek and the Medina River should be performed as part of subsequent investigations.

Modeling flows in the Guadalupe River near Spring Branch indicated a reduction in median annual flows from 224,345 acft without the project to 194,162 acft with implementation of Option G-30, a decrease of 13.5 percent. Monthly median flow estimates without Option G-30 ranged from 18,245 acft to 5,797 acft without the project and from 16,598 acft to 5,561 acft with the project (Figure 2.4-4). Estimated percent reductions in the monthly medians ranged from 4.1 percent to 21.0 percent. Comparison of monthly streamflows with and without the project (Figure 2.4-4) indicated that streamflow reductions would occur mostly in the highest flow regimes. Reductions in flow might have an effect on the biological communities below the diversion and above Canyon Lake. For example, the relative abundance of fish species collected in a study conducted on the Guadalupe River appeared to be affected to some extent by instream flows.[8] Some species of fish, as well as other organisms, can be expected to be less tolerant of flow reductions than others. Flows below Canyon Dam and at the Saltwater Barrier are not expected to be significantly affected by this project.

The Guadalupe River downstream from the City of Comfort flows through Kendall County. The Interior Least Tern (*Sterna antillarum athalassos),* a seasonal migrant, is reported to occur in Kendall County. The Interior Least Tern, which is listed by USFWS and TPWD as endangered, nests on large sandbars on the Red River, and is unlikely to be affected by

[8] Academy of Natural Sciences, Philadelphia, Report No. 91-27, Philadelphia, Pennsylvania, 1991.



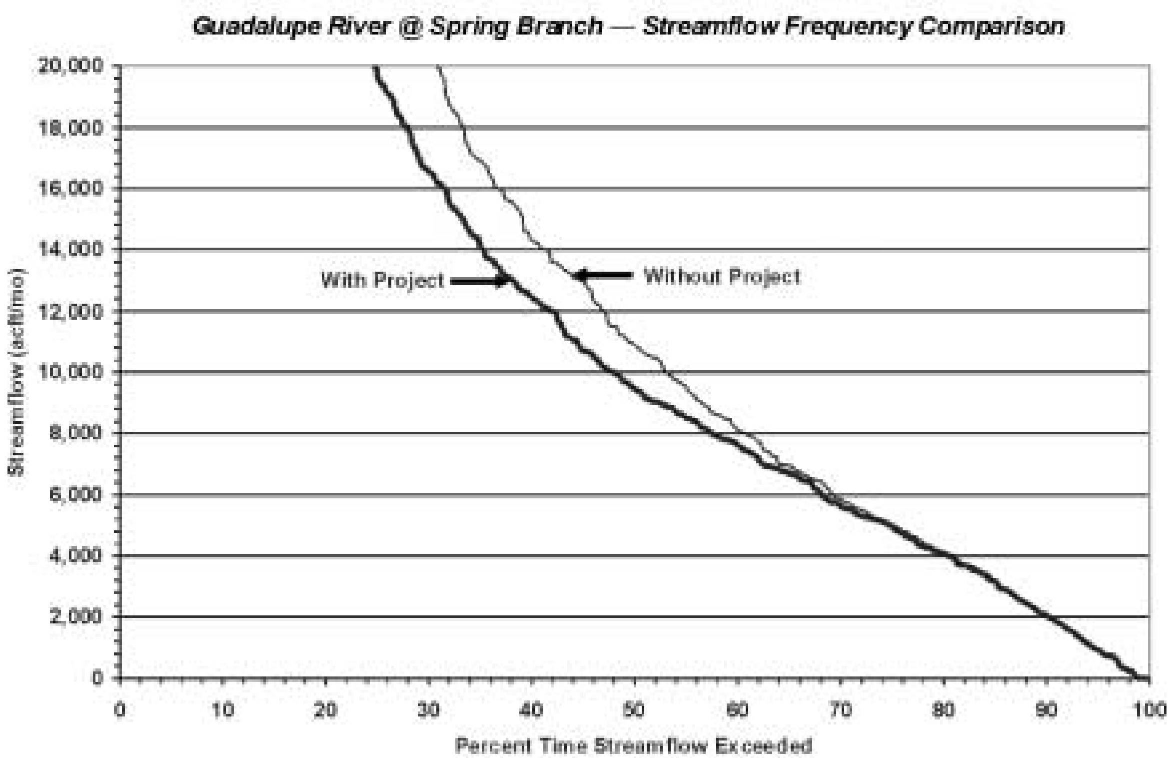


Figure 2.4-4. Guadalupe River Diversion for Recharge Enhancement Streamflow Comparisons

Option G-30. Cagle's Map Turtle *(Graptemys caglei)* is a federal candidate species that could be affected by the diversion infrastructure and/or flow reductions in the Guadalupe River below the City of Center Point. The Blue Sucker is listed by TPWD as threatened in Texas. Studies of the Guadalupe River in the area around the diversion infrastructure, and of the downstream reaches should be conducted in later phases of the study before implementing Option G-30.

A construction right-of-way 6.7 miles long extending from Diversion Lake to the recharge zone would affect approximately 114 acres, including about 54.7 percent brush, 35.6 percent wood and park, 5.4 percent pasture, and 4.3 percent riparian brush.

Soil types in the vicinity of Medina Lake are characterized by the undulating Brackett association and undulating Tarrant Rock outcrop association on uplands with slopes from 1 to 8 percent. The steep Tarrant-Brackett association is found on uplands with steep slopes between 20 and 45 percent. These areas are low in available water capacity, and are used for range and wildlife habitat.[9]

Vegetation surrounding Medina Lake includes Live Oak-mesquite-Ashe juniper parks and woods. Existing wetland habitats within the lake boundaries are classified as lacustrine and consist of deep and shallow open-water habitats where wetland vegetation is not a dominant feature. In upstream and downstream reaches of the Medina River, the Medina Irrigation Canal, Diversion Lake, and tributary streams, riverine and palustrine wetlands occur. These areas are generally small in size and are typically associated with a drainage feature or water body. In addition to open-water and streambed wetland areas, small areas of forested wetlands dominated by either broad-leaved deciduous or needle-leafed deciduous species occur downstream of Medina Dam.

Because Medina Lake is an existing reservoir, Option G-30 would not have direct impacts on existing land uses within the reservoir boundaries. For Option G-30, a volume of water equal to about 90 percent of that diverted from the Guadalupe River would be diverted from Diversion Lake for transmission to the recharge zone. Thus, the quantity of recharge to the Edwards Aquifer would increase under this scenario. Water surface elevations in Medina Lake would continue to fluctuate essentially as they do at present. Streamflows in the Medina River downstream of Diversion Lake would be essentially unaffected by this project.

[9] U.S. Department of Agriculture, Soil Conservation Service (SCS), “Soil Survey of Bandera County, Texas,” in cooperation with Texas Agricultural Experiment Station, Texas A&M University, College Station, 1977.

Several rare plant species with no regulatory status, the bracted twistflower (*Streptanthus bracteatus)*, the Buckley triodia (*Tridens buckleyanus*), and the Texas amorpha (*Amorpha roemeriana*)*,* have been reported near Medina Lake. Because no inundation will occur outside the existing reservoir, this species will not be affected by this option. In addition, several vascular plans of concern have been mapped along the pipeline alignment from Diversion Lake to northwestern Bexar County. These species include the bracted twistflower, Texas amorpha, Texas fescue (*Festuca versuta*), spreading leastdaisy (*Chaetopappa effusa*), glass mountain coral root (*Hexalectris nitida*), and heller's marbleseed (*Onosmodium helleri*). These species reside within habitats that consist of juniper oak and mesic woodlands supported by sandy or calcareous soils. Each is a rare species, but is not under regulatory status by either the state or federal wildlife agencies. The Widemouth Blindcat (*Satan eurystomus)* and the Toothless Blindcat *(Trogloglanis pattersoni),* both candidates for federal listing and listed by TPWD, are troglobitic species known only from deep wells in the Edwards Aquifer beneath the City of San Antonio. Because Option G-30 is expected to increase recharge and not affect recharge water quality, adverse impacts on these species are not anticipated.

No impacts to cultural resources are anticipated as a result of modified Medina Lake operations. Cultural resources surveys will be required in areas to be disturbed by the construction of the infrastructure to implement Option G-30. Because Medina Lake is an existing reservoir, no mitigation requirements are anticipated for the reservoir itself. Mitigation may be required for impacts associated with the infrastructure if sensitive ecological or cultural resources are identified in the future.

Waters imported from the Guadalupe River to Medina Lake and, subsequently, withdrawn from Diversion Lake are to be delivered to a proposed series of small recharge enhancement dams located primarily in northern Bexar County. The terrestrial habitat impacts associated with these recharge dams will depend on the amount of clearing done, frequency of inundation, and the rapidity of pool drainage following delivery of imported water or capture of local runoff. As the alignment of the pipeline from Diversion Lake and the exact locations and sizes of recharge dams are not known at this time, specific estimates of associated acreage affected were not computed.

Because these recharge dams are designed to facilitate direct percolation into karst features (fractures, holes, and/or caves) present below the stream channel, disturbance of the local karst system and its fauna is a possibility. The fauna inhabiting these caves are usually small in both species diversity and population size, and are adapted to relatively stable physical habitats, which presumably makes them particularly sensitive to disturbances outside of the natural regime. The results of the investigation of the karst fauna in northern Bexar County, however, seem to indicate that caves with biological communities have not been encountered in streambeds there.[10] Openings in the streambed are naturally exposed to the erosive force of flowing water, lessening the likelihood that an organized "terrestrial" community would be able to develop and persist in such a location.

Karst openings in the vicinity of these proposed recharge dams that presently experience periodic flooding may be inundated for longer periods, or experience an increase in the maximum elevation to which the water rises following a runoff event, possibly causing flow across the recharge zone. Both terrestrial and aquatic communities are extensive in the karst openings associated with the Edwards limestone, and significant threats to these habitats presently exist as a result of human activities in many areas including northern Bexar County.[11,12] The extent of intermittently flooded karst zones that would be affected by the recharge dams, the extent to which these zones are inhabited, and how hydrologic changes might affect resident communities, is unknown.

Numerous caves in the vicinity of the proposed recharge dams in northern Bexar County have been explored and the faunas have been inventoried.[13, 14] Government Canyon Bat Cave supports a population of Cave Myotis bats *(myotis velifer)*; additionally, several of the caves support cave beetles, including *Rhadina infernalis.* There are also caves in the vicinity of San Geronimo Creek (northeastern Medina County), but none have been explored. In the vicinity of Culebra Creek, lack of access to the property has prevented a search for caves. No caves have been identified in the vicinity of Deep or Limekiln Creeks.

A petition to the USFWS to list as endangered or threatened nine new species of invertebrates with limited distributions in caves of northern Bexar County, including the *Rhadina*

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[10] Elliot, W.R., "Cave Fauna Conservation in Texas," proceedings of the 1991 National Cave Management Symposium, Bowling Green, Kentucky, American Cave Conservation Association, Horse Cave, Kentucky, 1993.
[11] Ibid.
[12] Longley, G., "The Edwards Aquifer: Earth's Most Diverse Ground Water Ecosystem?" Internatl. J. Speleol. 11:123-128, 1981.
[13] Veni, G., Personal Communication, April 22, 1994.
[14] Elliott, W., Personal Communication, November 21, 1995.

beetle, has been filed. The petition identifies specific inhabited caves, including Government Canyon Bat Cave, and a study is underway to identify additional habitat areas. All of the proposed recharge dams are in areas that have potential for caves containing endangered species.[15]

Government Canyon Bat Cave is located in the immediate vicinity of the potential recharge dam site on Government Creek. Although the known opening of this cave is located well above the impoundment elevation, the depth to which *Cicurina* (Troglobitic spider) habitat extends is not known, and additional site surveys would be required to determine whether it might be affected by an increase in the duration of inundation events, or by an increase in the maximum inundation elevation within the cave. On-site surveys of the reservoir and surrounding areas and mitigation or relocation of the recharge dam may be required if caves with protected species are found and will be affected by project development.

Government Canyon, including the Government Canyon Bat Cave site, is the location of a new state park. The Government Canyon State Park plan includes environmental resource preservation, a preserve for nesting Golden-cheeked warblers and Black-capped vireos, and some recreational facilities. Although dam construction may be a concern, natural recharge in the canyon (including water imported from the Guadalupe River via Medina Lake) may not conflict with preserving the environmental resources of the area or the park development plan.

The Government Creek area is known to contain numerous prehistoric sites and a 17th century Spanish colonial trail. Other recharge sites may contain similar cultural resources. Cultural resources protection on public lands in Texas, or lands affected by projects regulated under U.S. Army Corps of Engineers permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

[15] Veni, G., Personal Communication, April, 22, 1994.

2.4.4 Engineering and Costing

For this option (G-30), water potentially available for diversion from the Guadalupe River near Comfort would be pumped to a tributary of the Medina River for delivery to Diversion Lake below Medina Lake, and pumped from Diversion Lake to a series of recharge enhancement dams located primarily in northwestern Bexar County. The benefits of this project could include enhanced recharge of the Edwards Aquifer resulting in increased water supply for municipal, industrial, and irrigation use as well as enhanced springflow for recreational use and protection of endangered species. The major facilities required to implement Option G-30 include:

- Guadalupe River Intake and Pump Station
- Raw Water Pipeline to Medina River Tributary
- Reservoir Intake and Pump Station
- Raw Water Pipeline to Recharge Zone
- Recharge Structures

Diversions from the Guadalupe River through a 72-inch import pipeline could provide for average enhanced Edwards Aquifer sustained yield of about 3,902 acft/yr at a unit cost of $2,079 per acft/yr. These unit costs include an intake structure and pump station at Diversion Lake, a 72-inch transmission pipeline from Diversion Lake to the recharge area, and several small recharge dams. Project costs and annual costs are summarized in Table 2.4-2.

2.4.5 Implementation Issues (G-30)

Implementation of Option G-30 could directly affect the feasibility of other water supply options under consideration, including L-18, S-13B, G-15C, G-24, G-32, G-38C, SCTN-6, SCTN-8, SCTN-10, SCTN-16a, SCTN-16b, and/or SCTN-16c.

An institutional arrangement is needed to implement projects including financing on a regional basis.

Guadalupe River Channel Dam and Diversion Lake Intake

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right permit.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the channel dam and intake structures.
   c. GLO Sand and Gravel Removal permits.

Table 2.4-2.
Cost Estimate Summary for
Guadalupe River Diversions near Comfort to
Recharge Zone via Medina Lake (G-30)
(Second Quarter 1999 Prices)

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Rehab and Construction of Recharge Dams)	$5,763,000
Intakes and Pump Stations (95 MGD, 85 MGD)	18,978,000
Transmission Pipelines (72-inch dia., 5.2 miles; 72-inch dia., 6.7 miles)	24,208,000
Total Capital Cost	**$48,949,000**
Engineering, Legal Costs and Contingencies	$15,922,000
Environmental & Archaeology Studies and Mitigation	570,000
Land Acquisition and Surveying (256 acres)	833,000
Interest During Construction (4 years)	10,605,000
Total Project Cost	**$76,879,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$4,883,000
Reservoir Debt Service (6 percent for 40 years)	642,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	678,000
Dam and Reservoir	86,000
Pumping Energy Costs (27,575,783 kW-hr @ $0.06/kW-hr)	1,655,000
Purchase of Water (2,725 Acft/yr @ $61/acft)	166,000
Total Annual Cost	**$8,110,000**
Available Project Yield (acft/yr)	**3,902**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$2,079**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$6.38**

1 Reported Annual Cost is for additional water supply in the Edwards Aquifer.

   d. GLO Easement for use of state-owned land.
   e. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Habitat mitigation plan.
   b. Environmental studies.
   c. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

Requirements Specific to Diversion of Water from Guadalupe River and Recharge to Edwards Aquifer

1. Necessary permits:
   a. TNRCC permit to divert unappropriated water.
   b. TNRCC Interbasin Transfer Approval.
   c. TNRCC authorization to use Medina River and its tributaries to deliver Guadalupe River water to Medina Lake and then use the water for recharge purposes in the San Antonio River Basin.
   d. EAA authorization to recharge and to recover water through Recharge Recovery Permit.
2. Permitting will require these studies:
   a. Instream flow effects.
   b. Environmental studies.
   c. Evaluation of potential effects on recreation.
3. Agreement with GBRA for purchase of firm yield reduction at Canyon Lake.
4. Agreement with Bexar-Medina-Atascosa Counties Water Control and Improvement District to transport water through Medina Lake, and to construct an intake and pump station at Diversion Lake to transfer Guadalupe River water to the recharge zone.

Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

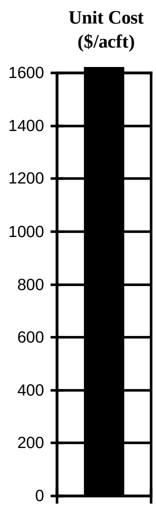
Requirements Specific to Surface Recharge Structures

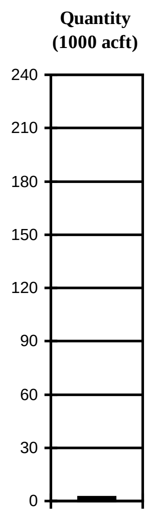
1. Detailed field investigation of each potential recharge site to determine natural and expected recharge rates.
2. For water imported to the recharge zone: water compatibility testing and assessment of treatment needs (if any), including biological and chemical characteristics.
3. Necessary permits could include:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.
   e. EAA authorization to recharge and to recover water through Recharge Recovery Permit
4. Permitting, at a minimum, will require these studies:
   a. Determination of impact plans for parkland, wildlife preserves, and other conservation programs.
   b. Study of impact on karst geology organisms from a sustained recharge program.
   c. Other environmental studies.

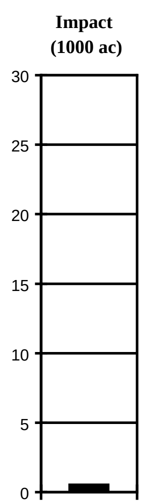
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/31/99







OPTION NUMBER: G-32

OPTION NAME: Diversion of Canyon Lake Flood Storage to Recharge Zone via Cibolo Creek—Long-Term Average

OPTION DESCRIPTION: *Canyon Lake is located on the Guadalupe River 12 miles northwest of New Braunfels, and has a flood control capacity of 355,000 acft. Water would be diverted from the flood control pool when available and delivered to the Edwards Aquifer recharge zone via Cibolo Creek to increase the quantity of Edwards Aquifer water available for pumpage.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$6,198**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**2,088**	**acft/yr[2]**
LAND IMPACTED:	**518**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Canyon Lake intake and pump station, raw water pipelines (two 108-inch diameter lines), transmission pump station, and a 10,000-acft storage capacity recharge structure on Cibolo Creek.

[2]**QUANTITY OF WATER:** 2,088 acft/yr is the additional potential municipal aquifer pumpage or sustained yield based on using GWSIM-IV.

[3]**LAND IMPACTED:** Pipeline right-of-way and recharge reservoir sites. This does not include land in the floodplain above the recharge pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Effects of pipeline right-of-way on terrestrial habitat. Resource conflicts can be avoided by careful selection of pipeline routes. Construction can be scheduled to avoid nesting schedules of any threatened or endangered species. Additional studies of recharge effects on specific karst associations could be necessary to address project effect on unique habitats.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water per acre-foot of recharge recovery is high. Option enhances Comal Springs flow more than it provides for increased aquifer pumpage. Ability of sponsors to obtain credits for recharge that can be expressed in quantities of additional Edwards Aquifer pumpage rights.

ADDITIONAL FACTORS: Ability to obtain permits and Canyon Lake water for this purpose. Potential effects on Natural Bridge Caverns or Bat Cave.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, S-13B, G-16C1, G-30, SCTN-6, and/or SCTN-8.

2.5 Diversion of Canyon Lake Flood Storage to Recharge Zone via Cibolo Creek (G-32)

2.5.1 Description of Option

Option G-32 includes the diversion of water from the flood storage pool of Canyon Lake and importation of this water for enhancement of Edwards Aquifer recharge. Canyon Lake is a multi-purpose project located on the Guadalupe River in Comal County about 12 miles northwest of New Braunfels. It was originally developed by the U.S. Army Corps of Engineers in the early 1960s as a water supply and flood control project with an estimated conservation storage capacity of 382,000 acre-feet (acft) below elevation 909 feet-mean sea level (ft-msl) and an estimated flood storage capacity of about 355,000 acft between elevation 909 ft-msl and the crest of the emergency spillway at 943 ft-msl. Water potentially available for diversion under this option is the portion of the flood flows temporarily impounded above 909 ft-msl, which can be diverted during the period that flood releases are being made at Canyon Dam. As shown in Figure 2.5-1, the major facilities associated with this option include an intake structure and pump station at Canyon Lake, an import pipeline to a tributary of Cibolo Creek, and a recharge enhancement dam located on Cibolo Creek at the proposed site of the Cibolo Creek Recharge Enhancement Project (Section 2.2). The enhanced recharge might be recaptured through a recharge recovery permit,[1] which could be obtained through the Edwards Aquifer Authority (EAA). It is important to note that the conceptual basis, statutory authority, and administrative procedures associated with recharge recovery permits are issues under consideration in the EAA's ongoing development of rules.

2.5.2 Available Yield

The available yield for Option G-32 would be realized in the form of additional groundwater available for pumpage due to enhanced Edwards Aquifer recharge obtained through the importation of water from the flood pool of Canyon Lake and its delivery to the recharge zone via Cibolo Creek. As storage in the flood pool of Canyon Lake is most likely to occur simultaneously with flood events and natural recharge in the Cibolo Creek watershed, a recharge enhancement structure on Cibolo Creek sized to impound about 10,000 acft (Section 2.2) is

[1] HDR Engineering, Inc. (HDR), "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

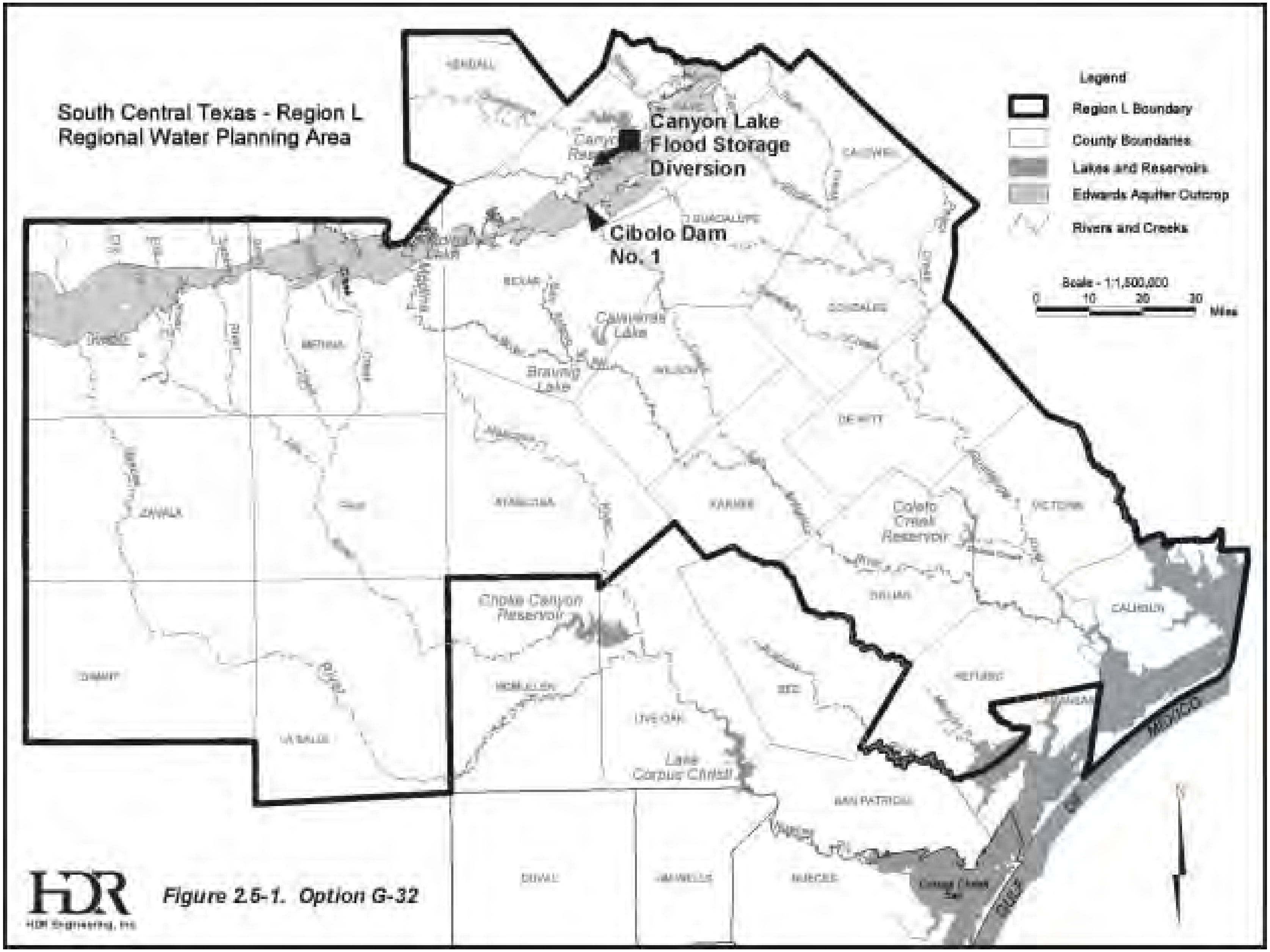


Figure 2.5-1. Option G-32

included as a component of this option. The procedures and assumptions pertinent to the computation of water potentially available from Canyon Lake flood storage, recharge enhancement associated with its importation, and Edwards Aquifer sustained yield increases are described in the following paragraphs.

In order to quantify water potentially available for diversion from Canyon Lake flood storage, it was first necessary to compute the firm yield derived from the conservation storage pool of Canyon Lake. This task was accomplished using the Guadalupe-San Antonio River Basin Model[2] (GSA Model). New hydrologic evaluations were not necessary for evaluation of this option, as the volumes of water determined to be available under previous studies[3] remain relatively unchanged under the general assumptions used for the South Central Texas Regional Water Plan analyses. The assumptions used in developing flood flows available for diversion to the recharge zone include full subordination of hydropower water rights to Canyon Lake, fixed Edwards Aquifer pumpage of 400,000 acft/yr, return flows at rates reported in 1988, current Canyon Lake firm yield estimates, and diversion of the uncommitted firm yield of Canyon Lake at a downstream location after honoring current Guadalupe-Blanco River Authority (GBRA) contractual commitments. Review of this simulation reveals that Canyon Lake would have temporarily impounded some water in the flood pool in about 50 percent of the months during the 1934 to 1989 period. During the critical drought period extending from July 1947 through February 1958, however, there would have been no storage in the flood pool and no water available for diversion under this option.

Current guidelines for flood releases from Canyon Lake are set forth in Schedule #1 from the U.S. Army Corps of Engineers Reservoir Regulation Manual. These guidelines generally provide for the release of 1,500 cubic feet per second (cfs) (2,975 acft/day) when the lake level is between 909 ft-msl and 911 ft-msl and 5,000 cfs (9,920 acft/day or 302,000 acft/month) when the lake level exceeds 911 ft-msl. The GSA Model was modified to simulate flood pool operations in Canyon Lake for one specified flood release rate and one specified diversion rate subject to conservation pool operations dictated by the assumptions and firm yield quoted in the previous paragraph. A fixed flood release rate of 5,000 cfs (approximating that under current

[2] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[3] HDR, et al., "Trans-Texas Water Program, West Central Study Area, Phase I – Interim Report," Volume 4, San Antonio River Authority, et al., January 1996.

guidelines) was assumed for this option as consideration of dam safety and flood hazard issues associated with a lesser flood release rate is beyond the scope of this study. As flood storage in Canyon Lake is federally authorized and generally occurs when water throughout the Guadalupe-San Antonio River Basin is plentiful, environmental flow criteria were not applied.

Water potentially available for diversion from flood storage in Canyon Lake was analyzed for a range of diversion rates in previous analyses,[4] and optimization analyses considering potential import pipeline diameters were performed to select the most appropriate importation facilities based on minimum unit cost and reasonable incremental unit cost of Edwards Aquifer recharge enhancement. These optimization analyses resulted in the selection of two parallel 108-inch diameter import pipelines from Canyon Lake with a combined transmission capacity of about 40,000 acft/month, or 660 cfs.

Water potentially available for diversion via these two 108-inch diameter pipelines would average about 21,100 acft/yr over the long-term (1934 to 1989) and 0 acft/yr during the critical drought period for Canyon Lake (July 1947 to February 1958). Figure 2.5-2 shows the water available for diversion from Canyon Lake flood storage for recharge enhancement, assuming two parallel 108-inch diameter pipes. As is apparent in this figure, water availability would be highly variable from year to year and severely limited or non-existent during drought periods. Water availability is somewhat limited by the assumptions that flood releases begin immediately when the lake level rises above 909 ft-msl and would occur simultaneously with flood pool diversions. For example, given a flood release rate of 5,000 cfs and a maximum flood pool diversion rate of 660 cfs (based on two 108-inch diameter import pipelines), 88 percent of the flood storage would be released down the Guadalupe River and 12 percent would be diverted to the recharge zone via Cibolo Creek.

A recharge enhancement structure located on Cibolo Creek just upstream of Bracken was included in Option G-32 to improve recharge efficiency for the imported water because flood storage in Canyon Lake is likely to occur simultaneously with natural recharge events in the Cibolo Creek watershed. This recharge structure is assumed to be located at the site of Cibolo Dam No. 1 which was originally identified by Espey, Huston & Associates[5] and is included in

[4] Ibid.

[5] Espey, Huston & Associates, Inc. (EHA), "Feasibility Study of Recharge Facilities on Cibolo Creek," Draft, Edwards Underground Water District, October 1982.

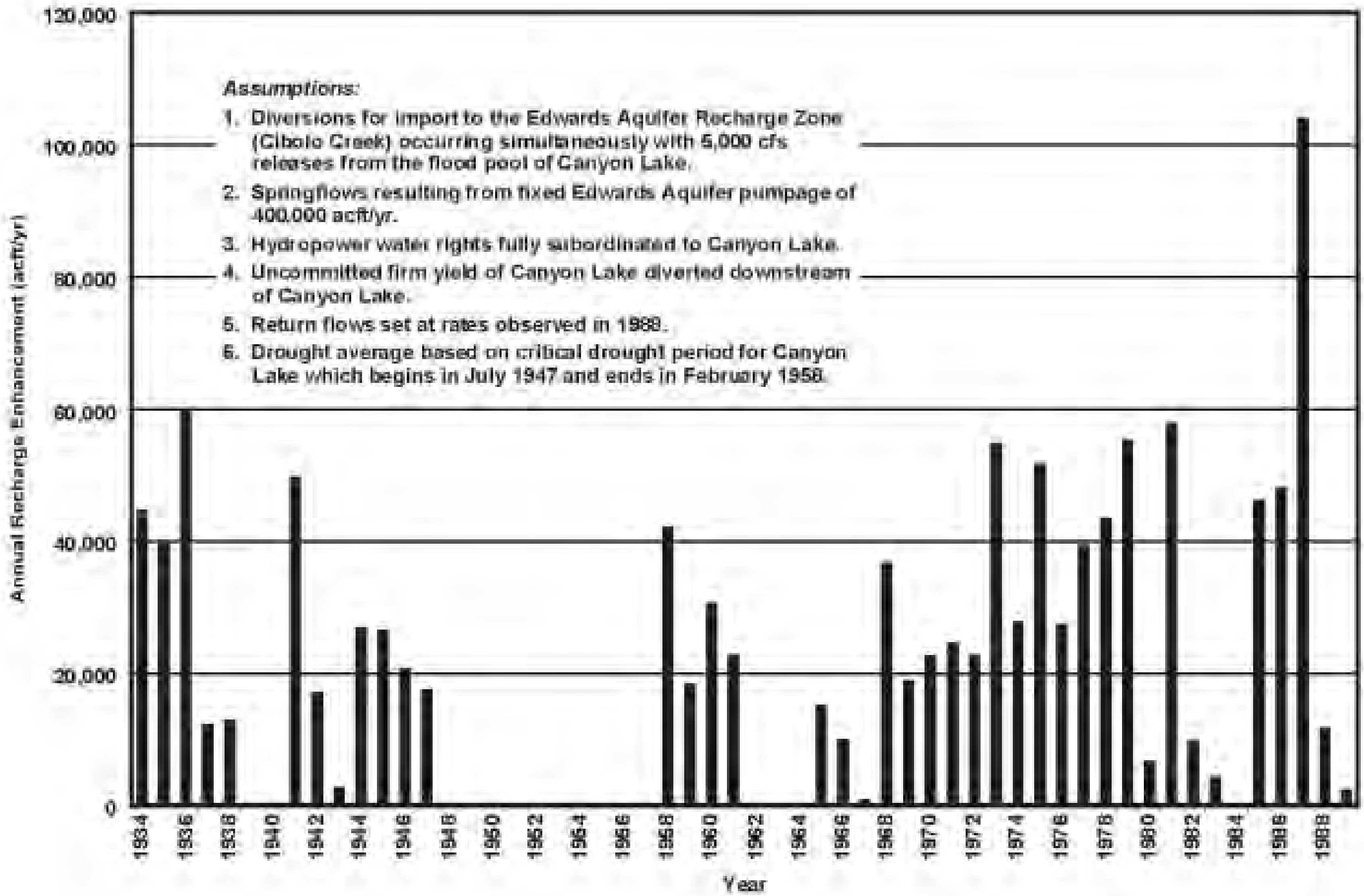


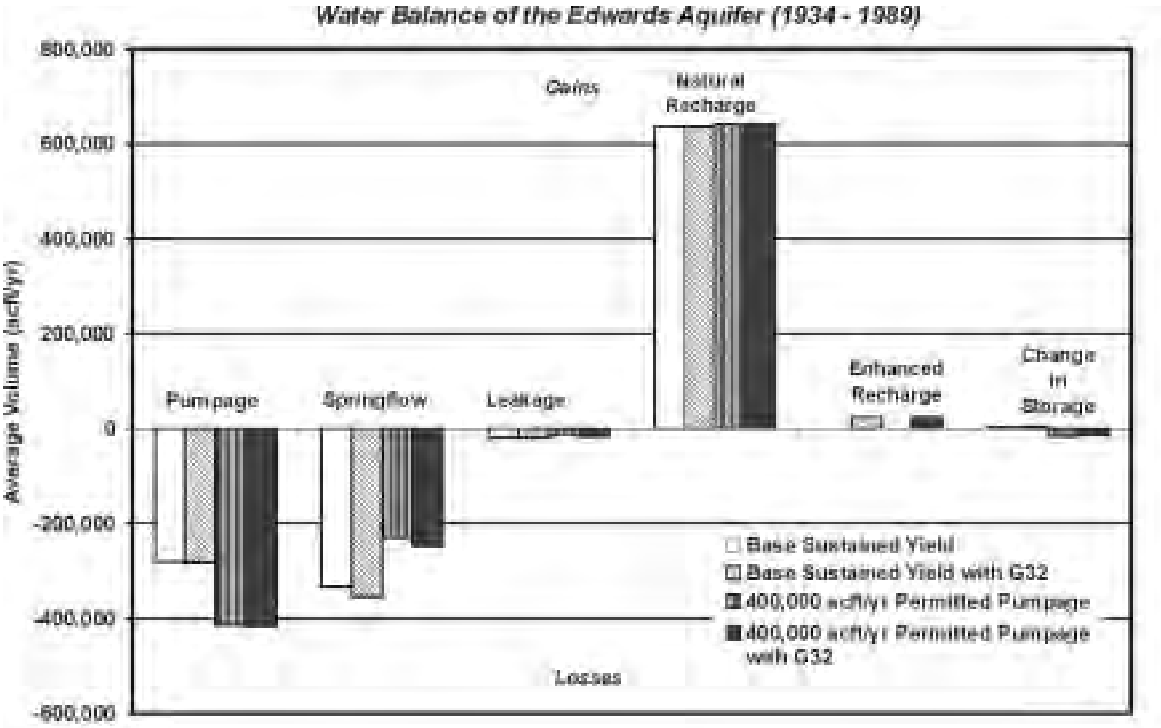
Figure 2.5-2. Annual Canyon Lake Flood Waters Available for Recharge Enhancement (Option G-32)

recently completed[6] and ongoing studies for the South Central Texas Regional Water Planning Group (Section 2.2). Assuming a storage capacity of 10,000 acft, long-term average (1934 to 1989) recharge enhancement associated with Cibolo Creek Recharge Enhancement Project would be about 8,500 acft/yr[7] without importation of water from Canyon Lake. Considering monthly importation from Canyon Lake flood storage averaging about 24,600 acft/yr for the 1934 to 1989 period and accounting for about 40 cfs (2,400 acft/month) of additional recharge capacity in Cibolo Creek[8] as well as available storage capacity in the recharge reservoir, additional recharge enhancement due to importation from Canyon Lake would average about 16,100 acft/yr. Hence, about 76 percent of the Canyon Lake flood storage potentially available for diversion could contribute recharge to the Edwards Aquifer under Option G-32. The remaining 24 percent of Canyon Lake flood storage potentially available for diversion would not contribute to Edwards Aquifer recharge because it would occur at times when simulations indicate that there would be no available recharge capacity in Cibolo Creek and no available storage capacity at the Cibolo Creek Recharge Enhancement Project.

Once the monthly enhanced recharge values were generated, they were added to the recharge used by the GWSIM-IV model of the Edwards Aquifer at the spatial locations representing Cibolo Creek downstream of the confluence with Lewis Creek. The GWSIM-IV model provides a tool for determining the additional groundwater that could be made available on a sustained basis for a recharge recovery permit (Appendix C).

Figure 2.5-3 shows the mass balance accounting from the GWSIM-IV model used to determine the change in sustained yield associated with the enhanced recharge of this option. With average enhanced recharge of 24,600 acft/yr (the sum of recharge from the Cibolo Creek Recharge Enhancement Project and the diverted Canyon Lake flood water), the sustained yield pumpage would increase by 2,088 acft/yr, or 8.5 percent of the enhanced recharge. Quantification of an increase in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board rules for regional water supply

[6] HDR, "Trans-Texas Water Program, West Central Study Area, Phase II, Edwards Aquifer Recharge Analyses," San Antonio River Authority, et al., March 1998.
[7] HDR, Op. Cit., September 1993.
[8] Espey, Huston & Associates, Inc., Op. Cit., October 1982.



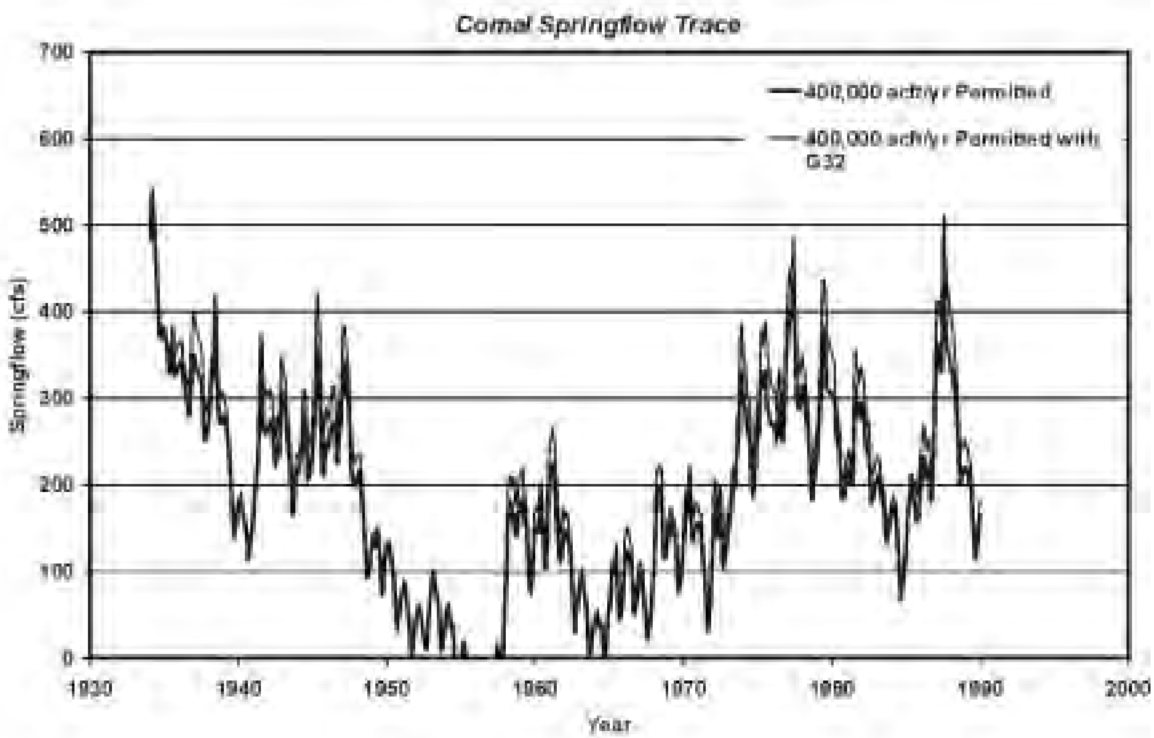


Figure 2.5-3. Canyon Lake Flood Storage Diversion for Recharge Enhancement Water Balance and Springflow Considerations

planning. At this time, the concept of sustained yield enhancement as a basis for recharge recovery permitting has not been adopted by the EAA.

The final step in the groundwater evaluation was to move from the sustained yield calculations to examine the effects of this enhanced recharge on the 400,000 acft/yr total pumpage management plan of the Edwards Aquifer. Assuming that the change in sustained yield might form the basis for a recharge recovery permit of 2,088 acft/yr, the GWSIM-IV model was applied with the additional 2,088 acft/yr distributed as municipal pumpage in the study area. Figure 2.5-3 shows that the Comal Springs flow patterns under the 400,000 acft/yr management plan with the additional pumpage of the recharge recovery permit are higher due to the close proximity of the recharge enhancement to Comal Springs. More specifically, 20,000 acft of the enhanced recharge (81 percent) becomes increased springflow. Hence, the enhanced recharge from this project increases springflow more effectively than it increases annual pumpage. If this option were evaluated in conjunction with a surface water project downstream of the springs, however, the increased springflow could serve to increase the yield or reliability of the surface water project.

2.5.3 Environmental Issues

The diversion of water from flood storage at Canyon Lake to the recharge zone on Cibolo Creek would require an intake structure at Canyon Lake and two, large diameter water transmission lines about 7.8 miles long (Figure 2.5-1). The corridor that would be traversed by the pipelines consists primarily of live oak-ashe juniper savanna (56 percent) and mesquite-invaded rangeland (4 percent). Developed areas total less than 3 percent and wetlands occupy less than 1 percent of the corridor. There are relatively few streams, and perched ponds supply water for livestock. The streams are typically intermittent and similar to other streams around Canyon Lake. Option G-32 also includes a recharge enhancement structure on Cibolo Creek discussed in Section 2.2 of this report.

The project area lies within central Comal County. The water transmission line traverses Brackett-Comfort-Real (shallow, undulating to steep soils over limestone or strongly cemented chalk) and Comfort-Rumple Eckrant (very shallow to moderately deep, undulating to steep and hilly soils over indurated limestone) soil associations. Both soil associations are characteristic of uplands of the Edwards Plateau.

The Edwards Plateau comprises the Hill Country in west-central Texas. On the east and south, the Balcones Escarpment, with its spectacular canyons, forms a distinct boundary to the Edwards Plateau. Soils are usually shallow, with a wide range of surface textures. They are underlain by limestone or caliche on the Plateau proper. The Edwards Plateau is predominantly rangeland, with cultivation largely confined to the deeper soils, valley bottoms, and around the larger towns. It has an excellent, but often sparse mixture of forage plants, and ranches are often stocked with combinations of cattle, sheep, and goats to make full use of the few edible plants. Deer are abundant on much of the area and serve as a valuable source of income for many ranchers.

The most important climax grasses of the Edwards Plateau Vegetational Area[9] include switchgrass, several species of bluestems and gramas, Indian grass (*Sorghastrum nutans),* Canada wild-rye *(Elymus canadensis),* curly mesquite *(Hilaria berlangeri)* and buffalo grass *(Buchloe dactyloides).* The rough, rocky areas typically support a tall or mid-grass understory and a brush overstory complex consisting primarily of live oak *(Quercus virginiana),* Texas oak *(Q. buckleyi),* shinnery oak *(Q. havardii),* juniper species *(Juniperus)* and mesquite *(Prosopis glandulosa).* Throughout the region, the brush species are generally considered as "invaders," with the climax largely grassland or open savannah, except on the steeper canyon slopes which have continually supported a dense cedar-oak thicket.

The rough, irregular surface of the Plateau is well drained, being dissected by several perennially flowing river systems that have their origin in the large number of springs in this limestone-based region. Noteworthy is the growth of bald cypress (*Taxodium distichum)* along most of the streams and rivers. Because of the many large canyons and rugged terrain, this area is of much botanical interest and has consequently been visited by many botanical collectors. The ferns as well as many of the flowering plants are primarily lithophilous, being represented mainly by various species of lipferns *(Cheilanthes spp.),* cloak-ferns *(Notholaena spp.),* and cliff brakes *(Pellaea spp.).* Columbine *(Aquilegia canadensis),* endemics such as *Anemone edwardsensis* and wand butterfly-bush *(Buddlega racemosa),* and other species are sometimes found together on large boulders in shaded ravines along with such species as mock-orange

[9] Gould, F.W., "Texas Plants--A Checklist and Ecological Summary," Texas Agricultural Experiment Station, Texas A&M University, 1962.

(Philadelphus spp.), American smoke-tree *(Cotinus americana),* spicebush *(Benzoin aestivale),* and the endemic silver bells *(Styrax platanifolia and S. texana).*

McMahan, et al.,[10] classified the vegetation types traversed by the proposed water import pipelines as live oak-Ashe juniper park and live oak-mesquite-Ashe juniper park. The proposed pipeline route between Canyon Lake and the outfall would be about 7.8 miles long and would follow existing roadways (FM 2673 and FM 3159). Pipeline installation, assuming a construction right-of-way width of 140 feet, would affect a total of 131.8 acres including 33.1 acres (25.2 percent) of park, 76.6 acres (58.1 percent) of grass/shrub, and 22.1 acres (16.7 percent) of brush. A right-of-way 40 feet wide maintained for the life of the project would affect a total of 37.6 acres. Areas outside the maintenance right-of-way would be seeded in appropriate grasses and brush would be expected to significantly invade or reinvade within 5 to 10 years following construction.

The Hill Country Wild-Mercury (*Argythamia aphoroides),* a perennial herb, is reported to occur along the proposed pipeline route southwest of the City of Startzville. The Hill Country Wild-Mercury is a rare endemic that inhabits dry sandy and rocky soil over limestone on the Edwards Plateau. It is listed as rare by U.S. Fish and Wildlife Service (USFWS) and the Texas Parks and Wildlife Department (TPWD), but with no status, and is a Texas Organization of Endangered Species (TOES) watch list plant.

Protected species that appear most likely to be encountered during construction include the Texas Salamander (*Eurycea neotenes;* reported on the Smithson, 7.5-minute quadrangle*)*, the Texas Horned Lizard *(Phrynosoma cornutum)*, the Texas Mock-orange *(Philadelphus texensis)*, and the Edwards Plateau Springs Salamander *(Euryced Sp-7).* Texas Mock-orange is unlikely to be encountered along the existing roadway. Potential conflicts can be avoided with appropriate habitat and important species surveys.

Comal County is within the range of the Golden-cheeked Warbler (*Dendroica chrysoparia)* and Black-capped Vireo *(Vireo atricapillus*). The Golden-cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. In addition to the Golden-cheeked Warbler and Black-

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[10] McMahan, C.A., R.G. Frye and K.L. Brown, "The Vegetation Types of Texas Including Cropland," Texas Parks and Wildlife Department, Austin, TX, 1984.

capped Vireo, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Zone-tailed Hawk, Henslow's Sparrow, and Whooping Crane) are reported to occur in Comal County. It is unlikely that Option G-32 would adversely impact these birds. Because Option G-32 would involve construction mostly along existing right-of-ways, habitat for either of these birds is unlikely to be encountered. Additionally, important habitats can be avoided by selection of the pipeline route. A complete list of important species having habitat or known to occur in the study area is tabulated in Table 2.5-1.

Canyon Lake is a water conservation and flood control reservoir located on the Guadalupe River in Comal County. Canyon Lake covers about 8,231 surface acres and stores 382,000 acft below its conservation pool elevation of 909 ft-msl. An additional 355,000 acft can be temporarily impounded in the flood control pool located between elevations 909 ft-msl and 943 ft-msl.

In addition to the Guadalupe River, several smaller streams drain into Canyon Lake. These include Rebecca, Schultz, Potters, Jentsch, and Tom Creeks. Like most creeks in the area, these are intermittent streams that tend to be dry in the summer, but may have isolated pools within their streambeds during some years. At the mouths of drainages on the lake, shallow coves tend to support more wetland and mesic shoreline habitats than other areas. Emergent vegetation and broadleaf shrub in shoreline wetlands are more common along the upper shoreline away from the dam.[11]

The Canyon Lake flood pool is primarily surrounded by residential and recreational developments including public parks. In addition to Canyon Lake itself, the Guadalupe River (above and below the lake) is a popular recreational destination that has seen substantial shoreline development in recent years. Surrounding land use is predominately rangeland with a spreading ring of suburban residential developments centered around the lake shore. Public access to scenic views and the lake shore is provided at parks operated by the U.S. Army Corps of Engineers. Private marinas, restaurants, and vacation properties allow additional lake access to tourists and area residents. Randolph Air Force Base Recreational Area and the 5th Army Retreat are located on the north shore of the lake near the dam.

[8] U.S. Fish and Wildlife Service, "National Wetland Inventory Map Series; Devils Backbone; Fischer; Sattler; and Smithson Valley," U.S. Geological Service Quadrangles, U.S. Department of the Interior, 1990.

Table 2.5-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Diversion of Canyon Lake Flood Storage to Recharge Zone via Cibolo Creek (G-32)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T	E	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Cling to objects in streams; adults fly especially at night	E		NL	Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E		NL	Resident
Comal Springs Salamander	*Eurycea sp. 8*	Endemic; Comal Springs			NL	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Fountain Darter	*Etheostoma fonticola*	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Glass Mountain Coral Root	*Hexalectris nitida*				NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant

Table 2.5-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3]	Potential Occurrence in County
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Lindheimer's Tickseed	*Desmodium lindheimeri*	Presumably flowers in mid-summer			WL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened with silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Peck's Cave Amphipod	*Stygobromus pecki*	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*				WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident

Table 2.5-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C1 = Candidate Category, Substantial Information
C2 = Candidate Category C3 = No Longer a Candidate for Protection PE/PT = Proposed Endangered/Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Simulated streamflows below Canyon Lake without Option G-32 have monthly medians ranging from 17,106 acft to 6,849 acft (Figure 2.5-4). Monthly medians with implementation of Option G-32 ranged from 15,795 acft to 6,849 acft with the greatest percent reduction in monthly median being 11.6 percent. Decreased median flows were limited to the wettest months (spring). Plotting streamflow frequency with and without the project indicates that reductions in flow due to the project would be limited to the highest 50 percent of monthly flows (Figure 2.5-4). There would be no significant changes in streamflows at the Guadalupe River Saltwater Barrier. Option G-32 would not be expected to have a measurable effect on the ecology of the Guadalupe River or the Guadalupe Estuary.

Under Option G-32, water will be imported from the flood storage pool of Canyon Lake to Cibolo Creek for natural recharge in the streambed and/or impoundment by Cibolo Creek Recharge Enhancement Project. It is currently estimated that the Cibolo Creek Recharge Enhancement Project would be sized to impound up to 10,000 acft and periodically inundate up to about 500 acres.[12] The terrestrial habitat impacts associated with this recharge dam will depend on the amount of clearing done, frequency of inundation, and the rapidity of pool drainage following delivery of imported water or capture of local runoff.

[12] HDR, Op. Cit., September 1993.

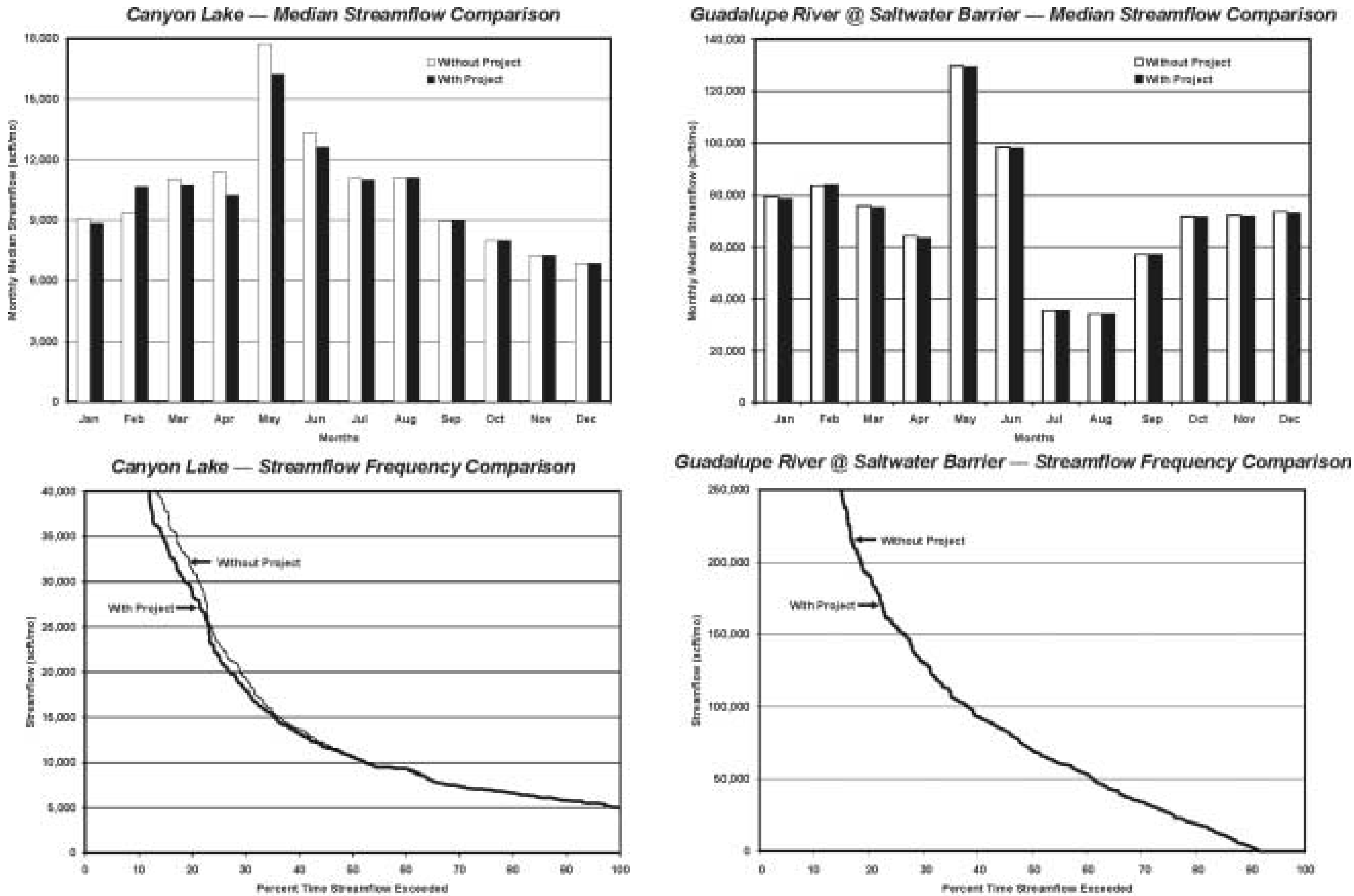


Figure 2.5-4. Canyon Lake Flood Storage Diversion for Recharge Enhancement Streamflow Comparisons

Because the Cibolo Creek Recharge Enhancement Project would be designed to facilitate direct percolation into karst features (fractures, holes, and/or caves) present below the stream channel, disturbance of the local karst system and its fauna is a possibility. The fauna inhabiting these caves are usually small in both species diversity and population size, and are adapted to relatively stable physical habitats, which presumably makes them particularly sensitive to disturbances outside of the natural regime. Openings in the streambed are naturally exposed to the erosive force of flowing water, lessening the likelihood that an organized "terrestrial" community would be able to develop and persist in such a location.

Karst openings in the vicinity of Cibolo Creek Recharge Enhancement Project that presently experience periodic flooding may be inundated for longer periods, or experience an increase in the maximum elevation to which the water rises following a runoff event, possibly causing flow across the recharge zone. Both terrestrial and aquatic communities are extensive in the karst openings associated with the Edwards limestone, and significant threats to these habitats presently exist as a result of human activities in many areas.[13,14] The extent of intermittently flooded karst zones that would be affected by this project, the extent to which these zones are inhabited, and how hydrologic changes might affect resident communities, is unknown. Additional studies to assess potential effects of this option on Natural Bridge Caverns and/or Bat Cave would likely be required.

A petition to the USFWS to list as endangered or threatened nine new species of invertebrates with limited distributions in caves of northern Bexar County has been filed. The petition identifies specific inhabited caves, and a study is underway to identify additional habitat areas. The Cibolo Creek Recharge Enhancement Project is located in an area that has potential for caves containing endangered species.[15]

Cultural resources protection on public lands in Texas, or lands affected by projects regulated under U.S. Army Corps of Engineers permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas disturbed during construction will be first surveyed by qualified professionals for the

[13] Ibid.
[14] Longley, G., 1981, "The Edwards Aquifer: Earth's Most Diverse Ground Water Ecosystem?" Int'l. J. Speleol. 11:123-128.
[15] Ibid.

presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided. Additional studies of recharge impacts on specific karst associations would be required.

2.5.4 Engineering and Costing

For this option (G-32), water potentially available for diversion from Canyon Lake flood storage would be pumped to a tributary of Cibolo Creek for direct recharge and delivery to a recharge structure on Cibolo Creek. The benefits of this project would be enhanced recharge of the Edwards Aquifer resulting in increased water supply for municipal, industrial, and irrigation use as well as enhanced springflow for recreational use and protection of endangered species. The major facilities required to implement Option G-32 include:

- Canyon Lake Intake and Pump Station
- Raw Water Pipeline to Cibolo Creek Tributary
- Raw Water Transmission Pump Station
- Recharge Structure

Optimization analyses were performed in previous studies[16] to select the appropriate import pipeline size for delivery of water from Canyon Lake to a tributary of Cibolo Creek. Diversion from Canyon Lake through two 108-inch import pipelines was found to be the optimum pumping configuration and could provide for an average enhanced Edwards Aquifer recharge of about 24,600 acft/yr. Aquifer model analyses with this recharge enhancement show a potential sustained recharge recovery rate during the drought of record of 2,088 acft/yr at a unit cost of $6,198 per acft. The unit cost includes the cost of developing a 10,000 acft Cibolo Creek Recharge Enhancement Project. Project costs and annual costs calculated to develop the unit costs associated with this option are summarized in Table 2.5-2.

2.5.5 Implementation Issues

Implementation of diversions from Canyon Lake flood storage to the Edwards Aquifer recharge zone via Cibolo Creek could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, S-13B, G-16C1, G-30, SCTN-6, and/or SCTN-8.

[16] HDR, Op. Cit., January 1996.

Table 2.5-2.
Cost Estimate Summary for Diversion of Canyon Lake Flood Storage to Edwards Aquifer Recharge Zone via Cibolo Creek (G-32)
Second Quarter 1999 Prices

Item	***Estimated Cost***
Capital Costs	
Recharge Dam and Reservoir (Conservation Pool: 10,000 acft; 476 acres; 871.9 ft-msl)	$8,292,000
Intake and Pump Station (429 MGD)	17,191,000
Transmission Pump Station (429 MGD)	13,627,000
Transmission Pipeline (two 108-inch dia, 7.8 miles)	59,455,000
Total Capital Cost	**$98,565,000**
Engineering, Contingencies and Legal Costs	$31,525,000
Environmental & Archaeology Studies, Mitigation, and Permitting	607,000
Land Acquisition and Surveying	2,630,000
Interest During Construction (2 years)	10,666,000
Total Project Cost	**$143,993,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$992,000
Debt Service (6 percent for 30 years)	9,370,000
Dam, Intake, Pipeline, Pump Station Operation and Maintenance	1,489,000
Pumping Energy Costs (18,168,000 kWh @ $0.06 per kWh)	1,090,000
Total Annual Cost	**$12,941,000**
Available Project Yield (acft/yr) Raw Water in Aquifer[1]	2,088
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	$6,198
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	$19.01

[1] Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer.

Requirements Specific to Diversion of Water From Canyon Lake

1. Necessary permits:
   a. TNRCC permit to divert unappropriated water.
   b. TNRCC Interbasin Transfer Approval.
   c. TNRCC authorization to use Cibolo Creek and its tributaries to deliver Guadalupe River water for recharge purposes to the San Antonio River Basin.
   d. U.S. Army Corps of Engineers (USCE) Sections 10 and 404 dredge and fill permits for the intake structure.
2. Permitting could require these studies:
   a. Instream flow issues and impact.
   b. Environmental studies.
3. Agreements with USCE and, possibly, Guadalupe-Blanco River Authority to construct and operate an intake and pump station at Canyon Lake to transfer Guadalupe River water to the recharge zone.
4. Agreement with GBRA regarding changes in the number of days Canyon Lake remains in the flood pool as this affects operations and maintenance costs shared by GBRA and USCE.

Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Surface Recharge Structures

1. Detailed field investigation of potential recharge site on Cibolo Creek to determine natural and expected recharge rates.
2. Compatibility testing of water imported to the recharge zone and assessment of treatment needs (if any), including biological and chemical characteristics.
3. Necessary permits could include:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.

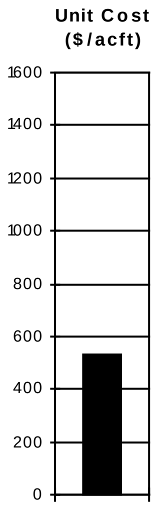
e. EAA authorization to recharge and to recover water through a recharge recovery permit.

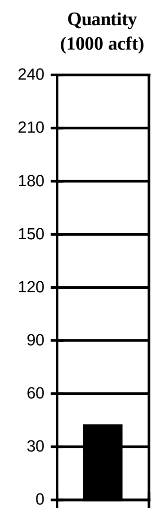
4. Permitting, at a minimum, will require these studies:
   a. Determination of impact plans for parkland, wildlife preserves, and other conservation programs.
   b. Study of impact on karst geology organisms from a sustained recharge program.
   c. Other environmental studies.
   d. Studies of potential water level changes at Natural Bridge Caverns and Bat Cave and studies to determine if impacts are significant.

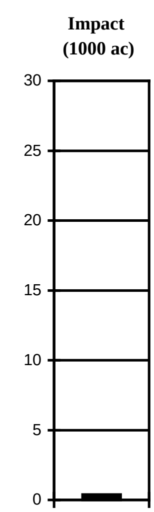
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 12/13/99







OPTION NUMBER: SCTN-6a
OPTION NAME: Edwards Aquifer Recharge Enhancement with Guadalupe River Diversions at Lake Dunlap

OPTION DESCRIPTION: *Conceptually, the project diverts unappropriated streamflow from the Guadalupe River at Lake Dunlap to the recharge zone of the Edwards Aquifer where it is released to streams that naturally recharge the aquifer. The enhanced recharge would migrate through the aquifer along with the natural recharge and would eventually be discharged by wells or springs. The concept is based on filling the aquifer during periods when unappropriated streamflow is available; then, during drought, the stored water sustains pumpage at established rates and maintains springflows above critical levels.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$534**	**per acft[1]**	**Raw Water in Aquifer**
QUANTITY OF WATER:	**42,121**	**acft/yr[2]**	
LAND IMPACTED:	**443**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Construction of intake at Lake Dunlap, 52 miles of transmission pipeline, one transmission pump station, and four recharge dams.

[2]**QUANTITY OF WATER:** The diversion from the Guadalupe River, including enhanced springflow from Comal Springs, averages 101,907 acft/yr.

[3]**LAND IMPACTED:** Intake facilities on Guadalupe River at Lake Dunlap, pipeline right-of-way, transmission pump station site, and recharge dams.

ENVIRONMENTAL ISSUES: Guadalupe River instream flows and effects of pipeline routes and recharge structures upon terrestrial habitat.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain credits for recharge enhancement that can be expressed in quantities of additional Edwards Aquifer pumping rights, confidence in the GWSIM4 Model, availability of suitable recharge areas in northwestern Bexar County, and concerns of downstream Guadalupe River water right owners.

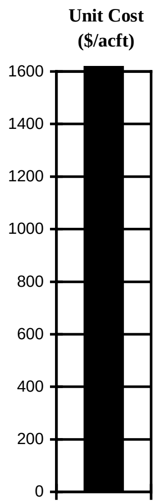
ADDITIONAL FACTORS: Ability to obtain permits for the unappropriated streamflow in the Guadalupe River.

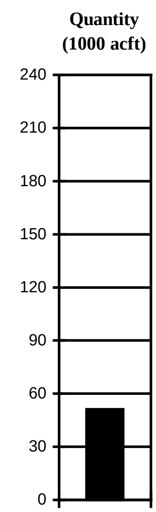
OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-16C1, G-17C1, G-19, G-20, G-30, G-32, G-38C, S-15Db, S-15Dc, S-15Ea, S-15Eb, SCTN-16b, and/or SCTN-16c.

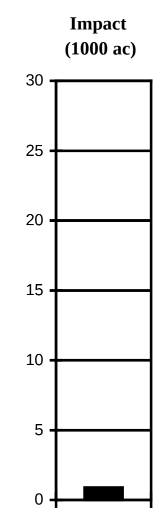
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 12/13/99







OPTION NUMBER: **SCTN-6b**

OPTION NAME: **Edwards Aquifer Recharge Enhancement with Guadalupe River Diversions near Gonzales**

OPTION DESCRIPTION: *Conceptually, the project diverts unappropriated streamflow from the Guadalupe River near Gonzales to the recharge zone of the Edwards Aquifer where it is released to streams that naturally recharge the aquifer. The enhanced recharge would migrate through the aquifer along with the natural recharge and would eventually be discharged by wells or springs. The concept is based on filling the aquifer during periods when unappropriated streamflow is available; then, during drought, the stored water sustains pumpage at established rates and maintains springflows above critical levels.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$1,941**	**per acft**[1]	**Raw Water in Aquifer**
QUANTITY OF WATER:	**51,133**	**acft/yr**[2]	
LAND IMPACTED:	**893**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Construction of intake on the Guadalupe River near Gonzales, 138 miles of transmission pipeline, three transmission pump stations, water treatment plant, and four recharge dams.

[2]**QUANTITY OF WATER:** The diversion from the Guadalupe River, including enhanced springflow from Comal and San Marcos Springs, averages 147,995 acft/yr.

[3]**LAND IMPACTED:** Intake facilities on Guadalupe River near Gonzales, pipeline right-of-way, transmission pump station site, and recharge dams.

ENVIRONMENTAL ISSUES: Guadalupe River instream flows and effects of pipeline routes and recharge structures upon terrestrial habitat.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Ability of sponsors to obtain credits for recharge enhancement that can be expressed in quantities of additional Edwards Aquifer pumping rights, confidence in the GWSIM4 Model, availability of suitable recharge areas in northwestern Bexar County, and concerns of downstream Guadalupe River water right owners.

ADDITIONAL FACTORS: Ability to obtain permits for the unappropriated streamflow in the Guadalupe River.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-16C1, G-17C1, G-19, G-20, G-30, G-32, G-38C, S-15Db, S-15Dc, S-15Ea, S-15Eb, SCTN-16b, and/or SCTN-16c.

2.6 Edwards Aquifer Recharge Enhancement with Guadalupe River Diversions (SCTN-6)

2.6.1 Description of Option

This water supply option involves increasing permitted pumpage from the Edwards Aquifer as a result of the enhancement of recharge utilizing unappropriated streamflow from the Guadalupe River downstream of Comal Springs. This option has been advanced as having a significant potential to (1) increase the amount of water available from the Edwards Aquifer, (2) stabilize and/or enhance aquifer water levels, and (3) maintain springflow during droughts. Conceptually, the project diverts unappropriated water from the Guadalupe River to the recharge zone of the Edwards Aquifer, where it is released to streams that naturally recharge the aquifer. The enhanced recharge would migrate through the aquifer along with the natural recharge and would eventually be discharged by wells or springs. The concept is based on filling the aquifer during periods when unappropriated streamflow is available; then, during drought, using the stored water to sustain pumpage at established rates and maintain springflows above critical levels. Hence, the enhanced recharge might be recaptured through a recharge recovery permit[1], which could be obtained through the Edwards Aquifer Authority (EAA). It is important to note that the conceptual basis, statutory authority, and administrative procedures associated with recharge recovery permits are issues under consideration in the EAA's ongoing development of rules.

The option considers two potential diversion points. One is from Lake Dunlap on the Guadalupe River southeast of New Braunfels and the other is from the Guadalupe River below the mouth of the San Marcos River near Gonzales (Figure 2.6-1). For each diversion point, a broad range of maximum diversion rates is considered to assess relative effectiveness in terms of cost, pumpage, springflows, water levels, and streamflows in the Guadalupe River.

The selection of target streams to recharge the aquifer with water from the Guadalupe River is based on several factors. Four of the major factors are: (1) the time delay between the recharge in the outcrop and discharge at major springs; (2) stream reaches that are conducive to water losses to the Edwards Aquifer; (3) location of existing or proposed recharge structures on

[1] HDR Engineering, Inc. (HDR), "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.

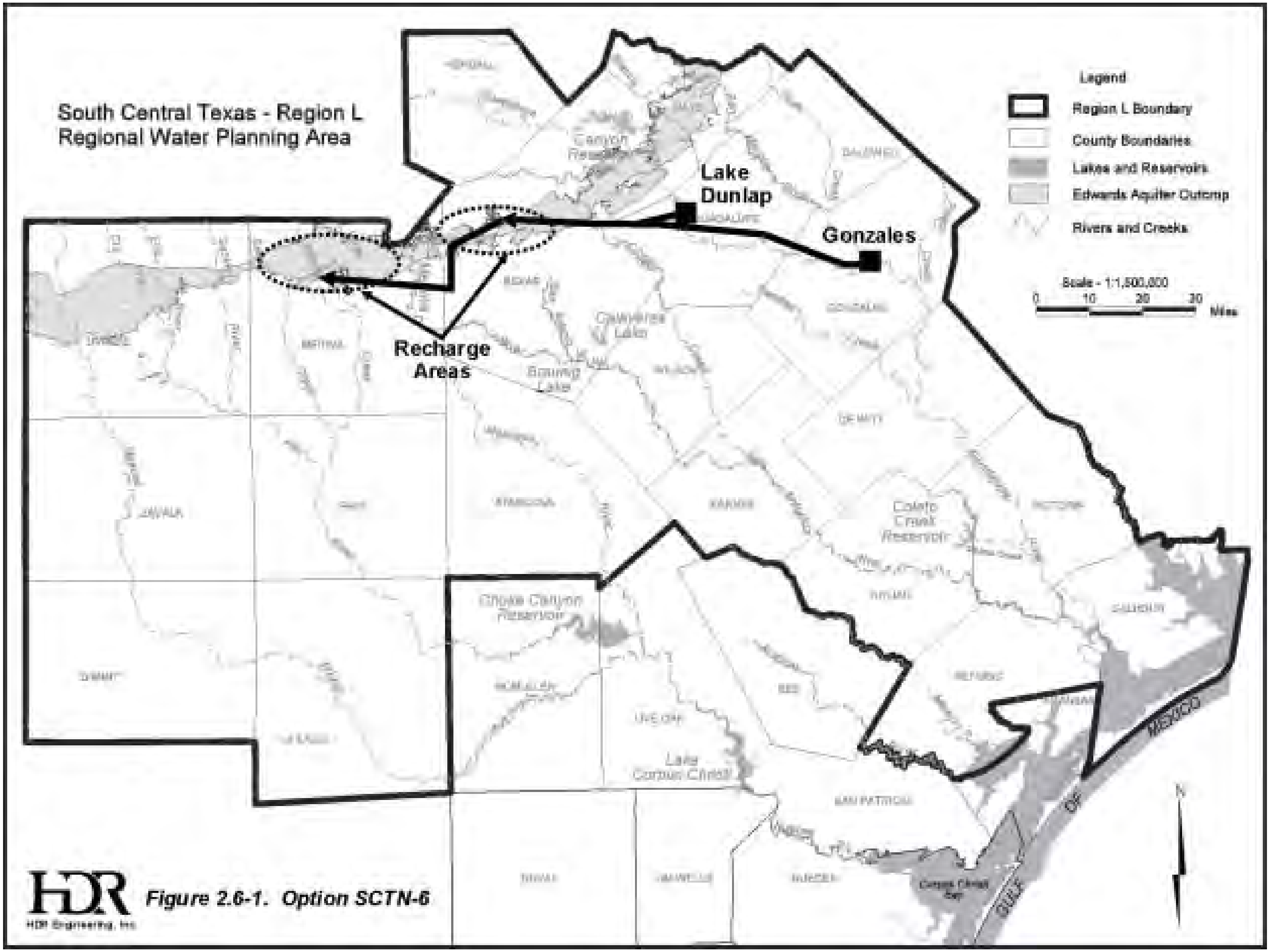


Figure 2.6-1. Option SCTN-6

the streams,[2] and (4) the expected capital and operating costs. Considering the hydrogeology, recharge east of the Bexar-Medina County line tends to move either toward the northeast and Comal and San Marcos Springs or pumping centers in San Antonio, while recharge west of this county line tends to move toward the southwest before turning toward San Antonio and then to Comal and San Marcos Springs.[3] Because of this circulation pattern, recharge in Bexar County is expected to show a relatively short time response in Comal Springs, while recharge in Medina County would have a delayed response. San Geronimo Creek, Government Canyon, Culebra Creek, Helotes Creek, Leon Creek, Salado Creek, and Panther Springs Creek in Bexar County and eastern Medina County were selected recharge areas for the first 200 cubic feet per second (cfs). Verde Creek, Hondo Creek, Parker Reservoir, and Seco Creek in Medina County were selected for flows greater than 200 cfs. General water delivery locations are shown in Figure 2.6-1.

The simulation period used extends from 1934 to 1989, and includes the drought of record. All simulations were performed on a monthly timestep. The procedure for evaluating this option is summarized as follows:

Phase I: Baseline Simulations

1. Calculate springflow from Comal Springs for a baseline scenario of 400,000 acft/yr of permitted pumpage using the GWSIM4 Model of the Edwards Aquifer, which was developed by the Texas Water Development Board (Appendix C).
2. Calculate the "sustained yield" of the Edwards Aquifer by adjusting all pumpage by the same factor in a trial and error procedure until the minimum simulated monthly flow at Comal Springs (in one and only one month) is 60 cfs.

Phase II: Preliminary Assessment of Projects

3. Calculate unappropriated streamflow and any streamflow deficits in the Guadalupe River at Lake Dunlap and near Gonzales using the Guadalupe-San Antonio River Basin Model (GSA Model).[4,5] The calculations are based on naturalized streamflows except for Edwards Aquifer springs, which were adjusted to match the results of the

[2] HDR Engineering, Inc., "Nueces River Basin, Edwards Aquifer Recharge Enhancement Project Phase IVA, Nueces River Basin," Edwards Underground Water District, June 1994.
[3] Maclay, R.W., and Land, L.F., "Simulation of Flow in the Edwards Aquifer, San Antonio Region, Texas, A Refinement of Storage And Flow Concepts"; U.S. Geological Survey, Water Supply Paper 2336, 48p., 1988.
[4] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[5] HDR, "Guadalupe-San Antonio River Basin Model Modifications and Enhancements, Trans-Texas Water Program. West Central Study Area," San Antonio River Authority, et al., March 1998.

baseline 400,000 acft/yr permitted pumpage calculated by the GWSIM4 Model in Step 1.

4. Calculate the enhanced recharge for a range of five maximum diversion rates from the river using 400,000 acft/yr of permitted pumpage with GWSIM4. For each timestep, the enhanced recharge is initially set equal to the unappropriated streamflow and adjusted subject to the following criteria:
   a. If the streamflow deficit calculated in Step 3 is greater than the enhanced springflow from Comal Springs (previous month springflow minus the springflow calculated in Step 1), then there is no streamflow or springflow available for enhanced recharge; thus, the enhanced recharge for the month is set to zero. Otherwise, enhanced recharge is equal to the unappropriated flow calculated in Step 3;
   b. Limit enhanced recharge availability to the capacity of the transmission system; and
   c. Temporarily stop enhanced recharge when water levels in the target recharge areas are above a preset limit.
5. Using GWSIM4, calculate the sustained yield of the Edwards Aquifer for the five maximum diversion rates (projects) by using the enhanced recharge calculated in Step 4 and adjusting municipal pumpage on a trial and error basis until the minimum monthly flow at Comal Springs is 60 cfs.
6. Calculate the increase in sustained yield attributable to each of the five projects by subtracting the results of Step 2 from Step 5.
7. Add the enhanced recharge and the increase in municipal pumpage to the baseline pumpage and baseline recharge (Step 1) and run GWSIM4 for each of the five projects to calculate flows from Comal Springs and water levels at J-17.
8. Calculate the costs for each of the five projects.
9. Select the most apparently feasible project size for each river diversion on the basis of unit cost, increase in sustained yield, and effects on flow from Comal Springs and water levels in J-17.

Phase III: Calculate Increase in Sustained Yield for Selected Projects

10. For the selected projects, calculate the enhanced springflow from Comal Springs attributable to the project by subtracting baseline values (Step 1) from values for the selected projects (Step 9). Add the enhanced springflow to the enhanced recharge calculated in Step 4 to create a new enhanced recharge series.
11. Calculate new sustained yields of the Edwards Aquifer for the new enhanced recharge associated with the selected projects, by adjusting municipal pumpage on a trial and error basis until the minimum monthly flow at Comal Springs is 60 cfs.
12. Calculate the increases in sustained yield attributable to the projects by subtracting the results of Step 2 from Step 11.

13. If the change in sustained yield is significantly greater than previously calculated, re-calculate enhanced springflow from Comal Springs and repeat Steps 10, 11, and 12. Repeat this series of steps until the increase in sustained yield between iterations is negligible. The final simulation is used for evaluation of these projects.

Phase IV: Calculate Streamflow Changes in the Guadalupe River

14. For the selected diversion rates, calculate flows in the Guadalupe River at key locations that account for diversions to the recharge zone and changes in discharge from Comal Springs.
15. Compare the flows from Comal Springs and in the Guadalupe River and water levels at J-17 for baseline conditions and the selected projects.

Phase V: Estimate Costs for the Selected Projects

16. Estimate capital, project, annual, and unit costs for selected projects with diversions from the Guadalupe River at Lake Dunlap and at Gonzales.

Quantification of increases in sustained yield of the Edwards Aquifer during the drought of record provides a means for direct comparison of recharge enhancement options with surface water supply options under Texas Water Development Board rules for regional water supply planning. At this time, the concept of sustained yield enhancement as a basis for recharge recovery permitting has not been adopted by the EAA.

2.6.2 Available Yield

The increased yield to users of the Edwards Aquifer for a project enhancing recharge to the Edwards Aquifer depends on two major components. One is the availability of water for enhanced recharge and the other is the efficiency of the aquifer to store water during the onset of severe drought conditions. The availability of water for enhanced recharge is based on unappropriated streamflow at the point of diversion, deficits in streamflows necessary to satisfy downstream water rights, enhanced springflow from Comal Springs attributable to the project, groundwater levels in the target recharge area, and capacity of the transmission system. For this option, the GSA Model was used to calculate unappropriated streamflows available for given maximum diversion rates and to quantify streamflow deficits. The GWSIM4 program code was modified to (1) restrict diversions for recharge enhancement during periods of streamflow deficits; (2) turn the diversion 'OFF' and 'ON' on the basis of ground water levels at index monitoring wells located near the two recharge areas; and (3) calculate and add enhanced springflow from Comal Springs to the unappropriated streamflow diversions. The efficiency of the aquifer to store water for wells is indicated by the lag time between recharge and discharge at major springs.

To select the most apparently feasible project for Lake Dunlap and for Gonzales, several potential projects having a wide range of maximum diversion rates were evaluated for each point of diversion. The potential maximum diversion rates from Lake Dunlap include 100, 150, 200, 250, and 300 cfs; and, the potential maximum diversion rates from Gonzales include 200, 300, 400, 500, and 600 cfs. For this phase of the evaluation, selection of the most apparently possible project for each of the diversion points is based on scenarios in which enhanced recharge is limited to the availability of unappropriated streamflow and capacity of the transmission system.

The evaluation and selection of projects is jointly based on cost of the additional water supply and support of the Edwards Aquifer Optimization program by maintaining higher flows from the springs, especially Comal Springs, and higher groundwater levels, especially at J-17. Summaries of performance and cost from the preliminary assessment of projects at Lake Dunlap and near Gonzales are presented in Figure 2.6-2. Of major interest, the increase in sustained yield, which, under the preliminary assessment (Phase II), does not benefit from recirculation of enhanced springflow, ranges from 5,137 acft/yr for the 100 cfs project at Lake Dunlap to 39,159 acft/yr for the 600 cfs project at Gonzales. Average annual diversions for these two projects ranged from 34,682 acft to 136,673 acft, respectively. The efficiency of the enhanced recharge in increasing the availability of water supplies from the Edwards Aquifer is about 15 percent for projects at Lake Dunlap, which recharges the area east of Medina Lake, and about 25 percent for projects at Gonzales, which recharges areas both east and west of Medina Lake. A summary of the impacts of potential projects on key references for critical hydrologic conditions is shown in Figure 2.6-3. All of the potential projects substantially reduce the number of months when flows from Comal Springs and water levels at J-17 are below given reference levels.

Based on variations in unit cost and improvements in flow from Comal Springs and water levels in J-17, the most apparently feasible projects that would best support an increase in water supplies are associated with maximum diversion rates of 200 cfs from Lake Dunlap and 400 cfs from Gonzales.

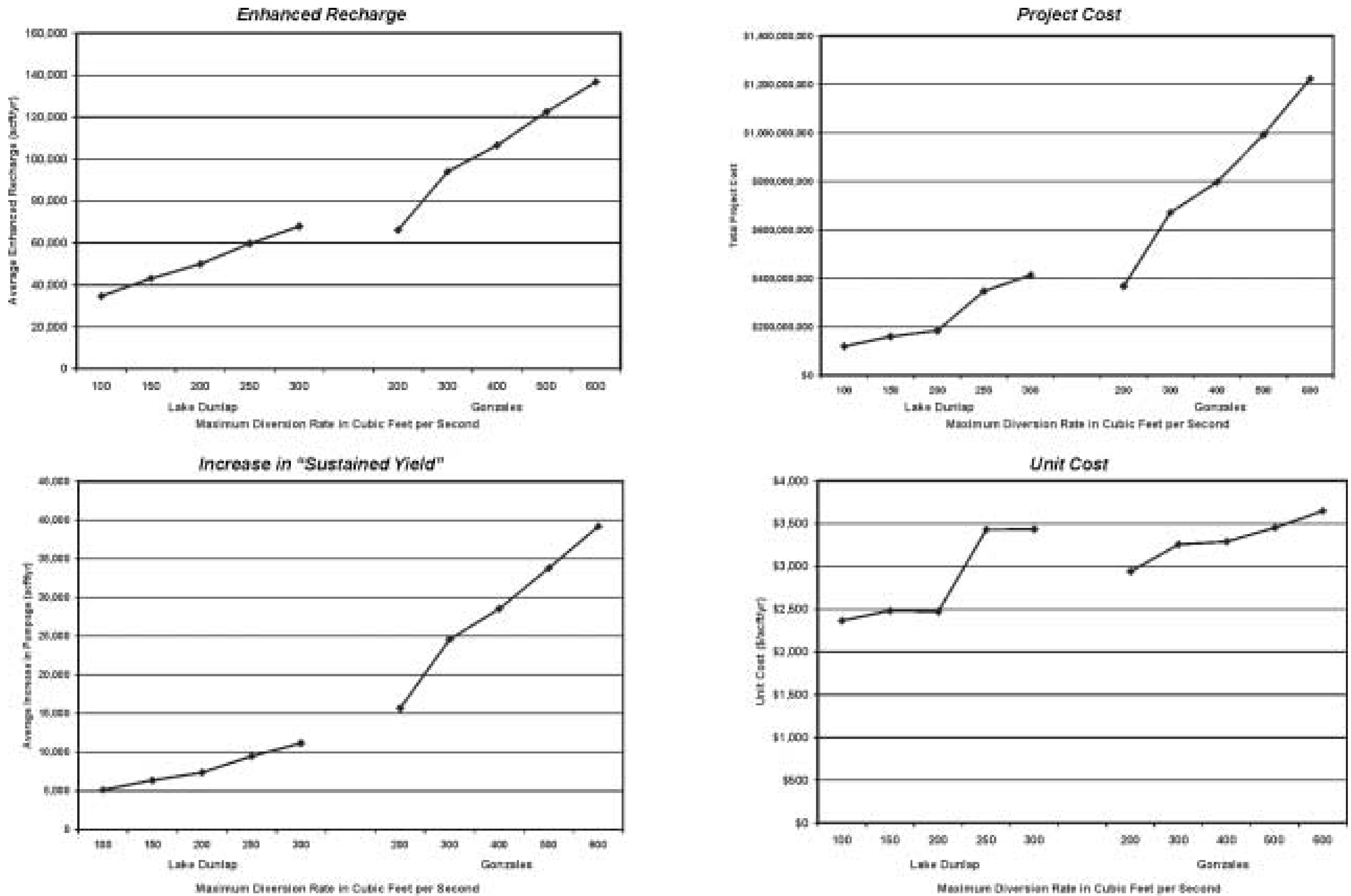


Figure 2.6-2. Comparison of Enhanced Recharge, Increase in Sustained Yield, and Costs for Preliminary Assessment of Projects

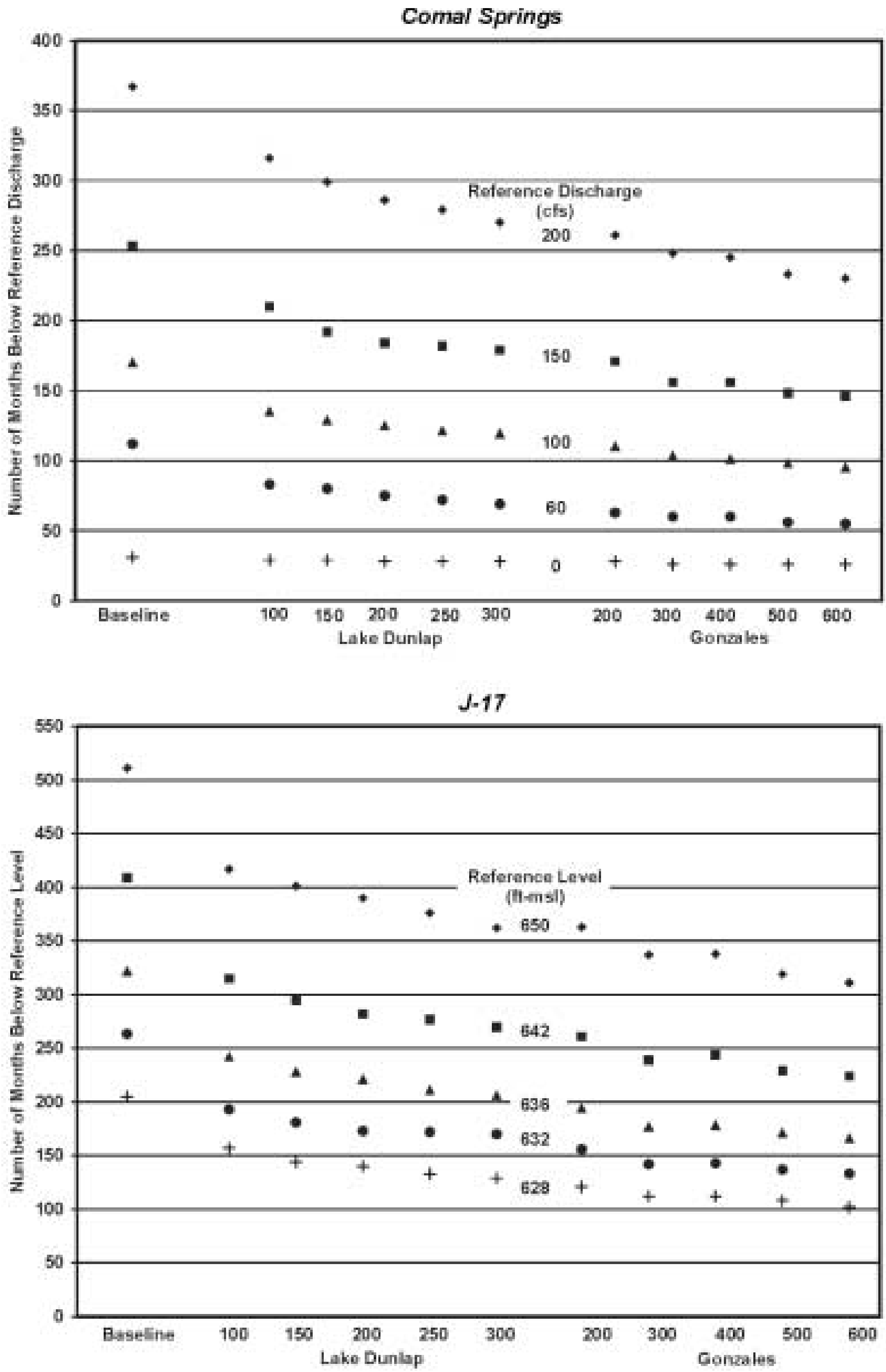


Figure 2.6-3. Performance of Potential Projects Relative to Key References for Critical Hydrologic Conditions

For these two selected projects, additional analyses and evaluations were performed. These analyses included: (1) adding the enhanced recharge from Comal Springs to the availability of unappropriated streamflow from the Guadalupe River; (2) recalculating the increase in sustained yield; and (3) quantifying changes in streamflow at selected locations on the Guadalupe River. The effects of the two selected projects on the Edwards Aquifer are summarized in Figures 2.6-4 and 2.6-5, which show the water balance of the aquifer for the projects diverting at Lake Dunlap and near Gonzales, respectively. The increase in sustained yield is 42,121 and 51,133 acft/yr for the Lake Dunlap and Gonzales projects, respectively. The enhanced recharge, which now includes unappropriated streamflow and enhanced springflow from Comal Springs, varies considerably during the simulation period (Figure 2.6-6) and averages 101,907 and 147,995 acft/yr for the Lake Dunlap and Gonzales projects, respectively. Of major interest, the combined flow from all springs increased by 42,764 and 56,113 acft/yr for the Lake Dunlap and Gonzales projects, respectively. For Comal Springs, Figure 2.6-7 indicates flows with the projects will be greater than baseline conditions nearly all the time.

Changes in streamflow in the Guadalupe River are expected because the projects divert all or a portion of the unappropriated streamflow and enhanced springflow from Comal Springs at the two diversion points. As shown in Figure 2.6-8, both projects reduce the median monthly streamflow in the Guadalupe River at Cuero and at the Saltwater Barrier in every month. On average, the median monthly streamflow at Cuero is reduced about 5,100 and 8,800 acft/month for the selected Lake Dunlap and Gonzales diversion projects, respectively. At the Saltwater Barrier, the reduction in median monthly streamflow is slightly less, about 4,600 and 7,700 acft/month, respectively. Figure 2.6-9 summarizes changes in streamflow frequency for the Guadalupe River at Cuero and the Saltwater Barrier for the baseline simulation and in two selected projects.

2.6.3 Environmental Issues

Option SCTN-6 diverts water from either the Guadalupe River near Gonzales or Lake Dunlap southeast of New Braunfels and releases it into streams in Medina and Bexar Counties in the upper regions of the Edwards Aquifer outcrop. The diversion site near Gonzales falls within the East Central Texas Plains ecoregion including the pipeline until it reaches the northeast region of Guadalupe County where it crosses into the Texas Blackland Prairies. Upon entrance

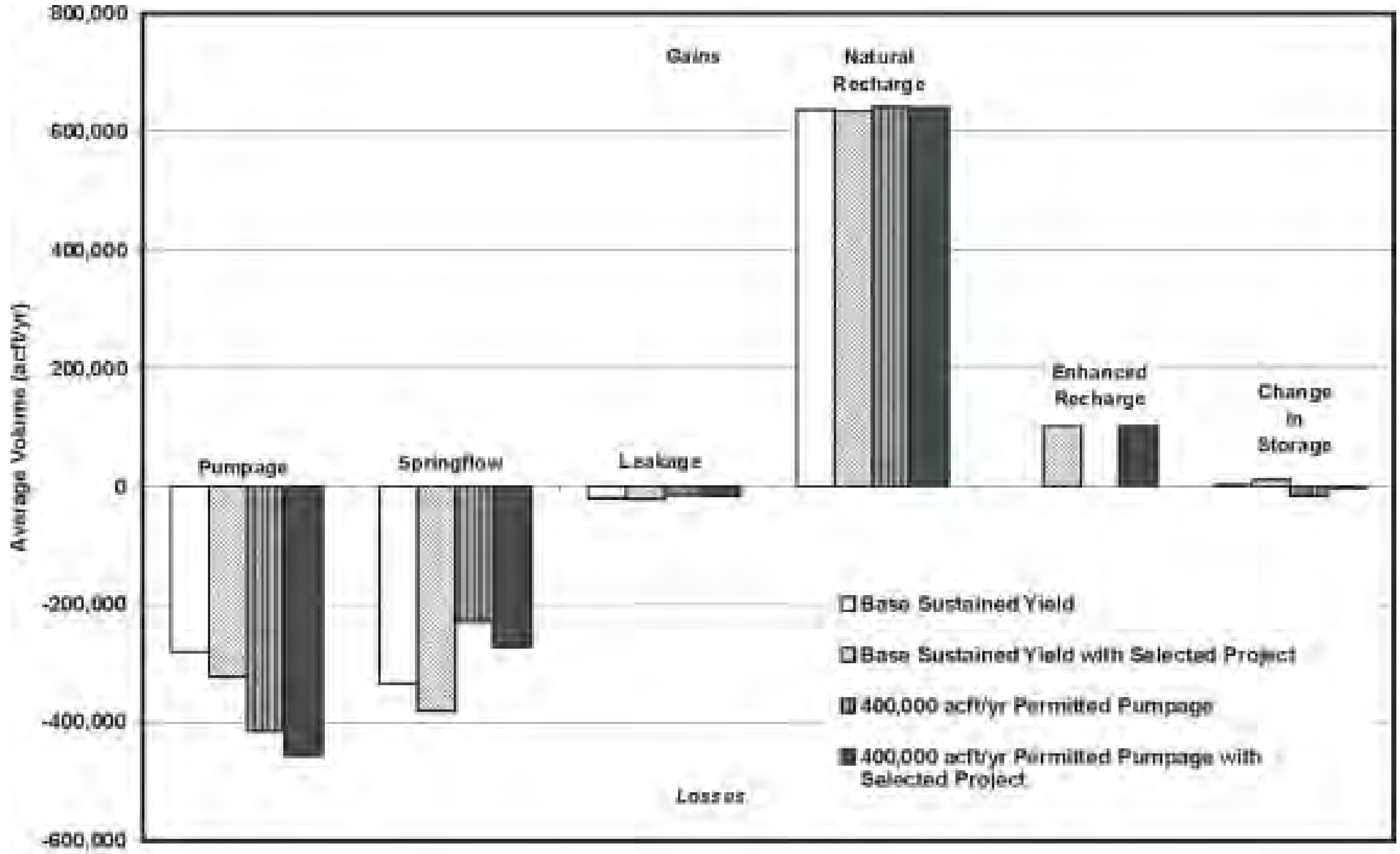


Figure 2.6-4. Edwards Aquifer Water Balances for Baseline and Selected Project with Diversion at Lake Dunlap

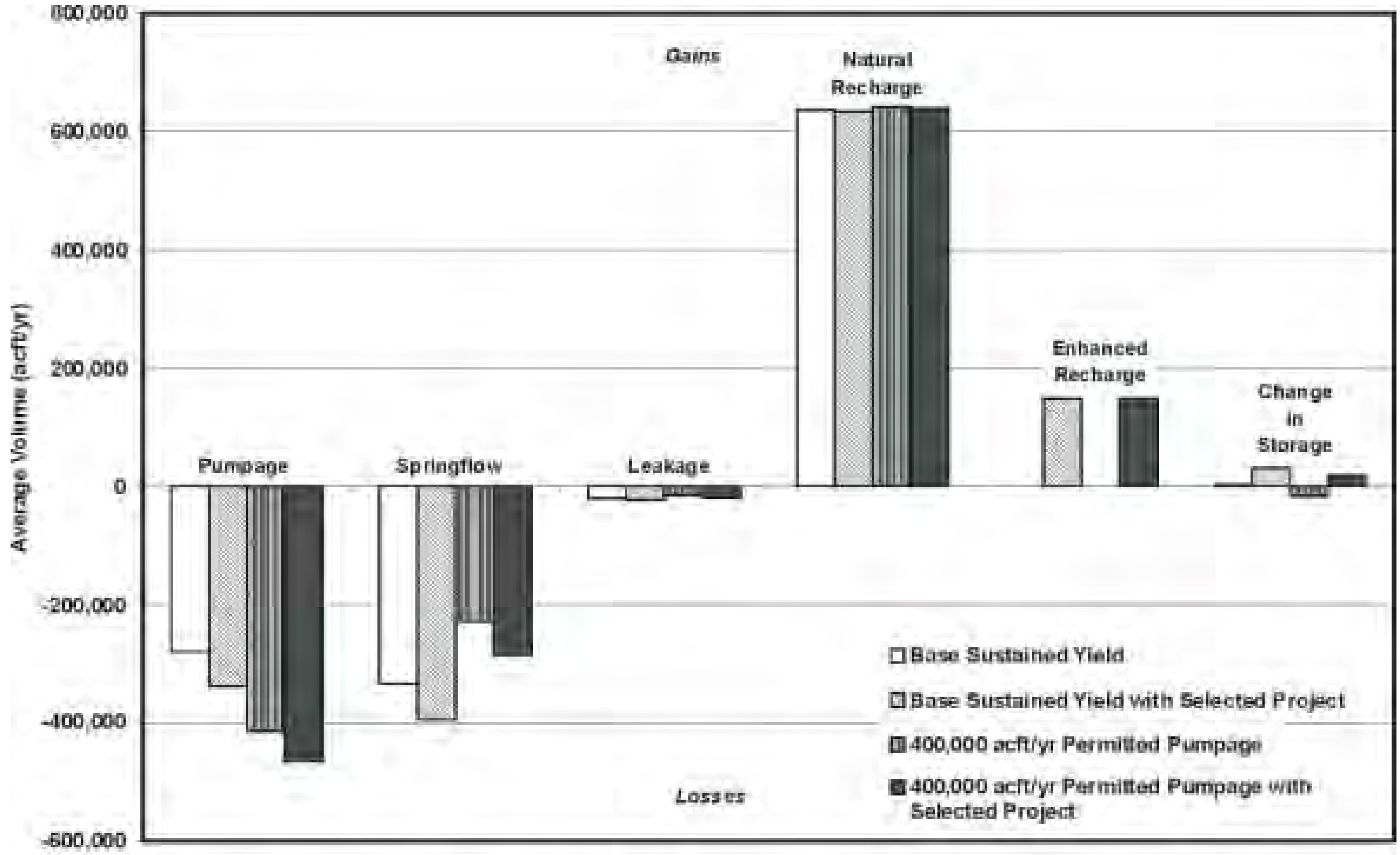
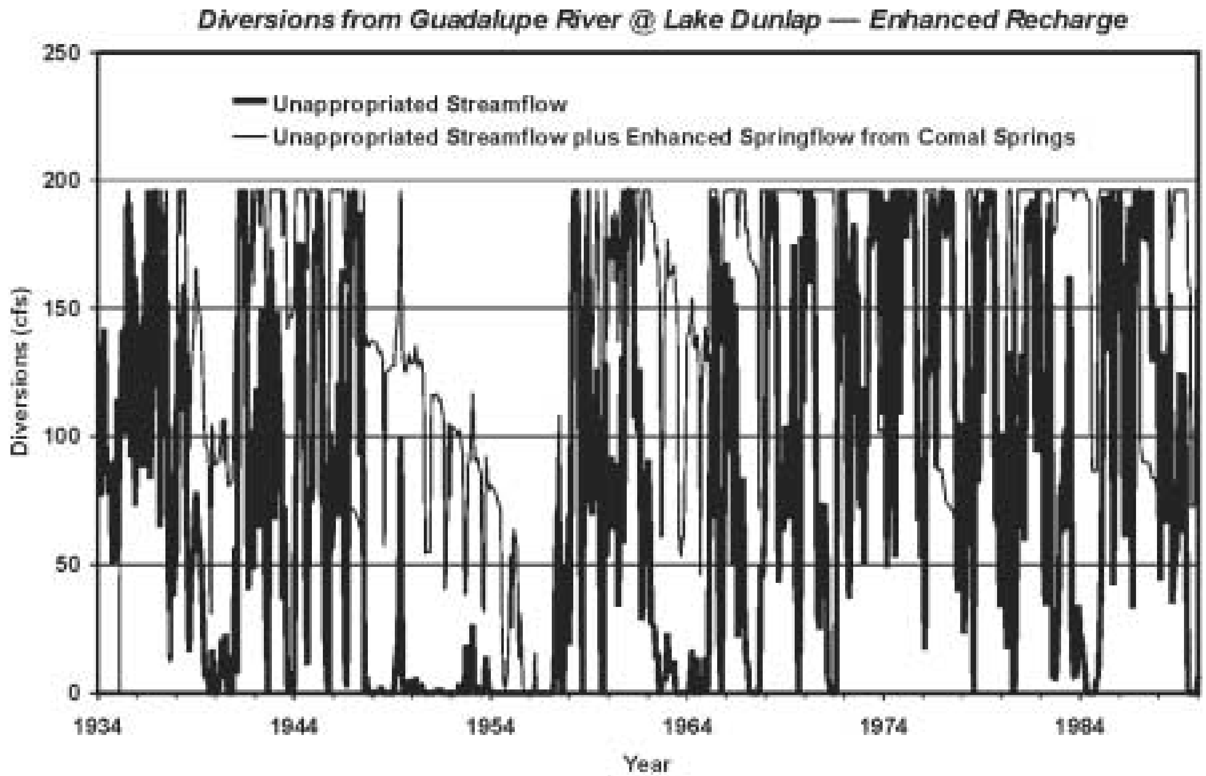


Figure 2.6-5. Edwards Aquifer Water Balances for Baseline and Selected Project with Diversion near Gonzales



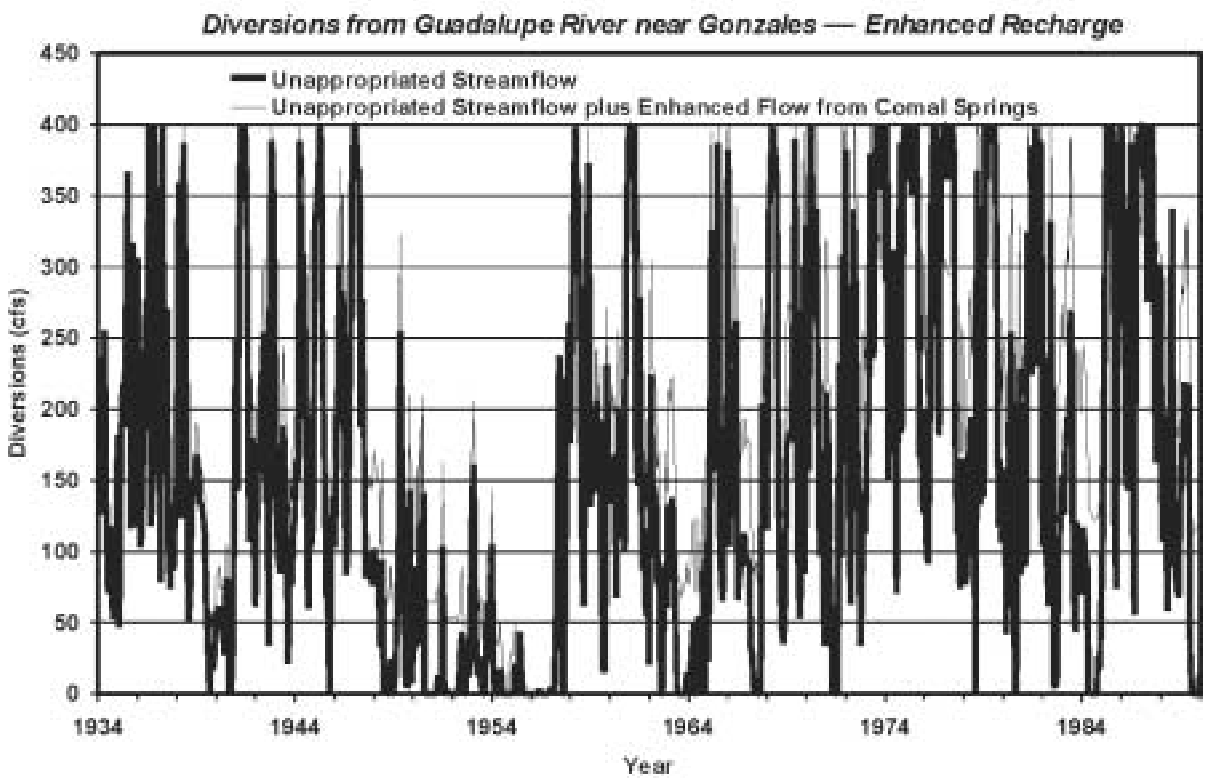
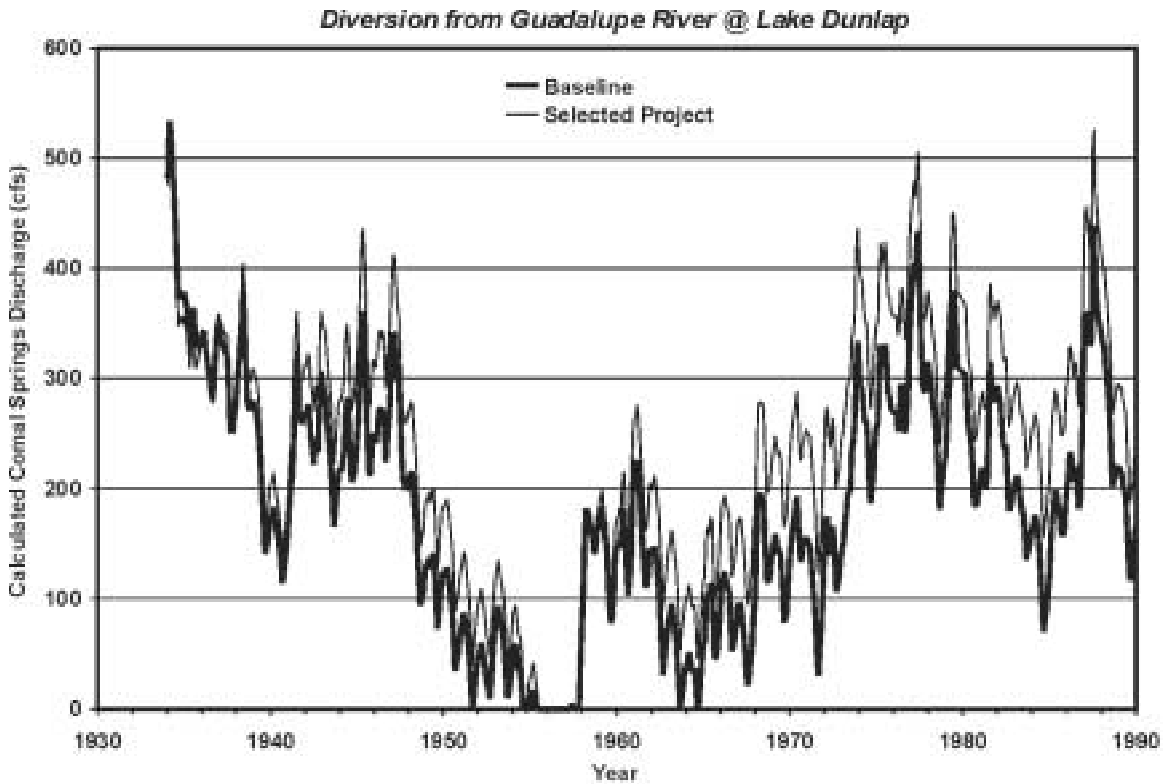


Figure 2.6-6. Enhanced Recharge for Selected Projects



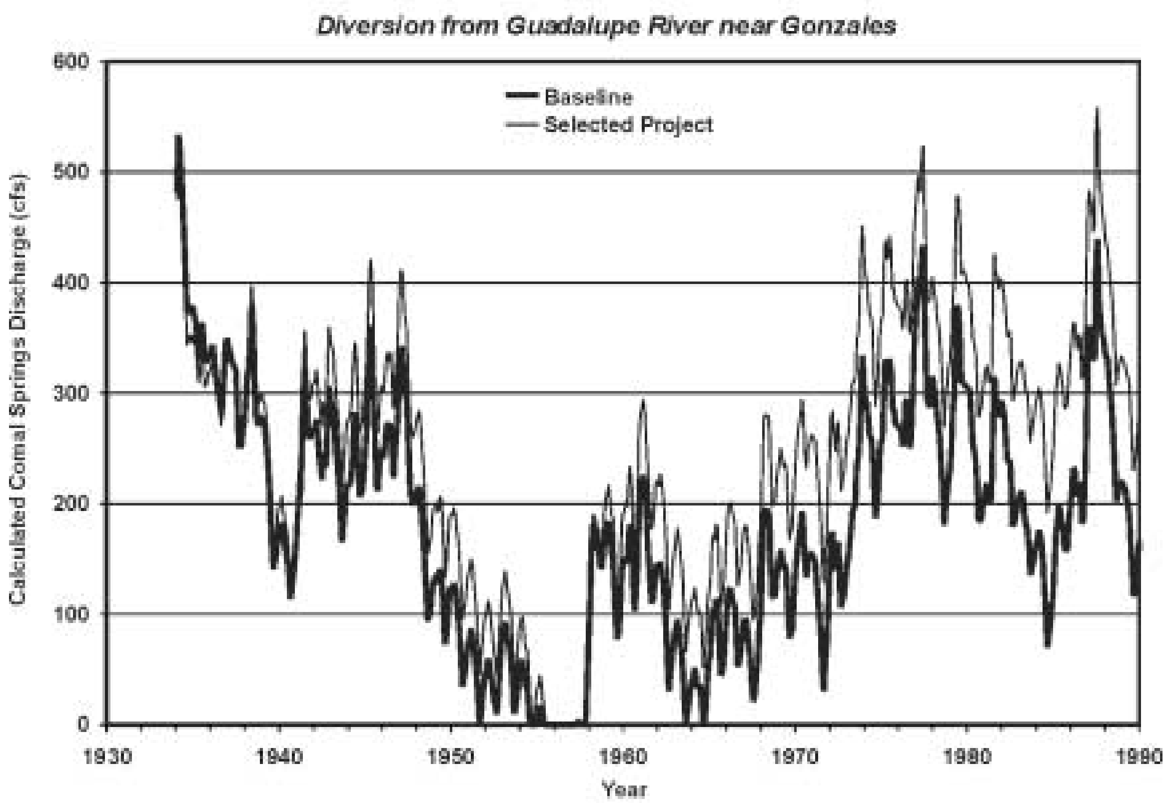
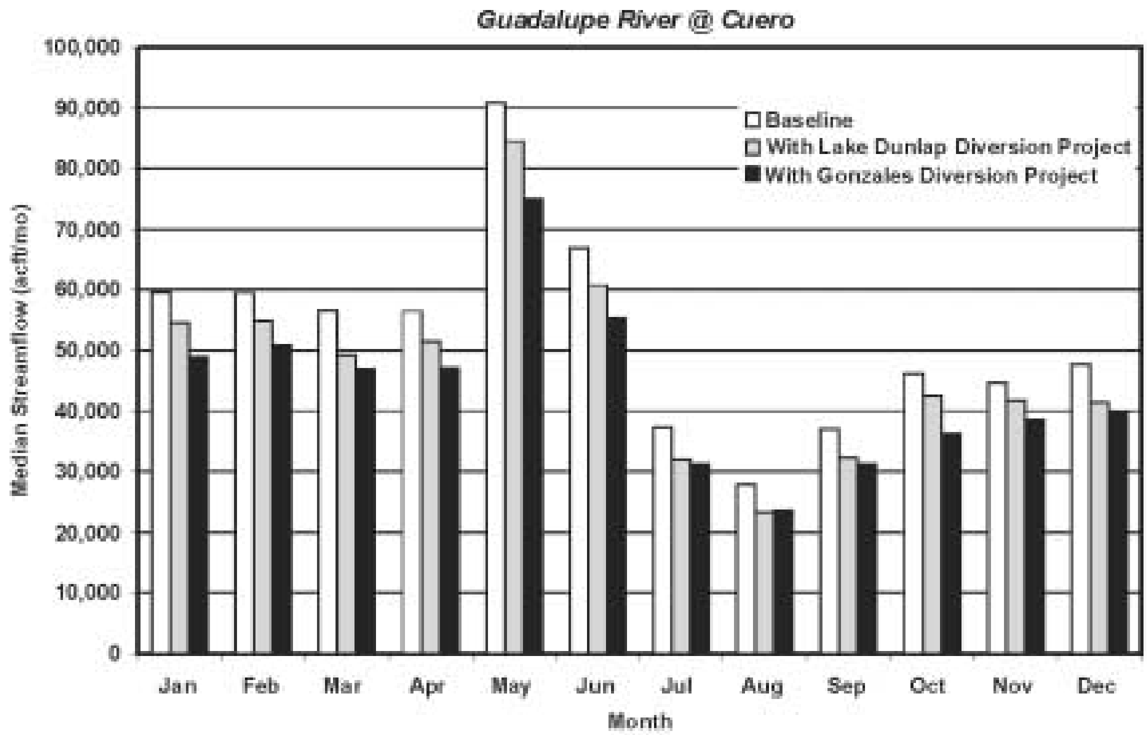


Figure 2.6-7. Comparison of Flows from Comal Springs for Baseline and Selected Projects



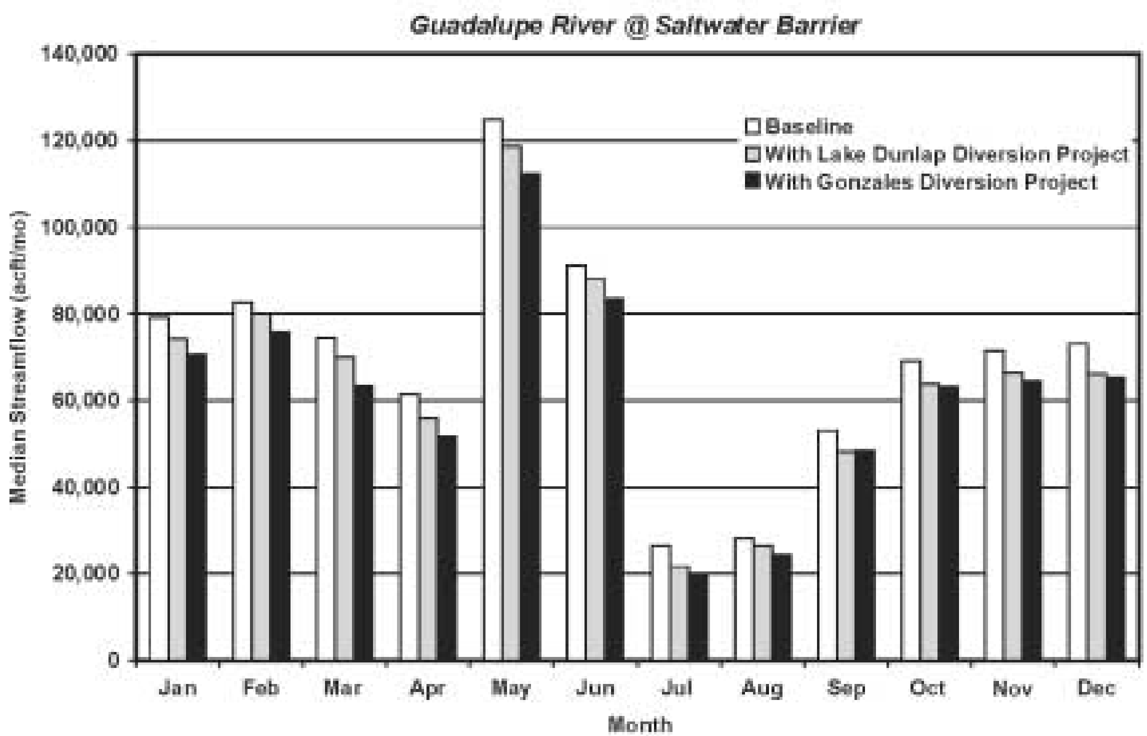
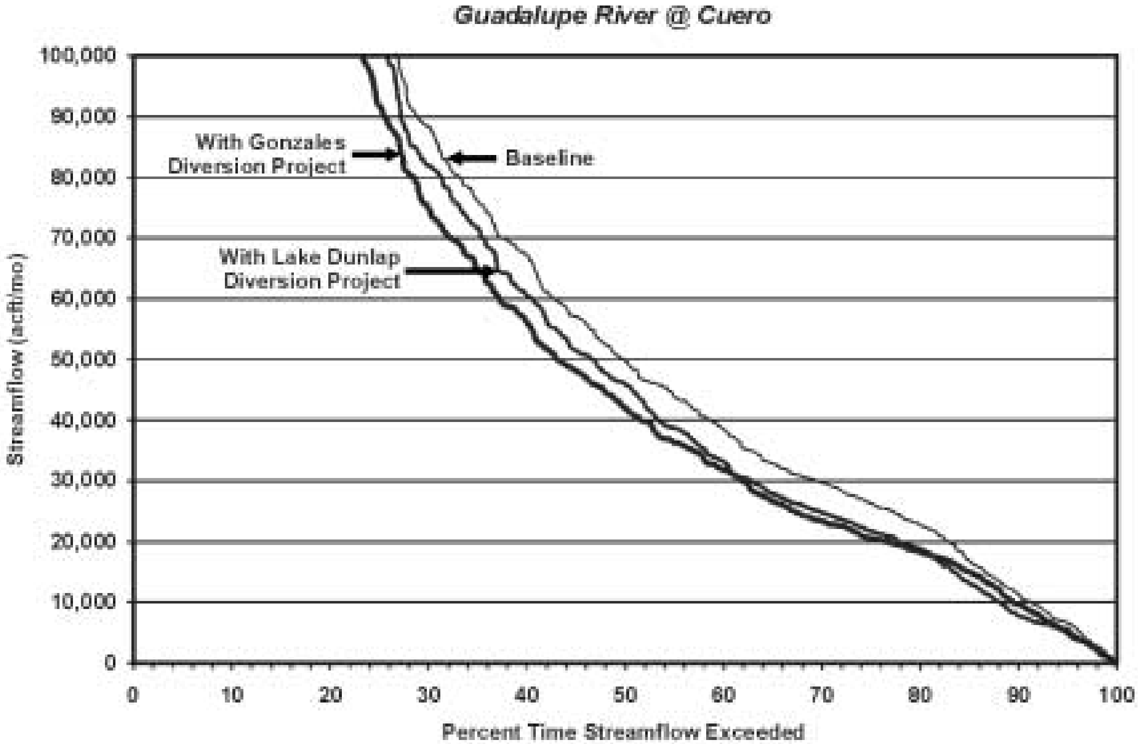


Figure 2.6-8. Median Streamflow Comparisons at Two Locations on the Guadalupe River for Baseline and Selected Projects



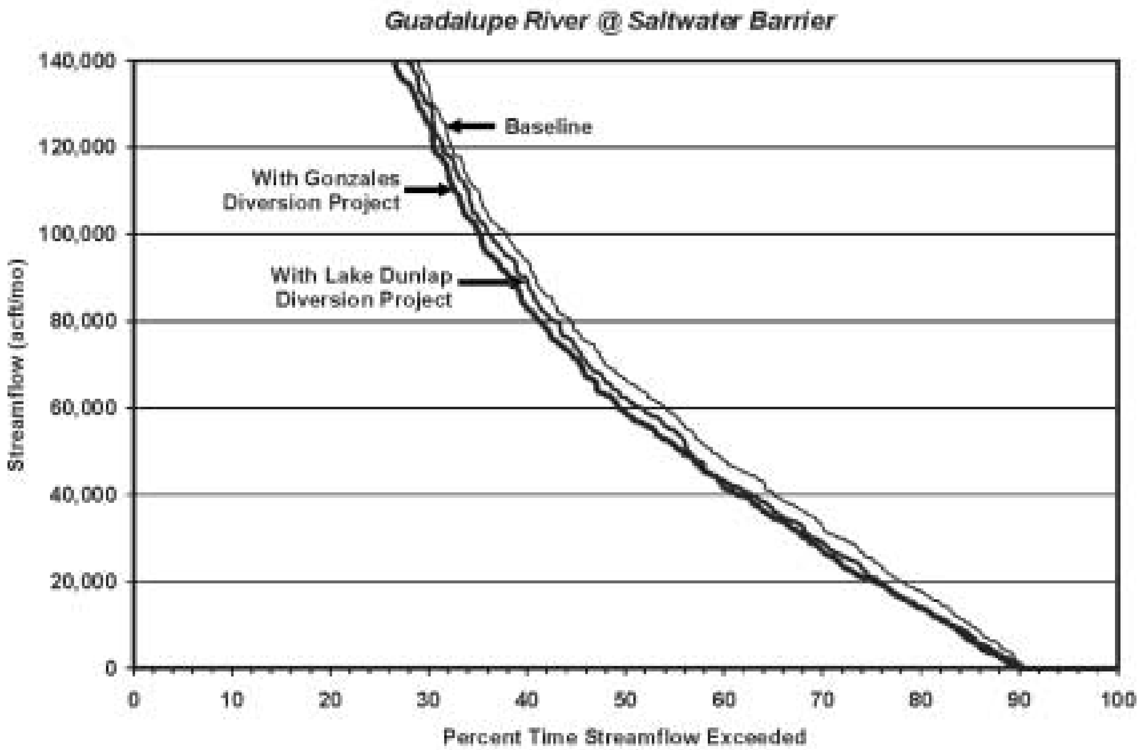


Figure 2.6-9. Streamflow Frequency Comparisons at Two Locations on the Guadalupe River for Baseline and Selected Projects

of the transmission pipeline into Bexar County, it follows along the border of the Central Texas Plateau ecoregion which it eventually enters[6]. According to Blair, this project traverses two biotic provinces, the Texan in Gonzales and Guadalupe Counties and Tamaulipan within Bexar and Medina Counties. The pipeline neighbors the Tamaulipan and Balconian border in Bexar and Medina Counties and may intermittently invade the Balconian province[7].

The study area spans four of Gould's vegetational areas. Within Gonzales County, which includes the Guadalupe River diversion and pipeline, lie the Blackland Prairies. As the route approaches the western border of the county, it penetrates the Post Oak Savannah. Within the western portion of Bexar County and all of Medina County, the transmission pipeline straddles the Edwards Plateau and South Texas Plains[8].

The dominant vegetation of the Blackland Prairies is mesquite, post oak, bluestems, switchgrass and blackjack supported by clay soils mixed with sandy loams. The Post Oak Savannah vegetational area is characterized by gently rolling to hilly terrain with an understory that is typically tall grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*). The South Texas Plains is mostly rangeland and has shifted from grassland to shrubs and low trees. Sandy or clay loam soils of the area support grasses such as eastern little bluestem, tanglehead, buffelgrass, common curlymesquite, arizona cottontop, bristlegrass, paspalum and windmillgrass. The most important climax grasses of the Edwards Plateau Vegetational area[9]include switchgrass, several species of blustems and gramas, indian grass, Canada wild-rye, curly mesquite and buffalo grass. The rough, rocky areas typically support a tall or mid-grass understory and brush overstory complex consisting primarily of live oak, Texas oak, shinnery oak, juniper species and mesquite. Throughout the region, brush species are generally considered as "invaders," with the climax largely grassland or open savannahs, except on the steeper canyon slopes which have continually supported a dense cedar-oak thicket.

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[6] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[7] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[8] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[9] Gould, F.W., "Texas Plants—A Checklist and Ecological Summary," Texas Agricultural Experiment Station, Texas A&M University, 1962.

In Guadalupe County the proposed pipeline route traverses Crockett-Demona-Windhorst, Sunev-Sequin, Branton-Barbarosa-Lewisville, Houston Black-Heiden soil associations.[10] Crockett-Demona-Windhorst soils are deep, moderately well drained, gently sloping to sloping, loamy to sandy soils on uplands. The USDA, Soil Conservation Service has not produced soil maps for the Gonzales County.

The following species are reported to occur in the project area by the Texas Natural Heritage Program. At the river diversion in Gonzales County, Cagle's map turtle (federal candidate for listing) and the Guadalupe bass are cited, as they both inhabit the Guadalupe River. The Guadalupe bass has also been found one mile downstream from the Cibolo Creek crossing. The Texas Tauschia resides in wet wooded areas near the diversion site. The spikerush, is found near the pipeline corridor near Seguin and resides in fresh and moderately alkaline marshes and along coasts in fresh and water marshes.[11] Adjacent to the pipeline which releases water into Salado Creek, Heller's Marbleseed, Buckley Triodia, Bracted Twistflower, and the Texas Fescue may occur, in addition to two ground beetles. At the Hondo Creek site, the Texas Mock-Orange finds habitat and the Leaf-chinned bat (*Mormoops megalophylla)* at Seco Creek. Helotes mold beetle and the Texas garter snake are found less than one mile from the transmission pipeline in Bexar County.

Within north and northwest Bexar County, karst features are prominent along and adjacent to the pipeline corridor. Numerous species have been mapped by the Texas Natural Heritage Program including Madla's cave spider (*Cicurina madla*), two species of ground beetles (*Rhadine exilis*, *R. infernalis*), Helotes mold beetle (*Batrisodes venyivi*), government canyon cave spider (*Neoleptoneta microps*) and Vesper cave spider (*Cicurina vespera*). The aforementioned species and others that may possibly reside in the study area are presented in Table 2.6-1. These arachnids and insects are listed by the U.S. Fish and Wildlife Service as potentially endangered. These karst organisms can potentially be affected, as additional water will be released into the streams. Inundation of caves within this area of Bexar County is possible dependent on the amount and quality of water released and streamflow fluctuations.

[10] Soil Conversation Service, "Soil Survey of Guadalupe County Texas," SCS, USDA, in cooperation with Texas Agricultural Experiment Station, 1977.
[11] Hotchkiss, Neil, "Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada," Dover Publications, Inc., New York, 1972.

Table 4.6-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Edwards Aquifer Recharge Enhancement with Guadalupe River Diversions (SCTN-6)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Buckley Triodia	*Tridens buckleyanus*	Margins of the Edwards plateau			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Frio Pocket Gopher	*Geomys texensis bakeri*	Sandy surface layers with loam going as deep as two meters			NL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Heller's Marbleseed	*Onosmodium helleri*	Juniper-oak woodlands			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Leaf-chinned bat	*Mormoops megalophylla*	Desert scrub to tropical forest, caves, tunnels and mines[6]			NL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Leaf-chinned bat	Mormoops megalophylla	Desert scrub to tropical forest, caves, mines, tunnels[6]			NL	Resident

Table 2.6-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and plowed fields	PT		NL	Nesting/Migrant
Palmetto Pill Snail	*Euchemotrema Cheatumi*					
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[5]			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Spreading Leastdaisy	*Chaetopappa effusa*	Calcareous soils[4]			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Amorpha	*Amorpha roemeriana*				NL	Resident
Texas Fescue	*Festuca versuta*	Margins of Edwards Plateau[4]			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[4]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Upland pine and deciduous woodlands, sandy or clay soil; dense ground cover		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Valdina Farms Sinkhole Salamanders	*Eurycea troglodytes*	Intermittent pools of subterranean streams			NL	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

Table 2.6-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas
5 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.
6 Nowak, Ronald M. 1991. Walker's Mammals of the World Volume 1. Johns Hopkins University Press, Baltimore.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Numerous vascular plants are mapped near the pipeline along with the karst features. The species include the Bracted Twistflower, Texas Amorpha, Texas Fescue (*Festuca versu*ta), Spreading Leastdaisy (*Chaetopappa effusa*), Glass Mountain Coral Root (*Hexalectris nitida*) Buckley Triodia (*Tridens buckleyanus*) and Heller's Marbleseed (*Onosmodium helleri*). These species reside within habitats that consist of juniper oak and mesic woodlands supported by sandy or calcareous soils. Each is a rare species, but is not under regulatory status by either the state or federal wildlife agencies.

In addition, a number of the species listed for each county have habitat requirements or preferences that indicate they could be present within the project area. The Golden-cheeked Warbler (*Dendroica chrysoparia*) inhabits mature oak-Ashe juniper woods for nesting. Warblers have been located less than a mile from the Salado Creek facility and in northwest Bexar County. The Black-capped Vireo (*Vireo atricapillus*) nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. The Mountain Plover has also been mapped by NHP near the Lake Dunlap diversion and within the pipeline corridor near Sequin. In addition to the Golden-cheeked Warbler, Mountain Plover. and Black-capped Vireo, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Henslow's Sparrow, Interior Least Tern, White-faced Ibis, Wood Stork, Whooping Crane and Zone-tailed Hawk) are reported to occur with the four county stretch. A survey of the project area may be required prior to construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

2.6.4 Engineering and Costing

Preliminary engineering and cost analyses were conducted for five diversion rates from the Guadalupe River at Lake Dunlap and near Gonzales to two areas in the Edwards Aquifer recharge zone. The diversion rates range from 100 to 300 cfs at Lake Dunlap and from 200 to 600 cfs near Gonzales. The target recharge areas are in northwestern Bexar County and northern Medina County and in western Medina County.

Major facilities to transport the water from the Guadalupe River to the recharge areas include:

- Intake and pump stations;
- Raw water pipelines, transmission pump stations, and laterals ;
- Water treatment plant (direct filtration) for water diverted near Gonzales; and
- Recharge structures.

The intake structures and associated pump stations are located on the shores of Lake Dunlap and Guadalupe River near Gonzales. Raw water pipelines are sized to match the design capacities and pressures. For the more turbid water near Gonzales, water treatment was assumed to be necessary. Therefore, cost estimates included the treatment of this water through direct filtration (Level 2, Appendix A), which involves (1) addition of alum and polymer, (2) rapid mixing, (3) flocculation, (4) settling, and (5) gravity filtration.

The selected means of artificially recharging the Edwards Aquifer with diversions from the Guadalupe River is to utilize natural recharge areas. To take advantage of these areas, water is released in the target streams near the upper limit of the recharge zone and allowed to flow uncontrolled across the recharge zone. Near the downstream extent of the outcrop, a recharge reservoir captures any remaining water that did not percolate through the streambed. Suitable reservoir sites or recharge facilities exist on Panther Springs Creek, tributaries to Salado Creek, San Geronimo Creek, Verde Creek, Parkers Creek, and Seco Creek. Recent recharge enhancement studies have recommended a new reservoir on Hondo Creek[12]. Additional reservoirs associated with this study and included in the cost estimates are on Culebra Creek, Government Canyon Creek, Leon Creek, and Helotes Creek.

[12] HDR, et al., "Edwards Aquifer Recharge Analyses," Trans-Texas Water Program, West Central Study Area, San Antonio River Authority, et al., March 1998.

As shown in Table 2.6-2, the Lake Dunlap diversion project has a total project cost of $185,116,000, an annual cost of $22,489,000, and a unit cost of $534 per acft for a 42,121 acft/yr increase in sustained yield. As shown in Table 2.6-3, the Gonzales diversion project has a total project cost of $797,542,000, an annual cost of $99,259,000, and a unit cost of $1,941 per acft. This project increases sustained yield pumpage by 51,133 acft/yr. The increased cost of water for a project having a diversion from the Guadalupe River near Gonzales is a result of including water treatment facilities and additional transmission and distribution facilities for the delivery of water to northern Medina County.

2.6.5 Implementation Issues

Implementation of Option SCTN-6 could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-16C1, G-17C1, G-19, G-20, G-30, G-32, G-38C, S-15Db, S-15Dc, S-15Ea, S-15Eb, SCTN-16b, and/or SCTN-16c.

An institutional arrangement is needed to implement projects including financing on a regional basis.

Guadalupe River Diversion Facilities

1. It will be necessary to obtain these permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake structures.
   b. GLO Sand and Gravel Removal permits.
   c. GLO Easement for use of state-owned land.
   d. TPWD Sand, Gravel, and Marl permit.
2. Permitting will likely require these studies:
   a. Habitat mitigation plan.
   b. Environmental studies.
   c. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

Requirements Specific to Diversion of Water from Guadalupe River and Recharge to Edwards Aquifer

1. Necessary permits:
   a. TNRCC permit to divert unappropriated water.
   b. TNRCC Interbasin Transfer Approval.
   c. TNRCC authorization to use streams in the San Antonio River Basin for enhancement of Edwards Aquifer recharge.
   d. EAA authorization to recharge and to recover water through Recharge Recovery Permit.

Table 2.6-2.
Cost Estimate Summary for
Edwards Aquifer Recharge Enhancement with
Guadalupe River Diversions at Lake Dunlap (SCTN-6a)
Second Quarter 1999 Prices

Item		***Estimated Costs for Facilities***
Capital Costs		
Recharge Dam (4 @ 49 acres)		$5,763,000
Intake and Pump Station (124 MGD)		14,189,000
Water Treatment Plant		0
Transmission Pump Station (1)		7,997,000
Transmission Pipeline (84-inch dia., 52 miles)		96,077,000
Outlet		483,000
Power Connection		3,730,000
Total Capital Cost		**$128,239,000**
Engineering, Legal Costs and Contingencies		$38,946,000
Environmental & Archaeology Studies and Mitigation		1,583,000
Land Acquisition and Surveying (44 acres)		2,635,00
Interest During Construction (4 years		13,713,00
Total Project Cos		**$185,116,00**
Annual Costs		
Debt Service (6 percent for 30 years)		$13,030,000
Reservoir Debt Service (6 percent for 40 years)		535,000
Operation and Maintenance		
Intake, Pipeline, Pump Station		1,382,000
Dam and Reservoir		86,000
Water Treatment Plant		0
Pumping Energy Costs (124,269,000 kWh @ $0.06 per kWh)		7,456,000
Total Annual Cost		**$22,489,000**
Available Project Yield (acft/yr)		**42,121**
Annual Cost of Water ($ per acft)	**Raw Water in Aquifer[1]**	**$534**
Annual Cost of Water ($ per 1,000 gallons)	**Raw Water in Aquifer[1]**	**$1.64**

[1] Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer.

Table 2.6-3.
Cost Estimate Summary for
Edwards Aquifer Recharge Enhancement with
Guadalupe River Diversions Near Gonzales (SCTN-6b)
Second Quarter 1999 Prices

Item		Estimated Costs for Facilities
Capital Costs		
Recharge Dams (4 @ 49 acres)		$5,763,000
Intake and Pump Station (254 MGD)		15,989,000
Water Treatment Plant (254 MGD)		56,902,000
Transmission Pump Stations (3)		33,005,000
Transmission Pipeline (120-inch dia., 138 miles)		431,875,000
Outlet		975,000
Power Connection		12,610,000
Total Capital Cost		**$557,119,000**
Engineering, Legal Costs and Contingencies		$170,899,000
Environmental & Archaeology Studies and Mitigation		3,761,000
Land Acquisition and Surveying (893 acres)		6,685,000
Interest During Construction (4 years)		59,078,000
Total Project Cost		**$797,542,000**
Annual Costs		
Debt Service (6 percent for 30 years)		$57,522,000
Reservoir Debt Service (6 percent for 40 years)		535,000
Operation and Maintenance		
Intake, Pipeline, Pump Station		5,099,000
Dam and Reservoir		86,000
Water Treatment Plant		18,450,000
Pumping Energy Costs (292,778,000 kWh @ $0.06 per kWh)		17,567,000
Total Annual Cost		**$99,259,000**
Available Project Yield (acft/yr)		**51,133**
Annual Cost of Water ($ per acft)	**Raw Water in Aquifer[1]**	**$1,941**
Annual Cost of Water ($ per 1,000 gallons)	**Raw Water in Aquifer[1]**	**$5.96**

[1] Reported Annual Cost of Water is for additional water supply in the Edwards Aquifer

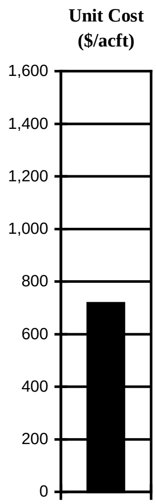
2. Permitting will require these studies:
a. Instream flow, and bay and estuary inflow effects.
b. Environmental studies.
   c. Evaluation of potential effects on recreation.

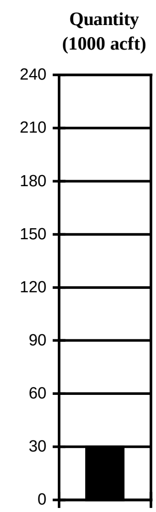
Requirements Specific to Pipelines

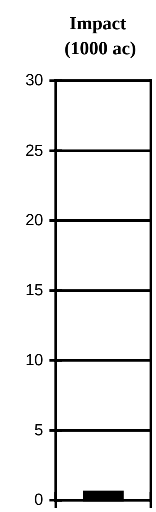
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Surface Recharge Structures

1. Detailed field investigation of each potential recharge site to determine natural and expected recharge rates.
2. For water imported to the recharge zone: water compatibility testing and assessment of treatment needs (if any), including biological and chemical characteristics.
3. Necessary permits could include:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.
   c. EAA authorization to recharge and to recover water through Recharge Recovery Permit
4. Permitting, at a minimum, will require these studies:
   a. Determination of impact plans for parkland, wildlife preserves, and other conservation programs.
   b. Study of impact on karst geology organisms from a sustained recharge program.
   c. Other environmental studies.







SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 12/13/99

OPTION NUMBER: G-38C

OPTION NAME: Guadalupe River Diversion at Gonzales to Mid-Cities and/or Major Water Providers, with Regional Water Treatment Plant

OPTION DESCRIPTION: *Diversion of unappropriated streamflows and uncommitted Canyon Lake yield from the Guadalupe River at Gonzales to a regional water treatment plant. Delivery of treated water to the Mid-Cities and/or Major Water Providers.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☐ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$736**	**per acft[1] Treated Water Delivered**
QUANTITY OF WATER:	**29,217**	**acft/yr[2]**
LAND IMPACTED:	**644**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Reservoir intake and pump station, raw water pipeline and pump station to water treatment plant, water treatment plant, off-channel reservoir at water treatment plant, finished water pump station and pipelines, and interconnections to Mid-Cities and/or Major Water Providers. System would be sized for uniform delivery to water treatment plant and municipal delivery from water treatment plant to entities.

[2]**QUANTITY OF WATER:** Quantities of unappropriated flow subject to instream flow requirements and quantity of uncommitted Canyon yield.

[3]**LAND IMPACTED:** Water treatment plant site and pipeline right-of-way.

ENVIRONMENTAL ISSUES: Terrestrial habitat effects along pipeline right-of-way and at water treatment plant location. Resource conflicts can be avoided by careful selection of water treatment plant and storage tank sites, and pipeline routes.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, and ability of the entities to develop a regional plan that realizes economies of size that benefit all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Guadalupe River Basin water to the San Antonio area.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-15C, G-16C1, G-17C1, G-19, G-20, G-21, G-22, G-24, G-30, G-40, SCTN-6, SCTN-16a, SCTN-16b, and/or SCTN-16c.

3.1 Guadalupe River Diversion at Gonzales to Mid-Cities, and/or Major Water Providers, with Regional Water Treatment Plant (G-38C)

3.1.1 Description of Option

This option considers diversion of water from the Guadalupe River at Gonzales for treatment at a potential regional water treatment plant near Marion and delivery of treated water on a wholesale basis to the Mid-Cities, and/or Major Water Providers in the South Central Texas Region. Such Major Water Providers may include San Antonio Water System (SAWS), Bexar Metropolitan Water District (BMWD), and Canyon Regional Water Authority (CRWA). The water potentially available for diversion at Gonzales (Figure 3.1-1) would be made up of periodically available run-of-river diversions made firm by allocation of a portion of the firm yield of Canyon Reservoir through contractual agreement with the Guadalupe-Blanco River Authority (GBRA).

3.1.2 Available Yield

The Guadalupe-San Antonio River Model (GSA Model)[1] was used to determine the amount of unappropriated streamflow available for diversion at Gonzales subject to senior water rights and the Consensus Environmental Criteria (Appendix B). Unappropriated streamflow was calculated subject to a minimum streamflow passage requirement of 317 cfs at the diversion location based upon maintenance of dissolved oxygen at 5 mg/L subject to current maximum effluent quantity and constituent concentrations.[2] Figure 3.1-2 indicates that unappropriated streamflow totaling about 30,000 acft/yr is available in about half of the years simulated. In the other years, stored water from Canyon Reservoir could be delivered via the Guadalupe River to the point of diversion, thereby making the run-of-river diversion a firm supply. A commitment of 24,645 acft/yr from the firm yield of Canyon Reservoir would be necessary to ensure that 30,000 acft/yr could be diverted at Gonzales, without interruption, through the historical drought of record.

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[1] HDR Engineering, Inc. (HDR), "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Vol. I, II, and III, Edwards Underground Water District, September 1993.

[2] HDR and Paul Price Associates, Inc., "Guadalupe – San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, San Antonio river authority, et al., March 1998.

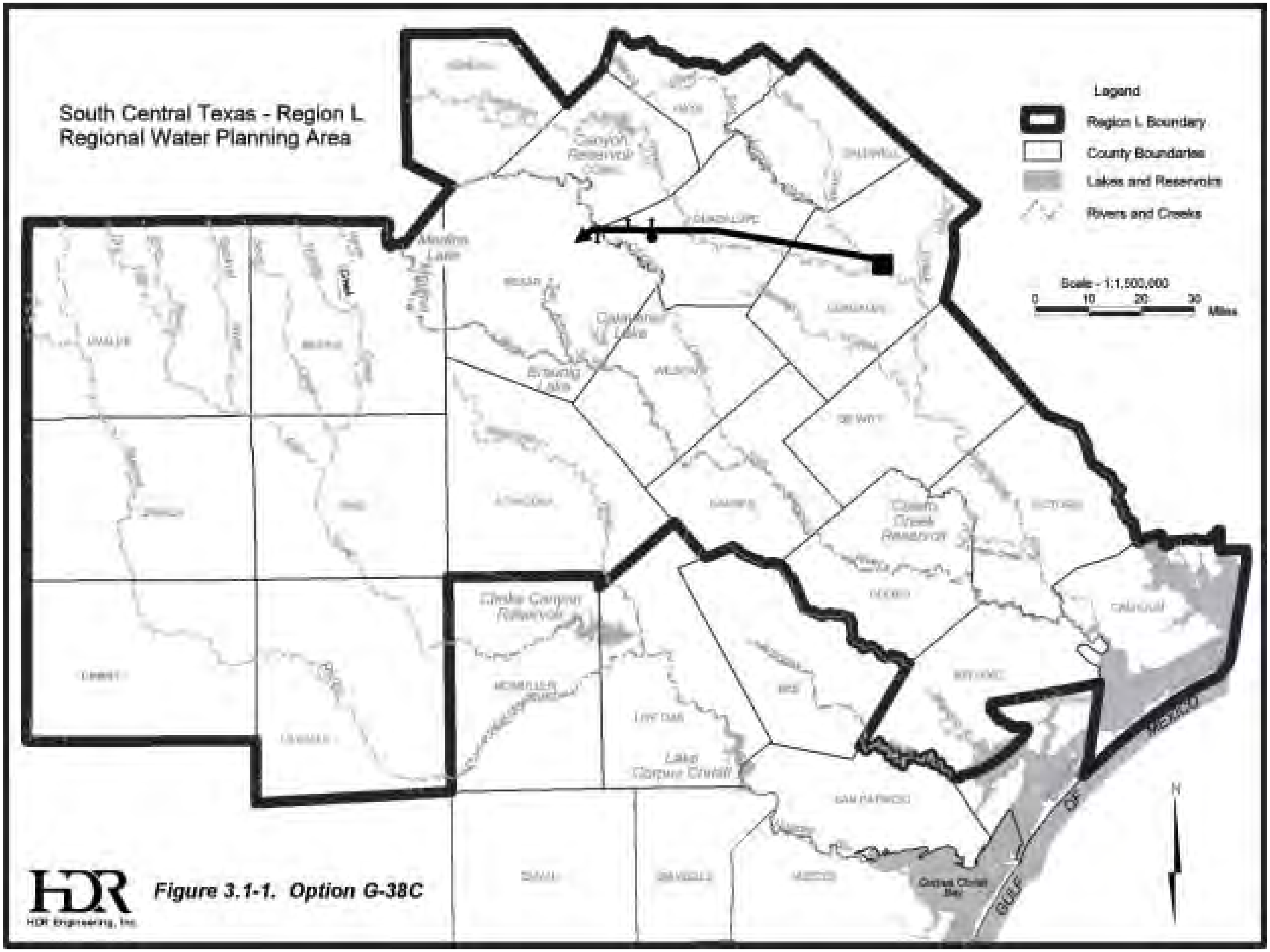

Figure 3.1-1. Option G-38C

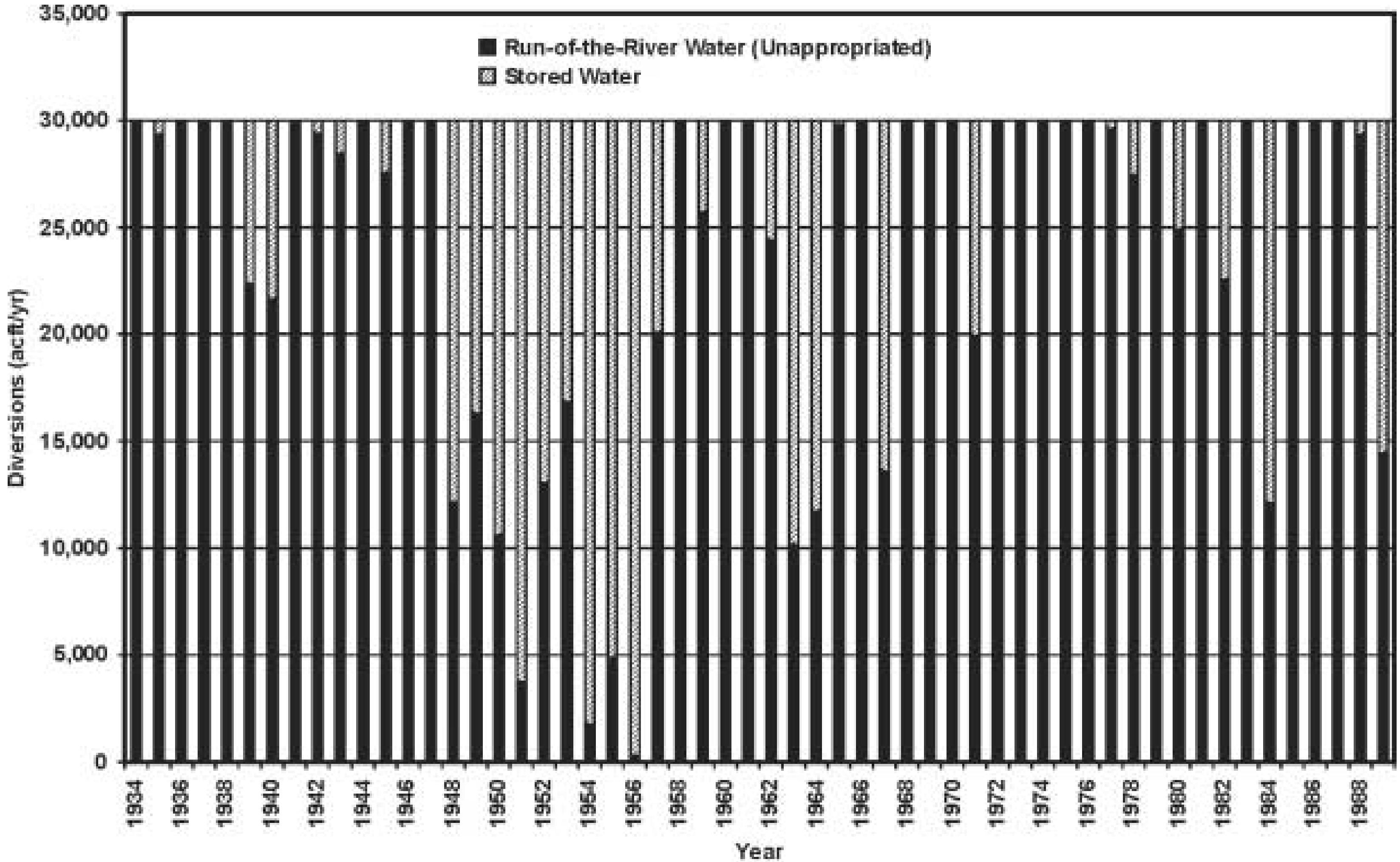

Figure 3.1-2. Guadalupe River Diversion at Gonzales, Water Availability (Option C-38C)

Diversion from the river to an off-channel (forebay) storage reservoir at the regional water treatment plant was assumed to occur in a uniform pattern. With the use of this forebay storage, some losses are incurred due to evaporation, as storage is maintained to facilitate delivery in a municipal seasonal pattern and to meet consumer peak demands. Reservoir contents simulations determined that the actual firm yield (the amount of water available to the municipal participants in this project) is 29,217 acft/yr.

Delivery facilities were sized to meet the projected year 2030 shortage to entities in the GBRA statutory area, with the remaining water available (19,098 acft/yr) allocated to Major Water Providers located primarily in Bexar County. However, in the interim period prior to year 2030, the total firm supply of 29,217 acft/yr was assumed to be available for delivery to the Major Water Providers in Bexar County. The primary transmission pipeline was sized to deliver the full 29,217 acft/yr to Bexar County, which is the likely scenario for the first year of operation. As water demands for Comal and Guadalupe Counties entities grow, more water would be delivered to them at intermediate delivery points and less water would be conveyed to Bexar County. The projected supply to Bexar County would be reduced to about 19,098 acft/yr, by the year 2030.

3.1.2 Environmental Issues

The proposed diversion of water from the Guadalupe River near the City of Gonzales and delivery to the Mid-Cities and Major Water Providers in Bexar County requires water transmission facilities, as well as a regional water treatment plant and forebay storage reservoir.

In Guadalupe County, the proposed pipeline route traverses Crockett-Demona-Windhorst, Sunev-Seguin, Branyon-Barbarosa-Lewisville, and Houston Black-Heiden soil associations.[3] Crockett-Demona-Windhorst soils are deep, moderately well drained, gently sloping to sloping, loamy to sandy soils on uplands. The USDA, Soil Conservation Service has not produced detailed soil maps for Gonzales County.

The section of the pipeline route between the City of Gonzales and the City of Marion (the location of the regional water treatment plant) traverses Post Oak Savannah in Gonzales and

[3] Soil Conservation Service. 1977. Soil Survey of Guadalupe County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

Guadalupe Counties and Blackland Prairie in central Gonzales County.[4] The section of the route between Marion and the other delivery locations continues in the Post Oak Savannah and then traverses the Blackland Prairie Vegetational area.

Vegetation types along the proposed pipeline route have been classified as crops, Pecan-Elm Forest (located along bottomlands of the Guadalupe River), and Post Oak Woods, Forest, and grassland mosaic.[5] These are most apparent on the sandy soils of the Post Oak Savannah.

The length of the water transmission pipeline from the City of Gonzales to the delivery points in the Mid-Cities and in Bexar County is about 68 miles. A 140 foot wide construction right-of-way would affect a total of 1,154 acres including 43 acres developed (3.7 percent), 832 acres crop (72.1 percent), 6 acres shrub (0.5 percent), 55 acres brush (4.7 percent), 55 acres park (4.7 percent), 163 acres wood (14.1 percent).[6] A mowed maintenance right-of-way, seeded in grass, would be required for the life of the project. A 40-foot wide maintenance right-of-way, 68 miles long, would affect a total of 330 acres including 12 acres developed, 238 acres crop, 1.5 acres shrub, 16.0 acres brush, 16.0 acres park, 46 acres wood, and 0.5 acres water (e.g., river crossings). However, the large proportion of this right-of-way that is in cropland can be returned to crop production following installation of the pipeline. Disturbed areas outside the maintenance right-of-way presently in brush and shrub can be expected to be invaded by woody vegetation in 5 to 10 years.

Important species having habitat or known to occur in Gonzales, Guadalupe, and Bexar Counties as listed by USFWS, TPWD and TOES are reported in Table 3.1-1. The Texas Natural Heritage Program does not report any species directly on the pipeline route, but a few have been sited within a one-mile corridor. At the beginning of the line in Gonzales County, Cagle's Map Turtle (federal candidate for listing) and the Guadalupe Bass are sited, as they both inhabit the Guadalupe River. Texas Tauschia is found in wet wooded areas. The only other species reported, Spikerush, is found within the pipeline corridor near Seguin. The Spikerush resides in fresh and moderately alkaline marshes and along coasts in fresh and saltwater marshes.

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[4] McMahan, C.A., R.G. Frye and K.L. Brown, "The Vegetation Types of Texas Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[5] Ibid.
[6] These preliminary estimates were based on available Soil Conservation Service Maps and USGS 7.5 minute quadrants: New Braunfels East, McQueeney, Marion, Schertz, New Braunfels West, and should be updated using aerial photographs from the EROS data center in a later phase of project development.

Table 3.1-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Guadalupe River Diversions at Gonzales to Mid-Cities and/or Major Water Providers (G-38C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and plowed fields	PT		NL	Nesting/Migrant
Palmetto Pill Snail	*Euchemotrema Cheatumi*					
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident

Table 3.1-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[4]			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Upland pine and deciduous woodlands, sandy or clay soil; dense ground cover		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
5 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

In addition, a number of the species listed for Bexar, Gonzales and Guadalupe Counties have habitat requirements or preferences that indicate they could be present within the study area. The Golden-cheeked Warbler (*Dendroica chrysoparia*) inhabits mature oak-Ashe juniper woods for nesting. The Black-capped Vireo (*Vireo atricapillus*) nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. In addition to the Golden-Cheeked Warbler and Black-capped Vireo, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Henslow's Sparrow, Interior Least Tern, Mountain Plover, White-faced Ibis, Whooping Crane, and Wood Stork) are reported to occur in Bexar, Guadalupe or Gonzales County. A survey of the project area may be required prior to construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

Significant impacts to important species by the project are unlikely. Species associated with Comal Springs (most of those on New Braunfels West) are well upstream of the project area. Other important species and critical habitats can be largely avoided by careful selection of the final pipeline alignment. Habitat surveys in a future phase of project development should be conducted to more accurately assess potential effects and to aid in selecting the final alignment. Cagle's Map Turtle and Guadalupe Bass inhabit the Guadalupe River. Flow changes resulting from Option G-38C (discussed below) are not expected to have an adverse effect on Cagle's Map Turtle or the Guadalupe Bass.

Stream crossings in the proposed corridor are mostly intermittent. Major stream crossings include the Guadalupe River near Seguin and Cibolo Creek, an intermittent stream. Numerous impounded ponds for stock and other agricultural uses dot the Blackland Prairie. Depending on the final alignment, the transmission line may cross the Guadalupe River at Seguin. However, the transmission line corridor is conceptual at this phase of the study. Exact impacts cannot be determined without further study.

Based on the 1934 to 1989 period of record, estimated annual median Guadalupe River flow at Cuero is 965,253 acft/yr. With implementation of Option G-38C, annual median streamflow is estimated to be 934,884 acft, a decrease of 3.1 percent. Monthly median streamflow at Cuero without Option G-38C ranged from 29,421 acft to 92,294 acft and with Option G-38C ranged from 25,802 acft to 89,952 acft (Figure 3.1-3). Reductions in monthly median streamflow at Cuero would range from 2.4 percent to 12.3 percent with implementation of Option G-38C.

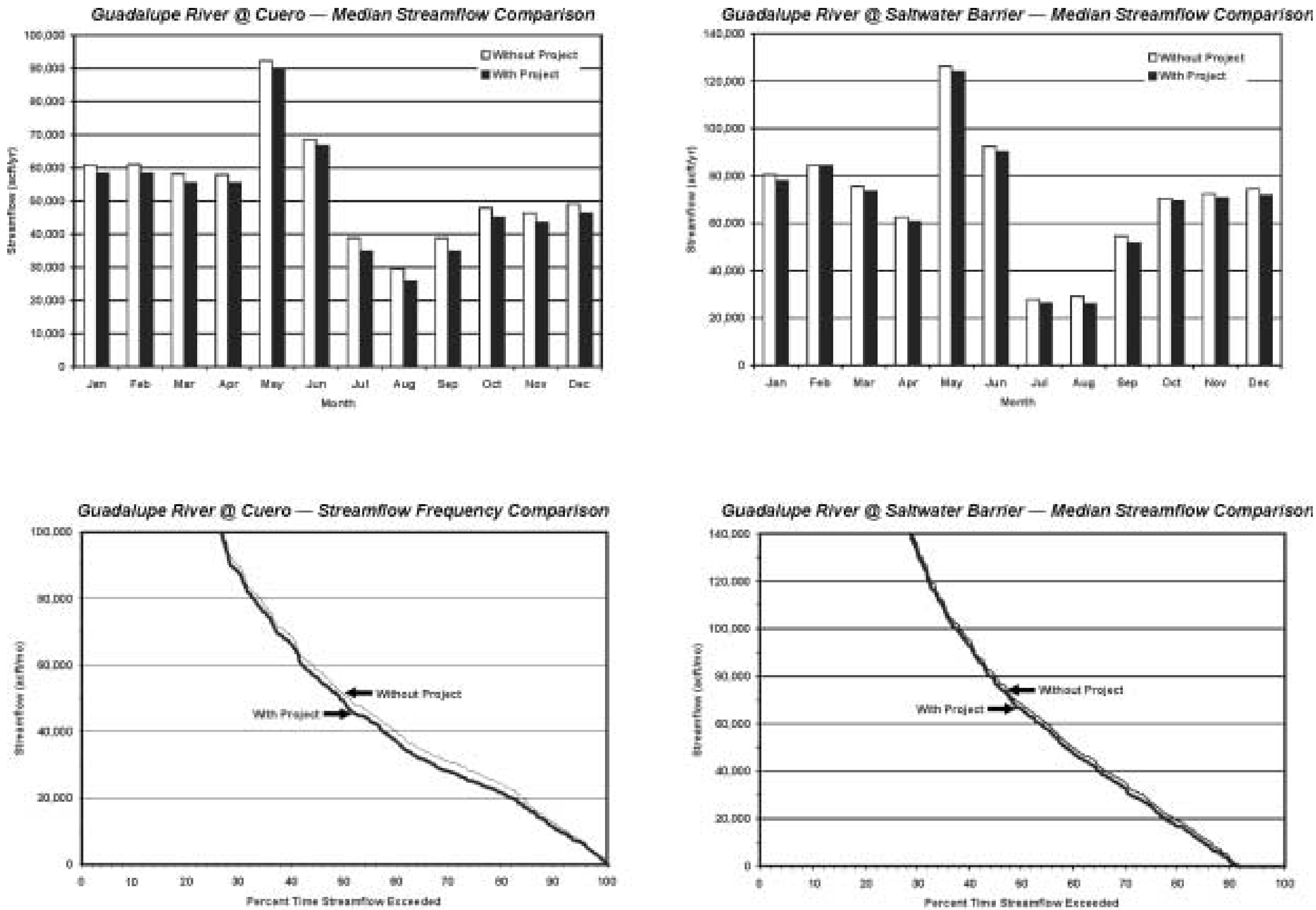

Figure 3.1-3. Guadalupe River Diversion at Gonzales, Streamflow Comparisons

Annual median flow at Guadalupe River Saltwater Barrier without project was 1,406,966 acft and monthly medians ranged from 27,907 acft to 126,250 acft. Under a uniform diversion pattern, annual median flow with implementation of Option G-38C is an estimated to be 1,383,872 acft, a 1.6 percent decrease in freshwater inflow to the Guadalupe Estuary (excluding ungaged runoff below the Saltwater Barrier). Monthly median estimates with project implementation ranged from 26,054 acft to 124,144 acft at the Guadalupe River Saltwater Barrier. Reductions in monthly median streamflow at the Guadalupe River Saltwater Barrier with implementation of Option G-38C would range from essentially zero up to 10.6 percent.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.1.3 Engineering and Costing

For this option, water diverted from the Guadalupe River at Gonzales would be treated at a regional water treatment plant near Marion and supplied on a wholesale basis to the Mid-Cities and/or Major Water Providers in the South Central Texas Region. Figure 3.1-1 shows the general location of the water treatment plant and a potential transmission pipeline route.

Raw water would be diverted at a new water intake to be located on the Guadalupe River downstream of the confluence with the San Marcos River and pumped to a forebay storage facility near the water treatment plant. The forebay storage facility provides for enhanced raw water quality by allowing selective pumping during periods of high river flows and possible lower water quality. Another benefit of the forebay storage is improved reliability of the surface water system by allowing continuing plant operation during raw water pipeline maintenance or unscheduled outages. The forebay storage was sized at about 5,000 acft, or approximately the amount needed during the summer to meet municipal needs and account for evaporation.

Water treatment would likely consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection).

The major facilities required to implement this option are:

- Reservoir Intake and Pump Station
- Raw Water Transmission Pump Station
- Raw Water Pipeline to Off-Channel (Forebay) Storage Facility
- Off-Channel Storage Facility
- Water Treatment Plant
- Treated Water Pump Station
- Transmission Pipeline
- Treated Water Transmission Pump Station
- Interconnections to the Mid-cities and/or Major Water Providers

Transmission facilities were sized to meet year 2030 projected needs for the Mid-Cities. Transmission facilities and interconnections for the Major Water Providers in Bexar County were sized for delivery of the full 29,217 acft/yr.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water from Canyon Lake, land, and environmental mitigation. Although the amount of stored water actually needed each year may be higher or lower, the annual cost is held constant at the firm yield amount, as would be the case with a "take-or-pay" type of purchase contract. The total estimated project cost of Option G-38C is $144,313,000 (Table 3.1-2), which results in a total annual cost, including operation and maintenance of $21,503,000.

The estimated cost of implementation and operation of this option would likely be allocated to each participant based on the pro-rata capacity of each component dedicated to meeting projected demands. Thus, participants would likely pay a pro-rata share of raw water and treatment facility costs based solely on the percentage of total capacity dedicated to meeting their water demands. For transmission and pump station costs, each participant would likely pay a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source could be proportionately greater.

Table 3.1-2 summarizes the total annual cost and the unit cost of water for year 2030. Early in project operation, less water may be delivered to some participants and all remaining available water delivered to Major Water Providers such as the SAWS and/or BMWD. The unit cost of water for year 2030 conditions is $736 per acft.

Table 3.1-2
Cost Estimate Summary for
Guadalupe River Diversion at Gonzales to Mid-Cities, and/or Major Water Providers with Regional Water Treatment Plant (G-38C)
(Second Quarter 1999 Prices)

Item	***Estimated Costs for Facilities***
Capital Costs	
Off-Channel Reservoir (5,000 acft)	$7,682,000
Intake and Pump Station (28.1 MGD)	$6,312,000
Water Treatment Plant (28.1 MGD)	$21,410,000
Transmission Pump Stations (3)	$14,853,000
Transmission Pipeline (various diameters, 68 miles)	$38,417,000
Total Capital Cost	**$88,674,000**
Engineering, Legal Costs and Contingencies	$29,115,000
Environmental & Archaeology Studies and Mitigation	$2,347,000
Land Acquisition and Surveying (644 acres)	$3,734,000
Interest During Construction (4 years)	$20,443,000
Total Project Cost	**$144,313,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$9,787,000
Reservoir Debt Service (6 percent for 40 years)	$896,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	$885,000
Dam and Reservoir	$115,000
Water Treatment Plant	$2,334,000
Pumping Energy Costs (99,716,955 kWh @ $0.06 per kWh)	$5,983,000
Purchase of Water (24,645 acft/yr @ $61 per acft)	$1,503,000
Total Annual Cost	**$21,503,000**
Available Project Yield (acft/yr)	**29,217**
Annual Cost of Water ($ per acft) Treated Water Delivered[1]	**$736**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Delivered[1]	**$2.26**

1 Reported Annual Cost of Water is for treated water delivered to Mid-Cities and/or Major Water Providers and does not include costs associated with distribution within municipal systems.

3.1.4 Implementation Issues

Implementation of Option G-38C could directly affect the feasibility of other water supply options under consideration, including G-15C, G-16C1, G-17C1, G-19, G-20, G-21, G-22, G-24, G-30, G-40, SCTN-6, SCTN-16a, SCTN-16b, and SCTN-16c.

An institutional arrangement is needed to implement projects including financing on a regional basis. Implementation of option G-38C would involve the following steps:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA and existing water rights owners
- Financing
- Engineering
- Permitting
- Construction
- Operation and Maintenance

Requirements Specific to Diversion of Water from Guadalupe River and Off-Channel Reservoir

To obtain more realistic values of surface water availability, additional in-depth studies of environmental water needs may be performed for affected reaches of the Guadalupe River. Results presented herein are consistent with the Environmental Water Needs Criteria of the Consensus Planning Process which allows the substitution of flow minimums based on stream-specific studies considering indigenous species, habitat, recreational utilization, water quality, and assimilative capacity of individual stream segments.

1. Necessary permits:
   a. Receipt of TNRCC approval of amendment to Canyon Reservoir Certificate of Adjudication which will authorize additional diversions.
   b. TNRCC permit to divert unappropriated streamflow.
   c. TNRCC Interbasin Transfer Approval.
   d. U. S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   e. GLO Sand and Gravel removal permits
   f. GLO Easement for use of state-owned land.
   g. TPWD Sand, Gravel, and Marl permit.

2. Permitting will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Environmental studies.
   c. Cultural resource studies.
3. Agreement with GBRA for use of and payment for water released from Canyon Reservoir.
4. Land will need to be acquired either through negotiations or condemnation.
5. Relocations for the reservoir include:
   a. Highways and railroads
   b. Other utilities

Requirements Specific to Pipelines

1. Necessary permits:
   a. U. S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel removal permits.
   c. TPWD Sand, Gravel and marl Removal permits.
2. Right-of-way and easement acquisition.
3. Crossings.
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into regional delivery systems.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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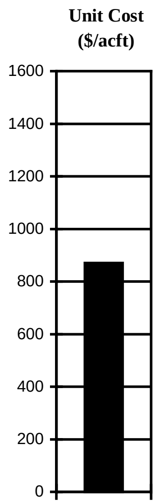

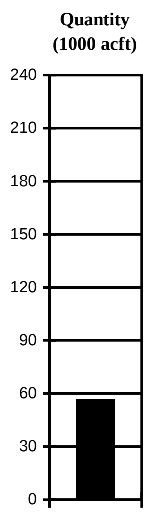

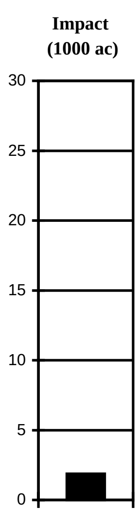

OPTION NUMBER: SCTN-16a
OPTION NAME: Lower Guadalupe River Diversions

OPTION DESCRIPTION: *Diversion of up to 50,000 acft/yr under existing water rights in Guadalupe River at the Saltwater Barrier to water treatment plant at the major municipal demand center of the South Central Texas Region (treated water to distribution system or recharge zone). Water available under existing rights will be made firm by delivery of presently uncommitted stored water from Canyon Reservoir to the Saltwater Barrier.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**870**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**56,276**	**acft/yr[2]**
LAND IMPACTED:	**1,884**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** River intake and pump station, off-channel dam and reservoir, reservoir intake and pump station, raw water pipeline to treatment plant, water treatment plant, and distribution to municipal systems or recharge zone. Costs include environmental and archaeological studies.

[2]**QUANTITY OF WATER:** Firm yield under existing water rights subject to senior water rights, reclaimed water use, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the off-channel reservoir, transmission facilities right-of-way, and water treatment plant site. This does not include land purchased for mitigation.

ENVIRONMENTAL ISSUES: Potential mitigation for 1,218 acres inundated by off-channel reservoir.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Policy and/or rules regarding interbasin transfer of water supplies.

ADDITIONAL FACTORS: Implementation of this option based on a greater quantity of water or in combination with other options may reduce the unit cost of water.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15D, S-15E, S-16C, G-16C1, G-17C1, G-20, G-38C, SCTN-11, SCTN-12b, and/or SCTN-14.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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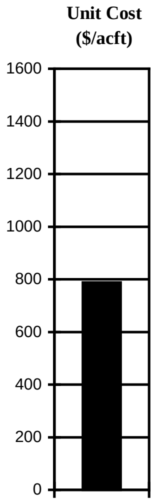
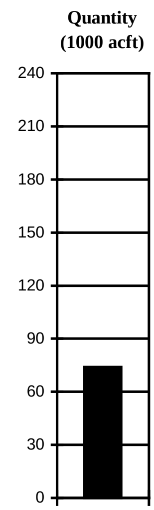
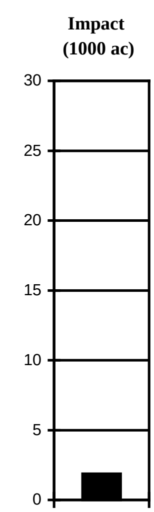






OPTION NUMBER: **SCTN-16b**
OPTION NAME: **Lower Guadalupe River Diversions**

OPTION DESCRIPTION: *Diversion of unappropriated streamflow and existing water rights (up to 50,000 acft/yr) from the Guadalupe River at the Saltwater Barrier to water treatment plant at the major municipal demand center of the South Central Texas Region (treated water to distribution system or recharge zone). Unappropriated streamflow and water available under existing rights will be made firm by delivery of uncommitted stored water (up to 15,000 acft/yr, firm yield equivalent) from Canyon Reservoir to the Saltwater Barrier.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**788**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**74,000**	**acft/yr[2]**
LAND IMPACTED:	**1,886**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** River intake and pump station, off-channel dam and reservoir, reservoir intake and pump station, raw water pipeline to treatment plant, water treatment plant, and distribution to municipal systems or recharge zone. Costs include environmental and archaeological studies.

[2]**QUANTITY OF WATER:** Firm yield under existing water rights and unappropriated streamflow subject to senior water rights, Consensus Criteria, reclaimed water use, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the off-channel reservoir, transmission facilities right-of-way, and water treatment plant site. This does not include land purchased for mitigation.

ENVIRONMENTAL ISSUES: Freshwater inflows to the Guadalupe Estuary and potential mitigation for 1,218 acres inundated by off-channel reservoir. The lower Guadalupe River in Victoria, Calhoun, and Refugio Counties is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Policy and/or rules regarding interbasin transfer of water supplies.

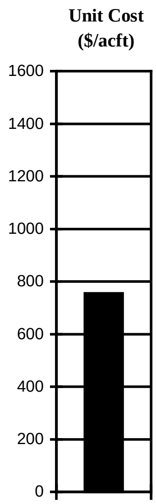
ADDITIONAL FACTORS: Implementation of this option based on a greater quantity or in combination with other options may reduce the unit cost of water.

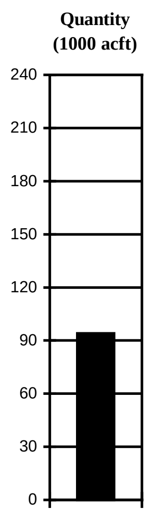
OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15D, S-15E, S-16C, G-16C1, G-17C1, G-20, G-38C, SCTN-11, SCTN-12b, and/or SCTN-14.

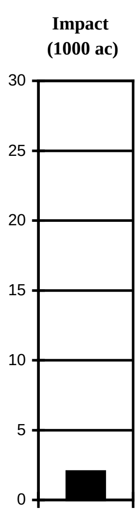
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/06/99







OPTION NUMBER: SCTN-16c
OPTION NAME: Lower Guadalupe River Diversions

OPTION DESCRIPTION: *Diversion of unappropriated streamflow and existing water rights (up to 50,000 acft/yr) from the Guadalupe River at the Saltwater Barrier to water treatment plant at the major municipal demand center of the South Central Texas Region (treated water to distribution system or recharge zone). Unappropriated streamflow and water available under existing rights will be made firm by delivery of groundwater from the Gulf Coast Aquifer and uncommitted stored water (up to 15,000 acft/yr, firm yield equivalent) from Canyon Reservoir to the Saltwater Barrier.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**755**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**94,000**	**acft/yr[2]**
LAND IMPACTED:	**2,040**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** River intake and pump station, off-channel dam and reservoir, reservoir intake and pump station, well fields, raw water pipeline to treatment plant, water treatment plant, and distribution to municipal systems or recharge zone. Costs include environmental and archaeological studies.

[2]**QUANTITY OF WATER:** Firm yield under existing water rights and unappropriated streamflow subject to senior water rights, Consensus Criteria, reclaimed water use, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the off-channel reservoir, wellhead areas, transmission facilities right-of-way, and water treatment plant site. This does not include land purchased for mitigation.

ENVIRONMENTAL ISSUES: Freshwater inflows to the Guadalupe Estuary and potential mitigation for 1,218 acres inundated by off-channel reservoir. The lower Guadalupe River in Victoria, Calhoun, and Refugio Counties is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Policy and/or rules regarding interbasin transfer of water supplies.

ADDITIONAL FACTORS: Implementation of this option based on a greater quantity or in combination with other options may reduce the unit cost of water.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15D, S-15E, S-16C, G-16C1, G-17C1, G-20, G-38C, SCTN-11, SCTN-12b, and/or SCTN-14.

3.2 Lower Guadalupe River Diversions (SCTN-16)

3.2.1 Description of Options

This group of water supply options (SCTN-16a, SCTN-16b, and SCTN-16c) involves the diversion of water from the Guadalupe River at the Saltwater Barrier located 3.5 miles north of Tivoli, transmission to an off-channel reservoir, transmission to a water treatment plant at the major municipal demand center of the South Central Texas Region, and distribution to municipal systems or the Edwards Aquifer recharge zone (Figure 3.2-1). Specific sources of water for these options include presently underutilized surface water rights (up to 50,000 acft/yr), presently uncommitted supply from Canyon Reservoir (up to 15,000 acft/yr), unappropriated streamflow, and groundwater from the Gulf Coast Aquifer. Depending upon the sources of supply, the diameter of the 120-mile transmission pipeline from the off-channel reservoir to the major municipal demand center ranges from 64 to 78 inches.

The Saltwater Barrier is an inflatable dam constructed approximately 0.4 miles below the confluence of the San Antonio River with the Guadalupe River. The dam serves to prevent the up-river intrusion of saltwater, which could adversely affect water quality for nearby municipal, industrial, and irrigation use. The Guadalupe River Saltwater Barrier creates a small impoundment facilitating diversions under rights held jointly by the Guadalupe-Blanco River Authority (GBRA) and Union Carbide Corporation (UCC). These rights total 172,501 acft/yr and represent about 30 percent of all surface water rights in the Guadalupe-San Antonio River Basin authorized for consumptive use.

The GBRA/UCC water rights at the Guadalupe River Saltwater Barrier are quite reliable, as the upstream watershed encompasses approximately 10,128 square miles and includes the two largest springs in Texas. In addition, substantial volumes of treated effluent are discharged to the San Antonio River from the San Antonio metropolitan area. In most years, there is unappropriated streamflow passing the Guadalupe River Saltwater Barrier and entering the Guadalupe Estuary. However, neither the GBRA/UCC rights nor these unappropriated streamflows are “firm” or 100 percent reliable during each month of a repeat of the most severe drought on record. Hence, this option includes consideration of Canyon Reservoir and/or an off-channel storage facility that could serve to “firm-up” (increase the reliability of) potential run-of-river diversions. Groundwater from the Gulf Coast Aquifer is considered an additional dependable source of water.

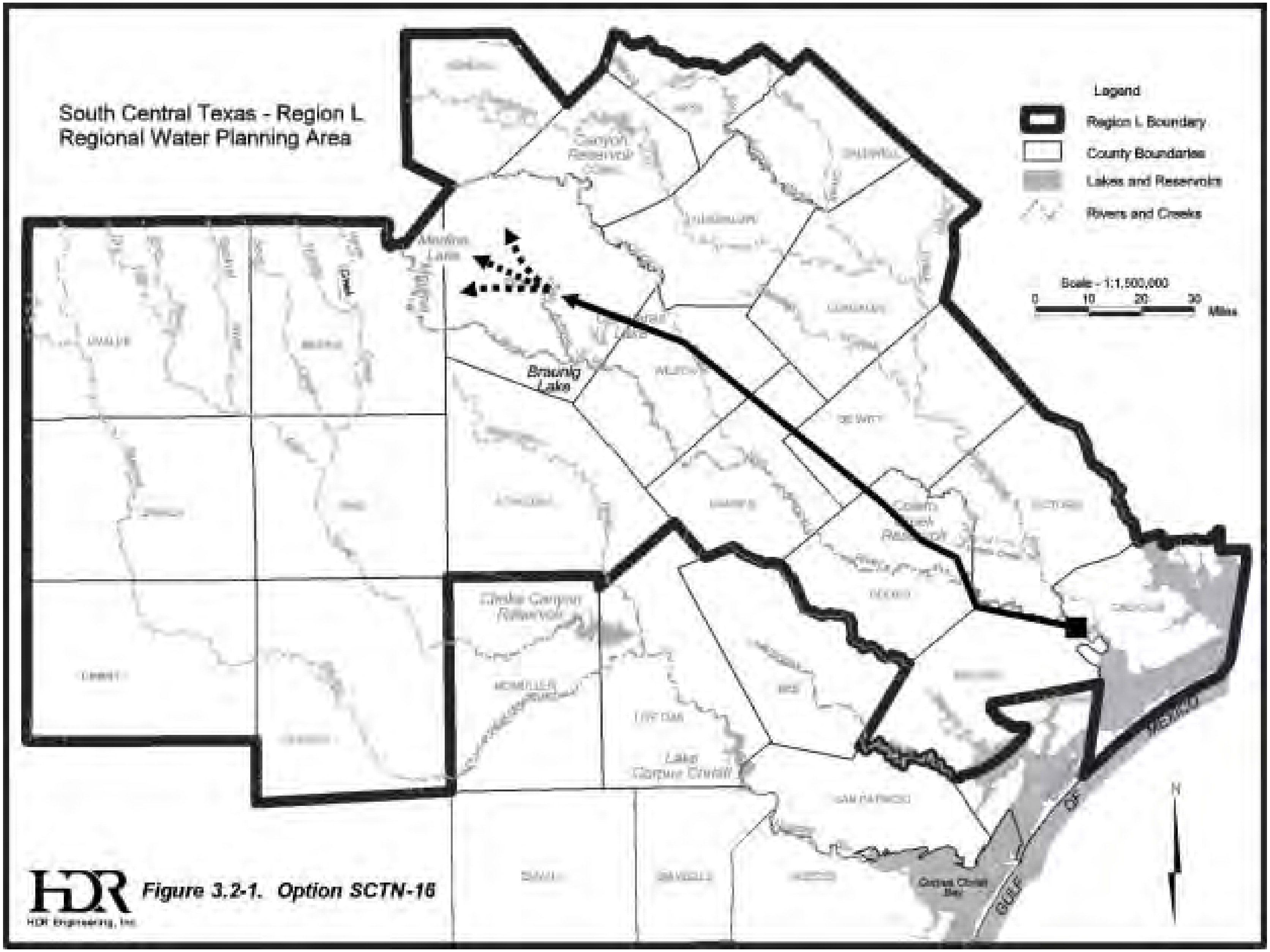


Figure 3.2-1. Option SCTN-16

3.2.2 Water Availability

The Guadalupe River Saltwater Barrier was constructed in the early 1960s at a location immediately downstream of the San Antonio River confluence and creates a reservoir pool extending some distance up both rivers. Diversions from this reservoir pool, whether under existing rights or as unappropriated streamflow, are dependent upon waters originating in both the Guadalupe and San Antonio Rivers and their respective tributaries. Hence, it is assumed herein that diversion from this location for use in the San Antonio River Basin does not constitute an interbasin transfer and that water rights committed to such a diversion would retain their current seniority relative to others. The TWDB has, by rule, established the river basin boundaries for Texas and indicated that the San Antonio River Basin extends only to the confluence.[1] Therefore, some modification of this rule may be necessary to retain seniority if diversion facilities are ultimately located below the confluence of the two rivers.

Maximum reported water use under GBRA/UCC rights totaling 172,501 acft/yr at the Guadalupe River Saltwater Barrier did not exceed 62,000 acft/yr during the 1991 through 1997 historical period.[2] For the purposes of evaluation of this water supply option, it is assumed that diversions of up to 50,000 acft/yr under one of these rights (Certificate of Adjudication #18-5178) could be made available for some period of time into the future. Certificate of Adjudication #18-5178 has a priority date of January 7, 1952 and authorized annual diversions totaling 106,000 acft for multiple uses including municipal, industrial, and irrigation.

The Guadalupe-San Antonio River Basin Model[3] (GSA Model) and supplemental spreadsheet calculations were used to quantify water available for diversion of up to 50,000 acft/yr under Certificate of Adjudication #18-5178. GSA Model simulations and calculations were performed subject to the General Assumptions for Applications of Hydrologic Models as adopted by the South Central Texas Regional Water Planning Group and listed in the Introduction. As shown in Figure 3.2-2, water available for diversion on an annual basis ranges from a maximum of 50,000 acft to a minimum of 27,257 acft in 1956. Water availability averages 47,885 acft/yr over the full simulation period (1934 through 1989) and 42,075 acft/yr

[1] TWDB, Personal Communication, October 1999.
[2] GBRA, Personal Communication, April 1999.
[3] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

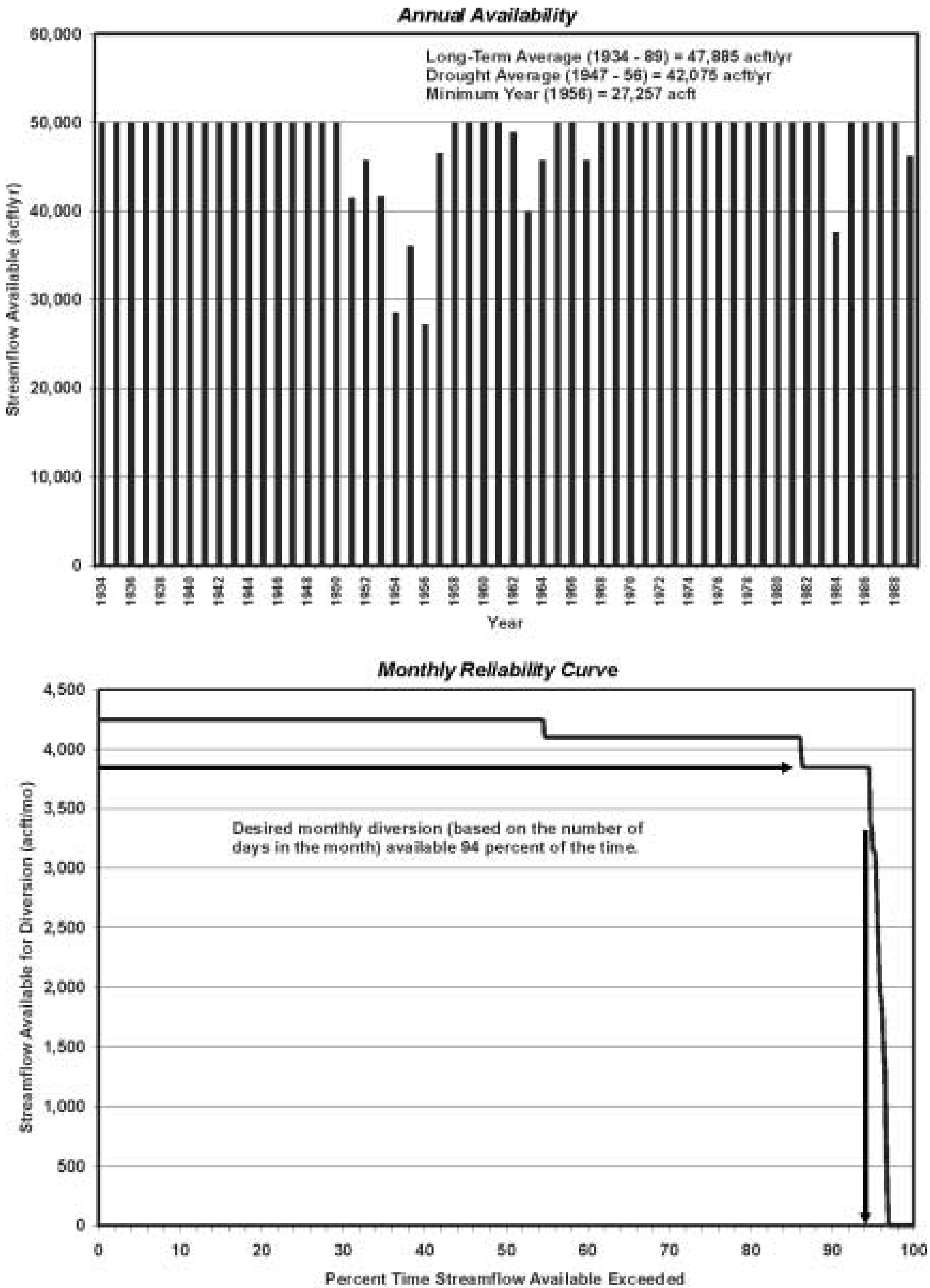


Figure 3.2-2. Water Availability Under Existing Rights (50,000 acft/yr) at the Guadalupe River Saltwater Barrier (SCTN-16a)

during the drought of record (1947 through 1956). Subject to a uniform seasonal diversion pattern, Figure 3.2-2 also indicates that the full monthly portion of 50,000 acft/yr is available in about 94 percent of the months simulated.

In order to obtain a reliable (firm) water supply through diversions from the Lower Guadalupe River at the Saltwater Barrier, several combinations of water rights, stored water commitments from Canyon Reservoir, and off-channel storage were considered. Potential commitments of stored water from Canyon Reservoir were evaluated using the GSA Model, while off-channel storage reservoir operations were simulated using an HDR utility program called RESSIM. These combinations and the associated firm water supply available are summarized by water supply option in Table 3.2-1.

Without off-channel storage, commitments from the firm yield of Canyon Reservoir of 15,000 to 19,193 acft/yr are necessary to ensure firm water availability of 44,354 to 50,000 acft/yr, respectively. With the addition of a 20,000-acft off-channel storage reservoir, firm water availability of 46,813 acft/yr to 56,276 acft/yr can be obtained, depending upon the level of commitment of stored water from Canyon Reservoir. Inclusion of off-channel storage, though not absolutely required, has certain operational advantages in addition to increasing firm water availability. These advantages include the capability of suspending river diversions to avoid poor water quality during flood events and/or facilitate maintenance without curtailing deliveries from the reservoir. The firm water availability or available project yield associated with water supply Option SCTN-16a is 56,276 acft/yr, based on up to 50,000 acft/yr of existing water rights; 20,000 acft of off-channel storage; and a 15,000 acft/yr commitment of stored water from Canyon Reservoir.

Water supply Option SCTN-16b includes all of the elements in Option SCTN-16a plus unappropriated streamflow. Unappropriated streamflow is that available for diversion after satisfying all water rights and passing flows in accordance with the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). Application of the Consensus Criteria for diversions from the Guadalupe River Saltwater Barrier includes use of the recommended monthly inflow needs of the Guadalupe Estuary associated with the maximum harvest (MaxH) of selected species[4] as a minimum amount to pass when flows exceed the

[4] TPWD and TWDB, "Freshwater Inflow Recommendation for the Guadalupe Estuary of Texas," Coastal Studies Technical Report No. 98-1, December 1998.

Table 3.2-1.
Water Availability Summary
Lower Guadalupe River Diversion (SCTN-16)

Option ID	***Firm Water Availability or Yield[1] (acft/yr)***	***Water Supply Sources***				
		Water Rights[2] (acft/yr)	***Canyon Reservoir Commitment[3] (acft/yr)***	***Off-channel Storage (acft)***	***Unappropriated Streamflow[4] (acft/yr)***	***Gulf Coast Aquifer (acft/yr)***
SCTN-16a	27,257[5]	50,000	—	—	—	—
	44,354	50,000	15,000	—	—	—
	50,000	50,000	19,193	—	—	—
	46,813	50,000	0	20,000	—	—
	50,000	50,000	4,361	20,000	—	—
	56,276	50,000	15,000	20,000	—	—
SCTN-16b	74,000	50,000	15,000	20,000	Variable	—
SCTN-16c	94,000	50,000	15,000	20,000	Variable	20,000

1 Amount of water available on an annual basis without shortage during the most severe drought on record. Estimates of firm water available or yield are based on a maximum diversion rate of about 250 cfs (96-inch diameter transmission pipeline).

2 Certificate of Adjudication #18-5178, Priority Date = January 7, 1952.

3 Commitment from the firm yield of Canyon Reservoir necessary to firm up other water supply sources on an as-needed basis.

4 Highly variable supply of water available subject to full utilization of water rights, Consensus Environmental Criteria (Appendix B), and maximum diversion rate.

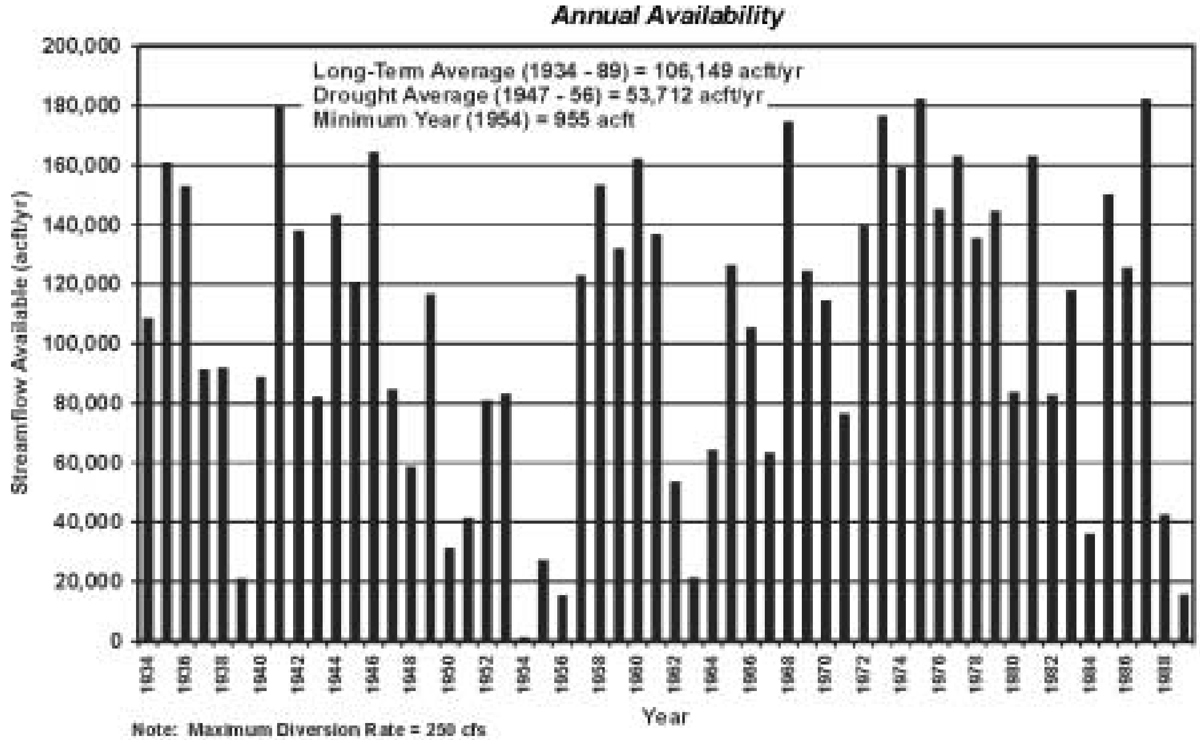
5 Simulated minimum water available in one calendar year (1956).

monthly natural daily median. When flows fall below the median, the monthly instream flow provisions in the Consensus Criteria are assumed to apply.

Monthly estimates of unappropriated streamflow subject to a maximum diversion rate of about 250 cfs (transmission capacity of a 96-inch diameter pipeline) were computed using an HDR utility program. As shown in Figure 3.2-3, unappropriated streamflow available for diversion on an annual basis ranges from a maximum of about 182,000 acft to a minimum of 955 acft in 1954. Unappropriated streamflow averages 106,149 acft/yr over the full simulation period (1934 through 1989) and 53,712 acft/yr during the drought of record (1947 through 1956). The reliability curve in Figure 3.2-3 indicates that unappropriated streamflow available exceeds the maximum diversion rate or transmission pipeline capacity in about 50 percent of the months simulated and that there is no unappropriated streamflow available in about 25 percent of the months simulated.

Utilization of unappropriated streamflow in addition to the other water sources considered in Option SCTN-16a results in a firm yield of about 74,000 acft for Option SCTN-16b. As indicated in Table 3.2-1, this represents an increase of more than 17,000 acft/yr (31 percent) in firm yield with essentially the same diversion and off-channel storage facilities. The available project yield associated with water supply Option SCTN-16b is 74,000 acft/yr, based on up to 50,000 acft/yr of existing water rights; periodic diversion of unappropriated streamflow; 20,000 acft of off-channel storage; and a 15,000-acft/yr commitment of stored water from Canyon Reservoir.

Water supply Option SCTN-16c includes all of the elements in Option SCTN-16b plus an estimated 20,000 acft/yr of dependable groundwater supply from the Gulf Coast Aquifer in northern Refugio and southern Victoria Counties near the potential off-channel storage reservoir site. Additional studies and a program of well testing would be necessary to assess the long-term reliability and potential localized effects of well fields operating at a production rate of 20,000 acft/yr in these counties. The available project yield associated with water supply Option SCTN-16c is 94,000 acft/yr, based on up to 50,000 acft/yr of existing water rights; periodic diversion of unappropriated streamflow; 20,000 acft of off-channel storage; a 15,000 acft/yr commitment of stored water from Canyon Reservoir; and 20,000 acft/yr of groundwater from the Gulf Coast Aquifer.



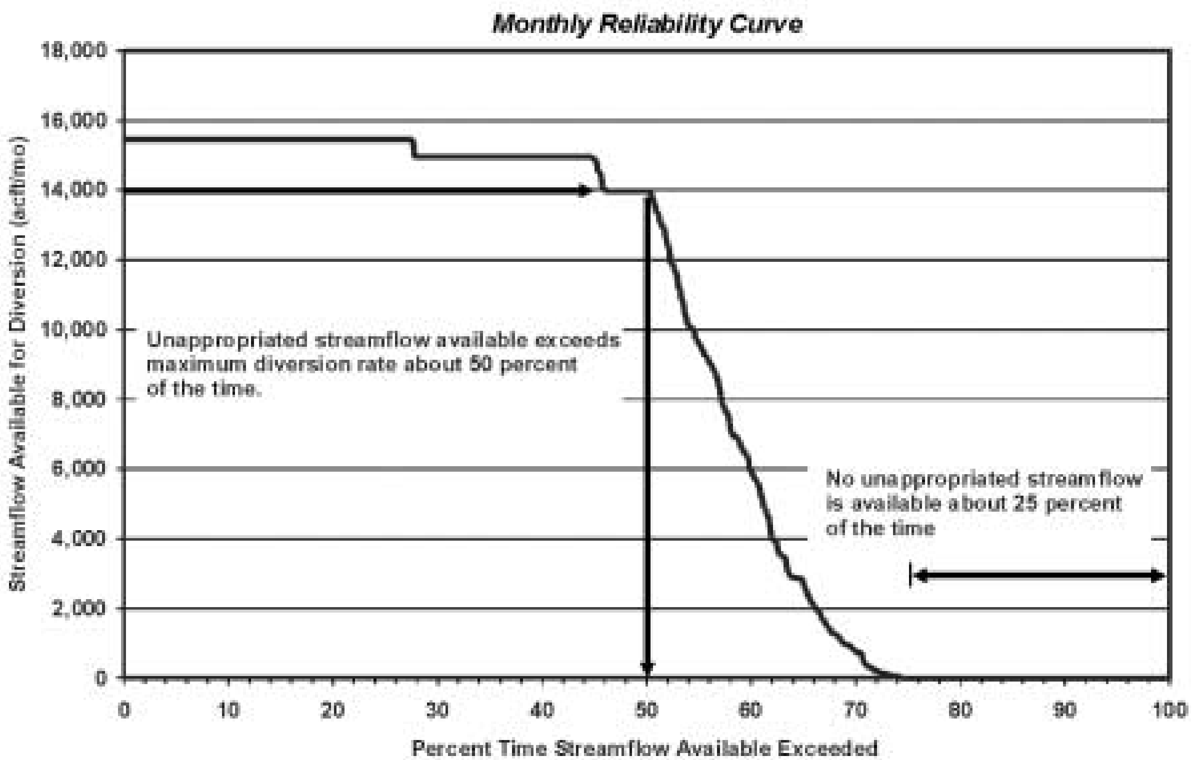


Figure 3.2-3. Unappropriated Streamflow Availability at the Guadalupe River Saltwater Barrier (SCTN-16b & c)

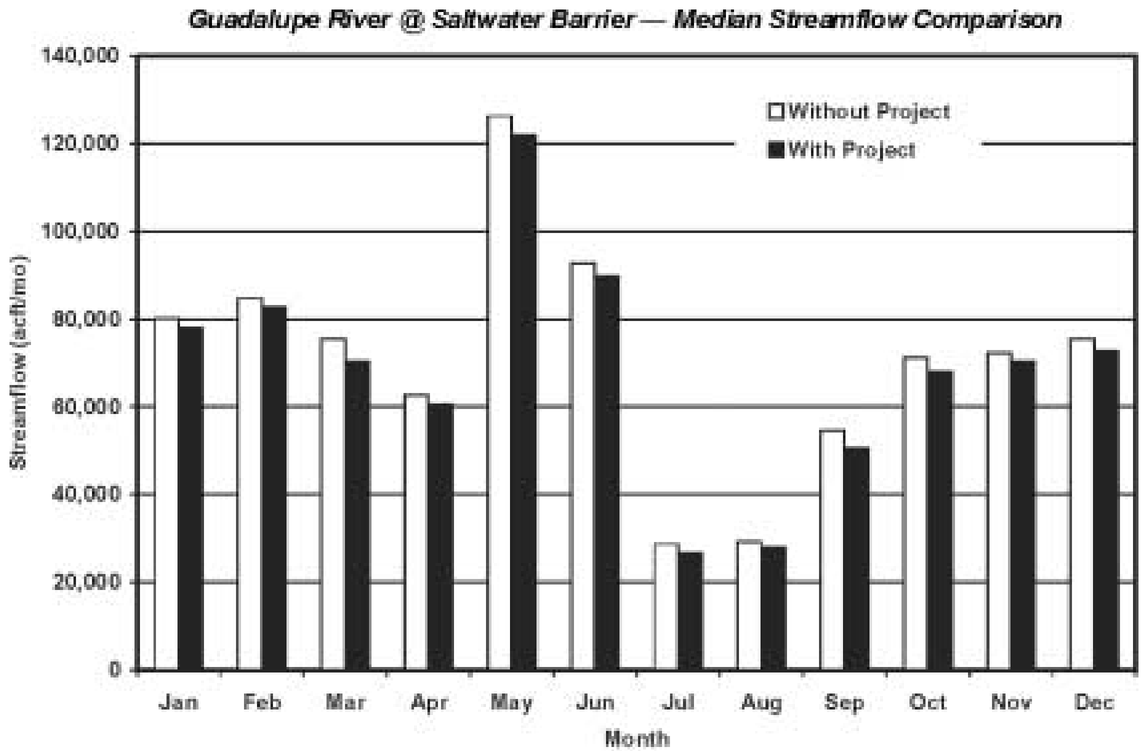
Monthly median streamflows and streamflow frequency curves for the Guadalupe River at the Saltwater Barrier with and without implementation of water supply Option SCTN-16b are presented in Figure 3.2-4. No streamflow comparison graphics are included for Options SCTN-16a (diversions under existing water rights) and SCTN-16c (identical to Option SCTN-16b with respect to streamflow). As indicated in Figure 3.2-4, decreases in monthly median streamflows associated with implementation of Option SCTN-16b would range from a minimum of 2.3 percent in February to a maximum of 7.6 percent in September. Average annual streamflows passing the Guadalupe River Saltwater Barrier would be reduced by approximately 1.5 percent. Streamflows during drought periods would remain essentially unaffected as unappropriated streamflow is not available under Consensus Criteria during these periods.

3.2.3 Environmental Issues

A 12.6-mile diversion pipeline from the Guadalupe River Saltwater Barrier to the off-channel reservoir would traverse Refugio County and a 120-mile long transmission pipeline from the off-channel reservoir to the point(s) of distribution would traverse Goliad, DeWitt, Karnes, Wilson, and Bexar Counties. A construction right-of-way of approximately 140-feet wide would affect a total area of approximately 2,200 acres. The construction of the pipeline would include the clearing and removal of woody vegetation. A 40-foot wide right-of-way corridor free of woody vegetation maintained for the life of the project would total 643 acres. The proposed pipeline route would traverse three of Omernik's[5] ecoregions: the Western Gulf Coastal Plain, the East Central Texas Plains, and the westernmost reaches of the Texas Blackland Prairie.

Surveys for protected species would be conducted within the proposed construction corridors where preliminary evidence indicates their existence. Many of these species appear to be dependent on shrubland or riparian habitat, such as the Texas Tortoise, the Reticulated Collared Lizard, the Texas Horned Lizard, and the Indigo Snake. The Texas Garter Snake may be present in wetland habitats and the Timber Rattlesnake may be found in riparian woody vegetation. Potential conflicts with plant and animal species of concern should be avoidable by employing appropriate habitat and important species surveys and appropriate construction techniques.

[5] Omernik, J. M, "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77: 118-125, 1987.



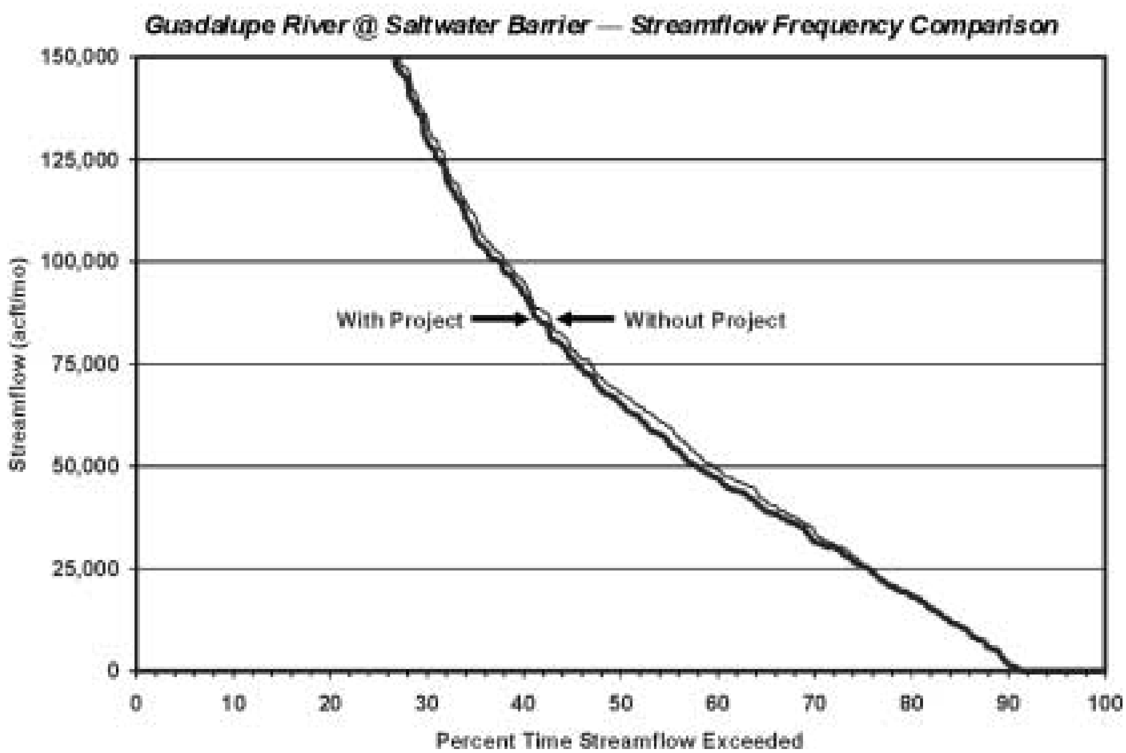


Figure 3.2-4. Lower Guadalupe River Diversion (SCTN-16b) Streamflow Comparisons

Destruction of potential habitat can be avoided by diverting the corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impacts. Wetland impacts, primarily pipeline stream crossings, could be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

The estuarine environments of the Guadalupe and San Antonio Bays serve as critical habitat and spawning grounds for many marine species and migratory birds. Estuaries are marine environments maintained in a brackish state by the inflow of freshwater from rivers and streams. Although bay volumes, inflows, and tidal exchanges with the Gulf of Mexico are so large relative to this alternative that substantial impacts to overall salinity, nutrient and sediment level are not likely, an assessment of changes in freshwater inflows to bays and estuaries will be necessary for permitting.

The Natural Heritage Program does not report the occurrence of any endangered, threatened, or species of concern in the area impacted by the off-channel reservoir. Although the Natural Heritage Program does not report the occurrence of any endangered, threatened or species of concern directly along the pipeline right-of-way, some have been reported within a 1-mile corridor. The only endangered specie known to exist within this 1-mile corridor is the Attwater's Greater Prairie Chicken in Goliad and Refugio Counties. The Attwater's Greater Prairie Chicken prefers the coastal prairies grassland in areas 0 to 24 inches in vegetational height. Several rare vascular plants on the Texas Organization for Endangered Species (TOES) watch list are known to exist within this 1-mile corridor. Big red sage (*Salvia penstemonoides*) is listed as candidate species for protection by the U.S. Fish and Wildlife Service (USFWS), as well as listed on the TOES watch list. Coastal Gay Feather (*Liatris bracteata*), Plains Gumweed (*Grindelia oolepsis*), Elmendorf's Onion (*Allium elmendorfii*), Parks' Jointweed (*Polygonella parksii*) and Welder Machaeranthera (*Psilactis heterocarpa*) are all found in this corridor and are listed on the TOES watch list.

Important aquatic species known to the San Antonio River and Guadalupe River include the Guadalupe Bass (*Micropterus treculi*) and Cagle's Map Turtle (*Graptemys caglei*). The

Guadalupe Bass is listed as a candidate (C2) for protection by the USFWS. Populations of Guadalupe Bass tend to decline as the river enters the Coastal Plains. Plant and animal species listed by the USFWS, the Texas Parks and Wildlife Department (TPWD) and TOES as endangered or threatened and those with candidate for listing or rare status in the project area are presented in Table 3.2-2. All species listed have habitat requirements or preferences that suggest they could be present within the project area.

All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence of absence of significant cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL 96-515), and the Archaeological and Historical Preservation Act (PL 93-291).

Table 3.2-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Lower Guadalupe River Diversion (SCTN-16)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Birds						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in All Counties
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in All Counties
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant in Karnes, Goliad, Refugio, Dewitt
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	T	Nesting/Migrant in Goliad, Refugio
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in All Counties
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	E	E	E	Nesting/Migrant in Refugio
Reddish Egret	*Egretta rufescens*	Coastal inlands for nesting, coastal marshes for foraging	C2	T		Migrant in Refugio
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and standing water formerly nested in TX		T	T	Migrant in Bexar, Wilson, Refugio, Dewitt
Bald Eagle	*Haliaeetus leucocephalus*	Large Bodies of water with nearby resting sites	T	T	E	Nesting/Migrant in Goliad, Refugio
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country, deciduous or pine-oak woodland; nests in various habitats		T	T	Nesting/Migrant in Bexar
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with patchy, distinctive two-layered aspect; shrub and tree layer with open, grassy space	E	E	T	Nesting/Migrant in Bexar

Table 3.2-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Coastal Prairies of Gulf Coastal Plain	E	E	E	Nesting in Goliad, Refugio — Known To Occur Within 1 Mile Of Pipeline Route
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields	C2	T	T	Migrant in Bexar, Wilson, Refugio
Piping Plover	*Charadrius melodus*	Beaches and flats of Coastal Texas	T	T	T	Migrant in Refugio
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant in Bexar, Wilson
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas; bare ground for running and walking				Nesting/Migrant in Bexar, Wilson
Reptiles						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges	C1		C1	Bexar, Dewitt
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush	C2	T	T	All Counties
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Bexar
Spot-tailed Earless Lizard	*Holbrookia lacerata*	central & southern Texas; oak-juniper woodlands and mesquite-prickly pear				Bexar, Karnes, Goliad, Refugio
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast	C2		T	Refugio
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Bexar, Karnes, Wilson, Goliad, Refugio
Timber Rattlesnake	*Crotalus horridus*	floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Bexar, Refugio
Gulf Saltmarsh Snake	*Nerodia clarkii*	Brackish to saline coastal waters	C2			Refugio
Scarlet Snake	*Cemophora coccinea*	Sandy soils of East Texas, central and south Gulf Coast		T	WL	Refugio
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Bexar, Karnes, Refugio
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Bexar, Wilson, Goliad, Refugio, Dewitt
Amphibians						
Black-spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	E	Bexar, Refugio
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of Southeast Texas		T	T	Goliad, Refugio
South Texas Siren (Lg. Form)	*Siren sp. 1*	Moist soils		T		Refugio
Mexican Treefrog	*Smilisca baudinii*	subtropical woodlands, resacas		T	T	Refugio
Fish						
Guadalupe Bass	*Micropterus treculi*	Clear flowing streams	C2		WL	Bexar

Table 3.2-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Insects						
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Found near slow-moving water, eggs laid on objects near water; aquatic larvae, adults prefer shady areas; males bite, females feed on nectar and pollen	C1			Goliad
Maculated Manfreda Skipper	*Stallingsia maculosus*	fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			WL	Bexar, Karnes, Wilson
Plants						
Black Lace Cactus	*Echinocereus reichenbachii var. albertii*	grasslands, thorn shrublands, mesquite woodlands on sandy, somewhat saline soils on coastal prairie	E	E	E	Refugio
Big Red Sage	*Salvia penstemonoides*	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade	C2		WL	Bexar, Wilson—Known to Occur Within 1 Mile of Pipeline Route
Coastal Gay Feather	*Liatris bracteata*	black clay soils of midgrass grasslands on coastal prairie remnants.			WL	Refugio—Known to Occur Within 1 Mile of Pipeline Route
Plains Gumweed	*Grindelia oolepsis*	early successional patches in coastal prairie on heavy clay soils, sometimes in disturbed habitats in urban areas			WL	Refugio—Known to Occur Within 1 Mile of Pipeline Route
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Bexar, Wilson, Refugio—Known to Occur Within 1 Mile of Pipeline Route
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Bexar, Wilson—Known to Occur Within 1 Mile of Pipeline Route
Bracted Twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Bexar
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tarnaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			WL	Bexar
Correll's False Dragon-Head	*Physostegia correllii*	wet soils including roadside ditches, irrigation channels			WL	Bexar
Glass Mountain Coral Root	*Hexalectris nitida*	mesic woodlands in canyons, lower elevations, under oaks				Bexar
Welder Machaeranthera	*Psilactis heterocarpa*	Coastal prairie; Shrub-infested grasslands and open mesquite-huisache woodlands			WL	Refugio—Known to Occur Within 1 Mile of Pipeline Route
Sandhill Woolywhite	*Hymenopappus carrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Bexar
Mammals						
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			C2	Bexar, Wilson
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scrub and live oak mottes	E	E	E	Karnes, Wilson, Goliad, Refugio
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Karnes, Wilson, Goliad, Refugio

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.

* E = Endangered T = Threatened C2 = Candidate Category C1 = Candidate Category, Substantial Information
PT = Proposed Threatened Blank = Rare, but no regulatory listing status WL = Watch List – Potentially threatened, especially in Texas

3.2.4 Engineering and Costing

The firm yield of an off-channel reservoir supplied by diversions from the pool formed by the Guadalupe River Saltwater Barrier would be diverted through an intake and pumped in a transmission line to a water treatment plant located at the major municipal demand center of the South Central Texas Region. Water might then be distributed to municipal supply systems or to an aquifer recharge zone. The diversion rate from the off-channel reservoir used for costing purposes was assumed to be uniform throughout the year. The major facilities required to implement this option include:

- River Intake and Pump Station;
- Off-Channel Dam and Reservoir;
- Reservoir Intake and Pump Station;
- Well Fields and Collection System (SCTN-16c only);
- Raw Water Pipeline to Treatment Plant;
- Water Treatment Plant (Level 3); and
- Distribution.

The river intake and pump station are sized to deliver up to 251 cfs through a 12.6-mile, 96-inch diameter pipeline to an off-channel storage facility in northern Refugio County, with a 5 percent downtime allowance. The off-channel reservoir is assumed to have a storage capacity of 20,000 acft. The purchase of 65,000 acft/yr (50,000 acft/yr existing run-of-river rights and 15,000 acft/yr of stored water from Canyon Reservoir) is included at a rate of $61 per acft. Estimated costs associated with implementation of Option SCTN-16a, SCTN-16b, or SCTN-16c, are summarized in Tables 3.2-3 through 3.2-5.

The total project cost for Option SCTN-16a, with an 120-mile, 64-inch diameter transmission pipeline, is $429,114,000 (Table 3.2-3). For a total annual cost of $48,947,000 and an available project yield of 56,276 acft/yr, the resulting unit cost for Option SCTN-16a is $870 per acft.

The total project cost for Option SCTN-16b, which includes the diversion of unappropriated streamflow and a 66-inch diameter transmission pipeline, is $487,549,000 (Table 3.2-4). For a total annual cost of $58,328,000 and an available project yield of 74,000 acft/yr, the resulting unit cost for Option SCTN-16b is $788 per acft.

Table 3.2-3.
Cost Estimate Summary for
Lower Guadalupe River Diversions (SCTN-16a)
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Diversion Facilities (251 cfs; 12.6-mile; 96-inch dia.)	$27,941,000
Off-Channel Reservoir (20,000 acft; 1,218 acres)	13,626,000
Intake and Pump Station (52.9 MGD)	8,819,000
Transmission Pump Stations (2)	12,432,000
Transmission Pipeline (64-inch dia.; 120 miles)	124,228,000
Water Treatment Plant (52.9 MGD)	36,607,000
Distribution	66,598,000
Total Capital Cost	**$290,251,000**
Engineering, Legal Costs and Contingencies	$94,320,000
Environmental & Archaeology Studies and Mitigation	4,923,000
Land Acquisition and Surveying (1,884 acres)	7,833,000
Interest During Construction (2 years)	31,787,000
Total Project Cost	**$429,114,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$29,478,000
Reservoir Debt Service (6 percent for 40 years)	1,552,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	2,771,000
Dam and Reservoir	204,000
Water Treatment Plant	4,237,000
Pumping Energy Costs (112,331,925 kWh @ $0.06 per kWh)	6,740,000
Purchase of Water (65,000 acft/yr @ $61 per acft)	3,965,000
Total Annual Cost	**$48,947,000**
Available Project Yield (acft/yr)	**56,276**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$870**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.67**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

**Table 3.2-4.
Cost Estimate Summary for
Lower Guadalupe River Diversions (SCTN-16b)
(Second Quarter 1999 Prices)**

Item	*Estimated Costs for Facilities*
Capital Costs	
Diversion Facilities (251 cfs; 12.6-mile; 96-inch dia.)	$27,941,000
Off-Channel Reservoir (20,000 acft; 1,218 acres)	13,626,000
Intake and Pump Station (69.6 MGD)	10,530,000
Transmission Pump Stations (2)	15,556,000
Transmission Pipeline (66-inch dia.; 120 miles)	137,169,000
Water Treatment Plant (69.6 MGD)	46,727,000
Distribution	79,257,000
Total Capital Cost	**$330,806,000**
Engineering, Legal Costs and Contingencies	$107,867,000
Environmental & Archaeology Studies and Mitigation	4,926,000
Land Acquisition and Surveying (1,886 acres)	7,835,000
Interest During Construction (2 years)	36,115,000
Total Project Cost	**$487,549,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$33,723,000
Reservoir Debt Service (6 percent for 40 years)	1,552,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	3,139,000
Dam and Reservoir	204,000
Water Treatment Plant	5,858,000
Pumping Energy Costs (164,778,969 kWh @ $0.06 per kWh)	9,887,000
Purchase of Water (65,000 acft/yr @ $61 per acft)	3,965,000
Total Annual Cost	**$58,328,000**
Available Project Yield (acft/yr)	**74,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$788**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.42**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Table 3.2-5.
Cost Estimate Summary for
Lower Guadalupe River Diversions (SCTN-16c)
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Well Field and Facilities	$8,034,000
Diversion Facilities (251 cfs; 12.6-mile; 96-inch dia.)	27,941,000
Off-Channel Reservoir (20,000 acft; 1,218 acres)	13,626,000
Intake and Pump Station (88.4 MGD)	11,073,000
Transmission Pump Stations (2)	16,817,000
Transmission Pipeline (78-inch dia.; 120 miles)	181,631,000
Water Treatment Plant (88.4 MGD)	55,664,000
Distribution	93,469,000
Total Capital Cost	**$408,255,000**
Engineering, Legal Costs and Contingencies	$132,751,000
Environmental & Archaeology Studies and Mitigation	4,982,000
Land Acquisition and Surveying (22,520 acres)	25,972,000
Interest During Construction (2 years)	45,758,000
Total Project Cost	**$617,718,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$43,102,000
Reservoir Debt Service (6 percent for 40 years)	1,552,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	3,843,000
Dam and Reservoir	204,000
Water Treatment Plant	7,018,000
Pumping Energy Costs (187,319,429 kWh @ $0.06 per kWh)	11,239,000
Purchase of Water (65,000 acft/yr @ $61 per acft)	3,965,000
Total Annual Cost	**$70,923,000**
Available Project Yield (acft/yr)	**94,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$755**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.32**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Option SCTN-16c includes the purchase of 20,000 acft/yr of groundwater obtained from well fields tentatively sited in northern Refugio County and southern Victoria County. The purchase cost of groundwater is assumed equivalent to outright purchase of the land necessary to construct the well fields. Groundwater collector lines from the well fields would tie directly into the pump station at the off-channel reservoir. The total project cost for Option SCTN-16c, which includes a 78-inch diameter transmission pipeline, is $617,718,000 (Table 3.2-5). For a total annual cost of $70,923,000 and an available project yield of 94,000 acft/yr, the resulting unit cost for Option SCTN-16c is $755 per acft.

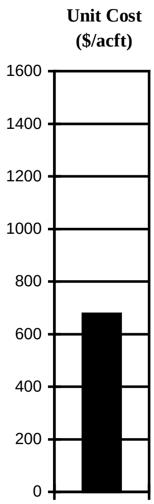
3.2.5 Implementation Issues

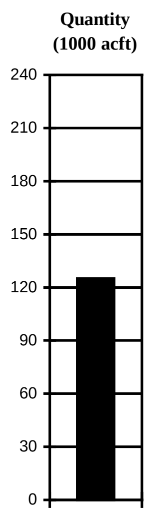
Implementation of Option SCTN-16 could directly affect the feasibility of other water supply options under consideration, including L-11, L-14, L-20, S-14D, S-15D, S-15E, S-16C, G-16C1, G-17C1, G-20, G-38C, SCTN-11, SCTN-12b, and/or SCTN-14.

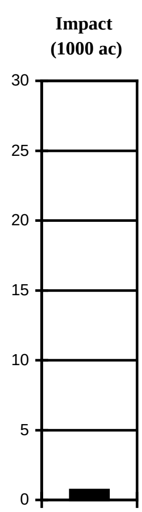
An institutional arrangement is needed to implement projects including financing on a regional basis.

1. It will be necessary to obtain the following:
    a. TNRCC Water Right and Storage Permits and Amendments.
    b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
    c. GLO Sand and Gravel Removal permits.
    d. GLO Easement for use of state-owned land.
    e. Coastal Coordination Council review.
    f. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
    a. Assessment of changes in freshwater inflows to bays and estuaries.
    b. Habitat mitigation plan.
    c. Environmental studies.
    d. Cultural resource studies and mitigation.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir include:
    a. County roads.
    b. Other utilities.
5. Other Coordination:
    a. Clarification of interbasin transfer issues as they may significantly affect the feasibility of this water supply option.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 11/02/99







OPTION NUMBER: C-17A
OPTION NAME: Colorado River in Colorado County — Buy Stored Water and Irrigation Rights; Firm Yield

OPTION DESCRIPTION: *Purchase a firm supply of about 125,000 acft/yr from the Lower Colorado River Authority (LCRA) comprised of 75,000 acft/yr of run-of-river water rights and 50,000 acft/yr of Highland Lakes stored water. Divert from Colorado River in Colorado County to an off-channel reservoir, deliver to a water treatment plant at the major municipal demand center of the South Central Texas Region, and distribute to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**677**	**per acft Treated Water Distributed**[1]
QUANTITY OF WATER:	**125,000**	**acft/yr**[2]
LAND IMPACTED:	**749**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Small channel dam, river intake and pump stations, raw water pipeline, two transmission pump stations, water treatment plant, and distribution to municipal system)(s) or recharge zone.

[2]**QUANTITY OF WATER:** 125,000 acft/yr from Colorado River: 75,000 purchase existing rights and 50,000 from LCRA storage.

[3]**LAND IMPACTED:** Water treatment plant site, pipeline right-of-way, off-channel reservoir, and transmission pump stations.

ENVIRONMENTAL ISSUES: Effects of off-channel reservoir and pipeline route on terrestrial habitats. The Texas Parks and Wildlife Department list eight endangered and fourteen threatened species that occur in the project area of this option. However, the off-channel reservoir could probably be sited on current crop or rangelands. Careful selection of pipeline route and other infrastructure sites could potentially avoid many resource conflicts.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water and ability of the entities to develop a regional plan that realizes economies of size that benefits all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Colorado River Basin water to the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-15Dc, S-15Eb, C-13C, C-17B, C-18, SCTN-2b, SCTN-11, SCTN-12b, and/or SCTN-15.

3.3 Colorado River in Colorado County – Buy Stored Water and Irrigation Rights; Firm Yield (C-17A)

3.3.1 Description of Option

This water supply option involves the potential diversion 125,000 acft/yr of water from the Colorado River near Columbus, Texas and conveying it through a pipeline to the major municipal demand center of the South Central Texas Region. Treated water would then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone. The river diversion location and pipeline route are shown in Figure 3.3-1. In this option, it is assumed that Colorado River water would be obtained by purchasing a combination of existing irrigation run-of-river water rights held by the Lower Colorado River Authority (LCRA) and stored water from the LCRA's Highland Lakes System. Existing irrigation rights sufficient to provide a reliable 75,000 acft/yr of water would be purchased and converted to municipal use. The remaining 50,000 acft/yr would be comprised of stored water purchased annually from LCRA.

The major water rights of the Lower Colorado River Basin below LCRA's Highland Lakes are shown in Table 3.3-1. These water rights are arranged in priority order with the most senior at the top of the table. Of those listed, the first eight are senior to the Highland Lakes, which have a priority date to impound water of 1926.[1] Inflows to the Highland Lakes must, therefore, be passed through the lakes when necessary to satisfy the eight senior downstream water rights. In a 1987 settlement between the City of Austin and LCRA, portions of the water rights owned by the LCRA (numbers 3, 4, and 6 in Table 3.3-1) have been subordinated to the City of Austin, but these rights retained their seniority relative to other rights.

Of the LCRA-held water rights, Garwood and Lakeside (nos. 1, 4, and 11) have historically had authorized diversion points just downstream of Columbus. Recently, the LCRA-Lakeside water right permit (nos. 4 and 11) was amended to include the LCRA portion of the Pierce Ranch water right (no. 6) with the diversion point near Columbus.[2] For the purposes of this option, it is assumed that a sufficient portion of these water rights to supply 75,000 acft/yr would be purchased or leased and converted to municipal use.

[1] Lower Colorado River Authority, "Water Management Plan for the Lower Colorado River Basin," March 1999.
[2] Amendment granted by the Texas Natural Resource Conservation Commission on May 30, 1997.

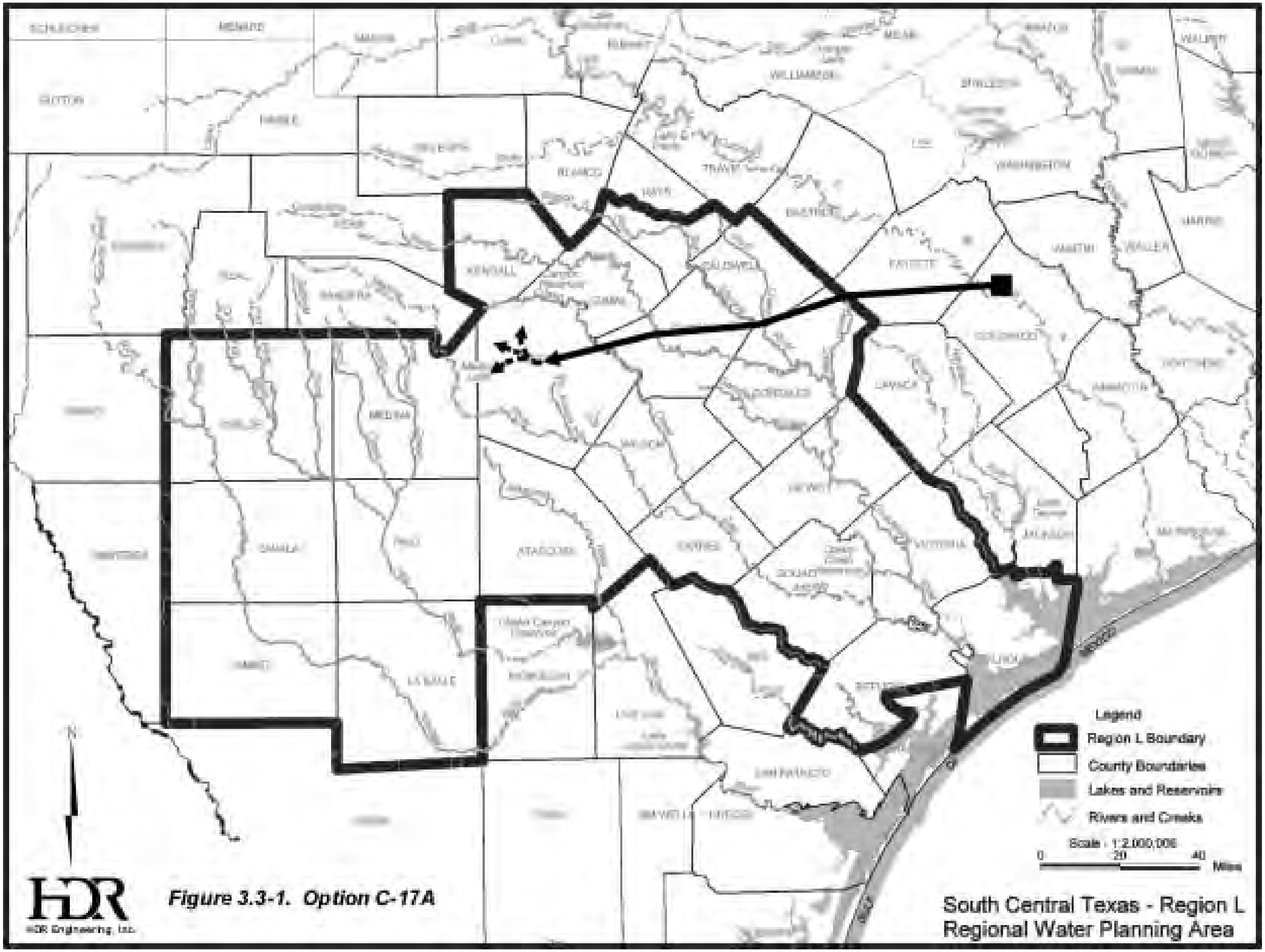


Figure 3.3-1. Option C-17A

Table 3.3-1.
Summary of the Principal Water Rights in the Lower Colorado River Basin below LCRA's Highland Lakes

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal
3	LCRA - Gulf Coast[1]	14-5476	12/01/1900	228,570	Irrigation
4	LCRA – Lakeside[1]	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch[1]	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403[2]	Municipal
9	City of Austin	14-5489	1945, 1965	36,456[3]	Industrial
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] These three water rights held by LCRA are subordinated to the 250,000 acft/yr municipal portion of the City of Austin's water right (no. 7).
[2] 22,403 acft/yr of this right are for municipal use, the balance is for steam electric.
[3] These water rights are for steam-electric generation and cooling.

3.3.2 Water Potentially Available at Columbus

The total of the annual authorized diversions of the major water rights in the Lower Colorado River Basin below Lake Travis is 1,004,609 acft. It is evident in Table 3.3-1 that, currently, a large portion (61 percent) of these Lower Colorado River Basin water rights is used for rice irrigation.

Although a typical water right permit specifies the total annual diversion, the maximum allowable rate of diversion, and the type of use for the water, it does not specify the day-by-day diversion pattern. However, this is strongly linked to the type of use. Figure 3.3-2 presents typical demand patterns, based on historical data, for both rice irrigation in the Lower Colorado River Basin and municipal use. A striking feature of Figure 3.3-2 is the strong seasonal concentration of the irrigation demand pattern during the late-spring through summer period

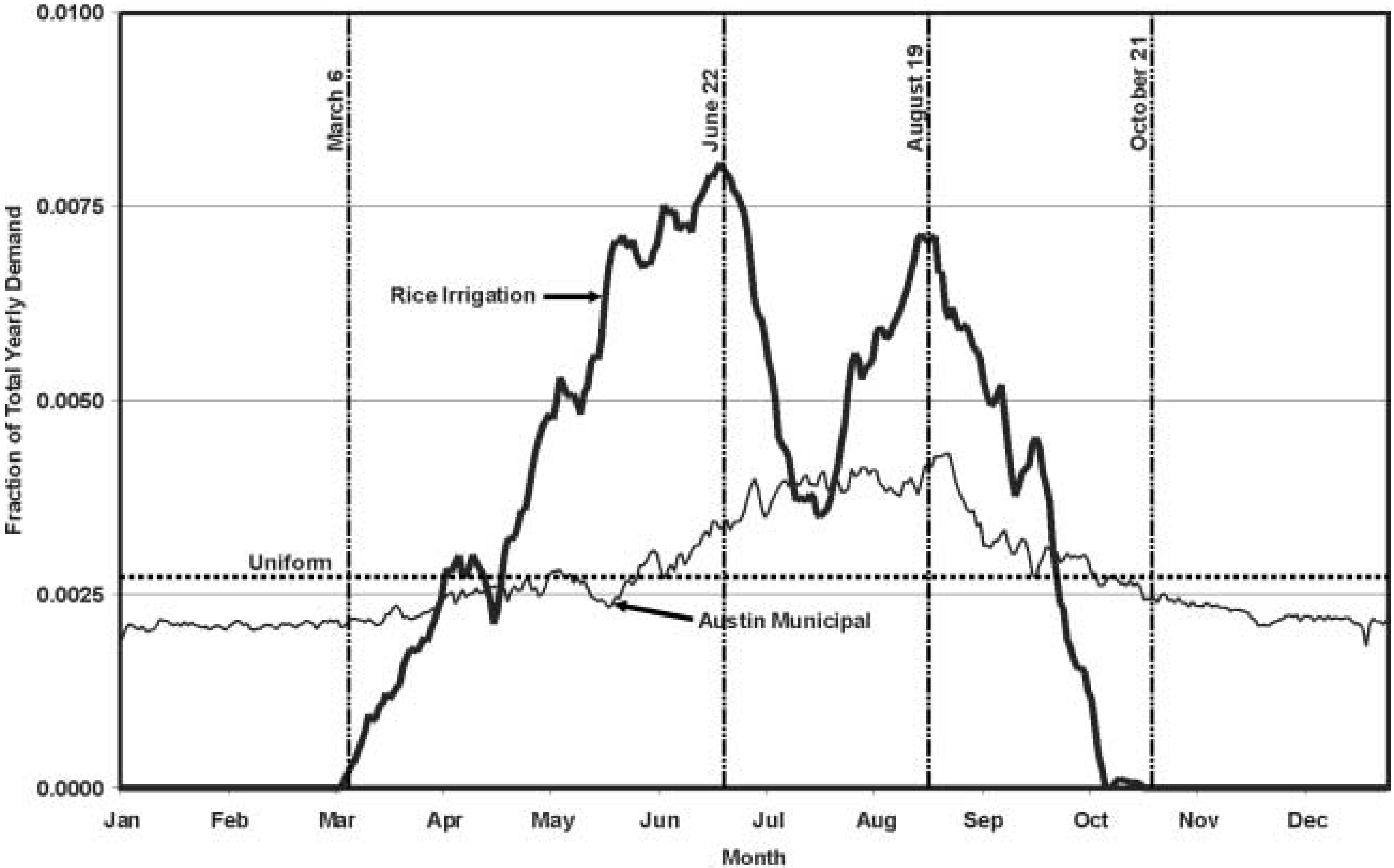


Figure 3.3-2. Typical Demand Patterns by Type of Water Use in the Lower Colorado River Basin

(May 15 to September 15), when 75 percent of the total irrigation demand is exercised. There is acute competition among the water rights in the summer period when water availability is typically low.

For the purposes of evaluating the water availability for this option it is assumed that the LCRA-Garwood, LCRA-Lakeside and LCRA-Pierce Ranch water rights (nos. 1, 4, 6, and 11) could be converted from agricultural to municipal use. With these conversions, demand for Colorado River water in the lower basin would follow a more uniform pattern,[3] thereby spreading some of the concentrated summertime demand to other portions of the year.

In order to evaluate water availability under these assumptions, the LCRA's RESPONSE model of the lower Colorado River was utilized. The RESPONSE model examines how much of the demands of downstream senior water rights below the Highland Lakes, in priority order, can be satisfied from the run-of-river flows originating below the lakes. The model can be executed to examine water availability of the competing water rights with differing assumed diversion patterns. The period of record of the model is from 1941 to 1965, which covers the critical drought period of the mid-1950s in the Colorado River Basin.

One of the critical variables of the RESPONSE model is the level of assumed return flows from the City of Austin's wastewater treatment plants. This can be a considerable input volume especially during the critical drought period and is important for supplying downstream water rights demands. Recent estimates of Austin's return flow percentages are in the range of 55 percent. In this analysis it was assumed that this would be reduced to 44 percent, a 20 percent reduction in return flow due to reuse initiatives. This gives a future volume of 120,000 acft/yr at that point in time when Austin's utilizes the full 272,000 acft/yr of municipal rights (nos. 7 and 8 in Table 3.3-1).[4]

In order to evaluate the water available to the LCRA-Garwood, LCRA-Lakeside and LCRA-Pierce Ranch water rights if they were converted to municipal use, two scenarios were evaluated with the RESPONSE model:

- **Agricultural Baseline:** All eleven of the major water rights were simulated with the indicated diversion pattern shown in Table 3.3-1.

[3] An anticipated conversion to municipal and/or industrial use in the lower reaches of the lower Colorado River basin is modeled as a uniform rate because long transport facilities and off-channel storage would be necessary.
[4] As a result of the 1987 agreement between Austin and the LCRA, 250,000 acft/yr of the City's Certificate of Adjudication 14-5471 (no. 7 in Table 3.3-1) are backed up by stored water in the Highland Lakes.

- **Municipal Conversion:** The LCRA-Garwood, LCRA-Lakeside and LCRA-Pierce Ranch were set to a uniform demand pattern. An anticipated conversion to municipal and/or industrial use in the lower reaches of the Lower Colorado River Basin is modeled as a uniform rate because long transport facilities and off-channel storage would be necessary.

Estimates of water availability under the two scenarios are shown in Table 3.3-2. Under the columns labeled "Water Availability under Agricultural Baseline" are the results of the first scenario with LCRA-Garwood, LCRA-Lakeside and LCRA-Pierce Ranch water rights diverting under an agricultural demand pattern. In this baseline scenario, the minimum year "firm" water of the LCRA-Garwood right is 100,770 acft. This is only 76 percent of the full authorized diversion ("face" amount) of the water right although this is the most senior in the Colorado River basin. Other water rights fare worse because of their junior status. For instance, the LCRA-Pierce Ranch water right would yield 5,543 acft in the minimum year, or only 10.1 percent of the authorized 55,000 acft. The LCRA-Lakeside right would yield only 6,146 (5473 + 673) compared to the full authorization of 131,250. The low availability of water to these rights under this scenario is in large part due to the acute competition for water with the highly concentrated demand pattern of rice irrigation (Figure 3.3-2).

Table 3.3-2 also shows the water availability to the major water rights after the LCRA-Garwood, LCRA-Lakeside and LCRA-Pierce Ranch are converted to municipal use. Generally, the results of converting a large portion of the total water demands (319,250 acft/yr) in the lower Colorado River basin from irrigation to municipal use would be beneficial for most of the water rights. For example, the water availability for the LCRA-Garwood water right would improve substantially in the minimum year from 100,770 acft/yr to 119,857 acft/yr. The three converted LCRA rights would gain nearly 30,300 acft/yr from the conversion to supply a total of 170,103 acft/yr of "firm" water in the minimum year as compared to 139,810 under the original agricultural demand pattern.

Because the transfer of water outside of the Colorado River Basin would constitute an "interbasin" transfer under current Texas law, the converted water right(s) might take on a current (i.e., year 1999) priority date if sold outright. However, this new law is unclear with respect to potential long-term lease arrangements for this water. Therefore, if the water rights were to lose their respective priorities, it would be necessary to purchase or lease a larger portion

Table 3.3-2.
Comparison of Water Availability for Major Water Rights in the Lower Colorado River Basin after Conversion of LCRA's Garwood, Pierce Ranch, and Lakeside Rights to Municipal Demand

	Right	Demand	Water Availability under Agricultural Baseline			Water Availability after Conversions to Municipal			Change	
			Minimum Year	Min. Year Percent Demand Met	1947-56 Drought Average	Minimum Year	Min. Year Percent Demand Met	1947-56 Drought Average	Minimum Year	1947-56 Drought Average
1	Garwood-LCRA	133,000	100,770	75.8%	117,025	119,857	90.1%	125,825	+19,087	+8,800
2	Garwood-Corpus Christi	35,000	25,284	72.2%	29,422	29,412	84.0%	31,280	+4,128	+1,858
3	LCRA-Gulf Coast	228,570	32,824	14.4%	69,143	38,531	16.9%	82,792	+5,707	+13,649
4	LCRA-Lakeside	52,500	5,473	10.4%	13,137	10,693	20.4%	21,295	+5,220	+8,158
5	Pierce Ranch	55,000	5,401	9.8%	13,543	6,915	12.6%	16,534	+1,514	+2,991
6	LCRA-Pierce	55,000	5,543	10.1%	13,065	8,435	15.3%	19,276	+2,892	+6,211
7	Austin 250k mun. 1913	250,000	81,689	32.7%	135,497	89,695	35.9%	147,696	+8,006	+12,199
8	Austin 46k elec-mun. 1914	46,403	3,820	8.2%	10,267	1,834	4.0%	9,469	-1,986	-798
9	Austin 36k Jr. 1945	36,456	6	0.0%	1,406	0	0.0%	1,286	-6	-120
	Total Austin Rights	**332,859**	**85,515**	**25.7%**	**147,170**	**91,529**	**27.5%**	**158,450**	**+6,014**	**+11,281**
10	LCRA-Jr. Gulf Coast	33,930	302	0.9%	2,525	349	1.0%	2,699	+47	+174
11	LCRA-Jr. Lakeside	78,750	673	0.9%	5,226	3,280	4.2%	12,995	+2,607	+7,769
	Total Converted LCRA Rights	**495,320**	**139,810**	**28.2%**	**204,458**	**170,103**	**34.3%**	**240,888**	**+30,293**	**+36,430**

of the water rights. For the purposes of this water availability option, it is assumed that 75,000 acft/yr of "firm" water would be purchased (or leased) in either case.

All of the other non-converted irrigation rights (e.g., Pierce Ranch or LCRA-Gulf Coast) would also benefit. These positive results are simply due to moving some of the highly concentrated summer demand of rice irrigation, when flows are typically low, into the late fall through early spring portion of the year when flows are typically greater.

The City of Austin would benefit substantially, gaining 6,014 in the minimum year and 11,281 acft on average over the 1947 to 1956 critical drought period. The City of Austin would gain additional water because of the conversion of the LCRA-Garwood irrigation right, which is senior to the City's rights and not subordinated to them.

3.3.3. Environmental Issues

The option to divert water from the Colorado River near Columbus includes purchasing water under existing run-of-river and firm yield water rights and conveying the water to the major municipal demand center of the South Central Texas Region via an approximately 132-mile transmission pipeline. The project area spans the Texas Blackland Prairies and East Central Texas Plains Ecoregions.[5]

The pipelines has the potential to adversely affect Federal or state listed endangered or threatened (protected) species) depending on the route alignment. The pipeline would most likely intersect protected species in Bexar County as it crosses Selma Creek and dips south paralleling IH-13 into San Antonio. Both juniper-oak woodland and karst features present in the Balcones Fault Zone are found in this vicinity. Protected species may occur in areas where habitat is appropriate. The maturity of the woodlands and appropriate nesting habitat for the Golden-cheeked Warbler or the Black-capped Vireo can not be fully determined from either mapped or aerial references, so ground surveys would be required in areas of potential habitat delineated in this study.

Karst resources within Bexar County have been mapped extensively. The biological communities in many springs and sinks have been inventoried. However, a site reconnaissance

[5] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.

would be necessary to locate karst features and determine the habitat quality for protected species.

The pipeline route in Bexar and western Guadalupe Counties are on Quaternary sediments and fluvial terraces adjacent to the Edwards Plateau in the Balcones Fault Zone. These are relatively recent deposits parallel to modern river and stream valleys composed predominantly of gravel, limestone, dolomite, and chert. Karst habitats are not present in these formations. The pipeline crosses the San Marcos River, York Creek, the Guadalupe River, and Cibolo Creek, where localized Quaternary deposits of time transgressant terrigennous clastics are deposited in river systems. These deposits are associated with a high potential for buried archeological features. These relatively recent formations outcrop locally along upland divides and in the stream floodplains traversed by the transmission pipeline, where potentially significant prehistoric sites may occur. Other areas along this pipeline route may display a potential of impacting prehistoric sites are the minor creek crossings.

Archival research has identified this route as one of the historically documented routes of the Old San Antonio Road, also known as the El Camino Real, generally along this route. The pipeline route appears to potentially impact cultural resource site 41HY273 (San Marcos de Neve) near the San Marcos River crossing. Depending on the pipeline alignment, the route may impact historical sites. Careful alignment selection may reduce the potential for historic impacts.

The reservoir lies within the Texas Blackland Prairie Ecoregion, while the pipeline is also present in the East Central Texas Plains Ecoregions. A wide variety of soil types are present along this pipeline corridor. Beginning in Fayette County at Columbus and continuing through Gonzales County, the soils are alkaline loamy to clayey soils.[6] The vegetation of these counties alternates between Post Oak Savannah species, mainly tall grasses, mesquite trees, oaks, and elms, and Blackland Prairie flora, typically grassland species.[7] As the transmission line continues through Guadalupe and Bexar counties the vegetation becomes more dominantly Blackland Prairie vegetation, including little bluestem, feathery bluestem, sideoats grama, plains lovegrass, indiangrass, hairy dropseed, buffalograss, Texas wintergrass, live oak, shin oak, and

[6] Clements, J., 1988, Texas Facts, Clements Research II, Inc. Dallas, Texas.
[7] Blair, W. F., 1950, "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp.93-117.

Ashe juniper.[8] The soil types which support the vegetation types in this region include moderately well drained sandy to clayey soils over stream terraces or limestone.[9,10]

The fauna present in areas where suitable habitat remains will be typically neotropical and grassland species.[11] On-site surveys will be necessary to determine the specific fauna of the corridor since the pipeline corridor is a mosaic of the Post Oak Savannah and the Blackland Prairie ecoregions and could potentially include a wide variety of species.

The 132-mile transmission pipeline, pump stations, storage tanks, and off-channel reservoir will affect a total area of 1,749 acres. Cultivation accounts for approximately 34 percent of this area. Woodlands, brushlands, and shrublands comprise roughly 31 percent, grasslands an additional nine percent, and the remaining area is largely developed (e.g., roadways). The construction of the pipeline would include the clearing and removal of woody vegetation. An approximately 30-foot wide corridor free of woody vegetation would be maintained for the life of the project. Destruction of potential habitat can be avoided by diverting the corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impact.

Texas Tauschia (*Tauschia texana*) has been mapped by the Texas Parks and Wildlife Department less than one-half mile from the proposed pipeline route, and the Guadalupe Bass (*Micropterus treculi*) spotted at two locations, one about 1 mile off the route and the other a mile and a half. Although the Natural Heritage Program does not report any endangered or threatened species directly along the proposed pipeline corridor, some have been reported in the vicinity (Table 3.3-3). Many of these appear to be dependent on shrubland or riparian habitat, such as the Texas tortoise, Houston Toad, the reticulate collared lizard, the Texas horned lizard, and the Indigo snake. The Texas garter snake may be present in wetland habitats and the timber rattlesnake may be found in riparian woody vegetation. The endangered Navasota Ladies'

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[8] Gould, F. W., 1975, The Grasses of Texas, Texas A & M University Press, College Station, Texas.
[9] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1977. Soil Survey of Guadalupe County, Texas. USDA.
[10] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1991. Soil Survey of Bexar County, Texas USDA.
[11] Blair, W. F., 1950, "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp.93-117.

Table 3.3-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Colorado River in Colorado County — Buy Stored Water and Irrigation Rights (C-17A)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Meadow-rue	*Thalictrum texanum*	Outskirts of mesic woodlands or forests			WL	Resident
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident

Table 3.3-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL = Potentially Endangered/Threatened
Blank = Rare, but no regulatory listing status NL = Not Listed

Tresses may be found off of the post oak woodland margins, while the Interior Least Tern may inhabit areas surrounded by large rivers. Cagle's Map Turtle may also be of concern, as it resides in the Guadalupe River Basin and the pipeline crosses the Guadalupe River. For approximately 2 miles at the beginning of the pipeline corridor, construction would encroach on the northern portion of what is considered to be essential habitat for the Attwater's Prairie Chicken,[12] however, no Attwater's Prairie Chicken currently occupy the area, and effects of the construction on this habitat should be minimal. Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts.

When potential protected species habitat or significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use, or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, could be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL 96-515), and the Archaeological and Historical Preservation Act (PL 93-291).

3.3.4 Engineering and Costing

For this option, 125,000 acft/yr of run-of-river and firm yield water released by LCRA would be pumped from the Colorado River near Columbus to the major municipal demand center of the South Central Texas Region at a uniform rate of 172.2 cubic feet per second (112 MGD).

There are several major facilities that would have to be constructed for this water supply option. These facilities and the estimated cost for them are itemized in Table 3.3-4. At the Colorado River diversion site, a low head channel dam costing approximately $3.87 million

[12] Attwater's Prairie Chicken Recovery Team, "Attwater's Prairie Chicken Recovery Plan," U. S. Fish and Wildlife Service, 1983.

Table 3.3-4.
Cost Estimate for Colorado River in Colorado County in Columbus (C-17A)
Second Quarter 1999 Prices

Item	***Estimated Costs***
Capital Costs	
Channel Dam (500 feet; 10-feet high)	$3,872,000
Intake and Pump Station (117 MGD)	9,939,000
Water Treatment Plant (117 MGD)	71,192,000
Transmission Pump Stations (2)	13,065,000
Transmission Pipeline (84-inch dia., 132 miles)	216,614,000
Distribution	115,539,000
Off-Channel Reservoir (1,000 acft)	3,052,000
Power Connection Costs ($125/HP)	4,480,000
Total Capital Cost	**$437,753,000**
Engineering, Contingencies, Legal Costs	$141,233,000
Environmental & Archaeology Studies, Mitigation and Permitting	2,830,000
Land Acquisition and Surveying (749 acres)	6,561,000
Interest During Construction (4 years)	101,040,000
Water Right Purchase (75,000 acft)	43,125,000
Total Project Cost	**$732,542,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$52,407,000
Debt Service (6 percent for 40 years)	742,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	2,845,000
Water Treatment Plant	10,054,000
Pumping Energy Costs (222,477,521 kW-hr @ 0.06 $/kW-hr)	13,349,000
Purchase of Water (50,000 acft/yr @ 105 $/acft)	5,250,000
Total Annual Cost	**$84,647,000**
Available Project Yield (ac-ft/yr)	**125,000**
Annual Cost of Water ($ per acft)	**$677**
Annual Cost of Water ($ per 1,000 gallons)	**$2.08**

would provide a pool for the pump intakes. Next, the river intake and large pumping station would cost approximately $9.94 million. A relatively small 1,000 acft off-channel reservoir would be needed to provide temporary storage during times of transition from the water of the 75,000 acft run-of-river water rights to firm yield water released by LCRA. This facility would cost approximately $3.05 million.

The largest capital expenditure, by far, would be for the approximately 132-mile transmission pipeline, shown in Figure 3.3-1. This would require an 84-inch diameter line costing about $216.61 million. Associated with the pipeline are the two required transmission pump stations along the length on the line. These are estimated to cost approximately $13.07 million. Another important capital cost is $115.54 million for distribution to municipal systems or the Edwards Aquifer recharge zone. Costs associated with land acquisition for the pipeline right-of-way, pump stations, and off-channel reservoir are approximately $6.56 million.

The cost of purchasing the necessary water rights to yield a firm supply of 75,000 acft/yr was estimated based on the recent sale of two of the major rights of Table 3.3-1 In 1992, 35,000 acft/yr of the Garwood Irrigation Co. water right (no. 2) was sold to the City of Corpus Christi for $15.75 million. In 1998 the remaining 133,000 acft/yr of this water right (no.1) was sold to the LCRA for $75 million. Based on the fully authorized amount of these water rights, these transactions lead to "face" unit values of the water rights of approximately $450/acft in 1992 dollars and $563/acft in 1998 dollars, respectively. Because of their seniority, these water rights would supply 90.1 percent and 84.0 percent of the face amount as "firm" water in the minimum year (Table 3.3-2). On a firm basis, the unit values of the water rights are approximately $535/acft and $626/acft, respectively. For the purpose of this evaluation, the value of a water right purchase was estimated as $575/acft of "firm" water.

Since the three converted LCRA water rights (nos. 1, 4, 6, and 11 of Table 3.3-1) could supply much more that the necessary 75,000 acft/yr in the minimum year, it was assumed that only a portion of these rights would need to be purchased. The total value of such a one-time water right purchase was estimated by multiplying $575 by 75,000 acft = $43,125,000.

With engineering, contingencies, legal costs, and other studies the total project cost would be $732.54 million.

The majority of the project would be financed over 30 years at a 6 percent annual interest rate, resulting in an annual cost of $52.41 million. The small channel dam and off-channel reservoir would be financed at 6 percent for 40 years for an annual cost of approximately $0.74 million. Operation and maintenance costs are estimated to total $12.903 million annually. Large annual costs are associated with the delivery of water from the Colorado River near Columbus. The total amount of water diverted annually from the Colorado River, 125,000 acft/yr, was used to calculate the pumping cost. With the vertical lift and friction losses along the pipeline, the annual pumping costs are estimated to be $13.35 million.

Another principal annual cost is that of the 50,000-acft/yr firm yield water to be purchased from the LCRA. This cost was estimated at the current rate of $105 per acft purchased based on the current contract price with the City of Austin. This leads to the total of $5.25 million per year.

The annual costs, including debt repayment, interest, raw water purchases, and operation and maintenance, total $84.65 million. For an annual supply of 125,000 acft the resulting annual cost of water is $677 per acft/yr, or $2.08 per 1,000 gallons.

3.3.5 Implementation Issues

Implementation of Colorado River diversions under existing water rights supplemented by stored water from the Highland Lakes System could directly affect the feasibility of other water supply options under consideration, including S-15Dc, S-15Eb, C-13C, C-17B, C-18, SCTN-2b, SCTN-11, SCTN-12b, and/or SCTN-15.

An institutional arrangement is needed to implement projects potentially including financing on a regional basis.

Requirements Specific to Transfer of Existing Water Rights

1. Obtain TNRCC approval for amendments to the existing water rights to reflect:
   a. New type of water use.
   b. New diversion point.
   c. Interbasin transfer.
2. Water rights sales and contracts must be approved by the TNRCC.

Off-Channel Reservoir

1. Necessary permits for the off-channel storage reservoir could include:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.

   c. GLO Sand and Gravel Removal review.
   d. GLO Easement for use of state-owned land.
   e. TPWD Sand, Gravel, and Marl permit
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoir could include:
   a. Highways and railroads
   b. Other utilities

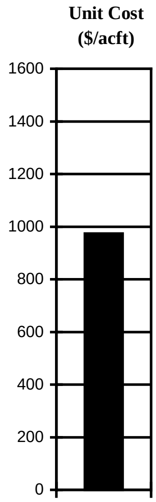
Requirements Specific to the Transmission Pipeline

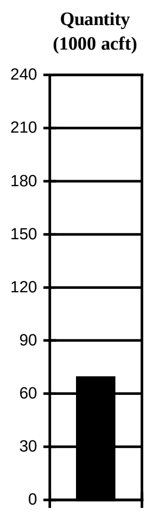
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities

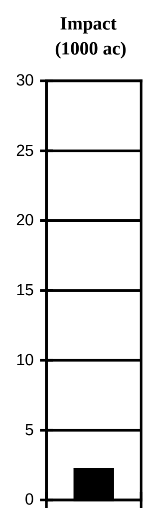
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 11/02/99







OPTION NUMBER: C-17B
OPTION NAME: Colorado River in Wharton County — Buy Irrigation Rights and Groundwater; Firm Yield

OPTION DESCRIPTION: *Purchase a firm supply of about 70,000 acft/yr from private and other interests (comprised of run-of-river water rights made firm by groundwater from the Gulf Coast Aquifer and off-channel storage), divert from Colorado River in Wharton County to an off-channel reservoir, deliver to a water treatment plant at the major municipal demand center of the South Central Texas Region and distribute to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$974**	**per acft Treated Water Distributed**[1]
QUANTITY OF WATER:	**69,000**	**acft/yr**[2]
LAND IMPACTED:	**2,216**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Upgrade existing small channel dam, river intake, and pump station. Raw water pipeline and three transmission pump stations to water treatment plant, water treatment plant, and distribution to municipal system(s) or recharge zone.

[2]**QUANTITY OF WATER:** 55,000 acft/yr from Colorado River with 1907 priority. 14,000 acft/yr from Gulf Coast Aquifer.

[3]**LAND IMPACTED:** Water treatment plant site, pipeline right-of-way, off-channel reservoir, and transmission pump stations.

ENVIRONMENTAL ISSUES: Effects of off-channel reservoir, well field, and pipeline route on terrestrial habitats. The Texas Parks and Wildlife Department lists 11 endangered and 18 threatened species that occur in the counties potentially affected by this option. However, the off-channel reservoir and well field could probably be sited on current croplands. Careful selection of pipeline route and other infrastructure sites could potentially avoid many resource conflicts.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water and ability of the entities to develop a regional plan that realizes economies of size that benefits all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Colorado River Basin water to the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-13C, C-17A, C-18, SCTN-2b, SCTN-11, SCTN-12b, and/or SCTN-15.

3.4 Colorado River in Wharton County — Buy Irrigation Rights and Groundwater; Firm Yield (C-17B)

3.4.1 Description of Option

This option involves the potential diversion of water from the Colorado River near Wharton, Texas, combining it with groundwater from the Gulf Coast Aquifer, and conveying it through a pipeline to the major municipal demand center of the South Central Texas Region. Treated water would then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone. The river diversion location and pipeline route are shown in Figure 3.4-1. Colorado River water could potentially be obtained by either purchase of water from the Lower Colorado River Authority (LCRA), or by purchase of existing run-of-river water rights, or a combination of the two. In this option it is assumed that a privately held run-of-river water right in the lower basin would be purchased and the water right converted to municipal use.

The major water rights of the Lower Colorado River Basin below LCRA's Highland Lakes are shown in Table 3.4-1. These water rights are arranged in priority order with the most senior at the top of the table. Of those listed, the first eight are senior to the Highland Lakes which have a priority date to impound water of 1926[1]. Inflows to the Highland Lakes must, therefore, be passed through the lakes when necessary to satisfy the senior downstream water rights. In a 1987 settlement between the City of Austin and LCRA, portions of the water rights owned by the LCRA (nos. 3, 4, and 6 in Table 3.4-1) have been subordinated to the City of Austin, but these rights retained their seniority relative to other rights.

As evident in Table 3.4-1 the Pierce Ranch water right is the only privately held major water right in the lower Colorado River basin. For the purposes of this option it is assumed that this water right would be purchased and converted to municipal use. Because the transfer of water outside of the Colorado River basin would constitute an "interbasin" transfer under current Texas law, the water right might take on a current (i.e., year 1999) priority date if the right were sold outright. However, this new law is unclear with respect to a potential long-term lease arrangements for this water. Therefore, the water availability and cost of this option are evaluated for both the 1907 priority date and a current priority date.

[1] Lower Colorado River Authority, "Water Management Plan for the Lower Colorado River Basin," March 1999.

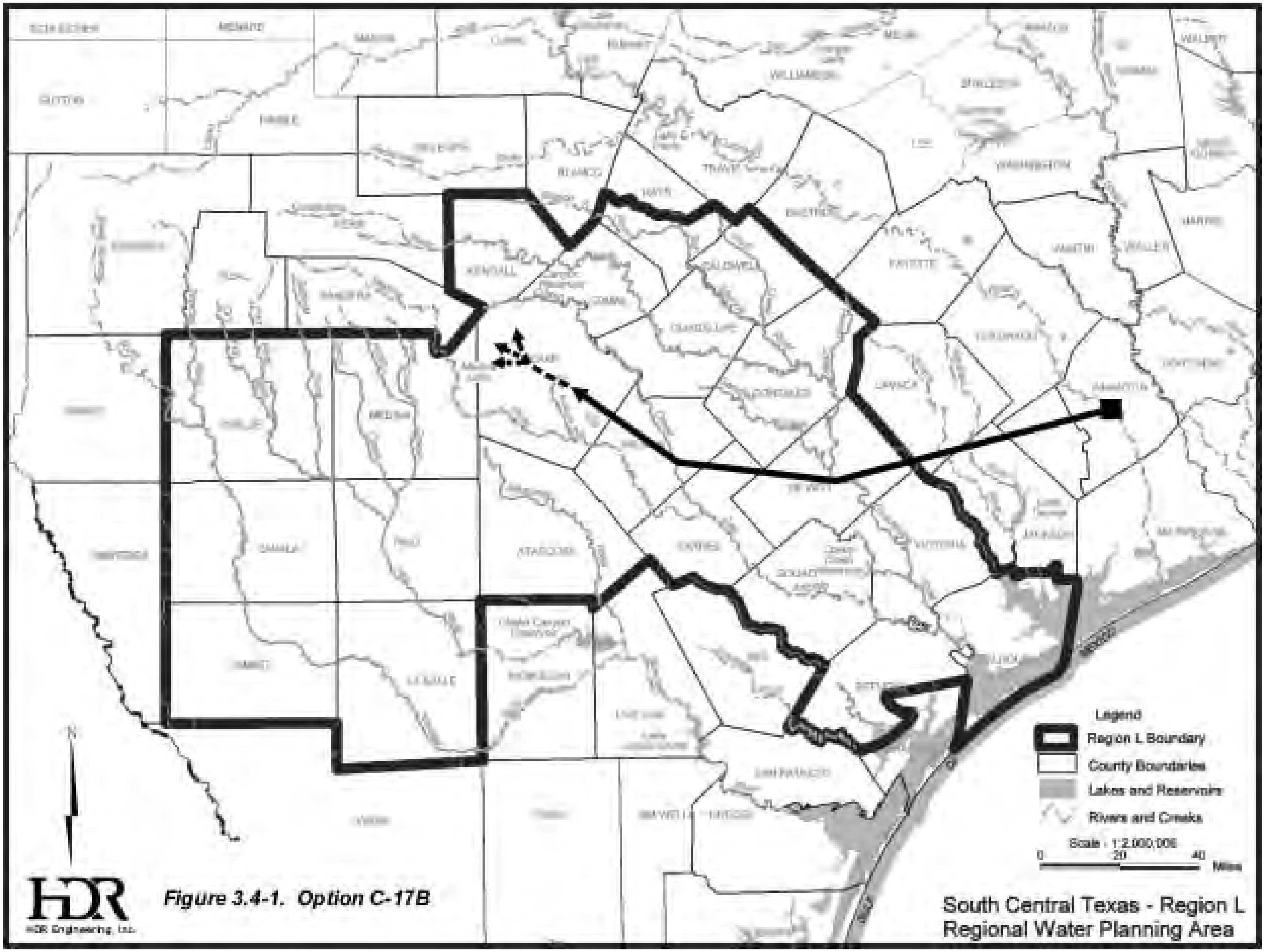


Figure 3.4-1. Option C-17B

Table 3.4-1.
Summary of the Principal Water Rights in the
Lower Colorado River Basin below LCRA's Highland Lakes

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation[1]
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal
3	LCRA - Gulf Coast[2]	14-5476	12/01/1900	228,570	Irrigation
4	LCRA - Lakeside[2]	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch[2]	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403[3]	Municipal
9	City of Austin	14-5489	1945, 1965	36,456[4]	Industrial
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] Currently the use type of this right is for irrigation, but in this study it was assumed that it would be converted to a municipal pattern.
[2] These three water rights held by LCRA are subordinated to the 250,000 acft/yr municipal portion of the City of Austin's water right (no. 7).
[3] 22,403 acft/yr of this right are for municipal use; the balance is for steam-electric.
[4] These water rights are for steam-electric generation and cooling.

3.4.2 Water Potentially Available at Wharton

With the 1907 priority date, Pierce Ranch would have the right to divert those waters in the Colorado River, including those originating above the Highland Lakes, only after the LCRA-Garwood, Corpus Christi-Garwood, and LCRA's senior Gulf Coast and Lakeside water rights (nos. 3 and 4) are satisfied.

For the purposes of evaluating the water availability for this option it is assumed that the Pierce Ranch water right would be converted from agricultural to municipal use. It is also assumed that the LCRA will convert the recently purchased Garwood water right and their portion of the Pierce Ranch water right (no. 6) to a municipal demand pattern.

In order to evaluate water availability for the Pierce Ranch water right, the LCRA's RESPONSE model of the lower Colorado River was utilized. The RESPONSE model determines how much of the demands of downstream senior water rights can be satisfied from the run-of-river flows originating below the Highland Lakes. The run-of-river flows values for the Colorado River below the Highland Lakes needed by the RESPONSE model were derived by the former Texas Department of Water Resources (TDWR).[2] The flows above the Highland Lakes were derived by the former Texas Water Commission (TWC).[3] The period of record of these flows is from 1941 to 1965 which covers the critical drought period of the mid-1950s in the Colorado River basin.

One of the critical variables in the RESPONSE model is the level of assumed return flows from the City of Austin's wastewater treatment plants. This can be a considerable input volume, especially during the critical drought period, and is important for supplying downstream water rights demands. As a result of the 1987 agreement between Austin and the LCRA, 256,000 acft/yr of the City's Certificate of Adjudication 14-5471 (nos. 7 in Table 3.4-1) is backed up by stored water in the Highland Lakes. Recent estimates of Austin's return flow percentages are in the range of 55 percent. In this analysis it is assumed that this would be reduced to 44 percent, a 20 percent reduction in return flow due to reuse initiatives. This gives a future return flow volume of 120,000 acft/yr at that point in time when the full 272,000 acft/yr of municipal rights are utilized (nos. 7 and 8).

To evaluate the water available to the Pierce Ranch water right for this option, two scenarios were evaluated with the RESPONSE model:

1. **1907 priority date and 200 cfs diversion rate with off-channel storage**. Although the Pierce Ranch water right is limited to 55,000 acft/yr, equivalent to 76.0 cfs on a continuous basis, the maximum instantaneous rate of diversion authorized in the permit (Certificate of Adjudication 14-5477A) is 400 cfs. Since the current pumping capacity at Pierce Ranch is approximately 200 cfs (397 acft/day), this diversion rate was utilized for as many days as necessary until the 55,000 acft yearly maximum is reached, if possible. Such a diversion strategy, because it would be in effect for only a portion of the year, would have to be combined with an off-channel storage reservoir. The off-channel storage would allow for a uniform delivery rate and more cost-effective pipeline delivery facilities on the outlet side.

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[2] Texas Department of Water Resources, *Present and Future Surface-Water Availability in the Colorado River Basin, Texas*, Report LP-60, June 1978.

[3] Dr. Quentin Martin, Lower Colorado River Authority, personal communication.

2. **1999 priority date, 200 cfs diversion rate with off-channel storage**. This scenario is the same as before, except it examines the effect that changing to a diversion with a 1999 priority would have.

The RESPONSE model found that with the 1907 priority date and the 200 cfs diversion rate, the Pierce Ranch water right could capture the full 55,000 acft in each year. The 55,000 acft yearly total was reached in 221 days on average, with a range of 139 to 362 days. The results of this scenario appear as the horizontal line at 55,000 acft in Figure 3.4-2.

In the second scenario the Pierce Ranch diversion rate was 200 cfs and the water right was assumed to have a 1999 priority date, last in the priority ordering sequence. Even with the 200 cfs diversion rate, the loss of priority date would have considerable impact on this water right's ability to divert from the Colorado River. As shown by the dashed line with round symbols on Figure 3.4-2, the minimum year water availability in the critical drought period falls to 14,060 acft/yr.[4] The average availability falls to 45,800 acft/yr as compared to 55,000 acft/yr under the 1907 priority date. In this scenario, for the years in which the 55,000 acft yearly total was reached, it took an average of 243 days to do so. As shown in Figure 3.4-2, there were 9 years in which the full 55,000 acft was not attained.

For both of these scenarios, the rate of diversion during the year would be highly variable. For instance, in a wet year with the 1907 priority date, only a portion of the year would be required to capture the full 55,000 acft. For the 1999 priority date scenario this is further amplified by a variable supply from year to year. In order to make efficient use of such a variable supply rate from the Colorado River, it is necessary to firm-up this water by combining it with a storage facility which can be filled at the variable input rate and deliver water to a potential user at a uniform rate out of the reservoir.

Also, in order to potentially provide additional water beyond the 55,000 acft/yr and to fill in gaps when Colorado River supply is unavailable, a well field was added to the analysis. It was estimated that up to 18 wells each supplying 1 mgd (1.55 cfs) could be accommodated within the confines of the Pierce Ranch property.

[4] The four critical drought years 1953 to 1956,with an average availability of 29,202 acft/yr, have a dominant influence on the necessary infrastructure to make this variable supply more dependable.

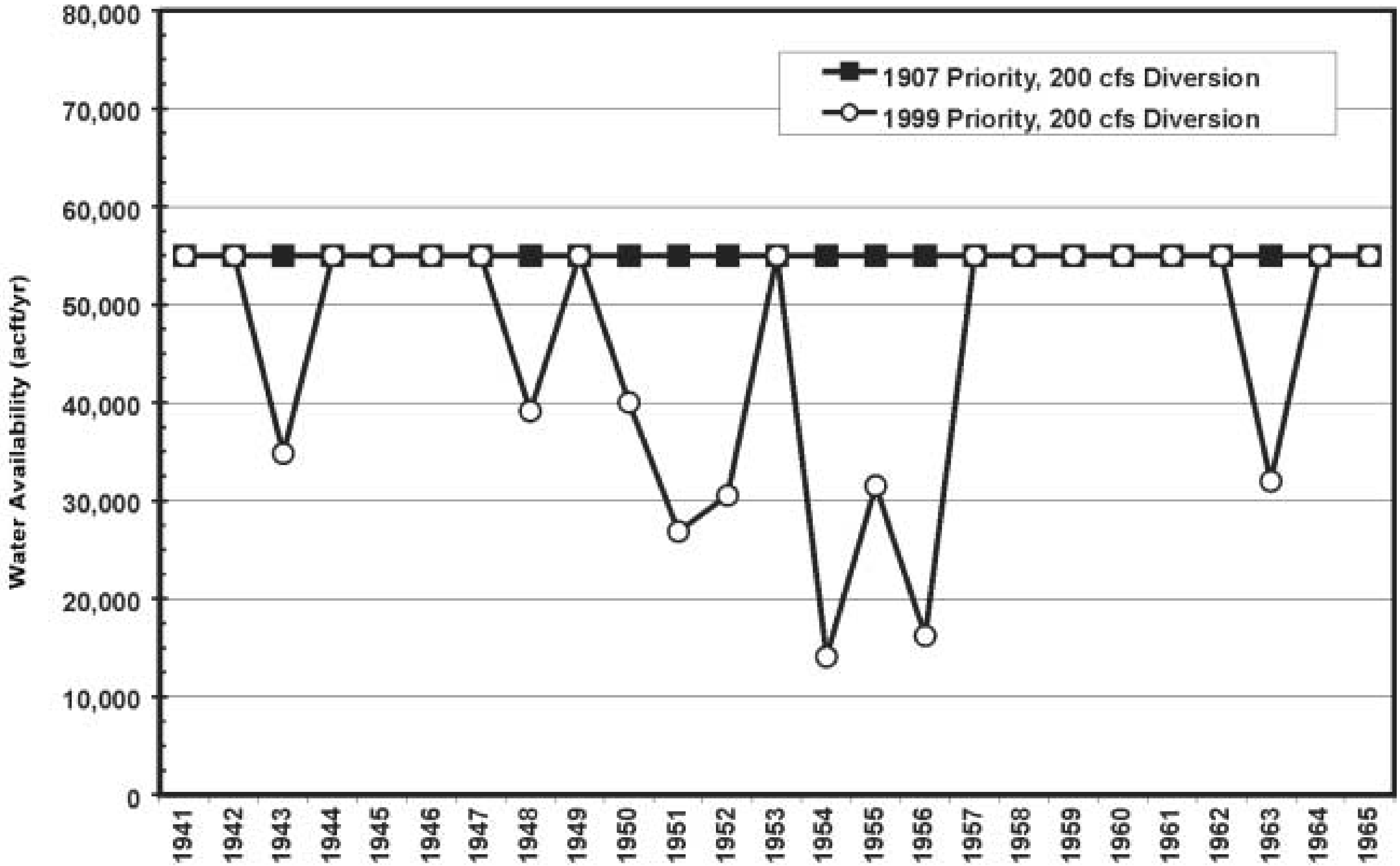

Figure 3.4-2. Comparison of Water Availability to Existing Water Right at Wharton

In order to find the necessary size for the off-channel reservoir, a spreadsheet program was developed to simulate the day-to-day operations of such a reservoir. The simulation was from 1941 to 1965, included evaporation, and started with the reservoir empty. The input to the off-channel reservoir was a combination of the highly variable available supply from the Colorado River predicted by the RESPONSE model (up to 200 cfs) and groundwater from a series of wells each providing 1.55 cfs. For the analysis, the groundwater wells were activated only when the storage content of the off-channel reservoir fell below 90 percent full. To avoid evaporative losses the groundwater was assumed to be pumped directly into the pipeline exiting the off-channel reservoir. The outlet rate of the off-channel reservoir was curtailed by the amount of groundwater being pumped such that the total water flow entering the transmission pipeline was a constant value $Q_{FY,}$ the firm yield of the reservoir-well field system. Several sizes of off-channel reservoirs and numbers of wells were simulated in order to try to provide the largest available supply and assess the optimal size.

Table 3.4-2 summarizes the results of these firm yield determinations. As shown in the upper portion of the table, if the source of water is just the Colorado River diversion (0 wells) with a 1907 priority date, the firm yield ranges from approximately 42,200 acft/yr with a 15,000 acft capacity reservoir to 54,400 acft/yr with the 25,000 acft reservoir. Larger reservoirs were not advantageous because of additional evaporation losses.

If 18 groundwater wells are added as a water source to the 1907 priority date surface water, the firm yields are increased to between 61,000 acft/yr to 69,000 acft/yr. Although the firm yield increased by approximately 6,000 acft/yr for the change from a 15,000 to 20,000 acft reservoir, the gain for the next increment in storage was only about 2,000 acft/yr. This indicates that reservoirs larger that the 25,000-acft capacity would provide little additional benefit in firm yield increase. Therefore, the combination of a 25,000-acft off-channel reservoir with 18 groundwater wells was used for further analysis.

The lower half of Table 3.4-2 summarizes the results for the use of Colorado River water if the priority date is changed to 1999. With no wells the firm yields fall to the 20,600 to 25,400 acft/yr range. However, with the groundwater wells in place, a maximum combined firm yield of about 44,700 acft/yr can still be obtained. Although the total firm yield with 18 wells increased by approximately 3,600 acft/yr for the change from a 15,000 to 20,000 acft reservoir, the gain for the next increment in storage was only about 1,600 acft/yr. This indicates that

Table 3.4-2.
Firm Yield of Various Off-Channel
Reservoir/Groundwater Well Field Combinations

off-channel storage (ac-ft)	***Firm yield (ac-ft)***			
	number of wells			
	0	***6***	***12***	***18***
1907 Priority Date for Colorado River Diversion				
15,000	42,226	48,529	54,636	60,989
supply from Colorado River	42,226	46,510	50,278	52,837
from groundwater	0	2,019	4,358	8,152
% groundwater	0.0%	4.2%	8.0%	13.4%
20,000	51,062	57,236	62,881	66,919
supply from Colorado River	51,062	53,678	54,231	54,187
from groundwater	0	3,558	8,650	12,732
% groundwater	0.0%	6.2%	13.8%	19.0%
25,000	54,382	59,687	64,241	69,021
supply from Colorado River	54,382	54,638	54,527	54,501
from groundwater	0	5,048	9,714	14,519
% groundwater	0.0%	8.5%	15.1%	21.0%
1999 Priority Date for Colorado River Diversion				
15,000	20,562	26,666	32,921	39,474
supply from Colorado River	20,562	24,025	27,215	30,367
from groundwater	0	2,641	5,706	9,107
% groundwater	0.0%	9.9%	17.3%	23.1%
20,000	23,884	30,268	36,664	43,087
supply from Colorado River	23,884	27,458	30,642	33,517
from groundwater	0	2,810	6,022	9,570
% groundwater	0.0%	9.3%	16.4%	22.2%
25,000	25,434	31,789	38,224	44,708
supply from Colorado River	25,434	29,045	32,224	35,064
from groundwater	0	2,744	6,000	9,644
% groundwater	0.0%	8.6%	15.7%	21.6%

reservoirs larger that the 20,000 acft capacity would provide little additional benefit in firm yield increase. Therefore, the combination of a 20,000 acft off-channel reservoir with 18 groundwater wells with a yield of 43,100 acft/yr was used for further analysis of the 1999 priority date scenario.

3.4.3. Environmental Issues

The option to divert water from the Colorado River near Wharton includes purchasing and existing run-of-river right and conveying the water to the major municipal demand center of the South Central Texas Region via an approximately 170-mile transmission pipeline. The off-channel reservoir lies within the Western Gulf Coastal Plain, while the pipeline transverses the Western Gulf Coastal Plain, East Central Texas Plain, and Texas Blackland Prairie.[5] Blair's regional classification[6] places the reservoir in the Texas biotic Province, a "broad ecotone" between western grasslands and eastern forests. Blair's biogeographical listing of wildlife fauna of this region, like the vegetation, is a mix of western grassland-associated and eastern forest-associated organisms. The reservoir is within the gulf Prairie vegetational area of Texas, while the pipeline also crosses the Post Oak Savannah and South Texas Plains[7] within the Tampaulipan biotic province.[8]

Post oak savannahs and tall grass prairies dominated by oaks, mesquites (*Prosopis glandulosa*), acacias, and prickly pears (*Opuntia spp*.) characterize the Gulf Prairie. This vegetation is supported by acidic clays and clay loams interspersed by sandy loams.[9] The Post Oak Savannah is characterized by gently rolling to hilly terrain, with an understory that is typically tall grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*).[10] Most of the Post Oak Savannah is composed of improved pastures and small farms. The South Texas Plains is mainly comprised of rangeland. The vegetation

[5] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77:118-125, 1987
[6] Blair, W. Frank, "The biotic Provinces of Texas," Texas Journal of Science 2(1): 93-117, 1950.
[7] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[8] Blair, W. Frank, Op. Cit., 1950.
[9] Gould, F.W., Op. Cit., 1975.
[10] Correll, D.S. and M.C. Johnston, "Manual of Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.

associated with this area has shifted from a grassland or savannah to shrubs characterized by mesquite, live oak (*Quercus virginiana*), acacia, and post oak.[11]

Plant and animal species as listed by the Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service (USFWS), and the Texas Organization for Endangered Species (TOES) that may be within the vicinity of the project are listed in Table 3.4-3. The Natural Heritage Program maps four species in close proximity to the pipeline route: Cagle's Map Turtle (*Graptemys caglei*), Texas Pink-Root (*Spigelia texana*), Crown Coreopsis (*Coreopsis nuecensis*), and Parks' Jointweed (*Polygonella parksii*).[12] These species are on watch list status, with the exception of Cagle's Map Turtle, which is a federal candidate for protection. Bird habitats are numerous within Wharton County and along the transmission pipeline and include the endangered Black-capped Vireo (*Vireo atricapillus*), Golden-cheeked Warbler (*Dendroica chrysoparia*), Attwater's Greater Prairie Chicken (*Tympanuchus cupido attwateri*), and Interior Least Tern (*Sterna antillarum athalassos*). These species inhabit shrublands, woodlands, and thick grass open prairies. Birds that may have habitat within the reservoir project area of Wharton County are the Bald Eagle (*Haliaeetus leucocephalus*), Eskimo Curlew (*Numenius borealis*), Whooping Crane (*Grus americana*), and Attwater's Greater Prairie Chicken.

Two mammals listed by all three organizations, the endangered Ocelot (*Felis pardalis*) and Jaguarundi (*Felis yagouaroudi*), occupy thick brushlands, dense chaparral thickets, mesquite-thorn scrub, and live oak motes. The Texas Garter Snake (*Thamnophis sirtalis annectens*) may be present in wetland habitats and grasslands. The Timber Rattlesnake (*Crotalus horridus*) is associated with dense bottomland woods. The threatened Texas horned lizard (*Phrynosoma cornutum*) and Smooth Green Snake (*Liochlorophis vernalis*) may be present in grassland areas and the Texas Tortoise (*Gopherus berlandieri*) in open brush with a grass understory. The endangered Houston Toad (*Bufo houstonensis*) lives in loamy, friable soils and ponds surrounded by forest or grass. For the counties potentially affected by this option (Bexar, DeWitt, Jackson, Karnes, Lavaca, Wilson, and Wharton), there are 12 endangered and 17 threatened species as listed by the USFWS or TPWD.

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[11] Gould, F.W., Op. Cit., 1975.
[12] Texas Parks and Wildlife Department, Texas Natural Heritage Program, Protected Resources Division, Austin, Texas, 1999.

Table 3.4-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Colorado River in Wharton County — Buy Irrigation Rights and Groundwater (C-17B)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	DL	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	DL	T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T-PDL	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Brown Pelican	*Pelecanus occidentalis*	Coastal islands for nesting, shallow areas for foraging	E	E	E	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils			NL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Eskimo Curlew	*Numenius borealis*	Grasslands, pastures, occasionally marshes and mudflats	E	E	E	Nesting/Migrant
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T	NL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident

Table 3.4-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn shrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T	NL	Nesting/Migrant
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays and coastal marshes		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]			NL	Resident

Table 3.4-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils, coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, Donovan S. and Marshall Johnston, "Manual of the Vascular Plants of Texas," University of Texas at Dallas, Austin, Texas, pp. 1201, 1979.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Federally Proposed Endangered or Threatened
DL/PDL = Federally Delisted/Proposed Delisted WL = Potentially Endangered/Threatened
Blank = Rare, but no regulatory listing status NL = Not Listed

Two fish species may be adversely affected within the Edwards Aquifer if water was used for recharge enhancement. The Toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) both inhabit the aquifer under the city of San Antonio. Both of these threatened species may incur negative impacts if the water quality of the aquifer is not maintained.

3.4.4 Engineering and Costing

There are several major facilities that would have to be constructed for this water supply option. These facilities and the estimated cost for them are itemized in Table 3.4-4. In the following discussion, the facilities information and costs are for the 1907 priority date which is capable of diverting the full 55,000 acft/yr from the Colorado River. Analogous data and cost for the case of a 1999 priority date are indicated in square brackets [ ] and also itemized in Table 3.4-4.

The river intake and large pumping station are necessary facilities for diverting water from the Colorado River. Also required is a low head channel dam for the pump intakes. A small dam already exists in the vicinity of Wharton and the assumption is made that this could be utilized here. The Colorado River water would be pumped from the river into the off-channel reservoir, a lift of approximately 50 feet. An existing pump station and intake structure could be modified such that a diversion rate of up to 200 cfs could be utilized, for a cost of approximately $1.85 million.[13] The other source of water for this option is a well field of 18 1-MGD wells. The estimated capital cost for this, which includes 3 backup wells and piping and transfer facilities to the off-channel reservoir, is $5.92 million.

The off-channel reservoir storage needed to blend and firm-up Colorado River water and groundwater would be 25,000 acft [20,000 acft] capacity. This very large ring-dike would cost $15.42 million [$13.98 million].

The largest capital expenditure, by far, would be for the approximately 170-mile pipeline which would deliver water from the off-channel reservoir at a uniform rate to the major municipal demand center as shown in Figure 3.4-1. The delivery rate would be approximately 95.2 cfs [61.7 cfs] or 69,000 acft/yr [43,100 acft/yr]. This would require a 64-inch [48-inch] diameter line with a capital cost of a little over $197.71 million [$120.34 million].

Associated with the pipeline are the initial reservoir transfer pump station and the booster pump stations along the length on the line. The reservoir transfer pump station and 3 [4] additional transmission stations are estimated to cost approximately $23.81 million [$23.64 million]. Another important capital cost is $75.65 million [$52.15 million] for distribution to the municipal distribution system or the Edwards Aquifer recharge zone. Land

[13] This is 50 percent of the cost of a new pump station and intake structure.

Table 3.4-4.
Cost Estimate Summary for Colorado River in Wharton County (C-17B)
Second Quarter 1999 Price

Item	Estimated Costs (1907 Priority Date)	Estimated Costs (1999 Priority Date)
Capital Costs		
River Intake and Pump Station Upgrade	$1,854,000	$1,854,000
Off-Channel Reservoir (25,000 [20,000] acft)	15,418,000	13,977,000
Water Treatment Plant[1] (62 [39] MGD)	43,843,000	29,012,000
Reservoir Transfer and Transmission Stations (4 [5])	23,814,000	23,635,000
Transmission Pipeline (170 mi., 64-inch [48-inch]	197,709,000	120,337,000
Well Field (18 wells @ 1 mgd)[2]	5,921,000	5,921,000
Distribution	75,650,000	52,151,000
Power Connection Cost ($125/HP)	3,685,000	3,142,000
Total Capital Cost	**$367,894,000**	**$250,029,000**
Engineering, Contingencies and Legal Costs	$117,410,000	$80,061,000
Environmental & Archaeology Studies, Mitigation, and Permitting	19,376,000	19,016,000
Pipeline Land Acquisition and Surveying (841 [837] acres)	8,065,000	7,999,000
Off-channel Reservoir Land and Survey. (1,389 {1,106] acres)	1,670,000	1,340,000
Well field Land and Survey (13,440 acres)	14,784,000	14,784,000
Water Right Purchase (1907 [1999] priority)	31,625,000	16,775,000
Interest During Construction (4 years)	89,732,000	62,400,000
Total Project Cost	**$650,556,000**	**$452,404,000**
Annual Costs		
Debt Service (6 percent for 30 years)	$45,239,000	$31,061,000
Debt Service (6 percent for 40 years)	1,850,000	1,652,000
O&M: Reservoir, Pipeline, Pump Station	3,001,000	2,095,000
O&M: Water Treatment Plant, Distribution System	6,050,000	3,787,000
Pumping Energy Costs (river & pipeline 175,555 [156,049] 1,000 kWh)	10,801,000	8,950,000
Pumping Energy Costs (groundwater, 4,568 [3,015] 1,000 kWh)	274,000	181,000
Total Annual Cost	**$67,215,000**	**$47,726,000**
Available Project Yield (acft/yr)	69,021	43,087
Total Annual Cost of Water ($ per acft) Treated Water Distributed[1]	$974	$1,108
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	$2.99	$3.40

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

acquisition and surveying for the off-channel reservoir and the pipeline right-of-way are \$1.68 million [\$1.34 million] and \$8.06 million [\$8.00 million], respectively.

The cost of the water right was estimated to depend upon the priority date of the water because this influences the water available from the Colorado River (see Section 3.4.2 above). The assumed value of the water right with a 1907 priority date is based on the 1992 sale of 35,000 acft/yr of the Garwood Irrigation Co. water right to the City of Corpus Christi for \$15.75 million, and the 1998 sale of the remaining 133,000 acft/yr to LCRA for \$75 million. These water rights can supply nearly the full amount authorized under any pumping scenario due to their seniority[14] (Table 3.4-1) Therefore, the unit cost of these recent purchases were approximately \$450/acft in 1992 and \$563/acft in 1998 dollars, respectively. For this option, the 1907 priority water right was valued at \$575 per acft of "firm" water in year 1999 dollars. Since the water right with 1907 priority could supply the full permit amount (Figure 3.4-3), the total value was estimated by multiplying \$575 by 55,000 acft/yr = \$31,625,000.

For 1999 priority water right, the off-channel reservoir simulations found that the decreased Colorado River water available in the four critical period years 1953 to 1956 were of overriding importance in that they dictate the total system yield, the size of the off-channel reservoir, pipeline cost, and the pumping and delivery cost. Therefore, the value of the water right with a current priority date was calculated as the ratio of the average water available from the Colorado River for these four years = 29,202 acft / 55,000 acft * \$575 = \$305/acft. This results in an estimated value of \$16,775,000.

With engineering, contingencies, legal costs, and other studies the total project cost would be \$650,556,000 [\$452,404,000].

Financing the non-reservoir portion of the project over 30 years at a 6 percent annual interest rate results in an annual cost of \$45,239,000 [\$31,061,000]. The reservoir and associated costs, financed at 6 percent for 40 years, are \$1,850,000 [\$1,652,000] annually. Operation and maintenance costs total \$9,051,000 annually [\$5,882,000]. Large annual costs are associated with the pumping of Colorado River water and groundwater to the off-channel reservoir and the subsequent transfer from Wharton County. The total amount of water diverted annually from the Colorado River, 55,000 acft/yr [average 33,500 acft/yr], was used to calculate the pumping cost

[14] HDR Engineering, "Dependability and Impact Analyses of Corpus Christi's Purchase of the Garwood Irrigation Company Water Right, Draft," September 1998

into the off-channel reservoir. These are added to the pumping cost for the conveyance of the combined Colorado River and groundwater. This was calculated with the total system firm yield of 69,000 acft/yr [43,100 acft/yr]. With nearly 700 feet of vertical lift and friction losses along the pipeline, the annual pumping cost are $10.801 million [$8.95 million]. Other pumping costs are associated with the groundwater, which must be pumped approximately 200 feet vertically from the Gulf Coast Aquifer. The average withdrawal for the 1941 to 1965 period, 14,520 acft/yr [9,570 acft/yr] was used to calculate the pumping cost of $274,000 [$181,000] for the groundwater.

The annual costs, including debt repayment, interest, raw water purchases, and operation and maintenance, total $67,215,000 [$47,726,000]. For an annual supply of 69,021 acft [43,087 acft], the resulting annual cost of water of is $974 per acft/yr [$1,108 per acft/yr] or $2.99 per 1,000 gallons [$3.40 per 1,000 gallons].

3.4.5 Implementation Issues

Implementation of Colorado River diversions under existing water rights made firm by groundwater from the Gulf Coast Aquifer could directly affect the feasibility of other water supply options under consideration, including S-15Dc, S-15Eb, C-13C, C-17A, C-18, SCTN-2b, SCTN-11, SCTN-12b, and/or SCTN-15.

An institutional arrangement is needed to implement projects potentially including financing on a regional basis.

Requirements Specific to Transfer of Existing Water Rights

1. Obtain TNRCC approval for amendments to the existing water rights to reflect:
   a. New type of water use.
   b. New diversion point.
   c. Interbasin transfer.
2. Water rights sales and contracts must be approved by the TNRCC.

Off-Channel Reservoir

1. Necessary permits for the off-channel storage reservoir could include:
   a. Texas Natural Resource Conservation Commission (TNRCC) Storage permit.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal review.

   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit
2. Permitting may require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoir could include:
   a. Utilities

Groundwater Well Field

1. Competition for groundwater in the area with others.
2. Potential regulations by local groundwater district which may form.
3. Insufficient technical data and information on the hydrogeology and environment to make a comprehensive determination on the effects of the pumping the Gulf Coast Aquifer for an extended period of time.

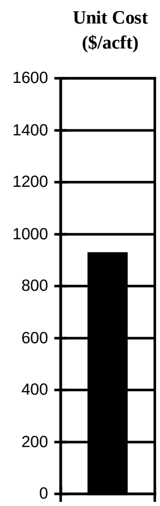
Requirements Specific to the Transmission Pipeline

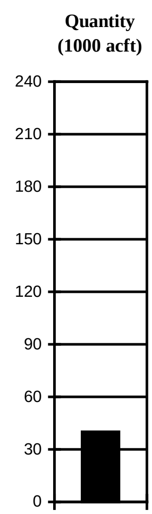
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. General Land Office (GLO) Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

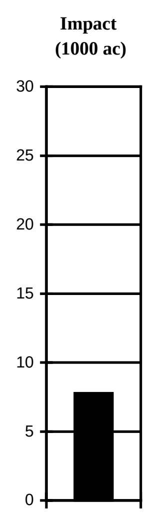
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/13/99







OPTION NUMBER: SCTN-11

OPTION NAME: Purchase/Lease Surface Water Irrigation Rights for Municipal/Industrial Use

OPTION DESCRIPTION: *In the Lower Guadalupe, Lower Colorado, and Lavaca River Basins, and the adjacent Brazos-Colorado, Colorado-Lavaca, and Lavaca-Guadalupe Coastal Basins, there are five large irrigation areas, supplied by run-of-river and stored surface water rights for irrigation use in excess of 1.0 million acft/yr. Most of these rights are for use in the production of rice, which is done with a two-crop per year system. Due to poor economic conditions regarding rice production, a part of these water rights is not used. Thus, a part of the unused irrigation surface water rights may be available for sale or lease for municipal and industrial use. In addition, quantities of currently used rights may be available.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**1,007 to $1,185**	**per acft Treated Water to Distribute**[1]
QUANTITY OF WATER:	**20,000 to 80,000**	**acft/yr**[2]
LAND IMPACTED:	**2,315-10,030**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** River intake(s), and pump station(s); off-channel reservoir(s); raw water pipeline(s) and transmission pump stations to water treatment plant; water treatment plant; and distribution to municipal system(s) or recharge zone.

[2]**QUANTITY OF WATER:** 20,000 to 40,000 acft/yr from Guadalupe River and 20,000 to 40,000 acft/yr from Colorado River for a range of 20,000 to 80,000 acft/yr combined.

[3]**LAND IMPACTED:** Water treatment plant site, pipeline right-of-way(s), off-channel reservoir(s), and transmission pump stations.

ENVIRONMENTAL ISSUES: Effects of off-channel reservoir(s) and pipeline route(s) on terrestrial habitats.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water and ability of the entities to develop a regional plan that realizes economies of size that benefits the participants.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Guadalupe River and Colorado River Basin water to the major municipal demand center of the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: C-13C, C-17A, C-17B, SCTN-12B, SCTN-14, and/or SCTN-16.

3.5 Purchase/Lease Surface Water Irrigation Rights for Municipal/Industrial Use (SCTN-11)

3.5.1 Description of Option

This water supply option involves the potential conversion of parts of surface water irrigation rights in the lower reaches of the Colorado and Guadalupe Rivers. Parts of these water rights, for the production of rice, are currently underutilized. Thus, a part or all of the unused rights may be available for sale or lease for municipal and industrial use. Additionally, some portion of currently used irrigation rights may also be available for sale or lease (e.g., Options C17A and C17B).

In this option, water from the Colorado River from converted irrigation rights would be diverted near Bay City, Texas and conveyed through a pipeline to the vicinity of the Guadalupe River Saltwater Barrier, as shown in Figure 3.5-1. At this point, this raw water supply could be combined with a similarly derived supply from converted irrigation water rights of the Guadalupe River Basin. This combined raw water supply could then be delivered via a large pipeline to the major municipal demand center of the South Central Texas Region. Treated water could then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone.

Because the transfer of water outside of the Colorado River or Guadalupe River basins would constitute an "interbasin" transfer, the water right(s) might take on a current (i.e., year 1999) priority date. However, this "interbasin" law is unclear with respect to a potential long-term lease arrangement for this water. In this option it has been assumed that any converted irrigation water rights would be assigned a junior (=1999) priority date.

3.5.2 Water Potentially Available

The major water rights of the lower Colorado River and Guadalupe River basins that are utilized for irrigation are shown in Table 3.5-1. As is evident, there are large portions of some rights that have been underutilized in recent years. Based upon this information, varying quantities of water that may be available from these underutilized water rights are considered for delivery. This is done in order to assess if there is a significant variation in the delivered water cost as a function of the quantity delivered and also to contrast the cost variation in Colorado River and Guadalupe River source locations.

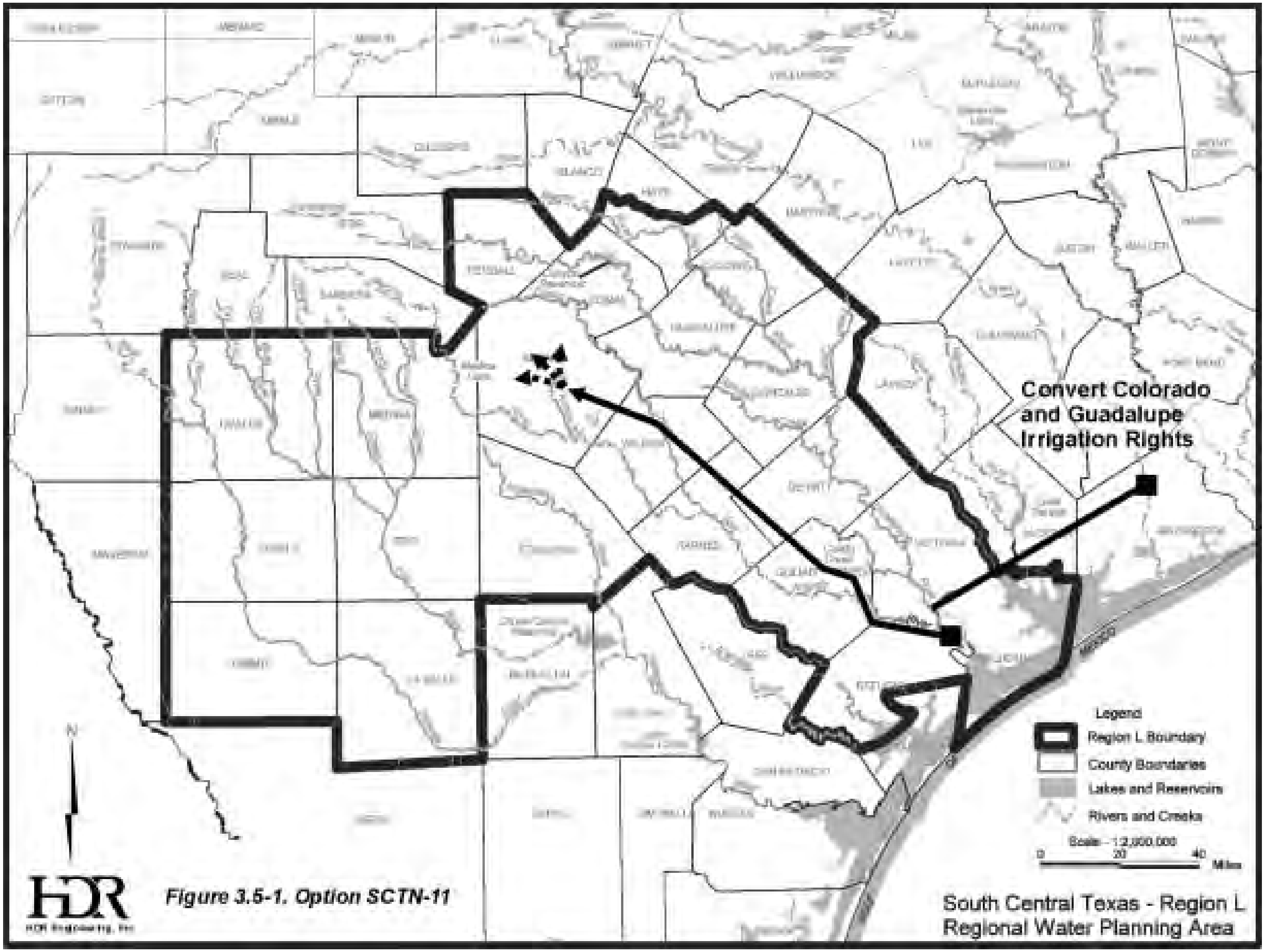


Figure 3.5-1. Option SCTN-11

Table 3.5-1.
List of Principal Irrigation Water Rights of the
Lower Colorado River and Guadalupe River Basins and Recent Use Statistics

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Reported Use (acft/yr)	Underutilized (acft/yr)
Colorado River Basin					**Average Use 1989 to 1998**	
1	LCRA – Garwood	14-5434A	11/01/1900	133,000	98,237	34,763
2	LCRA - Gulf Coast[1]	14-5476A	12/01/1900	262,500	145,217	117,283
3	LCRA - Lakeside[2]	14-5475	01/04/1901	131,250	132,914	—
4	Pierce Ranch	14-5477A	09/01/1907	55,000	38,970	16,030
5	LCRA - Pierce Ranch[3]	14-5477B	09/01/1907	55,000	0	55,000
	Colorado River Total	—	—	636,750	415,339	223,075
Guadalupe River Basin					**Average Use 1991 to 1997**	
6	GBRA - Calhoun Canal Diversion[4]	18-5178	01/07/1952	106,000	56,174	49,826

[1] 228,570 acft/yr of this water right have a December 1, 1900 priority; the remainder has a 1987 priority date.
[2] 52,500 acft/yr of this water right hold the January 4, 1901 priority; the remainder has a 1987 priority date.
[3] This water right was combined with 14-5475 in March 1997, but water use reports obtained from TNRCC continue to track 14-5475 separately.
[4] This water right is authorized for irrigation, municipal, and/or industrial use.

3.5.2.1 Part A — Colorado River Source

Table 3.5-1 shows that the two most-underutilized irrigation water rights in the Lower Colorado River Basin are LCRA-Gulf Coast and LCRA-Pierce Ranch (numbers 2 and 5 in Table 3.5-1). The underutilized portions total 172,283 acft/yr on average over the 1989 to 1998 period. For the purposes of this option, these two water rights were considered as the irrigation rights that could potentially be converted. For evaluations of this water supply option, it was assumed that 100,000 acft/yr of these two rights could be available for purchase or lease, and then converted to municipal use.

In order to evaluate water availability under these assumptions, the LCRA's RESPONSE model of the lower Colorado River was utilized. The RESPONSE model examines how much of the demands of downstream senior water rights below the Highland Lakes, in priority order, can be satisfied from the run-of-river flows originating downstream of the lakes. For a fuller discussion of this model procedure see Sections 3.3 and 3.4, (Options C-17A and C-17B). The

RESPONSE model can be operated to examine water availability of the competing water rights having differing assumed diversion patterns and/or priority dates.[1] The period of record of the model is from 1941 to 1965, which includes the critical drought period of the mid-1950s in the Colorado River Basin.

In this analysis, the 100,000 acft/yr of irrigation water right was considered to be comprised of pro-rated portions of the LCRA-Gulf Coast and LCRA-Pierce Ranch (nos. 2 and 5) (Table 3.5-1) water rights. Thus, the annual demands of these two irrigation water rights were reduced by pro-rated amounts to 181,896 acft/yr[2] and 35,604 acft/yr, respectively. The converted irrigation water right amount was then assigned to junior priority date status such that its demand would be satisfied last.

The RESPONSE model results are summarized in Figure 3.5-2, which shows the water available to this converted 100,000-acft/yr water right at several different diversion rates from the Colorado River on an annual basis. Generally, with the junior priority date, water is only available to this converted water right during short periods of two types: 1) in the fall and winter months when the demands of other more senior irrigation rights are zero or minimal,[3] and 2) periods of high river flow when other senior demands are met. In fact, the RESPONSE model showed that there were 49 months in the 1941 to 1965 period when no water at all would be available to this converted right. There were four years with four or more months with no water available, including five months in 1956 and 1963. Under these conditions, very large diversion facilities may be required in order to capture water when available to create a supply large enough to warrant development.

For example, if a 200 cfs diversion rate were utilized (requiring a 90-inch diameter diversion intake), the estimated water available to this 100,000 acft/yr converted irrigation water right would be 26,171 acft/yr on average for the 1941 to 1965 period, and only 6,999 acft/yr in

[1] A critical variable of the RESPONSE model is the level of return flows from the City of Austin's wastewater treatment plants. This can be a considerable input volume especially during the critical drought period and is important for supplying river flows to meet the demands of downstream water rights. In this option, Austin's return flow was set to 120,000 acft/yr as in other Colorado River options (C-13C, C-17A, C-17B).

[2] The LCRA-Gulf Coast water right is comprised of a 228,570-acft/yr authorization with a December 1901 priority date and a 33,930-acft/yr portion with a 1987 priority date. In this evaluation it has been assumed that the purchased or leased portion of this water right would be from the December 1901 priority date. With the pro-rated reduction, the senior portion of this water right becomes 147,966 acft/yr. The 1987 priority date portion is left unaltered.

[3] There is a strong seasonal concentration of the irrigation demand pattern; during the late spring through summer period (May 15 to September 15) 75 percent of the total irrigation demand is exercised.

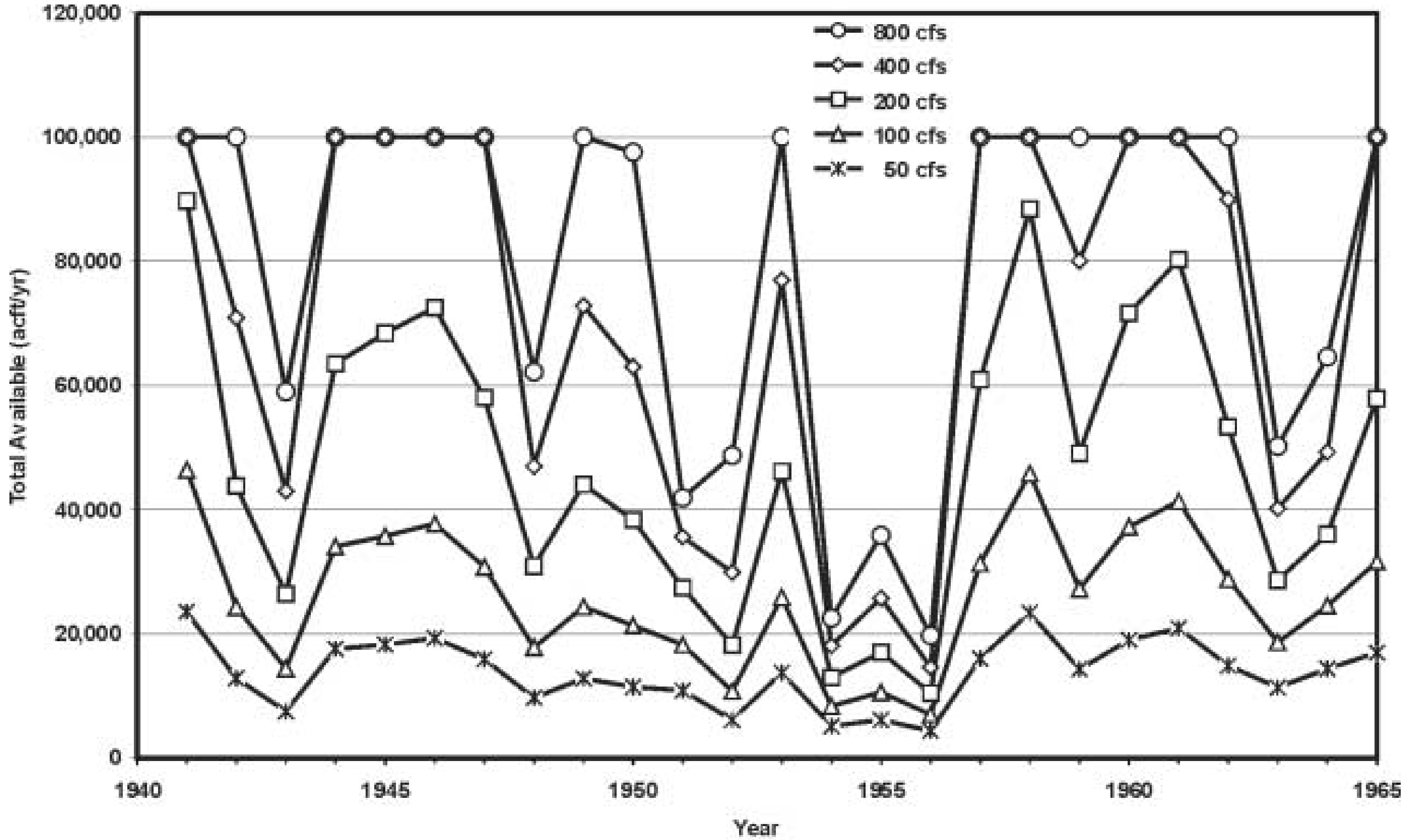


Figure 3.5-2. Water Availability to Converted 100,000 acft of Colorado River Irrigation Rights to Municipal Rights with Junior Priority

the minimum year. The low availability of water to this converted water right under this scenario is due to the loss of priority. Diversion rates up to 800 cfs (requiring two 10-foot diameter diversion intakes) were evaluated as shown on Figure 3.5-2. With the 800-cfs diversion rate the water availability would increase to 80,096 acft/yr on average and 19,278 acft/yr in the minimum year.

For any of these diversion facilities, the rate of diversion during the year would be highly variable. For instance, in a wet year with the 400-cfs diversion, only 126 days would be required to capture the full 100,000 acft of Colorado River water. Also, as mentioned above there, are many months of zero water availability. Because the delivery of the Colorado River water to the Guadalupe River Saltwater Barrier would be via an 81 mile long pipeline, it would be excessively costly to construct such a long, large diameter pipeline capable of delivering a high rate, but operating for a short period of the year. In order to lower the cost of obtaining such a variable supply from the Colorado River, it is necessary to provide storage with an off-channel storage facility which can be filled at the variable input rate available from river flows and then deliver water at a uniform rate from the reservoir.

In order to find the necessary size of storage facilities, the RESIM reservoir operation model program was used. RESIM determines the firm yield of a reservoir given a specified input source of monthly flows, the reservoir area-volumetric capacity relationship, and the local net evaporation record. It was assumed that water would be withdrawn from the off-channel reservoir with a uniform demand pattern. The simulation was from 1941 to 1965 and started with the reservoir full. The input to the off-channel reservoir was the highly variable supply from the Colorado River predicted by the RESPONSE model (up to 800 cfs). Several sizes of off-channel reservoirs were simulated in order to determine the least cost combination(s) of reservoir and Colorado River diversion facilities size to deliver various quantities of water to the Guadalupe River Saltwater Barrier.

Figure 3.5-3 summarizes the results of firm-yield determinations for the off-channel reservoirs with the 100,000 acft/yr converted irrigation right. For example, with the 400-cfs maximum diversion rate from the Colorado River, and a 20,000 acft size reservoir, the firm yield would be 25,280 acft/yr. If the off-channel reservoir storage were increased to 50,000 acft capacity, maintaining the 400-cfs maximum diversion rate, the firm yield would be 32,138 acft/yr. The trend of the curves on Figure 3.5-3 indicates that in order to capture large

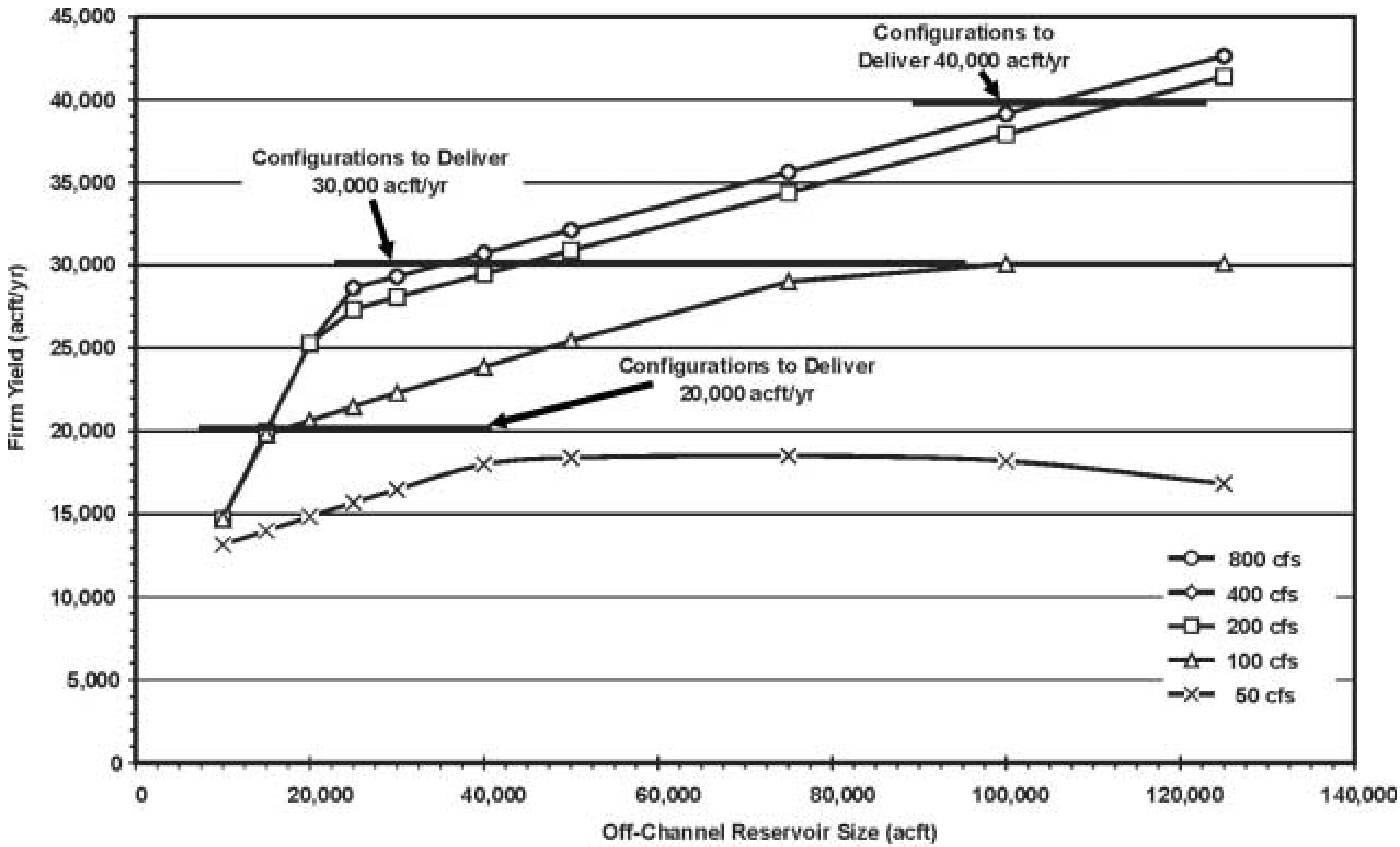


Figure 3.5-3. Firm Yield of Off-Channel Reservoirs Utilizing 100,000 acft/yr of Converted Colorado River Irrigation Water Rights, Various Diversion Rates

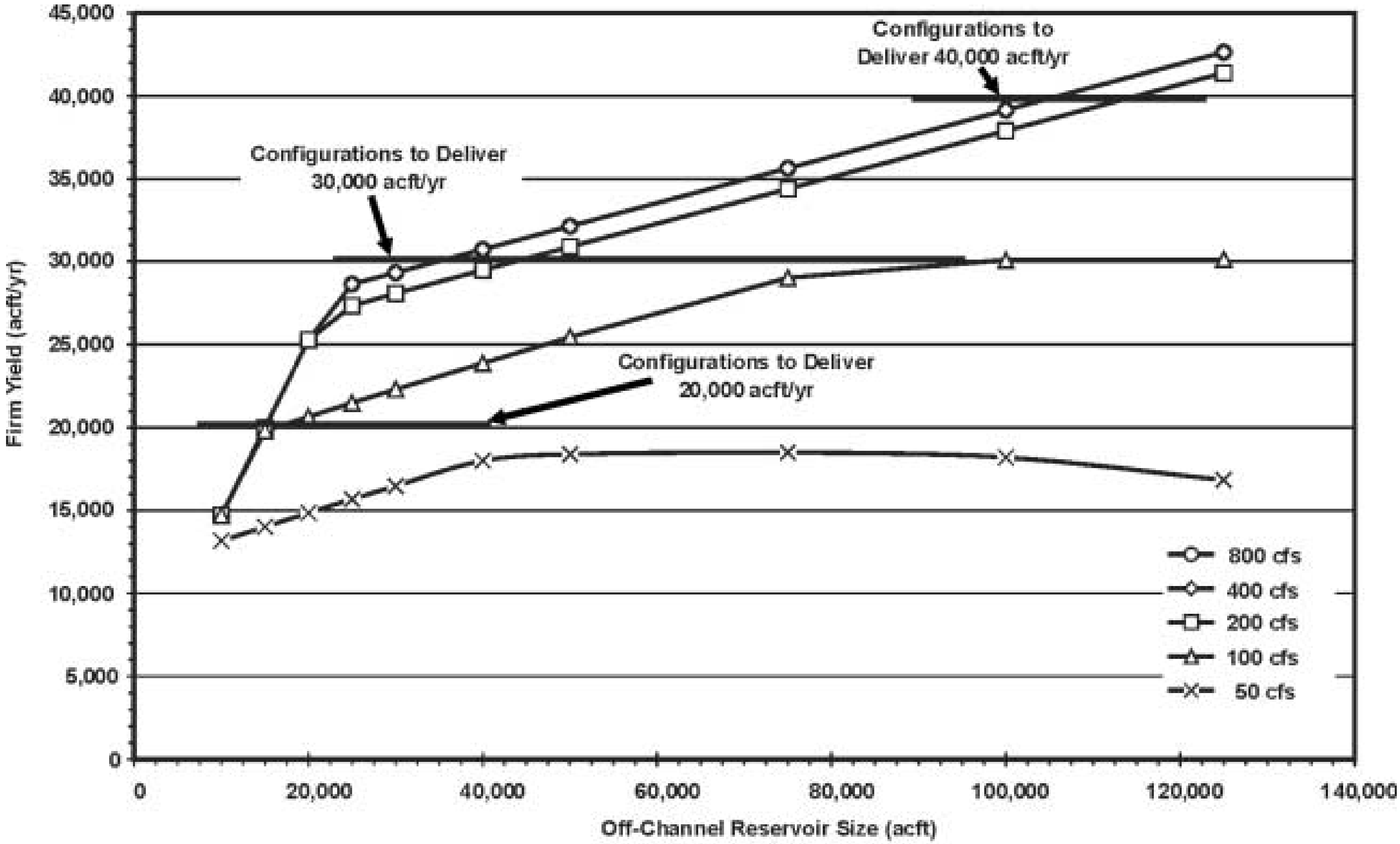


Figure 3.5-3. Firm Yield of Off-Channel Reservoirs Utilizing 100,000 acft/yr of Converted Colorado River Irrigation Water Rights, Various Diversion Rates

quantities of the available water from the Colorado River, large diversion rates and large off-channel storage facilities would be required. Another important result of Figure 3.5-3 is that diversion rates above 400 cfs are not warranted since the firm yields of the reservoirs with 400 or 800 cfs are virtually the same.

It is realized that some of the potential immense off-channel reservoir volumes evaluated here may not be feasible.[4] For instance a single 30,000-acft circular ring dike off-channel reservoir with a 20-foot embankment height (water depth of 17-feet) would be approximately 10,000 feet in diameter. However, in order to assess what would be needed to firm up the junior priority of the converted water rights these potential facilities are evaluated. Storage volumes greater than 30,000 acft would be comprised of combinations of smaller individual off-channel reservoirs.

In order to assess the cost of delivering a range of quantities of water to the Saltwater Barrier, the amounts 20,000; 30,000; and 40,000 acft/yr of firm water were selected for further analyses. As shown by the bold horizontal lines on Figure 3.5-3, there are multiple combinations of diversion rate/off-channel reservoir storage that would deliver 20,000; 30,000; or 40,000 acft/yr of firm water. In order to select which combination to use for each delivery amount (20,000; 30,000 and 40,000 acft/yr), a preliminary optimization was performed. The capital cost for each of these potential diversion rate/reservoir storage combinations was calculated in order to minimize the total cost. For delivering 40,000 acft/yr of firm yield water from converted irrigation water rights, a combination of an immense 105,000 acft size off-channel reservoir and a 400-cfs diversion facility had the least cost. For the 30,000 acft/yr of firm yield water delivery, a combination of a 35,000-acft off-channel reservoir and a 400-cfs diversion facility would have the least cost. For the 20,000-acft/yr case, 15,000 acft of off-channel storage and a 100-cfs diversion facility was most economical. More details are presented below on the cost of delivering this water to the Saltwater Barrier for potential combination with Guadalupe River source water. From there, these sources could be combined and delivered to the major municipal demand center for treatment and distribution.

[4] For comparison, the mainstem Colorado River reservoir known as Shaw's Bend discussed in Section 5.14 (Option C-18) would have a storage volume of 132,000 acft.

3.5.2.2 Part B —Guadalupe River Source

The GBRA Calhoun Canal water right (Table 3.5-1) on the Guadalupe River was assumed as the source of irrigation water which could potentially be converted to municipal and/or industrial use at the major municipal demand center. For this analysis it was assumed that 60,000 acft/yr of this water right could be converted. It was also assumed that the converted water right would take on a junior (=1999) priority date.

The water that would be available to this converted portion of the water right was determined with the Guadalupe-San Antonio River Basin Model[5] (GSA Model). The GBRA Calhoun Canal water right, which is currently senior to Canyon Lake, was evaluated as a junior right at the Guadalupe River Saltwater Barrier.

Figure 3.5-4 illustrates the results of the GSA Model predictions of water availability to this converted right at different diversion rates. For example, if a 100 cfs diversion rate were utilized (requiring a 64-inch diameter diversion intake), the estimated water available to this 60,000 acft/yr converted irrigation water right would be 57,498 acft/yr on average for the 1941 to 1965 period, and 19,887 acft/yr in the minimum year. Diversion rates up to 400 cfs (requiring a 10-foot diameter diversion intake) were evaluated. With the 400-cfs diversion rate the water availability would improve to 59,915 acft/yr on average and 55,214 acft/yr in the minimum year. These are however, yearly averages. The GSA Model found that with the junior priority date, there would be 40 months in the 1934 to 1989 period with no water available to this converted right. There were four years with four or more months with no water available, including 6 months in 1954 and 7 months in 1956. As with converted Colorado River irrigation rights, to make this highly variable supply firm it is necessary to utilize combined high diversion rates with off-channel reservoir storage.

As in the case of the Colorado River source, the RESIM reservoir operation model program was used. The simulations were from 1934 to 1989 and started with the reservoir full. The input to the off-channel reservoir was the highly variable supply from the Guadalupe River predicted by the GSA model (up to 400 cfs). Again, various combinations of reservoir sizes and river diversion facilities were simulated in order to determine the least cost combinations of

[5] HDR Engineering, Inc. (HDR), “Guadalupe-San Antonio River Basin Recharge Enhancement Study,” Edwards Underground Water District, September 1993.

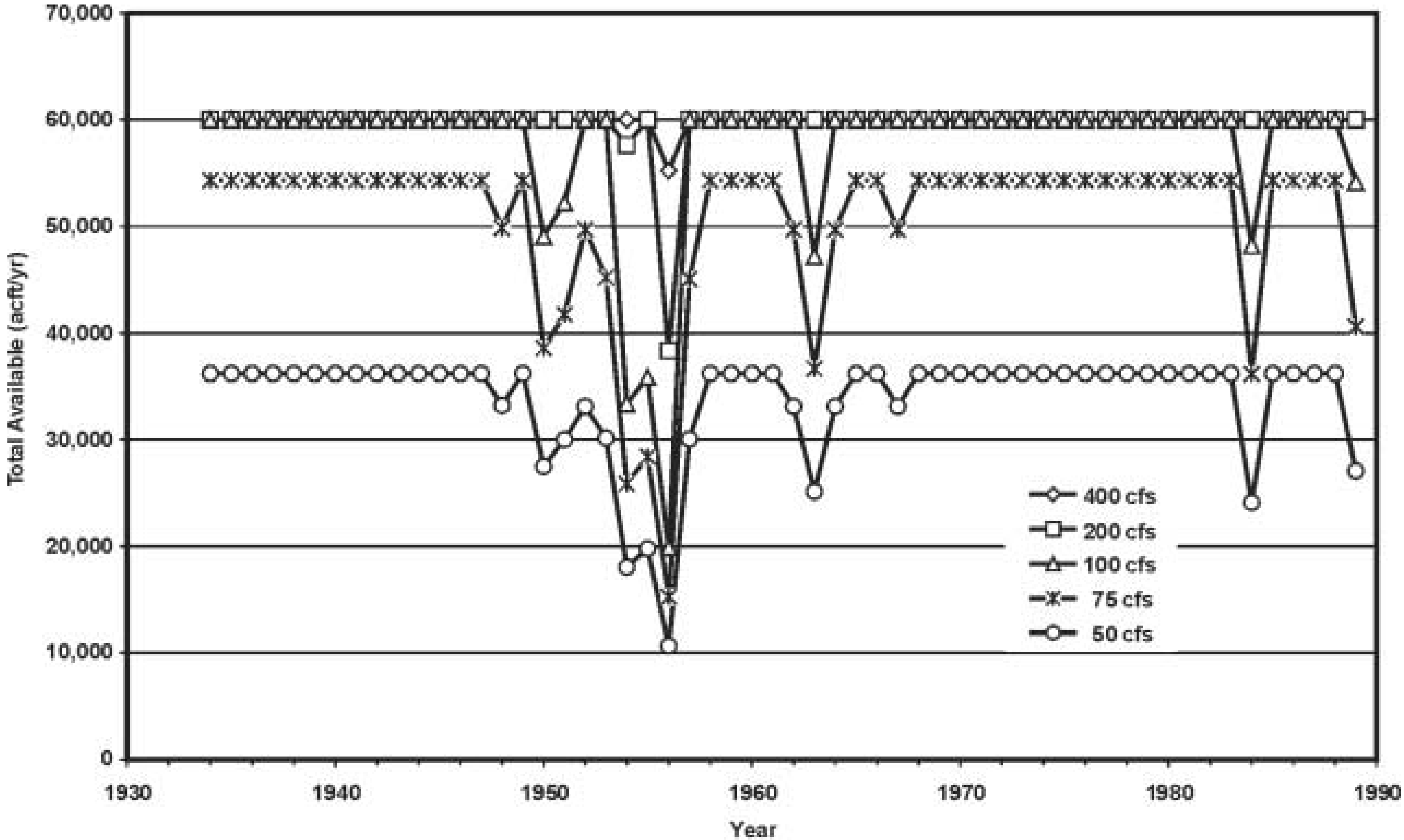


Figure 3.5-4. Water Availability to Converted 60,000 acft of Guadalupe River Irrigation Rights to Municipal Rights with Junior Priority

storage and diversion facilities sizes for various quantities of water to be delivered from the source.

Figure 3.5-5 shows the results of firm-yield determinations for the off-channel reservoirs with the converted irrigation right. For example, if a 100-cfs diversion rate is used in combination with a 10,000-acft off-channel reservoir, the firm yield would be approximately 15,000 acft/yr. With a 200-cfs diversion rate and 20,000 acft off-channel reservoir the firm yield would be approximately 28,000 acft/yr.

As was the case with the Colorado River source, it was desired to develop the costs for a range of quantities of water from the Guadalupe River. The firm yield amounts of 20,000; 30,000; and 40,000 acft/yr were also used here for further analysis. A preliminary cost minimization was performed in order to select diversion rate/off-channel reservoir storage combination to use for each delivery amount (20,000; 30,000; and 40,000 acft/yr). For delivering 40,000 acft/yr of firm yield water from converted Guadalupe River irrigation water rights, a combination of a 37,000 acft of off-channel storage reservoir and a 200 cfs diversion facility had the lowest cost. For the 30,000 acft/yr of firm yield water delivery, a combination of a 23,000-acft off-channel storage reservoir and a 200-cfs diversion facility had the lowest cost. For the 20,000-acft/yr case, 18,000 acft of off-channel storage and a 100-cfs diversion facility was most economical. More details are presented below on the cost of delivering and treating this water to the major municipal demand center.

3.5.3 Environmental Issues

The transmission line that would run from the Colorado River near Bay City to the Guadalupe River at the Saltwater Barrier traverses the Western Gulf Coastal Plain ecoregion, in the Gulf Coast Prairie and Marsh Vegetational Area within Blair's Texas biotic province.[6,7,8] The Texan Biotic province is a broad, ecologically transitional region (ecotone) between the Tamaulipan Province to the west and the Austroriparian province to the east. Because of its ecotonal nature, the Texan Province supports a mixture of plant and animal species characteristic

[6] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[7] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[8] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.

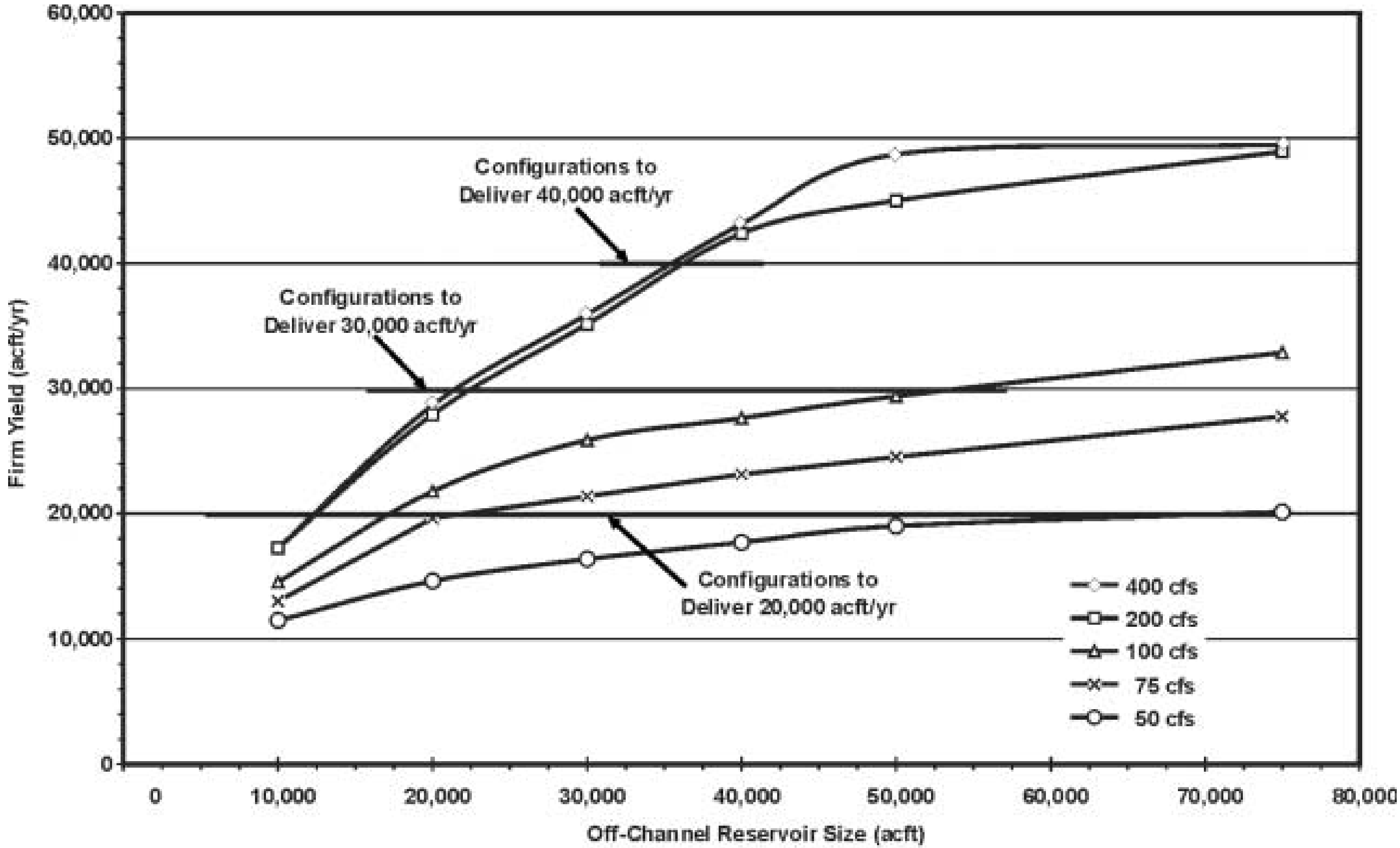


Figure 3.5-5. Firm Yield of Off-Channel Reservoirs Utilizing 60,000 acft/yr of Converted Guadalupe River Irrigation Water Rights — Various Diversion Rates

of the Tamaulipan and Austroriparian Provinces (Table 3.5-2). Rivers and associated riparian strips coursing through the Texas Province provide valuable habitat as well as corridors for migration.

The Gulf Prairies and Marshes Vegetational Area is a level, slowly drained plain lower than 150 ft-msl with numerous sluggish rivers, creeks, bayous, and sloughs. It is characterized by grasslands that support cattle ranching and farming. Woodlands tend to be concentrated near rivers, swamps, and freshwater marshes making them relatively uncommon and important habitat. Rainfall is higher along this coastal prairie compared to the South Texas Plain, and increases as one moves to the northeast. For example, Jackson County averages about 41 inches annually, whereas Wilson County on the South Texas Plain averages only 29.4 inches annually.[9]

The climax vegetation of the Gulf Prairies is considered to be tall grass prairie or post oak savannah. However, grazing practices and fire suppression have resulted in much of the area being invaded by trees and brush. Common species of the brushlands include mesquite (*Prosopis glandulosa*), oaks (especially live oak, *Quercus virginiana*), prickly pear cactus (*Opuntia spp*.), and several species of acacia. Prairie communities are dominated by species such as big bluestem (*Andropogon gerardi*), seacoast bluestem (*Schizachyrium scoparium var. littoralis*), Indian grass (*Sorghastrum avenaceum*) and gulf muhly (*Muhlenbergia capillaris*). Post oak savannah is generally dominated by little bluestem (*S. scoparium var. frequens*), Indian grass switchgrass (*Panicum virgatum*), and wintergrass (*Stipa leucotricha*), in addition to post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*).

Below Bay City, the Colorado River is tidally influenced (Segment 1401), and its aquatic community is characterized by more marine species. The river mouth has recently been relocated by the U.S. Army Corps of Engineers (USCE) so that it no longer discharges directly into the Gulf of Mexico, but into the eastern arm of Matagorda Bay, as it did prior to its rapid delta propagation some 64 years ago. This action is expected to increase Colorado River inflows to Matagorda Bay by about 30 percent (from an average of 1.2 to about 1.7 million acre feet per year), but hydrologic and modeling studies are still in progress.[10]

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[9] Griffiths, J. and J. Bryan, "The Climates of Texas Counties," Natural Fibers Information Center, The University of Texas in cooperation with Office of the State Climatologist, Texas A&M University, 1987.
[10] Texas Water Development Board (TWDB), Unpublished data, Bay and Estuaries Study Program, TWDB, Austin, Texas, 1990.

Table 3.5-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Purchase/Lease Surface Water Irrigation Rights for Municipal/Industrial Use (SCTN-11)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Coastal waters	E	E	E	Resident
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA	T	T	Resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Brown Pelican	*Pelecanus Occidentalis*	Coastal islands; shallow Gulf and bays	E	E	E	Resident
Coastal Gay-feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Resident
Eskimo Curlew	*Numenius borealis*	Coastal prairies	E	E	E	Migrant
Green Sea Turtle	*Chelonia mydas*	Gulf Coast	T	T	T	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T	NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Coastal waters; bays	E	E	E	Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Coastal and offshore waters	E	E	E	Resident
Loggerhead Sea Turtle	*Caretta caretta*	Coastal waters; bays	T	T	T	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Peregrine Falcon	*Falco peregrinus*	Open country, cliffs, occasionally cities[7]	E/SA	NL	NL	Migrant/Nesting
Piping Plover	*Charadrius melodus*	Beaches, flats	T	T	T	Resident
Plains Gumweed	*Grindelia oolepsis*	Early successional patches in coastal prairies on heavy clay soils			WL	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T	NL	Nesting/Migrant
Scarlet Snake	*Cemophora coccinea*	Sandy soils		T	WL	Resident

Table 3.5-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
Snowy Plover	*Charadrius alexandrus*	Beaches, flats, streamsides			NL	Winter resident
Sooty Tern	*Sterna fuscata*	Coastal islands for nesting; deep Gulf for foraging		T	WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays and coastal marshes		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils of remnant coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Upland pine and deciduous woodlands, sandy or clay soil; dense ground cover		T	T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
West Indian Manatee	*Trichechus manatus*	Warm, vegetated coastal waters	E	E	E	
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Mycteria americana*	Prairie ponds, shallow standing water; roosts in tall snags		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. pg 86.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Bald eagle (*Haliaeetus leucocephalus*) nesting areas and rookeries are found in the project area. The bald eagle is under regulatory status by TPWD and the USFWS as threatened. One of the nesting sites is located within the vicinity of the Navidad River and Lake Texana; the pipeline crosses the bottom third of the nesting habitat. The second bald eagle site encompasses elm bayou and green lake. The eastern and southern border of the breeding area coincides with the transmission line. There are two rookeries located at the southern edge of green lake:

directly on the route, and approximately half a mile away. Bald eagles nest in areas where the water is clear, with tall trees and cliffs available.[11]

The Texas Natural Heritage Program reports only one species directly on or adjacent to the pipeline corridor. The coastal gay-feather is located in Matagorda County directly on the transmission line route. It resides on grasslands of coastal prairie remnants supported by black clays. This vascular plant is on the TOES watchlist but not under regulatory status by either USFWS or TPWD. There are no reported occurrences of species within the proposed off-channel reservoir site near Bay City.

There are important regulated species that may occur in the study area but are not mapped by TNHP. Numerous bird species may be encountered including Attwater's greater prairie chicken and the Eskimo curlew which reside in the coastal prairies, and the brown pelican and interior least tern found around bays or large rivers. The ocelot (Matagorda County) and jaguarundi (Calhoun County) inhabit tracts of thick brushlands, mesquite-thorn scrublands and dense chaparral thickets. The ocelot avoids open areas whereas the jaguarundi favors a territory near water. Each of the above species is listed as endangered by all agencies.

Besides the occurrence of important species, the Guadalupe Delta wildlife management area lies within the project area north of the intersection of State Highways 35 and 113.

Several small creeks would be crossed by the proposed pipeline between the Colorado River and the Saltwater Barrier including Briar Creek, Garcitas Creek, Juanita Creek, Lunis Creek, East and West Carancahua Creek, Placedo Creek, Tree Creek and Venado Creek. Additionally, because woodlands in this area are often limited to the riparian strips associated with creeks and rivers, these riparian woodlands constitute an important habitat for many plant and animal species. A detailed environmental assessment to include wetlands delineation, an endangered species survey, habitat mapping and an inventory of the vegetation affected along the pipeline right-of-way would be needed prior to implementing the project. With respect to pipeline installation, significant impacts to environmental resources can often be avoided by careful selection of the pipeline easement.

[11] Oberholser, Harry C. and Kincaid, Edgar B. "The Bird Life of Texas" UT Press, Austin, Texas, 1974.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources.

Other major facilities for this water supply option would be required for the water to be diverted from the Guadalupe River near the Saltwater Barrier and the subsequent conveyance to the major municipal demand center of the South Central Texas region. The Environmental Issues associated with the diversion facilities, the off-channel reservoir, and transmission pipeline are discussed in Section 3.2.

3.5.4 Engineering and Costing[12]

For this option, there are two distinct sources of raw water: converted irrigation water rights from the Colorado River Basin and from the lower Guadalupe River Basin. In the case of the Colorado River source, the raw water would be delivered first to the Guadalupe River Saltwater Barrier area for possible combination with Guadalupe River source waters. These combined waters could then be transported to the major municipal demand center of the South Central Texas Region for treatment and distribution. Because of the use of two distinct sources of water with differing infrastructure needs, the costs of delivering and treating this water are presented in parts.

3.5.4.1 Part A — Colorado River Source to Guadalupe River Saltwater Barrier

There are several major facilities that would have to be constructed for this portion of this water supply option. Water from converted irrigation water rights of the lower Colorado River basin would be diverted near Bay City and delivered via an 81-mile pipeline to the vicinity of the Guadalupe River Saltwater Barrier. The facilities and estimated cost are itemized in Table 3.5-3 for delivering 20,000; 30,000; or 40,000 acft/yr of firm raw water to the Guadalupe River Saltwater Barrier. For brevity these will be referred to as 20k, 30k, and 40k deliveries.

[12] The analyses presented below do not include factors pertaining to interbasin transfers. These issues will be addressed in later phases of the regional planning effort, as needed.

Table 3.5-3.
Cost of Developing Various Quantities of Firm Water from Converted Colorado River Irrigation Water Rights and Delivering Raw Water to the Guadalupe River Saltwater Barrier

Item	*Deliver 40k*	*Deliver 30k*	*Deliver 20k*
Capital Costs			
River Intake and Pump Station (4,221; 4,221; 1,055 HP)	$6,086,000	$6,086,000	$2,046,000
Off-channel reservoir (105,000; 35,000; 15,000 acft)	63,267,000	26,579,000	12,601,000
Transmission Pump Station & Intake (3,262; 2,454; 1,505 HP)	5,167,000	4,164,000	2,763,000
Transmission Pipeline (54, 48, 42 in.; 81 miles)	61,972,000	54,363,000	47,459,000
Power Connection Costs ($125/HP)	935,000	834,000	320,000
Total Capital Cost	**$137,427,000**	**$92,026,000**	**$65,189,000**
Engineering, Contingencies, Legal Costs	44,391,000	$28,937,000	$20,187,000
Pipeline Land Acquisition and Surveying (398 acres)	3,775,000	3,775,000	3,775,000
Off-Channel Reservoir Land & Survey (6,368; 2,137; 918 acres)	7,005,000	2,350,000	1,010,000
Interest During Construction (4 years)	36,630,000	25,471,000	19,368,000
Environmental & Archaeology Studies, Mitigation and Permitting	8,401,000	4,170,000	2,951,000
Water Right Purchase (1999 priority)	27,937,000	27,937,000	27,937,000
Total Project Cost	**$265,566,000**	**$184,666,000**	**$140,417,000**
Annual Costs			
Debt Service (6 percent for 30 years)	$10,968,000	$10,014,000	$8,605,000
Debt Service (6 percent for 40 years)	7,616,000	3,112,000	1,460,000
Operation and Maintenance:			
Intake, Pipeline, Pump Station	924,000	821,000	603,000
Off-Channel Reservoir	949,000	399,000	189,000
Pumping Energy Costs (27.72; 18.24; 11.26 million kWh @ $0.06 per kWh)	1,483,000	1,094,000	676,000
Total Annual Cost	**21,940,000**	**15,440,000**	**11,533,000**
Available Project Yield (ac-ft/yr)	**40,000**	**30,000**	**20,000**
Annual Cost of Raw Water at the Saltwater Barrier ($ per acft)	**548.5**	**514.7**	**576.7**
Annual Cost of Raw Water at the Saltwater Barrier ($ per 1,000 gallons)	**$1.68**	**$1.58**	**$1.77**

Because of the multitude of cost figures for three delivery amounts presented in Table 3.5-3, only the largest items will be discussed specifically. The river intake and large pumping station capable of diverting up to 400 cfs in the 40k and 30k cases would cost approximately $6,086,000. For the 20k delivery a smaller 100-cfs pump station and intake would cost $2,046,000. At the Colorado River diversion site, it is assumed that an existing low head channel dam could be utilized to provide a pool for the pump intakes.

A large capital cost item for each delivery amount would be the off-channel storage reservoir storage facilities required. For the delivery of 40,000 acft/yr of firm water, an immense storage volume of 105,000 acft would be required. This cost, $63,267,000 is calculated as the sum of three 30,000 and one 15,000 acft reservoirs. The 30k delivery option would require 35,000 acft of storage costing $26,579,000. The 15,000-acft facility required for the 20k delivery would cost approximately $12,601,000.

Another very large capital expenditure would be for the approximately 81-mile transmission pipeline, shown in Figure 3.5-1. For the delivery of 40,000 acft/yr to the Guadalupe River Saltwater Barrier a 54-inch diameter line would be required, which would cost about $61.97 million. In the 30k and 20k cases, the pipelines would cost $54.36 million and $47.46 million, respectively (Table 3.5-3).

Another principal cost is the purchase of the 100,000 of irrigation water rights converted to municipal use, but with a loss of priority date to junior status. As in other water supply options involving Colorado River water rights, valuation of the water right is based on the recent sale of two of the major rights of Table 3.5-1. In 1992, 35,000 acft/yr of the Garwood Irrigation Co. water right was sold to the City of Corpus Christi for $15,750,000. In 1998, the remaining 133,000 acft/yr was sold to LCRA for $75 million. These water rights can supply nearly the full amount authorized under any pumping scenario due to their seniority. Therefore, the unit cost of these recent purchases were approximately $450/acft in 1992 and $563/acft in 1998 dollars, respectively, for "firm" water. In options using Colorado River water, a water right was thus valued at $575 per acft of "firm" water (see Option C-17A and C-17B).

For a 1999 priority water right, the off-channel reservoir simulations found that the decreased Colorado River water available in the four critical period years 1953 to 1956 were of overriding importance in that they dictate the total system yield, the size of the off-channel reservoir, pipeline cost, and the pumping and delivery cost. Therefore, the value of the water right with a 1999 priority date was calculated as the ratio of the average water available from the Colorado River for these four years to the full face amount of the water right (100,000 acft/yr).

Of course, as shown above, the amount of water that can be captured depends on the size of the diversion facilities used (Figure 3.5-2). To derive a value that is more or less independent of the facilities utilized, a near maximum potential diversion rate of 1,200-cfs (three 10ft diameter intakes) was evaluated. With this diversion rate the water available in these four critical years would average 48,586 acft. This leads to a value of 48,586 / 100,000 acft * $575 = $279.37/acft. The resulting cost for the 100,000 acft of irrigation water rights was thus estimated at $27,937,000.

The total annual costs, including debt repayment, interest, raw water purchases, and operation and maintenance, are estimated at $21,940,000 for the delivery of 40,000 acft/yr of converted irrigation water to the Guadalupe River Saltwater Barrier. This is equivalent to an annual cost of raw water of $549 per acft/yr, or $1.68 per 1,000 gallons. The solid line of Figure 3.5-6 shows the cost in $/acft of delivering the various quantities of raw Colorado River water to the Guadalupe River Saltwater Barrier. There is a slight minimum at $515 per acft at the 30,000-acft/yr delivery level.

3.5.4.2 Part B — Guadalupe River Converted Irrigation Rights at the Saltwater Barrier

There are several major facilities that would have to be constructed for this portion of this water supply option. The facilities and estimated cost are itemized in Table 3.5-4 for developing either 20,000; 30,000; or 40,000 acft/yr of firm raw water at a location near the Guadalupe River Saltwater Barrier (Table 3.5-4).

The river intake and large pumping station capable of diverting up to 200 cfs in the 40k and 30k cases would cost approximately $3,701,000. For the 20k delivery a smaller 100-cfs pump station and intake would cost $2,046,000. At the Guadalupe River diversion site, it is assumed that the existing Saltwater Barrier could be utilized to provide a pool for the pump intakes.

Large capital expenditures would be required for the off-channel storage reservoir facilities. For the delivery of 40,000 acft/yr of firm water a storage volume of 37,000 acft would be required. This cost, $27,129,000 is calculated as the sum of two 18,500-acft reservoirs. The 30k delivery option would require 23,000 acft of storage costing $14,841,000. The 18,000-acft facility required for the 20k delivery would cost approximately $13,427,000.

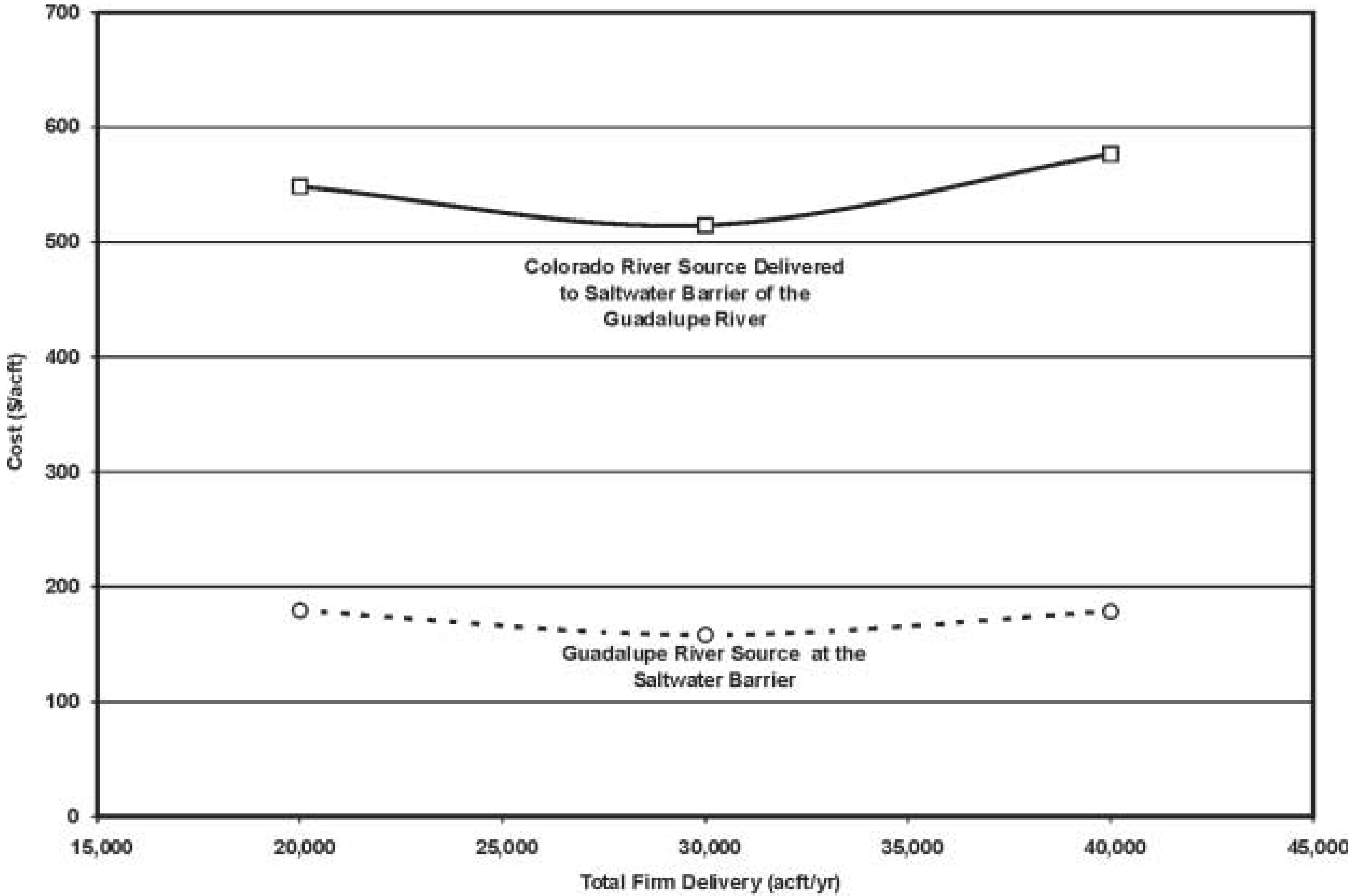


Figure 3.5-6. Unit Cost of Raw Water from Converted Irrigation Rights at Saltwater Barrier of the Guadalupe River

Table 3.5-4.
Cost of Developing Various Quantities of Firm Water from Converted Guadalupe River Irrigation Water Rights at the Guadalupe River Saltwater Barrier

Item	Deliver 40k	Deliver 30k	Deliver 20k
Capital Costs			
River Intake and Pump Station (2,110; 2,110; 1,055 HP)	$3,701,000	$3,701,000	$2,046,000
Off-channel reservoir (37,000; 23,000; 18,000 acft)	$27,129,000	$14,841,000	$13,427,000
Reservoir Pump & Intake Structure (330; 248; 165 HP)	$798,000	$798,000	$798,000
Transmission Pipeline	$0	$0	$0
Power Connection Costs ($125/HP)	$305,000	$295,000	$153,000
Total Capital Cost	**$31,933,000**	**$19,635,000**	**$16,424,000**
Engineering, Contingencies, Legal Costs	$10,936,000	$6,633,000	$5,598,000
Pipeline Land Acquisition and Surveying (2 acres)	$3,700	$3,700	$3,700
Off-Channel Reservoir Land & Survey (2,256; 1,398; 1,098 acres)	$2,482,000	$1,538,000	$1,208,000
Interest During Construction (4 years)	$7,618,457	$4,673,747	$3,893,473
Environmental & Archaeology Studies, Mitigation and Permitting	$2,260,000	$1,402,000	$1,102,000
Water Right Purchase (1999 priority)	$0	$0	$0
Total Project Cost	**$55,233,157**	**$33,885,447**	**$28,229,173**
Annual Costs			
Debt Service (6 percent for 30 years)	$527,000	$526,000	$329,000
Debt Service (6 percent for 40 years)	$3,189,000	$1,771,000	$1,575,000
Water Purchase	$2,767,000	$2,031,000	$1,393,000
Operation and Maintenance:			
Intake, Pipeline, Pump Station	$120,000	$120,000	$75,.000
Off-Channel Reservoir	$407,000	$223,000	$201,000
Pumping Energy Costs (6.156; 4.551; 2.996 million kWh @ $0.06 per kWh)	$369,000	$273,000	$186,000
Total Annual Cost	**7,379,000**	**4,944,000**	**3,759,000**
Available Project Yield (ac-ft/yr)	**40,000**	**30,000**	**20,000**
Annual Cost of Raw Water at the Saltwater Barrier ($ per acft)	**185**	**165**	**188**
Annual Cost of Raw Water at Saltwater Barrier ($ per 1,000 gallons)	**$0.57**	**$0.51**	**$0.58**

Another principal cost is the purchase of the water made available under the 60,000 acft of irrigation water rights converted to municipal use. Unlike the Colorado River basin, there is no recent sale of a major water right to act as a precedent for valuing such a sale. In this case the value of the water right was not calculated, but instead it is assumed that the water diverted would be purchased on an annual basis. The average quantity that would have been available for diversion over the 1934 to 1989 period was utilized and each was multiplied by the current price of $61 acft of raw water charged by GBRA. For example, in the 40,000-acft delivery case the average diversion from the river could have been 45,362 acft/yr. At $61 per acft this would have an annual cost of $2,767,000.

The total annual costs, including debt repayment, interest, raw water purchases, and operation and maintenance are estimated at $7,379,000 for the delivery of 40,000 acft/yr of converted irrigation water at the Guadalupe River Saltwater Barrier. This is equivalent to an annual cost of raw water of $185 per acft/yr, or $0.57 per 1,000 gallons (Table 3.5-4). The lower dashed line of Figure 3.5-6 shows these costs in $/acft of delivering the various quantities of firm raw Guadalupe River water at the Saltwater Barrier. There is a slight minimum of $165 per acft ($0.51 per 1,000 gallons) at the 30,000-acft/yr delivery level.

3.5.4.3 Part C —Delivery and Treatment Cost to Major Municipal Demand Center

Thus far the cost of these converted irrigation water rights sources have dealt with only raw water cost at the Guadalupe River Saltwater Barrier. It would be necessary to transport this water from one or both river sources to the major municipal demand center and treat it for further use. There are several major facilities that would have to be constructed in order to accomplish this.

The costs of this transport and treatment have been evaluated in other options (SCTN-16 and SCTN-17) and those results are utilized here. Figure 3.5-7 presents a cost curve constructed utilizing the unit cost for delivery of various quantities of raw water from the Guadalupe River Saltwater Barrier to the major municipal demand center of South Central Texas, and the subsequent treatment and distribution thereof. These costs were utilized to estimate the additional incremental cost of delivering varying amounts of the raw water derived from the Guadalupe River and/or the Colorado River.

Table 3.5-5 presents the overall results for delivering various quantities, from 20,000 acft/yr comprised of only Guadalupe River water, up to the maximum of 80,000 acft/yr

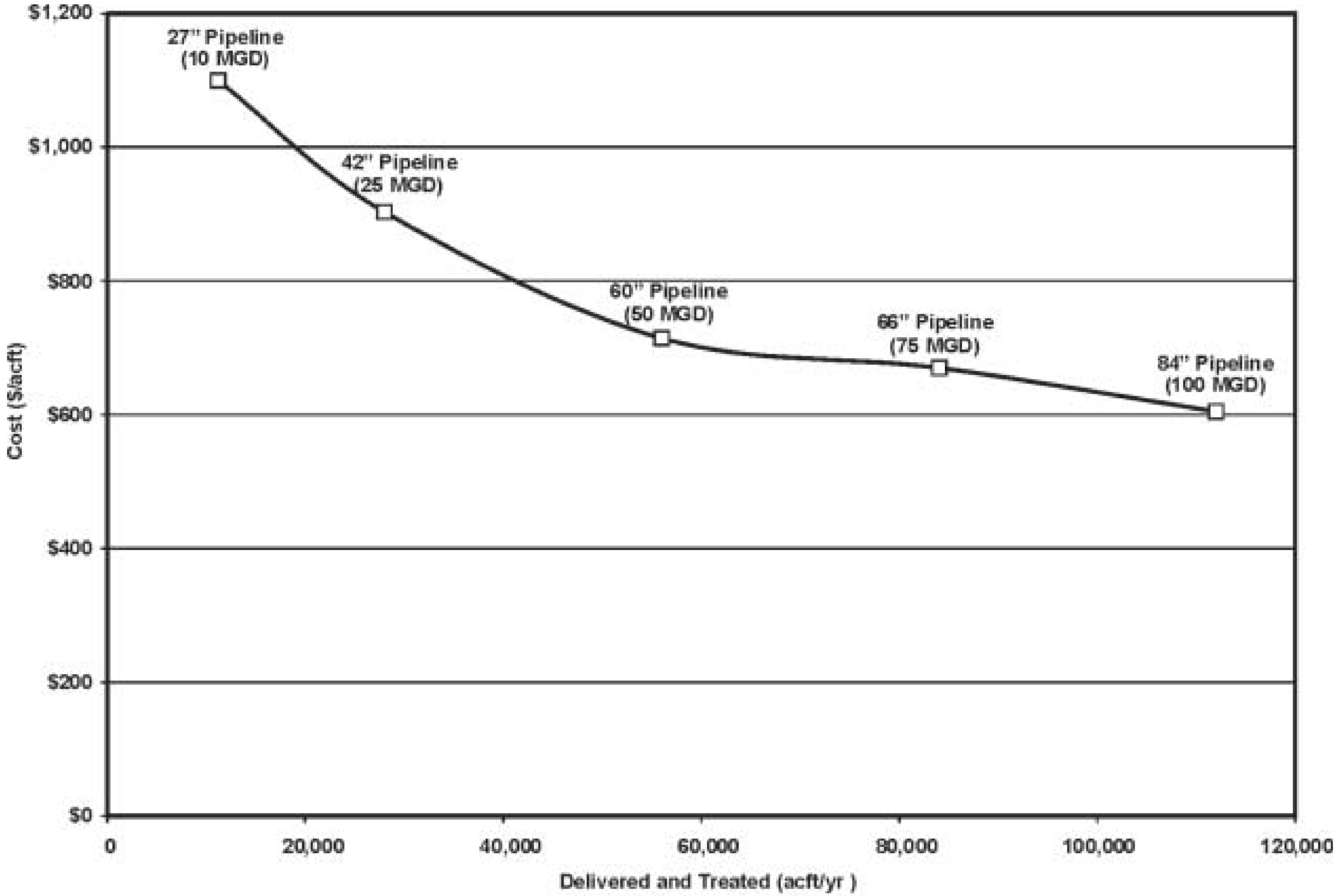


Figure 3.5-7. Unit Cost Curve for Delivery and Distribution of Treated Water Derived from Raw Water at Saltwater Barrier

Table 3.5-5.
Summary of Cost to Deliver and Treat Varying Amounts of Water form Converted Irrigation Rights

Item	Guadalupe River Source Only			Guadalupe River and Colorado River Source			
	Deliver 20k	Deliver 30k	Deliver 40k	Deliver 50k	Deliver 60k	Deliver 70k	Deliver 80k
Total Delivered to Demand Center (acft/yr)	20,000	30,000	40,000	50,000	60,000	70,000	80,000
Guadalupe River source	20,000	30,000	40,000	30,000	30,000	30,000	40,000
Colorado River source	0	0	0	20,000	30,000	40,000	40,000
Raw Water Cost							
Annual Cost - Guadalupe River source	$3,759,000	$4,944,000	$7,379,000	$4,944,000	$4,944,000	$4,944,000	$7,379,000
(See Table 3.5-4)							
Annual Cost - Colorado River source	$0	$0	$0	$11,533,000	$15,440,000	$21,940,000	$21,940,000
(See Table 3.5-3)							
Total Annual Cost	$3,759,000	$4,944,000	$7,379,000	$16,477,000	$20,384,000	$26,884,000	$29,319,000
Annual Cost ($ per acft)(A)	188.0	164.8	184.5	329.5	339.7	384.1	366.5
Treated Water Cost							
Cost of Delivery and Treatment to Major Municipal Demand Center ($ per acft)(B)	997.0	889.7	822.2	754.7	707.9	692.0	676.1
Total Annual Cost of Treated Water at Major Municipal Demand Center	$23,699,000	431,634,595	$40,267,698	$54,214,420	$62,856,168	$75,324,329	$83,410,194
($ per acft)(Sum of A & B)	1185	1054	1007	1084	1048	1076	1043
($ per 1000 gallons)	$3.64	$3.24	$3.09	$3.33	$3.22	$3.30	$3.20

made up of equal parts Guadalupe River and Colorado River sources. For the initial 20,000 acft/yr from the Guadalupe River converted irrigation water rights, the cost of treated water would be $1,185 per acft ($3.64 per 1,000 gallons) (Table 3.5-5). This decreases through the 40,000-acft/yr delivery, which is comprised of just Guadalupe River source water, to $1,007 per acft ($3.09 per 1,000 gallons) (Table 3.5-5)

For the next increment to 50,000 acft/yr, there is an increase in unit cost to $1,084 per acft because of the necessity of combining 20,000 acft/yr of raw water derived from the Colorado River source. From that point, the unit cost fluctuates only slightly. For the delivery of 80,000 acft/yr of water derived equally from converted irrigation water rights of the Guadalupe River and Colorado River Basins, the unit cost would be $1,043 per acft ($3.20 per 1,000 gallons).

3.5.5 Implementation Issues

Implementation of Purchase/Lease Surface Water Irrigation Rights for Municipal/ Industrial Use could directly affect the feasibility of other water supply options under consideration, including: C-13C; C-17A; C-17B; SCTN-12B; SCTN-14; and SCTN-16.

An institutional arrangement is needed to implement projects potentially including financing on a regional basis.

Requirements Specific to Transfer of Existing Water Rights

1. Obtain TNRCC approval for amendments to the existing water rights to reflect:
   a. New type of water use.
   b. New diversion point.
   c. Interbasin transfer.
2. Water rights sales and contracts must be recognized by the TNRCC.

Off-Channel Reservoir

1. Necessary permits for the off-channel storage reservoir could include:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal review.
   d. GLO Easement for use of state-owned land.
   e. TPWD Sand, Gravel, and Marl permit

2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoir could include:
   a. Highways and railroads
   b. Other utilities

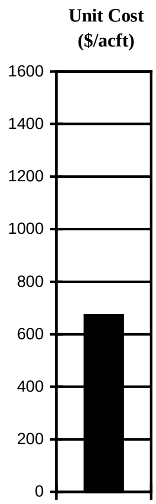
Requirements Specific to the Transmission Pipelines

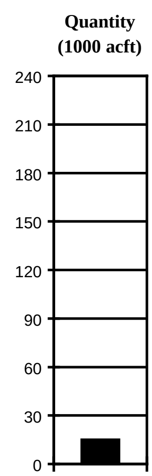
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities

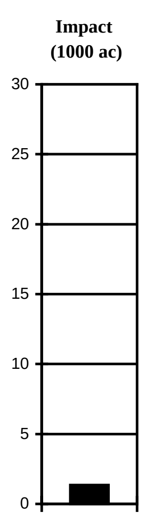
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 11/02/99







OPTION NUMBER: G-15C
OPTION NAME: Canyon Lake Water Released to Lake Nolte – Treated Water to Distribution System or Recharge Zone

OPTION DESCRIPTION: *Purchase 15,000 acft/yr uncommitted stored water from Canyon Lake and release to Lake Nolte. Pump at a uniform rate to water treatment plant at the major municipal demand center of the South Central Texas Region and distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$672**	**per acft**	**Treated Water Distributed**[1]
QUANTITY OF WATER:	**15,000**	**acft/yr**[2]	
LAND IMPACTED:	**151**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Reservoir intake and pump station, raw water pipeline and pump station, water treatment plant, finished water pipeline and pump station, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** Quantity of uncommitted Canyon Lake water available for sale.

[3]**LAND IMPACTED:** Pipeline right-of-way, water treatment plant, and transmission pump stations.

ENVIRONMENTAL ISSUES: Selection of pipeline routes to avoid habitats for endangered species, and cultural resources.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, and public acceptance of recharging the Edwards Aquifer with surface water, if to recharge zone.

ADDITIONAL FACTORS: Ability to obtain permits to use Canyon Lake water to recharge the Edwards Aquifer, if to recharge zone.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-24, G-38C, and/or SCTN-16.

4.1 Canyon Lake Released to Lake Nolte - Firm Yield (G-15C)

4.1.1 Description of Option

This water supply option considers the purchase of uncommitted stored water in Canyon Lake for delivery to the major municipal demand center in the South Central Texas Region, where treated water would either be delivered directly to water users or to the Edwards Aquifer recharge zone. Canyon Lake, the Lake Nolte diversion point, and the conveyance system to the major municipal demand center are shown in Figure 4.1-1.

Canyon Lake is located on the Guadalupe River in Comal County and is about 14 miles west of San Marcos and 12 miles northwest of New Braunfels. Construction of the water supply and flood control project was initiated by the U.S. Army Corps of Engineers in 1958, with deliberate impoundment of water beginning in 1964. The lake contains 382,000 acft of conservation storage; controls 1,432 square miles of drainage area; and inundates 8,231 acres at the full conservation storage level of 909 ft-msl. The conservation storage pool of Canyon Lake is owned and operated by the Guadalupe-Blanco River Authority (GBRA).

4.1.2 Available Yield

Current authorized diversions from Canyon Lake total 50,000 acft/yr pursuant to Certificate of Adjudication 18-2074 and contractual obligations held by GBRA. Authorized diversions from Canyon Lake will likely be increased in the near future as a result of GBRA's subordination of various downstream hydropower rights to Canyon Lake. GBRA has applied to TNRCC for a permit amendment to allow use of approximately 90,000 acft/yr of Canyon Lake water for municipal, industrial, and other purposes. Thus, the quantity of water of this option is expected to be available without affecting other Guadalupe River Basin water users during times of drought.

4.1.3 Environmental Issues

Option G-15C involves diversion of water that is currently uncommitted and subject to pending authorizations. This option would increase flows in the Guadalupe River between Canyon Dam and Lake Nolte. Below the proposed diversion, Guadalupe River flows would remain about the same, relative to the existing condition, and part of the diverted water would likely return to the system as treated wastewater flows in the San Antonio River or springflow

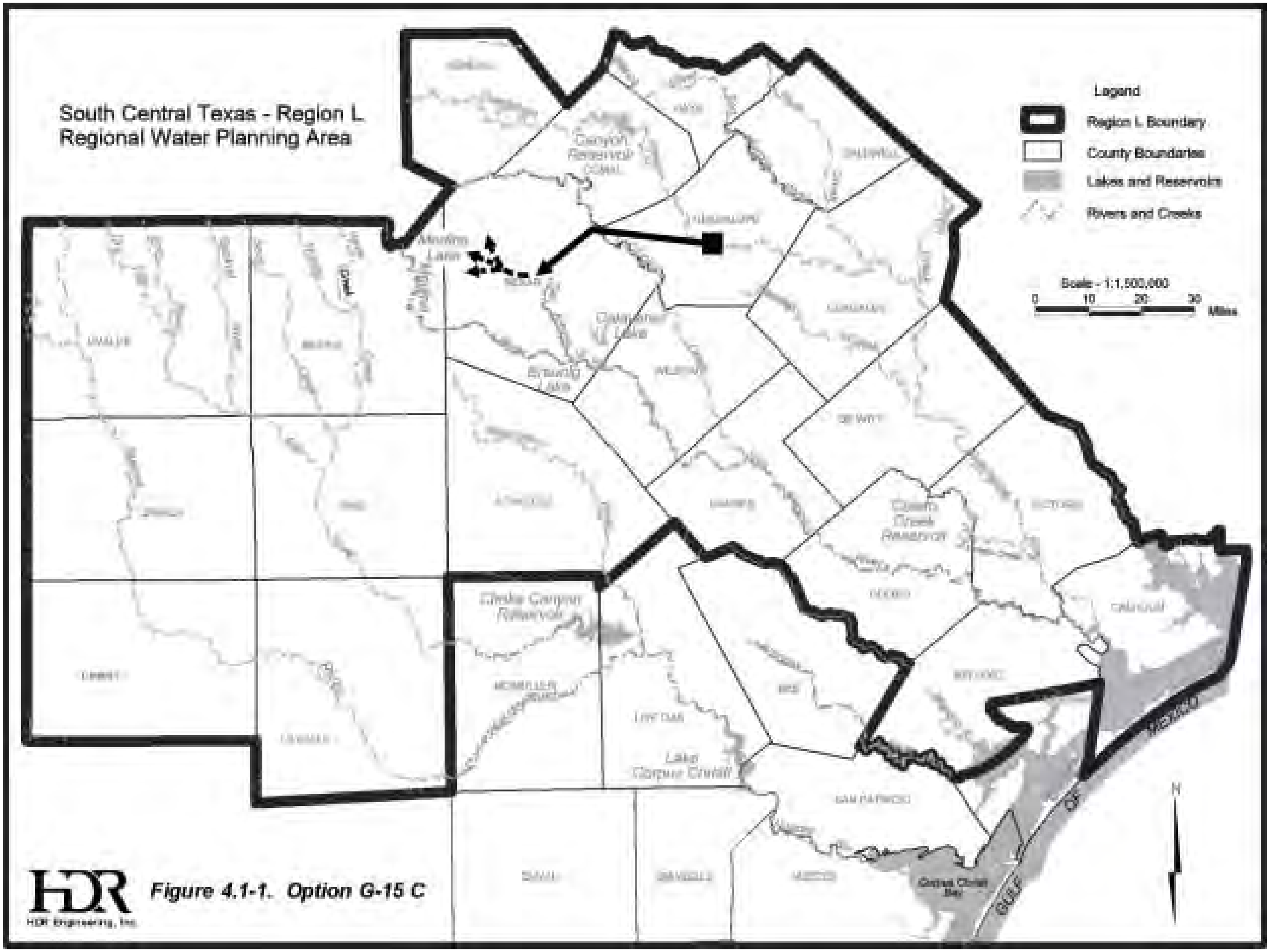


Figure 4.1-1. Option G-15 C

from the Edwards Aquifer. Water surface elevations in Canyon Lake would fluctuate somewhat more than at present with this alternative in place. However, this change would occur whenever this water is sold and diverted, regardless of the end user.

Construction of the 39-mile pipeline would impact a 100-foot corridor (473 acres) and a permanent right-of-way of 30 feet (142 acres). Land use in this area consists of pasture and cropland with urban areas around Universal City and San Antonio. Lake Nolte and the proposed pipeline lie within the Texas Blackland Prairies and Central Texas Plateau Ecoregions.[1] The vegetational area of the pipeline is Blackland Prairies,[2] which is characterized by clay soils mixed with sandy loams. The dominant vegetation is mesquite, post oak, bluestems, switchgrass and blackjack. Lake Nolte is found in Post Oak Savannah and also consists of clays and sandy loams that support tall grass prairies, hackberries, pecan, oak and hickory.[3]

Endangered, threatened and watch list plant and animal species listed by the Texas Parks and Wildlife Department (TPWD), the U.S. Fish & Wildlife Service (USFWS), and the Texas Organization for Endangered Species (TOES) for Guadalupe and Bexar Counties are presented in Table 4.1-1. While none have been reported around Lake Nolte, several protected bird species may have habitat in the vicinity of the transmission line. The endangered Black-capped Vireo (*Vireo atricapillus*) and Golden-cheeked Warbler (*Dendroica chrysoparia*) which occupy broad-leaved shrubland and woodland respectively will need to be assessed along the route and avoided. Karst features are also of concern and have been thoroughly assessed by the USFWS. Another species that may be of concern is Cagle's Map Turtle, which is found in the Guadalupe River Basin and is a federal candidate for protection. Glass Mountain Coral Root, Hill Country Wild-Mercury, and the South Texas Rushpea are vascular plants and of concern in woodland habitats. Many other species which appear to be dependent on the habitat within the project area include the threatened Texas Tortoise, Indigo Snake and Plains Spotted Skunk.

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[1] Omernik, J.M. 1897. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers. 77: 118-125.
[2] Gould, F.W. 1975. The Grasses of Texas. Texas A&M University Press. College Station, Texas.
[3] Nature and the Environment, Texas Natural Regions. Online. Texas Parks and Wildlife Department Homepage. Internet. September 9, 1997. www.tpwd.state.tx.us.

Table 4.1-1
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Canyon Lake Water Released to Lake Nolte (G-15C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Moist, seasonally wet clay or silt, creekbeds and seepage slopes.			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Cling to objects in streams; adults fly especially at night	E		NL	Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E		NL	Resident
Comal Springs Salamander	*Eurycea sp. 8*	Endemic; Comal Springs			NL	Resident
Correl's False Dragon-head	*Physostegia correllii*	Wet soils such as irrigation channels			WL	Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Fountain Darter	*Etheostoma fonticola*	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features found in north and northwest Bexar County	PE		NL	Resident
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers			NL	Nesting
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident

Table 4.1-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Lindheimer's Tickseed	*Desmodium lindheimeri*	Presumably flowers in mid-summer			WL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter, pupae cocoon in leaves fastened with silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; known from wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and plowed fields	PT		NL	Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Peck's Cave Amphipod	*Stygobromus pecki*	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on very shallow sandy or clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Warnock's Coral Root	*Hexalectris warnockii*	Oak-juniper woodlands in mountain canyons; terraces along creekbeds			NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Wood Stork	*Mycteria americana*	Prairie ponds, shallow standing water; roosts in tall snags		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

The Texas Natural Heritage Program includes three mapped species located in the vicinity of the pipeline. The Toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) have threatened status and habitat in the Edwards Aquifer under the City of San Antonio. This option may increase recharge to the aquifer, but as long as water quality is not affected, impacts on the blindcats are not expected. The only other mapped species, Big Red Sage (*Salvia penstemonoides*), is located along the pipeline route and found in moist or seasonally wet areas, especially creekbeds.[4] There is a rookery mapped in the San Antonio area in the region of the major municipal demand center that needs to be avoided.

Environmental and cultural resource issues are driven primarily by state and federal regulations that govern project construction and operation. Intake and transmission pipeline construction could include wetlands that are subject to the U.S. Army Corps of Engineers (USCE) jurisdiction under Section 404 of the Clean Water Act (33 USC 1344) regulating the discharge of dredged or fill material into the waters of the United States and Section 10 of the Rivers and Harbors Act of 1889 regulating structures in navigable waters of the United States. The Fort Worth District of the USCE has issued a regional permit to allow intake and utility backfill, which have insignificant impacts on wetlands and conform to conditions of a letter of permit.

These U.S. Army Corps of Engineers-administered permits require compliance with Section 106 of the Secretary of the Interior's Guidelines for Historic Preservation and the Endangered Species Act (16 USC 1531 *et seq*.). Compliance with the Antiquities Code is accomplished through consultation with the State Historic Preservation Officer (SHPO) at the Texas Historical Commission. Compliance with the Endangered Species Act is addressed in the application for the permit and in the District Engineer's consultation with the local U.S. Fish and Wildlife Service. The Texas Natural Resources Conservation Commission (TNRCC) has certified discharges authorized by the regional permit pursuant to Section 401 of the Clean Water Act. If an individual permit is required, TNRCC will consider the project individually.

The intake site and portions of the pipeline route are on Quaternary sediments and fluvial terraces adjacent to the Edwards Plateau in the Balcones fault zone. These are relatively recent deposits parallel to modern river and stream valleys composed predominantly of gravel,

[4] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

limestone, dolomite, and chert. Karst habitats are not present in these formations. The pipeline crosses localized Quaternary deposits of time transgressant terrigennous clastics deposited in river systems. These deposits are associated with a high potential for buried archeological features. These relatively recent formations outcrop locally along upland divides and in the estimated half mile the waterline route traverses the Guadalupe and Cibolo floodplains where potentially significant prehistoric sites may occur. Other areas along this pipeline route that may display a potential of impacting prehistoric sites are the minor creek crossings. Archival research has identified this route as one of the historically documented routes of the Old San Antonio Road; also known as the El Camino Real, generally along this route. Careful alignment selection may reduce the potential for historic impacts.

4.1.4 Engineering and Costing

For this option, water would be released at Canyon Dam and allowed to flow downstream to Lake Nolte below Sequin, where diversions in the amount of 15,000 acft/yr would be made in a uniform seasonal pattern. The major facilities required to implement this alternative are:

- Lake Nolte Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Raw Water Transmission Pump Station
- Water Treatment Plant
- Distribution

The reservoir intake and pump station is sized to deliver 1,250 acft/month (13 MGD) through a 30-inch diameter pipeline. The operating cost was determined for the total raw water delivery of 15,000 acft/year through a 39-mile transmission pipeline. Financing the project over 30 years at 6.0 percent annual interest rate results in an annual expense of $6,378,000 (Table 4.1-2). The annual cost of water purchased from GBRA is $61 per acft, resulting in a total payment of $915,000 per year for water. Operation and maintenance costs, including power and purchase of stored water, total $3,702,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $10,080,000. For an annual firm supply of 15,000 acft, the resulting annual cost of water is $672 per acft (Table 4.1-2).

Table 4.1-2
Cost Estimate Summary for
Canyon Lake Water Released to Lake Nolte (G-15C)
Second Quarter 1999 Prices

Item	Estimated Cost
Capital Costs	
Intake and Pump Station	$4,680,000
Water Treatment Plant (13 MGD)	13,300,000
Transmission Pump Station (1)	2,618,000
Transmission Pipeline (30 in dia., 39 miles)	24,602,000
Distribution	16,744,000
Total Capital Cost	**$61,944,000**
Engineering, Legal Costs and Contingencies	$20,085,000
Environmental & Archaeology Studies and Mitigation	996,000
Land Acquisition and Surveying (151 acres)	1,385,000
Interest During Construction (1 year)	3,377,000
Total Project Cost	**$87,787,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$6,378,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station, Distribution	505,000
Water Treatment Plant	1,199,000
Pumping Energy Costs (18,000,000 kWh @ $0.06 per kWh)	1,083,000
Purchase of Water (15,000 acft/yr @ $61.00 per acft)	915,000
Total Annual Cost	**$10,080,000**
Available Project Yield (acft/yr)	**15,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$672**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.06**

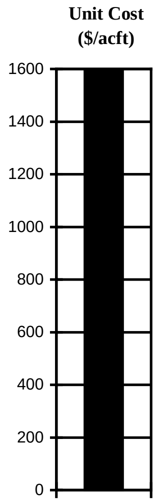
[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated, and distributed within the municipal distribution system or the Edwards Aquifer recharge zone.

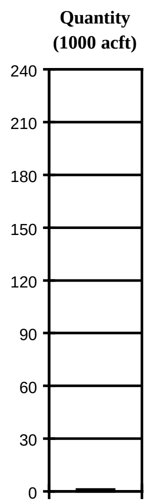
4.1.5 Implementation Issues

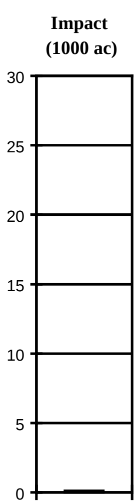
Implementation of contractual obligation of a portion of the firm yield of Canyon Lake as described in this option could directly affect the feasibility of other water supply options under consideration, including: G-24, G-38C, and/or SCTN-16.

1. Necessary permits:
   a. Receipt of requested amendment to Certificate of Adjudication #18-2074 (Canyon Lake) from the TNRCC.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   c. General Land Office (GLO) Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities
4. Financing:
   a. Sponsoring entity must be identified and be able to incur debt to finance project.
   b. Participating entities must negotiate water purchase contract with GBRA and establish rate structure.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET







OPTION NUMBER: **G-24**
OPTION NAME: **Wimberley and Woodcreek Water Supply from Canyon Reservoir; 2030 Demands**

OPTION DESCRIPTION: *A water treatment plant would be constructed near the south end of Canyon Reservoir to meet the projected 2030 demands, and a treated water pipeline would be constructed from the treatment plant a distance of approximately 23 miles north to the Wimberley and Woodcreek communities.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15 yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$1,595**	**per acft**[1]
QUANTITY OF WATER:	**1,048**	**acft/yr**[2]
LAND IMPACTED:	**119**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Reservoir intake and pump station, raw water pipeline to treatment plant, water treatment plant, clearwell, treated water pump station, finished water pipeline to Wimberley and Woodcreek, storage reservoir, and interconnects to retail water utilities.

[2]**QUANTITY OF WATER:** Adequate quantities of firm yield are available in the lake to meet the projected quantities of this option.

[3]**LAND IMPACTED:** Site for water treatment plant, storage tanks, and pipeline rights-of-way.

ENVIRONMENTAL ISSUES: Any resource conflicts can be avoided by careful selection of water treatment plant and storage tank sites, and pipeline routes. Construction can be scheduled to avoid nesting schedules of any threatened or endangered species.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Local experience with declining yields of wells in the underlying Trinity Group of Aquifers is driving local residents to consider development of additional water supplies. Cost of water.

ADDITIONAL FACTORS: Recognition by Wimberley and Woodcreek residents of the need to act in a timely manner.

4.2 Wimberley and Woodcreek Supply from Canyon Reservoir (G-24)

4.2.1 Description of Area with Projections of Population and Water Demand

The unincorporated communities of Wimberley and Woodcreek are located next to each other near the Blanco River, within the Guadalupe River Basin, in Hays County, about 12 air miles to the northeast of Canyon Reservoir (Figure 4.2-1). As in the case of subdivisions around Canyon Reservoir, water has been supplied by water supply corporations, with water obtained from wells drilled into the Trinity Aquifer, which is inadequate to meet all of the projected needs in the future. One potential source of additional water is Canyon Reservoir. This supply could be utilized by the construction of a pipeline that would bring water from a water treatment plant at Canyon Reservoir to the present water supply corporation systems (wholesale storage locations) for retail distribution through existing distribution systems.

The Texas Water Development Board's (TWDB) population and municipal water demand projections (most likely case, below normal rainfall and advanced water conservation) are presented in Table 4.2-1 for the Wimberley and Woodcreek communities. In 1990, the population of Wimberley was 2,520 and is projected to increase to 7,402 by 2050. The population of Woodcreek was 978 in 1990, with projections to 2050, of 1,120 people. The total population for these two neighboring communities was 3,498 in 1990, with projections of 8,522 by 2050.

In 1990, total water use in the Wimberley and Woodcreek communities was 914 acft, all of which was obtained from the Trinity Aquifer. For these two communities, TWDB projected water demands in 2030 are 1,048 acft, and in 2050 are 1,285 acft annually (Table 4.2-1). Since the Trinity Aquifer is not expected to be able to continue to yield the quantities needed to meet present and projected needs of the local area, this option has been identified as a potential way to provide water to these two communities. The option is sized and costed at the year 2030 projected demand of 1,048 acft/yr (Table 4.2-1).

4.2.2 Available Yield

The firm yield of Canyon Reservoir is defined to be the maximum amount of water the reservoir could have supplied through the drought of record after allowing for passage of inflows when required for senior (i.e., senior in time) downstream water rights. The drought of record for Canyon Reservoir covers a 116-month period of time that begins in July 1947 and ends in

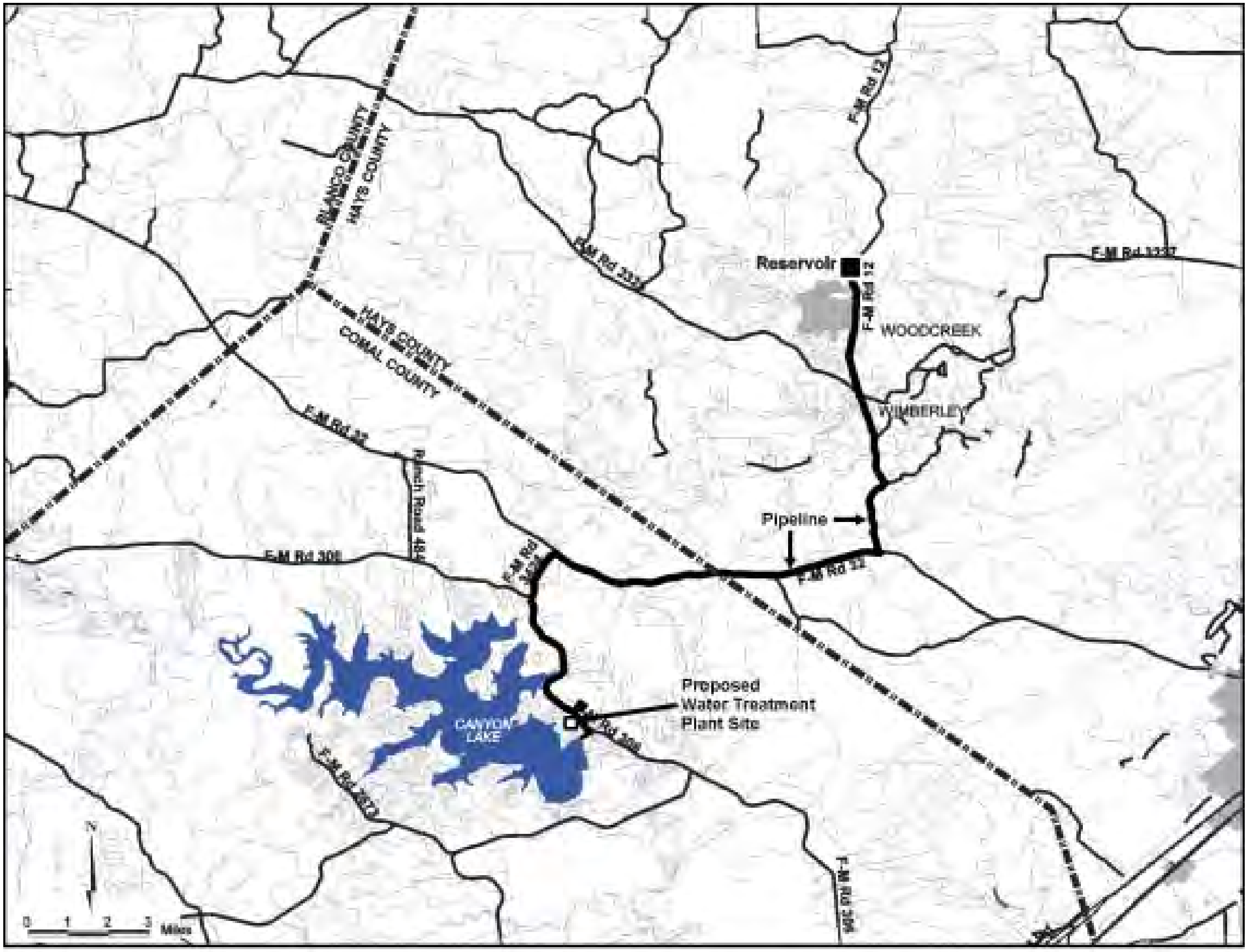


Figure 4.2-1. Wimberley and Woodcreek Water Supply from Canyon Reservoir

Table 4.2-1.
Population and Water Demand Projections
Wimberley and Woodcreek Areas of Hays County

Area/Projection	*1990 Actual*	*Projection Date*					
		2000	*2010*	*2020*	*2030*	*2040*	*2050*
Population [1]							
Wimberley	2,520	3,325	4,301	5,001	5,728	6,494	7,402
Woodcreek	978	1,000	1,021	1,022	1,044	1,082	1,120
Total	3,498	4,325	5,322	6,023	6,772	7,576	8,522
Water Demand (ac-ft) [2]							
Wimberley	732	615	732	790	898	1,004	1,128
Woodcreek	182	171	160	149	150	153	157
Total	914	786	892	939	1,048	1,157	1,285
Supply from Trinity Aquifer [3]	914	914	914	914	914	914	914
Shortage	0	0	0	25	134	243	371

[1] Texas Water Development Board; 1997 Consensus Water Plan, Most Likely Case, as revised January 21, 1999.
[2] Texas Water Development Board; 1997 Consensus Water Plan, Most Likely Case, below normal rainfall and advanced water conservation, as revised January 21, 1999.
[3] Assuming continued use of existing wells.

February 1957. Below Canyon Reservoir, there are senior water rights totaling more than 225,000 acft/yr that periodically require passage of lake inflows. When river flows originating below Canyon Reservoir exceed senior water rights requirements, inflows to the reservoir can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the base flow of the Guadalupe River and, consequently, provides water for a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights which have been subordinated to Canyon Reservoir. Subordination of hydroelectric rights means that inflows to Canyon Reservoir are not subject to being called upon to meet specified hydroelectric target flow rates downstream of Canyon Reservoir. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights demands must be met by passage of Canyon Reservoir inflows making less water available for storage.

The year 2030 and 2050 projected water demands for the Wimberley/Woodcreek area are 1,048 and 1,285 acft/yr, respectively. Once a pending amendment to Certificate of Adjudication #18-2074 is obtained from the Texas Natural Resource Conservation Commission (TNRCC), the uncommitted firm yield of Canyon Reservoir will be increased substantially. Therefore, the projected water demand for the area could be met with Canyon Reservoir yield provided a purchase contract is signed with GBRA. For conceptual design, costing, and environmental analysis, the treatment and distribution system is sized to meet the projected year 2030 demand of 1,048 acft/yr.

4.2.3 Environmental Issues

The environmental assessments of this report been developed by reference to existing information in published reports, maps, aerial photography, unpublished documents and communications from government agencies, individuals, and private organizations. These have been summarized to provide a general review level of the environmental disturbance that would be associated with the production of new water supplies. This general review and screening level discussion does not address secondary impacts.

Important species include the local dominant (most abundant) species, species having some economic or recreational importance, those exerting disproportionate habitat impacts (habitat formers) and species listed, or proposed for listing, by either the State of Texas or the federal government (protected species) or the Texas Organization for Endangered Species (TOES). The numerous unlisted species that are nevertheless of concern because of rarity, restricted distribution, direct exploitation or habitat vulnerability have not been included in the following discussions because the level of effort required to obtain the detailed distributional and life history information necessary to any meaningful evaluation is beyond that appropriate to a screening level survey.

4.2.3.1 Environmental Setting

Wimberley and Woodcreek communities are located about 12 miles northeast of Canyon Reservoir in Hays County on the Edwards Plateau. Wimberley and Woodcreek are located in a valley of the Blanco River at about 800 to 900 feet-mean sea level (Figure 4.2-1). Spring-fed Cypress Creek flows through the center of town. Large cypress trees line Cypress Creek and portion of the Blanco River. The scenic Wimberley area is a popular tourist destination. Both the Blanco River and Cypress Creek are heavily used recreational resources.

Land use in Wimberley and Woodcreek is rural residential, suburban residential and recreational. Most of the surrounding land use is rangeland. Although an alignment study has not been performed, this report assumes that the waterline right-of-ways will cross the Blanco River west of the FM 12 crossing avoiding the mature cypress banks and springs at Wimberley.

The Option G-24 study corridor consists primarily of live oak-ashe juniper savanna (46 percent) and mesquite invaded plateau live oak with midgrass series rangeland (48 percent). Developed areas total 5 percent and wetlands occupy less than 1 percent of the study corridor. There are relatively few streams, and perched ponds supply water for livestock. These mostly unnamed creeks are typically intermittent and similar to small creeks around Canyon Reservoir. Important water resources in the study corridor are the Blanco River, Cypress Creek and a multitude of associated Edwards Aquifer springs.[1,2,3,4]

Important species known to occur in Hays County and likely to have habitat within the study area are listed in Table 4.2-2. Although the species listed in the table do not necessarily occur at the specific local of the alternative water supply facilities, this is a list of species and their preferred habitats that would be investigated, along with others known to Comal and Hays Counties, or considered in a field survey program. In the case of migratory or transient species, the field survey would attempt to identify and evaluate habitat that may be attractive to these wandering species, such as the endangered Whooping Crane and threatened Zone-tailed Hawk.

The Golden-cheeked Warbler and Black-capped Vireo, both listed as endangered by the U.S. Fish and Wildlife Service (USFWS), are known to nest in Comal and Hays Counties in areas with appropriate habitat.[5] The Golden-cheeked Warbler and the Black-capped Vireo are upland woodland/brushland species. Endemic species such as the Texas salamander are known to occur in springs along the Blanco River drainage basin. Cagle's map turtle and the Guadalupe bass are found in the Blanco River and throughout the upper Guadalupe Basin.[6,7] The Texas

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[1] USFWS, National Wetland Inventory Map Series, Devils Backbone and Wimberley, Texas Quadrangles, USGS, 1991.

[2] Texas Parks and Wildlife Department (TPWD), Unpublished 1994, September 1994, Data and Map Files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[3] Gould, F.W., "Texas Plants; A Checklist And Ecological Summary," Texas A&M University, Texas Agricultural Experiment Station, MP-585/Rev., College Station, Texas, 1975.

[4] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas Including Cropland," TPWD, Austin, Texas, 1982.

[5] TPWD, Data and Map Files of the Natural Heritage Program, Resource Protection Division, Austin, Texas, Unpublished, September 1994

[6] Gary P. Garrett, "Guidelines for the Management of Guadalupe Bass," TPWD, Austin, Texas, 1991.

[7] Haynes, David and Ronald R. McKown, "A New Species of Map Turtle (Genus *Graptemys)* from the Guadalupe River System in Texas," Tulane Studies in Zoology and Botany, Vol.18, Num. 4. pp. 143-152, 1974.

Table 4.2-2.
Important Species Known to Occur in the Study Area[1]
Wimberley and Woodcreek Water Supply from Canyon Reservoir; 2030 Demands (G-24)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco Blind Salamander	*Eurycea robusta*	Troglobitic; Stream bed of the Blanco River		T	T	Resident
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River			NL	Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Cling to objects in streams; adults fly especially at night	E		NL	Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E		NL	Resident
Comal Springs Salamander	*Eurycea sp. 8*	Endemic; Comal Springs			NL	Resident
Dark Noseburn	*Tragia nigricans*				WL	Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Ezell's Cave Amphipod	*Stygobromus flagelloatus*	Known from artesian wells				Resident
Flint's Net-Spinning Caddisfly	*Cheumatopsyche flinti*	"a spring"				Resident
Fountain Darter	*Etheostoma fonticola*	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Glass Mountain Coral Root	*Hexalectris nitida*				NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Horseshoe Liptooth	*Polygyra hippocrepis*	Steep, wooded hillsides of Land Park in New Braunfels			NL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Lindheimer's Tickseed	*Desmodium lindheimeri*	Presumably flowers in mid-summer			WL	Resident
Peck's Cave Amphipod	*Stygobromus pecki*	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident

Table 4.2-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
San Marcos Gambusia extirpated)	*Gambusia georgei*	Endemic; upper San Marcos River	E	E	E	Resident
San Marcos Saddle-case Caddisfly	*Protoptila arca*	Swift; well-oxygenated warm water 1-2 m deep				Resident
San Marcos Salamander	*Eurycea nana*	Headwaters of the San Marcos River	T	T	T	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Sycamoreleaf Snowbell	*Styrax plantanifolius var platanifolius*				NL	Resident
Texas Amorpha	*Amorpha roemeriana*				NL	Resident
Texas Barberry	*Berberis swaseyi*				NL	Resident
Texas Blind Salamander	*Eurycea rathbuni*	Troglobitic; Caverns along 6 mile stretch of San Marcos Springs Fault	E	E	T	Resident
Texas Cave Shrimp	*Palamonetes antrorum*	Subterranean sluggish streams and pools				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Texas Wild-Rice	*Zizania texana*	Upper 2.5 km of the San Marcos River	E	E	E	Resident
Warnock's Coral Root	*Hexalectris warnockii*	Oak-juniper woodlands in mountain canyons; terraces along creekbeds			NL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL Potentially Endangered/Threatened Blank = Rare, but no regulatory listing status
NL = Not Listed

Horned Lizard is a denizen of open, well-drained habitats with sparse cover. The decline of Texas horned lizard populations is associated with the invasion of fireants (*Solenopsis invicta*), agricultural practices and urbanization, all of which are present in the Wimberley and Woodcreek areas.[8]

[8] Price, A., W. Donaldson, and J. Morse," Final Report as Required by the Endangered Species Act, Section 6, Texas Project No. E-1-4," Texas Parks and Wildlife Department, Austin, Texas. 1993

Two species of interest are the Blanco blind salamander and the hill country wild-mercury (*Argythamnia aphoroides*). The Blanco blind salamander is a troglobitic salamander found once in the Blanco River streambed. Other populations of this little known troglobitic may be present in the Blanco River Basin. The Hill Country wild-mercury, a plant, is listed in Hays County based on historic occurrence reports from before 1900.

4.2.3.2 Effects Assessment

The waterline to Wimberley and Woodcreek from Canyon Reservoir, assumed to mostly parallel existing roadways, would be about 23 miles long (Figure 4.2-1). The waterline would require a construction corridor of about 100 feet and a maintenance corridor of about 30 feet. Construction would involve the disturbance of soils and vegetation on up to 295 acres, and the long-term impacts of maintaining the right-of-way free of woody vegetation would affect about 90 acres, including the water plant site. One major stream crossing at the Blanco River would affect an estimated half acre of this lower perennial stream during construction and require about one-tenth acre permanent easement.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. The Texas salamander, Blanco blind salamander, Texas mock-orange, Golden-cheeked Warbler and Black-capped Vireo are species most likely to be in conflict with portions of this option. The Golden-cheek Warbler is currently mapped as occurring within a portion of the pipeline route. These conflicts may be avoidable by selecting an alternative pipeline route. In addition to the birds, any future detailed assessment should include a complete review for springs and karst associated species and other important species with appropriate habitat. No mapped occurrences of important species showed direct conflict with the general facilities layout. Where right-of-way clearing and construction activity cannot avoid affecting a federally protected species, consultation with the USFWS concerning the need for a permit for the incidental take of that species should be conducted. This level of study would occur during facility siting studies in later phases.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

Based on the relatively small annual quantity and diversion from an existing reservoir, this option should not adversely affect instream flows or bays and estuaries.

4.2.4 Engineering and Costing

For this option, surface water supply for the Wimberley/Woodcreek area would be supplied from a treatment plant at Canyon Reservoir on a wholesale basis to existing water utilities in the service area. The facilities required for this option would include a raw water intake on Canyon Reservoir, a raw water pipeline, water treatment plant, clearwell, and treated water pump station near Canyon Reservoir, a treated water transmission line from the plant to Wimberley/Woodcreek, and a terminal reservoir located near Wimberley and Woodcreek.

This option has a highly reliable quantity of supply since the source is a small portion of the presently uncommitted firm yield of Canyon Lake. This would be a regional system supplying two neighboring communities. The option is sized to meet projected municipal demands at the advanced water conservation level; thus, it would be an efficient use of existing supply.

For purposes of costing and general environmental assessment of this option, a surface water intake site is shown on Figure 4.2-1 in the general vicinity of the south end of Canyon Dam. From the intake, raw water would be pumped to a treatment plant located within one mile of the intake. From the treatment plant, a 12-inch treated water transmission line to the Wimberley and Woodcreek area would be required. To treat the high quality water from Canyon Reservoir, either a membrane filtration plant or a modular facility employing high-rate clarification with filtration could be used. For this study, the treatment plant is assumed to be either one of these two options. The facilities serving Wimberley/Woodcreek have been sized for delivery of year 2030 demands of 1,048 acft/yr. With a maximum day to average day peaking factor of 2.0, the intake, treatment plant, and finished water pump station are sized for 1.87 mgd with a 12-inch pipeline from the plant to the Wimberley and Woodcreek communities.

Table 4.2-3 provides a cost summary for the Wimberley/Woodcreek supply option. The operating cost for the option was calculated for a total static lift of 91 feet and an annual delivery of 1,048 acft to Wimberley and Woodcreek. Financing the construction and associated capital costs were calculated at a 6.0 percent annual interest rate, with a repayment period of 30 years. The annual cost of water purchased from GBRA was calculated at $61 per acft. Total annual costs, including debt repayment, interest, and operation and maintenance, are $1,671,721. For an annual delivery of 1,048 acft, the resulting cost of water is $1,595 per acft, or $4.90 per 1,000 gallons (Table 4.2-3). This is the cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system.

The Wimberley-Woodcreek Option would have no impact upon other water management options and strategies since it would be supplied from an existing water supply source. In addition, it is not expected to impact groundwater/surface water interrelationships, would not be a threat to agriculture and natural resources of the region, and would not have an effect upon navigation. The option has been described and evaluated in the same manner as is being done for other options, therefore it is receiving consistent and equitable treatment with other options that are being considered in the region.

4.2.5 Implementation Issues

<u>Requirements Specific to Treatment and Distribution</u>

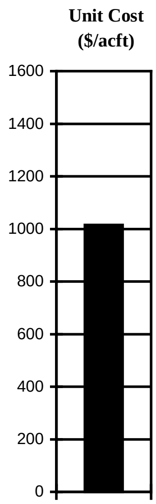
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for intake at Canyon Reservoir and stream crossings.
   b. TNRCC discharge of water treatment plant settling basin blowdown and filter backwash.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways
   b. Creeks and rivers
   c. Other utilities
4. Financing:
   a. Sponsoring entity must be identified and be able to incur debt to finance project.
   b. Participating entities must negotiate water purchase contract with GBRA and establish rate structures.

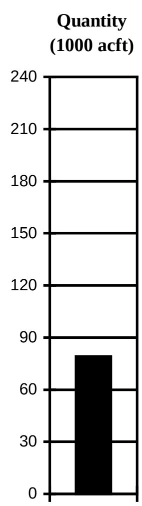
Table 4.2-3.
Cost Estimate Summaries for Wimberley and Woodcreek
Supply from Canyon Reservoir (G-24)
(Second Quarter 1999 Prices)

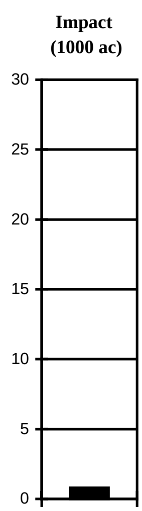
Item	***Estimated Cost***
Capital Costs:	
Floating Raw Water Intake (1,300 gpm)	$500,000
Raw Water Pipeline (1 mile, 12-inch)	184,800
Water Treatment Plant[1] (2 MGD)	4,275,403
Wimberley Transmission Pipeline (23 mile, 12-inch)	4,270,000
Wimberley Reservoir (500,000 gal.)	393,600
Interconnects to Existing Systems	244,200
Power Connection Cost	50,000
Total Capital Cost	**$9,918,003**
Engineering, Contingencies, & Legal Costs[2]	$3,231,061
Environmental & Archeology Studies, Mitigation, and Permitting	640,151
Land Acquisition (90 acres)	801,180
Topographic Mapping and Surveying[3]	80,118
Interest During Construction (1 year)	586,821
Total Project Cost	**$15,257,334**
Annual Costs:	
Debt Service (6 percent for 30 years)	$1,107,682
Operation & Maintenance:	
Pipelines	44,548
Water Treatment Plant	318,986
Pump Stations & Reservoir	22,085
Water Purchase (1,048 acft/yr @ $61 per acft)	63,928
Pumping Energy Costs (1,908,207 kWh @ $0.06 per kWh)	114,492
Total Annual Cost	**$1,671,721**
Water Supply (acft/yr)	1,048
Total Annual Cost of Water per acft	$1,595
Total Annual Cost of Water per 1,000 gallons	$4.90

[1] Also includes the cost of a clearwell and a finished water pump station.
[2] Calculated as 30 percent of total construction cost for pipelines and 35 percent for all other facilities.
[3] Calculated as 10 percent of total land acquisition cost.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft – 12/13/99







OPTION NUMBER: SCTN-14a
OPTION NAME: Joint Development of Water Supply with Corpus Christi — Firm Yield

OPTION DESCRIPTION: *Diversion of enhanced supply in the Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System from Choke Canyon Reservoir to a water treatment plant at the major municipal demand center of the South Central Texas Region (treated water to distribution system or recharge zone). Enhanced supply in the CCR/LCC System created by purchase and delivery of water from the Guadalupe River at the Saltwater Barrier under existing water rights made firm with groundwater from the Gulf Coast Aquifer.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$1,015**	**per acft**[1]
QUANTITY OF WATER:	**79,000**	**acft/yr**[2]
LAND IMPACTED:	**810**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Purchase of 80,000 acft/yr of water rights with loss of priority in the Guadalupe-San Antonio River Basin. **Delivery of Water from Guadalupe River Saltwater Barrier to Corpus Christi:** River intake and pump station, transmission pump station, well field and collection piping, and a raw water transmission line. **Delivery of Water from Choke Canyon Reservoir:** Lake intake pump station, transmission pump station, raw water transmission line, water treatment plant, and distribution.

[2]**QUANTITY OF WATER:** 80,000 acft/yr of existing water rights at the Guadalupe River Saltwater Barrier delivered to Corpus Christi in exchange for 79,000 acft/yr of exports from Choke Canyon Reservoir to the South Central Texas Region.

[3]**LAND IMPACTED:** Intake and pump station sites, well fields, and pipeline right-of-way.

ENVIRONMENTAL ISSUES: Selection of facility sites and pipeline routes to minimize impacts on endemic species and cultural resources.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Willingness of affected Nueces River Basin water suppliers to consider development of cooperative water supply with the South Central Texas Region.

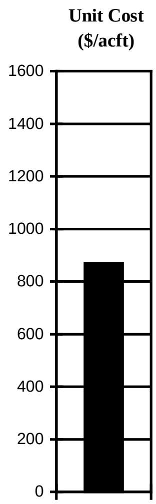
ADDITIONAL FACTORS: Use of well fields for additional water during non-critical periods.

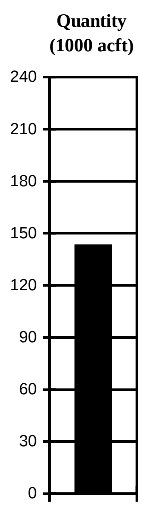
OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: SCTN-2b, SCTN-11, SCTN-12b, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

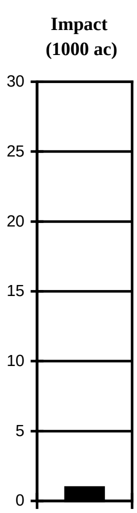
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/13/99







OPTION NUMBER: **SCTN-14b**

OPTION NAME: **Joint Development of Water Supply with Corpus Christi — Firm Yield**

OPTION DESCRIPTION: *Diversion of enhanced supply in the Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System from Choke Canyon Reservoir to a water treatment plant at the major municipal demand center of the South Central Texas Region (treated water to distribution system or recharge zone). Enhanced supply in the CCR/LCC System created by purchase and delivery of water from the Guadalupe River at the Saltwater Barrier under existing water rights made firm with groundwater from the Gulf Coast Aquifer **and** by purchase and delivery of unappropriated streamflow and/or reclaimed water from the San Antonio River near Falls City.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$869**	**per acft**[1]
QUANTITY OF WATER:	**148,200**	**acft/yr**[2]
LAND IMPACTED:	**958**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Purchase of 80,000 acft/yr of water rights with loss of priority in the Guadalupe-San Antonio River Basin. **Delivery of Water from Guadalupe River Saltwater Barrier to Corpus Christi:** River intake and pump station, transmission pump station, well field and collection piping, and a raw water transmission line. **Delivery of Water from Choke Canyon Reservoir:** Lake intake pump station, booster pump station, raw water transmission line, water treatment plant, and distribution. **Delivery of Water from Falls City to Choke Canyon Reservoir:** Diversion structure in San Antonio River, surface water intake and pump station, raw water pipeline, and discharge structure in Choke Canyon Reservoir.

[2]**QUANTITY OF WATER:** 80,000 acft/yr of existing water rights at the Guadalupe River Saltwater Barrier delivered to Corpus and unappropriated streamflow and/or reclaimed water from San Antonio River near Falls City to Choke Canyon Reservoir in exchange for 148,200 acft/yr of exports from Choke Canyon Reservoir to San Antonio.

[3]**LAND IMPACTED:** Intake and pump station sites, well fields, and pipeline right-of-way.

ENVIRONMENTAL ISSUES: Effects of reduced flows downstream of Falls City. Selection of facility sites and pipeline routes to minimize impacts on endemic species and cultural resources. Potential effects arising from mixing San Antonio River water with waters of the Nueces River Basin

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Willingness of affected Nueces River Basin water suppliers to consider development of cooperative water supply with the South Central Texas Region.

ADDITIONAL FACTORS: Public acceptance of diverting San Antonio River flows, having high percentages of reclaimed water into Choke Canyon Reservoir, a raw water supply reservoir and recreation resource. Use of well fields for additional water during non-critical periods.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S 15Ea, S-15Eb, S-16C, SCTN-2b, SCTN-11, SCTN-12b, SCTN-14a, SCTN-16a, SCTN-16b, SCTN-16c,

4.3 Joint Development of Water Supply with Corpus Christi — Firm Yield (SCTN-14a & SCTN-14b)

4.3.1 Description of Options

The development of a cooperative water supply with the City of Corpus Christi and the Nueces and Coastal Bend Region could involve diversion of enhanced firm yield from the Choke Canyon Reservoir/ Lake Corpus Christi (CCR/LCC) System to a water treatment plant at the major municipal demand center of the South Central Texas Region. Options SCTN-14a and SCTN-14b consider enhancing the CCR/LCC System firm yield by purchase and delivery of 80,000 acft/yr of water from the Guadalupe River at the Saltwater Barrier under existing water rights (SCTN-14a), and by delivery of unappropriated streamflow and treated effluent from the San Antonio River at Falls City to the CCR/LCC System via Choke Canyon Reservoir (SCTN-14b). For both options, water available under 80,000 acft/yr of Guadalupe River rights made firm by groundwater from the Gulf Coast Aquifer would be uniformly delivered to the City of Corpus Christi's O.N. Stevens Water Treatment Plant. In addition to 80,000 acft/yr from the Saltwater Barrier, Option SCTN-14b analyzes five diversion rates from the San Antonio River near Falls City to temporary storage in Choke Canyon Reservoir in order to increase the firm yield of the CCR/LCC System and maximize beneficial diversions from Choke Canyon Reservoir to the major municipal demand center of the South Central Texas Region.

As shown in Figure 4.3-1, the major facilities needed to deliver raw water from the Guadalupe River to Corpus Christi include a river intake pump station on the Guadalupe River near the Saltwater Barrier, a transmission pump station, and a 76-mile transmission pipeline. In addition to the surface water facilities, a well field near McFaddin is necessary to deliver groundwater to Corpus Christi whenever the surface water supply is limited or unavailable. Also shown in Figure 4.3-1 is the location of the facilities necessary to deliver raw water from Choke Canyon Reservoir to a water treatment plant in the South Central Texas Region. This portion of the project includes an intake pump station at Choke Canyon Reservoir, intermediate transmission pump station(s), and a 78-mile transmission pipeline. The facilities needed to divert and deliver unappropriated streamflow and treated effluent from the San Antonio River at Falls City to Choke Canyon Reservoir are shown in Figure 4.3-2. The additional facilities needed for Option SCTN-14b include a diversion structure in the San Antonio River, surface

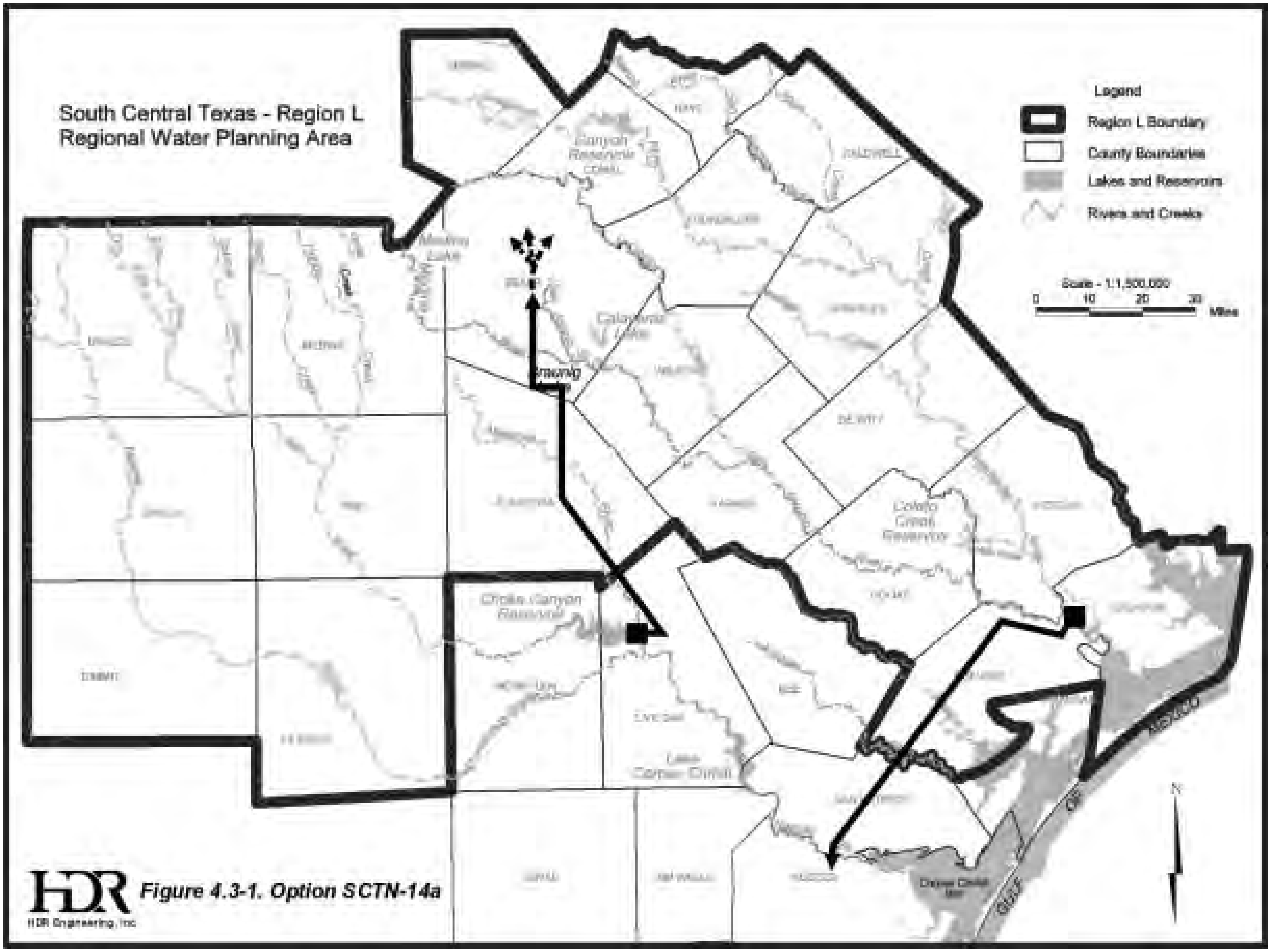


Figure 4.3-1. Option SCTN-14a

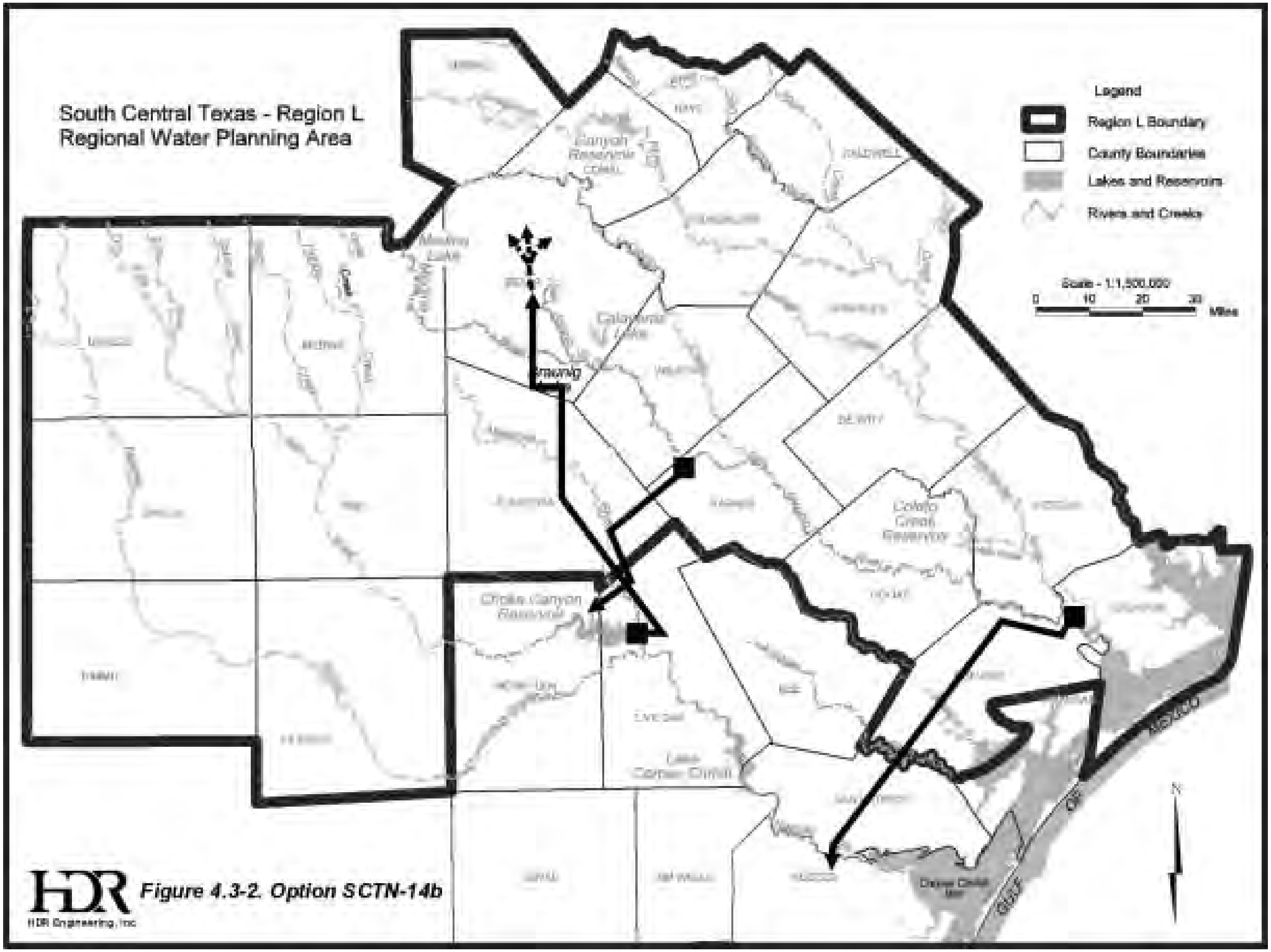


Figure 4.3-2. Option SCTN-14b

water intake pump station, a 40-mile transmission line to Choke Canyon Reservoir, and a discharge structure in Choke Canyon Reservoir.

4.3.2 Available Yield

Using the general assumptions outlined in the Introduction, the Guadalupe-San Antonio River Basin Model (GSA Model) was applied to calculate water available from the Guadalupe River under 80,000 acft/yr of existing rights at the Saltwater Barrier. Since delivery of Guadalupe River water to Corpus Christi involves an interbasin transfer, the existing water rights were simulated in two ways: (1) retaining their senior priority dates; and (2) becoming the most junior water rights in the Guadalupe-San Antonio River Basin. In order to simulate the two priority scenarios in the GSA Model, it was necessary to more specifically identify the 80,000 acft/yr of existing water rights. Without loss of priority, the 80,000 acft/yr is the “last“ (most junior) water taken from 172,501 acft/yr of water rights jointly held by the Guadalupe-Blanco River Authority (GBRA) and Union Carbide Corporation (UCC). For the loss of priority analysis, the 80,000 acft/yr at the Guadalupe River Saltwater Barrier is made up of 67,200 acft/yr of GBRA/UCC rights currently projected to be uncommitted in year 2010,[1] 8,813 acft/yr of other existing water rights, 3,687 acft/yr of GBRA/UCC committed irrigation water rights, and 300 acft/yr of GBRA/UCC committed domestic and livestock water rights.

The difference between the two priority scenarios is reflected in the amount of groundwater needed from the Gulf Coast Aquifer to firm up 80,000 acft/yr. Figure 4.3-3 compares the groundwater pumpage necessary to firm up 80,000 acft/yr for each scenario. As expected, the groundwater needed to firm up the surface water increases when the surface water rights become the most junior in the basin. The maximum groundwater demand for both cases is in the year 1956, when groundwater accounts for 60 percent and 42 percent of the water supply with and without the loss of priority, respectively. Over the entire simulation period, groundwater accounts for 8 percent of the water supply with loss of priority and 5 percent of the water supply without loss of priority.

Changes in Guadalupe River streamflow at the Saltwater Barrier with and without the project are displayed in Figure 4.3-4. Without loss of priority, the specified 80,000 acft/yr of

[1] Personal communications with GBRA, April 28, 1999.

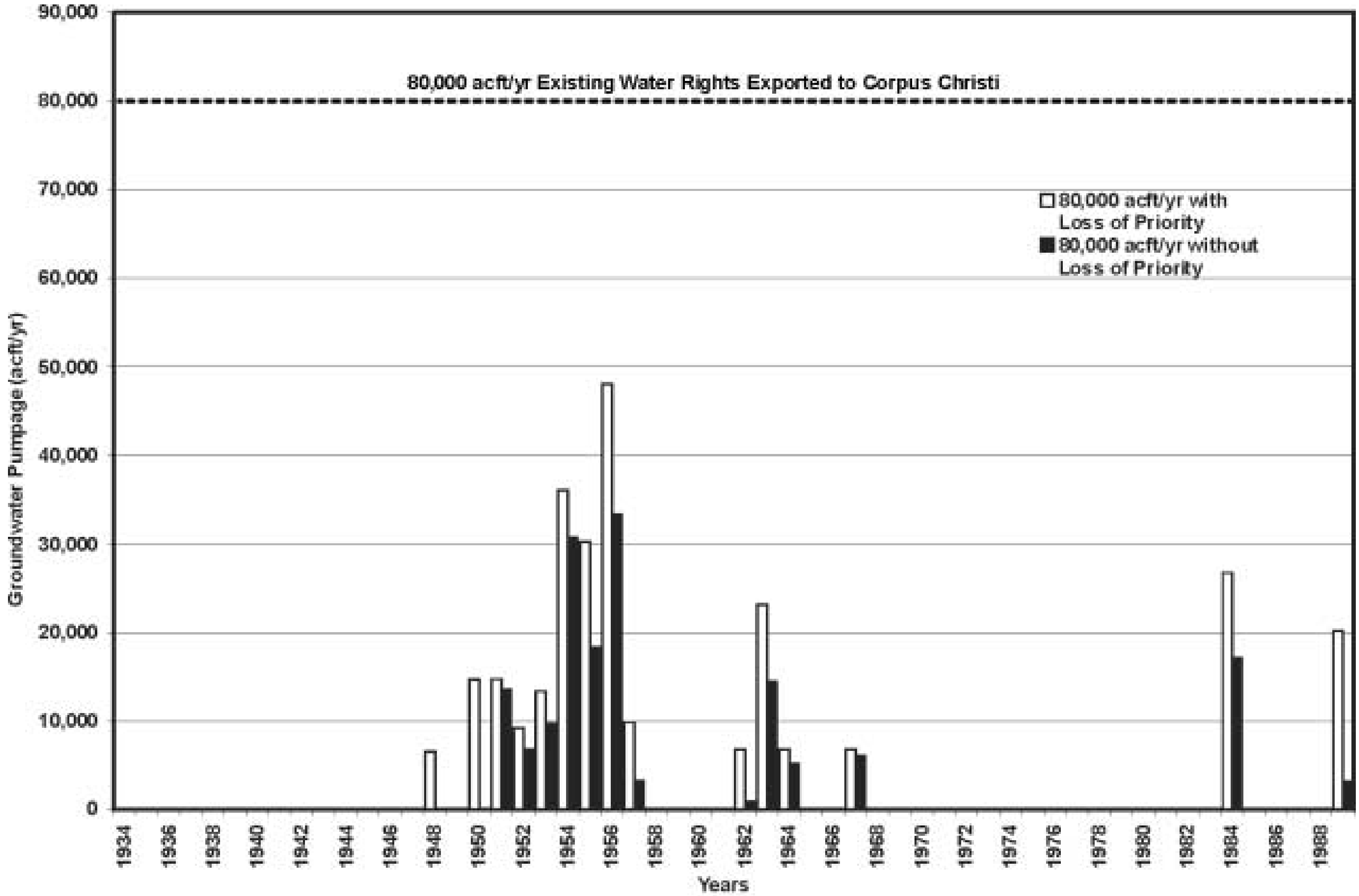
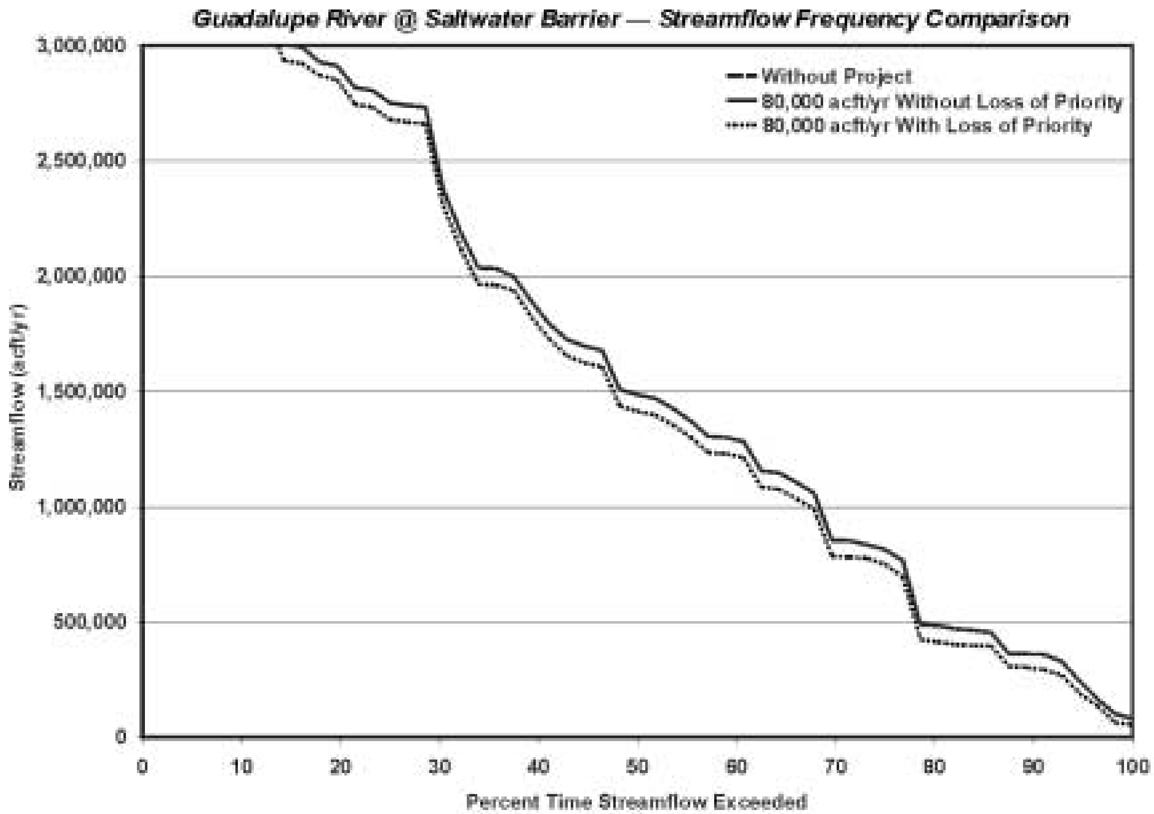


Figure 4.3-3. Annual Groundwater Pumpage from Gulf Coast Aquifer (SCTN-14a)



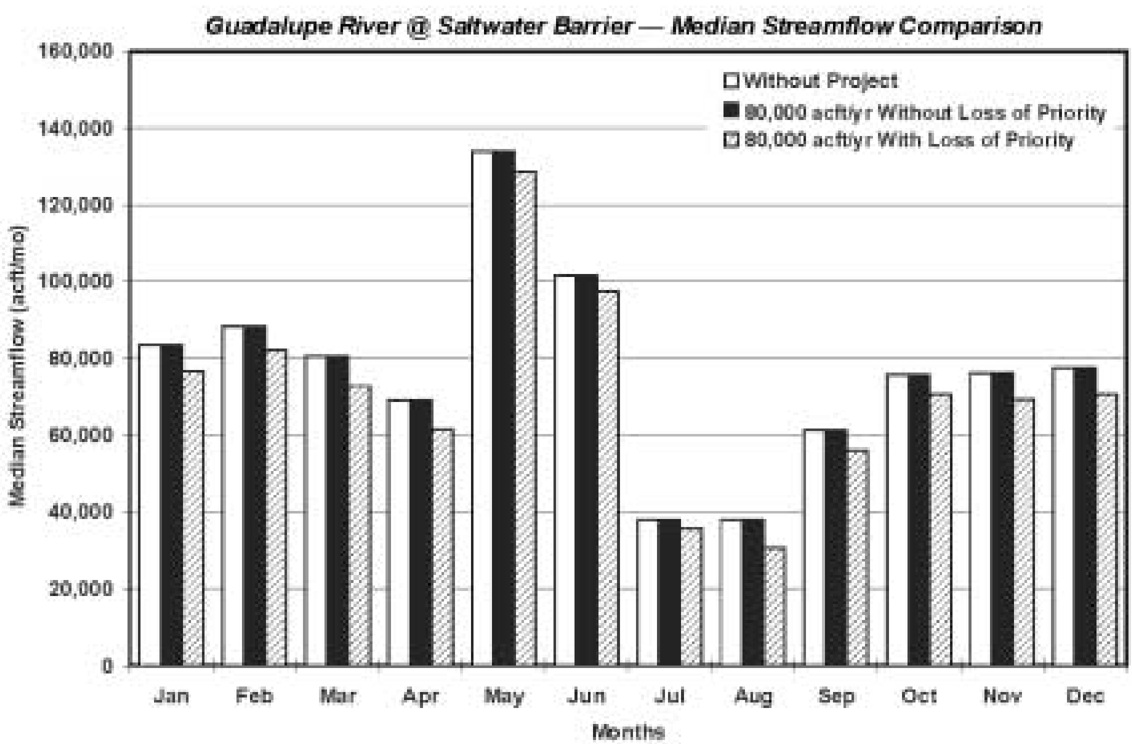


Figure 4.3-4. Joint Development of Water Supply with Corpus Christi (SCTN-14a), Streamflow Comparisons

GBRA/UCC water rights remain senior to Canyon Reservoir and streamflows passing the Guadalupe River Saltwater Barrier with the project remain the same as those without the project. With loss of priority, however, Canyon Reservoir may impound more inflows resulting in reduced streamflows passing the Guadalupe River Saltwater Barrier after diversions of the specified 80,000 acft/yr are made under junior water rights.

For Option SCTN-14b, the diversion and delivery of surface water from the San Antonio River near Falls City to Choke Canyon Reservoir is included in the analysis. Using the same five maximum diversion rates analyzed in Option L-14 (Section 1.5), the GSA Model was applied to calculate water available from the San Antonio River at Falls City and under 80,000 acft/yr of existing water rights at the Guadalupe River Saltwater Barrier. The existing water rights are assumed to lose their priority since Option SCTN-14b involves an interbasin transfer.

The water available at Falls City is the sum of unappropriated water diverted under the Consensus Environmental Criteria (Appendix B) and SAWS reclaimed water delivered via bed and banks subject to channel losses and intervening water rights. Figure 4.3-5 compares average annual diversions for each project for the entire simulation period and for the critical drought. As shown, increases in maximum diversion rate start to have less of an effect on increases in average annual diversion amounts beyond the 60-inch project. During the critical drought, the increase from the 60-inch diversion to the 96-inch diversion, a 156 percent increase in capacity, results in only a 21 percent increase in average annual diversion. Reclaimed water accounts for most of the average annual diversions. Reclaimed water makes up almost 100 percent of the flow for the 18-inch and 36-inch diversion projects, and contributes 93 percent, 80 percent, and 69 percent of the diversions for the 60-inch, 96-inch and 120-inch diversion projects, respectively.

Effects on streamflow in the San Antonio River at Falls City for the five maximum diversion rates are shown in Figure 4.3-6. The upper plot compares the streamflow frequency with and without the project for each of the diversion rates. As the curves move to the left, the diversion rate increases. At Falls City, the published 7Q2 is 197.3 cubic feet per second (cfs),[2] or approximately 12,000 acft/month. As shown by the arrows on the chart, streamflow would

[2] Texas Administrative Code, Chapter 307, Texas Surface Water Quality Standards.

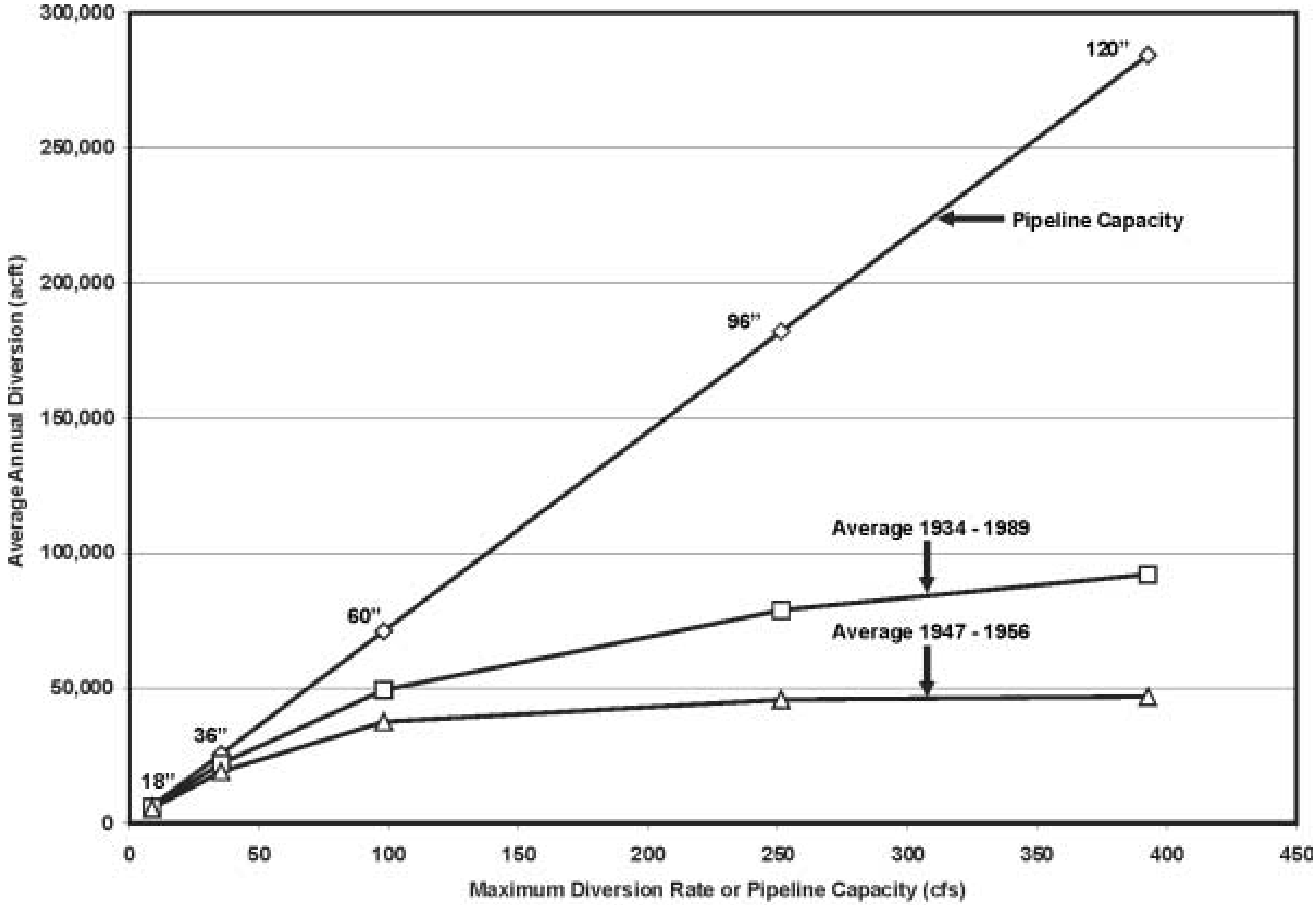
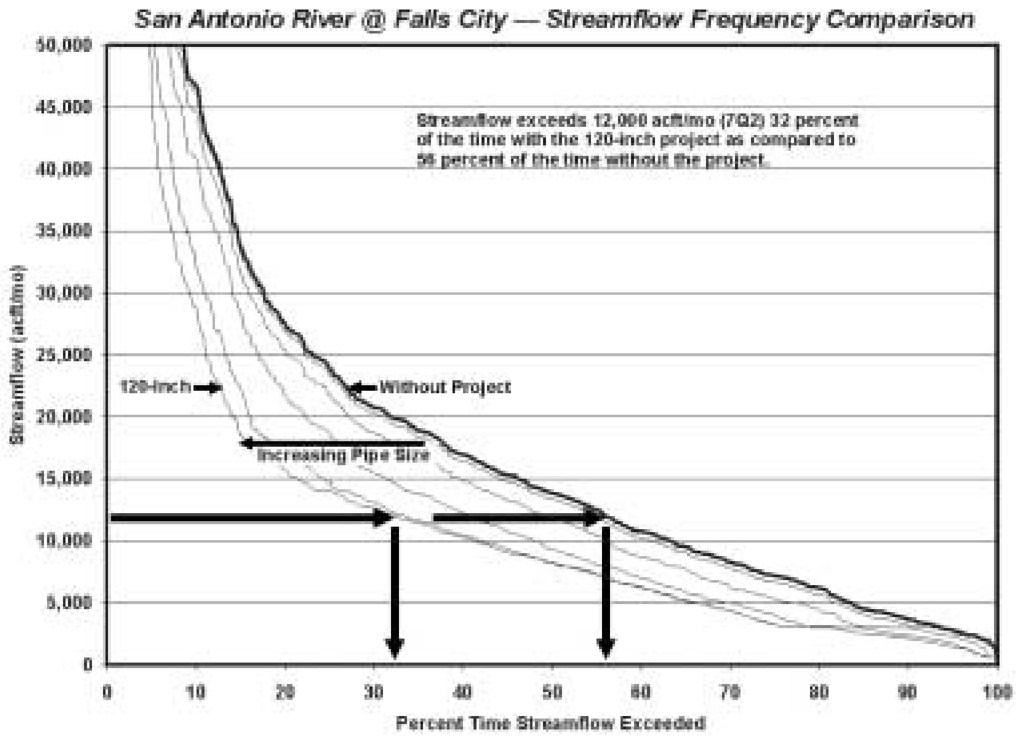
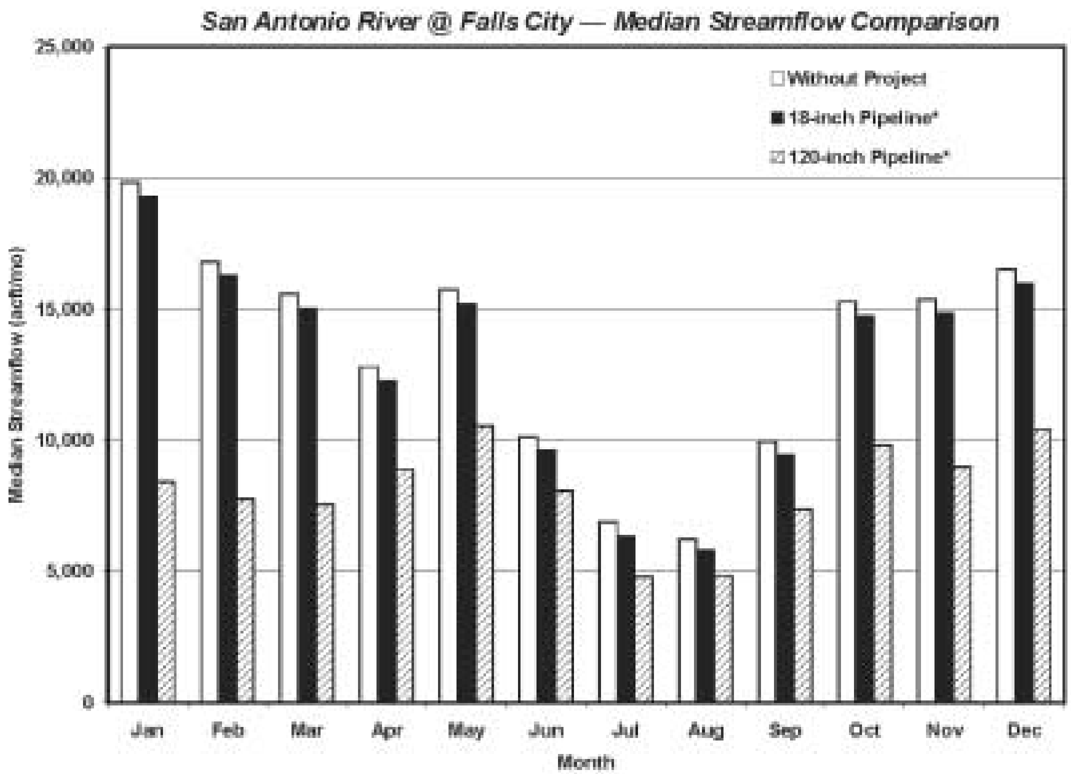


Figure 4.3-5. Water Available for Diversion from San Antonio River at Falls City





*The 18-inch and 120-inch projects represent the minimum and maximum impacts to the monthly median streamflows at Falls City, respectively. The impacts of the other diversion rates lie between the minimums and maximums established by the 18-inch and 120-inch projects.

Figure 4.3-6. Joint Development of Water Supply with Corpus Christi (SCTN-14b), San Antonio River Streamflow Comparisons exceed 12,000 acft/month 32 percent of the time with the 120-inch project, as compared to 56 percent of the time without the project. The 18-inch, 36-inch, 60-inch, and 96-inch diversion projects exceed the 12,000 acft/month 55 percent, 49 percent, 41 percent, and 34 percent of the time, respectively. Figure 4.3-6 also shows a comparison of monthly median flows for the largest and smallest projects to the monthly median flows without the project. In August, the month with the lowest median streamflow, the median flow would be reduced by 7 percent for the 18-inch project and 22 by percent for the 120-inch project. As with the 18-inch and 120-inch diversion projects, the median monthly flows for the three other diversion rates decrease as the respective maximum diversion rates increase.

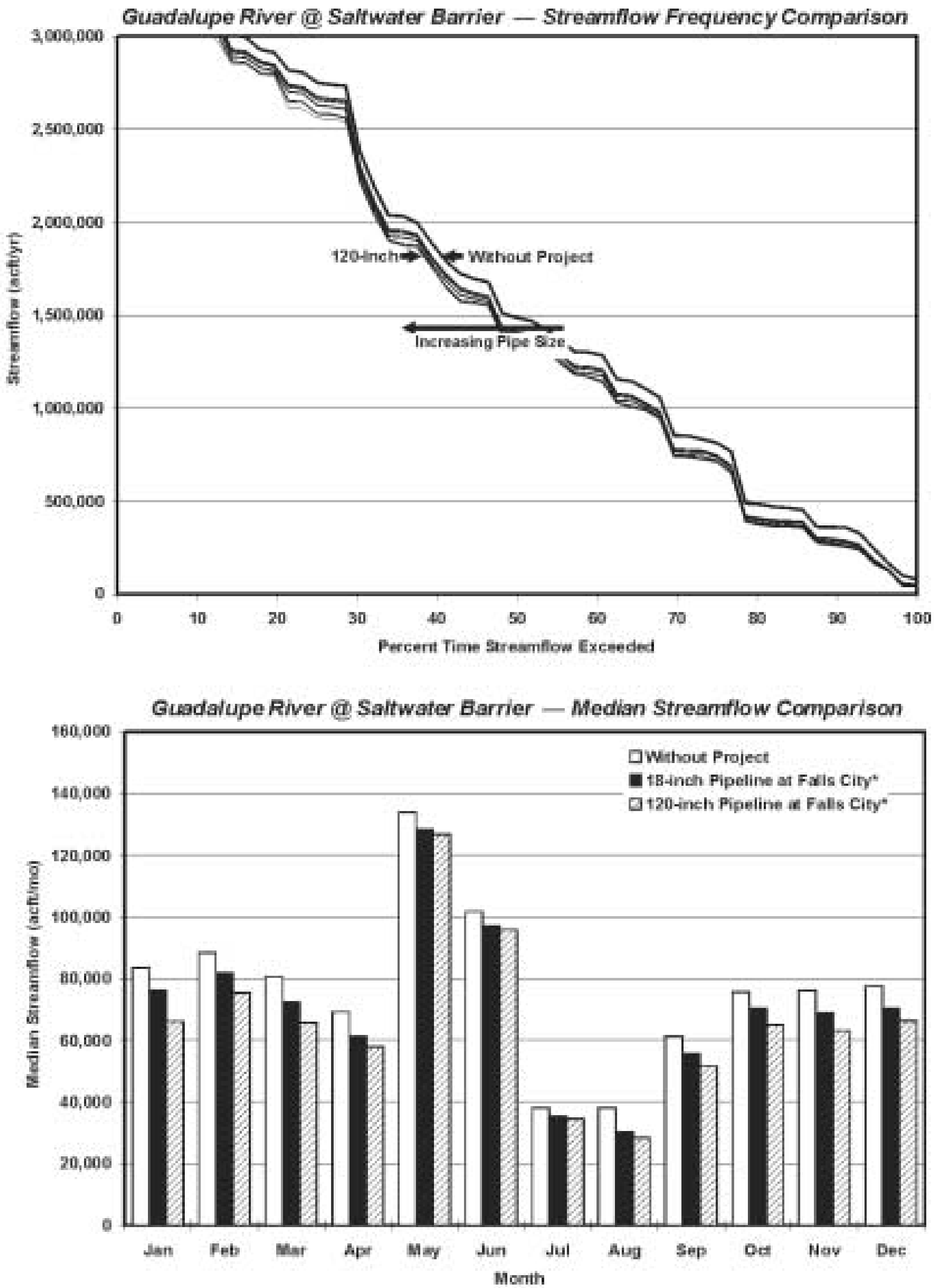
Figure 4.3-7 displays similar streamflow comparisons at the Guadalupe River Saltwater Barrier. As the size of the diversion project increases, the percent of time a selected streamflow is exceeded decreases. In August, the month with the lowest median flow, the median would be reduced by 20 percent with an 80,000-acft/yr diversion from the Guadalupe River at the Saltwater Barrier and the 18-inch diversion project on the San Antonio River near Falls City. With the 120-inch project at Falls City and the 80,000 acft/yr diversions at the Saltwater Barrier, the monthly median flow would be reduced by 25 percent in August.

In order to quantify effects on the CCR/LCC System firm yield, the Nueces River Basin Model and the Lower Nueces River Basin and Estuary Model (Nubay) were applied with the following assumptions:

- 1934 to 1989 period of record;
- 2010 sediment accumulation;
- Monthly diversions from Falls City (summed from daily analyses) imported to Choke Canyon Reservoir;
- 80,000 acft/yr is uniformly imported to Corpus Christi from the Guadalupe River;
- The City of Corpus Christi's Phase IV[3] (maximum yield) Operations Policy governs CCR/LCC System operations; and
- 41,840 acft/yr of pumpage from Lake Texana to Corpus Christi.

Based on recent updates to the Nueces River Basin and the Nubay Models,[4] the drought of the 1990s is the new critical drought for the Lower Nueces River Basin. The yield of the CCR/LCC

[3] City of Corpus Christi Code of Ordinances, Chapter 55, Utilities, Article XII, Water Conservation, Section 55-156, Water Conservation and Drought Contingency Plan.
[4] HDR Engineering, Inc., "Water Supply Update for City of Corpus Christi Service Area," City of Corpus Christi, Texas, 1999.



*The 18-inch and 120-inch projects represent the minimum and maximum impacts to the monthly median streamflows in the Guadalupe River at the Saltwater Barrier, respectively. The impacts of the other diversion rates lie between the minimums and maximums established by the 18-inch and 120-inch projects.

Figure 4.3-7. Joint Development of Water Supply with Corpus Christi (SCTN-14b), Guadalupe River Streamflow Comparisons

System has been reduced by about 2.5 percent (4,000 acft/yr) as a result of the 1990s drought. Since the GSA Model only simulates the 1934 to 1989 period (and the critical drought period for the Guadalupe-San Antonio River Basin occurred in the 1950s), it is assumed that the incremental change in CCR/LCC System yield from the Falls City imports over the 56-year period (1934 to 1989) is representative of that which would occur by including the 1990s.

Table 4.3-1 summarizes enhancements to the CCR/LCC System yield for the different scenarios analyzed for Options SCTN-14a and SCTN-14b. The enhanced firm yield of the CCR/LCC System ranges from 79,000 acft/yr, with only the 80,000 acft/yr delivered to Corpus Christi from the Guadalupe River, up to 152,500 acft/yr, with the addition of a 120-inch diameter pipeline delivering available water from the San Antonio River near Falls City to Choke Canyon Reservoir.

Table 4.3-1. CCR/LCC System Yield Enhancement and Exports to South Central Texas Region

Pipe Size (inches)	Export to Corpus Christi (acft/yr)	Pipe Size (inches)	Average Annual Pumpage to Choke Canyon Reservoir (acft/yr)	Pipe Size (inches)	CCR/LCC Enhanced Firm Yield Exported (acft/yr)	Incremental Change in Exports (acft/yr)
72	80,000	0	0	90	79,000	0
72	80,000	18	5,936	90	84,900	5,900
72	80,000	36	22,019	96	100,500	15,600
72	80,000	60	49,215	96	124,000	23,500
72	80,000	96	78,802	108	148,200	24,200
72	80,000	120	92,100	108	152,500	4,300

With the 80,000 acft/yr base loading the Corpus Christi System, the releases made by Choke Canyon Reservoir to fill the City of Corpus Christi's demands and the Nueces Bay and Estuary freshwater inflow requirements are reduced by 52 percent over the 1934 through 1989 period. On average, operational releases from Choke Canyon Reservoir would be reduced from 74,500 acft/yr without the project to 34,200 acft/yr with the project.

4.3.3 Environmental Issues

Option SCTN-14a diverts water from Choke Canyon Reservoir to the South Central Texas Region via a 78-mile transmission line. The pipeline route lies within the South Texas

Plains vegetational area and traverses the Southern Texas Plains (about 40 percent), East Central Texas Plains (about 35 percent), and Texas Blackland Prairies (about 25 percent) ecoregions.[5,6,7] This option also diverts water from the Guadalupe River to the City of Corpus Christi via a 76-mile transmission line. This pipeline route is in the Gulf Prairies vegetation area and the Western Gulf Coastal Plain ecoregion.[5,6,7] In addition to these first two routes, Option SCTN-14b diverts water from the San Antonio River at Falls City to the Choke Canyon Reservoir via a 40-mile transmission line. This additional pipeline is in the South Texas Plains vegetational area. It begins in the East Central Texas Plains (about 60 percent) and terminates in the South Texas Plains (about 40 percent) ecoregions.[5,6,7] All three proposed pipeline routes are in the Tamaulipan biotic province.

Post oak savannah and tall grass prairies dominated by oaks, mesquites (*Prosopis glandulosa*), acacias, and prickly pears (*Opuntia spp.*) characterize the gulf Prairie vegetational area. This vegetation is supported by acidic clays and clay loams interspersed by sandy loams.[7] The South Texas Plains vegetation area is mainly comprised of rangeland. The vegetation associated with this are has shifted from grassland or savannah to shrubs characterized by mesquite, live oak (*Quercus virginiana*), acacia, and post oak. Soils in this area range from clay to sandy loams and calcareous to slightly acid.[7]

Plant and animal species listed by the U.S. Fish & Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and the Texas Organization for Endangered Species (TOES) that may be within the vicinity of one or more of the three pipeline routes are listed in Table 4.3-2. The Texas Natural Heritage Program maps several species of concern directly on the pipeline route from Choke Canyon Reservoir to San Antonio: Sandhill Woolywhite (*Hymenopappus carrizoanus*), Parks' Jointweed (*Polygonella parksii*), Elmendorf's Onion (*Allium elmendorfii*), Crown Coreopsis (*Coreopsis nuecensis*), and the Texas Garter Snake (*Thamnophis Sirtalis Annectens*). The Silver Wild-mercury (*Argythamnia argyraea*) and South Texas Rushpea (*Caesalpinia phyllanthoides*) are found within a mile of the pipeline corridor.

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[5] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1): pp. 118-125, 1987.
[6] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[7] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.

Table 4.3-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Joint Development of Water Supply with Corpus Christi (SCTN-14a & SCTN-14b)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Audubon's Oriole	*Icterus graduacauda audubonnii*	South Texas; Mesquite and evergreen woodlands	C2		NL	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black Lace Cactus	*Echinocereus reichenbachii var. albertii*	Grasslands; thorn shrublands; mesquite woodlands on sandy, possibly saline soils on coastal prairie	E	E	E	Resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Brown Pelican	*Pelecanus Occidentalis*	Coastal islands; shallow Gulf and bays	E	E	E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Coastal Gay-feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils			NL	Resident
Drummond Rushpea	*Caesalpinia drummondii*				NL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*				NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T	NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant

Table 4.3-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*					Resident
Maritime Pocket Gopher	*Geomys personatus maritimus*	Fossorial, in deep sandy soils			NL	Resident
Mathis Spiderling	*Boerhavia mathisiana*	Open thorn shrublands in sandy to gravelly soils over limestone or on bare limestone or caliche outcrops			E	Resident
Mexican Treefrog	*Smilisca baudinii*	Subtropical woodlands	NL	T	T	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Opossum Pipefish	*Microphis brachyurus*	Brooding adults in fresh or low salinity waters; young carried into more saline waters		T	T	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Peregrine Falcon	*Falco peregrinus*		E/SA	NL	NL	
Piping Plover	*Charadrius melodus*	Beaches, flats	T	T	T	Resident
Plains Gumweed	*Grindelia oolepsis*	Early successional patches in coastal prairies on heavy clay soils			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T	NL	Nesting/Migrant
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	T	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Scarlet Snake	*Cemophora coccinea*	Sandy soils	NL	T	WL	Resident
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes		T	T	Resident
Silvery Wild-Mercury	*Argythamnia argyraea*	Whitish clay soils in shrub-invaded grasslands			WL	Resident
Snowy Plover	*Charadrius alexandrus*	Beaches, flats, streamsides	NL		NL	Winter resident
South Texas Rushpea	*Caesalpinia phyllanthoides*				WL	Resident

Table 4.3-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
South Texas Siren (Large form)	*Siren sp. 1*			T	NL	
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Botteri's Sparrow	*Aimophila botterii texana*	Coastal prairies		T	T	Resident
Texas Cave Shrimp	*Palamonetes antrorum*	Subterranean sluggish streams and pools				Resident
Texas Diamondback Terrapin	*Malaclemys terrapin litoralis*	Bays and coastal marshes		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Pipefish	*Syngnathus affinis*	Corpus Christi Bay; inhabits seagrasses			WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils; coastal prairie grasslands	E	E	WL	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils of remnant coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL = Potentially Endangered/Threatened
Blank = Rare, but no regulatory listing status NL = Not Listed

A population of endangered Attwater's Greater Prairie Chicken has been active on private lands in northwest Refugio County on the pipeline route from the Guadalupe River to Corpus Christi. This species, which prefers coastal prairie habitat, is listed as endangered by TPWD, USFWS, and TOES, which lists habitat loss, modification, and population fragmentation as reason for the decline of the Prairie Chicken. The endangered Texas Windmill Grass (*Chloris texensis*) has been mapped within 2 miles of the proposed route and is found in sandy to sandy loam soils in coastal prairie grasslands. Several species of concern are also mapped along or in close proximity to this route: Coastal Gay-feather (*Liatris bracteata*), Welder Machaeranthera (*Psilactis heterocarpa*), Plains Gumweed (*Grindelia oolepsis*), Threeflower Broomweed (*Thurovia triflora*), Elmendorf's Onion, and the Drummond Rushpea (*Caesalpinia drummondii*). Two amphibians listed as threatened by TPWD, the Black-spotted Newt (*Notophthalmus meridionalis*) and the South Texas Siren (*Siren sp. 1*), are mapped downstream from the pipeline crossing of the Aransas River. The Black-spotted Newt is listed as endangered by the USFWS.

Three species of concern are reported in the vicinity of the proposed route from the San Antonio River to the Choke Canyon Reservoir. These are the Silver Wild-mercury, Drummond Rushpea, and Texas Garter Snake. The Garter Snake lives in varied habitats but prefers wet areas in bottomlands and pastures. Migratory wetlands have established rookeries on this pipeline route and near the proposed discharge site in McMullen County.

Several protected species were not mapped directly along the pipeline corridor, but may have habitat found in the vicinity. Many of these are dependent on thornbrush and wooded habitat, such as the Jaguarundi (*Felis yagouaroundi*), Ocelot (*Felis pardalis*), Reticulated Collared Lizard (*Crotaphytus reticulatus*), Texas Tortoise (*Gopherus berlandieri*), Indigo Snake (*Drymarchon corais erebennus*), and Sheep Frog (*Hypopachus variolosus*). One endangered plant, the Black-lace Cactus (*Echinocereus reichenbachii var. albertii*) is also found within thornbrush habitats. The Mexican Treefrog (*Smilisca baudinii*), which lives in dense subtropical woodlands and is reported by TPWD in Refugio County, may have some habitat within the study area.

The Golden-cheeked Warbler (*Dendroica chrysoparia*) and Black-capped Vireo (*Vireo atricapillus*) nest in Bexar County. From March through August, the Golden-cheeked Warbler inhabits the mature oak-Ashe juniper woods of Bexar County. It requires strips of Ashe juniper bark for nest material. The Black-capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

In addition to the Golden-cheeked Warbler and Black-capped Vireo, several federally- and state-protected birds (Texas Botterii Sparrow, White-tailed Hawk, Interior Least Tern, and Zone-tailed Hawk) have been reported to occur in counties where pipeline routes have been proposed for this project (Table 4.3-2 shows a description of status and preferred habitat). The Texas Botterii Sparrow (*Aimophila botterii texana*), White-tailed Hawk (*Buteo albicaudatus*), and Interior Least Tern (*Sterna antillarum athalassos*) are on the county list for San Patricio, which is part of the area crossed by the pipeline corridor from the Guadalupe River to the city of Corpus Christi. The Interior Least Tern also inhabits McMullen, Karnes, and Live Oak Counties. Both the proposed route from the San Antonio River to Choke Canyon Reservoir and the route from Choke Canyon Reservoir to San Antonio transverse one or more of these three counties. The Zone-tailed Hawk (*Buteo albonotatus*) has been sited in Bexar County and prefers arid, open county that has deciduous or pine-oak woodland.

Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and vegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

Option SCTN-14b involves a transfer of water from the San Antonio River Basin to the Nueces River Basin. Potential impacts of this interbasin transfer, such as the introduction of species, should be considered when evaluating this option.

4.3.4 Engineering and Costing

Tables 4.3-3 and 4.3-4 and Figure 4.3-8 summarize the costs associated with implementing Option SCTN-14a and/or SCTN-14b. Table 4.3-3 shows the cost of diverting up to 80,000 acft/yr under existing water rights (with loss of priority) from the Guadalupe River to

Table 4.3-3.
Cost Estimate Summary for
Joint Development of Water Supply with Corpus Christi (SCTN-14a)
Second Quarter 1999 Prices

Item	Estimated Costs
Capital Costs	
Pipeline From Guadalupe River Saltwater Barrier to Corpus Christi	
Intake and Pump Station (75 MGD)	$7,395,000
Transmission Pump Station	10,801,000
Transmission Pipeline (72-inch dia., 76 miles)	92,725,000
Pipeline From Choke Canyon Reservoir To South Central Texas Region	
Intake and Pump Station (109 MGD)	11,522,000
Water Treatment Plant (109 MGD)	67,492,000
Transmission Pump Stations	13,426,000
Transmission Pipeline (90-inch dia., 78 miles)	153,222,000
Distribution	110,911,000
Well Field	
Wells (40)	13,142,800
Power Connection and Collection Piping	20,232,000
Total Capital Cost	**$500,868,800**
Engineering, Legal Costs and Contingencies	$159,337,000
Environmental & Archaeology Studies and Mitigation	20,219,000
Land Acquisition and Surveying (21,129 acres)	24,390,000
Interest During Construction (2 years)	50,401,000
Total Project Cost	**$755,215,800**
Annual Costs	
Pipeline From Guadalupe River Saltwater Barrier to Corpus Christi	
Debt Service (6 percent for 30 years)	$11,306,000
Intake, Pipeline, Pump Station Operation and Maintenance	495,000
Pumping Energy Costs (51,733,333 kWh @ $0.06 per kWh)	3,104,000
Purchase of Water (80,000 acft/yr @ $61 per acft)	4,880,000
Pipeline From Choke Canyon Reservoir To South Central Texas Region	
Debt Service (6 percent for 30 years)	37,545,000
Operation and Maintenance:	
Intake, Pipeline, Distribution, Pump Station	2,464,000
Water Treatment Plant	8,493,000
Pumping Energy Costs (88,650,000 kWh @ $0.06 per kWh)	5,319,000
Purchase of Water	0
Well Field	
Debt Service (6 percent for 30 years)	6,015,000
Well Field Operation and Maintenance	318,000
Pumping Energy Costs (3,666,670 kWh @ $0.06 per kWh)	220,000
Purchase of Water	0
Total Annual Cost	**$80,159,000**
Available Project Yield (acft/yr)	**79,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$1,015**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$3.11**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Table 4.3-4.
Cost Estimate Summary for
Joint Development of Water Supply with Corpus Christi (SCTN-14b)
Second Quarter 1999 Prices

Item	Estimated Costs
Capital Costs	
Pipeline From Falls City to Choke Canyon Reservoir	
Intake and Pump Station (138 MGD)	$12,567,000
Transmission Pipeline (96-inch dia., 40 miles)	$81,355,000
Outlet	$674,000
Pipeline From Guadalupe River Saltwater Barrier to Corpus Christi	
Intake and Pump Station (75 MGD)	$7,395,000
Transmission Pump Station	$10,801,000
Transmission Pipeline (90-inch dia., 76 miles)	$92,725,000
Pipeline From Choke Canyon Reservoir To South Central Texas Region	
Intake and Pump Station	$16,456,000
Water Treatment Plant	$120,180,000
Transmission Pump Station	$21,227,000
Transmission Pipeline (108-inch dia., 78 miles)	$227,287,000
Distribution	$184,846,000
Well Field	
Wells (40)	$13,142,800
Power Connection and Collection Piping	20,232,000
Total Capital Cost	**$808,887,800**
Engineering, Legal Costs and Contingencies	$257,016,000
Environmental & Archaeology Studies and Mitigation	$21,302,000
Land Acquisition and Surveying (21,277 acres)	$26,329,000
Interest During Construction (2 years)	$83,099,000
Total Project Cost	**$1,196,634,000**
Annual Costs	
Pipeline From Falls City to Choke Canyon Reservoir	
Debt Service (6 percent, 30 years)	$9,870,000
Intake, Pipeline, Pump Station Operation and Maintenance	$954,000
Pumping Energy Costs (25,100,000 kWh @ $0.06 per kWh)	$1,506,000
Purchase of Water	$0
Pipeline From Guadalupe River Saltwater Barrier to Corpus Christi	
Debt Service (6 percent for 30 years)	$11,306,000
Intake, Pipeline, Pump Station Operation and Maintenance	$495,000
Pumping Energy Costs (51,733,333 kWh @ $0.06 per kWh)	$3,104,000
Purchase of Water (80,000 acft/yr @ 61.00 $/acft)	$4,880,000
Pipeline From Choke Canyon Reservoir To South Central Texas Region	
Debt Service (6 percent for 30 years)	$59,744,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$4,144,000
Water Treatment Plant	$15,260,000
Pumping Energy Costs (168,216,667 kWh @ $0.06 per kWh)	$10,928,000
Purchase of Water	$0
Well Field	
Debt Service (6 percent for 30 years)	$6,015,000
Well Field Operation and Maintenance	$318,000
Pumping Energy Costs (4,116,670 kWh @ $0.06 per kWh)	$247,000
Purchase of Water	$0
Total Annual Cost	**$128,771,000**
Available Project Yield (acft/yr)	**148,200**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$869**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.67**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

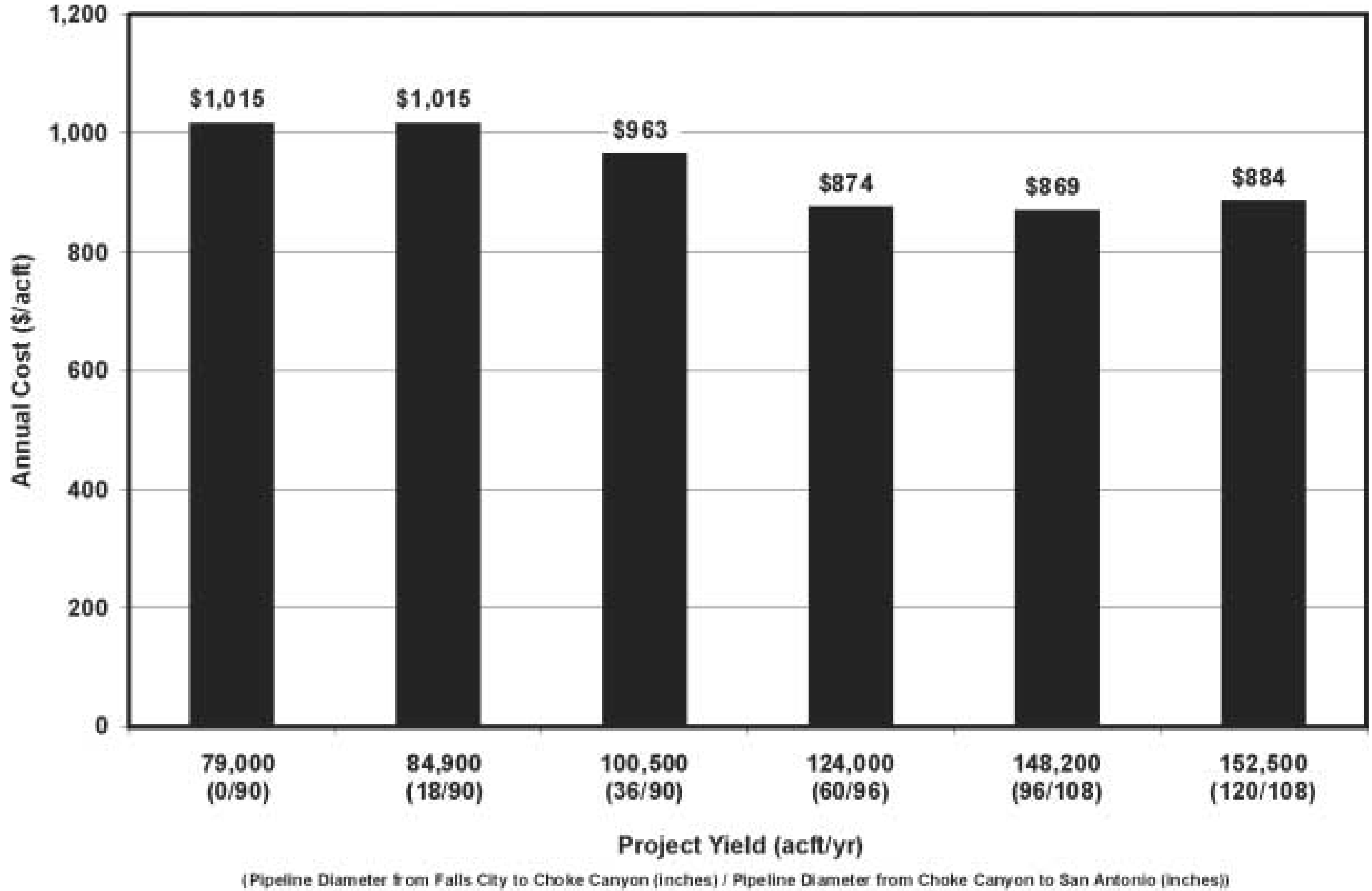


Figure 4.3-8. Joint Development of Water Supply with Corpus Christi Annual Cost of Water Comparison

Corpus Christi and firming up these rights with pumpage from the Gulf Coast Aquifer. The primary difference between the 80,000 acft/yr losing or retaining its priority is the energy costs needed to pump groundwater versus surface water. Since there are months in which no surface water is available (in either case), the capacity of the well fields for both scenarios is the same. For a uniform delivery of 80,000 acft/yr (6,666 acft/month), 34 wells yielding 1,500 gpm are required. Six additional wells were included in the cost estimate to provide sufficient backup. The amount of time when the groundwater wells are activated and the surface water facilities are shut down differs between the two scenarios, as shown in Figure 4.3-3. The annual energy cost increases by $25,000 if the water rights lose their priority, resulting in an annual difference of $0.32 per acft between the two scenarios. Even though the 80,000 acft/yr is not 100 percent reliable from surface water, the purchase cost is assumed to be $61 per acft, which is the current cost of buying firm water from GBRA. The purchase cost of groundwater is assumed to be zero, since it is assumed that the land necessary to construct the well fields will be purchased outright.

The major cost elements for delivering 79,000 acft/yr of CCR/LCC System enhanced yield to a regional water treatment plant in the South Central Texas Region are also summarized in Table 4.3-3. The costs include treatment and distribution. The annual cost of Option SCTN-14a at a firm yield of 79,000 acft/yr is $1,015 per acft.

The possibility of constructing an off-channel storage reservoir was analyzed in an attempt to reduce the number of wells needed to firm up the 80,000 acft/yr delivery. Results indicate that it would likely be more cost effective to construct a larger well field than to build an off-channel storage reservoir.

The annual costs of water for the different project sizes analyzed in Option SCTN-14a and SCTN-14b are plotted against project yield in Figure 4.3-8. The projects range from an annual cost of $1,015 per acft for 79,000 acft of firm yield to $869 per acft for 148,200 acft of firm yield. The largest project with the lowest annual cost includes a 72-inch pipeline from the Guadalupe River Saltwater Barrier to Corpus Christi, a well field near McFaddin, a 96-inch pipeline from Falls City to Choke Canyon Reservoir and a 108-inch pipeline from Choke Canyon Reservoir to the major municipal demand center of the South Central Texas Region. Table 4.3-4 presents the cost for the most cost-effective project for Option SCTN-14b. This project provides a firm water supply of 148,200 acft/yr at an annual cost of $869 per acft.

4.3.5 Implementation Issues

Implementation of SCTN-14a could directly affect the feasibility of other water supply options under consideration, including SCTN-2b, SCTN-11, SCTN-12b, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

Implementation of SCTN-14b could directly affect other options under consideration, including L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, S-16C, SCTN-2b, SCTN-11, SCTN-12b, SCTN-14a, SCTN-16a, SCTN-16b, and/or SCTN-16c.

Since this option involves delivering SAWS reclaimed water via the San Antonio River and exporting water from the Guadalupe-San Antonio River Basin to the Nueces River Basin, a bed-and-banks permit and interbasin transfer permit from the TNRCC will be required. In addition, water suppliers in the Nueces River Basin must be willing to develop a cooperative water supply between the South Central Texas Region and the Nueces and Coastal Bend Region. Prior to implementation of this water supply option, water quality compatibility studies of the co-mingled water in Choke Canyon Reservoir and water treatment studies for the City of Corpus Christi, to treat blended water from three different raw water supplies, should be completed. Additional consideration should be given to the groundwater facilities necessary during critical periods. Since the groundwater facilities are only used during critical periods, they could be used to deliver additional water to Corpus Christi or to other entities in the area during non-critical times.

Requirements Specific to Water Rights

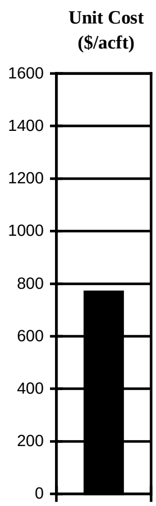
1. It will be necessary to obtain these permits:
   a. TNRCC Water Right permits and amendments.
   b. TNRCC Interbasin Transfer(s) Approval
   c. TNRCC bed and banks authorization for use of San Antonio River to deliver SAWS treated effluent.
   d. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   e. General Land Office (GLO) Sand and Gravel Removal permits.
   f. GLO Easement for use of state-owned land.
   g. Coastal Coordination Council review.
   h. TPWD Sand, Gravel, and Marl permit.

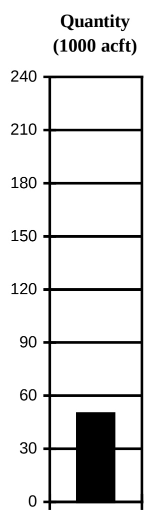
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Other Considerations:
   a. Water demand reduction programs by SAWS may reduce the quantity of future return flows.
   b. Use of return flows must be negotiated with SAWS. Use arrangements should consider drought contingency planning that might result in a reduction of effluent discharged by SAWS.
   c. Water compatibility testing, including biological and chemical characteristics will need to be performed.
   d. Willingness of interests in the South Central Texas Region and the Nueces and Coastal Bend Region to develop a joint water supply.

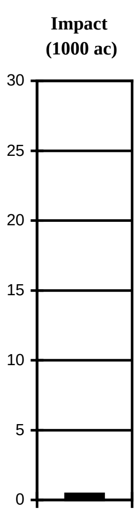
Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel, and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads
   b. Creeks and rivers
   c. Other utilities

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/06/99







OPTION NUMBER: **C-13C**
OPTION NAME: **Colorado River at Bastrop – Purchase of Stored Water — Firm Yield**

OPTION DESCRIPTION: *Purchase a firm water supply of 50,000 acft/yr from the Lower Colorado River Authority (LCRA) to be provided as stored water from the Highland Lakes System. Divert from the Colorado River near Bastrop, deliver via an 89.4-mile transmission pipeline to a water treatment plant at the major municipal demand center of the South Central Texas Region, and distribute to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$769**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**50,000**	**acft/yr[2]**
LAND IMPACTED:	**440**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Small channel dam, river intake and pump station, raw water pipeline, two pump stations, water treatment plant, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** 50,000 acft/yr from storage of Highland Lakes purchased under existing LCRA rights.

[3]**LAND IMPACTED:** Water treatment plant and transmission pump station sites and pipeline right-of-way.

ENVIRONMENTAL ISSUES: The Colorado River from Longhorn Dam in Travis County downstream to Matagorda Bay is recommended for designation as an Ecologically Unique River Segment by the Texas Parks and Wildlife Department.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, and ability of the entities to develop a regional plan which realizes economies of size that benefits all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Colorado River Basin water to the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-17A, C-17B, C-18, SCTN-11, SCTN-12b, and/or SCTN-15.

4.4 Colorado River at Bastrop – Purchase of Stored Water — Firm Yield (C-13C)

4.4.1 Description of Option

This water supply option involves the potential diversion of water from the Colorado River near Bastrop and conveying it through an 89.4-mile transmission pipeline to the major municipal demand center of the South Central Texas Region. Treated water would then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone. The river diversion location and approximate pipeline route are shown in Figure 4.4-1. In this option, it is assumed that Colorado River water would be obtained through the purchase of firm stored water from the Lower Colorado River Authority's (LCRA) Highland Lakes System.

4.4.2 Water Potentially Available at Bastrop

The LCRA has determined that the combined firm yield of the Highland Lakes System (Lakes Buchanan, Inks, LBJ, Marble Falls, and Travis) is 536,312 acft/yr.[1] The most recent LCRA Water Management Plan states that much of this firm yield is currently committed, as summarized in Table 4.4-1. Of the remaining 126,196 acft/yr, 50,000 acft/yr is reserved for future needs in the LCRA's 33-county service area. This leaves a balance of 76,196 acft/yr currently uncommitted. For purposes of this study, it was assumed that 50,000 acft/yr of this uncommitted water could be made available for purchase. For this water supply option, it is assumed that the purchased water would be released from the Highland Lakes, diverted at a uniform rate near Bastrop, and transmitted via pipeline to the major municipal demand center of the South Central Texas Region. Delivery of Highland Lakes water to the vicinity of Bastrop for diversion will result in an increase of up to 50,000 acft/yr in streamflow above the proposed diversion location. Changes in streamflow downstream of Bastrop will not result directly from operation of Option C-13C. Until such time as the 50,000 acft/yr might have been committed to other users, some decrease (less than 50,000 acft/yr) in climatically driven spills from the Highland Lakes may be expected as a result of the release of water that would otherwise have been in storage when inflow events occur.

[1] Lower Colorado River Authority, "Water Management Plan for the Lower Colorado River Basin," pg. 37, March 1999.

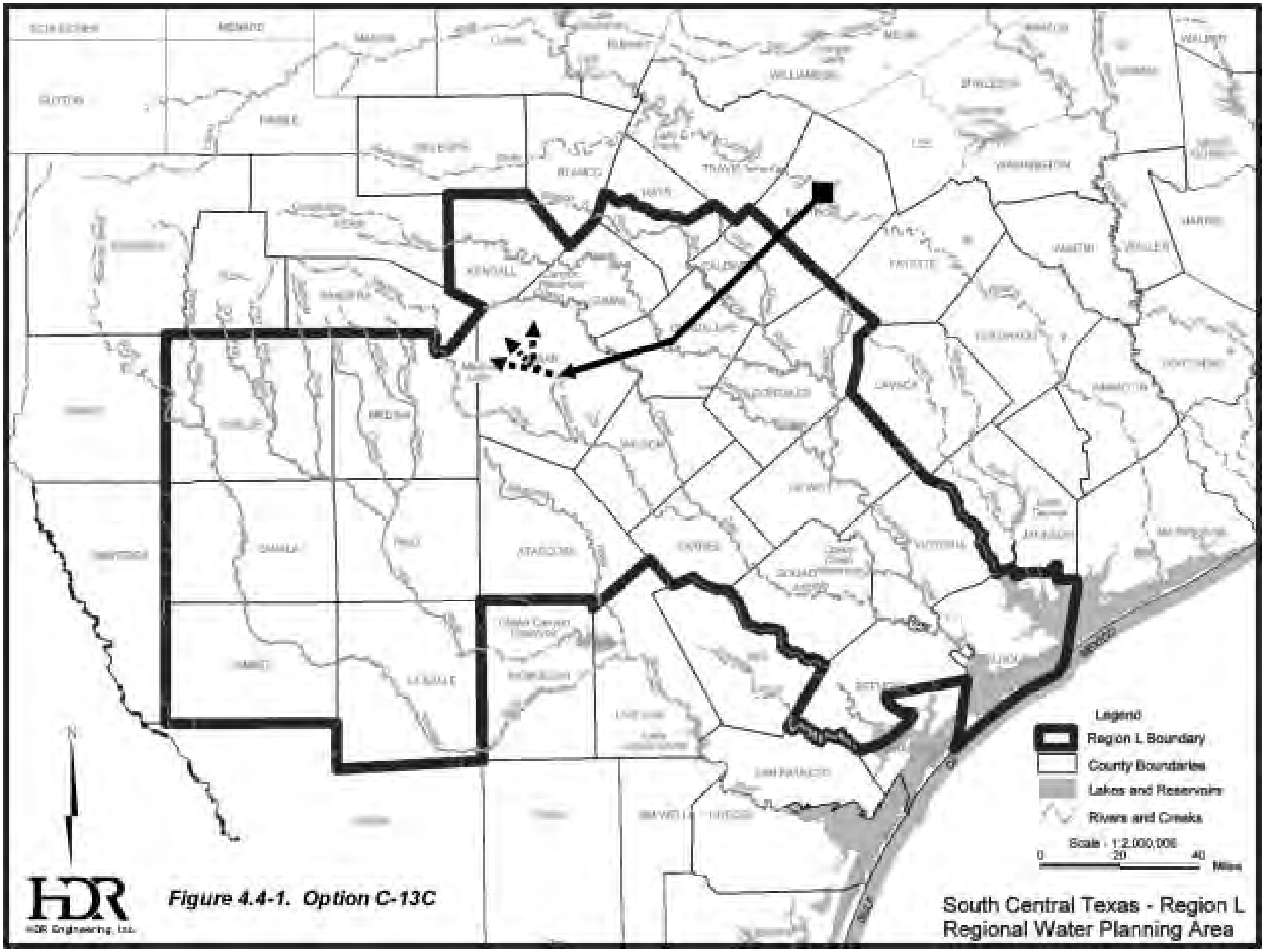


Figure 4.4-1. Option C-13C

Table 4.4-1.
Summary of Commitments of the
Firm Yield of the LCRA's Highland Lakes System

Firm Yield Commitment	Amount (acft/yr)
Owen Ivie Reservoir	90,546
City of Austin	148,300
LCRA Power Plants	63,851
South Texas Project	5,680
Instream Flow Maintenance (annual average)	12,860
Bays & Estuaries (annual average)	3,090
Other Contracts	85,789
Total	410,116

4.4.3 Environmental Issues

The 89.4-inch transmission pipeline follows the Texas Blackland Prairies ecoregion.[2] Ninety percent of the pipeline falls within Blair's Texan biotic province, while approximately 10 percent dips into the Tamaulipan biotic province within Bexar County.[3]

The diversion occurs within the Post Oak Savannah vegetational area, which is characterized by gently rolling to hilly terrain with an understory that is typically tall grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*).[4] The transmission pipeline corridor runs along the confluence of the Post Oak Savannah and Blackland Prairies. The Blackland Prairies are dominated by little bluestem, long-leaved rushgrass (*Sporobolus asper*), switchgrass (*Panicum virgatum*), yellow Indiangrass (*Sorghastrum nutans*), sideouts grama (*Bouteloua curtipendula*), Texas winter-grass (*Stipa leuotricha*) and hairy grama (*B. hirsuta*). This vegetation is supported by dark calcareous clays.[4] In most of the Blackland Prairie, historic overgrazing and intensive agricultural land use has left

[2] Omernik, James M, "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[3] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[4] Gould, F.W, "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.

little habitat for species other than those tolerant of development. Suburban, rural-residential, and urban land uses have affected wildlife habitats and population in the vicinity of San Antonio.

The 89.4-mile transmission pipeline would affect a total area of approximately 430 acres from the Colorado River near Bastrop to the Edwards Aquifer recharge zone in eastern Bexar County. Impacts on wildlife habitats can generally be avoided by locating the pipeline right-of-way in previously disturbed areas, such as crop and pasturelands. A cleared pipeline right-of-way through a woodland or brushy habitat could be beneficial to some wildlife by providing edge habitat, except that the majority of these areas are small, fragmented remnants, and do not suffer from a shortage of edges.

The Texas Natural Heritage Program reports occurrences of protected species within and adjacent to the proposed pipeline project (Table 4.4-2). The Mountain Plover (*Charadrius montanus*), which resides in shortgrass plains and fields, sandy deserts and plowed fields, has been mapped less than 1 mile from the transmission pipeline in Guadalupe County. The Mountain Plover is proposed to be listed as threatened by the U.S. Fish and Wildlife Service (USFWS). The only other species reported by Texas Natural Heritage Program is the Guadalupe Bass, which has been sited in the Guadalupe River at the border of Guadalupe and Caldwell Counties.

The Texas Parks and Wildlife Department (TPWD) listings for Bastrop, Bexar, Caldwell and Guadalupe Counties show that many protected species may be present within the project vicinity. Many species are dependent on thorn or scrubland habitat, such as the endangered Jaguarundi, Ocelot, Indigo Snake, Texas Tortoise, which prefers open brush with a grass understory, and Texas Horned Lizard, which may be found in sparsely vegetated uplands. The Federal- and State-protected Golden-cheeked Warbler and Black-capped Vireo reside in mature oak-Ashe woodlands and semi-open woodlands with dense underbrush, respectively. The Texas Garter Snake may be present in wetland habitats and the Timber Rattlesnake in riparian zones. The protected Houston Toad may be present in loamy soils around ponds surrounded by grass or forest.

When potential protected species habitat cannot be avoided, additional studies would have to be conducted to evaluate habitat use. Sites of historic or prehistoric significance will be evaluated for possible inclusion in the National Register for Historic Places. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate

Table 4.4-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Colorado River at Bastrop – Purchase of Stored Water (C-13C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Intermittently wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident

Table 4.4-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

4.4.4 Engineering and Costing

For this option, 50,000 acft/yr of water released from the Highland Lakes by LCRA would be pumped from the Colorado River near Bastrop to the major municipal demand center of the South Central Texas Region at a uniform rate. Potential benefits from this project could include the addition of a new potable water supply for municipal distribution systems or the enhancement of Edwards Aquifer recharge. There are several major facilities that would have to be constructed for this water supply option. These facilities and the estimated cost for them are itemized in Table 4.4-3.

The river intake and large pumping station are obviously necessary facilities for diverting water from the Colorado River. Also required is a low-height channel dam to provide a pool for the pump intakes. The pump station and intake structure, as well as the pipeline and transmission pump stations, are designed such that a uniform diversion rate of about 73 cfs could be utilized to deliver 50,000 acft/yr when operating 95 percent of the time. The river intake and pump stations would cost approximately $6.7 million, while the channel dam would cost approximately $3.9 million.

The largest capital expenditure, by far, would be for the approximately 89.4-mile transmission pipeline, as shown in Figure 4.4-1. This would require a 54-inch diameter pipeline that costs almost $86 million. Associated with the pipeline are the two required transmission pump stations along the length of the pipeline. These are estimated to cost approximately $7.9 million.

Other important capital costs are a water treatment plant for $33 million and $60 million for distribution. Costs associated with land acquisition for the pipeline right-of-way, pump stations, and treatment facilities are approximately $4.3 million.

With engineering, contingencies, legal costs, and other studies the total project cost would be about $314 million.

The majority of the project would be financed over 30 years at a 6.0 percent annual interest rate, resulting in an annual cost of $22 million. The small channel dam would be financed at 6 percent for 40 years, for an annual cost of approximately $0.4 million. Operation and maintenance costs are estimated to total $5.6 million annually. Large annual costs are associated with the transmission of water from the Colorado River to the point(s) of delivery. The total amount of water diverted annually from the Colorado River, 50,000 acft/yr, was used to calculate the pumping cost. With the vertical lift and friction losses along the pipeline the annual pumping costs are estimated to be $4.8 million.

Table 4.4-3.
Cost Estimate Summary for
Colorado River at Bastrop – Purchase of Stored Water (C-13C)
(Second Quarter 1999 Prices)

Item	***Estimated Costs***
Capital Costs	
Channel Dam (500 feet; 15 feet high)	$3,872,000
Intake and Pump Station (47 MGD)	6,734,000
Water Treatment Plant (47 MGD)	33,000,000
Transmission Pump Stations (2)	7,916,000
Transmission Pipeline (54-inch dia.; 89.4 miles)	85,845,000
Distribution	60,519,000
Power Connection Costs	1,602,000
Total Capital Cost	**$199,488,000**
Engineering, Contingencies, and Legal Costs	$64,796,000
Environmental & Archaeology Studies, Mitigation and Permitting	2,377,000
Land Acquisition and Surveying (440 acres)	4,310,000
Interest During Construction (4 years)	43,355,000
Total Project Cost	**$314,326,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$22,395,000
Debt Service (6 percent for 40 years)	403,000
Operation and Maintenance:	
Intake, Pipeline, Pump Stations	1,283,000
Water Treatment Plant and Distribution	4,359,000
Pumping Energy Costs (79,549,339 kWh @ $0.06 per kWh)	4,773,000
Purchase of Water (50,000 acft/yr @ $105 per acft)	5,250,000
Total Annual Cost	**$38,463,000**
Available Project Yield (acft/yr)	**50,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$769**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.36**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Another principal annual cost is that of the firm water to be purchased from the LCRA. This cost was estimated at the current rate of $105 per acft purchased, based on the current contract price with the City of Austin. This leads to a total of $5.25 million per year.

The annual costs, including debt repayment, interest, raw water purchases, and operation and maintenance, total $38,463,000. For an annual supply of 50,000 acft the resulting annual cost of water is $769 per acft, or $2.36 per 1,000 gallons.

4.4.5 Implementation Issues

Implementation of purchase of stored water from the Highland Lakes System and diversion of same from the Colorado River near Bastrop could directly affect the feasibility of other water supply options under consideration, including S-15Dc, S-15Eb, C-17A, C-17B, C-18, SCTN-11, SCTN-12b, and/or SCTN-15.

An institutional arrangement is needed to implement projects including financing on a regional basis.

Requirements Specific to Transfer of Existing Water Rights

1. Obtain TNRCC approval for amendments to existing water rights to reflect:
   a. New diversion point.
   b. Interbasin transfer.
2. Water rights sales and contracts must be approved by the TNRCC.

Requirements Specific to the Low-Head Channel Dam

1. Necessary permits:
   a. TNRCC Water Rights and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel and Marl permits.
2. Land acquisition.

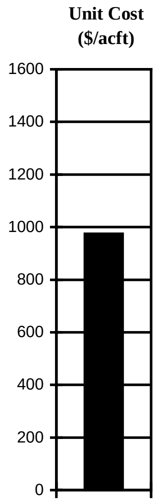
Requirements Specific to the Transmission Pipeline

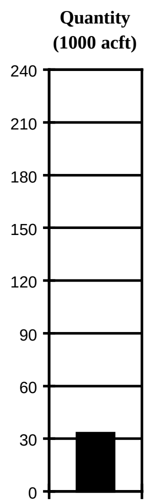
1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.

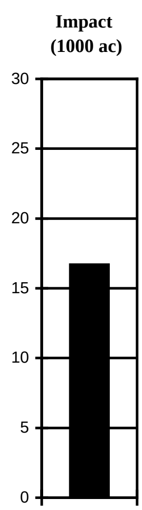
2. Right-of-way and easement acquisition.

3. Crossings:

   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.







OPTION NUMBER: S-15C
OPTION NAME: Cibolo Reservoir — Firm Yield

OPTION DESCRIPTION: *The firm yield of the proposed Cibolo Reservoir, located in Wilson County, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$975**	**per acft**[1]
QUANTITY OF WATER:	**33,200**	**acft/yr**[2]
LAND IMPACTED:	**16,700**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, intake and pump station, raw water pipeline to treatment plant, water treatment plant, finished water distribution system improvements.

[2]**QUANTITY OF WATER:** Firm yield of Cibolo Reservoir; instream flow requirements, return flows of reclaimed water to meet downstream water rights and levels of Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Reservoir site size and sites for pipelines, pump stations, and water treatment plant.

ENVIRONMENTAL ISSUES: Inundation of 18 miles of stream channel, much of which is bottomland hardwood and riparian communities. Habitat mitigation of 28,958 acres has be estimated.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Quantity of instream flows required and habitat mitigation requirements.

ADDITIONAL FACTORS: Not Applicable.

5.1 Cibolo Reservoir — Firm Yield (S-15C)

5.1.1 Description of Option

The firm yield from the proposed Cibolo Reservoir, located in Wilson County, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region. The proposed reservoir site is located on Cibolo Creek about 8 miles east of Floresville and has a 748 square mile watershed. The project has been studied several times,[1,2,3] most recently in the 1996 Trans-Texas Water Program by HDR Engineering, Inc. (HDR).[4]

The dam would likely be an earthfill embankment with a gate-controlled concrete spillway. The dam would extend about 4 miles across the Cibolo Creek valley and provide a conservation storage capacity of about 409,700 acft below elevation 416 ft-msl. At full conservation pool, the reservoir would inundate about 16,700 acres along approximately 18 miles of stream channel. The probable maximum flood elevation has been estimated at 426 ft-msl. The approximate locations of Cibolo Reservoir and the 42-mile transmission pipeline conveying its firm yield to the major municipal demand center of the South Central Texas Region shown in Figure 5.1-1.

5.1.2 Available Yield

The firm yield of the proposed Cibolo Reservoir was estimated based on assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction. The Guadalupe-San Antonio River Basin Model[5] (GSA Model) was used to estimate flow available for impoundment at the Cibolo Reservoir. Since Cibolo Reservoir would be located on Cibolo Creek between the Selma (USGS #0818500) and Falls City (USGS #0818600) gages, inflows were calculated based on a drainage area ratio method assuming that about 82 percent of the incremental flow between Selma and Falls City would be available at the

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[1] U.S. Bureau of Reclamation (USBR), "Texas Basins Project," February 1965.
[2] USBR, "Feasibility Report, Cibolo Project, Texas," February 1971.
[3] Espey Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," February 1986.
[4] HDR Engineering, Inc. (HDR), "West Central Study Area Phase I Interim Report," Volume IV, Trans-Texas Water Program, January 1996.
[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September 1993.

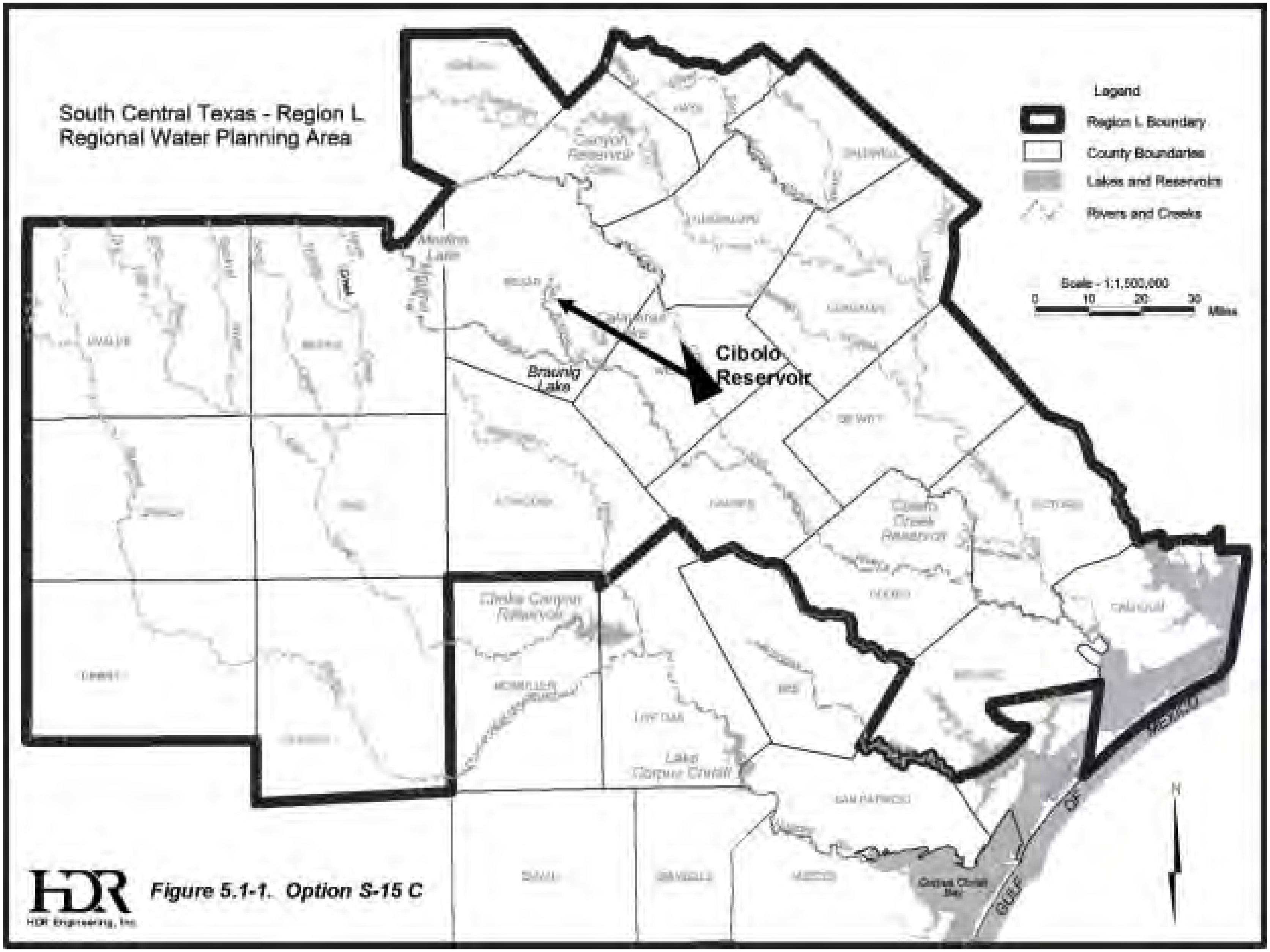


Figure 5.1-1. Option S-15 C

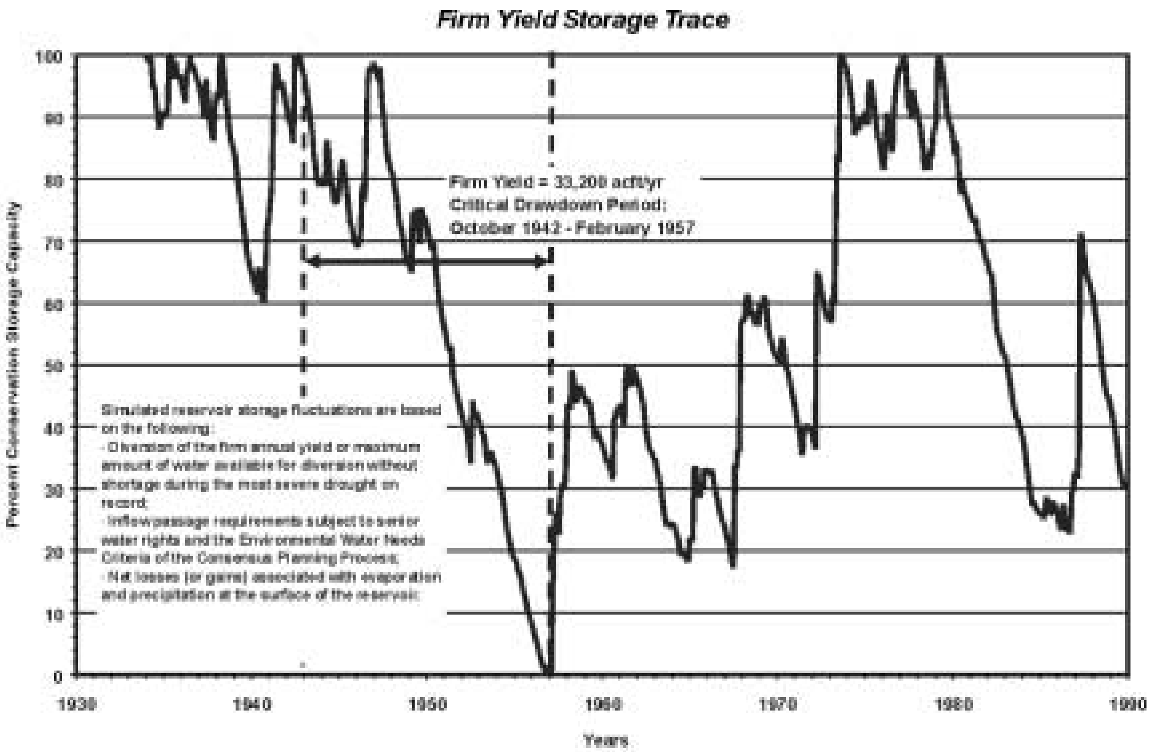
Cibolo Reservoir site. The GSA Model calculates total daily streamflow, daily streamflow passed for downstream water rights, and daily streamflow passed for bay and estuary requirements. These streamflows at the reservoir site were used to compute firm yield using the SIMDLY model originally developed by the Texas Water Development Board (TWDB) and modified by HDR to simulate reservoir operations subject to daily inflow passage criteria using water availability estimates from the GSA Model. Finally, the GSA Model was used to assess changes in streamflow for the Guadalupe River at the Saltwater Barrier assuming Cibolo Reservoir operations with diversion of the firm yield.

The computed firm yield for Cibolo Reservoir is 33,200 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. Figure 5.1-2 illustrates simulated Cibolo Reservoir storage fluctuations for the 1934 to 1989 historical period and a reservoir storage frequency curve as operated under the Environmental Consensus Criteria (Appendix B) and subject to diversion of the firm yield of 33,200 acft/yr. Monthly median streamflows and streamflow frequency curves with and without the project are presented in Figure 5.1-3 for Cibolo Creek at Falls City and for the Saltwater Barrier at the mouth of the Guadalupe River. Changes in monthly median streamflow at the Cibolo dam site are quite significant because of the large storage capacity of Cibolo Reservoir and the application of the Consensus Environmental Criteria. More specifically, inflow passage is often limited during the simulation period because reservoir storage has fallen below 80 percent or 50 percent of capacity (Figure 5.1-2). Importation of water to Cibolo Reservoir from the San Antonio River and/or other sources as considered in Options S-15D and S-15E would tend to reduce the indicated changes in streamflow median and frequency at the dam site (Figure 5.1-3). Streamflow changes at the Guadalupe River Saltwater Barrier would be minimal as a result of the implementation of Cibolo Reservoir as described in this section.

5.1.3 Environmental Issues

The proposed Cibolo Reservoir is in the East Central Texas Plains Ecoregion and the South Texas Plains vegetation region.[6,7] Omernik describes the ecoregion as irregular plains

[6] Omernik, James M., 1987, "Ecoregions of the Conterminous United States," EPA/600/D-86, U.S. EPA, Corvallis, Oregon.
[7] Gould, Frank W., 1975, The Grasses of Texas, Texas A & M University, College Station, Texas.



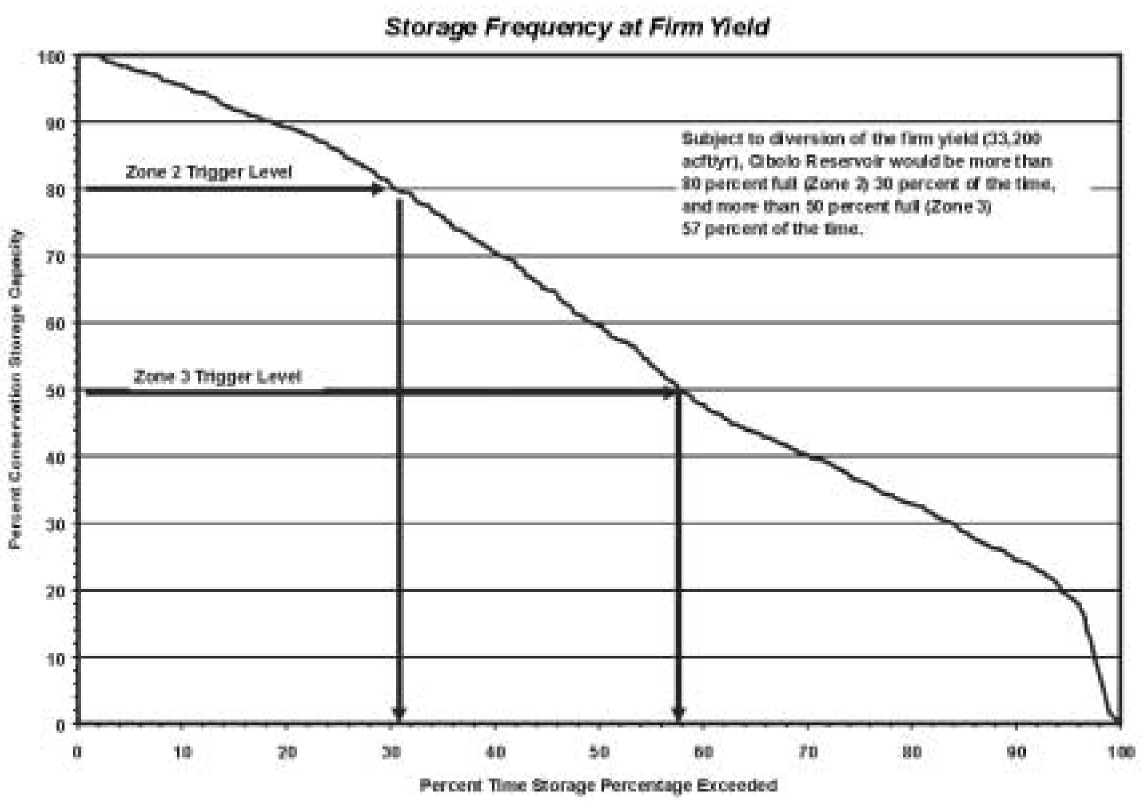


Figure 5.1-2. Cibolo Reservoir Storage Considerations

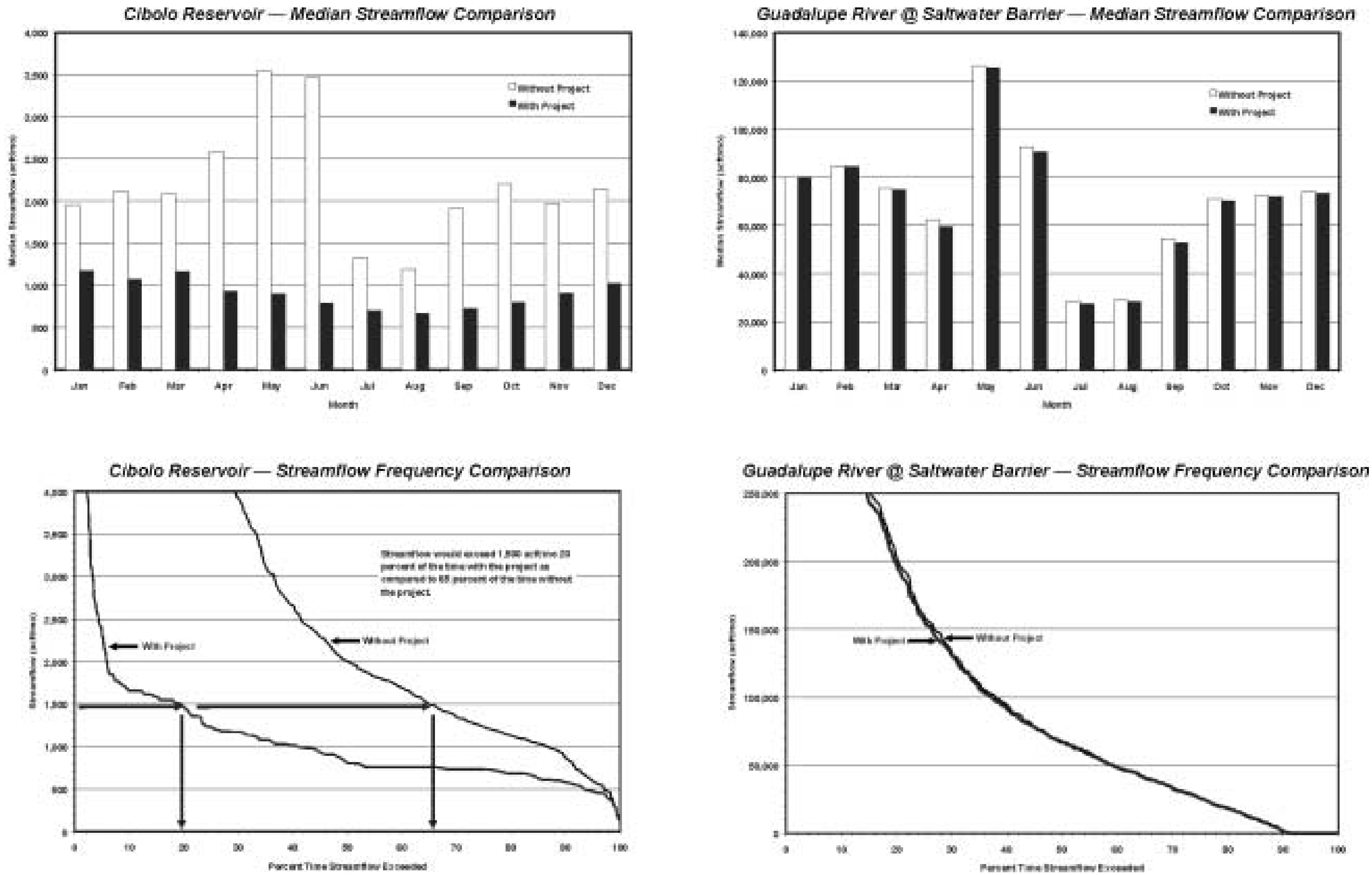


Figure 5.1-3. Cibolo Reservoir Streamflow Comparison

with oak and hickory woodlands, with some cropland and pasture on dry alfisols soils.[8] Correl and Johnston describe the South Texas Plains ecotone as being characterized by open prairies and a growth of mesquite, granjeno, cacti, clepe, coyotillo, guayacan, white brush, brasil, bisbirinda, cenizo, huisache, catclaw, black brush, guajillo and other small trees and shrubs.[9] There are distinct differences in climax plant communities and successional patterns depending upon local soils, topography, and position on the regional moisture gradient.

Soil types in the area of the proposed reservoir are of the Wilco-Floresville-Miguel (WFM), Elmendorf-Luling-Denhawken (ELD), and Tabor-Crockett (TC) associations.[10] The WFM association exhibits deep, nearly level to sloping, well drained, slowly permeable, and very slowly permeable sandy and loamy soils that have clayey lower layers. The ELD association consists of deep, nearly level to gently sloping, well drained, very slowly permeable, loamy and clayey soils that have clayey lower layers. The TC association has deep, nearly level to gently sloping, moderately well drained, very slowly permeable sandy and loamy soils that have clayey lower layers.[11]

Characteristic grasses of the sandy loam soils are seacoast bluestem, species of *Setaria*, *Paspalum*, *Chloris* and *Trichloris*, silver bluestem and coast sandbur. The characteristic grasses on the clay and clay loams are silver bluestem, Arizona cottontop, buffalo grass, curly mesquite, and species of *Setaria*, *Pappophorum* and *Bouteloua*. Grasses of the oak savannahs are mainly seacoast bluestem, Indian grass, switch grass, crinkle-awn and species of *Paspalum*. The brush and shrub communities often occur as scattered, overgrown pastures or abandoned cultivated fields surrounded by cultivated land.

Blair considers this area to be in the Tamaulipan Biotic Province which he characterizes as being dominated by thorny brush, including mesquite, various species of *Acacia* and *Mimosa*, granjeno, lignum vitae, cenizo, white brush, prickly pear, tasajillo, *Condalia*, and *Castel*.[12]

Although recent improvements in wastewater treatment facilities have greatly improved the quality of surface water in the upper reaches of Cibolo Creek, water quality remains poor in

[8] Omernik, James M., 1987, "Ecoregions of the Conterminous United States," EPA/600/D-86, U.S. EPA, Corvallis, Oregon.
[9] Correll, D.S., and M.C. Johnston. 1979, Manual of the Vascular Plants of Texas, Texas Research Foundation, Renner, Texas.
[10] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station, 1975, Soil Survey of Goliad County, Texas, USDA.
[11] Ibid.
[12] Blair, W. Frank, 1950, The Biotic Provinces of Texas, Texas Journal of Science, Vol 2, No. 1: pp. 93-117.

its middle reaches due to multiple municipal point source discharges.[13] Specific water quality assessments should be considered if Cibolo Reservoir becomes an element of the South Central Texas Regional Water Plan.

The reservoir would inundate approximately 16,700 acres of land and approximately 18 miles of stream channel (about 1,645 acres of lotic habitat) would be converted to lentic (lake) habitat.[14] Direct impacts resulting from inundation would include converting grasslands (2,900 acres), croplands (6,850 acres), brushlands (2,510 acres), parklands (555 acres), woodlands (3,715 acres), and wetlands (70 acres) into lentic aquatic habitat. Of particular significance is the loss of bottomland hardwood and riparian communities, and hydric soils along the creek and in the floodplain, which represent important wildlife habitat. Bottomland hardwood and riparian forest habitat types are not extensive in this region. Substantial areas of these woodlands have been cleared in order to convert the land to agricultural uses. As the extent of these habitat types is reduced, the value of the remaining areas increases. An indication of the ecological value of these habitats is the inclusion and preliminary listing in The Natural Areas of Texas of a zone averaging 0.5 mile wide on Cibolo Creek as it flows through Wilson County.[15]

The vertebrate community within the area of the proposed reservoir includes species from both the Tamaulipan and Texan Biotic Provinces.[16] The vertebrate community of the Texan province consists of approximately 49 species of mammals, 16 species of lizards, 2 species of Terrapene, at least 39 species of snakes, 5 species of urodeles, 18 species of anurans and an undetermined number of bird species. In addition, some of the vertebrate community of the Tamaulipan Biotic Province may be found in the area. Vertebrates of this biotic province may include neotropical, grassland, Austroriparian and some Chihuahuan province species. At least 61 species of mammals, 36 species of snakes, 19 species of lizards, 2 species of Terrapene, 3 urodeles and 19 anurans occur in the Tamaulipan province. Six of the 19 species of lizards of this province occur in the state only in this province. One species of land turtle, *Gopherus berlandieri*, is restricted to the Tamaulipan. Six of the 36 species of snakes known from the

[13] Texas Water Development Board (TWDB), "Water for Texas; Today and Tomorrow," Texas Water Development Board, Austin, Texas, December 1990.
[14] EH&A, "Water Availability Study for the Guadalupe and San Antonio River Basins," 1986.
[15] Ibid.
[16] Blair, W. Frank, 1950, The Biotic Provinces of Texas, Texas Journal of Science, Vol 2, No. 1:93-117.

Tamaulipan are unknown from other provinces in the state, however only two of them range as far north as the proposed reservoir. One species of urodel and five of the 19 species of anurans are restricted to this province but probably do not range as far north as the study area.

Several important aquatic species that warrant attention are the river darter *(Percina shumardi)*, the freshwater prawn *(Macrobrachium carcinus)*, and the American eel *(Anguilla rostrata).*[17] The river darter, an unprotected non-game fish, occurs in Cibolo Creek. The American eel and the freshwater prawn, although not recently collected, are known to have occurred historically in the Guadalupe River Basin. Reservoir development would alter the fishery from that of a stream (lotic) habitat to a reservoir (lentic) habitat. Species dependent upon a lotic type habitat for their life cycle would be eliminated within the lentic habitat.

Compensation will likely be required where unavoidable losses of ecologically important habitats occurs. Texas Parks and Wildlife Department has estimated that full compensation of terrestrial habitat losses for the project outlined by Espey, Huston & Associates, Inc., would require 28,958 acres of land under a minimum management scenario.[18]

While none have been reported from the reservoir site, several protected and candidate species listed by the Natural Heritage Program for Wilson County may have habitat in the vicinity of the proposed reservoir (Table 5.1-1). Bottomland hardwoods are habitat for the threatened Timber/Canebrake Rattlesnake. Many of these species appear to be dependent on upland habitats, including the reticulate collared lizard, Texas horned lizard, the Indigo snake, and Texas tortoise. Neither the warbler nor the vireo is likely to be present near the reservoir site, but the bald eagle, zone-tailed hawk, Texas garter snake, big red sage, and Parks' Jointweed could occur within the reservoir site. Two endangered species that occupy brushlands and dense thickets of mesquite-thorn scrub are the Ocelot and Jaguarundi. They are now listed by TPWD for Wilson County. Implementation of this alternative will require surveys for protected species or other biological resources of restricted distribution within the proposed reservoir area.

An archaeological investigation in 1967 (41WN1-41WN28, 41WN31-41WN56) recorded 54 sites in the proposed Cibolo Reservoir dating from the Archaic, Neo-American, and Historic periods. Of 21 sites recommended for investigation seven were recommended for excavation.[19]

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[17] Ibid.
[18] Espey, Huston & Associates, Inc., 1986, "Water Availability Study, for the Guadalupe - San Antonio River Basins."
[19] Ibid.

Table 5.1-1.
Important Species Known to Occur in the Study Area[1]
Cibolo Reservoir — Firm Yield (S-15C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	E	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T	E	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*				NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Jaguarundi	*Felis yaguarondi*	Thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened with silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident

Page 1 of 2

Table 5.1-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	T	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*				WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered/Threatened Blank = Rare, but no regulatory listing status

Page 2 of 2

The area covered for this survey was confined to the immediate first terrace and did not constitute a comprehensive survey of the entire reservoir site.[20] In addition, site 41WN72 was recorded by Texas A&M University in 1979 on the western edge of the proposed reservoir.

Cultural resources protection on public lands in Texas, or lands affected by projects regulated under Department of the Army permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

5.1.4 Engineering and Costing

The cost estimate for the dam and reservoir were originally performed by EH&A.[21] That cost estimate has been updated to Second Quarter 1999 costs by using the Engineering News Record Construction Cost Indexes.

For this option, the firm yield of the proposed reservoir would be diverted through an intake and pumped in a transmission pipeline to a water treatment plant at the major municipal demand center of the South Central Texas Region. The diversion rate from the reservoir has been assumed uniform throughout the year. Potential benefits from this project might include the addition of a new surface water supply to the major municipal demand center and/or enhanced recharge to the Edwards Aquifer and the increased availability of water to supply wells and springs. The major facilities or cost elements required to implement this option include:

- Dam and Reservoir;
- Reservoir Intake and Pump Station;
- Raw Water Pipeline to Treatment Plant;
- Water Treatment Plant; and
- Distribution.

The reservoir intake and pump station is sized to deliver 2,800 acft/month (48 cfs) through a 48-inch diameter pipeline, approximately 42 miles in length. The operating cost was determined for the total raw water static lift of 350 feet and an annual water delivery of

[20] Ibid.
[21] EH&A, Op. Cit., February 1986.

33,200 acft/yr. Financing the reservoir over 40 years at a 6 percent annual interest rate and the remaining project over 30 years at a 6 percent annual interest rate results in an annual expense of $25,642,000 (Table 5.1-3). Operation and maintenance costs, including power, total $6,741,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $32,383,000. For an annual firm yield of 33,200 acft, the resulting annual cost of water is $975 per acft (Table 5.1-3). The firm yield of Cibolo Reservoir can be increased and the annual unit cost of water decreased with the importation of water from the San Antonio River and/or other sources as considered in Options S-15D and S-15E.

5.1.6 Implementation Issues

Implementation of Cibolo Reservoir could directly affect the feasibility of other water supply options under consideration, including L-18 and/or S-16C.

An institutional arrangement is needed to implement projects including financing on a regional basis.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. General Land Office (GLO) Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
   2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads
   b. Other utilities

Table 5.1-3.
Cost Estimate Summary for
Cibolo Reservoir — Firm Yield (S-15C)
(Second Quarter – 1999 Prices)

Item	***Estimated Cost***
Capital Costs	
Dam and Reservoir (Conservation Pool: 409,700 acft; 16,700 acres; 416 ft-msl)	$127,335,000
Intakes and Pump Stations	7,654,000
Water Treatment Plant (31.2 MGD)	23,312,000
Transmission Pipeline (48-inch; 42.3 miles)	31,295,000
Distribution	3,354,000
Total Capital Cost	**$192,950,000**
Engineering, Legal Costs, and Contingencies	$65,585,000
Environmental & Archaeology Studies and Mitigation	25,862,000
Land Acquisition and Surveying (18,059 acres)	29,230,000
Interest During Construction (4 years)	50,181,000
Total Project Cost	**$363,808,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$17,179,000
Debt Service (6 percent for 40 years)	8,463,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	451,000
Dam and Reservoir	1,910,000
Water Treatment Plant	2,567,000
Pumping Energy Costs (30,222,963 kWh @ $0.06 per kWh)	1,813,000
Total Annual Cost	**$32,383,000**
Available Project Yield (acft/yr)	33,200
Annual Cost of Water ($ per acft)	$975.39
Annual Cost of Water ($ per 1,000 gallons)	$2.99

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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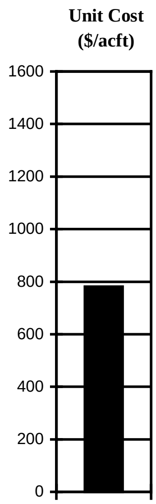

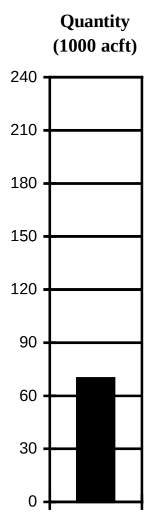

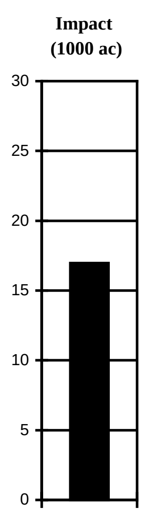

OPTION NUMBER: S-15Da

OPTION NAME: Cibolo Reservoir With Imported Water From the San Antonio River — Firm Yield

OPTION DESCRIPTION: *The firm yield of the proposed Cibolo Reservoir located in Wilson County would be supplemented with water diverted from the San Antonio River near Floresville via a 72-inch diameter pipeline, and then delivered to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$779**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**69,925**	**acft/yr[2]**
LAND IMPACTED:	**16,960**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Dam and reservoir, intake and pump station at the reservoir, San Antonio River intake and pump station, transmission pipelines, treatment plant and treatment costs, and mitigation.

[2]**QUANTITY OF WATER:** Reclaimed water availability from the San Antonio River and diversion pipeline size, instream flow requirements, Edwards Aquifer pumpage levels, and quantities of return flows needed in the San Antonio River to meet downstream water rights.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of 18 miles of stream channel, much of which is lined with bottomland hardwoods and riparian communities.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Instream flow requirements, habitat mitigation, and technical factors affecting use of San Antonio River water via storage in Cibolo Reservoir.

ADDITIONAL FACTORS: Additional studies considering water quality issues need to be undertaken for this option.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Db, S-15Dc, S-15Ea, S-15Eb, S-16C, G-16C1, G-17C1, G-20, SCTN-6, SCTN-14b, SCTN-16b, and/or SCTN-16c.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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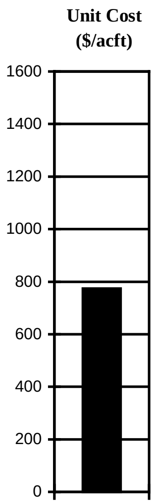
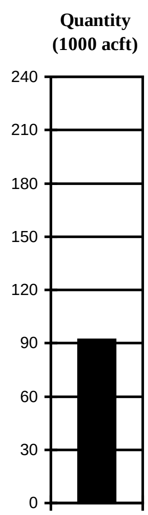
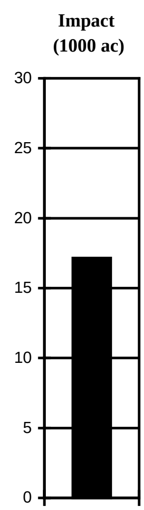






OPTION NUMBER: **S-15Db**

OPTION NAME: **Cibolo Reservoir with Imported Water from the San Antonio and Guadalupe Rivers — Firm Yield**

OPTION DESCRIPTION: *The firm yield of Cibolo Reservoir, located in Wilson County, would be supplemented with water diverted from the San Antonio River near Floresville via a 72-inch diameter pipeline, and water from the Guadalupe River at Cuero via an 84-inch diameter pipeline, and then delivered to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$773**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**91,942**	**acft/yr[2]**
LAND IMPACTED:	**17,160**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, intakes and pump station at the reservoir, San Antonio and Guadalupe Rivers intakes and pump stations, transmission pipelines, treatment plant and costs, and mitigation.

[2]**QUANTITY OF WATER:** Water availability from the San Antonio and Guadalupe Rivers and diversion pipeline sizes; instream flow requirements, Edwards Aquifer pumpage levels, and quantities of flows needed in the San Antonio and Guadalupe Rivers to meet downstream water rights.

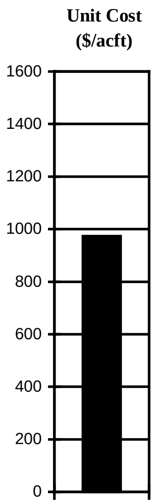
[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

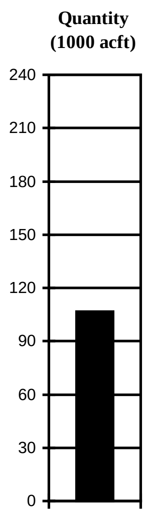
ENVIRONMENTAL ISSUES: Inundation of 18 miles of stream channel, much of which is bottomland hardwoods and riparian communities.

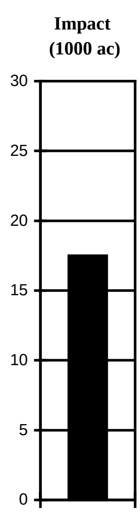
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Quantity of instream flow requirements, habitat mitigation, and technical factors affecting use of San Antonio River water via storage in Cibolo Reservoir.

ADDITIONAL FACTORS: Ability to obtain permits to move water from the Guadalupe River Basin to the San Antonio area. Additional studies considering water quality issues need to be undertaken for this option.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Dc, S-15Ea, S-15Eb, S-16C, G-16C1, G-17C1, G-20, G-21, G-22, G-38C, SCTN-6, SCTN-14b, SCTN-16b, and/or SCTN-16c.







SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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OPTION NUMBER: S-15Dc
OPTION NAME: Cibolo Reservoir with Imported Water from the San Antonio, Guadalupe, and Colorado Rivers — Firm Yield

OPTION DESCRIPTION: *The firm yield of Cibolo Reservoir, located in Wilson County, would be supplemented with water diverted from the San Antonio River near Floresville via a 72-inch diameter pipeline, from the Guadalupe River at Cuero via two 90-inch diameter pipelines, and from the Colorado River near Columbus via a 96-inch diameter pipeline, and then delivered to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$965**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**106,482**	**acft/yr[2]**
LAND IMPACTED:	**17,493**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, intakes and pump stations at the reservoir, San Antonio, Guadalupe, and Colorado Rivers intakes and pump stations, transmission pipelines, treatment plant and treatment costs, and mitigation.

[2]**QUANTITY OF WATER:** Water availability from the San Antonio, Guadalupe and Colorado Rivers and diversion pipeline sizes; instream flow requirements, Edwards Aquifer pumpage levels, and quantities of flows in the source rivers to meet downstream water rights.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of 18 miles of stream channel, much of which is lined with bottomland hardwoods and riparian communities. The Colorado River from Longhorn Dam in Travis County downstream to Matagorda Bay is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Quantity of instream flow requirements, habitat mitigation, and technical factors (e.g., water quality) affecting use of San Antonio River water via storage in Cibolo Reservoir.

ADDITIONAL FACTORS: Ability to obtain permits to move water from the Guadalupe and Colorado River Basins to the San Antonio area.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Ea, S-15Eb, S-16C, G-16C1, G-17C1, G-20, G-21, G-22, G-38C, C-13C, C-17A, C-17B, C-18, SCTN-6, SCTN-14b, SCTN-15, SCTN-16b, and/or SCTN-16c.

5.2 Cibolo Reservoir with Imported Water from the San Antonio (S-15Da), Guadalupe (S-15Db), and Colorado Rivers (S-15Dc) — Firm Yield

5.2.1 Description of Options

The firm yield of the proposed Cibolo Reservoir, located in Wilson County, would be supplemented with water diverted from the San Antonio River near Floresville, Guadalupe River near Cuero, and Colorado River near Columbus into Cibolo Reservoir, and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region. Treated water would then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone. The proposed reservoir site is located on Cibolo Creek about 8 miles east of Floresville. The project has been studied by the U.S. Bureau of Reclamation,[1,2] Espey, Huston & Associates, Inc.,[3] and most recently by HDR Engineering, Inc (HDR) in the Trans-Texas Water Program.[4] An evaluation of Cibolo Reservoir using only runoff from the Cibolo Creek watershed is presented in Section 5.1.

Cibolo Reservoir has a proposed conservation storage capacity of about 409,700 acft below elevation 416 ft-msl. As noted in Section 5.1 (Figure 5.1-2), the reservoir would fill only infrequently with runoff from the Cibolo Creek watershed, leaving ample capacity available for storage of water from other sources. Hence, Option S-15D, as presented herein, includes importation of unappropriated water from the San Antonio (as well as reclaimed water from the San Antonio River), Guadalupe, and Colorado Rivers to Cibolo Reservoir through a system of river intakes, pump stations, and pipelines, as shown in Figures 5.2-1 through 5.2-3. Three independent importation source scenarios for Cibolo Reservoir have been studied and are described as follows:

S-15Da Importing water from the San Antonio River near Floresville (Figure 5.2-1);

S-15Db Importing water from the San Antonio River near Floresville and the Guadalupe River at Cuero (Figure 5.2-2); and

S-15Dc Importing water from the San Antonio River near Floresville, the Guadalupe River at Cuero, and the Colorado River near Columbus (Figure 5.2-3).

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1 U.S. Bureau of Reclamation (USBR), "Texas Basins Project," February 1965.
2 USBR, "Feasibility Report, Cibolo Project, Texas," February 1971.
3 Espey Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," San Antonio River Authority, Guadalupe-Blanco River Authority, City of San Antonio, February 1986.
4 HDR Engineering, Inc. (HDR), "West Central Study Area Phase I Interim Report," Vol. IV, Trans-Texas Water Program, San Antonio River Authority, January 1996.

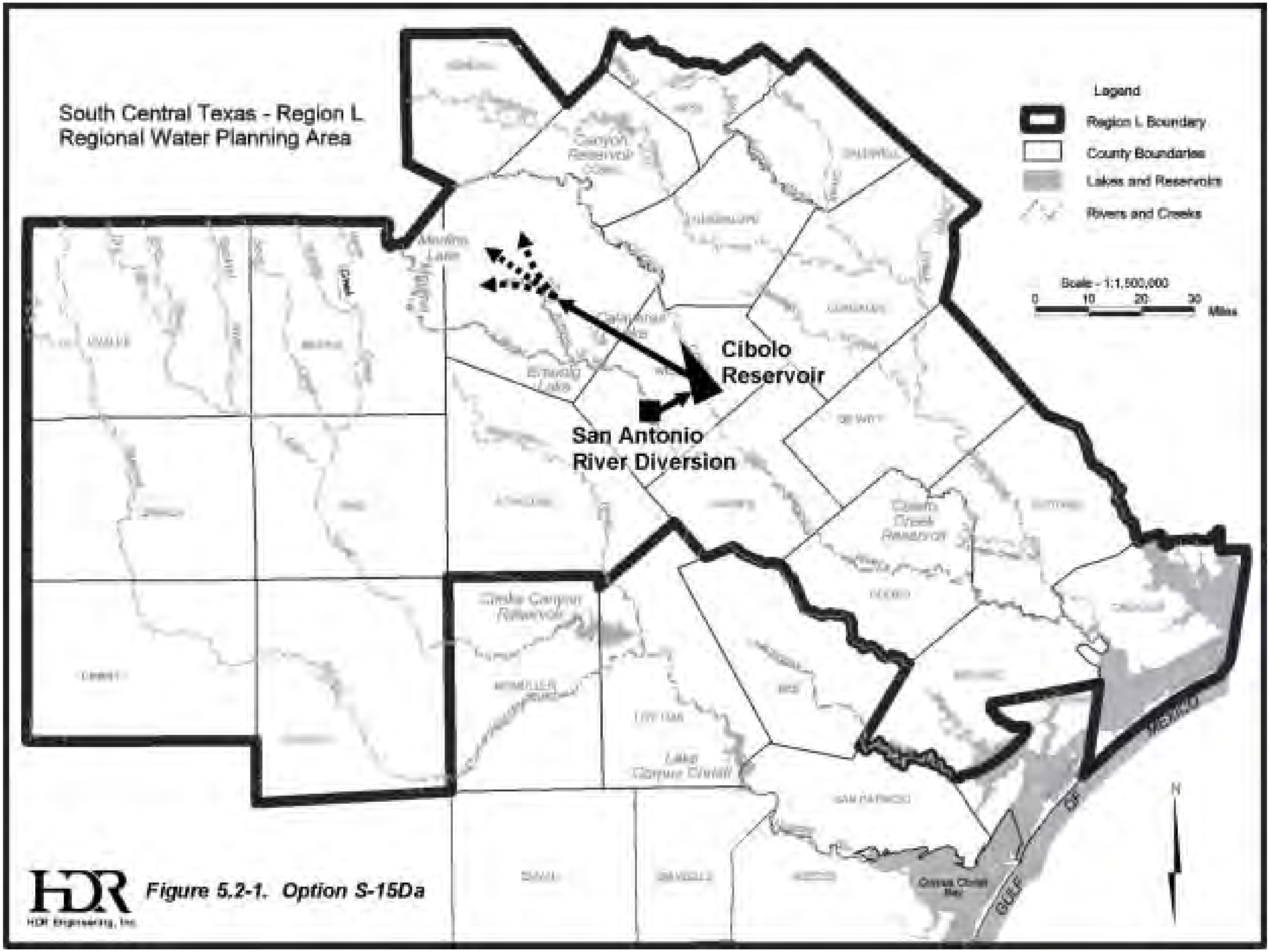


Figure 5.2-1. Option S-15Da

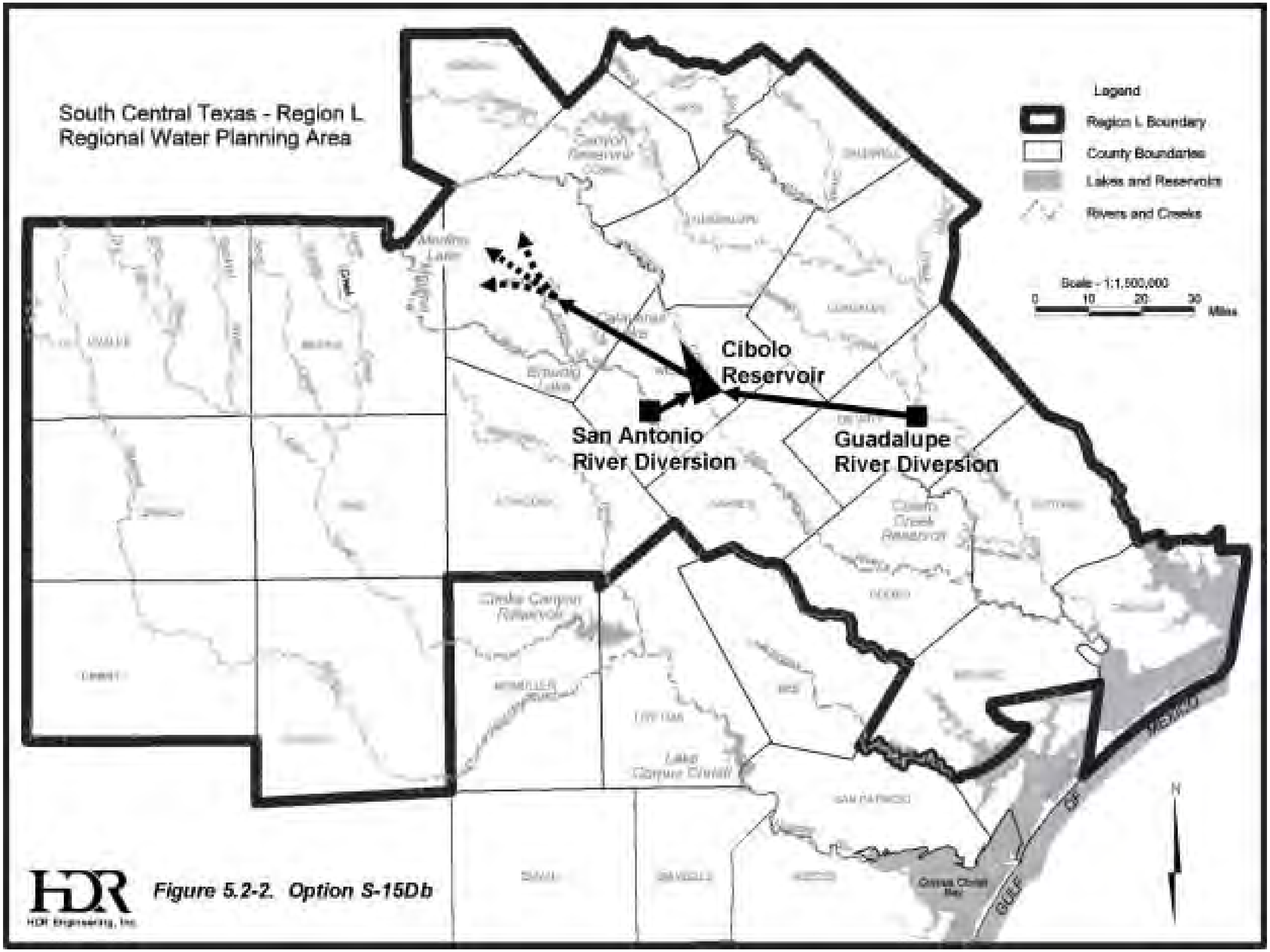


Figure 5.2-2. Option S-15Db

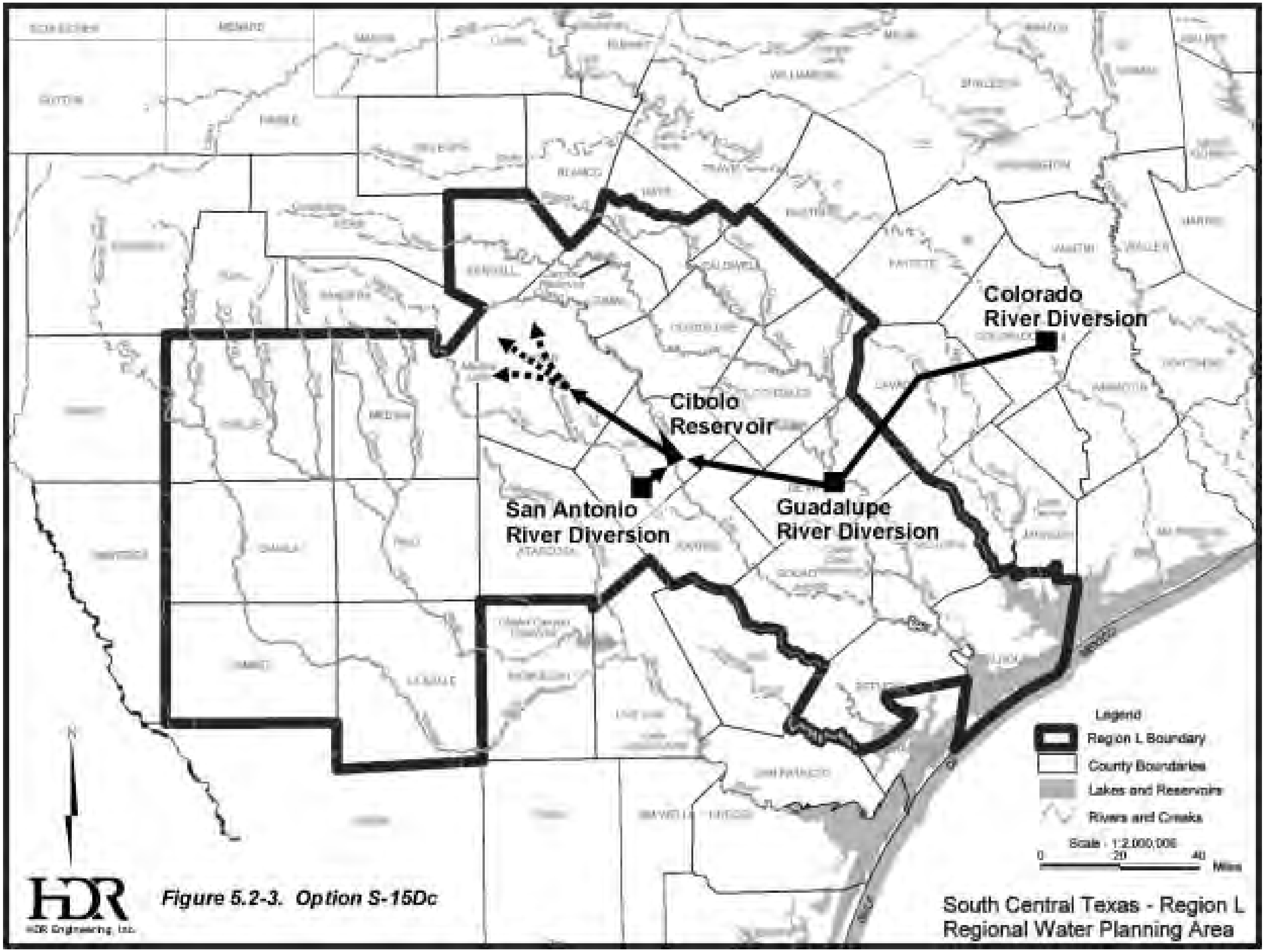


Figure 5.2-3. Option S-15Dc

5.2.2 Available Yield

Water potentially available for impoundment in the proposed Cibolo Reservoir and for importation from the San Antonio and Guadalupe Rivers was estimated using the Guadalupe-San Antonio River Basin Model[5] (GSA Model) based on a 1934 through 1989 period of record. Estimates of water availability in the Guadalupe-San Antonio River Basin were derived subject to the general assumptions for applications of hydrologic models as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

Unappropriated streamflow potentially available from the Colorado River near Columbus was estimated using the latest version of the Lower Colorado River Authority's (LCRA) RESPONSE model. This model simulates Highland Lake System storage and streamflow in the Colorado River and allocates water to authorized diversions, based on seniority of water rights, for a 1941 through 1965 simulation period. Water availability estimates from the Colorado River were derived subject to environmental criteria adopted for the Lower Colorado River and the Lavaca-Colorado Estuary.[6]

The SIMDLY model, originally developed by the Texas Water Development Board (TWDB) and modified by HDR, was utilized to calculate the firm yield of Cibolo Reservoir subject to daily inflow passage criteria and available imported water as computed by the GSA Model or the RESPONSE model. Finally, the GSA Model was used to assess changes in streamflow for the Guadalupe River at the Saltwater Barrier assuming Cibolo Reservoir operations with the diversion of the firm yield.

The water availability analyses and assessment of firm yield proceeded in a sequential manner, starting at the San Antonio River above Floresville, moving next to the Guadalupe River at Cuero, and, finally, adding unappropriated water potentially available from the Colorado River near Columbus. Water potentially available for diversion from the San Antonio River above Floresville was computed assuming reuse of available San Antonio Water System (SAWS) treated effluent. The GSA Model was used to estimate monthly SAWS effluent quantities arriving at the proposed diversion point after honoring intervening water rights and other uses for reclaimed water including SAWS recycling program and make-up water for Braunig

[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[6] LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

and Calaveras Lakes. Assuming diversion of available SAWS effluent, unappropriated streamflows above Floresville were then estimated subject to Consensus Environmental Criteria (Appendix B) using the GSA Model. Note that the 7Q2 value published in the Texas Natural Resource Conservation Commission's (TNRCC) Water Quality Standards (211.2 cfs) was used as the minimum (Zone 3) streamflow passage requirement although recent water quality modeling indicates that substantially less streamflow need pass Falls City to comply with the TNRCC's 5 mg/L standard for minimum dissolved oxygen.[7] The monthly amounts of available SAWS effluent, uniformly distributed to a daily pattern, and the daily unappropriated streamflows were combined to determine the totals available for diversion from the San Antonio River above Floresville into Cibolo Reservoir. Total availability was limited to the transmission capacity of a 72-inch diameter pipeline, which was identified as the optimum size in a previous study.[8]

The computed firm yield of Cibolo Reservoir with importation of water from the San Antonio River (S-15Da) is 69,925 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. Figure 5.2-4 illustrates simulated Cibolo Reservoir storage fluctuations and a reservoir storage frequency as operated under the Consensus Environmental Criteria (Appendix B) and subject to diversion of the firm yield.

Once total water available from the San Antonio River above Floresville was established, unappropriated streamflow from the Guadalupe River at Cuero was estimated using the GSA Model. Water availability estimates for the Guadalupe River account for water diverted from the San Antonio River and water impounded in Cibolo Reservoir, thereby avoiding overestimation of unappropriated streamflow. Availability from the Guadalupe River was limited to the transmission capacity of an 84-inch diameter pipeline, which was identified as the optimum size in a previous study.[9]

The computed firm yield of Cibolo Reservoir with importation of water from the San Antonio and Guadalupe Rivers (S-15Db) is 91,942 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. Figure 5.2-5 illustrates

[7] HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, San Antonio River Authority, et al., March 1998.
[8] HDR, Op. Cit., January 1996.
[9] Ibid.

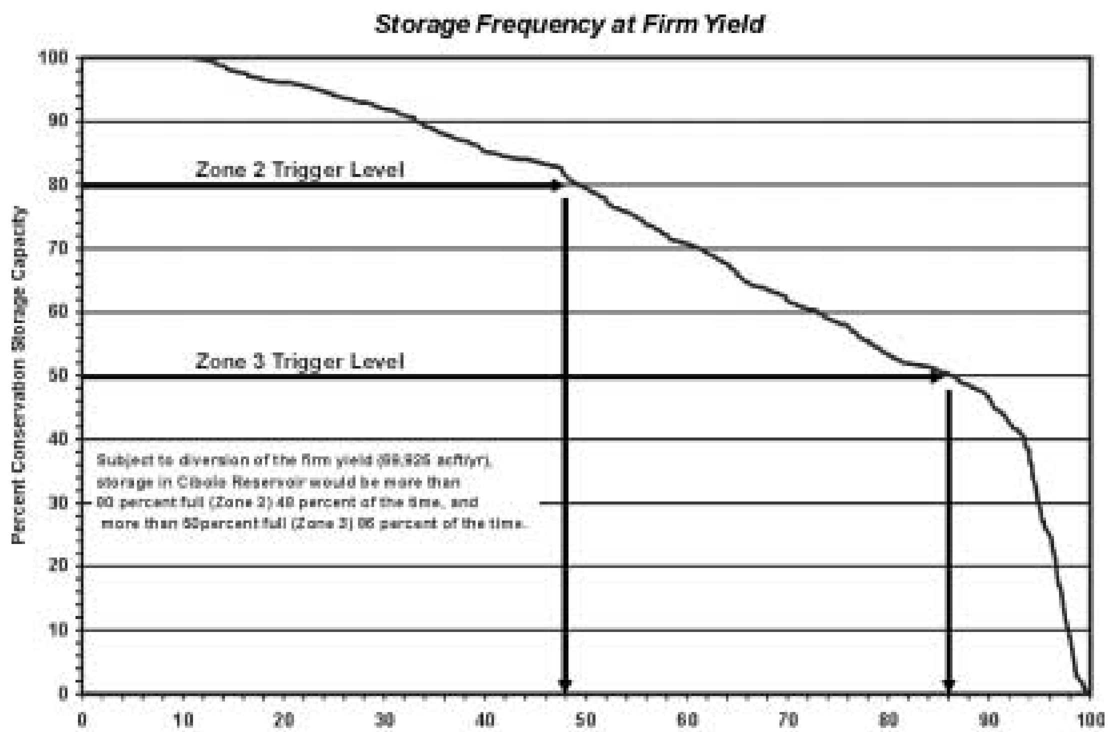


Figure 5.2-4. Cibolo Reservoir with San Antonio River, Storage Considerations

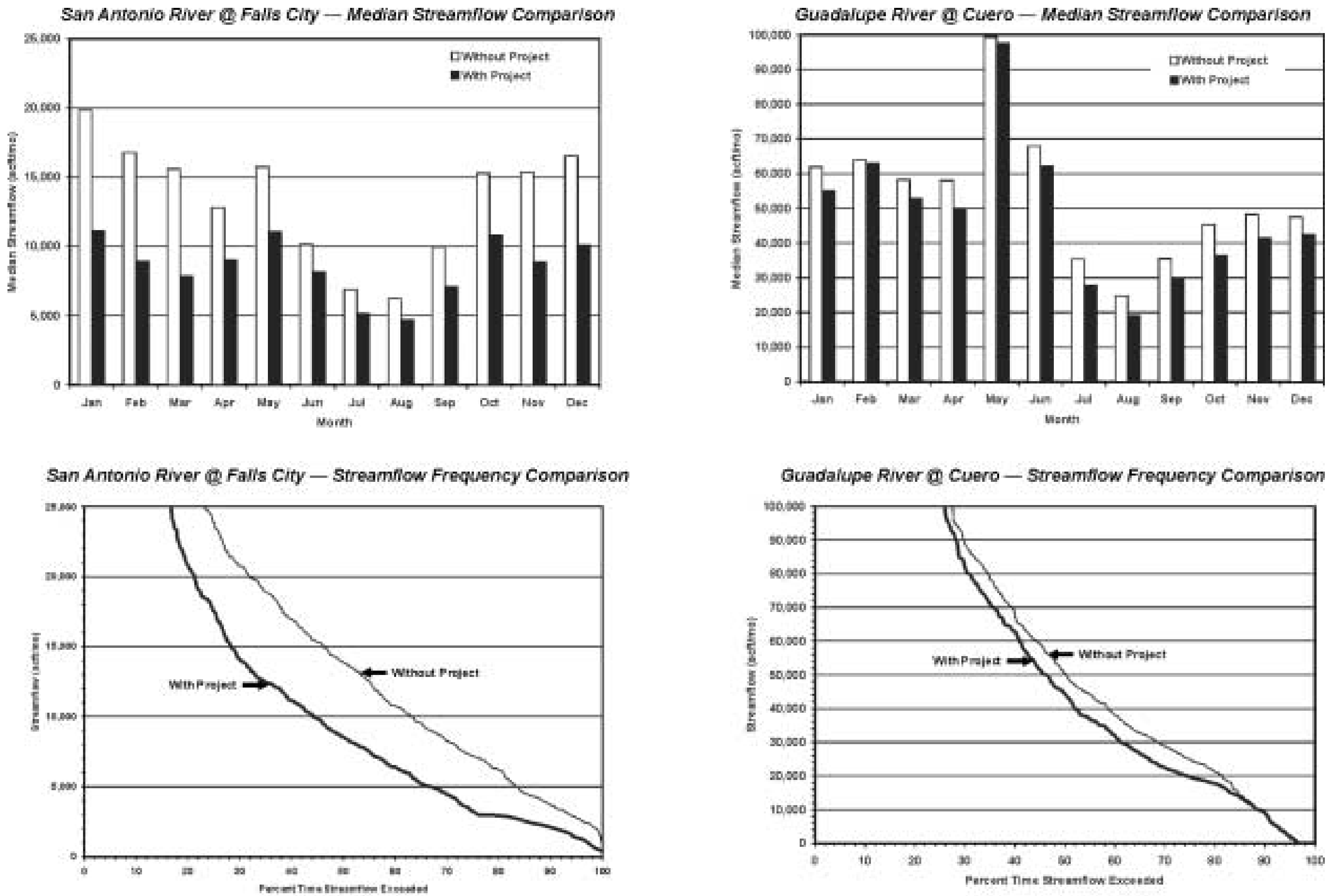


Figure 5.2-6. Cibolo Reservoir with San Antonio and Guadalupe Rivers, Streamflow Comparisons

simulated Cibolo Reservoir storage fluctuations and reservoir storage frequency as operated under the Consensus Environmental Criteria (Appendix B) and subject to diversion of the firm yield. Note that the duration of the critical drought period would be reduced and the frequency of higher reservoir levels would be increased with importation of water from the Guadalupe River to Cibolo Reservoir. Monthly median streamflows and streamflow frequency curves with and without the project are presented for the San Antonio and Guadalupe Rivers in Figure 5.2-6 and for the Cibolo Reservoir site and the Guadalupe River Saltwater Barrier in Figure 5.2-7.

The computed firm yield of Cibolo Reservoir with importation of water from the San Antonio, Guadalupe, and Colorado Rivers (S-15Dc) is 106,482 acft/yr, which represents a reliable supply based on the 1941 to 1965 historical period of hydrologic record and a 96-inch transmission pipeline from the Colorado River. Neither reservoir storage considerations nor streamflow comparisons are presented for this option because of the shorter period of available hydrologic record.

5.2.3 Environmental Issues

The proposed Cibolo Reservoir near Stockdale (Option S-15) has been described in Section 5.1, hence, the following discussion focuses on issues relevant to diverting water from the San Antonio, Guadalupe, and Colorado Rivers, and the transmission pipelines required to transport it to the proposed Cibolo Reservoir (Figures 5.2-1 through 5.2-3). Option S-15D involves water transmission lines between the San Antonio River near the City of Floresville and the proposed Cibolo Reservoir, and between the Colorado River east of the City of Altair (upstream from Garwood) and Cibolo Reservoir. Additional water would be diverted from the Guadalupe River where the Colorado River to Cibolo Reservoir pipeline crosses the Guadalupe River near the City of Cuero.

The project area for Option S-15D includes Colorado, Lavaca, DeWitt, Karnes, Wilson, and Bexar Counties. The proposed Floresville to Cibolo Reservoir pipeline lies within the South Texas Plains Vegetational Area near its northern boundary with the Blackland Prairies Vegetational Area. The Colorado River to Cibolo Reservoir pipeline courses through the Post Oak Savannah Vegetational Region in Colorado County, near the boundary between the Blackland Prairies and Post Oak Savannah in Lavaca and northern Dewitt Counties, and through the South Texas Plains in southern Dewitt, Karnes and Wilson Counties.

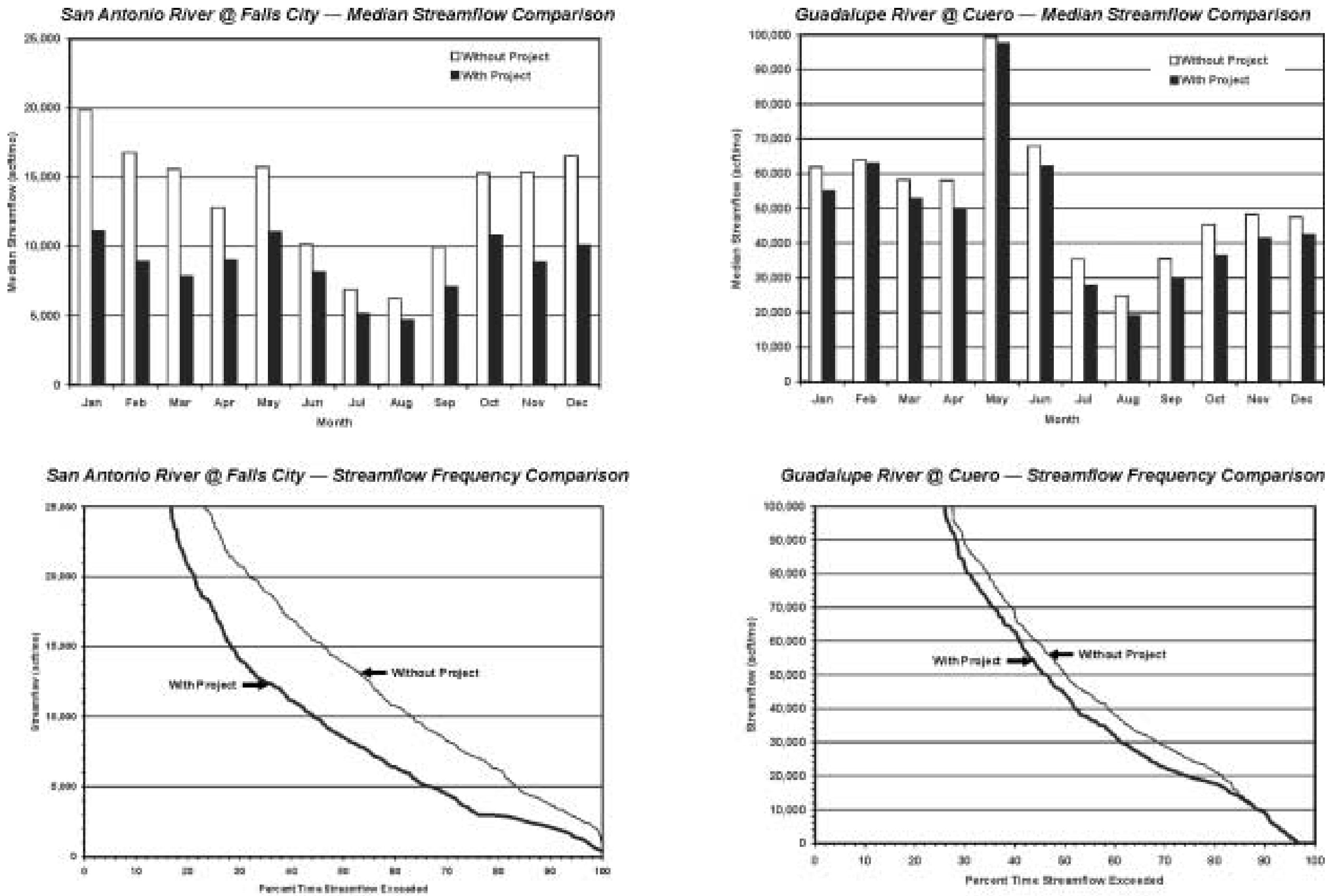


Figure 5.2-6. Cibolo Reservoir with San Antonio and Guadalupe Rivers, Streamflow Comparisons

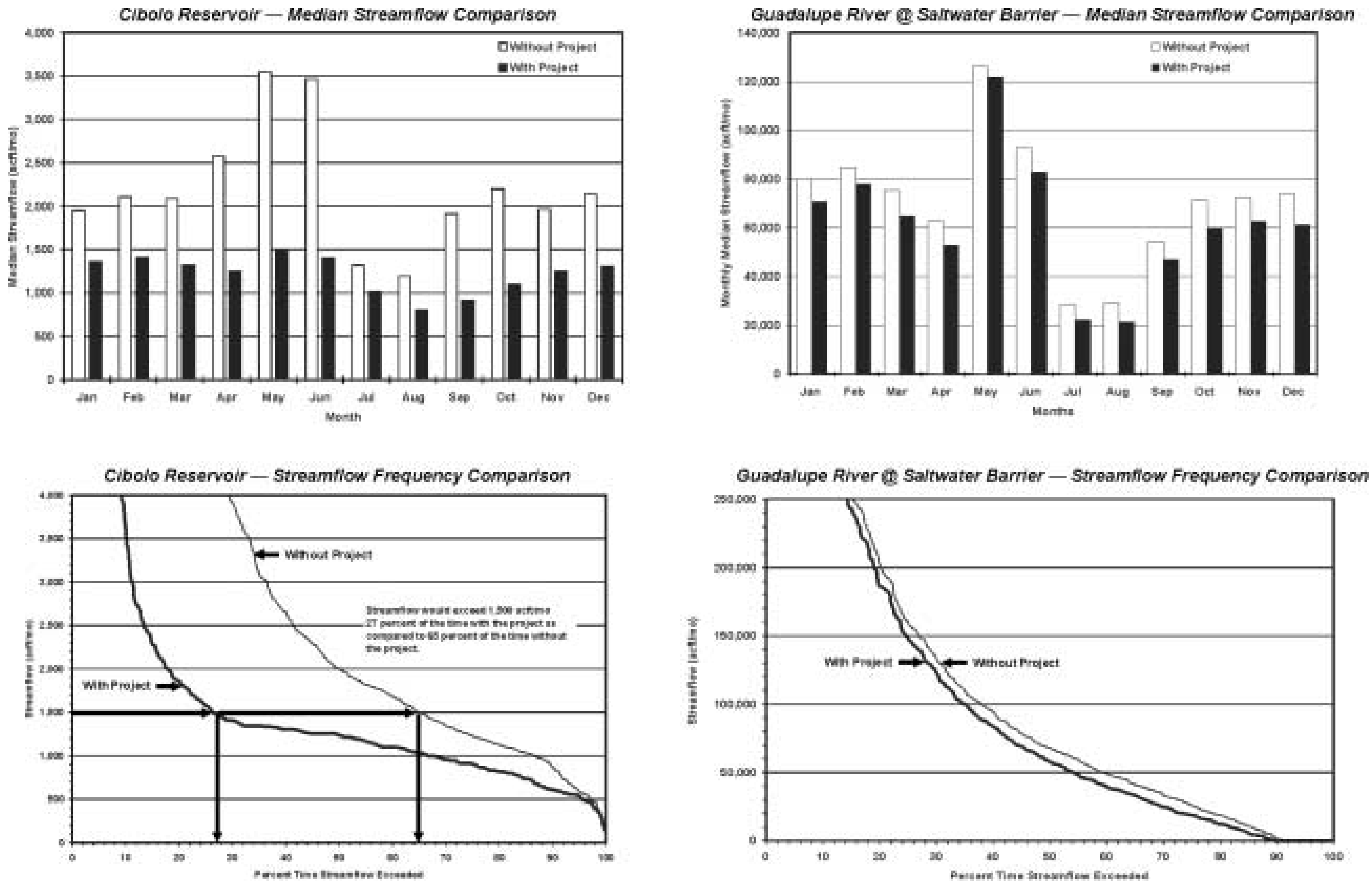


Figure 5.2-7. Cibolo Reservoir with San Antonio and Guadalupe Rivers, Streamflow Comparisons

The South Texas Plains lie within Blair's Tamaulipan Biotic Province. The Post Oak Savannah and Blackland Prairies Vegetational Regions lie within the Texan Biotic Province. The Texan Biotic Province is an ecotone, or ecologically transitional region between the Austroriparian Biotic Province to the northeast and the Tamaulipan Province to the southwest. The plant and animal species of the Texan Province are a mixture of species characteristic of the Austroriparian and Tamaulipan Provinces. Furthermore, riparian woodlands dissecting the Texan Province provide corridors for migration and an important habitat type in this predominately grassland region.

The Blackland Prairies region includes the San Antonio and Fayette Prairies. Topography is gently rolling to nearly level, well dissected with rapid surface drainage. Blackland Soils are fairly uniform dark-colored calcareous clays interspersed with some gray acid sandy loams. For the most part, this fertile area has been brought under cultivation, although a few native hay meadows and ranches remain. The Blackland Prairies Vegetational Region is a true prairie with little bluestem (*Schizachyrium scoparium var. frequens)* as a climax dominant. Other important grasses include big bluestem, Indian grass, switchgrass *(Panicum virgatum),* sideoats grama *(Bouteloua curtipendula),* hairy grama, *(Bouteloua hirsuta),* tall dropseed *(Sporoboulus asper),* silver bluestem *(Bothriochloa saccharoides)* and Texas winter-grass *(Stipa hirsuta).* Under heavy grazing, Texas wintergrass, buffalo grass *(Buchloe dactyloides),* Texas grama *(B. rigidiseta),* smutgrass and many annuals increase or invade. Mesquite *(Prosopis glandulosa)* also has invaded hardland sites of the southern portion of the Blackland Prairies. Post oak *(Quercus stellata)* and blackjack oak *(Q. marilandica)* increase on the medium- to light-textured soils. Although classed as a true prairie, the Blackland Prairie has much timber, especially along the streams that traverse it. Common tree species include a variety of oaks, pecan, cedar elm (*Ulmus crassifolia),* bois d'arc *(Maclura pomifera)* and mesquite.

The Post Oak Savannah Area lies immediately west of the primary forest region of Texas.[10] Some authorities consider the plant association as part of the oak-hickory formation. Based on the fact that the typical understory vegetation is tall grass, others classify the area as part of the true prairie association of the grassland formation. There is evidence that the brush

[10] Correl, D.S. and M.C. Johnston, “Manual of the Vascular Plants of Texas, “ The University of Texas at Dallas, Richardson, Texas, 1979.

and tree densities have increased tremendously from the virgin condition. Topography of the Post Oak Savannah is gently rolling to hilly. Rainfall averages 35 to 45 inches annually. Soils on the uplands are light-colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the Post Oak Savannah is in native or improved pastures although small farms are common. Climax grasses include little bluestem, Indian grass, switchgrass, purpletop (*Tridens flavus)*, silver bluestem, Texas wintergrass *(Stipa leucotricha)* and *Chasmanthium sessiliflorum*. The overstory is primarily post oak and blackjack oak. Many other brush and weedy species are also common. Some invading plants are red lovegrass, broomsedge, splitbeard bluestem *(Andropogon ternarius)*, yankeeweed, bullnettle *(Cnidoscolus texanus)*, greenbrier, yaupon *(Ilex vomitoria)*, smutgrass and western ragweed.

The South Texas Plains are also termed the Rio Grande Plains, or Tamaulipan Brushlands.[11] The South Texas Plains Vegetational Area and the Gulf Prairies and Marshes Vegetational Area correspond with the Southern Texas Plains Ecoregion[12] and the Western Gulf Coastal Plain Ecoregion,[13] respectively. The topography is level to rolling, and the land is dissected by arroyos or by streams flowing into the Rio Grande and Gulf of Mexico. It is characterized by open prairies and a growth of mesquite, granjeno (*Celtis pallida), cacti, clepe (Ziziphus obtusifolia), coyotillo (Karwinskia Humboldtiana), guayacan (Porlieria angustifolia),* white brush *(Aloysia gratissima), brasil (Condalia Hookeri), bisbirinda (Castela texana), cenizo (Leucophyllum spp.), huisache (Acacia Farnesiana),* catclaw (*A. greggii)*, black brush *(A. rigidula), guajillo (A. Berlandieri)* and other small trees and shrubs that are found in varying degrees of abundance and composition.[14] Although historically the area was grassland or savannah type climax vegetation, long-continued heavy grazing and other factors have resulted in a general change to a cover of shrubs and low trees. Among the several species of shrubs and trees that have made dramatic increases are mesquite, live oak, post oak, *Opuntia spp.* and *Acacia spp.*[15] Blair[16] described the South Texas Plains (Tamaulipan Province) as being

[11] Ibid.
[12] Omernik, James M, "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1):pp. 118-125, 1986.
[13] Ibid.
[14] Correll, D. S. and M. C. Johnston, Op. Cit., 1979.
[15] Gould, F. W., "The Grasses of Texas," Texas A&M University Press, 1975.
[16] Blair, F.W, "The Biotic Provinces of Texas," The Texas Journal of Science, 2:93-117, 1950.

characterized by the predominance of thorny brush vegetation. This brushland stretches from the Balcones fault line southward into Mexico. A few species of plants account for the bulk of the brush vegetation and give it a characteristic aspect throughout the Tamaulipan Biotic Province of Texas. The most important include: mesquite, lignum vitae (*Porliera angustifolia), cenizo (L. texanum),* white brush *(A. gratissima),* prickly pear *(O. lindheimeri), tasajillo (O. leptocaulis), Condalia sp.* and *Castela sp.* The brush on sandy soils differs in species and aspect from that on clay soils. Mesquite, in an open stand and mixed with various grasses, is characteristic of sandy areas. Clay soils usually have all of the species listed above, including mesquite. Although rangeland predominates throughout the South Texas Plains/Tamaulipan Brushland, land use also includes significant acreages in croplands.

The water transmission pipeline between the San Antonio River and Cibolo Reservoir would be about 9.5 miles long. A construction right-of-way 140 feet wide would affect about 161 acres including 16 acres (10.4 percent) of grassland/pasture, 51 acres (31.6 percent) of brush, 7 acres (4.1 percent) of park, and 87 acres (53.9 percent) of crop. A 40-foot wide right-of-way maintained free of woody vegetation for the life of the project would total 46 acres with those areas in grassland/pasture or cropland expected to return to their original condition. Texas Natural Heritage program records indicate that Park's jointweed (*Polygonella parksii)* and Elmendorph's onion *(Allium elmendorii)* could occur along the proposed route. Site records for Park's jointweed and Elmendorph's onion are reported near the City of Floresville (Floresville and Dewees USGS 7.5-minute quadrangle). Park's jointweed is in the Knotweed family and has been assigned a status of 3C (no longer under federal review for listing; either more abundant or widespread than was previously thought) by U.S. Fish and Wildlife Department. However, Park's jointweed has been assigned a state rank of 2C (imperiled in the state because of rarity; very vulnerable to extirpation) by Texas Parks and Wildlife Department.

The water transmission pipeline between the Colorado River east of the City of Altair and Cibolo Reservoir would be about 108 miles long. A construction right-of-way 140 feet wide would affect a total of 1840 acres including 370 acres (20.1 percent) of grassland/pasture, 695 acres (37.8 percent) of brush, 31 acres (1.7 percent) of park, 35 acres (1.9 percent) of wood, and 641 acres (34.8 percent) of crop. About 68 acres (3.7 percent) has been developed for residential, commercial, and industrial purposes. A 40-foot wide right-of-way maintained free of woody vegetation for the life of the project would total 526 acres. Those areas within the 40 foot maintenance right-of-way that lie within grassland/pasture and cropland would be expected to return to their original condition upon completion of the project. Within 10 years, woody vegetation in the brush habitats would be expected to significantly encroach into those areas of the construction right-of-way that would not be mowed.

Important species having habitat or known to occur in counties potentially affected by Option S-15D are listed in Table 5.2-1. The Texas Natural Heritage Program reports several occurrences of the two-flower stickpea (Polygonella biflora) on the Yorkton East, USGS 7.5-minute quadrangle map. One reported site occurrence is along State Highway 119, which is on the proposed pipeline route. The Texas Organization of Endangered Species (TOES) considers the two-flower stickpea as a "Category V – TOES Watch List" plant (has either low population or restricted range in Texas and is not declining or being restricted in its range but requires attention to insure that the species does not become endangered or threatened."

Table 5.2-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cibolo Reservoir with Imported Water (S-15D)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Birds						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in Bexar, Wilson, Karnes, Dewitt, Lavaca, Colorado
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in Bexar, Wilson, Karnes, Dewitt, Lavaca, Colorado
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant in Dewitt, Karnes
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Coastal prairies of gulf coastal plain	E	E	E	Nesting in Lavaca, Colorado
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in Colorado, Bexar, Wilson, Karnes, Dewitt, Lavaca
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and shallow standing water formerly nested in Texas		T	T	Migrant in Dewitt, Bexar, Wilson, Lavaca, Colorado
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf Coastal Plain		T	T	Nesting/Migrant in Lavaca, Colorado
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country, deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant in Bexar
Black-capped Vireo	*Vireo atricapillus*	Oak/juniper woodlands with patchy, distinctive, two-layered aspect; shrub and tree layer with open, grassy space	E	E	T	Nesting/Migrant in Bexar
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant in Colorado

Table 5.2-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3]	Potential Occurrence in County
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on mature ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar
White-faced Ibis	*Pelages chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields	C2	T	T	Migrant in Bexar, Wilson, Lavaca, Colorado
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant in Bexar, Wilson, Lavaca, Colorado
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas; bare ground for running and walking				Nesting/Migrant in Bexar, Wilson, Lavaca, Colorado
Reptiles						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe river system, transition areas between riffles and pools, nests within 30 ft of water's edges	C1		C1	Dewitt, Bexar, Lavaca—Known to exist 1 mile from proposed route
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush	C2	T	T	Bexar, Wilson, Karnes, Dewitt, Lavaca, Colorado
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Bexar, Lavaca, Colorado
Spot-Tailed Lizard	*Holbrookia lacerata*	Central & southern Texas; oak-juniper woodlands and mesquite-prickly pear				Bexar, Karnes
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Bexar, Karnes, Wilson, Lavaca
Western Smooth Green Snake	*Opheodrys vernalis blanchardi*	Coastal prairies of upper Texas coast		E	E	Lavaca, Colorado
Timber Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Bexar, Lavaca, Colorado
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Bexar, Karnes
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands and sandy areas				Bexar, Dewitt, Wilson
Amphibians						
Houston Toad	*Bufo houstonensis*	Endemic, ephemeral pools, water in pools, sandy substrate, stock tanks, associated with soils of the Reklaw, Weches, Sparta, Carrizo, Queen City, Goliad, Willis geologic formations	E	E	E	Lavaca, Colorado
Black-Spotted Newt	*Notophthalmus meridionalis*	Ponds And Resacas in South Texas		T	E	Resident in Bexar
Fish						
Blue Sucker	*Clycleptus elongatus*	Large Rivers Throughout Mississippi River Basin South And West in Major Streams Of Texas To Rio Grand River	C2	T	WL	
Guadalupe Bass	*Micropterus treculi*	Clear flowing streams	C2		WL	Bexar— Known to exist 1 mile from proposed route
River Darter	*Percina shumardi*	Guadalupe River				Dewitt
Freshwater Prawn	*Macrobrachium carcinus*	Guadalupe River Basin				Historic in Dewitt
American Eel	*Anguilla rostrata*	Guadalupe River Basin				Historic in Dewitt
Insects						

Table 5.2-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Found near slow-moving water, eggs laid on objects near water; larvae are aquatic, adults prefer shady areas; females bite, males feed on nectar and pollen	C1			Resident in Colorado
Maculated Manfreda Skipper	*Stallingsia maculosus*	Fast Erratic Flight, Larvae Feed Inside A Leaf Shelter, Pupate in Cocoon Made Of Leaves & Silk			WL	Bexar, Karnes, Wilson
Plants						
Big Red Sage	*Salvia penstemonoides*	Moist Creek And Stream Bed Edges; Historic; Introduced in Native Plant Nursery Trade	C2		WL	Bexar, Wilson
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from queen city and similar eocene formations			WL	Bexar, Wilson—Known to exist 1 mile from proposed route
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; Subherbaceous Annual in Deep Loose Sands, Spring-Summer			WL	Bexar, Wilson
Bracted Twistflower	*Streptanthus bracteatus*	Endemic, Openings in Juniper-Oak Woodlands, Rocky Slopes				Bexar
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			WL	Bexar
Correll's False Dragon-Head	*Physostegia Correllii*	Wet soils including roadside ditches, irrigation channels			WL	Bexar
Glass Mountain Coral Root	*Hexalectris Nitida*	Mesic Woodlands in Canyons, Lower Elevations, Under Oaks				Bexar
Sandhill Woolywhite	*Hymenopappus Carrizoanus*	Endemic, deep loose sands of Carrizo, disturbed areas				Bexar
Mammals						
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			C2	Bexar, Wilson, Lavaca, Colorado
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	E	E	E	Karnes, Wilson
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Karnes, Wilson

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

* E = Endangered T = Threatened PT = Proposed Threatened 3C = No Longer a Candidate for Protection
C2 = Candidate Category C1 = Candidate Category, Substantial Information WL = Watch List – Potentially threatened, especially in Texas
Blank = Rare, but no regulatory listing status

Several species potentially affected by the project are associated with the rivers. The blue sucker and Guadalupe Bass (*Micropterus treculi),* may have habitat near the proposed diversions on the Colorado and Guadalupe Rivers. The blue sucker *(Cycleptus elongatus)* is listed by U.S. Fish and Wildlife Service as a candidate (C2) for protection and by Texas Parks and Wildlife Department as Threatened. Recent studies have not reported blue sucker in the lower Guadalupe River.[17] Additionally, there is a site record for Cagle's map turtle (*Graptemys*

[17] Academy of Natural Sciences, "A Review of Chemical and Biological Studies on the Guadalupe River, Texas, 1949-1989," Report No. 91-9, Acad. Nat. Sci. Phil., Philadelphia, PA, 1991.

cagleii) on the Guadalupe River south of the City of Cuero (Cuero USGS 7.5-minute quadrangle). Although Cagle's map turtle is not presently listed by U.S. Fish and Wildlife Service or Texas Parks and Wildlife Department as threatened or endangered it is listed as a federal Candidate, Category 1 (C1) species and a state S3 species (rare or uncommon).

The site of the proposed intake on the Colorado River is located in Colorado County, in the Eagle Lake Reach. A recent study conducted by the LCRA[18] reports fish species and fish-habitat associations identified in the Colorado River downstream from Austin. There are two major diversions for rice irrigation in Eagle Lake Reach, LCRA's Lakeside Irrigation District and Garwood Irrigation Company in the reach. The Eagle Lake Reach is primarily a gravel bed stream with localized outcrops of resistant calcite cemented sands. A major clay/sandstone outcrop of the Lissie and Beaumont Formations forms the hydraulic control for Lakeside Irrigation District's diversion point. This formation constitutes the most extensive complex of rapids between the City of Columbus and the Gulf of Mexico. The LCRA[19] report states that "Downstream of Columbus, the potential impact of diversions on the instream flows becomes substantial." The rock outcrops appear to provide significant spawning habitat for the blue sucker. In February 1990, numerous tuberculate males in spawning condition were observed in the rapids and gravid females were collected in pools immediately downstream. It was concluded that "target flow to maintain community diversity at Eagle Lake was 400 cfs" and that "500 cfs should be maintained from early March through May for successful spawning of *C. elongatus."*[20] Although the American eel (*Anguilla rostrata)* is not threatened or endangered it appears it was uncommon in the fish collections and tended to be restricted in distribution to the breeding habitat of pre-spawning male blue suckers. Guadalupe Bass also was collected in the Eagle Lake reach and in various habitats. Whereas blue sucker occurred in association with particular types of habitat, there was no statistically detectable association between Guadalupe Bass and particular habitat types.[21]

Potential changes in streamflow resulting from the implementation of the San Antonio and Guadalupe River importation source scenario (S-15Db) associated with the proposed Cibolo

[18] Mosier D.T. and R.T. Ray, “Instream Flows for the Lower Colorado River: Reconciling Traditional Beneficial Uses With the Ecological Requirements of the Native Aquatic Community,” LCRA, Austin, TX, 1992.
[19] Ibid.
[20] Ibid.
[21] Ibid.

Reservoir were evaluated for each point of diversion in the Guadalupe-San Antonio River Basin, Cibolo Creek below Cibolo Reservoir, and the Guadalupe River Saltwater Barrier. Monthly median streamflows and annual streamflow frequencies at each of these locations with and without the project are compared in Figures 5.2-6 and 5.2-7.

Modeling the operations of Cibolo Reservoir, including the interbasin transfers, indicated reduced median annual flow in Cibolo Creek from 64,139 acft/yr to 24,098 acft/yr, a decrease of 62.4 percent. Generally, estimated decreases in monthly medians ranged from 23 to 60 percent. Estimated monthly medians without the project ranged between 3,546 acft/month and 1,194 acft/month, whereas those with the project ranged between 1,490 acft/month and 801 acft/month. Implementation of Option S-15Db would result in a significant reduction in terms of median annual flow and a reduction of variability in flow, especially in terms of reduced high flow events.

Results of modeling the diversion of water from the Guadalupe River at Cuero indicated a decrease in annual median flows from 990,755 acft/yr without the project to 942,811 acft/yr with the project, a 4.8 percent decrease. Monthly median flow decreased from as much as 23.3 percent in August to as little as 1.2 percent in February.

Modeling flow changes in the Guadalupe River at the Saltwater Barrier with implementation of Option S-15Db indicated a decrease in annual medians from 1.41 million acft/yr to 1.28 million acft/yr (8.8 percent). Although the pattern of variation in monthly flows was maintained and the greatest decreases in volume occurred in the high flow range, percent flow reductions were greatest in the low flow range, because reclaimed water represents a greater proportion of the water diverted during low flows compared with that diverted during higher flows.

With respect to the diversion of water from the San Antonio River, modeling of flows near Falls City indicated a reduction in median annual flow from 208,205 acft/yr without the project to 149,505 acft/yr with implementation of the project, a decrease of 28.2 percent. Although the greatest reductions in monthly medians were in the high flow months, significant reductions in median flows occurred in all months. The greatest percentage reductions would occur in the low flow range because reclaimed water represents a greater proportion of the water diverted in the low flow periods. Streamflows near Falls City with the project would fall below

55,000 acft/yr in nine (16.1 percent) of the 56 years simulated while natural streamflows less than 55,000 acft/yr at this location would have occurred once (1.8 percent) in the 56 years.

Changes in Guadalupe-San Antonio River Basin streamflows quoted in the preceding paragraphs would be reduced somewhat by the importation of water from the Colorado River Basin.

The Academy of Natural Sciences of Philadelphia (ANSP) conducted studies of the macroinvertebrate fauna of the Guadalupe River from 1949 to 1987.[22] Six sites in Victoria County were surveyed in 1949, 1950, 1952, 1962, 1966, 1973 and 1987. In terms of species richness and abundance, populations of mollusks and crustaceans have remained constant over the sampling period. Dominant species of mollusks and crustaceans include Asiatic clam (*Corbicula fluminea),* golden orb *(Quadrula aurea),* Texas lilliput *(Toxolasma texasensis),* grass shrimp *(Palaemontes spp.),* crayfish *(Procambarus clarkii),* and blue crab *(Callinectes sapidus).*

Kuehne,[23] Hubbs,[24] and Lee, et al.,[25] considered together, provide a comprehensive list of fishes likely to inhabit the San Antonio and Guadalupe Rivers, given appropriate habitats. Hubbs, et al.[26] provides an inventory and bibliography dealing with the fishes of Texas. In addition to studying macroinvertebrate communities, ANSP has studied fish communities of the Guadalupe River periodically since 1949. Based on increasing capture records, populations of threadfin shad (*Polydactylus spp.),* green sunfish *(Lepomis cyanellis),* longear sunfish *(L. megalotis),* and warmouth *(L. gulosis)* appear to be increasing in the Guadalupe River. Introduced species including Mexican tetra *(Astyanax mexicanus),* orangespotted sunfish *(L. humilis),* sailfin molly *(Poecilia latipinna),* white crappie *(Pomoxis annularis),* black crappie *(P. nigromaculatus)* and white bass *(Morone chrysops)* also appear to be increasing in abundance.

The construction of diversion dams in the San Antonio, Guadalupe, and Colorado Rivers would convert a portion of the channels into a reservoir environment. Stream impoundment can

[22] Academy of Natural Sciences, Op. Cit., 1991.
[23] Kuehne, R.A., "Stream Surveys of the Guadalupe and San Antonio Rivers," IF Report No. 1, Texas Game and Fish Commission, Austin, TX, 1955.
[24] Hubbs, C., "A Checklist of Texas Freshwater Fishes," Tech. Series No. 11:1-12, Texas Parks and Wildlife Department, Austin, Texas, 1982.
[25] Lee, S. L., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, J.R. Stauffer, Jr., "Atlas of North American Feshwater Fishes," Publ. No. 1980-12 of the North Carolina Biological Survey, 1980.
[26] Hubbs, C., J.D. McEachran and C.R. Smith, "Freshwater and Marine Fishes of Texas and the Northwestern Gulf of Mexico," The Texas System of Natural Laboratories, Inc., Austin, TX, 1994.

result in environmental changes (e.g., reduced mixing energy, increased depth) that interact to produce a cascade of effects within and downstream of a newly created reservoir. The actual nature and intensity of these effects are largely dependent on characteristics of the particular site (e.g., reservoir capacity, ratio of depth to surface area, rate of water exchange, nutrient and sediment loading, biological community type). The minimal storage capacity in the pools created by these small diversion dams, however, would not be expected to have significant effects on the downstream flow regime. Any such effects would result from the magnitude and seasonal distribution of the actual diversions. Studies of the reaches to aid in determining the location of intake structures should be conducted in order to avoid critical habitats for spawning and early life stages of fish such as the blue sucker and Guadalupe Bass.

The possibility of transferring organisms from the Colorado River to the Guadalupe-San Antonio River Basin is likely to be of concern and will need to be addressed. The U.S. Army Corps of Engineers is studying this issue at present.[27] However, exotic species already inhabit both river systems. Because of the close proximity of these river systems, the presence or absence of appropriate habitats may be a more important isolating mechanism than physical separation of the river drainages.

The Guadalupe-San Antonio Estuary includes a system of freshwater, brackish, and saltwater marshes.[28] Many plant species found in marshes can tolerate a wide range of salinities and may occur in more than one type of marsh. Other plants may have narrower niche requirements and can be characteristic of a particular type of marsh habitat. Drier, high marshes are characterized by species such as gulf cordgrass (*Spartina spartinae)*, paspalum *(Paspalum spp.),* smartweed *(Polygonum spp.),* panic grass *(Panicum spp.),* sea ox-eye daisy *(Borrichia frutescens),* beak rush *(Rhynchospora macrostachya),* sedge *(Fimbristylis spp.),* mexican devil-weed *(Aster spinosus),* saltmeadow cordgrass *(Spartina patens),* and scattered bulrush *(Scirpus spp.),* spike rush, and flatsedge. Wetter, low marshes are characterized by cattail *(Typha spp.),* three-square bulrush *(Eleocharis spp.),* flatsedge *(Cyperus spp.),* water hysop *(Bacopa monnieri),* rush *(Juncus spp.),* water primrose *(Ludwigia spp.),* arrowhead *(Sagittaria spp.),* and paspalum *(Paspalum lividum).* Shrubs such as rattlebush *(Sesbania drummondii),* retama

[27] U.S. Army Corps of Engineers, "Potential Aquatic Ecological Effects of Two Proposed Interbasin Water Transfers in the South Central Study Area," USCOE Technical Memorandum, Fort Worth District.
[28] Texas Parks and Wildlife Department, 1992.

(Parkinsonia aculeata), and black willow tend to be scattered around the margins of freshwater marshes.

Average inshore catch for all species in the Guadalupe-San Antonio Estuary for the period 1962 to 1976 exceeded 2.3 million pounds, the third highest out of eight estuaries in Texas. Shrimp accounted for over 90 percent of the bay harvest weight. The shellfish component consists of white shrimp (*Penaeus setiferus),* brown shrimp *(P. aztecus),* blue crab, and eastern bay oyster *(Crassostrea virginica).* The finfish component consists of croaker *(Micropogon undulatus),* spotted seatrout *(Cynoscion nebulosus),* red drum *(Scianenops ocellata),* black drum *(Pogonias cromis),* sheepshead *(Archosargus probatocephalus)* mullet *(Mugil sp.),* gulf menhaden *(Brevoortia patronus)* flounder *(Paralichthyes sp.),* and sea catfish *(arius felis).*[29] Commercial harvesting of spotted sea trout and red drum has been banned since 1981.

The Guadalupe-San Antonio Estuary also supports a significant sport fishery. Texas Parks and Wildlife Department estimates that harvest of all fish species represents 380,000 fish totaling 420,000 pounds in a single year. Sixty percent of the sport fishery is accounted for by spotted sea trout. Red drum , southern flounder (*P. lethostigma),* black drum, and sand sea trout account for an additional 25 percent of the recreational harvest. Atlantic croaker *(Micropogonias undulatus),* gafftopsail catfish *(Barge marinus),* requiem shark *(Carcharhinidae),* and southern kingfish *(Menticirrhus americanus)* account for five percent of the recreational harvest.

The commercial and sport fish depend upon many estuarine species for survival. Spotted seatrout, southern flounder, and red drum depend on shrimp, pinfish (*Lagodon rhomboides),* menhaden, anchovy *(Anchoa sp.),* and mullet for food. Larval fish depend upon plankton, polychaete worms, and crustaceans for food. Shrimp feed on detritus, polychaetes, epiphytes, and plankton. Gizzard shad *(Dorosoma cepedianum*), striped and white mullet, gulf menhaden, bay anchovy, clams *(Rangia cuneata and R. flexuosa),* and eastern bay oyster represent ecologically important species that feed directly on detritus and plankton. Shrimp and small fishes such as pinfish, gulf killifish and longnose killifish *(Fundulus spp.),* sheepshead minnows *(Cyprinodon variegatus),* silversides *(Menidia sp.),* silver perch and juvenile fish are a significant source of food for higher level consumers such as red drum, herons, egrets, porpoise, and spotted sea trout.

[29] Texas Parks and Wildlife Department, 1991.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources.

5.2.4 Engineering and Costing

For this option (S-15D), water potentially available for diversion from the various importation sources would be pumped at non-uniform rates to Cibolo Reservoir, which would serve as a storage and balancing reservoir. From Cibolo Reservoir, the firm yield would be pumped at a uniform rate to a water treatment plant at the major municipal demand center of the South Central Texas Region. Potential benefits from this project might include the addition of a new surface water supply to the major and other municipal demand centers and/or enhanced recharge to the Edwards Aquifer. The major facilities required to implement this option are:

- Importation Source River Intakes and Pump Stations
- Raw Water Pipelines to Cibolo Reservoir
- Dam and Reservoir
- Reservoir Intake and Pump Station
- Raw Water Pipeline from Cibolo Reservoir
- Water Treatment Plant (Level 3; see Appendix A)
- Distribution

Selection of the import pipeline size for delivery of water from each potential source to Cibolo Reservoir was performed in a previous study.[30]

For each source scenario or option, costs for the selected importation facilities were combined with costs for Cibolo Dam and Reservoir (Section 5.1), other major facilities listed above, and related project costs (land acquisition, mitigation, engineering, etc.) to obtain Total Project Cost. Total Project Cost was then converted to annual debt service (40 year finance period at 6 percent interest for the reservoir and 30 year finance period at 6 percent for all other capital costs) and combined with related operations and maintenance and power costs to obtain Total Annual Cost. Cost estimates for each importation source scenario are summarized in Tables 5.2-2 through 5.2-4 and discussed in the following subsections.

[30] HDR, Op. Cit., January 1996.

Table 5.2-2.
Cost Estimates for
Cibolo Reservoir with Imported Water from the San Antonio River (S-15Da)
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 409,700 acft; 16,700 acres; 416 ft-msl)	$139,446,000
Intakes and Pump Stations	18,769,000
Water Treatment Plant (65.7 MGD)	44,376,000
Transmission Pipeline (64-in. dia., 42.3 miles; 72-in. dia., 9.5 miles)	56,382,000
Distribution	76,316,000
Total Capital Cost	**$335,289,000**
Engineering, Legal Costs and Contingencies	$114,532,000
Environmental & Archaeology Studies and Mitigation	26,108,000
Land Acquisition and Surveying (18,310 acres)	28,098,000
Interest During Construction (4 years)	80,645,000
Total Project Cost	**$584,672,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$22,352,000
Reservoir Debt Service (6 percent for 40 years)	18,410,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	1,764,000
Dam and Reservoir	2,092,000
Water Treatment Plant	5,371,000
Pumping Energy Costs (74,853,280 kWh @ $0.06/kWh)	4,491,000
Total Annual Cost	**$54,480,000**
Available Project Yield (acft/yr)	**69,925**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$779**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.39**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Table 5.2-3.
Cost Estimates for
Cibolo Reservoir with Imported Water from the
San Antonio and Guadalupe Rivers (S-15Db)
(Second Quarter 1999 Prices)

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool: 409,700 acft; 16,700 acres; 416 ft-msl)	$139,446,000
Intakes and Pump Stations	36,798,000
Water Treatment Plant (86.4 MGD)	54,846,000
Transmission Pipeline (72-in. dia., 42.3 miles; 72-in. dia., 9.5 miles; 84-in, 40.2 miles)	126,793,000
Distribution	92,006,000
Total Capital Cost	**$449,889,000**
Engineering, Legal Costs and Contingencies	$145,645,000
Environmental & Archaeology Studies and Mitigation	27,118,000
Land Acquisition and Surveying (18,509 acres)	29,984,000
Interest During Construction (4 years)	104,423,000
Total Project Cost	**$757,059,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$34,876,000
Reservoir Debt Service (6 percent for 40 years)	18,410,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	2,684,000
Dam and Reservoir	2,092,000
Water Treatment Plant	5,371,000
Pumping Energy Costs (126,788,481 kWh @ $0.06/kWh)	7,607,000
Total Annual Cost	**$71,040,000**
Available Project Yield (acft/yr)	**91,942**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$773**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.37**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

***Table 5.2-4.
Cost Estimates for
Cibolo Reservoir with Imported Water from the
San Antonio, Guadalupe, and Colorado Rivers (S-15Dc)
Second Quarter 1999 Prices***

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool 409,700 acft, 16,700 acres, 416 ft-msl)	$139,446,000
Intakes and Pump Stations	60,179,000
Water Treatment Plant (100.1 MGD)	60,668,000
Transmission Pipeline (78-in, 42.3 miles; 72-in, 9.5 miles, two 90-in, 40.2 miles; 96-in, 68.2 miles)	316,396,000
Distribution	102,376,000
Total Capital Cost	**$679,065,000**
Engineering, Legal Costs and Contingencies	$208,560,000
Environmental & Archaeology Studies and Mitigation	28,826,000
Land Acquisition and Surveying (18,890 acres)	33,155,000
Interest During Construction (4 years)	151,938,000
Total Project Cost	**$1,101,544,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$59,902,000
Reservoir Debt Service (6 percent for 40 years)	$18,410,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$4,710,000
Dam and Reservoir	$2,092,000
Water Treatment Plant	$5,371,000
Pumping Energy Costs (204,711,310 kWh @ $0.06/kWh)	$12,283,000
Total Annual Cost	**$102,768,000**
Available Project Yield (acft/yr)	**106,482**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$965**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.96**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Option S-15Da: Import from San Antonio River

Cibolo Reservoir operated in conjunction with available water imported from the San Antonio River near Floresville could provide a firm yield of about 69,925 acft/yr at an annual cost of $779/acft. This firm yield and annual cost are based on a 72-inch diameter import pipeline from the San Antonio River and a 64-inch transmission pipeline from Cibolo Reservoir to the major municipal demand center of the South Central Texas Region.

Option S-15Db: Import from San Antonio and Guadalupe Rivers

Cibolo Reservoir operated in conjunction with available water imported from the San Antonio River near Floresville and the Guadalupe River at Cuero could provide a firm yield of about 91,942 acft/yr at an annual cost of $773/acft. This firm yield and annual cost are based on a 72-inch diameter import pipeline from the San Antonio River, an 84-inch import pipeline from the Guadalupe River, and a 72-inch transmission pipeline from Cibolo Reservoir to the major municipal demand center of the South Central Texas Region.

Option S-15Dc: Import from San Antonio, Guadalupe, and Colorado Rivers

Cibolo Reservoir operated in conjunction with available water imported from the San Antonio River near Floresville, the Guadalupe River at Cuero, and the Colorado River near Columbus could provide a firm yield of about 106,482 acft/yr at an annual cost of $965/acft. This firm yield and annual cost are based on a 72-inch diameter import pipeline from the San Antonio River, two 90-inch import pipelines from the Guadalupe River, a 96-inch diameter import pipeline from the Colorado River, and a 78-inch transmission pipeline from Cibolo Reservoir to the major municipal demand center of the South Central Texas Region. This is the importation source scenario presented in Figure 5.2-3.

5.2.5 Implementation Issues

Implementation of Cibolo Reservoir with water imported from the San Antonio, Guadalupe, and Colorado Rivers could directly affect the feasibility of other water supply options under consideration, including L-11, L-14, L-20, S-14D, S-15C, S-15Ea, S-15Eb, S-16C, G-16C1, G-17C1, G-20, G-21, G-22, G-38C, C-13C, C-17A, C-17B, C-18, SCTN-6, SCTN-14b, SCTN-15, SCTN-16b, and/or SCTN-16c.

An institutional arrangement is needed to implement projects including financing on a regional basis.

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer(s) Approval
   c. TNRCC bed and banks authorization for use of San Antonio River to deliver SAWS treated effluent.
   d. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   e. General Land Office (GLO) Sand and Gravel Removal permits.
   f. GLO Easement for use of state-owned land.
   g. Coastal Coordination Council review.
   h. TPWD Sand, Gravel, and Marl permit for stream crossings.

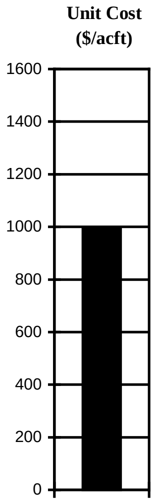
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

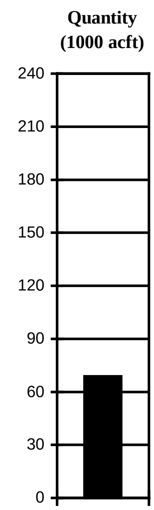
3. Land in the reservoir area and pipeline right-of-way and easements will need to be acquired through either negotiations or condemnation.

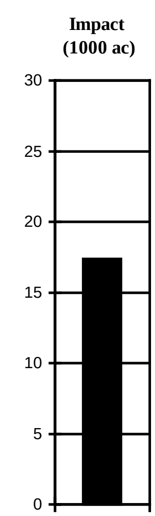
4. Relocations for the reservoir may include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

5. Other Considerations:
   a. Water demand reduction programs by SAWS may reduce the quantity of future return flows.
   b. Use of return flows must be negotiated with SAWS. Use arrangements should consider drought contingency planning that might result in a reduction of effluent discharged by SAWS.
   c. Water compatibility testing, including biological and chemical characteristics will need to be performed.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft – 12/06/99







OPTION NUMBER: **S-15Ea**

OPTION NAME: **Cibolo Reservoir with Imported Water from the Guadalupe River Saltwater Barrier — Firm Yield**

OPTION DESCRIPTION: *The firm yield of the Cibolo Reservoir located in Wilson County, would be supplemented with unappropriated water from the Guadalupe River at the Saltwater Barrier via a 60-inch diameter pipeline and then delivered to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$993**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**68,688**	**acft/yr[2]**
LAND IMPACTED:	**17,396**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, reservoir intake and pump station, raw water pipelines, Guadalupe River intake and pump station, water treatment plant, treatment costs, and mitigation.

[2]**QUANTITY OF WATER:** Water availability from the San Antonio and Guadalupe Rivers, including quantities of reclaimed and unappropriated water at the Saltwater Barrier.

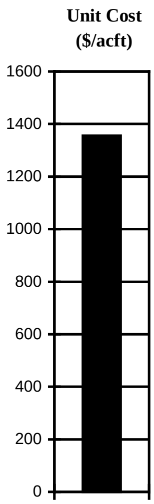
[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

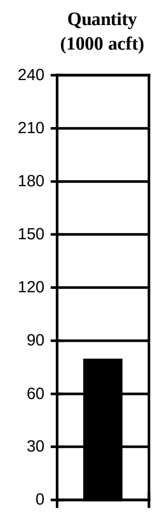
ENVIRONMENTAL ISSUES: The lower Guadalupe River in Victoria, Calhoun, and Refugio Counties is recommended for designation as an Ecologically Unique River Segment by the Texas Parks and Wildlife Department.

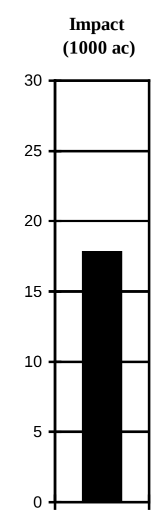
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Quantity of instream flow and bay and estuary requirements, habitat mitigation, and quantity of unappropriated flows of the Guadalupe River.

ADDITIONAL FACTORS: Ability to obtain permits to move water from the Guadalupe River Basin to the San Antonio area.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S-15Eb, S-16C, G-16C1, G-17C1, G-20, G-38C, SCTN-6, SCTN-14b, SCTN-16b, and/or SCTN-16c.







OPTION NUMBER: S-15Eb
OPTION NAME: Cibolo Reservoir with Imported Water from the Guadalupe River Saltwater Barrier and the Colorado River near Bay City

OPTION DESCRIPTION: *The firm yield of the Cibolo Reservoir, located in Wilson County, would be supplemented with unappropriated water from the Guadalupe River at the Saltwater Barrier via an 84-inch diameter pipeline, and from the Colorado River via a 60-inch diameter pipeline, and then delivered to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$1,355**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**79,090**	**acft/yr**[2]
LAND IMPACTED:	**17,787**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, reservoir intake and pump station, raw water pipelines, Guadalupe and Colorado Rivers intakes and pump stations, water treatment plant, treatment costs, and mitigation.

[2]**QUANTITY OF WATER:** Water availability in the San Antonio, Guadalupe, and Colorado Rivers, including quantity of unappropriated water in the Guadalupe and Colorado Rivers.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of 18 miles of stream channel, much of which is lined with bottomland hardwoods and riparian communities. The lower Guadalupe River in Victoria, Calhoun, and Refugio Counties and the Colorado River from Longhorn Dam in Travis County downstream to Matagorda Bay are recommended for designation as Ecologically Unique River Segments by the Texas Parks and Wildlife Department.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Quantity of instream flow and bay and estuary requirements, habitat mitigation, and quantity of unappropriated flows of the Guadalupe and Colorado Rivers.

ADDITIONAL FACTORS: Ability to obtain permits to move water from the Guadalupe and Colorado River Basins to the San Antonio area.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-16C, G-16C1, G-17C1, G-20, G-38C, C-13C, C-17A, C-17B, C-18, SCTN-6, SCTN-14b, SCTN-15, SCTN-16b, and/or SCTN-16c.

5.3 Cibolo Reservoir with Imported Water from the Guadalupe River Saltwater Barrier (S-15Ea) and the Colorado River (S-15Eb) — Firm Yield

5.3.1 Description of Options

The firm yield of the proposed Cibolo Reservoir, located in Wilson County, would be supplemented with water diverted from the Guadalupe River at the Saltwater Barrier and from the Colorado River near Bay City into Cibolo Reservoir and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region. Treated water would then be distributed either directly to municipal systems or to the Edwards Aquifer recharge zone.

Cibolo Reservoir is a proposed impoundment on Cibolo Creek located about 8 miles east of Floresville. The project has been studied by the U.S. Bureau of Reclamation,[1,2] Espey, Huston & Associates, Inc.,[3] and most recently by HDR Engineering, Inc (HDR) in the Trans-Texas Water Program.[4] An evaluation of Cibolo Reservoir using only runoff from the Cibolo Creek watershed is presented in Section 5.1.

Cibolo Reservoir has a proposed conservation storage capacity of about 409,700 acft below elevation 416 ft-msl. As noted in Section 5.1 (Figure 5.1-2), the reservoir would fill only infrequently with runoff from the Cibolo Creek watershed leaving ample capacity available for storage of water from other sources. Hence, Option S-15E includes importation of unappropriated water from the Guadalupe River Saltwater Barrier (located below the confluence of the San Antonio River near Tivoli) and from the Colorado River to Cibolo Reservoir through a system of river intakes, pump stations, and pipelines shown in Figures 5.3-1 and 5.3-2. Unappropriated water from the Colorado River would be diverted near Bay City and delivered via transmission pipeline to join the import pipeline from the Saltwater Barrier to Cibolo Reservoir. Two independent importation source scenarios for Cibolo Reservoir have been studied and are described as follows:

- S-15Ea Importing water from the Guadalupe River Saltwater Barrier (Figure 5.3-1); and
- S-15Eb Importing water from the Guadalupe River Saltwater Barrier and the Colorado River near Bay City (Figure 5.3-2).

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[1] U.S. Bureau of Reclamation (USBR), "Texas Basins Project," February 1965.
[2] USBR, "Feasibility Report, Cibolo Project, Texas," February 1971.
[3] Espey Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," San Antonio River Authority, Guadalupe-Blanco River Authority, City of San Antonio, February 1986.
[4] HDR Engineering, Inc. (HDR), "West Central Study Area Phase I Interim Report," Vol. IV, Trans-Texas Water Program, San Antonio River Authority, January 1996.

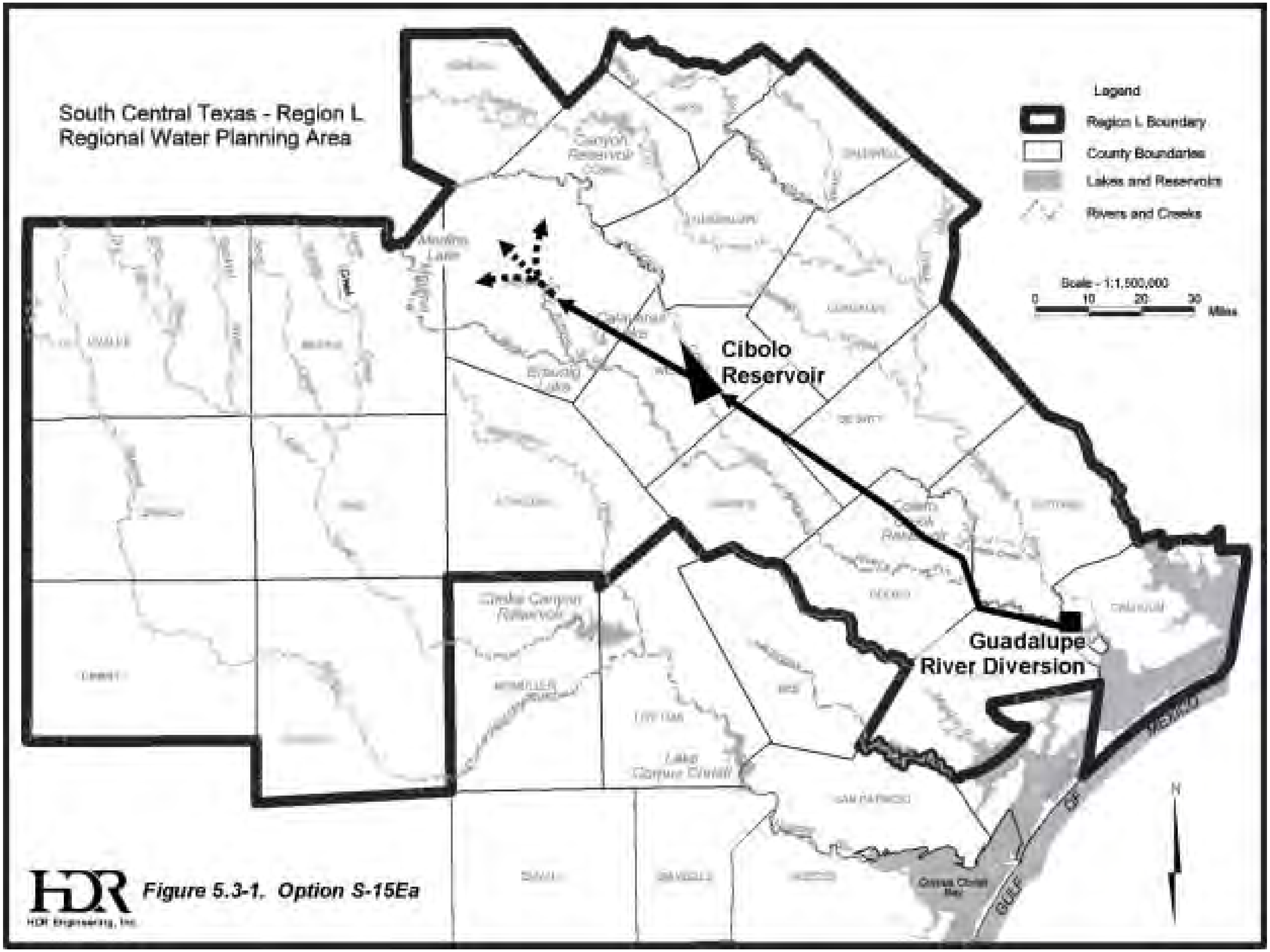

Figure 5.3-1. Option S-15Ea

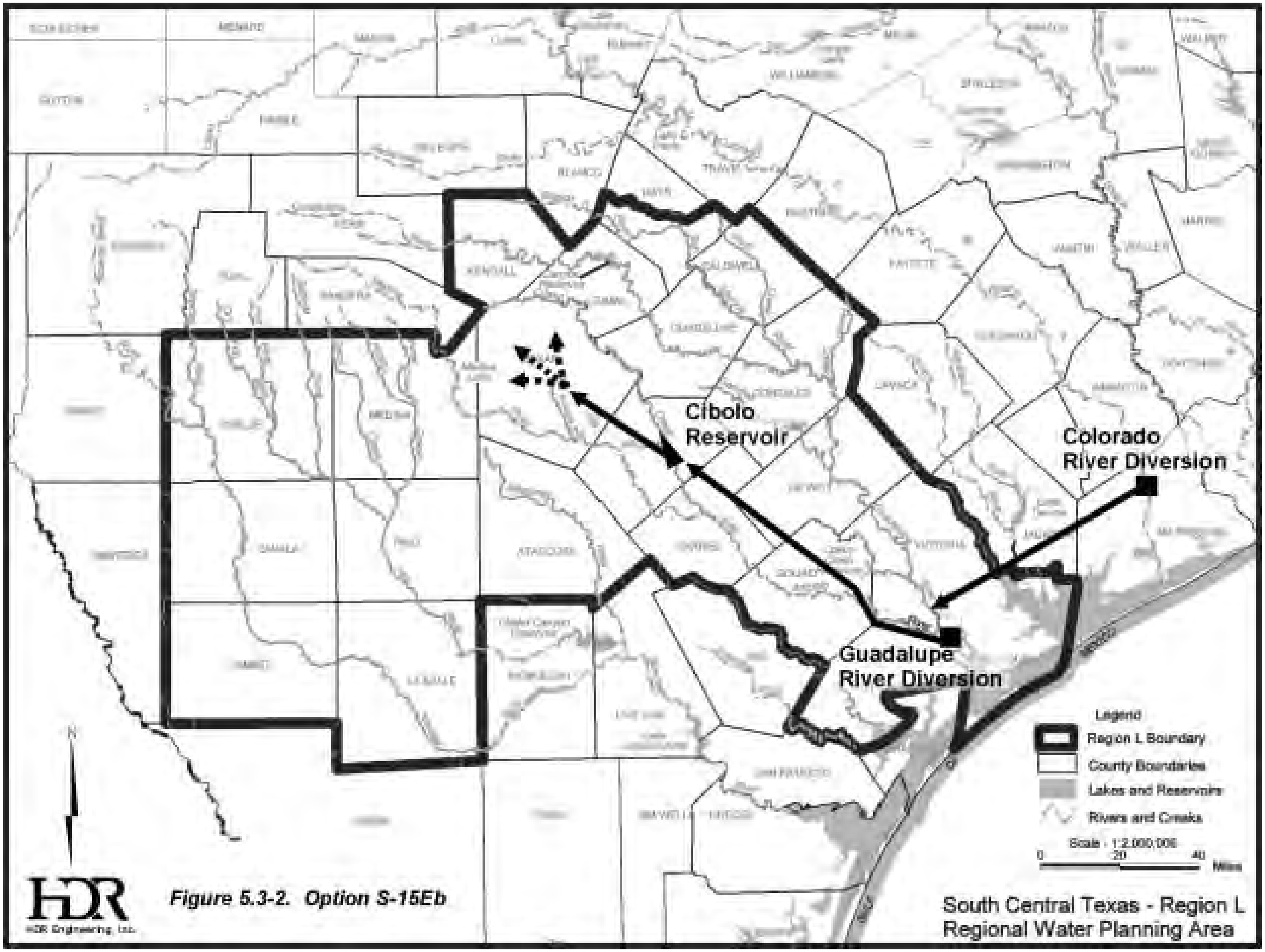

Figure 5.3-2. Option S-15Eb

5.3.2 Available Yield

Water potentially available for impoundment in the proposed Cibolo Reservoir and for importation from the Guadalupe River Saltwater Barrier was estimated using the Guadalupe-San Antonio River Basin Model[5] (GSA Model) based on a 1934 through 1989 period of record. Estimates of water availability in the Guadalupe-San Antonio River Basin were derived subject to the general assumptions for applications of hydrologic models as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

Unappropriated streamflow potentially available from the Colorado River near Bay City was estimated using the latest version of the Lower Colorado River Authority's (LCRA) RESPONSE model. This model simulates Highland Lake System storage and streamflow in the Colorado River and allocates water to authorized diversions, based on seniority of water rights, for a 1941 through 1965 simulation period. Water availability estimates from the Colorado River were derived subject to environmental criteria adopted for the Lower Colorado River and the Lavaca-Colorado Estuary.[6]

The SIMDLY model, originally developed by the Texas Water Development Board (TWDB) and modified by HDR, was utilized to calculate the firm yield of Cibolo Reservoir subject to daily inflow passage criteria and available imported water as computed by the GSA Model or the RESPONSE model. Finally, the GSA Model was used to assess changes in streamflow for the Guadalupe River Saltwater Barrier assuming Cibolo Reservoir operations with the diversion of the firm yield.

The water availability analyses and assessment of firm yield proceeded in a sequential manner, starting at the Guadalupe River Saltwater Barrier, and, then, adding unappropriated water potentially available from the Colorado River near Bay City. Water potentially available for diversion from the Guadalupe River Saltwater Barrier was computed assuming reuse of available San Antonio Water System (SAWS) treated effluent. The GSA Model was used to estimate monthly SAWS effluent quantities arriving at the proposed diversion point after honoring intervening water rights and other uses for reclaimed water including SAWS recycling program and make-up water for Braunig and Calaveras Lakes. Assuming diversion of available

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[5] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[6] LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

SAWS effluent, unappropriated streamflows at the Guadalupe River Saltwater Barrier were then estimated subject to Consensus Environmental Criteria (Appendix B) using the GSA Model. The monthly amounts of available SAWS effluent, uniformly distributed to a daily pattern, and the daily unappropriated streamflows were combined to determine the totals available for diversion from the Guadalupe River Saltwater Barrier into Cibolo Reservoir. Total availability was limited to the transmission capacity of a 60-inch diameter pipeline, which was identified as the optimum size in a previous study.[7]

The computed firm yield of Cibolo Reservoir with importation of water from the San Antonio River (S-15Ea) is 68,688 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. Figure 5.3-3 illustrates simulated Cibolo Reservoir storage fluctuations and reservoir storage frequency as operated under the Consensus Environmental Criteria (Appendix B) and subject to diversion of the firm yield.

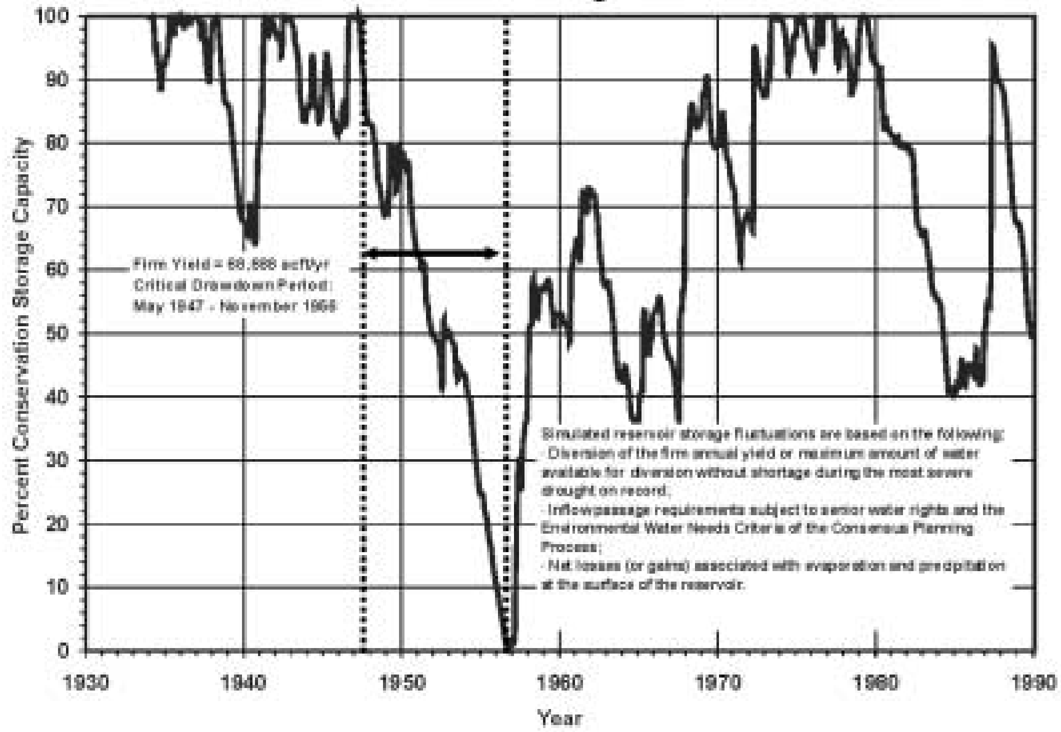
The computed firm yield of Cibolo Reservoir with importation of water from the Guadalupe and Colorado Rivers (S-15Eb) is 79,090 acft/yr, which represents a reliable supply based on the 1941 to 1965 historical period of hydrologic record and a 60-inch transmission pipeline from the Colorado River. Neither reservoir storage considerations nor streamflow comparisons are presented for this option because of the shorter period of available hydrologic record.

5.3.3 Environmental Issues

The proposed Cibolo Reservoir near Stockdale (Option S-15C) has been described in Section 5.1, hence, the following discussion focuses on issues relevant to diverting water from the Guadalupe and Colorado Rivers, and the import pipelines required to transport it to the proposed Cibolo Reservoir. The proposed Colorado River diversion would involve delivery of water to Cibolo Reservoir (Figures 5.3-1 and 5.3-2) along with additional water diverted from the Guadalupe River Saltwater Barrier.

The project area for Option S-15E includes Matagorda, Jackson, Victoria, Calhoun, Refugio, Goliad, Dewitt, Karnes, Wilson, and Bexar Counties. The project area in Matagorda, Jackson, Victoria, and Refugio Counties lies within the Gulf Prairies and Marshes Vegetational

[7] HDR, Op. Cit., January 1996.



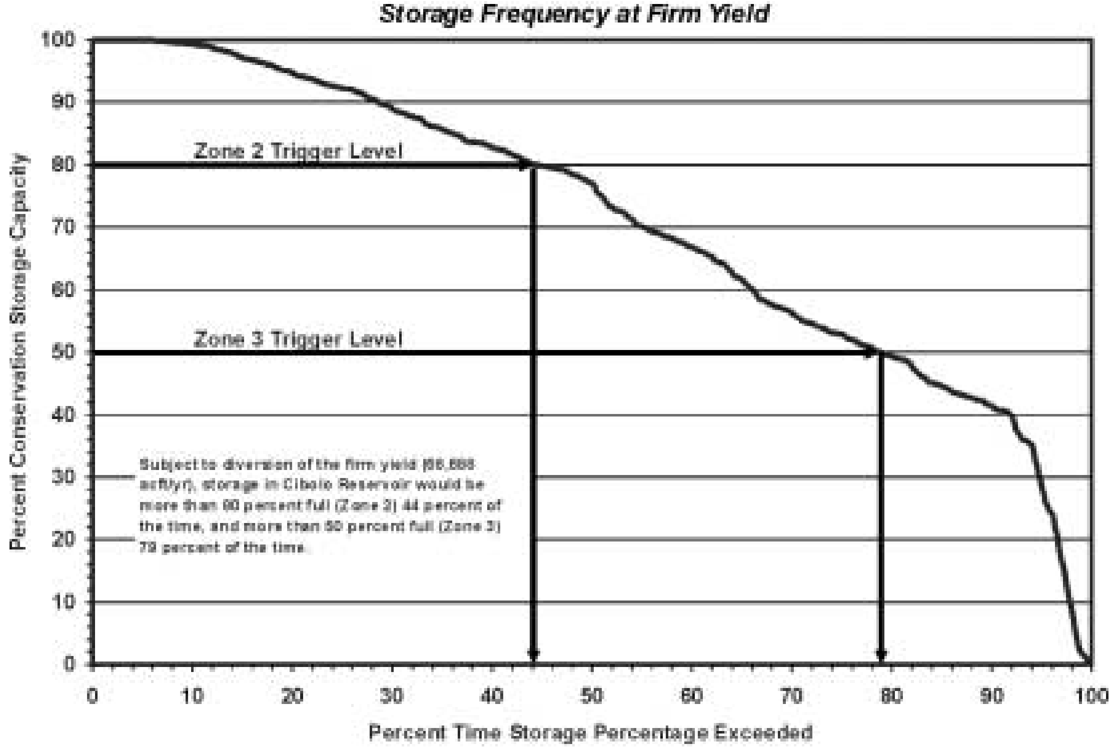


Figure 5.3-3. Cibolo Reservoir with Saltwater Barrier, Storage Considerations

Region.[8] The Gulf Prairies and Marshes Vegetational Area corresponds with Omernik's[9] Western Gulf Coastal Plain Ecoregion and Blair's[10] Texan Biotic Province. In Goliad County, the proposed pipeline passes through the southernmost extent of the Post Oak Savannah Vegetational Area. The Post Oak Savannah Vegetational Area in Goliad County also lies within Blair's Texan Province. The Texan Biotic Province is a broad, ecologically transitional region (ecotone) between the Tamaulipan Province to the west and the Austroriparian Province to the east. Because of its ecotonal nature, the Texan Province supports a mixture of plant and animal species characteristic of the Tamaulipan and Austroriparian Provinces. Rivers and associated riparian strips coursing through the Texan Province provide valuable habitat as well as corridors for migration. The project area in Dewitt, Karnes and Wilson Counties roughly follows the northeastern boundary of the South Texas Plains. The South Texas Plains Vegetational Area corresponds to Omernik's[11] Southern Texas Plains Ecoregion and Blair's[12] Tamaulipan Biotic Province.

The Gulf Prairies and Marshes Vegetational Area is a level, slowly drained plain lower than 150 ft-msl with numerous sluggish rivers, creeks, bayous, and sloughs. It is characterized by grasslands that support cattle ranching and farming. Woodlands tend to be concentrated near rivers, swamps, and freshwater marshes making them relatively uncommon and important habitat. Rainfall is higher along this coastal prairie compared to the South Texas Plain, and increases as one moves to the northeast. For example, mean precipitation for Matagorda and Jackson Counties averages about 41 inches annually, whereas Wilson County on the South Texas Plain averages only 29.4 inches annually.[13]

The climax vegetation of the Gulf Prairies is considered to be tall grass prairie or post oak savannah. However, grazing practices and fire suppression have resulted in much of the area being invaded by trees and brush. Common species of the brushlands include mesquite (*Prosopis glandulosa),* oaks (especially live oak, *Quercus virginiana),* prickly pear cactus

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[8] Gould, F.W, "Texas Plants--A Checklist and Ecological Summary," Texas Agricultural Experiment Station, MP-585, 1962.
[9] Omernik, James M, "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1):pp. 118-125, 1986.
[10] Blair, F.W, "The Biotic Provinces of Texas," The Texas Journal of Science, 2:93-117, 1950.
[11] Omernik, James M., Op. Cit., 1986
[12] Blair, W.F. 1950. Op. Cit.
[13] Griffiths, J. and J. Bryan, "The Climates of Texas Counties,"Natural Fibers Information Center, The University of Texas in cooperation with Office of the State Climatologist, Texas A&M University, 1987.

(Opuntia spp.), and several species of acacia. Prairie communities are dominated by species such as big bluestem *(Andropogon gerardi),* seacoast bluestem *(Schizachyrium scoparium var. littoralis),* Indian grass *(Sorghastrum avenaceum),* and gulf muhly *(Muhlenbergia capillaris).* Post oak savannah is generally dominated by little bluestem *(S. scoparium var. frequens),* Indian grass switchgrass *(Panicum virgatum),* and wintergrass *(Stipa leucotricha),* in addition to post oak (*Q. stellata*) and blackjack oak *(Q. marilandica).*

The South Texas Plains are also termed the Rio Grande Plains or Tamaulipan Brushlands.[14] The topography is level to rolling, and the land is dissected by arroyos or by streams flowing into the Rio Grande and the Gulf of Mexico. It is characterized by open prairies and a growth of mesquite (*P. glandulosa),* grangeno *(Celtis pallida),* cacti, clepe *(Ziziphus obtusifolia),* coyotillo *(Karwinskia Humboldtiana),* guayacan *(Porlieria angustifolia),* white brush *(Aloysia gratissima),* brasil *(Condalia Hookeri),* bisbirinda *(Castela texana),* cenizo *(Leucophyllum spp.),* huisache *(Acacia Farnesiana),* catclaw *(A. greggii),* black brush *(A. rigidula),* guajillo *(A. Berlandieri),* and other small trees and shrubs which are found in varying degrees of abundance and composition[15]. Historically, the area was grassland or savanna type climax vegetation, however, long-continued heavy grazing and other factors have resulted in a general change to a cover of shrubs and small trees. Among the several species of shrubs and trees that have made dramatic increases are mesquite, live oak, post oak, and *Acacia spp.*[16] Blair described the Tamaulipan province of Texas as being characterized by predominantly thorny brush vegetation.[17] This brushland stretches from the Balcones fault line southward into Mexico. A few species of plants account for the bulk of the brush vegetation and give it a characteristic aspect throughout the Tamaulipan Biotic Province of Texas. The most important of these include: mesquite, lignum vitae (*Porliera angustifolia),* cenizo *(L. texanum),* white brush *(A. gratissima),* prickly pear *(O. lindheimeri),* tasajillo *(O. leptocaulis), Condalia sp.,* and *Castela sp.* The brush on sandy soils differs in species and aspect from that on clay soils. Mesquite, in an open stand and mixed with various grasses, is characteristic of sandy areas. Clay soils usually have all of the species listed above, including mesquite. Although rangeland predominates

[14] Correl, D.S. and M.C. Johnston, "Manual of the Vascular Plants of Texas, " The University of Texas at Dallas, Richardson, Texas, 1979.
[15] Ibid.
[16] Gould, F. W., "The Grasses of Texas," Texas A&M University Press, 1975.
[17] Blair, F.W., Op. Cit., 1950.

throughout the South Texas Plains/Tamaulipan Brushland, land use also includes significant acreages in croplands.

The Post Oak Savannah Area[18] lies immediately west of the primary forest region of Texas. Some authorities consider this plant association as part of the oak-hickory formation. Based on the fact that the typical understory vegetation is tall grass, others classify the area as part of the true prairie association of the grassland formation. There is evidence that the brush and tree densities have increased tremendously from the virgin condition. Topography of the Post Oak Savannah is gently rolling to hilly. Rainfall averages 35 to 45 inches annually. Soils on the uplands are light-colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the Post Oak Savannah is in native or improved pastures although small farms are common. Climax grasses include little bluestem, Indian grass, switchgrass, purpletop (*Tridens flavus),* silver bluestem *(Bothriochloa saccharoides),* Texas wintergrass, and *Chasmanthium sessiliflorum.* The overstory is primarily post oak and blackjack oak *(Q. marilandica).* Many other brush and weedy species also are common. Some invading plants are red lovegrass, broomsedge *(A. virginicus),* splitbeard bluestem *(A. ternarius),* yankeeweed, bullnettle *(Cnidoscolus texanus),* greenbrier, yaupon *(Ilex vomitoria),* smutgrass, and western ragweed.

Option S-15E includes transmission pipelines between the Colorado River and the Guadalupe River Saltwater Barrier and between the Saltwater Barrier and the proposed Cibolo Reservoir. Important species having habitat or known to occur in counties potentially affected by Option S-15E are listed in Table 5.3-1. The Texas Natural Heritage program reports only one site location for endangered or threatened species along the proposed pipeline routes and this is for the Attwater's Greater Prairie Chicken.

The 81.2-mile long pipeline between the Colorado River and the Saltwater Barrier will require a right-of-way 40 feet wide and affect 394 acres. Most of the affected land could be returned to agricultural uses following construction. Pipeline construction would include some impact to woods, however, such impacts could be reduced from the figures given above by judicious pipeline alignment.

[18] Correl, D.S. and M.C. Johnston. 1979. Op. Cit.

Table 5.3-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cibolo Reservoir with Imported Water (S-15E)[1]

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS	TPWD	TOES	
Birds						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in All Counties
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in All Counties
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant in DeWitt, Karnes, Matagorda, Jackson, Victoria, Goliad, Calhoun, Refugio
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	T	Nesting/Migrant in Matagorda, Goliad, Victoria, Jackson, Calhoun, Refugio
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in All Counties
Eskimo Curlew	*Numenius borealis*	Coastal Prairies	E	E	E	Occasional in Victoria, Calhoun
Brown Pelican	*Pelecanus occidentalis*	Coastal inlands for nesting, shallow gulf and bays for foraging	E	E	E	Nesting/Migrant in Victoria, Matagorda, Jackson, Calhoun, Refugio
Reddish Egret	*Egretta rufescens*	Coastal inlands for nesting, coastal marshes for foraging	C2	T		Migrant in Victoria, Matagorda, Jackson, Calhoun, Refugio
Wood Stork	*Mycteria americana*	Forages in prairie ponds, ditches, and standing water; formerly nested in Texas		T	T	Migrant in DeWitt, Bexar, Wilson, Matagorda, Jackson, Victoria, Calhoun, Refugio
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant in Matagorda, Jackson, Victoria, Goliad, Calhoun, Refugio
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country, deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant in Bexar
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, distinctive two-layered aspect; shrub and tree layer with open, grassy space	E	E	T	Nesting/Migrant in Bexar
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Coastal Prairies of Gulf Coastal Plain	E	E	E	Nesting in Goliad, Victoria, Refugio—known to occur within 1 mile of pipeline route
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields	C2	T	T	Migrant in Matagorda, Victoria, Jackson, Bexar, Wilson, Calhoun, Refugio
Snowy Plover	*Charadrius alexandrinus*	Beaches, flats, streamsides; Winters on coast, rarely nests on coast	C3			Migrant in Matagorda, Calhoun
Piping Plover	*Charadrius melodus*	Beaches and flats of Coastal Texas	T	T	T	Migrant in Matagorda, Calhoun, Refugio
Sooty Tern	*Sterna fuscata*	Gulf coastal islands for nesting, deep Gulf for foraging		T	WL	Nesting in Matagorda, Calhoun

Table 5.3-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant in Bexar, Wilson
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas; bare ground for running and walking				Nesting/Migrant in Bexar, Wilson, Matagorda
Reptiles						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 feet of water's edges	C1		C1	DeWitt, Bexar
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush	C2	T	T	All Counties
Western Smooth Green Snake	*Opheodrys vernalis blanchardi*	Coastal prairies of upper Texas coast		E	E	Matagorda
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Bexar, Matagorda
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas; oak-juniper woodlands and mesquite-prickly pear				Bexar, Karnes, Goliad, Refugio
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays, coastal marshes of the upper two-thirds of Texas Coast	C2		T	Resident in Victoria, Jackson, Calhoun, Refugio
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Bexar, Karnes, Wilson, Goliad, Refugio
Timber Rattlesnake	*Crotalus horridus*	Floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense groundcover		T	T	Bexar, Victoria, Refugio
Gulf Saltmarsh Snake	*Nerodia clarkii*	Brackish to saline coastal waters	C2			Resident in Victoria, Matagorda, Jackson, Calhoun, Refugio
Scarlet Snake	*Cemophora coccinea*	Sandy soils of East Texas, central and south Gulf Coast		T	WL	Matagorda, Calhoun, Refugio
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbrush woodland and mesquite savannah of coastal plain		T	WL	Bexar, Karnes, Refugio
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands, and sandy areas				Bexar, DeWitt, Wilson, Victoria, Goliad, Refugio
Amphibians						
Black-spotted Newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	E	Resident in Victoria, Bexar, Refugio
Sheep Frog	*Hypopachus variolosus*	Deep sandy soils of Southeast Texas		T	T	Resident in Goliad, Refugio
South Texas Siren (Lg. Form)	*Siren sp. 1*	Moist soils		T		Refugio
Mexican Treefrog	*Smilisca baudinii*	Subtropical woodlands, resacas		T	T	Refugio
Fish						
Blue Sucker	*Cycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grande River	C2	T	WL	
Guadalupe Bass	*Micropterus treculi*	Clear flowing streams	C2		WL	Bexar, Victoria
River Darter	*Percina shumardi*	Guadalupe River				DeWitt
Freshwater Prawn	*Macrobrachium carcinus*	Guadalupe River Basin				Historic in DeWitt
American Eel	*Anguilla rostrata*	Guadalupe River Basin				Historic in DeWitt

Table 5.3-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	Listing Agency: TPWD[1]	Listing Agency: TOES[2,3]	Potential Occurrence in County
Insects						
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Found near slow-moving water, eggs laid on objects near water; aquatic larvae, adults prefer shady areas; males bite, females feed on nectar and pollen	C1			Resident in Goliad, Victoria
Maculated Manfreda Skipper	*Stallingsia maculosus*	Fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			WL	Bexar, Karnes, Wilson
Plants						
Black Lace Cactus	*Echinocereus reichenbachii var. albertii*	Grasslands, thorn shrublands, mesquite woodlands on sandy, somewhat saline soils on coastal prairie	E	E	E	Refugio
Big Red Sage	*Salvia penstemonoides*	Moist creek and streambed edges; historic; introduced in native plant nursery trade	C2		WL	Bexar, Wilson
Coastal Gay Feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Refugio—Known to Occur Within 1 Mile of Pipeline Route
Plains Gumweed	*Grindelia oolepsis*	Early successional patches in coastal prairie on heavy clay soils, sometimes in disturbed habitats in urban areas			WL	Refugio—known to occur within 1 mile of pipeline route
Texas Meadowrue	*Thalictrum texanum*	Coastal plains and savannah of south east Texas; historic in Harris County	C2		WL	Brazos, Waller, Gonzales
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Bexar, Wilson, Refugio—known to occur within 1 mile of pipeline route
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Bexar, Wilson
Bracted Twistflower	*Streptanthus bracteatus*	Endemic, openings in juniper-oak woodlands, rocky slopes				Bexar
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			WL	Bexar
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils including roadside ditches, irrigation channels			WL	Bexar
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, lower elevations, under oaks				Bexar
Welder Machaeranthera	*Psilactis heterocarpa*	Coastal prairie; Shrub-infested grasslands and open mesquite-huisache woodlands			WL	Resident in Victoria, Jackson, Refugio—known to occur within 1 mile of pipeline route
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic, deep loose sands of Carrizo, disturbed areas				Bexar
Mammals						
Plains Spotted Skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			C2	Bexar, Wilson
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes	E	E	E	Karnes, Wilson, Goliad, Refugio
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Karnes, Wilson, Goliad, Refugio

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

* E = Endangered T = Threatened C3 = No longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PT = Proposed Threatened Blank = Rare, but no regulatory listing status
WL = Watch List – Potentially threatened, especially in Texas

The proposed pipeline would cross several small creeks between the Colorado River and the Guadalupe River Saltwater Barrier. Because woodlands in this area are often limited to the riparian strips associated with creeks and rivers, these riparian woodlands constitute an important habitat for many plant and animal species. A detailed environmental assessment to include wetlands delineation, an endangered species survey, habitat mapping and an inventory of the vegetation affected along the pipeline right-of-way would be needed prior to implementing the project. With respect to pipeline installation, significant impacts to environmental resources can often be avoided by selection of the pipeline easement.

Intakes for implementing Option S15-E would be located on the Guadalupe and Colorado Rivers. The Colorado River flows from west to southeast through Texas from the Llano Estacado in New Mexico, across the Western High Plains Ecoregion through the Central Plains and across the Central Texas Plateau before crossing the Balcones Escarpment and flowing through the Blackland Prairies and East Central Plains to the Western Gulf Coastal Plains. In Matagorda County, the Colorado River is a large, low gradient stream generally exhibiting fine-grained sediments in extensive sandy braided reaches and occasional cobble and gravel riffles. As is commonly the case in coastal plain reaches, pool-riffle sequences are poorly developed. Low head dams impound two significant reaches of the river in Matagorda County. In addition to the numerous impoundments on the upper river and on major and minor tributaries, the Highland Lakes (large mainstream reservoirs constructed on the Edwards Plateau) are operated by the Lower Colorado River Authority to provide hydropower, flood control, and water storage in the lower Colorado River Basin. Operation of these reservoirs, particularly winter storage and summer releases of water for rice irrigation in Colorado, Wharton, and Matagorda Counties, has substantially altered the annual hydrography of the lower river (below Austin) from its historical condition.[19]

Below Bay City, the Colorado River is tidally influenced (Segment 1401), and its aquatic community is characterized by more marine species. The river mouth has recently been relocated by the U.S. Army Corps of Engineers (USCE) so that it no longer discharges directly into the Gulf of Mexico, but into the eastern arm of Matagorda Bay, as it did prior to its rapid delta propagation some 60 years ago. This action is expected to increase Colorado River inflows

[19] Mosier, D.T. and R.T. Ray, "Instream Flows for the Lower Colorado River," Lower Colorado River Authority, Austin, Texas, 1992.

to Matagorda Bay by about 30 percent (from an average of 1.2 million to about 1.7 million acft/yr), but hydrologic and modeling studies are still in progress.[20]

Potential effects on the Colorado River from operation of this option include entrainment of Colorado River flora and fauna, and reduced streamflows below the diversion. Although the numerous long-term agricultural diversions in place on this reach suggest that the present riverine community is tolerant of the effects of entrainment, it should be minimized by selection of an intake location that does not attract fish, and by use of appropriate screening technology to reduce potential losses to aquatic populations. The blue sucker (*Cycleptus elongatus)* and the Guadalupe bass *(Micropterus treculi)* occur in the reach of the Colorado River where the proposed intake would be constructed. The blue sucker is listed by the Texas Parks and Wildlife Department (TPWD) as threatened and by U.S. Fish and Wildlife Service (USFWS) as a Candidate 2 species. The Guadalupe bass is listed by USFWS as a Candidate 2 species. A survey of the river in the area of the diversion should be conducted to identify critical habitats (e.g., nursery habitat) for aquatic species that could be avoided.

Potential changes in streamflow resulting from the implementation of the smaller scale importation source scenario (S-15Ea) associated with the proposed Cibolo Reservoir were evaluated for Cibolo Creek below Cibolo Reservoir and the Guadalupe River Saltwater Barrier. Monthly median streamflows and monthly streamflow frequencies at each of these locations with and without the project are compared in Figure 5.3-4.

Modeling the operations of Cibolo Reservoir, including the interbasin transfers, indicated that annual median flow in Cibolo Creek would be reduced from 64,139 acft/yr to 11,326 acft/yr (82.3 percent). Decreases in monthly median flows would range from 77.6 percent to 41.7 percent. In terms of flows in Cibolo Creek at Falls City, the most significant effects would be a reduction in high flows with a concomitant reduction in flow variability. Plant and animal species favoring reduced, consistent flow can be expected to increase relative to those favoring more variable flows.

The estuarine environments of the Guadalupe and San Antonio Bays serve as critical habitat and spawning grounds for many marine species and migratory birds. Estuaries are marine environments maintained in a brackish state by the inflow of freshwater from rivers and

[20] TWDB, Unpublished data, Bay and Estuaries Study Program, Texas Water Development Board, Austin, Texas, 1990.

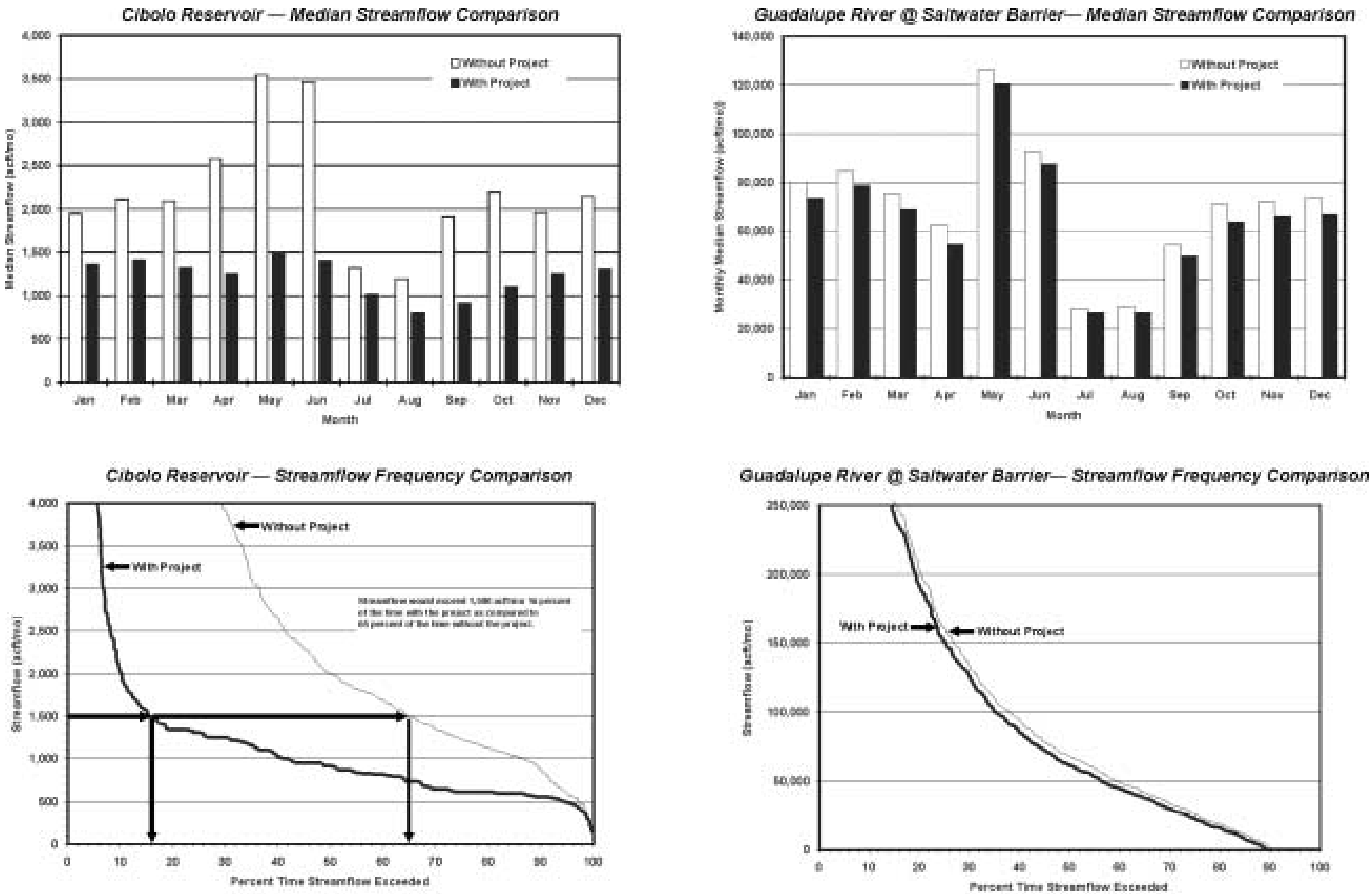


Figure 5.3-4. Cibolo Reservoir with Saltwater Barrier, Streamflow Comparisons

streams. Bay volume, freshwater inflow, and tidal exchange with the Gulf of Mexico are so large during periods of normal river flows that impacts to salinity gradients, nutrient loading, and sediment transport will not likely be detectable.

Modeling flows for the Guadalupe River below the Saltwater Barrier indicated that annual flow would be reduced from 1.41 million acft/yr to 1.32 million acft/yr (6.5 percent). Decreases in monthly median flows would range from 12.4 percent during the month of lowest flow to 4.5 percent in a higher flow month. In terms of medians, flow reductions would be fairly consistent from month to month and maintain a pattern of seasonal variation similar to that without the project. Although the monthly variation pattern would be maintained and the greatest decreases in flow volume would occur in the high flow range, percent flow reductions would be greatest in the low flow range. This is because reclaimed water represents a greater proportion of the water diverted during low flows compared with that diverted during higher flows. Detailed environmental studies would be needed to assess actual instream flow needs for the Colorado and Guadalupe Rivers prior to implementation of a project.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources.

5.3.4 Engineering and Costing

For this option (S-15E), water potentially available for diversion from the Saltwater Barrier would be pumped at non-uniform rates to Cibolo Reservoir, which would serve as a storage and balancing reservoir. Water potentially available for diversion from the Colorado River would be pumped at non-uniform rates to the Guadalupe River Saltwater Barrier and then to Cibolo Reservoir. From Cibolo Reservoir, the firm yield would be pumped at a uniform rate to the major municipal demand center of South Central Texas Region. The major facilities required to implement this option are:

- Importation Source River Intakes and Pump Stations
- Raw Water Pipelines to Cibolo Reservoir
- Raw Water Transmission Pump Stations

- Dam and Reservoir
- Reservoir Intakes and Pump Stations
- Raw Water Pipeline from Cibolo Reservoir
- Water Treatment Plant (Level 3; see Appendix A)
- Distribution

Optimization analyses were performed to select the appropriate import pipeline size for delivery of water from the Saltwater Barrier to Cibolo Reservoir in previous studies,[21] and thus, the previously determined pipe sizes were used in all importation analyses and cost estimates presented herein.

For each source scenario or option, costs for the selected importation facilities were combined with costs for Cibolo Dam and Reservoir (see Section 5.1), other major facilities listed above, and related project costs (land acquisition, mitigation, engineering, etc.) to obtain Total Project Cost. Total Project Cost was then converted to annual debt service (40 year finance period at 6 percent interest for the reservoir and 30 year finance period at 6 percent for all other capital costs) and combined with related operations and maintenance and power costs to obtain Total Annual Cost. Cost estimates for each importation source scenario are summarized in Tables 5.3-2 and 5.3-3 and discussed in the following subsections.

Option S-15Ea: Import from Guadalupe River Saltwater Barrier

Cibolo Reservoir operated in conjunction with available water imported from the Guadalupe River Saltwater Barrier could provide a firm yield of about 68,688 acft/yr at an annual cost of $993/acft. This firm yield and annual cost are based on a 60-inch diameter import pipeline from the Saltwater Barrier and a 64-inch transmission pipeline from Cibolo Reservoir to the major municipal demand center of the South Central Texas Region (Table 5.3-2).

Option S-15Eb: Import from Guadalupe River Saltwater Barrier and Colorado River

Cibolo Reservoir operated in conjunction with available water imported from the Guadalupe River Saltwater Barrier and the Colorado River near Bay City could provide a firm yield of about 79,090 acft/yr at an annual cost of $1,355 per acft. This firm yield and annual cost are based on an 84-inch diameter import pipeline from the Saltwater Barrier, a 60-inch diameter

[21] HDR, Op. Cit., January 1996.

Table 5.3-2.
Cost Estimates for
Cibolo Reservoir with Imported Water from the
Guadalupe River Saltwater Barrier (S-15Ea)
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool: 409,700 acft; 16,700 acres; 416 ft-msl)	$139,446,000
Intakes and Pump Stations (2 intakes and pump stations, 2 transmission pump stations)	31,374,000
Water Treatment Plant (64.6 MGD)	43,697,000
Transmission Pipeline (64-inch dia., 42.3 miles; 60-inch dia., 97.8 miles)	126,897,000
Distribution	74,027,000
Total Capital Cost	**$415,441,000**
Engineering, Legal Costs and Contingencies	$135,301,000
Environmental & Archaeology Studies and Mitigation	28,515,000
Land Acquisition and Surveying (18,782 acres)	32,221,000
Interest During Construction (4 years)	97,837,000
Total Project Cost	**$709,315,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$31,407,000
Reservoir Debt Service (6 percent for 40 years)	18,410,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	2,484,000
Dam and Reservoir	2,092,000
Water Treatment Plant	5,371,000
Pumping Energy Costs (140,719,597 kWh @ $0.06/kWh)	8,443,000
Total Annual Cost	**$68,207,000**
Available Project Yield (acft/yr)	**68,688**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$993**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$3.05**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Table 5.3-3.
Cost Estimates for
Cibolo Reservoir with Imported Water from the Guadalupe River Saltwater Barrier and the Colorado River near Bay City (S-15Eb)
Second Quarter 1999 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 409,700 acft; 16,700 acres; 416 ft-msl)	$139,466,000
Intakes and Pump Stations (3 intake and pump stations; 1 transmission pump station)	51,822,000
Water Treatment Plant (74.3 MGD)	49,600,000
Transmission Pipeline (66" dia., 42.3 miles; 84" dia.,97.8 miles; 60" dia., 81 miles)	399,804,000
Distribution	82,850,000
Total Capital Cost	**$723,542,000**
Engineering, Legal Costs and Contingencies	$225,114,000
Environmental & Archaeology Studies and Mitigation	28,512,000
Land Acquisition and Surveying (19,174 acres)	35,983,000
Interest During Construction (4 years)	162,105,000
Total Project Cost	**$1,175,256,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$65,255,000
Reservoir Debt Service (6 percent for 40 years)	18,412,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	5,476,000
Dam and Reservoir	2,092,000
Water Treatment Plant	5,371,000
Pumping Energy Costs (175,505,579 kWh @ $0.06/kWh)	10,530,000
Total Annual Cost	**$107,136,000**
Available Project Yield (acft/yr)	**79,090**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$1,355**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$4.16**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

import pipelines from the Colorado River to the Saltwater Barrier, and a 66-inch transmission pipeline from Cibolo Reservoir to the major municipal demand center of the South Central Texas Region (Table 5.3-3).

5.3.5 Implementation Issues

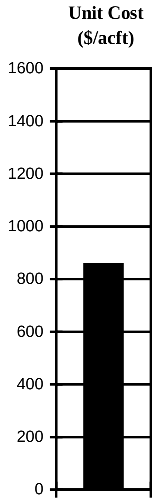
Implementation of Cibolo Reservoir with water imported from the Guadalupe and Colorado Rivers could directly affect the feasibility of other water supply options under consideration, including L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S-16C, G-16C1, G-17C1, G-20, G-38C, C-13C, C-17A, C-17B, C-18, SCTN-6, SCTN-14b, SCTN-15, SCTN-16b, and/or SCTN-16c.

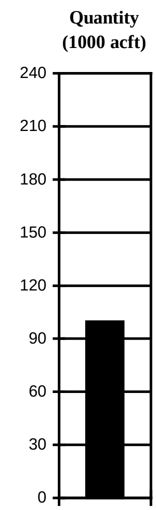
An institutional arrangement is needed to implement projects including financing on a regional basis.

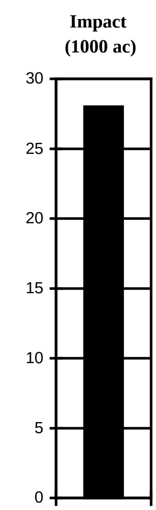
1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer(s) Approval.
   c. TNRCC bed and banks permit for use of affected reaches of San Antonio River to deliver SAWS treated effluent.
   d. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   e. General Land Office (GLO) Sand and Gravel Removal permits.
   f. GLO Easement for use of state-owned land.
   g. Coastal Coordination Council review.
   h. TPWD Sand, Gravel, and Marl permit for stream crossings.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land in the reservoir area and pipeline right-of-way and easements will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

5. Other Considerations:
   a. Water demand reduction programs by SAWS may reduce the quantity of future effluent discharges.
   b. Use of return flows must be negotiated with SAWS. Use arrangements should consider drought contingency planning that might result in a reduction of effluent discharges by SAWS.
   c. Water compatibility testing, including biological and chemical characteristics will need to be performed.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 11/16/99







OPTION NUMBER: **S-16C**
OPTION NAME: **Goliad Reservoir — Firm Yield**

OPTION DESCRIPTION: *The firm yield of the proposed Goliad Reservoir, located in Goliad County, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region and distributed to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☐ **5-15 yr.** ☒ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$856**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**99,687**	**acft/yr[2]**
LAND IMPACTED:	**28,272**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, intake and pump station, raw water pipeline to treatment plant, water treatment plant, and distribution to municipal systems or recharge zone. Costs include relocations, mineral right acquisition, and environmental and archaeological studies.

[2]**QUANTITY OF WATER:** Firm yield of Goliad Reservoir subject to instream flow requirements, reclaimed water use, water rights, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Mitigation for inundation of 27,810 acres and minimum releases for instream flows and freshwater inflows to bays and estuaries downstream of the reservoir.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The San Antonio River Valley Rural Historical District would be adversely affected by the proposed reservoir. Mitigation and studies for the District and rest of the reservoir site would be required.

ADDITIONAL FACTORS: Numerous mineral rights are present in the reservoir area and will require acquisition or relocation.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-11, L-14, L-20, S-14D, S-15C, S-15D, S-15E, G-16C1, G-17C1, G-20, SCTN-6, SCTN-16b, and/or SCTN-16c.

5.4 Goliad Reservoir (S-16C)

5.4.1 Description of Option

Goliad Reservoir is a proposed major impoundment located on the San Antonio River approximately 8 miles west of the City of Goliad in Goliad County. The project has been studied several times,[1,2] most recently in the 1996 Trans-Texas Water Program by HDR Engineering, Inc. (HDR).[3] The approximate locations of Goliad Reservoir and the 91-mile transmission pipeline conveying the firm yield to the major municipal demand center of the South Central Texas Region are shown in Figure 5.4-1.

The dam would likely be an earthfill embankment with a gate-controlled, concrete spillway. The dam would extend about 2.5 miles across the San Antonio River valley and provide a conservation storage capacity of about 707,500 acft below elevation 200 feet-mean sea level (ft-msl). At full conservation pool the reservoir would inundate about 27,810 acres along approximately 43 miles of stream channel. The probable maximum flood elevation has been estimated at 210 ft-msl.

5.4.2 Available Yield

The firm yield from a completed Goliad Reservoir was estimated based on assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction. The Guadalupe-San Antonio River Basin Model[4] (GSA Model) was used to estimate flow available for impoundment at the Goliad Reservoir. For modeling purposes, streamflows for the San Antonio River at Goliad (USGS# 08188500) were assumed representative of inflows to Goliad Reservoir. The GSA Model calculates monthly streamflow modified by upstream diversions and effluent discharges and then determines monthly streamflow available for diversion or impoundment subject to downstream senior rights or bay and estuary inflow requirements. Daily reservoir inflows and pass-throughs for senior water rights and bay and estuary inflows were then estimated based on historical gaged streamflow

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[1] U. S. Bureau of Reclamation, "Texas Basins Project," February 1965.
[2] Espey Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," February 1986.
[3] HDR Engineering, Inc. (HDR), "West Central Study Area Phase I Interim Report," Volume IV, Trans-Texas Water Program, January 1996.
[4] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Vol. I, II, and III, Edwards Underground Water District, September 1993.

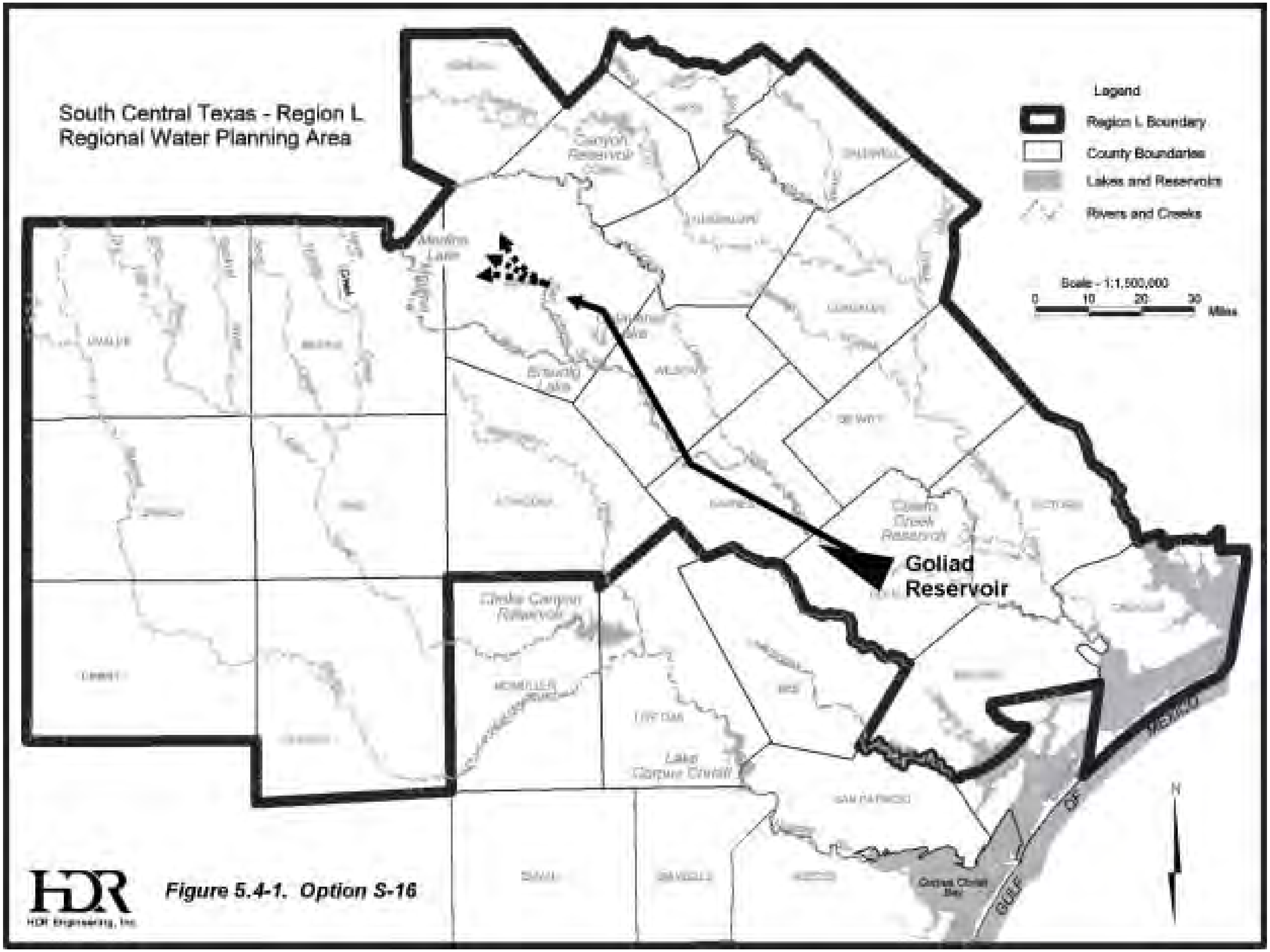


Figure 5.4-1. Option S-16

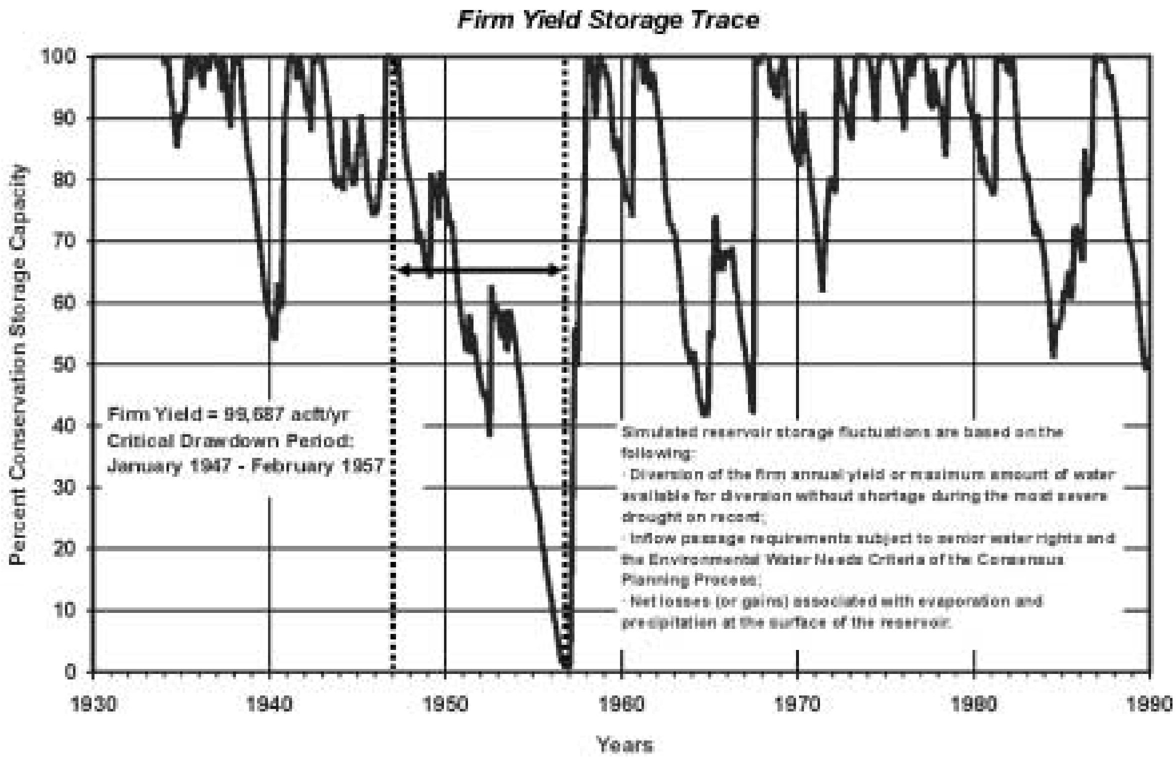
records. These daily streamflows and pass through requirements at the reservoir site were used to compute firm yield using the SIMDLY model originally developed by the Texas Water Development Board (TWDB) and modified by HDR Engineering, Inc. to simulate daily reservoir operations subject to Consensus Environmental Criteria (Appendix B). Note that the 7Q2 value published in the Texas Natural Resource Conservation Commission's (TNRCC) Water Quality Standards (211.2 cfs) was used as the minimum (Zone 3) streamflow passage requirement although recent water quality modeling indicates that substantially less streamflow need pass Goliad to comply with the TNRCC's 5 mg/L standard for minimum dissolved oxygen.[5] Finally, the GSA Model was used to assess changes in streamflow for the San Antonio River at Goliad and for the Guadalupe River at the Saltwater Barrier based on Goliad Reservoir operations with a diversion of the firm yield.

The computed firm yield for Goliad Reservoir is 99,687 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. Figure 5.4-2 illustrates simulated Goliad Reservoir storage fluctuations and a reservoir storage frequency curve for the 1934 to 1989 historical period if operated under the Consensus Environmental Criteria and subject to diversion of the firm yield of 99,687 acft/yr. Note that this estimate of firm yield and these presentations of storage considerations do not reflect the potential contribution of additional discharges of treated effluent to the San Antonio River that would likely result from the delivery of water supplies from Goliad Reservoir to the major municipal demand center of the South Central Texas Region. Monthly median streamflows and streamflow frequency curves with and without the project are presented in Figure 5.4-3 for San Antonio River at Goliad and the Saltwater Barrier at the mouth of the Guadalupe River.

5.4.3 Environmental Issues

The proposed reservoir is within the East Central Texas Plains Ecoregion. Omernik describes the ecoregion as irregular plains of oak and hickory woodlands with some cropland and pasture on dry alfisols soils.[6] Soil types in the area of the proposed reservoir are Leming-Papalote (LP) association, Runge-Sarnosa (RS) association, and Aransas-Sinton (AS)

[5] HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, San Antonio River Authority, et al., March 1998.
[6] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1), pp. 118-125, 1987.



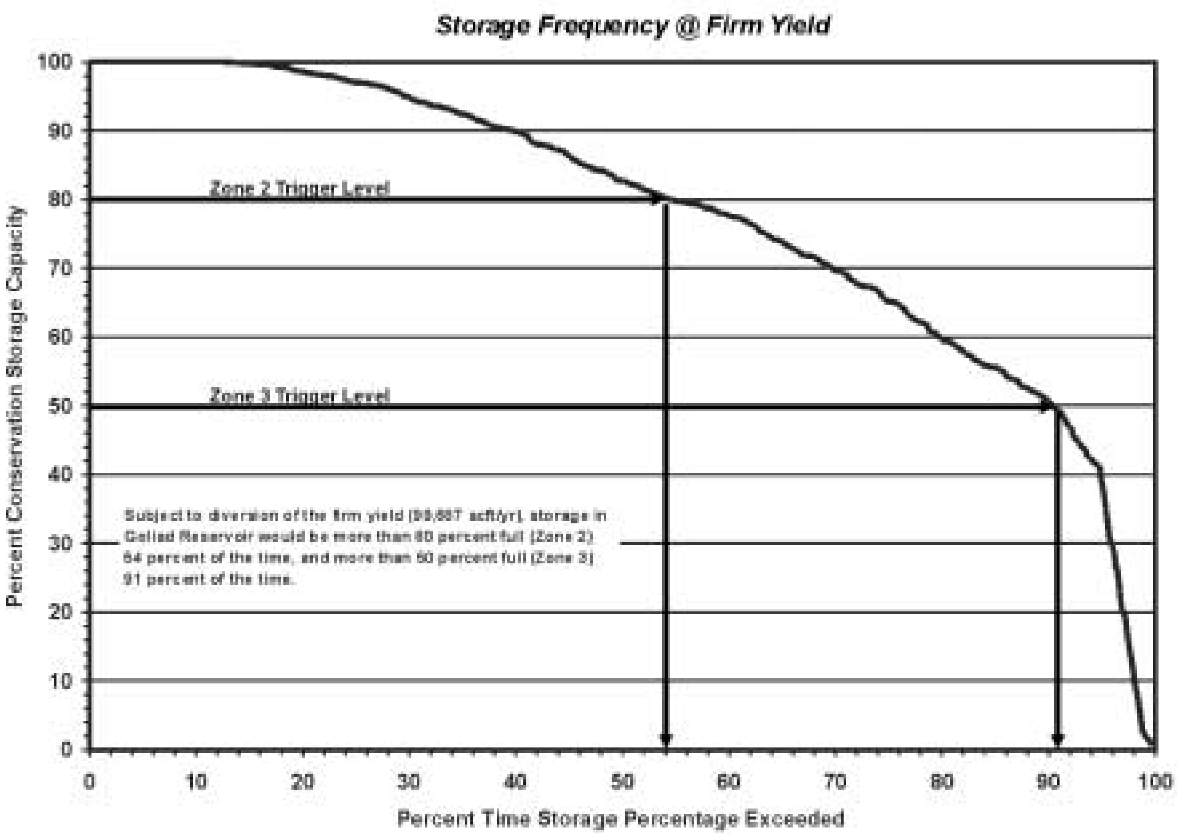


Figure 5.4-2. Goliad Reservoir Storage Considerations

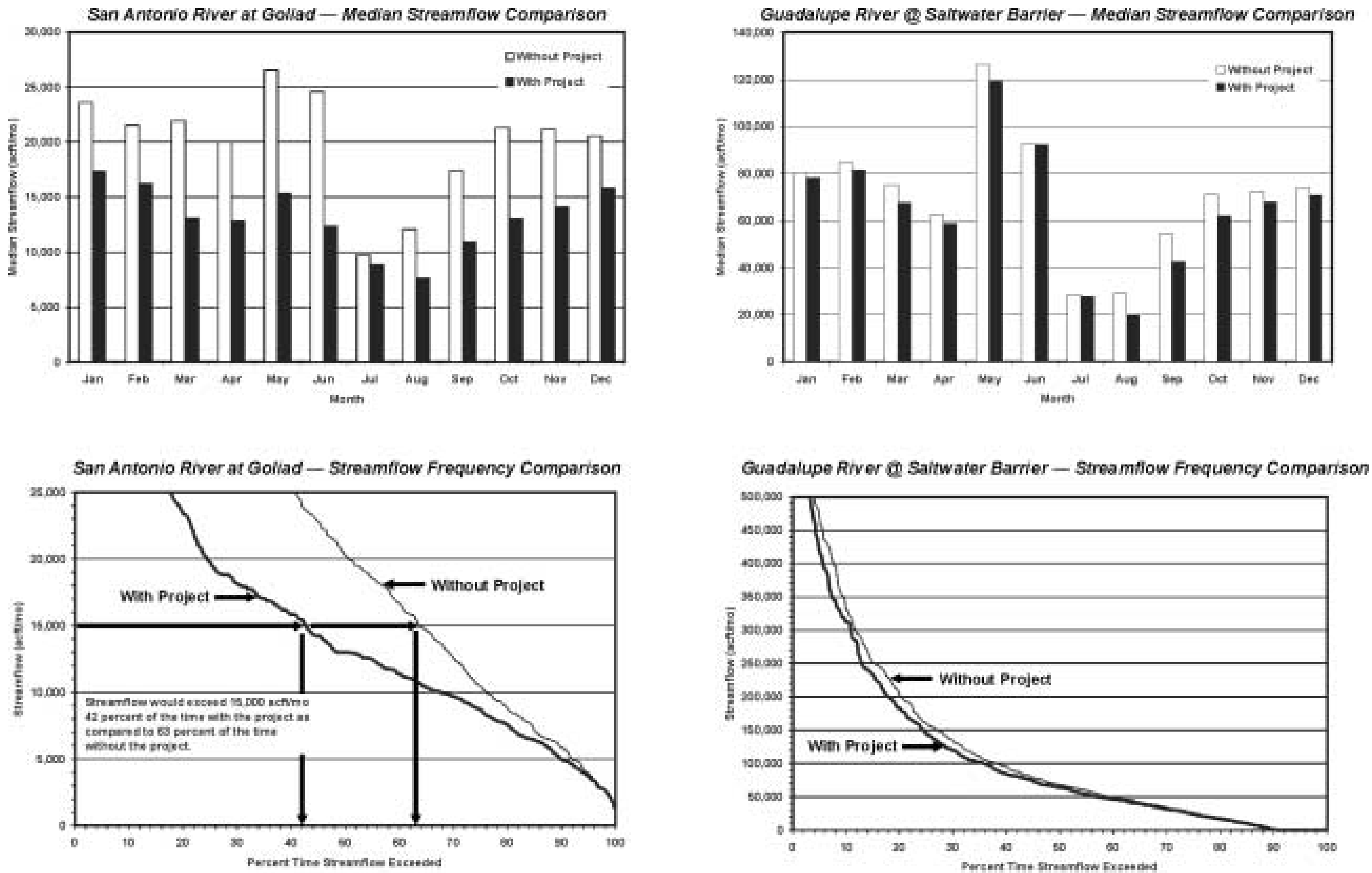


Figure 5.4-3. Goliad Reservoir Streamflow Comparisons

association.[7] The LP association is described as being nearly level to gently sloping, deep, slightly acid or neutral, sandy and loamy soils of the uplands; the RS association is gently sloping to sloping, deep, neutral to moderately alkaline, loamy soils of the uplands; the AS association is nearly level, deep, moderately alkaline, clayey and loamy soils of the bottomlands. The RS and AS soil associations are well drained and moderately permeable and have low shrink-swell potential. The LP soil association is moderately well drained and has a slowly permeable subsoil that has moderate shrink-swell potential.

Indirect impacts of reservoir construction and operation would include land use changes in the areas surrounding the reservoir, and mitigation would likely be required to compensate for losses of terrestrial habitat. The impacted area would include approximately 560 acres of wetlands, primarily the San Antonio River channel (43 river miles), Cabezo, Charo, and Hord Creeks, portions of Escondido, Ecleto, Hondo, and Cottonwood Creeks, and vegetated wetlands on the floodplain. Inundated uplands would consist of approximately 3,100 acres of woods, brush and shrublands, 23,950 acres of grass and cropland and 200 acres of developed areas.[8] Indirect impacts of reservoir construction and operation would include land use changes in the areas surrounding the reservoir, and mitigation will likely be required to compensate for losses of terrestrial habitat. Impacts to the reservoir area would include replacing terrestrial habitat and lotic aquatic habitat with lentic aquatic habitat. Of particular significance is the loss of bottomland hardwood and riparian communities, and hydric soils along the creek and in the floodplain, which represents important wildlife habitat. Wetland mapping has not been completed for this area, so a detailed inventory of wetland types is not available for this assessment.

The vertebrate community within the area of the proposed reservoir is made up primarily of those found in the Tamaulipan Biotic Province.[9] Vertebrates of this biotic province may include neotropical, grassland, Austroriparian and some Chihuahuan province species. At least 61 species[10] of mammals, 36 species of snakes, 19 species of lizards, 2 species of Terrapene, 3 urodeles, and 19 anurans occur in the Tamaulipan province. Six of the 19 species of lizards of

[7] United States Department of Agriculture Soil Conservation Service and Texas Agricultural Experiment Station, "Soil Survey of Goliad County, Texas," USDA, 1975.
[8] USGS, EROS Center, Color aerial photos, 1990.
[9] EH&A, Op. Cit. February 1986.
[10] Ibid.

this province occur in the state only in this province. One species of land turtle, Texas Tortoise (Table 5.4-1) is restricted to the Tamaulipan. Six of the 36 species of snakes known from the Tamaulipan province are unknown from other provinces in the state, however only two of them range as far north as the proposed reservoir. One species of urodel and five of the 19 species of anurans are restricted to this province but probably do not range as far north as the study area.[11]

Table 5.4-1.
Important Species* Having Habitat or Know to Occur in Counties Potentially Affected by Option Goliad Reservoir (S-16C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/ Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/ Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/ Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/ Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/ Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident

[11] Ibid.

Table 5.4-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/ Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/ Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/ Migrant
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Peregrine Falcon	*Falco peregrinus*	Open country, cliffs, occasionally cities[5]	E	T	NL	Nesting/ Migrant
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes		T	T	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaaphomyia texanus*					Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident

Table 5.4-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Two-Flower Stickpea	*Calliandra biflora*	Well drained sandy soils, grasslands and shrublands			WL	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/ Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/ Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/ Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/ Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. Pg. 86.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL = Potentially Endangered/Threatened
Blank = Rare, but no regulatory listing status NL = Not Listed

Important species with habitat in Bexar, Goliad, Karnes, and Wilson Counties are listed in Table 5.4-1. In accordance with the TPWD Natural Heritage Program, two species were located within the project area: Elmendorf's onion (*Allium elmendorfii*) was found on the pipeline route, while the Two-Flower stickpea (*Calliandra biflora*) was within the reservoir site. Aside from the mapped species, several protected plants and animals have habitat requirements or preferences that indicate that they could be present within the area. Within the proposed reservoir site, 3,100 acres of wood, brush, and scrublands will be inundated. This habitat is utilized by many protected species. The endangered Jaguarundi (*Felis yagouaroundi*) prefers thick brushlands, especially areas near water, while the Texas Tortoise (*Gopherus berlandieri*) inhabits the open brush with a grass understory. The Plains Spotted Skunk (*Spilogale putorius interrupta*) is found in both wooded and brushy areas. The endangered Ocelot (*Felis pardalis*) lives within mesquite-thorn scrubland and dense chaparral thickets along with the Indigo Snake (*Drymarchon corais erebennus*). The Texas Garter Snake (*Thamnophis sirtalis annectens*) may be found within the 560 acres of the proposed inundated wetlands. The Timber Rattlesnake (*Crotalus horridus*) may be found within the bottomland hardwoods. Other important species that may inhabit the project area include the Texas Horned Lizard (*Phrynosoma cornutum*), Attwater's Prairie Chicken (*Tympanuchus cupido attwateri*), Bald Eagle (*Haliaeetus leucocephalus*), Interior Least Tern (*Sterna antillarum athalassos*), and the Sheep Frog (*Hypopachus variolosus*). Several marine endangered species that may utilize San Antonio Bay should be considered in evaluating the potential effects of the modified inflow regime resulting from this option.

Two protected bird species that may be found within the study area are the Golden-cheeked Warbler (*Dendroica chrysoparia*) and Black-capped Vireo (*Vireo atricapillus*). The Golden-cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

The magnitude of impact to significant resources in the river's riparian zone is an important consideration in permit feasibility assessments when estimating the potential loss of riverine resources. The San Antonio River bottom riparian zone contains many large mature pecan trees. The reservoir would inundate these trees, along with mature walnut and oaks in the uplands. The pipeline route alignment must also consider impacts to the riparian corridor of the San Antonio River. Preliminary alignments show the route crossing the river twice and paralleling U.S. Highway 181 through most of Wilson County from Karnes County. Care should be taken to ensure that this pipeline is along existing disturbed easements that are outside of the riparian and wooded corridor that remains along the river.

With regard to cultural resources, there is some information that numerous cultural resource sites are located within the proposed reservoir.[12] One-third of the proposed reservoir encompasses much of the San Antonio River Valley Rural Historical District. This Rural

[12] Texas Historical Commission, Unpublished, Letter to Ms. Patsy Light, Friends for Conservation of the San Antonio River Basin (FCSARB), September 1993.

Historical District was listed in the National Register of Historic Places in 1995 and is the second largest National Register District in the State of Texas. The implementation of this option would inundate much of this resource and require substantial mitigation of adverse effects, which would likely be expensive.[13]

The San Antonio River Valley Rural Historical District is listed in the National Register and it will receive consideration in planning for Federal, federally licensed, and federally assisted projects. Section 106 of the National Historic Preservation Act of 1966 requires that Federal agencies allow the Advisory Council on Historic Preservation an opportunity to comment on all projects affecting historic properties either listed in or determined eligible for listing in the National Register. The State Historic Preservation Officer (SHPO) is also consulted in this consideration process and the Agency Official also considers the views of consulting parties and the public.

Adverse effects occur when an undertaking may directly or indirectly alter characteristics of an historic property that qualify it for inclusion in the Register. Reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance, or be cumulative, also need to be considered.[14] Under the Secretary of the Interior's *Standards*, the following are considered adverse effects:

- Destruction, relocation of a property;
- Change or use or physical features of a property's setting;
- Visual, atmospheric or audible intrusion;
- Neglect resulting in deterioration; or
- Transfer, lease, or sale of a property out of Federal ownership or control without adequate protection.

Section 106 of the National Historic Preservation Act (NHPA) has recently been revised to detail a series of consultations with timetables and public review of actions that may effect National Register properties. The steps include public hearing conflict resolution consultations with interested parties. New regulations define the role of memorandum of agreements to document program actions agreed to by consulting parties and regulatory agencies. If an agreement is not reached, Section 110(1) of the NHPA requires heads of agencies to document their decision. In this case, the agency would be the U.S. Army Corps of Engineers.

[13] Texas Historical Commission, Unpublished, Letter to Ms. Patsy Light, FCSARB, July 1999.
[14] 800.5(a)(1).

In addition to consideration of historic properties, a systematic pedestrian survey of the entire reservoir site would be required to search for surface indications of cultural deposits, while a geomorphologic study to evaluate the potential for buried deposits is also a likely requirement. Sites that may be located within the project area will have to be tested for cultural and historical significance, and for eligibility for listing on the National Register.

The potential environmental effects resulting from the construction and operation of water transport pipelines depends to a large extent on the exact placement of the construction corridor. In general, sensitive habitats, or habitats critical to the survival or protected species, are rare or of restricted distribution so that adverse impacts can often be avoided or minimized. More generally distributed habitats, although perhaps important to regional wildlife populations in some areas, may not be so easy to avoid, but because of the limited area affected by these corridors are unlikely to result in significant impacts. Specific construction corridors for the option have not been selected and assessed for this phase. Instead, it has been assumed that adverse impacts would be avoided and minimized to the extent practical by careful corridor selection in subsequent phases using vegetation, land use, and protected species information.

5.4.4 Engineering and Costing

The firm yield of Goliad Reservoir would be diverted through an intake and pumped in a transmission line to a water treatment plant located at the major municipal demand center of the South Central Texas Region. Water might then be distributed to municipal supply systems or to an aquifer recharge zone. The diversion rate from the reservoir used for costing purposes was assumed to be uniform throughout the year. The major facilities required to implement this alternative are:

- Dam and Reservoir;
- Reservoir Intake and Pump Station;
- Raw Water Pipeline to Treatment Plant;
- Water Treatment Plant (Level 3); and
- Distribution.

The cost estimate for the dam and reservoir was originally completed by Espey, Huston, & Associates, Inc. That cost estimate was updated to mid-1994 values during the Trans-Texas Water Program. The mid-1994 estimate has been updated to Second Quarter 1999 costs by multiplying the 1994 cost by the ratio of the Engineering News Record Construction Cost

Indexes. The reservoir intake and pump station is sized to deliver 8,850 acft/month (93 MGD) through a 78-inch diameter pipeline, with a 5 percent downtime allowance. The operating cost was determined for the total raw water pumping head and an annual water delivery of 99,687 acft/yr. The cost of mineral right acquisition was estimated from the Goliad County Tax Office appraisals. The total value of mineral rights in Goliad County is appraised at $130 million. The total appraised value of the mineral rights located within the project area was estimated to be 25 percent of the total value of the county, or $32,500,000. The 25 percent is based on the number of mineral references inside the reservoir area relative to the number of mineral references in the rest of the county. Relocation costs include the cost of relocating oil and gas pipelines, utilities, and roadways. The total annual cost for debt service for the project is $63,729,000. The debt for the reservoir and associated items is financed at 6 percent for 40 years and all other project costs are financed at 6 percent for 30 years (Table 5.4-2). Operation and maintenance costs, including power, total $21,605,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $85,334,000. For an annual firm yield of 99,687 acft, the resulting annual cost of water is $856 per acft (Table 5.4-2).

5.4.6 Implementation Issues

Implementation of Goliad Reservoir could directly affect the feasibility of other water supply options under consideration, including L-11, L-14, L-20, S-14D, S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, S-15Eb, G-16C1, G-17C1, SCTN-16b, and SCTN-16c.

An institutional arrangement is needed to implement projects including financing on a regional basis.

1. It will be necessary to obtain these permits:
    a. TNRCC Water Right and Storage permits.
    b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
    c. GLO Sand and Gravel Removal permits.
    d. GLO Easement for use of state-owned land.
    e. Coastal Coordination Council review.
    f. TPWD Sand, Gravel, and Marl permit

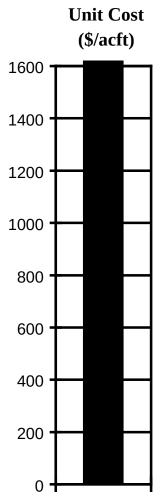
Table 5.4-2.
Cost Estimate Summary for
Goliad Reservoir (S-16C)
(Second Quarter 1999 Prices)

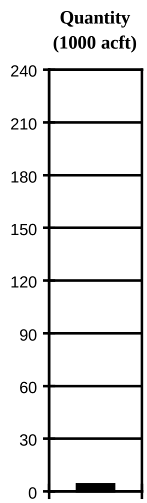
Item	*Estimated Costs*
Capital Costs	
Dam and Reservoir (Conservation Pool: 707,500 acft; 27,810 acres; 200 ft-msl)	$130,840,000
Intake and Pump Station (93 MGD)	10,099,000
Water Treatment Plant (93 MGD)	57,798,000
Transmission Pump Stations (2)	18,562,000
Transmission Pipeline (78-inch dia.; 91 miles)	130,228,000
Distribution (93 MGD)	97,282,000
Total Capital Cost	**$444,809,000**
Engineering, Legal Costs, and Contingencies	$149,172,000
Environmental & Archaeological Studies and Mitigation	78,331,000
Land Acquisition and Surveying (33,486 acres)	113,699,000
Interest During Construction (4 years)	125,763,000
Total Project Cost	**$911,774,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$36,763,000
Reservoir Debt Service (6 percent for 40 years)	26,966,000
Operation and Maintenance	
Intake, Pipeline, Pump Station, Distribution	2,915,000
Dam and Reservoir	1,451,000
Water Treatment Plant	7,330,000
Pumping Energy Costs (165,153,068 kWh @ $0.06 per kWh)	9,909,000
Total Annual Cost	**$85,334,000**
Available Project Yield (acft/yr)	**99,687**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$856**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$2.63**

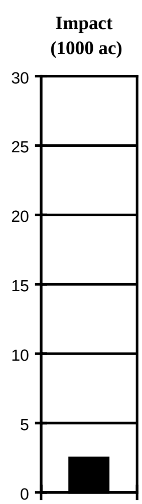
1 Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flows and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies and mitigation.
   e. Locating and plugging existing and abandoned petroleum wells.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Petroleum pipelines.
   c. Other utilities.
   d. Structures of historical significance.
   e. Cemeteries.
5. Other Coordination:
   a. The San Antonio River Basin Association (SRBA) represents organized opposition to consideration of this reservoir option. Implementation of this option would require substantial coordination with this group and with others (such as the San Antonio River Valley Rural Historical District) having specific local or regional interests.

SOUTH CENTRAL TEXAS REGIONAL WATER SUPPLY OPTIONS
OPTION DATA SHEET







OPTION NUMBER: S-14D
OPTION NAME: Applewhite Reservoir — Firm Yield

OPTION DESCRIPTION: *The firm yield of the proposed Applewhite Reservoir, located in Bexar County, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$3,192**	**per acft**[1]
QUANTITY OF WATER:	**4,032**	**acft/yr**[2]
LAND IMPACTED:	**2,500**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Dam and reservoir, intake and pump station, raw water pipeline to treatment plant, water treatment plant, finished water distribution system improvements.

[2]**QUANTITY OF WATER:** Firm yield of Applewhite Reservoir; instream flow requirements, return flows of reclaimed water to meet downstream water rights and levels of Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Reservoir site and sites for pipelines, pump stations, and water treatment plant.

ENVIRONMENTAL ISSUES: Mitigation for inundation of 2,500 acres of habitat and minimum releases for instream flows downstream of the reservoir.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Public opinion, as expressed in a 1995 election, opposed the project and resulted in its abandonment.

ADDITIONAL FACTORS: Not Applicable.

5.5 Applewhite Reservoir — Firm Yield (S-14D)

5.5.1 Description of Option

The firm yield of the proposed Applewhite Reservoir would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region. The Applewhite Reservoir site is located on the Medina River in southern Bexar County. Construction of the reservoir project was initiated in 1990 and terminated by referendum in 1995.[1] The project was studied most recently in the 1996 Trans-Texas Water Program by HDR Engineering, Inc. (HDR).[2]

The reservoir site has a potential a conservation storage capacity of approximately 45,250 acft; would control 1,070 square miles of the Medina River watershed; and would inundate approximately 2,500 acres at conservation pool level of 536 feet-mean sea level (ft-msl). The approximate locations of Applewhite Reservoir and the 22-mile transmission pipeline conveying its firm yield to the major municipal demand center of the South Central Texas Region is shown in Figure 5.5-1.

5.5.2 Available Supply and Yield

The firm yield from a completed Applewhite Reservoir was estimated based on assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction. The Guadalupe-San Antonio River Basin Model[3] (GSA Model) was used to estimate flow available for impoundment at the Applewhite Reservoir site. For modeling purposes, streamflows for the Medina River near Somerset (USGS# 08180800) were assumed representative of inflows to Applewhite Reservoir. The GSA Model calculates total daily streamflow, daily streamflow passed for downstream water rights, and daily streamflow passed for bay and estuary requirements. These streamflows at the reservoir site were used to compute firm yield using the SIMDLY model originally developed by the Texas Water Development Board and modified by HDR to simulate daily reservoir operations subject to

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[1] The land that had been acquired for the dam site is presently being managed and/or transferred to other uses by the San Antonio Water System.
[2] HDR Engineering, Inc., "West Central Study Area Phase I Interim Report," Volume II, Trans-Texas Water Program, May 1994.
[3] HDR, "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September 1993.

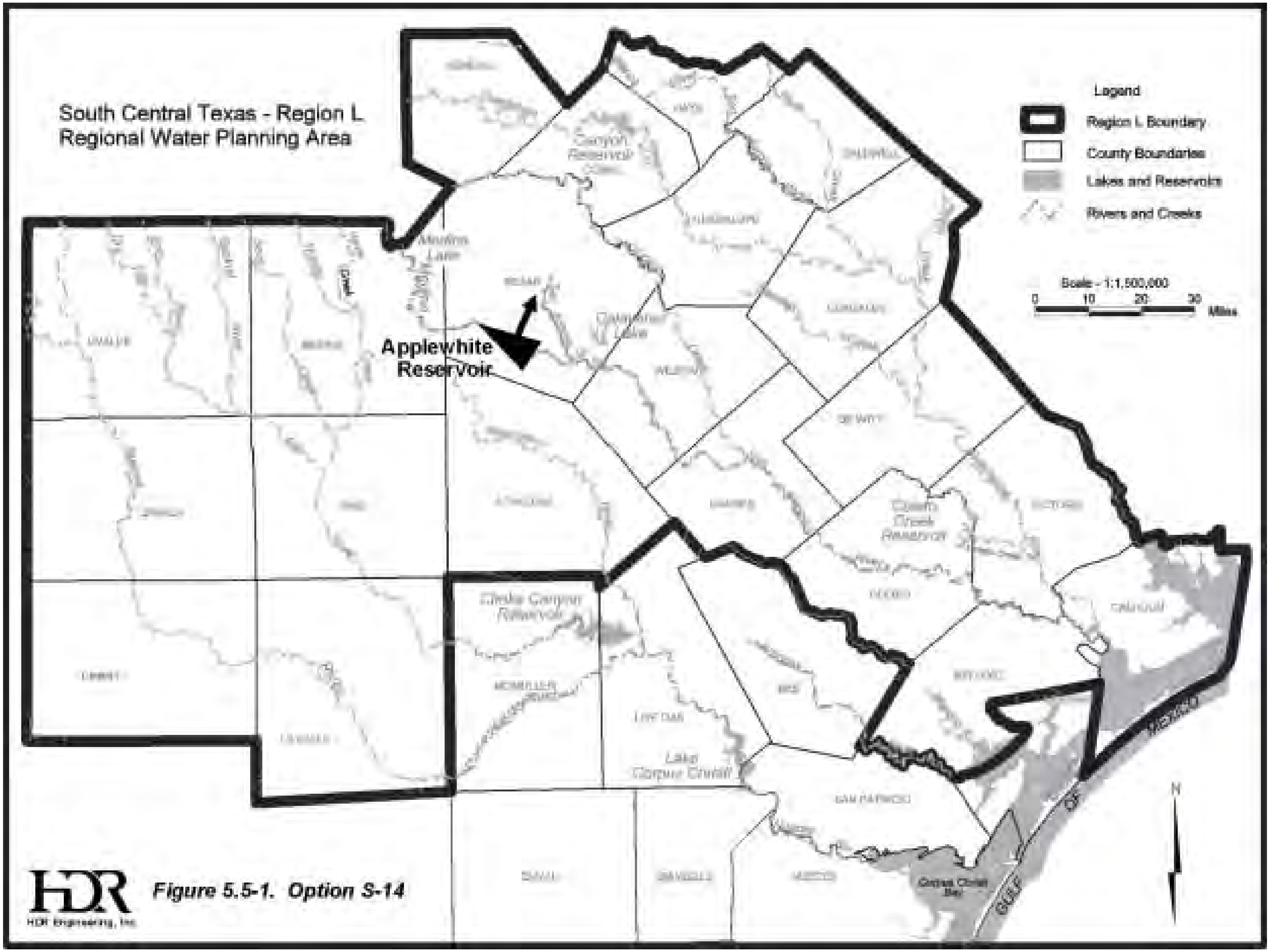

Figure 5.5-1. Option S-14

inflow passage criteria using water availability estimates from the GSA Model. Finally, the GSA Model was used to assess changes in streamflow at the Guadalupe Saltwater Barrier based on Applewhite Reservoir operations with diversion of the firm yield.

The computed firm yield of Applewhite Reservoir as determined in this study is 4,032 acft/yr, which is considered a reliable supply based on the 56-year period of hydrologic record considered. Figure 5.5-2 illustrates simulated Applewhite Reservoir storage fluctuations, a percent of capacity frequency curve for the 1934 to 1989 historical period, and a reservoir storage frequency curve if operated under the Environmental Water Needs Criteria of the Consensus Planning Process and subject to diversion of the firm yield of 4,032 acft/yr. Monthly median streamflows and streamflow frequency curves with and without the project are presented in Figure 5.5-3 for the Medina River near Somerset and the Saltwater Barrier at the mouth of the Guadalupe River. These graphs show a very limited impact on flows due to the reservoir.

5.5.3 Environmental Issues

The physical features of the proposed Applewhite Reservoir, its proposed location and associated structures have been described by the U. S. Army Corps of Engineers, Fort Worth District, in Draft and Final Environmental Impact Statements.[4,5] The proposed reservoir lies at the intersection of the Blackland Prairie Ecoregion, the Southern Texas Plains, and the East Central Plains Ecoregion,[6] while both the Medina River and Leon Creek originate within the Central Texas Plateau Ecoregion. The proposed reservoir is within the South Texas Plains vegetational area that encompasses the southern third of Bexar County. This area is also called the Rio Grande Plains[7] and corresponds roughly to Blair's[8] Tamaulipan Biotic Province.

Soil associations in southern Bexar County are a mosaic of clays and sandy loams.[9] Calcareous clays of the Lewisville - Houston terrace soil associations underlie southern urban San Antonio. Clay loams and sandy loams in the San Antonio-Crockett and the Hockley-Webb-

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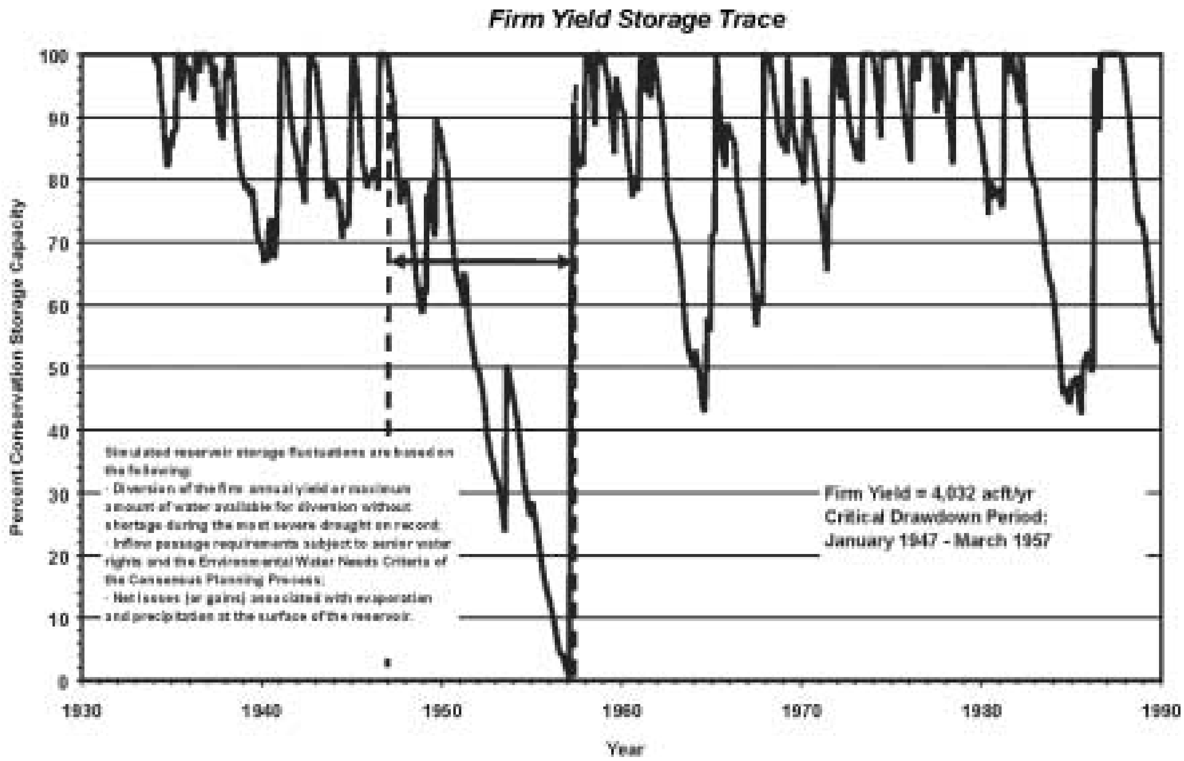
[4] U.S. Army Corps of Engineers, 1987, Applewhite Reservoir, Draft Environmental Impact Statement, Ft. Worth District, Ft. Worth, Texas;
[5] U.S. Army Corps of Engineers, 1989, Applewhite Reservoir, Final Environmental Statement, Ft. Worth, Texas.
[6] Omernik, James M., 1986, "Ecoregions of the conterminous United States," EPA/600/D - 86,USEPA, Corvallis, Oregon.
[7] Gould, Frank W., 1975, The Grasses of Texas, Texas A & M University, College Station, Texas.
[8] Blair, W. Frank, 1950, The biotic provinces of Texas, The Texas Journal of Science, Vol. 2, No. 1:93-117.
[9] Soil Conservation Service, 1991, Soil Survey Bexar County, Texas, Series 1962, No. 12. Reissued June 1991. U.S. Department of Agriculture.



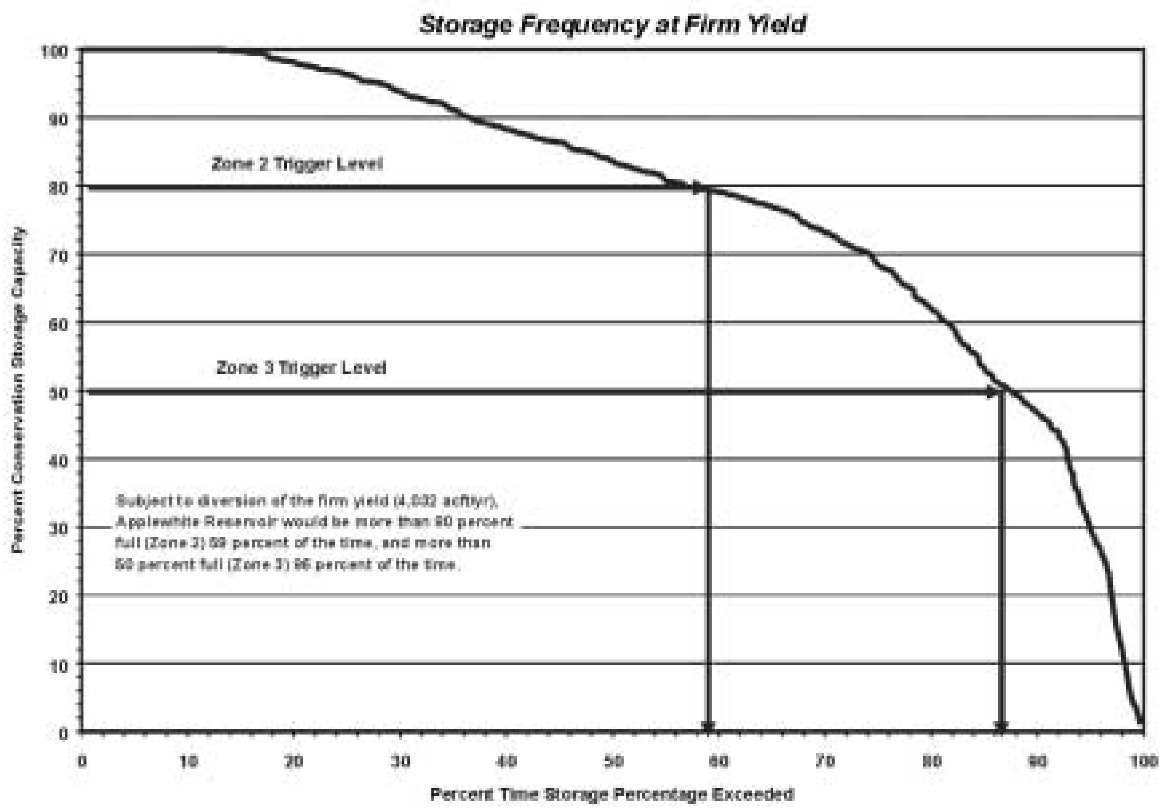


Figure 5.5-2. Applewhite Reservoir Storage Considerations

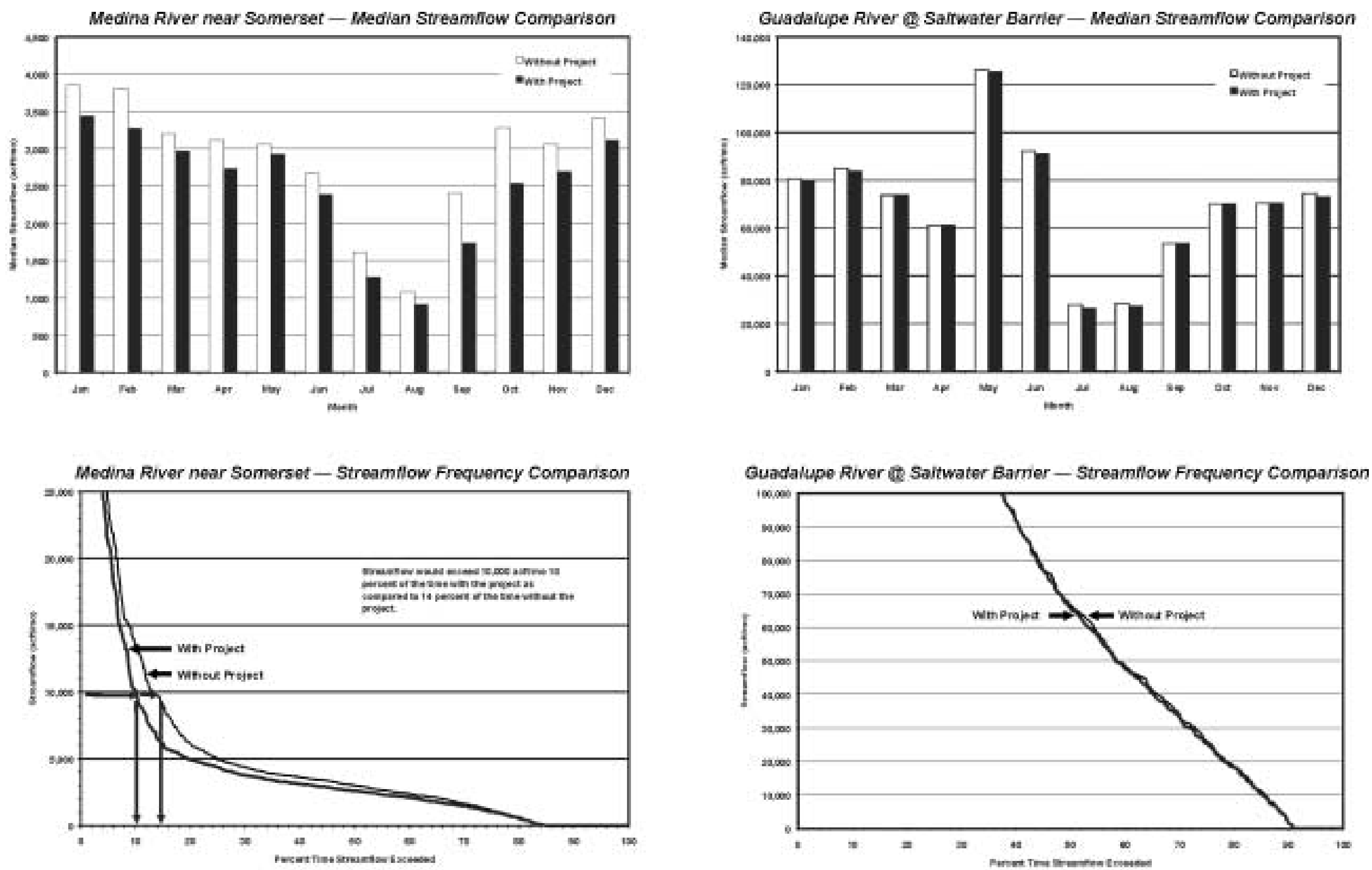


Figure 5.5-3. Applewhite Reservoir Streamflow Comparisons

Crockett associations cover the eastern and southern uplands. These soil associations are generally in irrigated cultivation, vacant mesquite-thornbrush range, and suburban development. Soil associations of the San Antonio River, Medina River and Leon Creek waterways are the Venus-Frio-Trinity soils. These are deep calcareous clay loams and clays found in bottomlands and stream terraces. Where the latter soils association is not in cultivation, riparian forest, mesquite brush, and recreational uses are prevalent.[10]

The riparian forests along the Medina River, Leon Creek and minor tributaries within the proposed project area consist of bald cypress, sycamore, eastern cottonwood, black willow, hackberry, elm, boxelder, and pecan overstory. The understory is sparse and limited by occasional flooding and grazing pressure. Managed pecan groves within the riparian corridor are used as pasture and have a grass cover. The riparian woodlands provide important habitat and migration corridors for wildlife. Wetlands in southern Bexar County occur in narrow bands within the stream channels and impoundments. Vegetation abruptly changes to mesquite brushland at the stream valley walls. Environmental studies estimate that 250 vertebrate species including 11 amphibians, 36 reptiles, 170 birds and 36 mammals live in and use the riparian forests.[11]

The brushlands are dominated by honey mesquite and other species, including whitebrush, agarito, huisache, yucca, Texas persimmon, and bluewood condalia. The herbaceous layer is a mixture of silver bluestem, plains lovegrass, buffalo grass, curly mesquite, purple three-awn, and hooded windmill grass. Brushlands dominate in the south and western portions of the proposed project area. An estimated 240 vertebrate species utilize this habitat type, including 5 amphibians, 45 reptiles, 150 birds, and 41 mammals.[12]

In 1984, a Habitat Evaluation Procedure (HEP) was performed to determine probable impacts on terrestrial wildlife and initiate mitigation planning for potential loss of habitat and associated wildlife populations. The vegetational and land use baseline for mitigation planning is presented in Table 5.5-1. This HEP study included a buffer area around the proposed reservoir that may experience indirect effects from secondary facilities and development.

[10] Ibid.
[11] U.S. Army Corps of Engineers, 1987, Applewhite Reservoir, Draft Environmental Impact Statement, Ft Worth District, Ft. Worth, Texas.
[12] Ibid.

Table 5.5-1.
Applewhite Dam and Reservoir Land Use Baseline

	Riparian Acres	Brushland Acres	Rangeland Acres	Cropland Acres	Urban Acres	Total Acres
Conservation Pool 536 ft-msl	908	940	62	584	6	2,500
Total Study Acreage	1,395	4,014	1,563	12,969	1,266	21,207
Source: U.S. Army Corps of Engineers, "Applewhite Reservoir, Draft Environmental Impact Statement," Ft. Worth District, Ft. Worth, Texas, 1987.						

The dominant land use within the project area has been farming and ranching. Because most rangeland and pasturelands in this area are heavily grazed, the HEP concluded that grazing was probably the single most important limiting factor to wildlife species in the project area. The HEP analysts concluded that when rangeland is in good condition, it can support approximately 155 vertebrate species. Small rural developments noted in the assessments as ranchettes do provide some habitat to urban compatible wildlife species.[13]

Aquatic habitats in the Medina River consist of riffles, pools, runs, and sand and gravel bars. Sampling was conducted in the mid-1980s to inventory habitats and biological communities of the reservoir site. Above Leon Creek, which enters the Medina River just below the proposed dam, invertebrate populations in the Medina River were diverse, indicating dissolved oxygen levels were adequate to maintain healthy aquatic communities. Below the confluence with Leon Creek, invertebrate assemblages showed decreased diversity and an increase in the number of organisms more typical of enriched conditions or low dissolved oxygen levels.[14]

Of a total of 68 fish species potentially occurring within this section of the San Antonio River basin, the assessment studies collected 13 species of fish from the Medina River between Diversion Dam and the San Antonio River. Mosquitofish, red shiner and bullhead minnows were the most abundant species below Leon Creek, while speckled chub, blacktail shiner, and mimic shiner were the most abundant upstream. Bluegill and largemouth bass juveniles were abundant in littoral areas and pools throughout the creek.[15]

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[13] Ibid.
[14] Ibid.
[15] Ibid.

Riverine habitat inundated by Option S-14 at the conservation pool level is an estimated 15 acres. Depending on the operating scenario, the reservoir may experience significant fluctuations in pool elevations during normal to dry years. Figure 5.5-2 shows the variation in reservoir capacity modeled over the period of record.

Return flows from the proposed Applewhite Reservoir water used by municipal and industrial customers would likely be returned to the Medina and/or San Antonio River either directly or via tributary streams. No significant downstream effects were predicted by previous environmental studies and assessment reports, and the Texas Natural Resource Conservation Commission (TNRCC) estimated that Applewhite Reservoir operation would reduce inflow to San Antonio Bay by 1.8 percent, an amount having a minimal effect on the bay. Later studies by Freese and Nichols, Inc., using basic calculations developed in the Texas Department of Water Resources Guadalupe River Estuary Study, estimated that projected total average bay inflow with Applewhite Reservoir in operation would be in excess of 2.6 million acft/year. Recent studies[16] by the Texas Water Development Board (TWDB) and Texas Parks and Wildlife Department indicate a desired freshwater inflow of about 1,147,000 acft/yr for maximum harvest of representative species in the Guadalupe Estuary. Simulations presented herein result in a long-term average freshwater inflow to the Guadalupe Estuary of 1.6 million acft/yr with Applewhite Reservoir operated at its firm yield.

No adverse impacts to protected species that migrate through the proposed project area were identified. The Applewhite environmental assessment predicted no adverse effects for protected species dependent on the Edwards Aquifer, Comal Springs and San Marcos Spring flows. Important species with habitat in the project vicinity are listed below in Table 5.5-2.

Mapped species shown to be in the vicinity of the project area are the Guadalupe Bass, Toothless and Widemouth Blindcat, and the Sandhill Woolywhite. Other species likely to be present within the project footprint include the Texas horned lizard, which is found in open arid and semi-arid regions with sparse vegetation including grass, cactus, scattered brush or scrubby trees over soils that may vary in texture from sandy to rocky. The Texas tortoise would be expected within the arid thornbrush section of the project area, although its population may have been affected by overgrazing. Overgrazing may have affected the indigo snake populations

[16] TWDB, TPWD, and TNRCC, "Texas Bays and Estuaries Program, Determination of Freshwater Inflow Needs," September 1998.

Table 5.5-2.
Important Species Known to Occur in the Study Area[1]
Applewhite Reservoir — Firm Yield (S-14D)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T	E	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*				NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened with silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident

Page 1 of 2

Table 5.5-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	Listing Agency: TPWD[1]	Listing Agency: TOES[2,3]	Potential Occurrence in County
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	T	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*				WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT Proposed Endangered/Threatened Blank = Rare, but no regulatory listing status

Page 2 of 2

similarly. Most of the riverine forest in the proposed project area is heavily impacted by grazing and may provide only limited habitat for the Texas garter snake and the state protected timber rattlesnake. Mitigation plans that restrict or prohibit grazing in bottomland hardwoods may increase habitat for the timber rattlesnake.

A wildlife mitigation plan was developed by an interagency team from U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, and U.S. Army Corps of Engineers, but at present, this potential plan has no sponsor or manager. The mitigation program would improve wildlife habitat by eliminating grazing on lands at the perimeter of the reservoir and in a preserved corridor of the Medina River between Castroville and the upper boundary of the Applewhite Reservoir.

Cultural resource surveys have identified and recorded 87 prehistoric and historic sites within the flood pool and associated construction area. Of these sites, 43 are at or below the conservation pool elevation. The most significant impacts of the proposed reservoir would be to historic sites that directly relate to the evolution from Spanish colonization through statehood. Prehistoric sites range from lithic scatters to temporary settlements by hunters and gatherers. Fifteen historic sites and three prehistoric sites may be eligible for the National Register. Most of the remaining sites will require further work to determine eligibility. Sites labeled as eligible in the assessment reports appear to meet National Register of Historic Places eligibility requirements as listed in 36 CFR 60. However, the final testing and mitigation program agreement has not been settled. A Programmatic Memorandum of Agreement between the Corps of Engineers, the Texas Historical Commission, the Advisory Council on Historic Preservation and the City of San Antonio would define the testing and mitigation procedures necessary to comply with Federal and state antiquities regulations. In March 1994, portions of the Rancho de Perez within the proposed reservoir were nominated for state archeological landmark status by the Antiquities Committee of the State of Texas. Any activity affecting a designated landmark would require coordination with the Antiquities Committee.

5.5.4 Engineering and Costing

Applewhite Reservoir firm yield would be diverted through an intake and pumped in a transmission line to a water treatment plant located at the major municipal demand center of the South Central Texas Region. The diversion rate from the reservoir was assumed uniform throughout the year. Benefits from this project might include the addition of a new potable water supply to public water supply distribution systems and/or the enhanced recharge to the aquifer and the increased availability of water to supply wells and possibly springs. Prior to distribution, delivery to recharge structures or direct injection to the aquifer, the water would be treated. Assuming the level of treatment required for drinking water systems may result in an overestimation of cost if final delivery is eventually determined to be aquifer recharge, however, it is likely that any water recharged to the aquifer will require significant treatment. The major facilities required to implement this option are:

- Dam and Reservoir;
- Reservoir Intake and Pump Station;
- Raw Water Pipeline to Treatment Plant;
- Water Treatment Plant; and
- Distribution.

The cost estimate for the dam and reservoir was originally completed by Freese & Nichols. That cost estimate was updated to mid-1994 values during the Trans-Texas Water Program.[17] The mid-1994 estimate has been updated to Second Quarter 1999 costs by multiplying the cost by the ratio (1999/mid-1994) of the Engineering News Record Construction Cost Indexes. The reservoir intake and pump station is sized to deliver 3.8 mgd through a 16-inch diameter pipeline. The operating cost was determined for the total raw water static lift of 242 feet and an average annual water delivery of 4,032 acft/year. Financing the reservoir over 40 years at a 6 percent annual interest rate and the remainder of the project over 30 years at a 6 percent annual interest rate results in an annual expense of $11,030,000 (Table 5.5-3). Annual operation and maintenance costs, including power, total $1,839,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $12,869,000. For an annual firm yield of 4,032 acft, the resulting annual cost of water is $3,192 per acft (Table 5.1-3).

5.5.6 Implementation Issues

Implementation of Applewhite Reservoir could directly affect the feasibility of other water supply options under consideration, including L-11, L-14, L-18, S-15D, S-15E, S-16C, SCTN-1, and/or SCTN-14b.

[17] HDR, Op. Cit., May 1994.

Table 5.5-3.
Cost Estimate Summary
for Applewhite Reservoir (S-14D)
(Second Quarter – 1999 Prices)

Item	*Estimated Cost*
Capital Costs	
Dams and Reservoirs (Conservation Pool: 45,250 acft; 2,5000 acres; 536 ft-msl)	$48,425,000
Intake and Pump Station (3.8 MGD)	1,042,000
Water Treatment Plant	5,000,000
Transmission Pump Stations(s) (0)	91,000
Transmission Pipeline (16-inch dia., 22 miles)	7,192,000
Distribution	4,387,000
Total Capital Cost	**$66,137,000**
Engineering, Contingencies, and Legal Costs	$22,731,000
Environmental & Archaeology Studies, Mitigation, and Permitting	25,770,000
Land Acquisition and Surveying (4,765 acres)	28,439,000
Interest During Construction (4 years)	22,893,000
Total Project Cost	**$165,970,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$7,812,000
Debt Service (6 percent for 40 years)	3,218,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	97,000
Water Treatment Plant	732,000
Reservoir	726,000
Pumping Energy Costs (4,738,601 kWh @ $0.06 per kWh)	284,000
Total Annual Cost	**$12,869,000**
Available Project Yield (acft/yr)	4,032
Annual Cost of Water ($ per acft)	$3,192
Annual Cost of Water ($ per 1,000 gallons)	$9.79

The Corps of Engineers Section 404 permit issued for this project expired at the end of 1994 and the TNRCC water right permit has been abandoned. Significant permitting efforts, including environmental and hydrologic studies, would be required in order to implement this project.

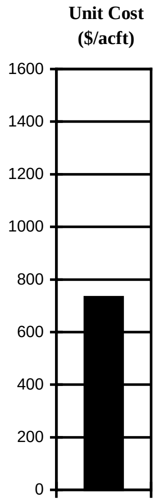
An institutional arrangement is needed to implement projects including financing on a regional basis.

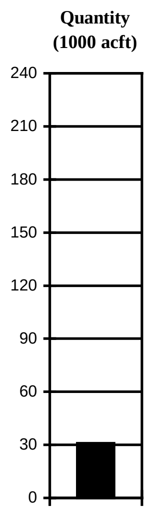
1. The following permits will be needed:
   a. TNRCC Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordinating Council review.
   f. TPWD Sand, Gravel, and Marl permit
2. Permitting, at a minimum, would require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Relocations:
   a. Highways and railroads
   b. Other utilities

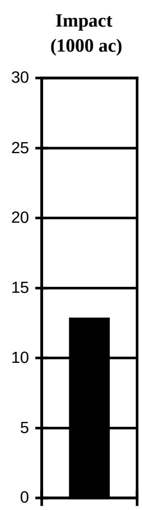
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 11/16/99







OPTION NUMBER: **G-19**

OPTION NAME: **Guadalupe River Dam No. 7 — Firm Yield**

OPTION DESCRIPTION: *Guadalupe River Dam No. 7 site is located near the center of Kendall County on the Guadalupe River, upstream of Canyon Lake. The conservation storage capacity at elevation 1,242 ft-msl is 600,000 acft. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☐ **5-15 yr.** ☒ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$732**	**per acft[1] Raw Water at Reservoir**
QUANTITY OF WATER:	**30,890**	**acft/yr[2]**
LAND IMPACTED:	**12,830**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Guadalupe River Dam No. 7, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, instream flow requirements, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 12,830 acres of land, including a 31-mile stretch of the Guadalupe River, and instream flow requirements. The land involved is 41 percent wooded and 43 percent brush and scrublands. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and passthrough of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, G-20, G-30, G-32, G-38C, SCTN-6, SCTN-16b, and/or SCTN-16c.

5.6 Guadalupe River Dam No. 7 (G-19)

5.6.1 Description of Option

Guadalupe River Dam No. 7 is a proposed impoundment located on the Guadalupe River, about 30 miles west of New Braunfels in Kendall County, and upstream of Canyon Reservoir. The project was originally proposed in 1942 in the "Initial Plan" of the Guadalupe-Blanco River Authority (GBRA)[1] approved by the State Board of Water Engineers. In a report entitled "Preliminary Report on the Proposed Guadalupe River Dam No. 7 and No. 8,"[2] the original purpose of the project was identified as primarily for power development. In 1959, Forrest and Cotton, Inc. studied Dam No. 7 as a water conservation project, located at a site 7 river miles upstream from the original study location.[3] The most recent published study of the Guadalupe Dam No. 7 project was performed in October 1981 by Espey, Huston and Associates, Inc. (EH&A) in their report entitled "Upper Guadalupe River Dam No. 7," in which the site was again studied with respect to water conservation potential. The location of the dam is shown in Figure 5.6-1.

The dam would consist of a rock-filled section with an earthen core and random fill outer shells, with a top-of-dam crest elevation of 1,263 feet-mean sea level (ft-msl) to impound runoff from the 1,124 square mile watershed (about 78 percent of the drainage area controlled by Canyon Reservoir). The spillway would consist of a 4,000 to 4,500-foot-long section cut into a nearby hill. Operating under this proposed embankment and spillway configuration, the reservoir would have a conservation pool capacity of 600,000 acft at elevation 1,242 ft-msl, permanently inundating about 12,830 acres along a 31-mile segment of the Guadalupe River. The spillway design flood elevation would be 1,258.2 ft-msl, inundating approximately 14,755 acres.

5.6.2 Water Availability

The firm yield of the proposed Guadalupe River Dam No. 7 was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria,

[1]Forest and Cotton, "Supplement to the Initial Plan of Development of the Guadalupe-Blanco River Authority," April 1959.
[2]Ibid.
[3]Ibid.

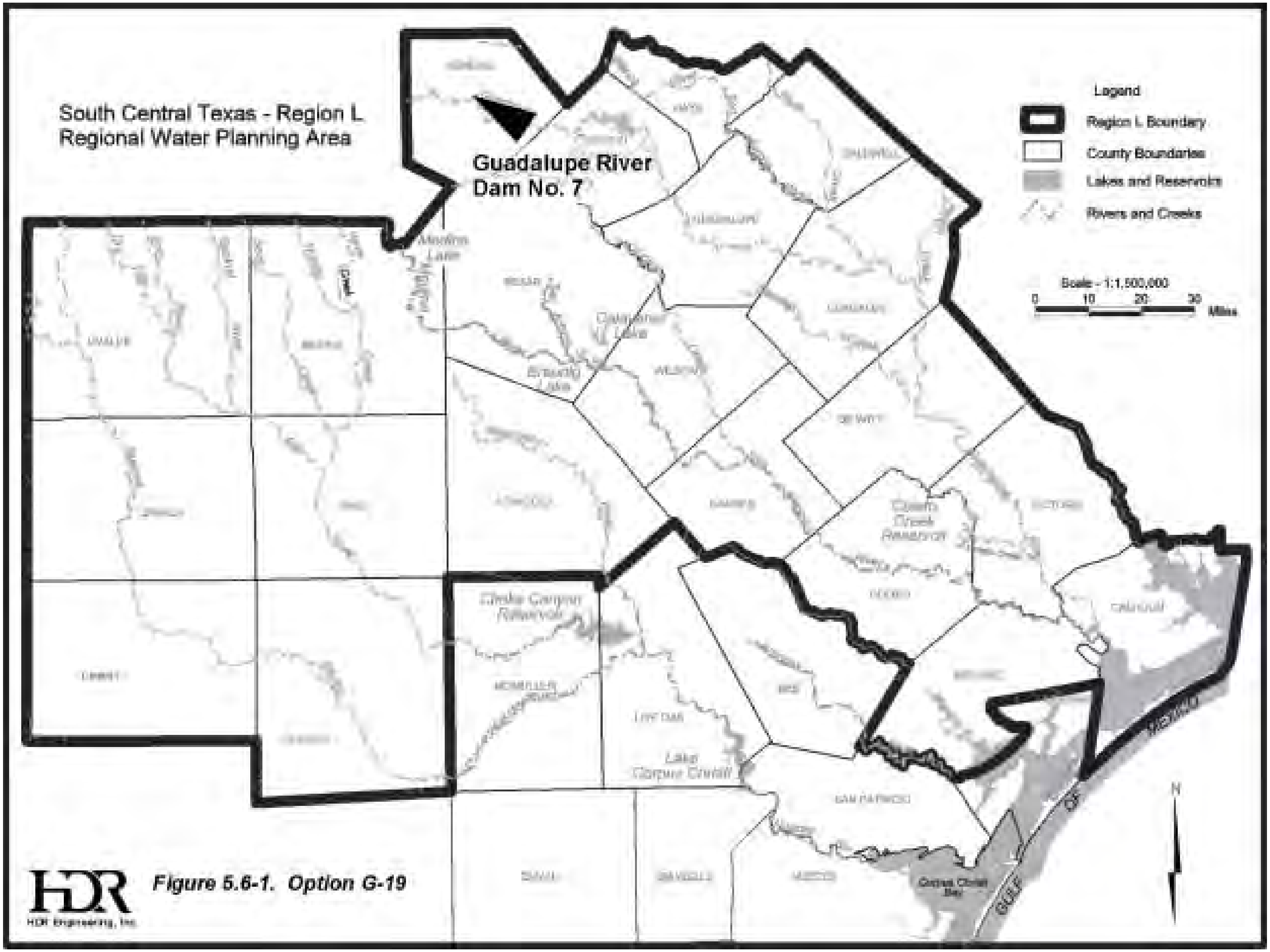


Figure 5.6-1. Option G-19

Appendix B). The Guadalupe-San Antonio River Basin Model[4] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

The GSA Model was used to compute total daily streamflow for the Guadalupe River at Comfort (USGS# 08167000) and the Guadalupe River at Spring Branch (USGS# 08167500), as the proposed reservoir site is located between these two gages. These flows are naturalized flows at the gages, adjusted for upstream water rights and return flows. Inflows at the reservoir site were estimated from the inflows at the gage locations using an interpolation routine based upon the drainage areas of the reservoir site and the two gages. The GSA Model computes streamflow available for impoundment without causing increased shortages to downstream rights. Daily streamflows to be passed through the reservoir to meet the requirements of downstream water rights were computed at the Spring Branch gage and adjusted for the difference in drainage area between the gage and the reservoir location.

The firm yield of the Guadalupe River Dam No. 7 was computed using the inflows and pass-through flows computed by the GSA Model and the modified version of the SIMDLY reservoir operation model originally written by the Texas Water Development Board. All inflows were passed during months when Canyon Reservoir storage was less than capacity. The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.6-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 30,890 acft/yr. This estimate of firm yield is considered a reliable water supply based on the 56-year period of historical hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows in the 1930s are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield. This firm yield assumes a Zone 3 pass-through requirement of 82 cfs (162 acft/day). This is equal to the TNRCC Water Quality Standards (7Q2) established for the stream segments at the Comfort (57 cfs) and Spring Branch (98.3 cfs) gages, interpolated to the reservoir location using drainage areas.

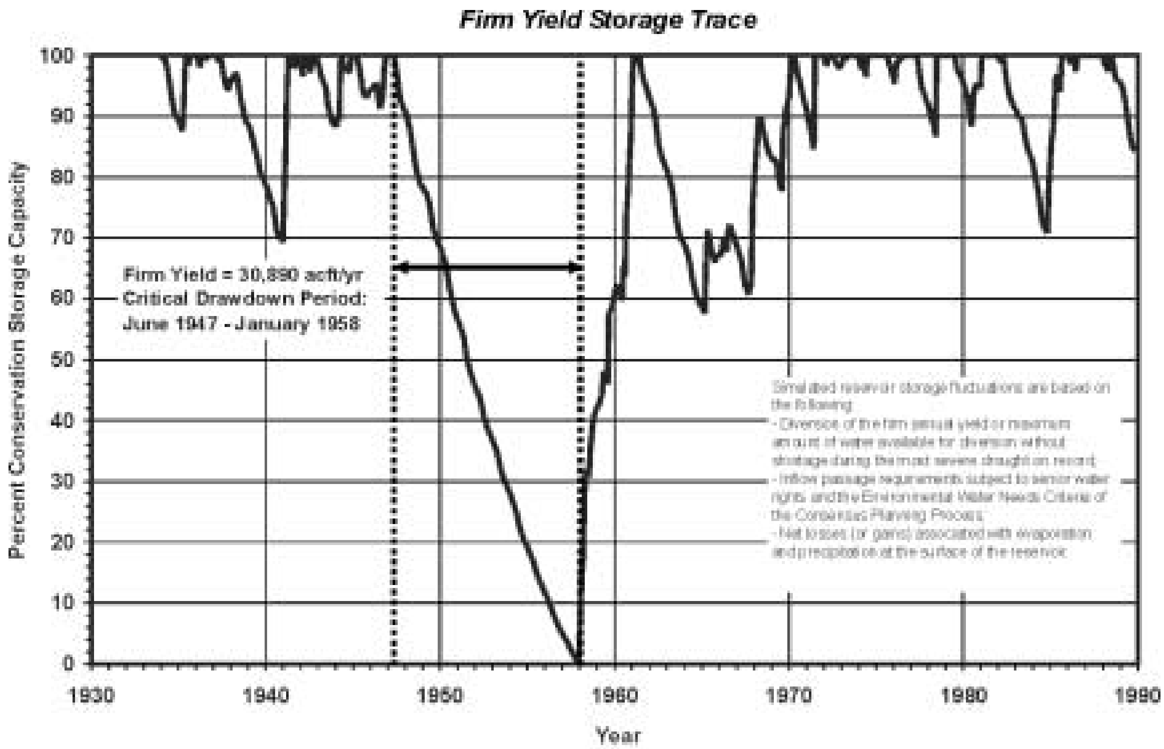
[4]HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

Table 5.6-1.
Daily Natural Streamflow Statistics
for the Guadalupe River Dam No. 7 (G-19)

Month	***Median Flows – Zone 1 Pass-Through Requirement (acft/day)***	***25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)***
January	289	154[1]
February	302	166
March	325	158[1]
April	308	174
May	400	162
June	327	135[1]
July	201	84[1]
August	150	64[1]
September	195	87[1]
October	250	104[1]
November	251	124[1]
December	288	145[1]
Zone 3 Pass-Through Requirement[2] (acft/day)		162

1 When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
2 Water Quality Standard (7Q2).

Figure 5.6-2 illustrates the simulated Guadalupe River Dam No. 7 storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield diversion of 30,890 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 66 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 85 percent of the time over the 1934 to 1989 historical period. Figure 5.6-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and at the Guadalupe River Saltwater Barrier. Monthly median streamflows would be reduced about 23 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced about 8 percent.



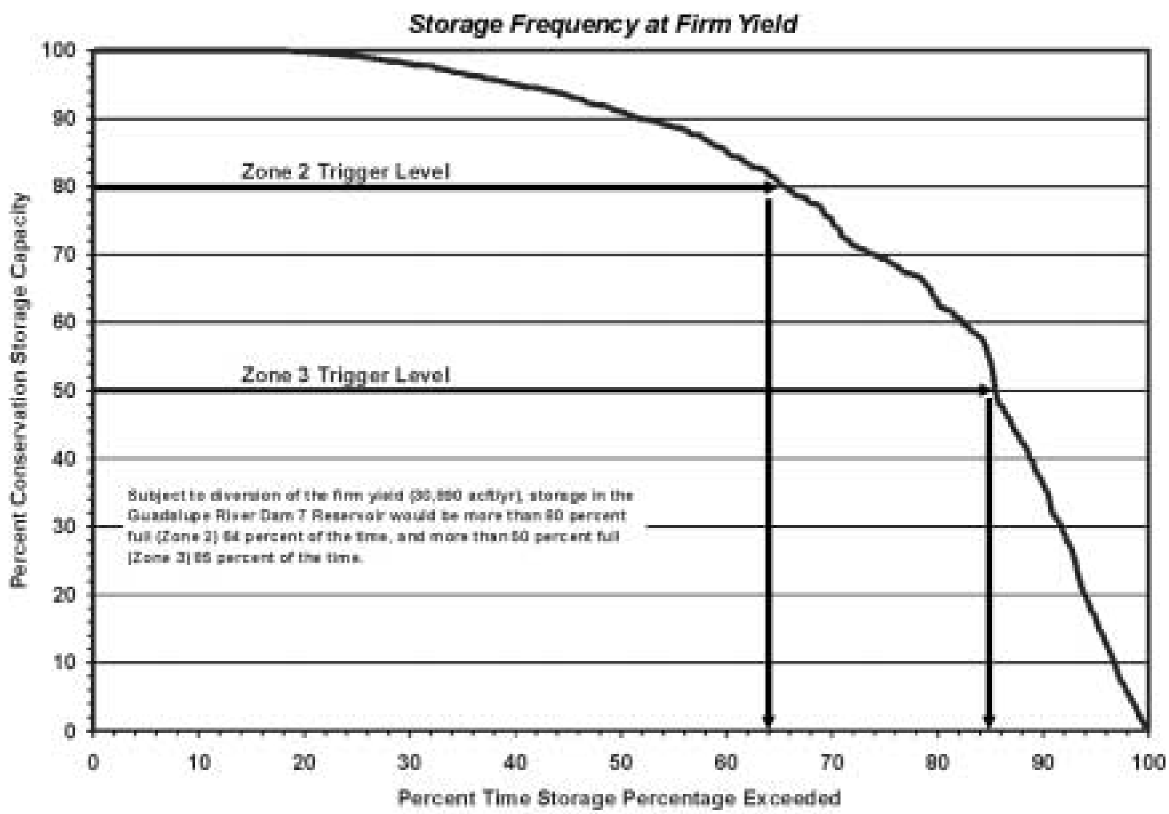


Figure 5.6-2. Guadalupe River Dam No. 7 Storage Considerations

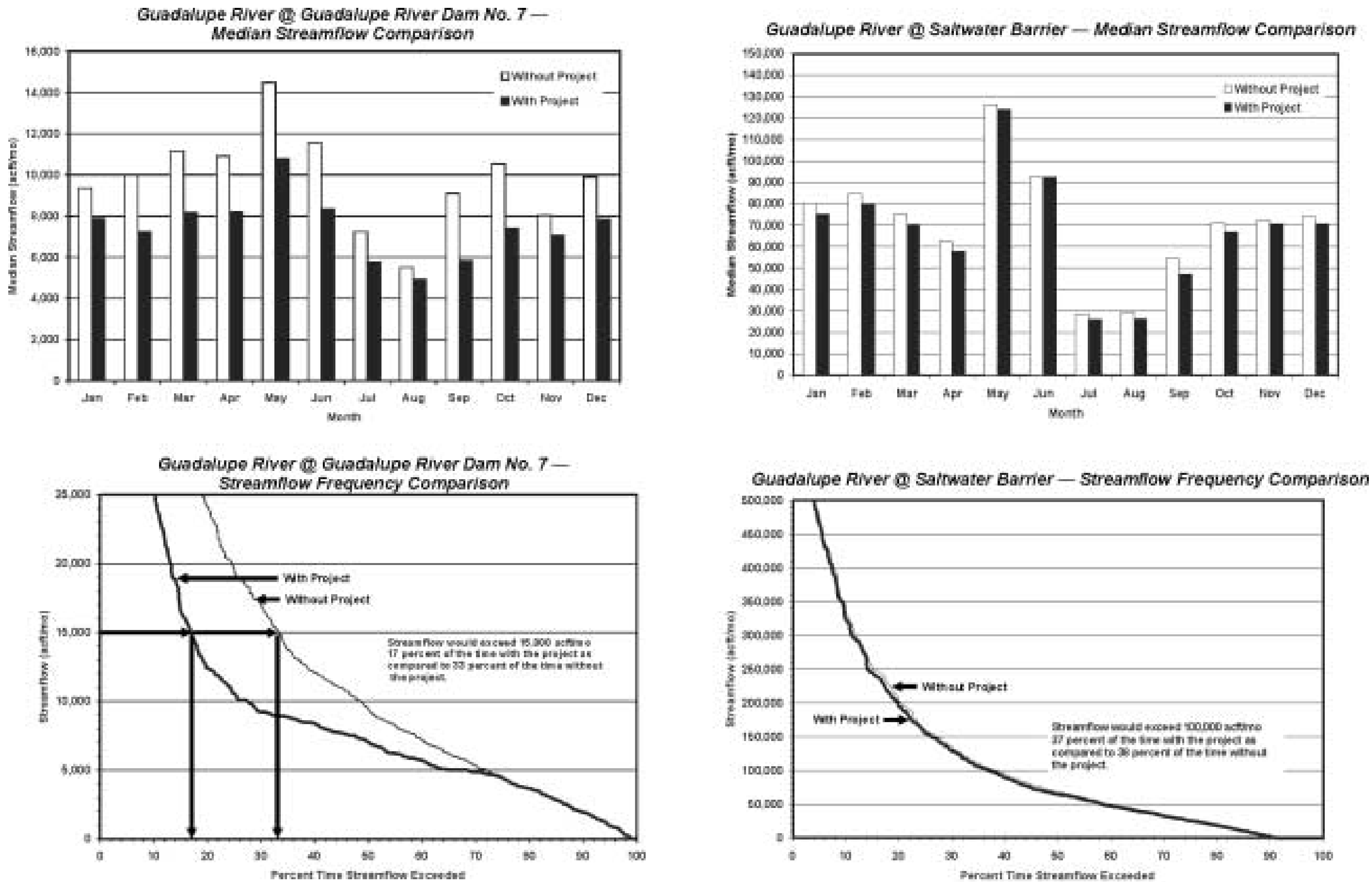


Figure 5.6-3. Guadalupe River Dam No. 7 Streamflow Comparisons

5.6.3 Environmental Issues

The Guadalupe River Dam No. 7 project involves dam construction and inundation of approximately 12,830 acres along a 31-mile reach of the Guadalupe River. The proposed reservoir is located in the eastern portion of Kendall County within the Central Texas Plateau ecoregion,[5] on the southern edge of the Edwards Plateau vegetational area of Texas,[6] and within the Balconian biotic province.[7]

The project area is heavily wooded (41 percent of total land area), with large expanses of brush and scrublands (43 percent) and small quantities of grassland, cropland, and wetland. The wooded upland areas typically support open to closed stands of plateau oak, Texas oak, shinnery oaks, Ashe juniper, cedar elm, and honey mesquite, with a tall or mid-grass understory. The most important grasses in these upland areas are little bluestem, gramas, curly mesquite, and buffalo grass. The wooded upland areas are primarily undeveloped, with open areas generally used for rangeland.[8]

The streamside vegetation present along the Dam No. 7 site is typical for streams of this size on the Edwards Plateau. These bottomland areas support a gallery forest of baldcypress, pecan, elms, ashes, sycamore, Texas sugarberry, and burr oak. The most important grasses in the bottomland areas are switchgrass and Canada wild rye. The wooded bottomland areas are typically undeveloped, while open bottomland areas with deep soils are generally used for rangeland and crops.[9]

Soils in the Dam No. 7 reservoir site consist of the well-drained Boerne fine sandy loam in the floodplains, and the gently undulating Eckrant-Comfort and steep Eckrant-Rock outcrop associations on uplands and hills. These associations are composed of shallow, cobbly, stony and mildly alkaline soils. The upland soils are poorly suited to cropland, improved pasturelands, urban uses and recreation due to a stony clay surface layer, large stones, rock outcrops, shallow

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[5]Omernik, James M., “Ecoregions of the Conterminous United States,” Annals of the Association of American Geographers, 77(1), pp. 118-125, 1986.
[6]Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[7]Blair, W.F., “The Biotic Provinces of Texas, “Tex. J. Sci. 2:93-117, 1950.
[8]Espey, Huston & Associates, Inc. (EH&A), “ Upper Guadalupe River Basin Water Supply Project, Final Report,” prepared for Upper Guadalupe River Authority and Guadalupe-Blanco River Authority, EH&A Document No. 81137-R1, October 1981.
[9]Ibid.

rooting depth, steep slopes, and very low available water capacity. Thus, rangeland is the most common usage.[10]

Areas that can be classified as wetlands by the U.S. Army Corps of Engineers and/or the U.S. Fish and Wildlife Service occur at the site. Wetlands in the project region consist of the riverine habitats of the Guadalupe River and its tributaries, and associated palustrine habitats generally consisting of fairly narrow bands of wetlands along the watercourses. The majority of the riverine and palustrine wetlands are in the unconsolidated shore or unconsolidated bottom class, although forested wetlands also occur within both the riverine and palustrine classes.

The assemblage of eastern, western, and endemic species and aquatic habitats closely associated with somewhat rugged terrestrial habitats makes the project site both biologically and aesthetically important.[11] Woodland-inhabiting fauna expected to typify the wildlife of the project area include the White-tailed Deer, Virginia Opossum, Eastern Cottontail, Raccoon, Ladder-backed Woodpecker, Blue Jay, Cañon Wren, Cardinal, Texas Spiny Lizard, and Western Diamondback Rattlesnake, among others.[12]

The Guadalupe River and its tributary streams are typically deeply incised channels with narrow floodplains, leading to high rates of runoff and flash flood conditions during major storm events. At other times these streams tend to flow relatively shallowly over rock or gravel beds, with high water clarity. The narrow channels are frequently shaded by streamside woodlands. Aquatic vegetation is limited by the scouring of stormwater flows and shading, as well as the low frequency of suitable substrate (muck or mud).[13] The Upper Guadalupe River (Segment 1806) from the upper end of Canyon Lake to the headwaters is designated for contact recreation and considered to have exceptional quality aquatic habitat.[14] Springs and shallow headwaters are numerous in the reservoir site. In addition, the major streams provide series of riffle and pool habitat. Common game fish of importance, when mature, are restricted primarily to the deeper pool areas. Spring and minor headwater habitats may serve as refuge from predators and competition for some aquatic species, including some small fish. Characteristic aquatic-associated species that may occur at the Dam No. 7 site include nutria, water snakes and several

[10]U S. Department of Agriculture, Soil Conservation Service (SCS), "Soil Survey of Kendall County, Texas," in cooperation with Texas Agricultural Experiment Station, Texas A&M University, College Station, March 1981.
[11]EH&A, Op. Cit., October 1981.
[12]Ibid.
[13]Ibid.
[14]Texas Water Commission, "Texas Surface Water Quality Standards," Texas Administrative Code, Section 307, 1991.

species of anurans and waterfowl. The Dam No. 7 site, because of its location on the Guadalupe River, probably receives significant utilization by migratory waterfowl and fish-eating birds.[15]

The primary impacts that would result from construction and operation of the Dam No. 7 Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Dam No. 7 reservoir site would be permanently inundated to 1,242 ft-msl with a surface area of 12,830 acres. Approximately 499 acres of riverine habitat would be converted to lacustrine habitat. Other resources of potential concern within the reservoir site include a cemetery, Century Caverns, and Camp Alfazar. Golden Fawn Ranch is located on the proposed reservoir boundary and could be impacted. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime below the dam and a minimal reduction of inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 36 percent in September, with the reduction for other months ranging from 9 to 31 percent. Low flows (those exceeded about 85 percent of the time) will be unchanged at the project site, largely due to the requirements of the Consensus Criteria, and by passage of inflows to maintain storage in the downstream Canyon Reservoir. As a new reservoir without a current operating permit, the Guadalupe River Dam No. 7 Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Flows at the Guadalupe River Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flows projected to decline by about 4 percent.

Plant and animal species listed by the U.S. Fish and Wildlife Service, Texas Parks and Wildlife Department, and Texas Organization for Endangered Species (TOES) within Kendall County are presented in Table 5.6-2. The Texas Natural Heritage Program records include reported occurrences of the Edwards Plateau Springs Salamander (*Eurycea sp. 7*), Guadalupe Bass (*Micropterus treculi*), Texas Mock-orange (*Philadelphus texensis*), Canyon Mock-orange (*Philadelphus ernestii*) and Edge Falls Anemone (*Anemone edwardsiana var. petraea*), which

[15]EH&A, Op. Cit., October 1981.

Table 5.6-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Guadalupe River Dam No. 7 (G-19)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	E	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Basin Bellflower	*Campanula reverchonii*	Dry gravel and shallow sandy soils			WL	Resident
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black Bear	*Ursus americanus*	Woods, brushlands and forest	T	T	T	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River			NL	Resident
Cagle's Map Turtle	*Graptemys cagleii*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau; mesic woodland canyons			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Edge Falls Anemone	*Anemone edwardsiana var. petraea*	woodlands in mesic canyons, shaded bluffs, boulders			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau streams, seeps, springs			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Headwater Catfish	*Ictalurus lupus*	Clear streams			WL	Resident
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

are all listed as rate with no regulatory status within the reservoir area. The Guadalupe Bass resides within streams of the Edwards Plateau while the Edwards Plateau Springs Salamander can also be found in seeps and springs. The mapped vascular plants prefer mesic woodland canyons and 41 percent of the prospective inundated land consists of wooded areas. Species that have been reported downstream approximately 2.5 miles or less of the project area include the Texas Salamander (*Eurycea neotenes*), Comal Blind Salamander (*Eurycea tridentifera*), Cagle's Map Turtle (*Graptemys cagleii*), Guadalupe Bass, and the Edwards Plateau Springs Salamander.

In addition, a number of the species listed for Kendall County have habitat requirements or preferences that indicate they could be present within the reservoir site. The Golden-cheeked Warbler (Dendroica chrysoparia) inhabits mature oak-Ashe juniper woods for nesting. Warblers have been located between 1.5 to 2.0 miles downstream of the proposed reservoir site along the Guadalupe River. The Black-capped Vireo (*Vireo atricapillus*) nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. In addition to the Golden-cheeked Warbler and Black-capped Vireo, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Interior Least Tern, and Whooping Crane) are reported to occur in Kendall County. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

The Guadalupe River may be considered a unique and ecologically sensitive area. The Texas Natural Area Survey[16] identified the Guadalupe River from its west boundary to its east boundary in Kendall County as a natural area. The Guadalupe River from Canyon Lake to its headwaters near Kerrville is on the preliminary inventory list of the Heritage Conservation and Recreation Service (HCRS) for possible inclusion in the National Wild and Scenic Rivers Program.[17] The HCRS is within the U.S. Department of the Interior. Although occurring on the inventory list does not officially protect the river, the HCRS will require interagency consultation for projects that may adversely affect the river.

Habitat types of importance to aquatic organisms of limited range or occurrence within the proposed Dam No. 7 site include springs and shallow headwaters, as well as the riffle/pool habitat of the Guadalupe River proper. The springs and headwater areas are often important to

[16]Texas Natural Area Survey, "The Natural Areas of Texas (Preliminary Listing), Student Council on Pollution and Environment, 1973.
[17] EH&A, Op. Cit., October 1981.

aquatic species that cannot persist under the competition/predation regime of larger water bodies, or are unable to survive the greater environmental fluctuation there. The Guadalupe Bass, a federal Category 2 candidate species, is restricted to the clear, relatively fast-flowing streams of the eastern Edwards Plateau.

The Upper Guadalupe River watershed, situated within the Central Texas cultural area, has rich potential for yielding both historic and prehistoric sites. No complete survey of Dam No. 7 reservoir site has been conducted. Based on the results of previous research performed in the Upper Guadalupe watershed[18,19,20] and on the known history and prehistory of the area, sites reflecting thousands of years of local habitation can be expected to be encountered. The Texas Archeological Research Laboratory lists a total of 78 recorded sites within the 1,274 square mile area that comprises Kendall County, Texas. Six prehistoric sites from the Archaic and Neo-American period, five habitation sites and one pictograph have been located within the designated study area.[21]

That portion of the Guadalupe River which is under consideration for designation as a National Wild and Scenic River has been ranked as outstandingly remarkable in scenic, recreation, and geologic values. The river segment has been recommended for inclusion in the proposed Texas Natural Rivers System. According to the Texas Parks and Wildlife Department, the river is rated as the No. 1 recreation river and the No. 2 scenic river in the state. Portions of the river have also been noted in the Texas Natural Areas Survey. The Survey notes the existence of rare vegetation, two major waterfalls, numerous rapids, and limestone bluffs. Interagency consultation would be required for a project (such as the proposed Dam No. 7) that may adversely affect the river.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291).

[18]Briggs, A.K., “Preliminary Archaeological Survey of Study Area on the Guadalupe River,” Office of the State Archaeologist, Special Reports 13, 1970.
[19] Bass, F. A., and T. R. Hester, “An Archaeological Survey of the Upper Cibolo Creek Watershed, Central Texas,” Center for Archaeological Research, Archaeological Survey Report No. 8, 1975.
[20]Kelly, T.C. and T.R. Hester, “Archaeological Investigations at Sites in the 1975 Upper Cibolo Creek Watershed, Central Texas,” Center for Archaeological Research, Archaeological Survey Report No. 17, 1976.
[21]EH&A, Op. Cit., October 1981.

All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources.

Implementation of this reservoir option is expected to require field surveys to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir. Where impacts to potential protected species habitat or significant cultural resources cannot be avoided, additional studies may be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

5.6.4 Engineering and Costing.

The cost estimate for this option is shown in Table 5.6-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate prepared by EH&A in October 1981. Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard costing methodology presented in Appendix A. Costs include land purchased within the spillway design flood pool (elevation 1,258.2 ft-msl; 14,755 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $21,451,000. Annual operation and maintenance costs total $1,173,000. The annual cost, including debt service and operation and maintenance, totals $22,624,000. For an annual firm yield of 30,890 acft, the resulting cost of raw water at the reservoir is $732/acft (Table 5.6-3). Depending upon the location(s) and type(s) of use for water supplies associated with the Guadalupe River Dam No. 7, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

Table 5.6-3.
Cost Estimate Summary for
Guadalupe River Dam No. 7 (G-19)
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool: 600,000 acft; 12,830 acres; 1,242 ft. msl)	
Relocations	$16,321,000
Diversion and Care of Water	9,958,000
Reservoir Clearing	1,651,000
Embankment	30,709,000
Slopes	456,000
Spillway	15,496,000
Grout Curtain	3,605,000
Total Capital Cost	**$78,196,000**
Engineering, Legal Costs and Contingencies	$27,368,000
Environmental & Archaeology Studies and Mitigation	85,967,000
Land Acquisition and Surveying (14,755 acres)	86,705,000
Interest During Construction (4 years)	44,518,000
Total Project Cost	**$322,754,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$21,451,000
Operation and Maintenance	1,173,000
Total Annual Cost	**$22,624,000**
Available Project Yield (acft/yr)	**30,890**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$732**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$2.25**

5.6.5 Implementation Issues

Implementation of Guadalupe River Dam No. 7 could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, G-20, G-30, G-32, G-38C, SCTN-6, SCTN-16b, and/or SCTN-16c. An institutional arrangement is needed to implement this project including financing on a regional basis.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

3. Land will need to be acquired through either negotiations or condemnation.

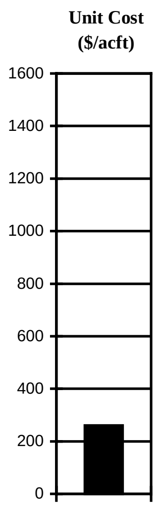
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

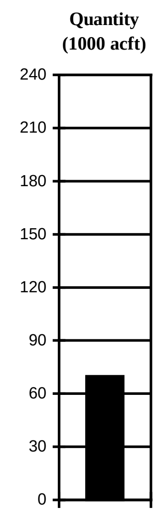
5. Other Coordination:
   a. Implementation of this option would require substantial coordination with groups having specific local or regional interests.

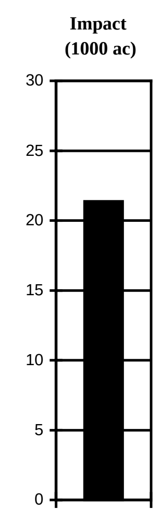
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 11/16/99







OPTION NUMBER: G-20

OPTION NAME: Gonzales Reservoir — Firm Yield

OPTION DESCRIPTION: *The Gonzales Reservoir site is located on the San Marcos River in Gonzales County, about 5 miles upstream of the San Marcos/Guadalupe confluence. The drainage area is 1,344 square miles and the reservoir conservation storage capacity would be 560,000 acre-feet. Cost developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☐ **5-15 yr.** ☒ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	$260	per acft[1] Raw Water at Reservoir
QUANTITY OF WATER:	69,897	acft/yr[2]
LAND IMPACTED:	21,370	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Gonzales Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, instream flow requirements, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 21,370 acres of land, including a 31-mile stretch of the San Marcos River, and instream flow requirements. The land involved is 9 percent wooded, 33 percent brush and scrublands, 54 percent cropland and grassland, 3 percent wetlands and riverine habitat, and 1 percent developed. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and passthrough of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, inundation of Palmetto State Park (with associated unique habitats) and the cities of Ottine and Slayden, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-16C1, G-17C1, G-21, G-38C, G-40, S-16C, SCTN-6, SCTN-16b, and/or SCTN-16c.

5.7 Gonzales Reservoir (G-20)

5.7.1 Description of Option

Gonzales Reservoir is a proposed impoundment located on the San Marcos River about 5 river miles upstream of its confluence with the Guadalupe River in Gonzales County. The project was originally proposed by the United States Army Corps of Engineers in 1950. In the Corps of Engineer's original study entitled "Report on Survey of Guadalupe and San Antonio Rivers and Tributaries, Texas for Flood Control and Allied Purposes," the Gonzales Reservoir site was to provide flood control, water conservation, and development of hydroelectric power. The location of the project is shown in Figure 5.7-1.

The dam would be an earthfill embankment (354 ft-msl top-of-dam elevation) with a gate-controlled concrete spillway (309 ft-msl crest elevation) to impound runoff from the 1,344 square mile watershed. The dam embankment would extend 15,700 feet across the San Marcos River valley and provide a conservation capacity of 560,000 acft at elevation 344 ft-msl; at full conservation pool the surface area would be 21,370 acres; the spillway design flood elevation would be 349 ft-msl, inundating approximately 25,000 acres; and approximately 31 miles of the San Marcos River channel would be permanently inundated by the reservoir.

5.7.2 Water Availability

The firm yield of the proposed Gonzales Reservoir was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). The Guadalupe-San Antonio River Basin Model[1] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

No long-term gage exists at the reservoir site. For modeling purposes, flows from the San Marcos River at Luling (USGS# 08172000) added to the flows from Plum Creek near Luling (USGS# 08173000) were assumed to be representative of inflows to the proposed Gonzales Reservoir. No adjustment to these flows was made to account for intervening drainage

[1] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

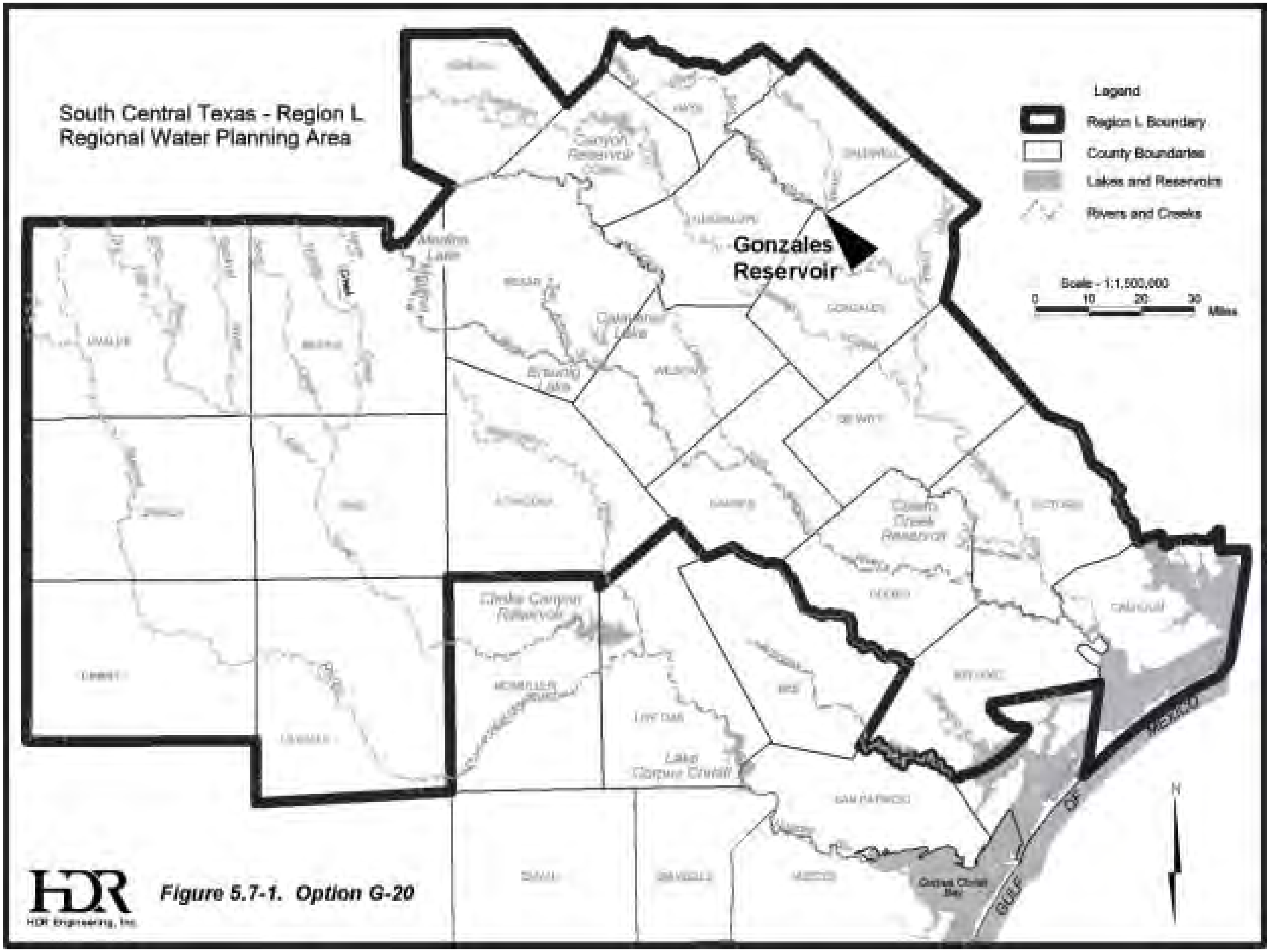


Figure 5.7-1. Option G-20

area, because the intervening drainage area represents less that 15 percent of the total drainage area above the reservoir site. These inflows represent the naturalized flows at the reservoir site, adjusted for upstream water rights and return flows. The GSA Model computes streamflow that is available for impoundment without causing increased shortages to downstream rights. Daily streamflows passed through the reservoir to meet the requirements of downstream water rights and environmental needs are also computed.

The firm yield of the Gonzales Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model originally written by the Texas Water Development Board. The streamflow statistics used to set the Consensus Criteria pass-through requirements are presented in Table 5.7-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 69,897 acft/yr. This estimate of firm yield is considered a reliable water supply based on the 56-year period of historical hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows in the 1930s are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield. This firm yield assumes a Zone 3 pass-through requirement of 320 acft/day, equal to the Water Quality Standard (7Q2) established by the TNRCC for the stream segment containing the San Marcos River at Luling streamflow gage (USGS #08172000).

Figure 5.7-2 illustrates the simulated Gonzales Reservoir storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield of 69,897 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 62 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1934 to 1989 historical period. Figure 5.7-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and at the Guadalupe River Saltwater Barrier. Changes in flows at the Saltwater Barrier were evaluated beginning at the next major watershed control point (stream gage) downstream from the reservoir site. Monthly median streamflows on the San Marcos River would be reduced about 27 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Guadalupe River Saltwater Barrier, would be reduced about 6 percent.

Table 5.7-1.
Daily Natural Streamflow Statistics
for the Gonzales Reservoir (G-20)

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	447	284[1]
February	492	313[1]
March	465	288[1]
April	531	270[1]
May	612	321
June	540	297[1]
July	399	229[1]
August	336	203[1]
September	362	217[1]
October	369	227[1]
November	383	239[1]
December	422	270[1]
Zone 3 Pass-Through Requirement[2] (acft/day)		320

1 When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
2 Water Quality Standard (7Q2).

5.7.3 Environmental Issues

The Gonzales Reservoir project involves dam construction and inundation of approximately 21,370 acres along a 31-mile reach of the San Marcos River. The proposed reservoir is located in north central Gonzales County on the boundary between the Texas Blackland Prairie and the East Central Texas Plains ecoregion[2] in the Post Oak Savannah vegetational area of Texas,[3] and the Texas biotic province.[4]

[2]Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1), pp. 118-125, 1986.
[3]Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[4]Blair, W.F., "The Biotic Provinces of Texas, "Tex. J. Sci. 2:93-117, 1950

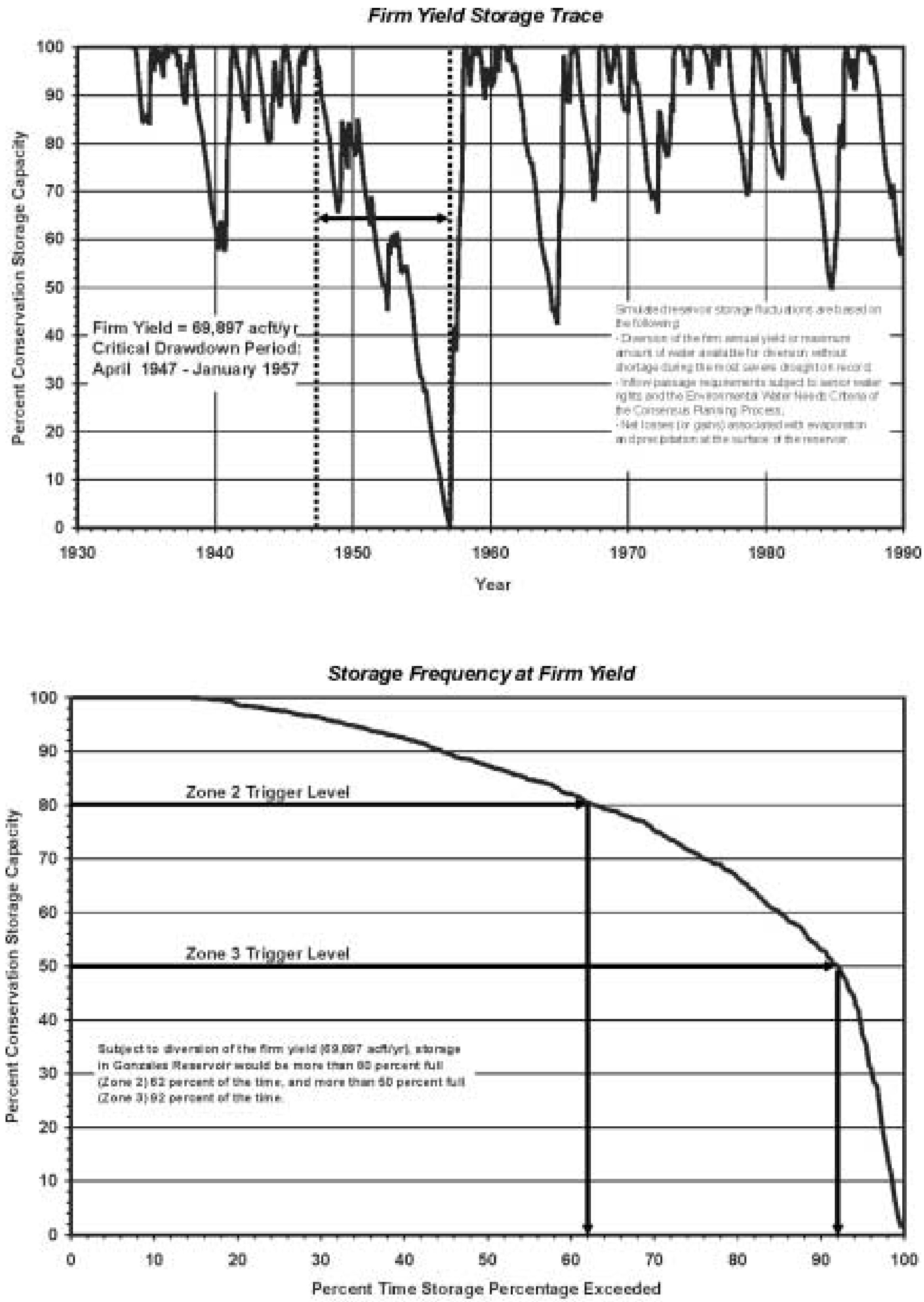


Figure 5.7-2. Gonzales Reservoir Storage Considerations

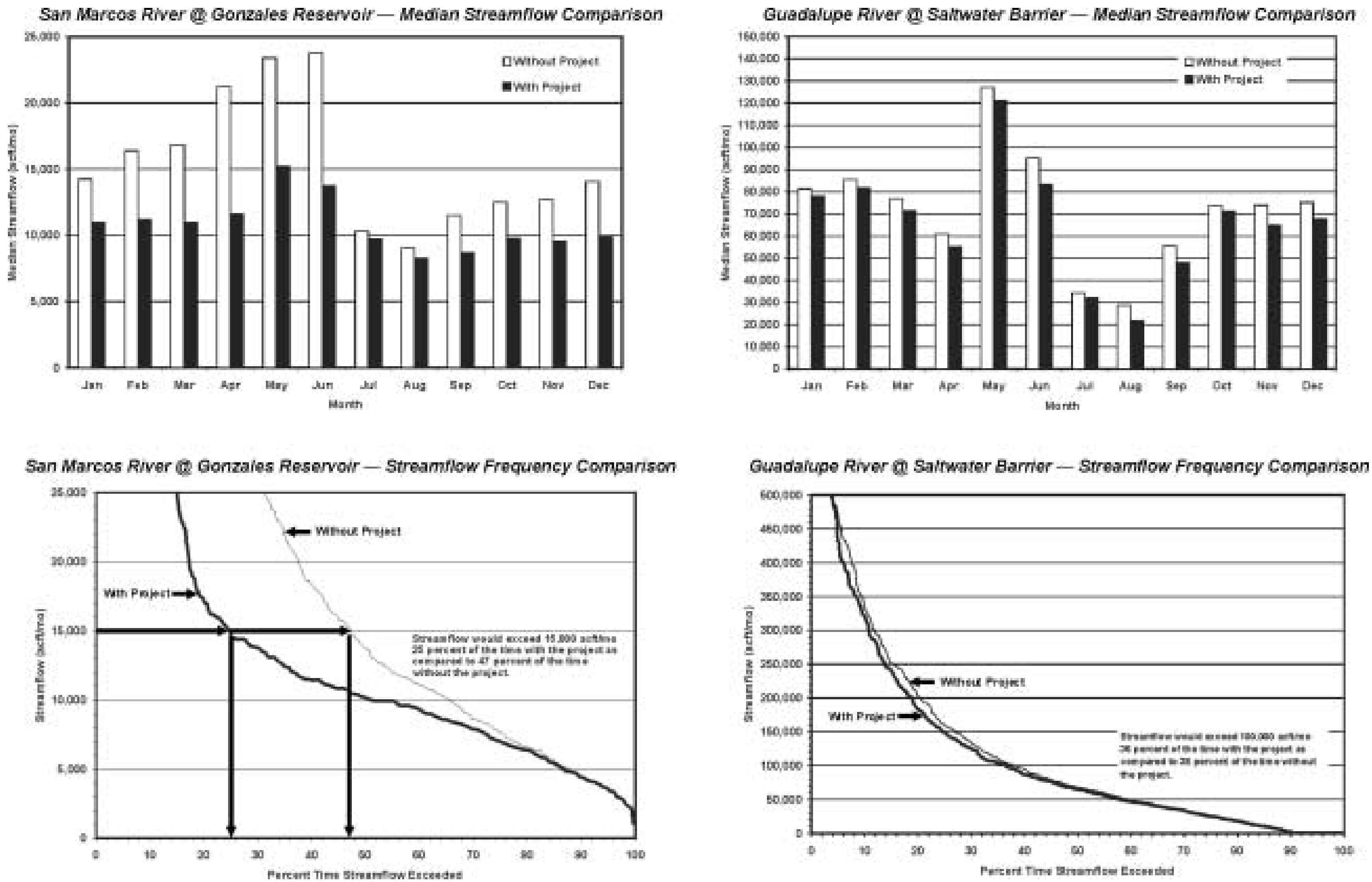


Figure 5.7-3. Gonzales Reservoir Streamflow Comparisons

Vegetation types within the proposed Gonzales Reservoir project area on the San Marcos River include grassland and cropland (54 percent), brushland (33 percent), upland and bottomland woodlands (9 percent), wetlands (3 percent), and developed areas (1 percent). Common grassland species include little bluestem, silver bluestem, sand lovegrass, beaked panicum, threeawn, sprangle-grass, tickclover, and various introduced grasses used in pastures and rangeland. Brushlands are typically dominated by honey mesquite, huisache, prickly pear, other small trees and shrubs, and a variety of grasses, including threeawns, lovegrasses, gramas, and bluestems. In the upland woodlands, post oak, blackjack oak, honey mesquite, live oak, and cedar elm are common overstory species. Typical overstory species in the bottomland woodlands include American elm, cedar elm, pecan, green ash, Eastern cottonwood, sycamore, black willow, and Texas sugarberry.[5] Wetlands within the conservation pool consist primarily of riverine perennial habitat, with small quantities of palustrine emergent, forested and scrub/shrub wetlands, and stockponds.

Within the floodplains, soils are a calcareous black clay of Tinn clay and Bosque clay loam. These soils have the highest fertility in the county, thus making excellent cropland. Gholson and Sunev soils are a fine loamy sand found in uplands with slopes of 1 to 5 percent and 3 to 8 percent, respectively.[6]

The primary impacts that would result from construction and operation of the Gonzales Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Gonzales Reservoir conservation pool would permanently inundate an area of 21,370 acres. Approximately 11,560 acres of grassland and cropland, 7,077 acres of brushland, 2,029 acres of woodland, 188 acres of wetlands, 366 acres of riverine habitat, and 150 acres of developed land would be converted to open water. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime below the dam and a modest reduction of inflows to the Guadalupe Estuary. At the project site,

[5]McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas, Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[6]U.S. Department of Agriculture, Soil Conservation Service (SCS), Personal communication with Gonzales County Soil Survey Staff, March 1994.

monthly median flows would be reduced by a maximum of 45 percent in April, with the reduction for other months ranging from 6 to 42 percent. Low flows (those exceeded about 85 percent of the time) will be unchanged at the project site, largely due to the requirements of the Consensus Criteria. As a new reservoir without a current operating permit, the Gonzales Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Flows at the Guadalupe River Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flows of about 7 percent

The San Marcos River within the project area is classified by the Texas Parks and Wildlife Department as having potential for scenic river designation. Reservoir construction would also inundate the 179-acre Palmetto State Scenic Park, which contains a unique area of subtropical vegetation.[7]

Plant and animal species listed by the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and the Texas Organization for Endangered Species (TOES) as endangered or threatened, and those with candidate status for listing in Gonzales County are presented in the Table 5.7-2. The Texas Natural Heritage Program records include reported occurrences within the proposed reservoir of the Cagle's Map Turtle *(Graptemys cagleii*), the Guadalupe Bass (*Micropterus treculi*), Smooth Blue-star (*Amsonia glaberrima*), Texas Pink-root (*Spigelia texana*), and Texas Tauschia (*Tauschia texana*). A few miles downstream of the proposed reservoir site, three species are reported to occur that may be impacted by construction: Cagle's Map Turtle, Guadalupe Bass, and Texas Tauschia. These species find habitat immediately upstream of the confluence of the San Marcos and Guadalupe Rivers. The proposed reservoir site may contain potential habitat for other threatened, endangered and candidate species that have been recorded in the county. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

The Gonzales Reservoir would affect several community facilities and towns within the reservoir site. The cities of Slayden and Ottine would be fully or partially inundated. Little Hill Church and the Gonzales Warm Springs Rehabilitation Foundation are located within the reservoir boundaries and would be inundated. In addition, the Texas State Elks Association Crippled Children's Hospital is located adjacent to the conservation pool and may be impacted.

[7]U.S. Bureau of Reclamation, "Special Report on the San Antonio-Guadalupe River Basins Study," November 1978.

Table 5.7-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Gonzales Reservoir (G-20)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	E	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Smooth Blue-Star	*Amsonia glaberrima*				NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]			NL	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Cultural resources known to occur within the Gonzales Reservoir site include the McKeller and Princeville cemeteries. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction could first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources.

Implementation of this reservoir option is expected to require field surveys to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir. Where impacts to potential protected species habitat or significant cultural resources cannot be avoided, additional studies may be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

5.7.4 Engineering and Costing

The cost estimate for Gonzales Reservoir is summarized in Table 5.7-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the United States Study Commission in 1960.[8] Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard costing methodology presented in Appendix A. Costs include land purchased within the spillway design flood pool (elevation 349 ft-msl; 24,980 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $17,091,000. Annual operation and maintenance costs total $1,070,000. The annual cost, including debt service and operation and maintenance, totals $18,161,000. For an annual firm yield of 69,897 acft, the resulting cost of raw water at the reservoir is $260 per acft (Table 5.7-3). Depending upon the location(s) and type(s) of use for water supplies associated with Gonzales Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

5.7.5 Implementation Issues

Implementation of Gonzales Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-16C1, G-17C1, G-21, G-38C, G-40, S-16C, SCTN-6, SCTN-16b and/or SCTN-16c.

An institutional arrangement is needed to implement this project including financing on a regional basis.

1. It will be necessary to obtain these permits:
    a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
    b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
    c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir.

[8] U.S. Study Commission, "Capacity-Cost Curve for Gonzales Reservoir Site," June 1960.

Table 5.7-3.
Cost Estimate Summary for
Gonzales Reservoir (G-20)
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool: 560,000 acft; 21,370 acres; 344 ft-msl)	
Relocations	$19,637,000
Diversion and Care of Water	365,000
Reservoir Clearing	11,887,000
Embankment	15,200,000
Spillway	23,294,000
General Items	983,000
Total Capital Cost	**$71,366,000**
Engineering, Legal Costs and Contingencies	$24,978,000
Environmental & Archaeology Studies and Mitigation	62,046,000
Land Acquisition and Surveying (24,980 acres)	63,295,000
Interest During Construction (4 years)	35,470,000
Total Project Cost	**$257,155,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$17,091,000
Operation and Maintenance	1,070,000
Total Annual Cost	**$18,161,000**
Available Project Yield (acft/yr)	**69,897**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$260**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$0.80**

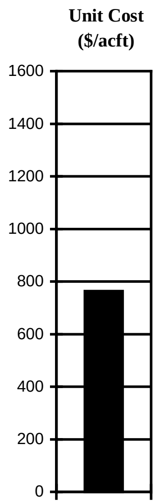
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.

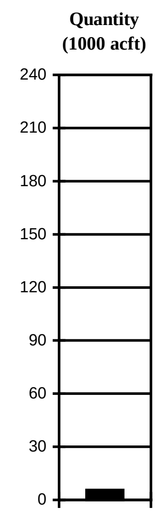
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

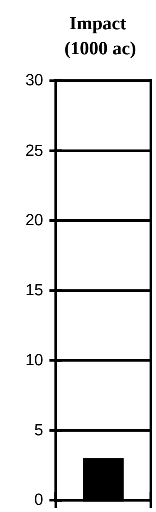
3. Land will need to be acquired through either negotiations or condemnation.

4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

5. Other Coordination:
   a. Implementation of this option would require substantial coordination with groups having specific local or regional interests.







OPTION NUMBER: G-21
OPTION NAME: Lockhart Reservoir — Raw Water at the Reservoir

OPTION DESCRIPTION: *Lockhart Reservoir site is located on Plum Creek, a tributary to the San Marcos River, north of Lockhart in Caldwell County. At elevation 482 ft-msl, the conservation pool capacity would be 50,000 acft. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**764**	**per acft**[1]	**Raw Water at Reservoir**
QUANTITY OF WATER:	**5,627**	**acft/yr**[2]	
LAND IMPACTED:	**2,910**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Lockhart Reservoir, additional facilities and costs could include raw include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Downstream water rights, instream flow requirements, and Edwards Aquifer pumpage.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 2,910 acres of land, including a 5-mile stretch of the Plum Creek, and instream flow requirements. The land involved is 4 percent wooded, 38 percent brush and scrubland, 30 percent cropland, 25 percent grasses, and 3 percent wetlands. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and pass-through of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, G-20, G-22, G-38C, SCTN-6, and/or CZ-10D.

5.8 Lockhart Reservoir (G-21)

5.8.1 Description of Option

The Lockhart dam and reservoir project is located at river mile 30.5 on Plum Creek (drainage area of 118 square miles), a tributary of the San Marcos River, just north of Lockhart in Caldwell County. Forrest and Cotton, Inc. first proposed the project in 1959 in their "Report on Supplement to the Initial Plan of Development of the Guadalupe-Blanco River Authority." The City of Lockhart's primary source of municipal water supply is groundwater, and the Lockhart project was proposed to provide additional municipal and industrial water to the local area. The location of the project is shown in Figure 5.8-1.

Forest and Cotton developed a preliminary design for the Lockhart project based on a field inspection, as adequate topographic information was not available at the time. The dam embankment, as proposed, would be approximately 5,900 feet long with a top-of-dam crest elevation of 508 ft-msl (maximum dam height of 73 feet), to control the 118 square mile watershed. The spillway system would consist of a 250-foot-long, broad-crested weir, with crest at elevation 482 ft-msl. The spillway design flood elevation would be 502 ft-msl, inundating approximately 5,430 acres. The reservoir would have a conservation pool capacity of 50,000 acft at elevation 482 ft-msl, permanently inundating 2,910 acres along a 5-mile segment of Plum Creek.

5.8.2 Water Availability

The firm yield of the proposed Lockhart Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendix B). The Guadalupe-San Antonio River Basin Model[1] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for Plum Creek near Luling (USGS# 08173000), adjusted for the difference in drainage area between the gage and the reservoir site, were

[1] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

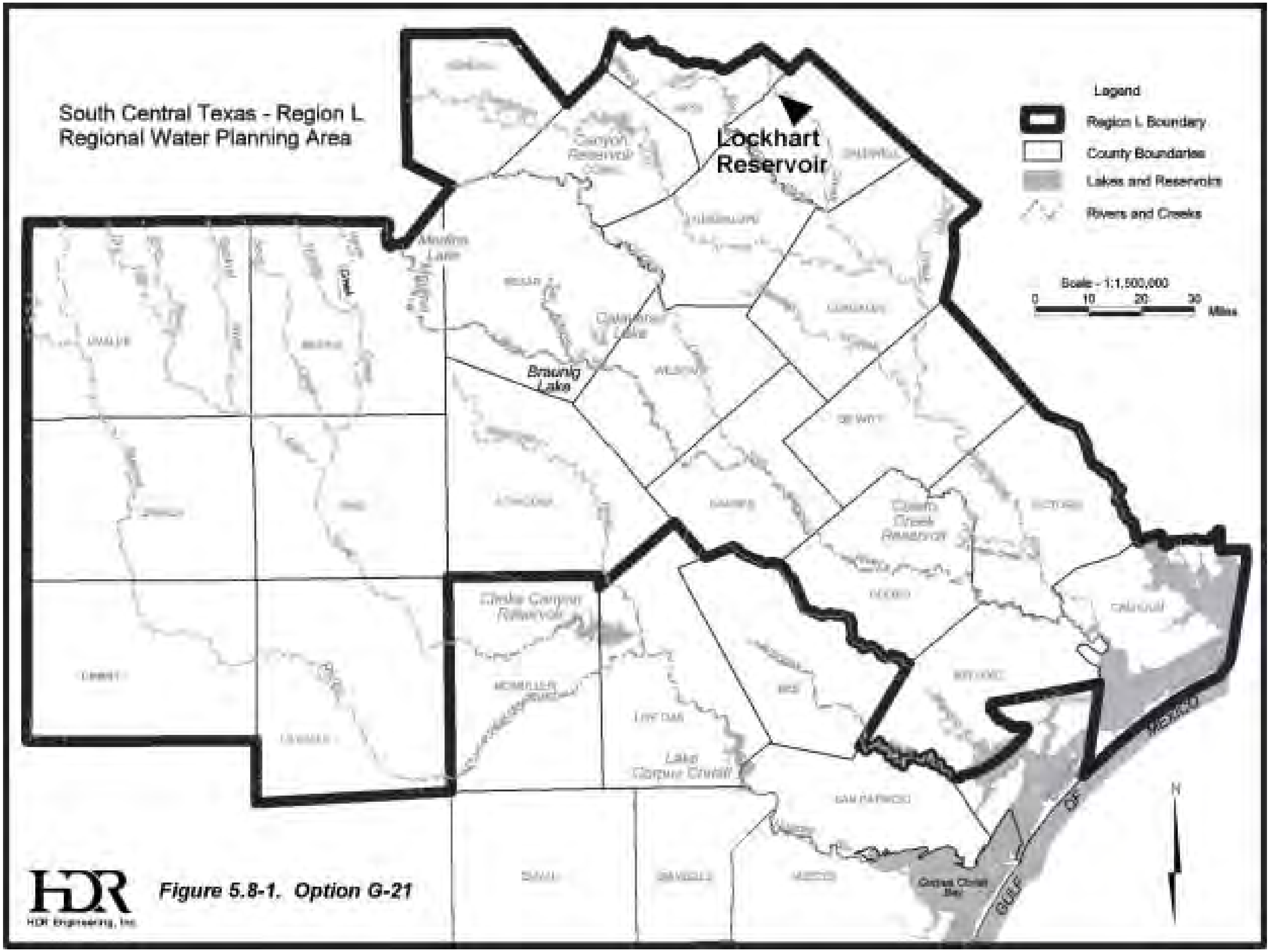


Figure 5.8-1. Option G-21

assumed representative of inflows to the proposed reservoir. These flows are the naturalized flows at the reservoir site, adjusted to account for upstream water rights and return flows. The GSA Model computes streamflow available for impoundment without causing increased shortages to downstream rights.

The firm yield of the Lockhart Reservoir was computed using the inflows and pass-through flows computed by the GSA Model and a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.8-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 5,627 acft/yr (which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record). In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows for 1935 and 1936 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield.

Table 5.8-1.
Daily Natural Streamflow Statistics
for the Lockhart Reservoir Site

Month	***Median Flows – Zone 1 Pass-Through Requirement (acft/day)***	***25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)***
January	28	14
February	36	16
March	29	13
April	24	11
May	32	11
June	24	8
July	10	3[1]
August	4	1[1]
September	8	2[1]
October	11	4
November	16	8
December	20	10
Zone 3 Pass-Through Requirement[2] (acft/day)		4

[1] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[2] Water Quality Standard (7Q2).

Figure 5.8-2 illustrates the simulated Lockhart Reservoir storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield of 5,627 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 60 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1934 to 1989 historical period. Figure 5.8-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and for the Guadalupe River at the Saltwater Barrier. Monthly median streamflows in Plum Creek would be reduced about 47 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced by about 1 percent.

5.8.3 Environmental Issues

The Lockhart Reservoir project involves dam construction and inundation of approximately 2,910 acres along a 5-mile reach of Plum Creek, a tributary of the San Marcos River. The proposed reservoir site is located in north Caldwell County within the Texas Blackland Prairies ecoregion,[2] in the Blackland Prairie vegetational area of Texas,[3] and in the Texan biotic province.[4] Vegetation types within the Lockhart Reservoir project area include crops (30 percent), native and introduced grasses (25 percent), brushland and shrubland (38 percent), small quantities of woodlands (4 percent), and intermittent river and palustrine scrub/shrub and forested wetlands (3 percent).

Within the proposed Lockhart Reservoir site, Heiden clays, which are frequently eroded, are found on uplands with slopes ranging from 3 to 8 percent. They are well-drained and frequently used for crops or pasture. Houston black clays are found on smooth uplands. They are moderately well drained and are used for crops. Trinity clays have formed in calcareous, clayey, alluvial sediments on floodplains along streams where slopes are less than 1 percent. These areas are used predominantly for crops and improved pasture. Frequently flooded Trinity soils are on nearly level floodplains. These soils are flooded several times a year and are used mostly for pasture.[5]

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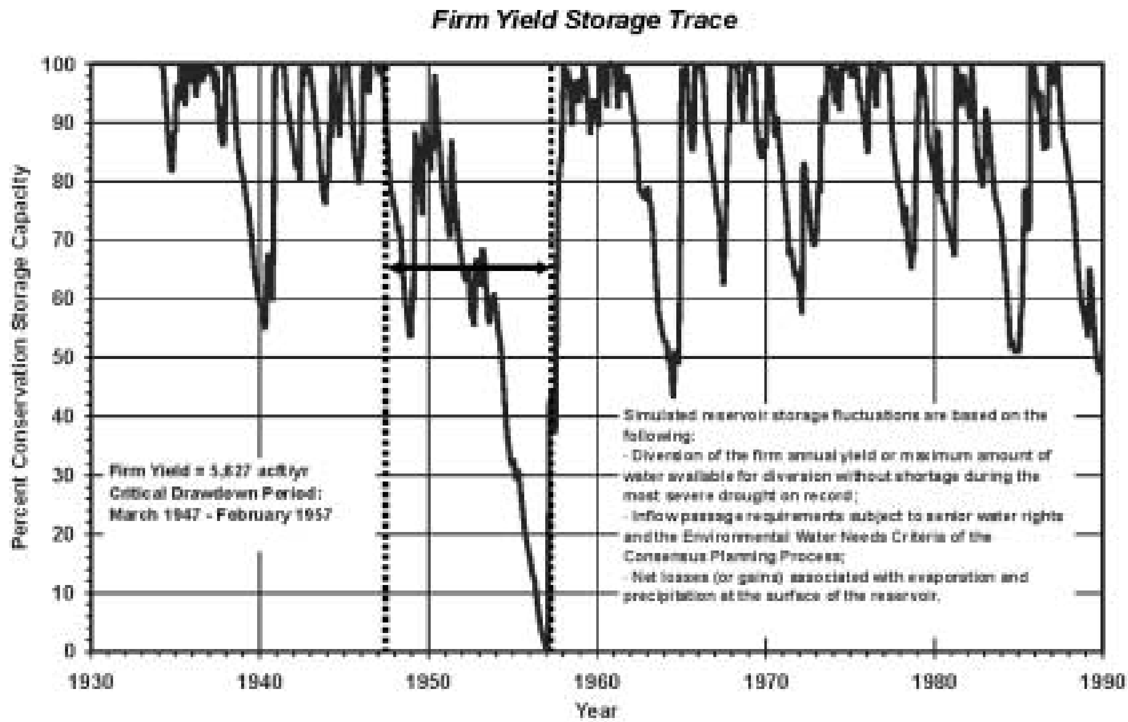
[2] Omernik, James M., “Ecoregions of the Conterminous United States,” Annals of the Association of American Geographers, 77(1), pp. 118-125, 1986.
[3] Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[4] Blair, W.F., “The Biotic Provinces of Texas, “Tex. J. Sci. 2:93-117, 1950.
[5] U.S. Department of Agriculture, Soil Conservation Service (SCS), “Soil Survey of Caldwell County, Texas,” in cooperation with Texas Agricultural Experiment Station, Texas A&M University, College Station, July 1978.



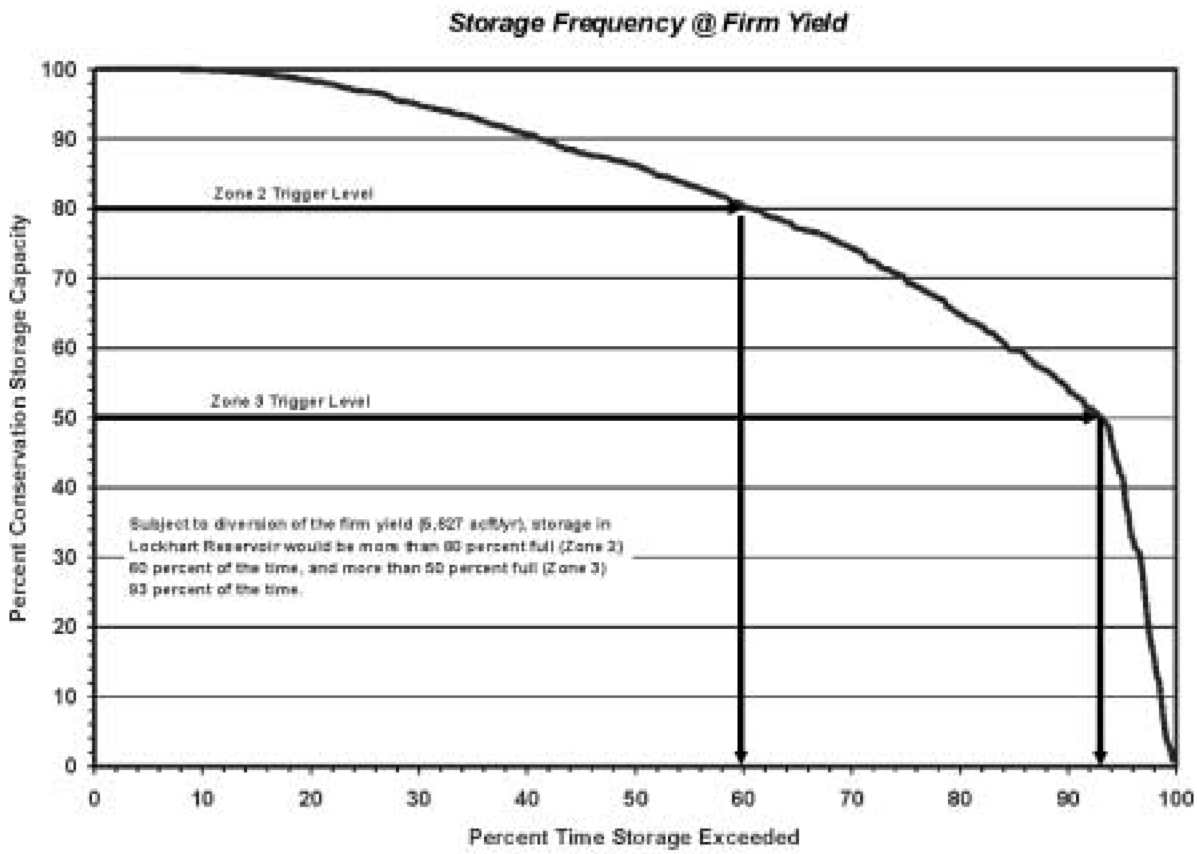


Figure 5.8-2. Lockhart Reservoir Storage Considerations

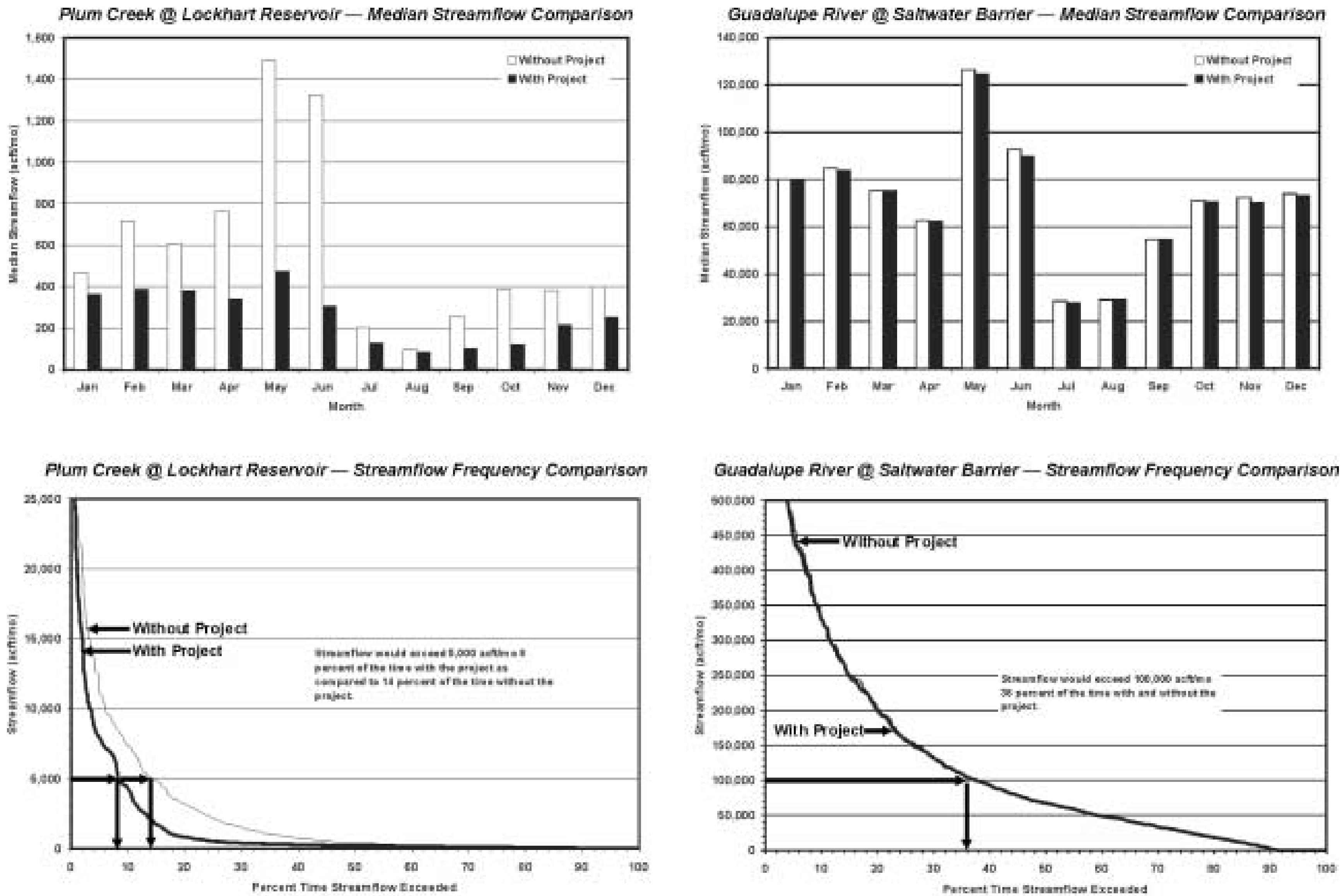


Figure 5.8-3. Lockhart Reservoir Streamflow Comparisons

The primary impacts that would result from construction and operation of the Lockhart Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Lockhart Reservoir would permanently inundate 2,910 acres below 482 ft-msl. Approximately 1,600 acres of grassland and cropland, 1,106 acres of brushland and shrubland, 116 acres of woodland, 37 acres of riverine habitat, and 51 acres of wetlands would be converted to open water upon reservoir filling. Based on available information, no communities or other special resources are located within the reservoir area. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime below the dam and a minimal reduction of freshwater inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 77 percent in June, with the reduction for other months ranging from 10 to 70 percent. Low flows (those exceeded about 85 percent of the time) will be unchanged at the project site, largely due to the requirements of the Consensus Criteria. As a new reservoir without a current operating permit, the Lockhart Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Flows at the Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flows of about 2 percent

In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Plant and animal species listed by the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and/or the Texas Organization for Endangered Species (TOES) as endangered or threatened, and those with candidate status for listing with potential habitat in Caldwell County are listed in Table 5.8-2. No protected species have been recorded in the study area, although the area may provide potential habitat to 17 endangered, threatened or candidate species found in Caldwell County. Other protected species may use habitats in the area during migration. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be affected.

Table 5.8-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Lockhart Reservoir (G-21)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Mountain Plover	*Charadrius montanus*	Shortgrass plains and plowed fields	PT		NL	Nesting/Migrant
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Upland pine and deciduous woodlands, sandy or clay soil; dense ground cover		T	T	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Mycteria americana*	Prairie ponds, shallow standing water; roosts in tall snags		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed to be listed endangered or threatened
WL Potentially Endangered/Threatened Blank = Rare, but no regulatory listing status

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). Implementation of this reservoir alternative is expected to require field surveys by qualified professionals to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir. Where impacts to potential protected species habitat or significant cultural resources could not be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

5.8.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.8-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the United States Study Commission in 1960,[6] subsequent to the Forrest and Cotton study. Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land purchased within the spillway design flood pool (elevation 502 ft-msl; 5,430 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $4,039,787. Annual operation and maintenance costs total $259,000. The annual cost, including debt service and operation and maintenance, totals $4,298,787. For an annual firm yield of 5,627 acft, the resulting cost of raw water at the reservoir is $764 per acft (Table 5.8-3). Depending upon the location(s) and type(s) of use for water supplies associated with Lockhart Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[6] United States Study Commission – Texas, "Capacity Cost Curve for Lockhart Reservoir Site," May 1960.

Table 5.8-3.
Cost Estimate Summary for
Lockhart Reservoir (G-21)
Second Quarter 1999 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 50,000 acft; 2,910 acres; 482 ft-msl)	
Relocations	$3,160,000
Diversion and Care of Water	185,000
Reservoir Clearing	489,000
Embankment	8,893,000
Spillway	4,192,000
General Items	369,000
Total Capital Cost	**$17,288,000**
Engineering, Legal Costs and Contingencies	$6,051,000
Environmental & Archaeology Studies and Mitigation	14,395,000
Land Acquisition and Surveying (5,430 acres)	14,667,000
Interest During Construction (4 years)	8,384,000
Total Project Cost	**$60,785,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$4,039,787
Operation and Maintenance	259,000
Total Annual Cost	**$4,298,787**
Available Project Yield (acft/yr)	5,627
Annual Cost of Water ($ per acft) Raw Water at Reservoir	$764
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	$2.34

5.8.5 Implementation Issues

Implementation of Lockhart Reservoir could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, G-20, G-22, G-38C, SCTN-6, and/or CZ-10D.

An institutional arrangement is needed to implement this project including financing on a regional basis.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

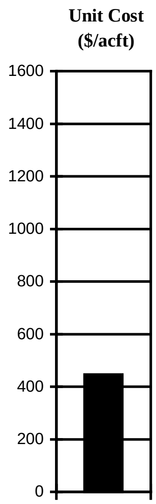
3. Land will need to be acquired through either negotiations or condemnation.

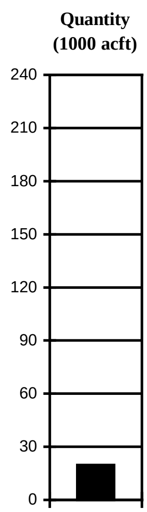
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

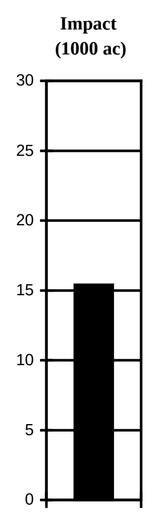
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 11/02/99







OPTION NUMBER: G-22
OPTION NAME: Dilworth Reservoir — Raw Water at the Reservoir

OPTION DESCRIPTION: *Dilworth Reservoir site is located on Peach Creek, a tributary of the Guadalupe River, approximately 6 miles east of Gonzales in Gonzales County. At elevation 293 ft-msl, the conservation pool capacity would be 275,000 acft. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$446**	**per acft[1]**	**Raw Water at Reservoir**
QUANTITY OF WATER:	**19,705**	**acft/yr[2]**	
LAND IMPACTED:	**15,400**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Dilworth Reservoir, additional facilities and costs could include Guadalupe River diversion works, raw water intake at the reservoir, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Downstream water rights, instream flow requirements, and level of Edwards Aquifer pumpage. As the Dilworth Reservoir project is somewhat large for the Peach Creek watershed and located near the Guadalupe River, its firm yield could be enhanced with periodic diversions from the Guadalupe River, similar to that described for Sandies Creek Reservoir (Option G-17C1).

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 15,400 acres of land, including a 13-mile stretch of Peach Creek, a tributary to the Guadalupe River, and instream flow requirements. The land involved is 39 percent grass and cropland, 18 percent woodlands, 9 percent wetlands, 32 percent brush and scrublands, one percent riverine habitat, and one percent developed. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and pass-through of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, and/or G-20.

5.9 Dilworth Reservoir (G-22)

5.9.1 Description of Option

The Dilworth dam and reservoir project is located at river mile 13.1 on Peach Creek, a tributary of the Guadalupe River, approximately 6 miles east of the City of Gonzales in Gonzales County. The United States Army Corps of Engineers (COE) first proposed the project in 1950. The COE report, "Report on Survey of Guadalupe and San Antonio Rivers and Tributaries, Texas for Flood Control and Allied Purposes," presented the Dilworth site as a flood control project. The site was not deemed very effective in a flood control role, however, and the dam and reservoir were not recommended for construction. The location of the dam is shown in Figure 5.9-1.

The dam would consist of a 15,700-foot earthen embankment with a top-of-dam crest elevation of 307 ft-msl (maximum dam height of 67 feet), to control the 438 square mile watershed. The spillway system would consist of a 700-foot controlled concrete weir section with radial gates at a crest elevation of 280 ft-msl. The spillway design flood elevation would be 300 ft-msl, inundating approximately 20,700 acres. The reservoir would have a conservation pool capacity of 275,000 acft at elevation 293 ft-msl, permanently inundating 15,400 acres along a 13-mile segment of Peach Creek.

5.9.2 Water Availability

The firm yield of the proposed Dilworth Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendix B). The Guadalupe-San Antonio River Basin Model[1] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for Peach Creek below Dilworth (USGS# 08174600) were assumed representative of inflows to the proposed reservoir. These inflows are the naturalized flows at the reservoir, adjusted for upstream water rights and return flows. The GSA

[1] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

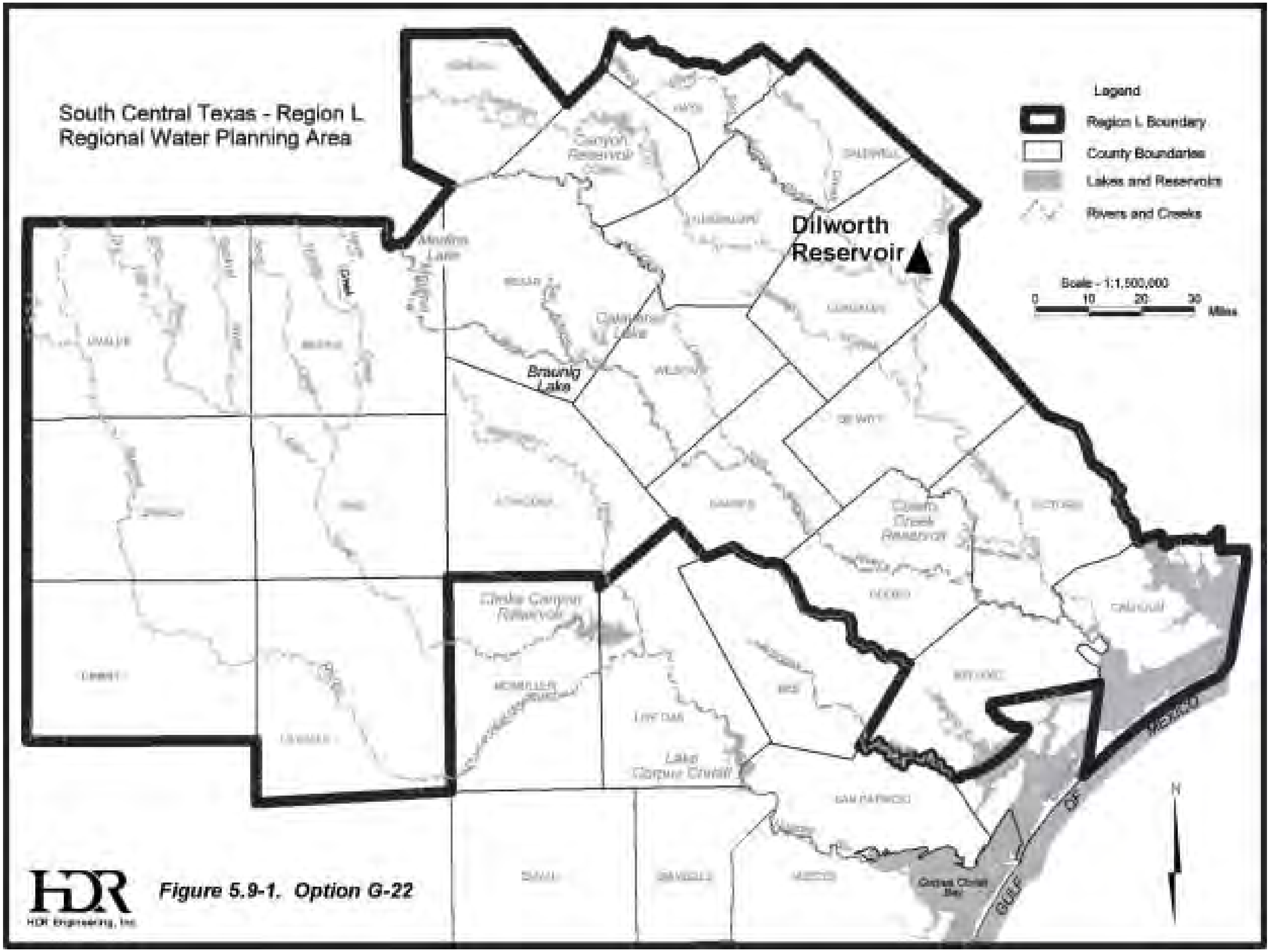


Figure 5.9-1. Option G-22

Model computes streamflow available for impoundment without causing increased shortages to downstream rights.

The firm yield of the Dilworth Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.9-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 19,705 acft/yr (which represents a reliable water supply based on the 1934 to 1989 historical period of hydrologic record). In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows for 1935 and 1936 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield.

Table 5.9-1.
Daily Natural Streamflow Statistics
for the Dilworth Reservoir Site

Month	***Median Flows – Zone 1 Pass-Through Requirement (acft/day)***	***25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)***
January	20	1
February	24	4
March	20	1
April	10	1
May	26	2
June	16	1
July	2	1
August	1	1
September	1	1
October	1	1
November	7	1
December	10	1
Zone 3 Pass-Through Requirement[1] (acft/day)		1

[1] HDR natural 7Q2 (1934 to 1989).

Figure 5.9-2 illustrates the simulated Dilworth Reservoir storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield of 19,705 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 49 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time over the 1934 to 1989 historical period. As the Dilworth Reservoir project is somewhat large for the Peach Creek watershed and located near the Guadalupe River, its firm yield could be enhanced with periodic diversions from the Guadalupe River. Such operation as a large-scale off-channel storage facility would be similar to that described for Sandies Creek Reservoir (Option G-17C1, Section 5.11). Figure 5.9-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and for the Guadalupe River at the Saltwater Barrier. Monthly median streamflows in Peach Creek would be reduced by about 90 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced by about 2 percent.

5.9.3 Environmental Issues

The Dilworth Reservoir project involves dam construction and inundation of approximately 15,400 acres along a 13-mile reach of Peach Creek, a tributary of the Guadalupe River. The proposed reservoir is located in northeastern Gonzales County on the boundary between the Texas Blackland Prairies and the East Central Texas Plains ecoregions,[2] in the Post Oak Savannah region of Texas,[3] and in the Texas biotic province.[4]

Vegetation types within the proposed Dilworth Reservoir project area include bottomland and upland woodlands, shrubland, grassland, cropland, and wetlands. Streamside vegetation within the proposed reservoir is typical of pecan-elm forests. These forests are found in bottomlands along the Brazos, Colorado, Guadalupe, San Antonio and Frio Rivers. They contain, among other species, American elm, cedar elm, pecan, cottonwood, sycamore, black willow, yaupon, greenbriar, Johnsongrass, frostweek and western ragweed.[5]

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[2] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1), pp. 118-125, 1986.

[3] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1975.

[4] Blair, W.F., "The Biotic Provinces of Texas," Tex. J. Sci. 2:93-117, 1950.

[5] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas, Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.

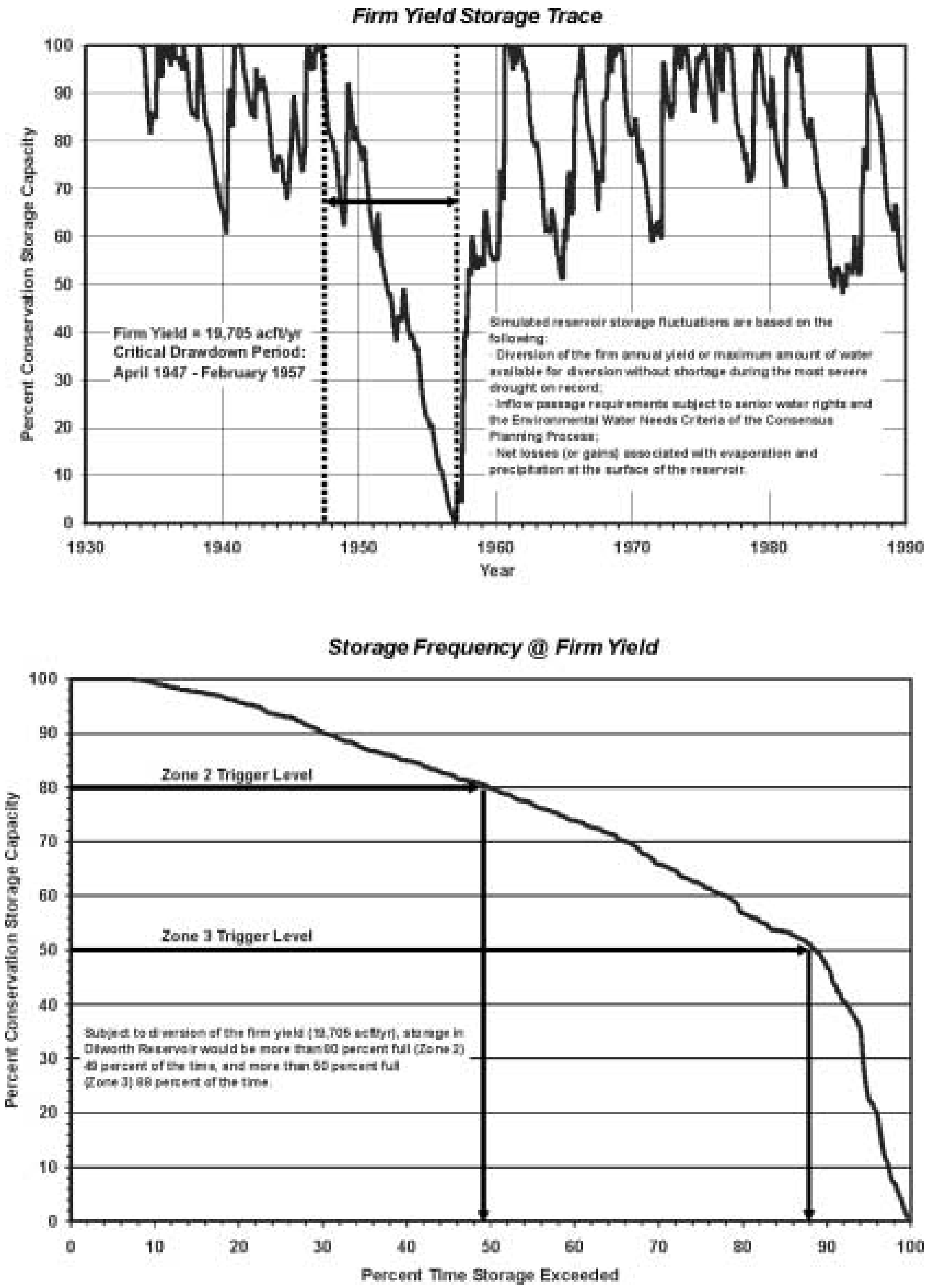


Figure 5.9-2. Dilworth Reservoir Storage Considerations

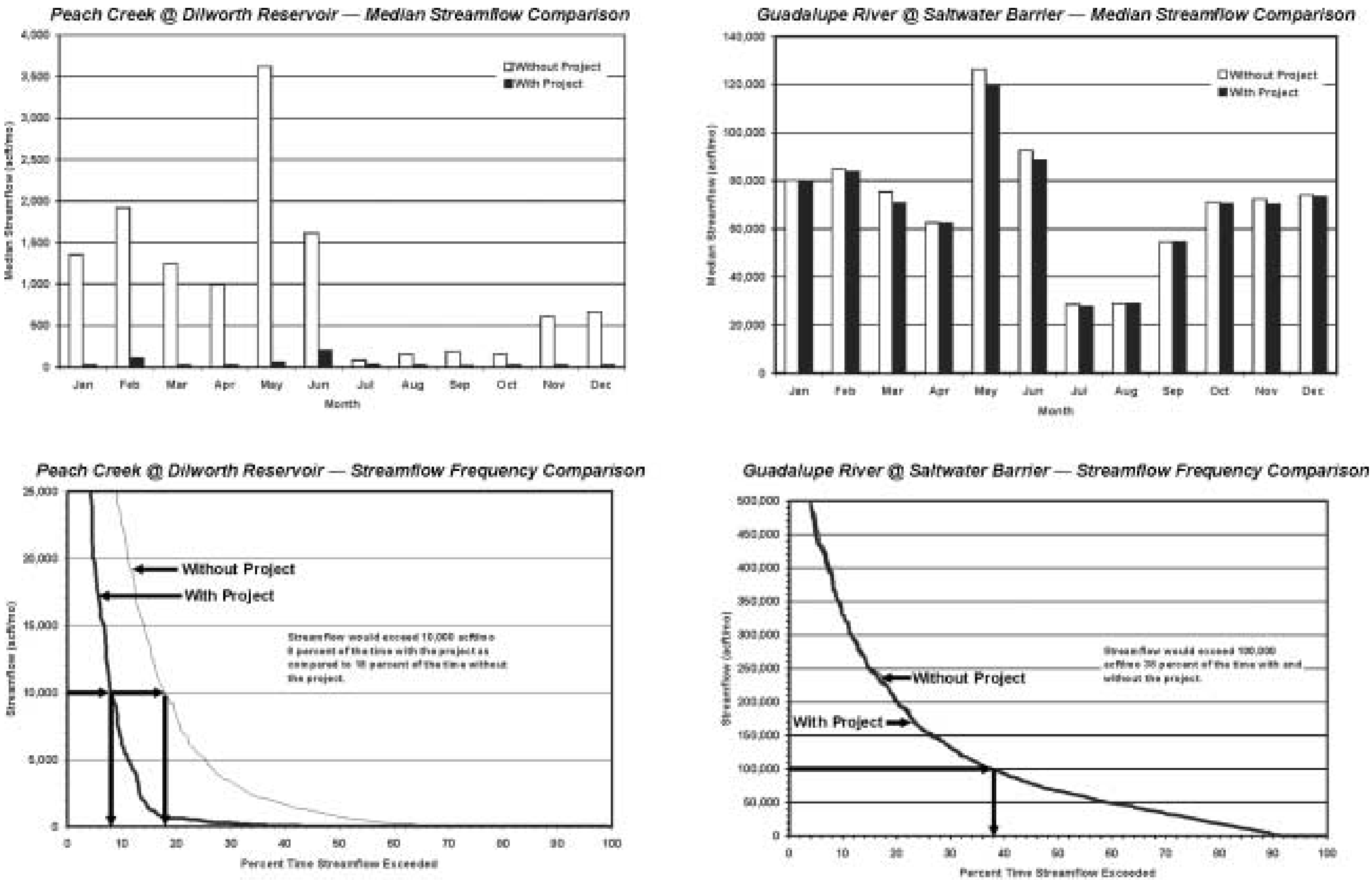


Figure 5.9-3. Dilworth Reservoir Streamflow Comparisons

Upland areas are dominated by post oak woods, forest and grassland mosaics. These areas are typically found on sandy soils. Common species include blackjack oak, eastern redcedar, mesquite, black hickory, live oak, hackberry, yaupon, American beautyberry, hawthorn, little bluestem, beaked panicum, three-awn and tickclover.[6]

Within the floodplains, soils are a calcareous black clay classified as Tinn clay and Bosque clay loam. These soils have the highest fertility in the county, thus making excellent cropland. Gholson and Sunev soils are a fine loamy sand found in uplands with slopes of 1 to 5 percent and 3 to 8 percent, respectively.[7]

Wetlands within the reservoir site include approximately 1,530 acres of palustrine forested, scrub/shrub, emergent and intermittent riverine wetlands.

The primary impacts that would result from construction and operation of the Dilworth Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Dilworth Reservoir site would be permanently inundated to 293 ft-msl with a surface area of 15,400 acres. Approximately 5,049 acres of brushlands, 5,967 acres of grasslands and croplands, 2,754 acres of woodlands, 68 acres of riverine habitat, 1,462 acres of wetlands, and 100 acres of developed land would be converted to open water. Several lakes would be inundated by the reservoir, including Post Oak, Laws, Jones, Wood, Mooney, Pogue, Bailey, Lee, Rinehart, and Long. The town of Little New York and St. James Cemetery would also be inundated by the proposed reservoir. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include substantial reductions in monthly median streamflows below the dam, but minimal reductions of freshwater inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 98 percent in January, March, and May, with the reduction for other months ranging from 61 to 95 percent. Reductions in monthly streamflow would result primarily from the reservoir impounding flood flows, which constitute the majority of the monthly flows at the reservoir location. Low flows (those exceeded about 85 percent of the time) would be

[6] Ibid.

[7] U.S. Department of Agriculture, Soil Conservation Service (SCS), Personal communication with Gonzales County Soil Survey Staff, March 1994.

unchanged at the project site, largely due to the requirements of the Consensus Criteria. Such an operating regine can be expected to have substantial effects on the downstream biological community in Peach Creek. As a new reservoir without a current operating permit, the Dilworth Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Guadalupe River flows at the Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flows of about 2.5 percent

Plant and animal species listed by the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and/or the Texas Organization for Endangered Species (TOES) as endangered or threatened, and those with candidate status for listing with potential habitat in Gonzales County are listed in Table 5.9-2. No protected species have been recorded on the site, but the area may provide potential habitat for ten threatened, endangered or candidate species that occur in Gonzales County. Other protected species may use habitats in the area during migration. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). Implementation of this option is expected to require field surveys by qualified professionals to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir. Where impacts to potential protected species habitat or significant cultural resources could not be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

5.9.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.9-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the United States Study Commission in 1960,[8] subsequent to the COE study. Inundated land and mitigation

[8] United States Study Commission – Texas, "Capacity Cost Curve for Dilworth Reservoir Site," May 1960.

Table 5.9-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Dilworth Reservoir (G-22)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/ Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered; T = Threatened; 3C = No Longer a Candidate for Protection; C2 = Candidate Category; C1 = Candidate Category, Substantial Information; WL = Potentially Endangered/Threatened; Blank = Rare, but no regulatory listing status; NL = Not Listed

land acquisition, and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land purchased within the spillway design flood pool (elevation 300 ft-msl; 20,700 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $8,269,406. Annual operation and maintenance costs total $528,000. The annual cost, including debt service and operation and maintenance, totals $8,797,406. For an annual firm yield of 19,705 acft, the resulting cost of raw water at the reservoir is $446/acft (Table 5.9-3). Depending upon the location(s) and type(s) of use for water supplies associated with Dilworth Reservoir, additional facilities and costs could include Guadalupe River diversion works, raw water intake at the reservoir, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

Table 5.9-3.
Cost Estimate Summary for
Dilworth Reservoir (G-22)
Second Quarter 1999 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 275,000 acft; 15,400 acres; 293 ft-msl)	
Relocations	$205,000
Diversion and Care of Water	183,000
Reservoir Clearing	4,207,000
Embankment	12,836,000
Spillway	16,158,000
Outlet Works	1,613,000
Total Capital Cost	**$35,202,000**
Engineering, Legal Costs and Contingencies	$12,320,000
Environmental & Archaeology Studies and Mitigation	29,353,000
Land Acquisition and Surveying (20,700 acres)	30,388,000
Interest During Construction (4 years)	17,162,000
Total Project Cost	**$124,425,000**
Annual Costs	
Debt Service (6 percent, 40 years)	$8,269,406
Operation and Maintenance	528,000
Total Annual Cost	**$8,797,406**
Available Project Yield (acft/yr)	19,705
Annual Cost of Water ($ per acft) Raw Water at Reservoir	$446
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	$1.37

5.9.5 Implementation Issues

Implementation of Dilworth Reservoir could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, and/or G-20.

An institutional arrangement is needed to implement this project including financing on a regional basis.

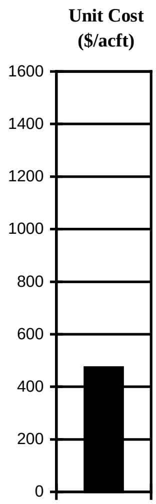
1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

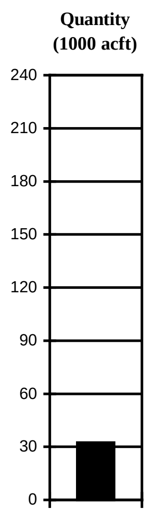
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

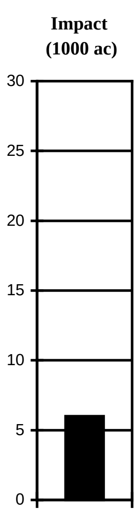
3. Land will need to be acquired through either negotiations or condemnation.

4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 11/02/99







OPTION NUMBER: **G-40**

OPTION NAME: **Cloptin Crossing Reservoir — Raw Water at the Reservoir**

OPTION DESCRIPTION: *The Cloptin Crossing Reservoir site is located in Hays and Comal Counties, on the Blanco River, about 2 miles southwest of Wimberley. At elevation 980.5 ft-msl, the conservation pool capacity would be 275,000 acre-feet. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☐ **5-15 yr.** ☒ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$473**	**per acft Raw Water at Reservoir**[1]
QUANTITY OF WATER:	**32,458**	**acft/yr**[2]
LAND IMPACTED:	**6,060**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Cloptin Crossing Reservoir, additional facilities and costs include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, downstream water rights, and instream flow requirements.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 6,060 acres of land within the conservation pool, including a 13-mile reach of the Blanco River, and instream flow requirements. The land involved is 24 percent grassland, 14 percent brushland, 20 percent woodland, 38 percent developed land, 1 percent wetlands, and 3 percent riverine habitat. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and passthrough of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, G-20, G-38C, S-15Db, S-15Dc, S-15E, SCTN-16b, and/or SCTN-16c.

5.10 Cloptin Crossing Reservoir (G-40)

5.10.1 Description of Alternative

The Cloptin Crossing dam and reservoir project is a proposed reservoir located at river mile 32.5 on the Blanco River in Hays and Comal Counties, about 2 miles southwest of the town of Wimberley. The proposed project was described in detail by the U.S. Army Corps of Engineers (COE) in 1980 as a flood control and water supply project. The COE report, "Cloptin Crossing Lake, Phase I General Design Memorandum," presented detailed siting information and found the project to be economically unfeasible.[1] The 1978 U.S. Bureau of Reclamation (BUREC) report, "Summary of Special Report, San Antonio-Guadalupe River Basins Study, Texas Basins Project," presents a summary of the project and a cost estimate. The location of the project is shown in Figure 5.10-1.

The dam would be a 7,520-foot earthen embankment with a top-of-dam crest elevation of 1,023 ft-msl (maximum dam height of 200 feet), to control the 307 square mile watershed. The spillway system would consist of a 760-foot concrete weir section at a crest elevation of 998 ft-msl. The spillway design flood would inundate approximately 7,730 acres. The reservoir would have a conservation pool capacity of 274,900 acft at elevation 980.5 ft-msl, permanently inundating approximately 6,060 acres along a 13-mile segment of the Blanco River.

5.10.2 Water Availability

The firm yield of the proposed Cloptin Crossing Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendix B). The Guadalupe-San Antonio River Basin Model[2] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for the Blanco River at Wimberley (USGS# 08171000) were assumed representative of inflows to the proposed reservoir. These inflows are

[1] The benefit-cost ratio for the flood protection element was less than 1.0, thus, the project was declared to be unfeasible.
[2] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

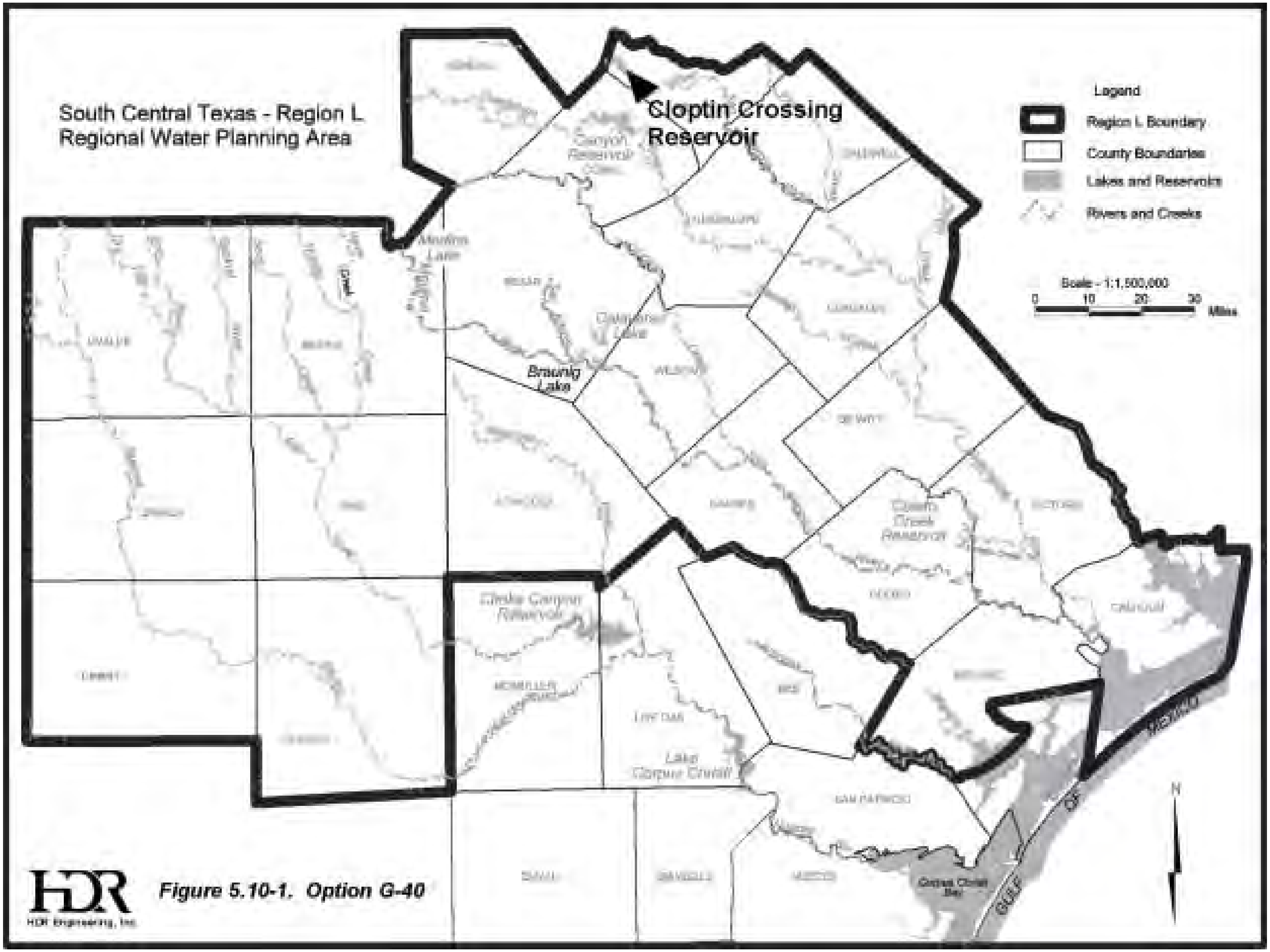


Figure 5.10-1. Option G-40

the naturalized flows from above the reservoir, adjusted for upstream water rights and return flows. The GSA Model computed the streamflow available for impoundment without causing increased shortages to downstream rights.

The firm yield of the Cloptin Crossing Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.10-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 32,458 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows in the 1930s are sufficient to fill the reservoir prior to the critical drawdown period, accounting for evaporation and the estimated firm yield.

Table 5.10-1.
Daily Natural Streamflow Statistics
for the Cloptin Crossing Reservoir Site

Month	*Median Flows – Zone 1 Pass-Through Requirement (acft/day)*	*25^{th} Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)*
January	105	52[1]
February	121	59[1]
March	137	58[1]
April	161	63
May	167	74
June	161	77
July	107	44[1]
August	65	34[1]
September	81	37[1]
October	96	40[1]
November	93	43[1]
December	105	44[1]
Zone 3 Pass-Through Requirement[2] (acft/day)		63

1 When the Zone 3 pass-through requirement is greater than the 25^{th} percentile flow, the 25^{th} percentile flow is superceded by the Zone 3 pass-through requirement.
2 Water Quality Standard (TNRCC 7Q2).

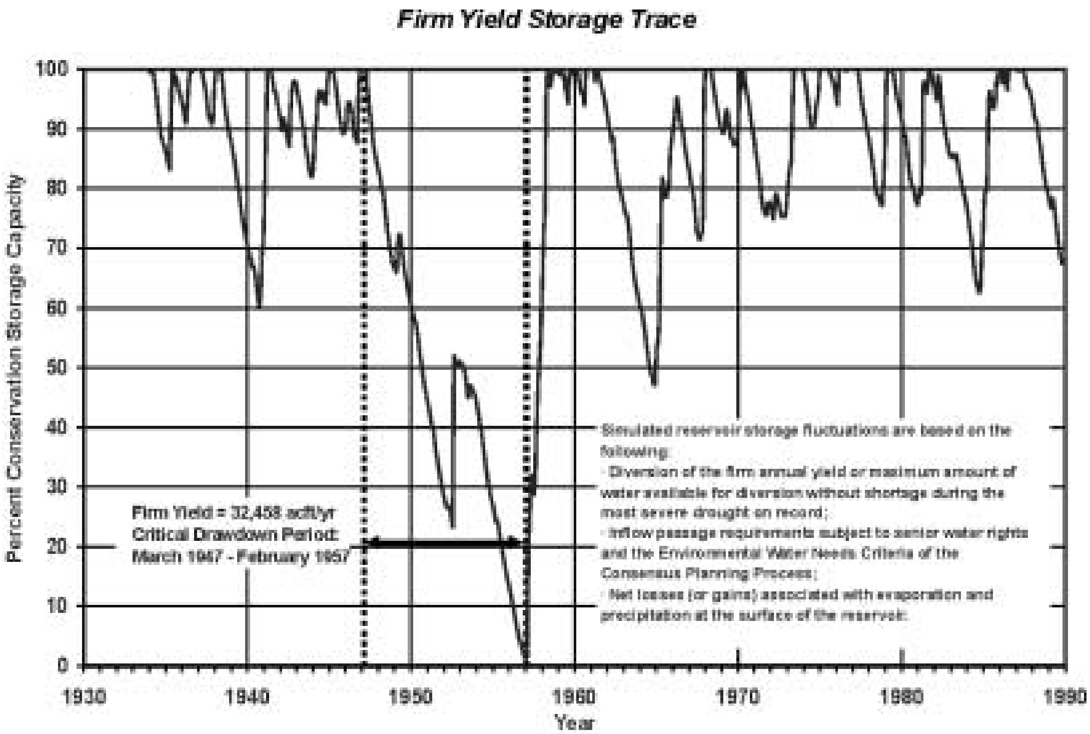
Figure 5.10-2 illustrates the simulated Cloptin Crossing Reservoir storage fluctuations for the 1934 to1989 historical period, subject to the firm yield of 32,458 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 63 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time over the 1934 to 1989 historical period. Figure 5.10-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and for the Guadalupe River at the Saltwater Barrier. Monthly median streamflows in the Blanco River would be reduced about 38 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced by about 3 percent.

5.10.3 Environmental Issues

The Cloptin Crossing Reservoir project involves dam construction and inundation of approximately 6,060 acres along a 13-mile reach of the Blanco River approximately 2 miles from Wimberley in Hays County. The dam centerline would be located approximately one-half mile upstream from Cloptin Crossing.

The proposed reservoir is located on the Edwards Plateau,[3] upstream of the Balcones Fault Zone and Blackland Prairie, and in the Texan biotic province.[4] Vegetation types within the project area on the Blanco River include riparian and upland woodland, park, brush, grassland, and wetland. Edwards Plateau vegetation has historically been grassland or open savannah-type plains with tree and understory species distributed primarily on rocky slopes and in stream bottoms. Throughout the more savannah-type level to rolling uplands of the Edwards Plateau, brush species (particularly Ashe juniper and mesquite) are common invaders, while the steeper canyon slopes have historically supported a dense oak-Ashe juniper thicket. The most important climax grasses of the Plateau include switchgrass (*Panicum virgatum*), several species of bluestems and gramas, Indian grass (*Sorghastrum nutans*), Canada wild-rye (*Elymus canadensis*), curly mesquite (*Hilaria berlangeri*), and buffalograss (*Buchloe dactyloides*). The rough, rocky areas typically support a tall or mid-grass understory and a brush overstory complex consisting primarily of live oak (*Quercus virginiana*), Texas oak (*Q. buckleyi*), shinnery oak (*Q. havardii*), Ashe juniper (*Juniperus ashei*), and mesquite (*Prosopis glandulosa*).

[3] Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[4] Blair, W.F, “The Biotic Provinces of Texas,” Texas Journal of Science 2:93-117, 1950.



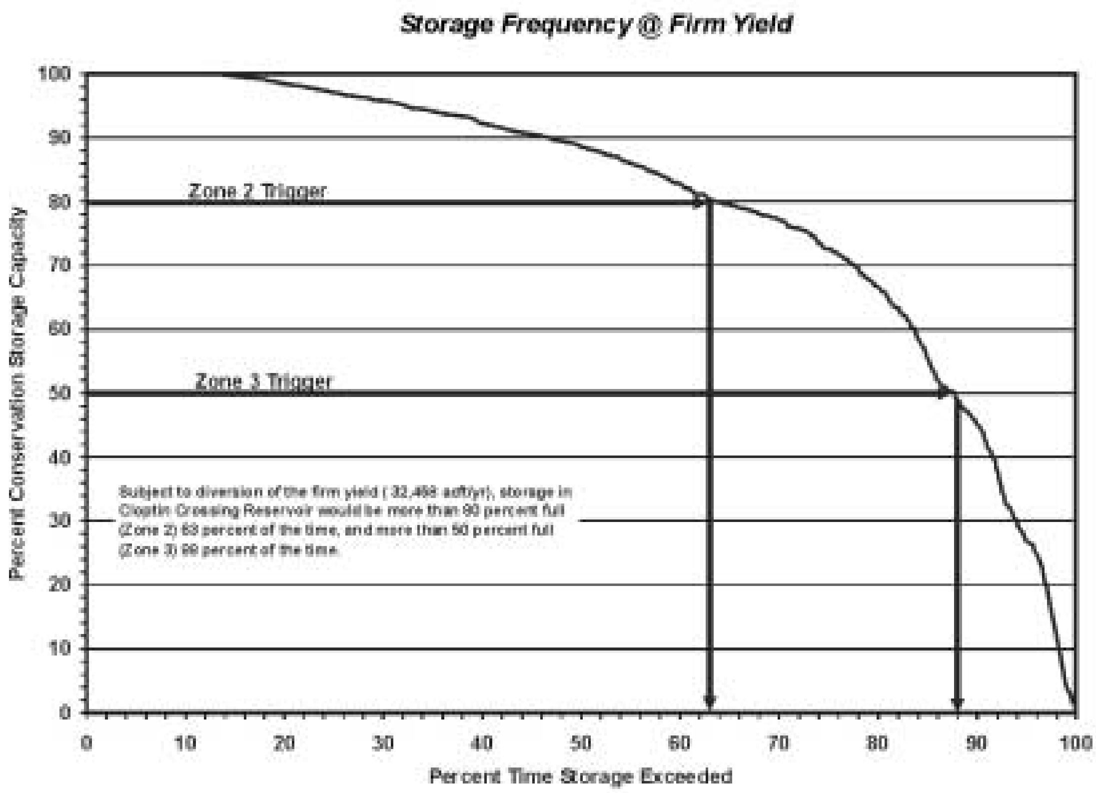


Figure 5.10-2. Cloptin Crossing Reservoir Storage Considerations

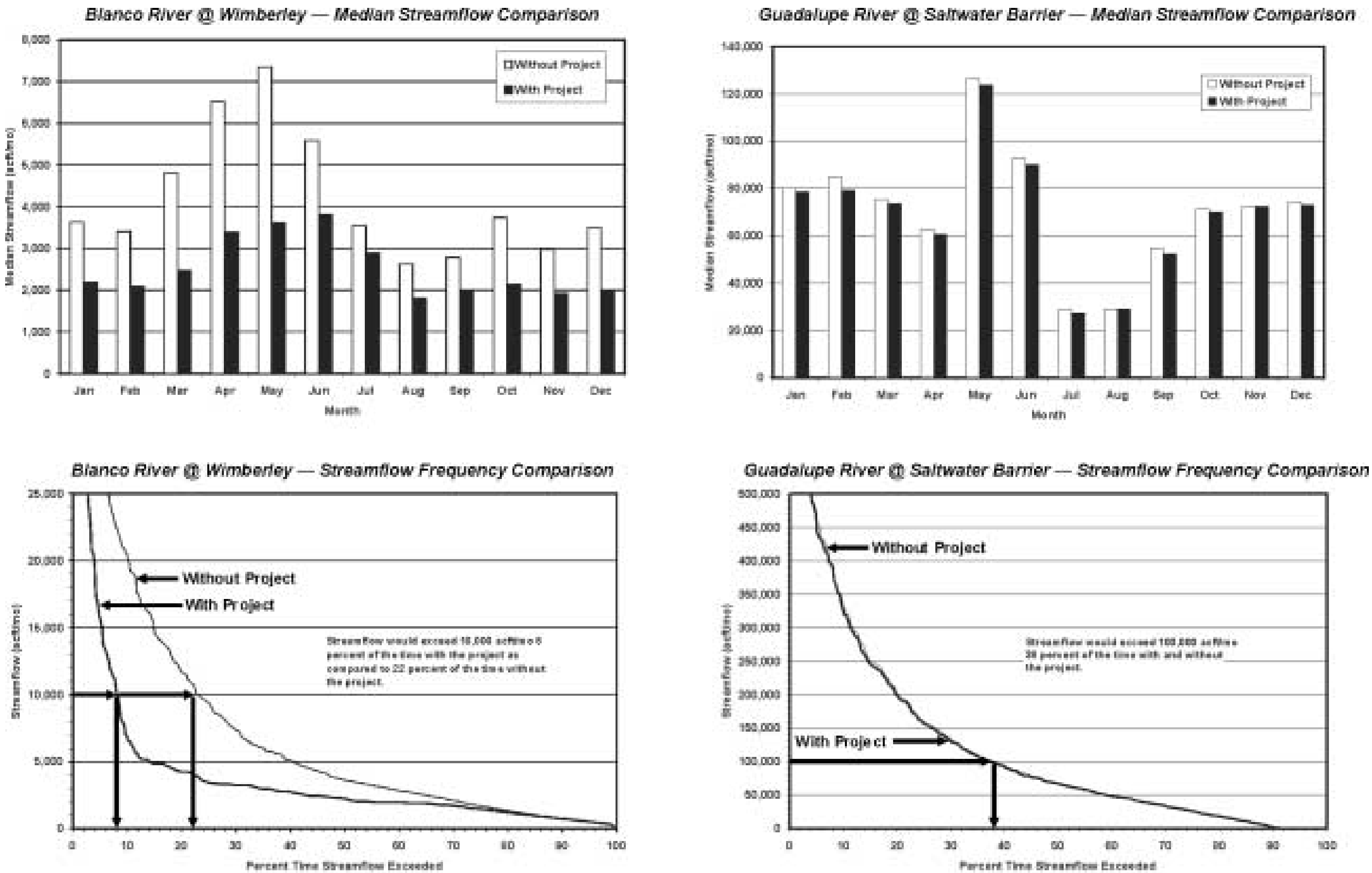


Figure 5.10-3. Cloptin Crossing Reservoir Streamflow Comparisons

Mesic stream bottom habitats were created as rivers and tributary streams, fed by numerous springs that occur at the base of the Edwards limestone, cut canyons through the plateau and formed isolated, mesic habitats that harbor a variety of plant species exhibiting disjunct distributions or endemism. Because of the many large canyons and rugged terrain, this area is of much botanical interest, and consequently has been visited by many collectors. The ferns, and many of the flowering plants which are common to the area are primarily lithophilous ("rock-loving"), and are represented primarily by various species of lipferns (*Cheilanthes* spp.), cloak-ferns (*Notholaena* spp.), and cliff brakes (*Pellaea* spp.). Columbine (*Aquilegia canadensis*) and endemic species such as anemone *(Anemone edwardsianas)* and wand butterfly-bush (*Buddlega racemosa*) also are present. These plants are sometimes found together with species such as mockorange (*Philadelphus* spp.), American smoke-tree (*Cotinus americana*), spicebush (*Benzoin aestivale*), and the endemic silver bells (*Styrax platanifolia* and *S. texana*) on large boulders and in shaded ravines.

The surface geology of the Cloptin Crossing Reservoir site is Cretaceous Glen Rose Limestone.[5] The soil units that have formed over these limestones are predominantly thin soils from the Brackett-Rock Outcrop-Comfort Complex (undulating), Brackett-Rock-Real Outcrop Complex (steep), Boerne Fine Sandy Loam (1 to 3 percent slopes), Lewisville Silty Clay (0 to 1 percent slopes), Lewisville Silty Clay (1 to 3 percent slopes), Purves Clay, and Oakalla Silty Clay Loam (rarely flooded).[6] The soils within the floodplain range from shallow to deep and are used typically for pastureland, cropland, and wildlife habitat.

Wetlands within the conservation pool include approximately 255 acres of riverine and palustrine habitats. Associated with the channel and banks of the Blanco River, the aquatic habitats are predominantly lower perennial riverine and palustrine that have substrates composed of both bedrock and unconsolidated bottom that are permanently flooded. The smaller drainages feeding the Blanco River are described as intermittent riverine habitats with streambeds that are temporarily flooded. A few small stock ponds are found within the upland area surrounding the project site.

[5] Fisher, W.L, "Geologic Atlas of Texas: San Antonio Sheet," Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas, 1983.
[6] Batte, C.D, "Soil Survey of Comal and Hays Counties, Texas," United States Department of Agriculture Natural Resource Conservation Service, 1984.

The primary impacts that would result from construction and operation of the Cloptin Crossing Reservoir include conversion of existing habitats, including existing stream habitats, and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing temperature, water quality, and flow regimes. Permanent inundation of the Cloptin Crossing Reservoir site would create a conservation pool with a surface area of 6,060 acres. Approximately 1,448 acres of grassland, 848 acres of brushland, 1,236 acres of woodland, 81 acres of wetlands, 174 acres of riverine habitat, and 2,273 acres of developed land would be converted to open water. In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and maximum flood pool elevation are anticipated due to temporary inundation during flood events. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the stream flow regime below the dam, and a minimal reduction of inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 51 percent in May, with the reduction for other months ranging from 18 to 49 percent. Low flows (those exceeded about 85 percent of the time) will be unchanged at the project site, largely due to the requirements of the Consensus Criteria. As a large new reservoir without a current water rights permit, the Cloptin Crossing Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Guadalupe River flows at the Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flow of about 2 percent

Plant and animal species listed by the U.S. Fish and Wildlife Service (USFWS), the Texas Parks and Wildlife Department (TPWD), and the Texas Organization for Endangered Species (TOES) as endangered or threatened, and those with candidate status for listing with potential habitat in Hays and Comal Counties are listed in Table 5.10-2. Although the most current TPWD data files show no reports of any federally or state listed endangered or threatened species, or TOES species of concern within the footprint of the proposed project, few surveys in the area have been conducted and an intensive survey of the project area would be required to assess the habitats within the project area accurately and determine the possibility of any associated threatened or endangered species occurrence. The species listed in Table 5.10-2 may

Table 5.10-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Cloptin Crossing Reservoir (G-40)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco Blind Salamander	*Eurycea robusta*	Troglobitic; Stream bed of the Blanco River		T	T	Resident
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River			NL	Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Cling to objects in streams; adults fly especially at night	E		NL	Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E		NL	Resident
Comal Springs Salamander	*Eurycea sp. 8*	Endemic; Comal Springs			NL	Resident
Dark Noseburn	*Tragia nigricans*	Deciduous woodlands, clay or clay loams, mesic canyons			WL	Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Flint's Net-Spinning Caddisfly	*Cheumatopsyche flinti*	"a spring"				Resident
Fountain Darter	*Etheostoma fonticola*	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Horseshoe Liptooth	*Polygyra hippocrepis*	Steep, wooded hillsides of Land Park in New Braunfels			NL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Lindheimer's Tickseed	*Desmodium lindheimeri*	Presumably flowers in mid-summer			WL	Resident

Table 5.10-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Peck's Cave Amphipod	*Stygobromus pecki*	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
San Marcos Gambusia (extirpated)	*Gambusia georgei*	Endemic; upper San Marcos River	E	E	E	Resident
San Marcos Saddle-case Caddisfly	*Protoptila arca*	Swift; well-oxygenated warm water 1-2 m deep				Resident
San Marcos Salamander	*Eurycea nana*	Headwaters of the San Marcos River	T	T	T	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Amorpha	*Amorpha roemeriana*				NL	Resident
Texas Blind Salamander	*Eurycea rathbuni*	Troglobitic; Caverns along 6 mile stretch of San Marcos Springs Fault	E	E	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges			NL	Resident
Texas Wild-Rice	*Zizania texana*	Upper 2.5 km of the San Marcos River	E	E	E	Resident
Warnock's Coral Root	*Hexalectris warnockii*	Oak-juniper woodlands in mountain canyons; terraces along creekbeds			NL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL = Potentially Endangered/Threatened
Blank = Rare, but no regulatory listing status NL = Not Listed

not necessarily be encountered within the project area. The TPWD data files show a number of important species within 2 miles of the proposed project site, including Golden-cheeked warbler (*Dendroica chrysoparia*), glass mountains coral-root (*Hexalectris nitida*), Texas amorpha (*Amorpha roemeriana*), Texas Mock-Orange (*Philadelphus texensis*), Dark Noseburn (*Tragia nigricans*), and Texas Salamander (*Eurycea neotenes*). Also found within two miles of the proposed project site is the Ashe juniper-Oak series which is considered important nesting and foraging habitat for the federally and state endangered Golden-cheeked warbler and Black-capped vireo (*Vireo atricapillus*).

There are several species that may inhabit locations within the vicinity of the reservoir. The Blanco River Springs Salamander (*Eurycea pterophila*) resides within the springs and caves of the Blanco River, while the endangered Blanco Blind Salamander (*Eurycea robusta*) hold habitat in the streambed. The Texas Garter Snake (*Thamnophis sirtalis annectens*) is found in bottomlands and pastures, but especially in wet areas. The Texas horned lizard (*Phrynosoma cornutum*) may be present in grassland areas, while the Plains Spotted Skunk (*Spilogale putorius interrupta*) occupies tall grass prairies and wooded, brushy areas. The Spot-tailed Earless Lizard (*Holbrookia lacerata*) may be found in oak-juniper woodlands and locations characterized by mesquite and prickly pear.

A search of the database at the Texas Archeological Research Laboratory (TARL) revealed 27 archeological sites recorded from within the general area of the proposed conservation pool. Prior to inundation, it must be determined if any cultural properties are located within the conservation pool by an on-site survey. Once all cultural properties within the conservation pool are identified, they will undergo preliminary assessment to determine the significance and potential for eligibility in the Register of Historic Places. Because the assessment methods used during the survey are limited in their ability to determine significance potential, some sites may have to undergo more extensive test-level investigations before their eligibility can be adequately determined. If cultural resource properties are determined to be eligible, additional work may be required by the State Historic Preservation Officer to protect the site, or to mitigate for unavoidable impacts. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291).

5.10.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.10-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the BUREC. Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard costing methodology presented in Appendix A.

Table 5.10-3.
Cost Estimate Summary for
Cloptin Crossing Reservoir (G-40)
(Second Quarter 1999 Prices)

Item	***Estimated Cost***
Capital Costs	
Dam and Reservoir[1] (Conservation Pool: 275,000 acft; 6,060 acres; 980.5 ft-msl)	$47,757,000
Total Capital Cost	**$47,757,000**
Engineering, Contingencies and Legal Costs	$16,715,000
Environmental & Archaeology Studies, Mitigation, and Permitting	62,530,000
Land Acquisition and Surveying (7,730 acres)	62,917,000
Interest During Construction (4 years)	30,388,000
Total Project Cost	**$220,307,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$14,641,996
Operation and Maintenance	716,000
Total Annual Cost	**$15,357,996**
Available Project Yield (acft/yr)	**32,458**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$473**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$1.45**

[1] Based on previous cost estimate developed by the U.S. Bureau of Reclamation (USBR), no detailed breakdown of construction costs from the USBR estimate was located. The cost shown here is the USBR estimate (1978) updated to 2nd Quarter 1999 prices.

Costs include land purchased within the spillway design flood pool (elevation 998 ft-msl; 7,730 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $15,094,000. Annual operation and maintenance costs total $716,000. The annual cost, including debt service and operation and maintenance, totals $15,810,000. For an annual firm yield of 32,458 acft, the resulting cost of raw water at the reservoir is $487 per acft (Table 5.10-3). Depending upon the location(s) and type(s) of use for water supplies associated with Cloptin Crossing Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

5.10.5 Implementation Issues

Implementation of Cloptin Crossing Reservoir could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, G-20, G-38C, S-15Db, S-15Dc, S-15E, SCTN-16b, and/or SCTN-16c.

An institutional arrangement is needed to implement projects potentially including financing on a regional basis.

Reservoir Alternative

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.

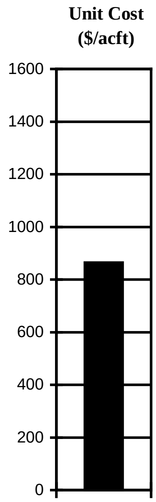
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

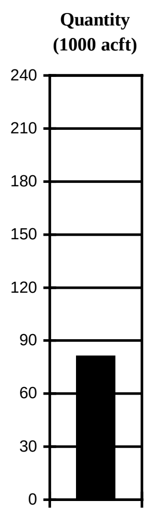
3. Land will need to be acquired through either negotiations or condemnation.

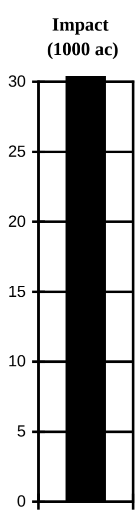
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

5. Other Coordination:
   a. Implementation of this option would require substantial coordination with groups having specific local or regional interests.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET







OPTION NUMBER: **G-17C1**
OPTION NAME: **Sandies Creek Reservoir — Firm Yield**

OPTION DESCRIPTION: *Firm yield of proposed Sandies Creek Reservoir on Sandies Creek, a tributary of the Guadalupe River in DeWitt and Gonzales Counties, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region, via a 64-inch, 73.7-mile long pipeline.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☐ **5-15 yr.** ☒ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$865**	**per acft**[1]
QUANTITY OF WATER:	**80,836**	**acft/yr**[2]
LAND IMPACTED:	**40,288**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**N/A**	**of**	**57**	(1=lowest unit)
QUANTITY OF WATER:	**N/A**	**of**	**57**	(1=highest volume)
LAND IMPACTED:	**N/A**	**of**	**57**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Dam and reservoir, Guadalupe River diversion, pump station and pipeline, reservoir intake and pump station, raw water pipeline and pump station, water treatment plant, finished water pipeline and pump station to municipal distribution system, and mitigation. Unit cost for raw water at the reservoir is $276 per acft.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, instream flow requirements, and level of hydropower subordination.

[3]**LAND IMPACTED:** Size of reservoir site, pipeline right-of-way, water treatment plant, distribution system improvements, and mitigation.

ENVIRONMENTAL ISSUES: Inundation of about 30 miles of Sandies Creek streambed, about 5,383 acres of wooded bottomland, 8,409 acres of brushland in the upland portion of the reservoir site, 904 acres of cropland, 2,600 acres of wetlands, and 9,390 acres of pastureland. Habitat for candidate species for protection, and three cemeteries. Archeological and cultural resource surveys have not been conducted. Streamflow below the dam would be modified, but sufficient flow to maintain bay and estuary sustenance would remain.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from Sandies Creek Reservoir.

5.11 Sandies Creek Reservoir — Firm Yield (G-17C1)

5.11.1 Description of Alternative

Sandies Creek Reservoir is a proposed reservoir located on Sandies Creek, a tributary of the Guadalupe River in DeWitt and Gonzales Counties. The project would impound water from the Sandies Creek watershed as well as water diverted from the Guadalupe River during periods of flow in excess of downstream needs. This reservoir was proposed as a water supply for in-basin needs as part of the Texas Basins Project[1] in the mid-1960s. Subsequent studies of the reservoir were performed,[2] the latest of which is by Espey, Huston & Associates, Inc.[3] in 1986, which provided the siting and basic data used herein. The location of the dam is shown in Figure 5.11-1.

The dam would be an earthfill embankment with a roller-compacted concrete spillway to control the 678 square mile watershed. The dam embankment would extend about 2 miles across the Sandies Creek valley, and provide a conservation storage capacity of 606,280 acft at elevation 232 ft-msl; at full conservation pool the surface area would be 26,875 acres; the spillway design flood elevation would be 240.5 ft-msl, inundating approximately 39,879 acres; and approximately 30 miles of Sandies Creek channel would be permanently inundated by the reservoir. Water supply developed by this project would be transported by a 64-inch diameter, 73.7-mile-long pipeline to the major municipal demand center of the South Central Texas Region.

5.11.2 Water Availability

The firm yield of the proposed Sandies Creek Reservoir was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). The Guadalupe-San Antonio River Basin Model[4] (GSA Model) was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site.

[1] United States Bureau of Reclamation, "Texas Basins Project," February 1965.
[2] Texas Water Development Board, "A Summary of the Preliminary Plan for Proposed Water Resources Development in the Guadalupe River Basin," July 1966.
[3] Espey, Huston & Associates, Inc. (EH&A), “Water Availability Study for the Guadalupe and San Antonio River Basins,” prepared for San Antonio River Authority, Guadalupe-Blanco River Authority, and City of San Antonio, Volumes I and II, EH&A Document No. 85580, February 1986
[4] HDR Engineering, Inc. (HDR), “Guadalupe-San Antonio River Basin Recharge Enhancement Study,” Edwards Underground Water District, September 1993.

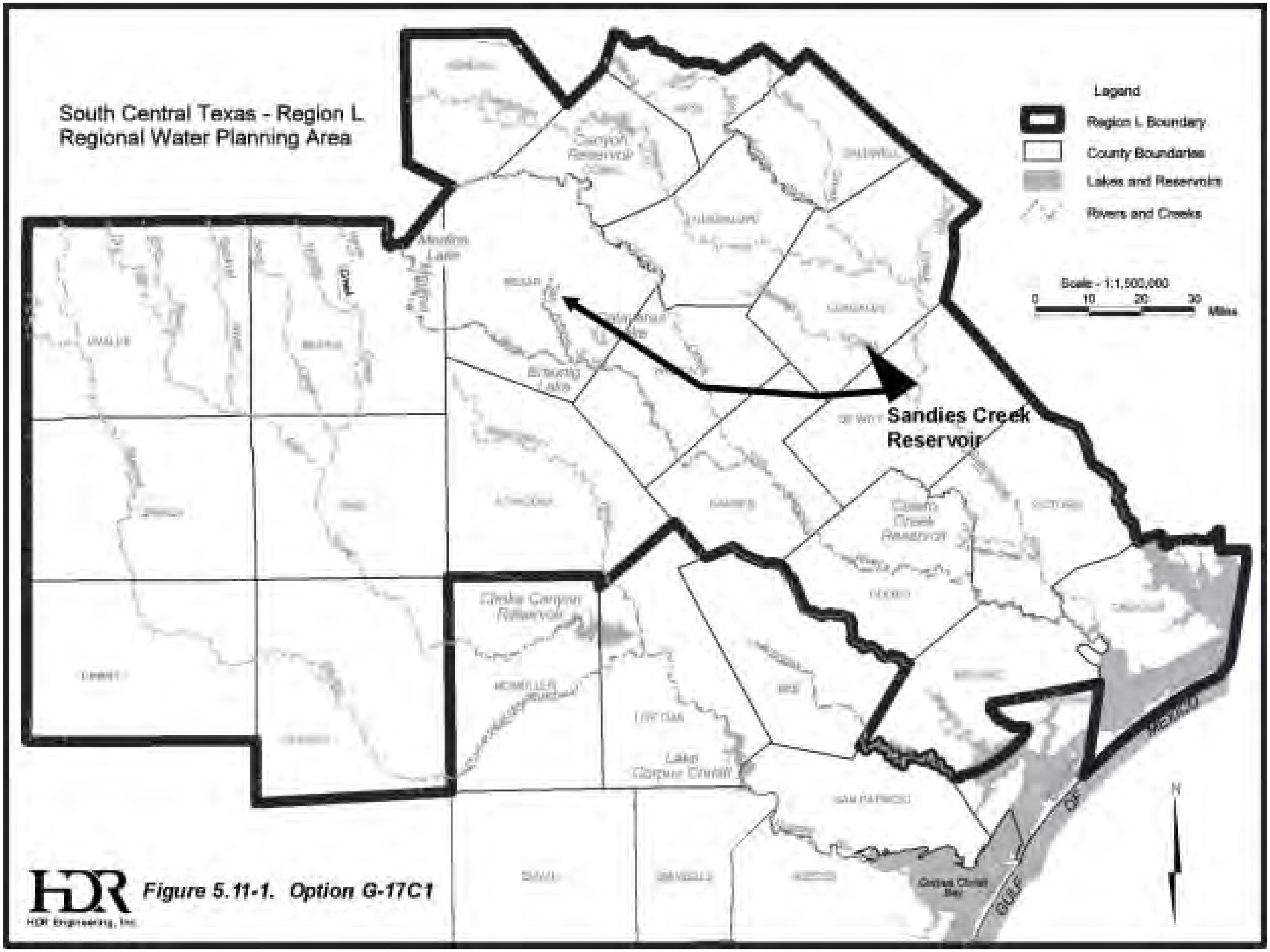


Figure 5.11-1. Option G-17C1

The GSA Model was also used to obtain daily estimates of unappropriated streamflow potentially available for diversion from the Guadalupe River upstream of the Sandies Creek confluence into Sandies Creek Reservoir, assuming full control of the Sandies Creek watershed above the proposed reservoir. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for Sandies Creek near Westhoff (USGS# 08175000) were assumed representative of inflows to Sandies Creek Reservoir. Streamflows for the Guadalupe River at Cuero (USGS# 08175800), less those for Sandies Creek near Westhoff, were assumed representative of flows at the diversion site. These inflows are the naturalized flows from above the reservoir and diversion sites, adjusted for upstream water rights and return flows.

The GSA Model computed the streamflow available for diversion from the Guadalupe River into Sandies Creek Reservoir without causing increased shortages to downstream rights and subject to the Consensus Criteria for direct diversion. In addition, various maximum transmission capacities associated with potential diversion pipeline sizes (48-inch, 72-inch, 96-inch, 120-inch, and parallel 120-inch pipelines) were considered. Figure 5.11-2 presents the mean annual water available from the Guadalupe River for diversion into Sandies Creek Reservoir for each of the maximum diversion rates investigated. The mean annual water availability is constrained substantially by downstream water rights and environmental requirements, particularly as the pipeline diversion capacity increases.

The firm yield of Sandies Creek Reservoir was computed with a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board), using the Sandies Creek inflows and the flows available for diversion from the Guadalupe River. Only inflows from the Sandies Creek watershed were subject to the Consensus Criteria pass-through requirements for Sandies Creek. The streamflow statistics used to determine the Consensus Criteria pass-through requirements for Sandies Creek Reservoir and the Guadalupe River diversion are presented in Tables 5.11-1 and 5.11-2. Subject to a uniform seasonal demand pattern, the firm yield of the project is 80,836 acft/yr. The estimate of the firm yield is considered a reliable water supply based on the 56-year period of historical hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of

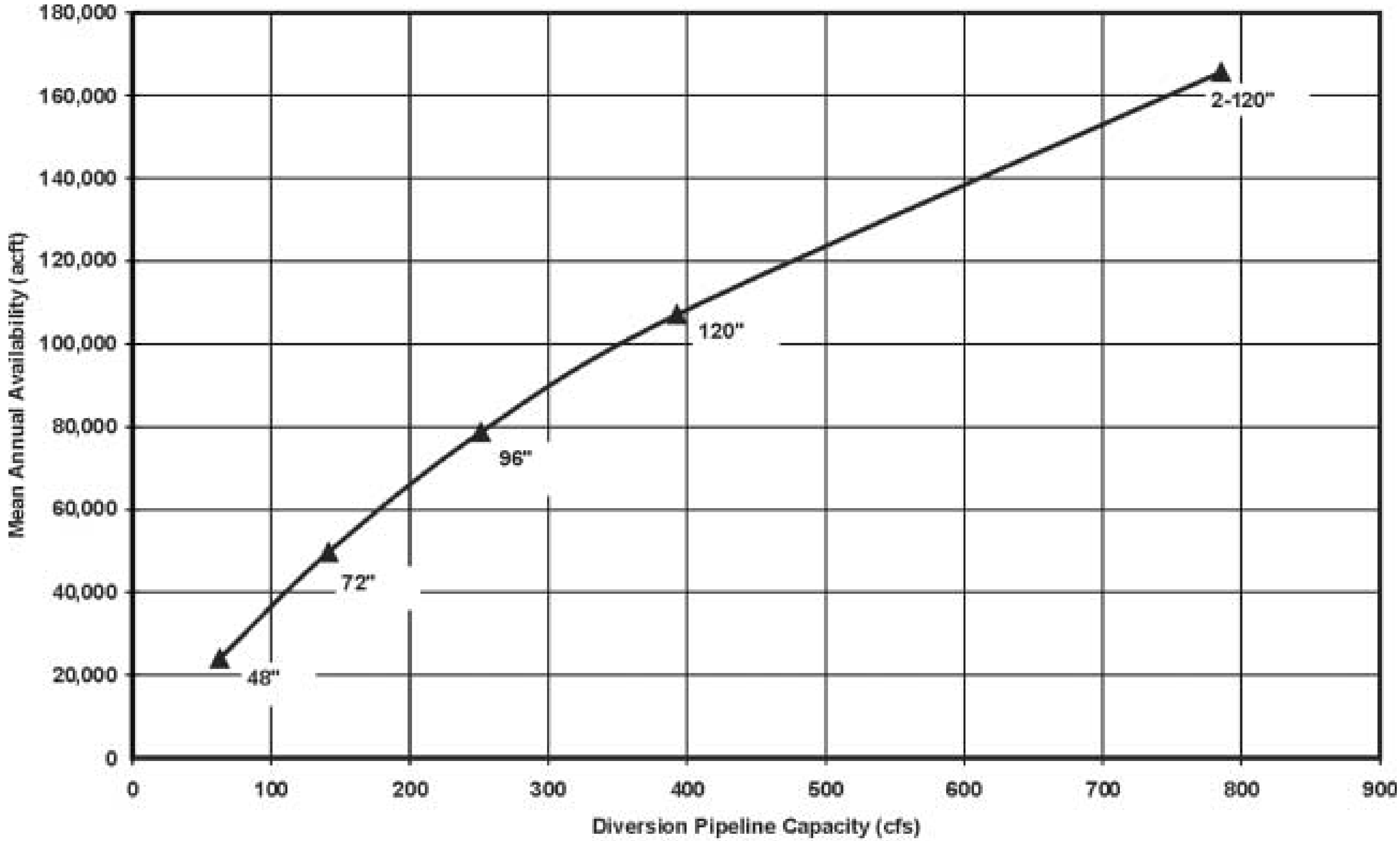


Figure 5.11-2. Water Available for Guadalupe River Diversion into Sandies Creek Reservoir

Table 5.11-1.
Daily Natural Streamflow Statistics for Sandies Creek Reservoir

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	33	21
February	39	22
March	34	21
April	32	16
May	40	15
June	34	14
July	19	6[1]
August	14	2[1]
September	21	8
October	23	10
November	28	14
December	30	18
Zone 3 Pass-Through Requirement[1,2] (acft/day)		7

1 When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
2 HDR Natural 7Q2 (1934 to 1989).

the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows for 1935 and 1936 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield. The firm yield assumes a Zone 3 pass-through requirement (629 acft/day) at the Guadalupe River diversion location based upon maintenance of dissolved oxygen at 5 mg/L, subject to current maximum effluent quantity and constituent concentrations.[5] The TNRCC has established a Water Quality Standard for the stream segment containing the proposed Guadalupe River diversion based on the 7Q2 flow statistic for 1969 to 1989. The firm yield of this project based upon honoring a Zone 3 pass-through requirement of 1,203 acft/day (rather than

5 HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, May 1998.

Table 5.11-2.
Daily Natural Streamflow Statistics
for the Guadalupe River Diversion Point

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	1,872	1,171
February	2,014	1,272
March	2,013	1,227
April	2,067	1,205
May	2,461	1,331
June	2,222	1,198
July	1,676	946
August	1,310	692
September	1,445	835
October	1,662	962
November	1,688	1,063
December	1,748	1,127
Zone 3 Pass-Through Requirement[1,2] (acft/day)		629

[1] Streamflow required for maintenance of dissolved oxygen at 5 mg/L. (HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, March 1998.

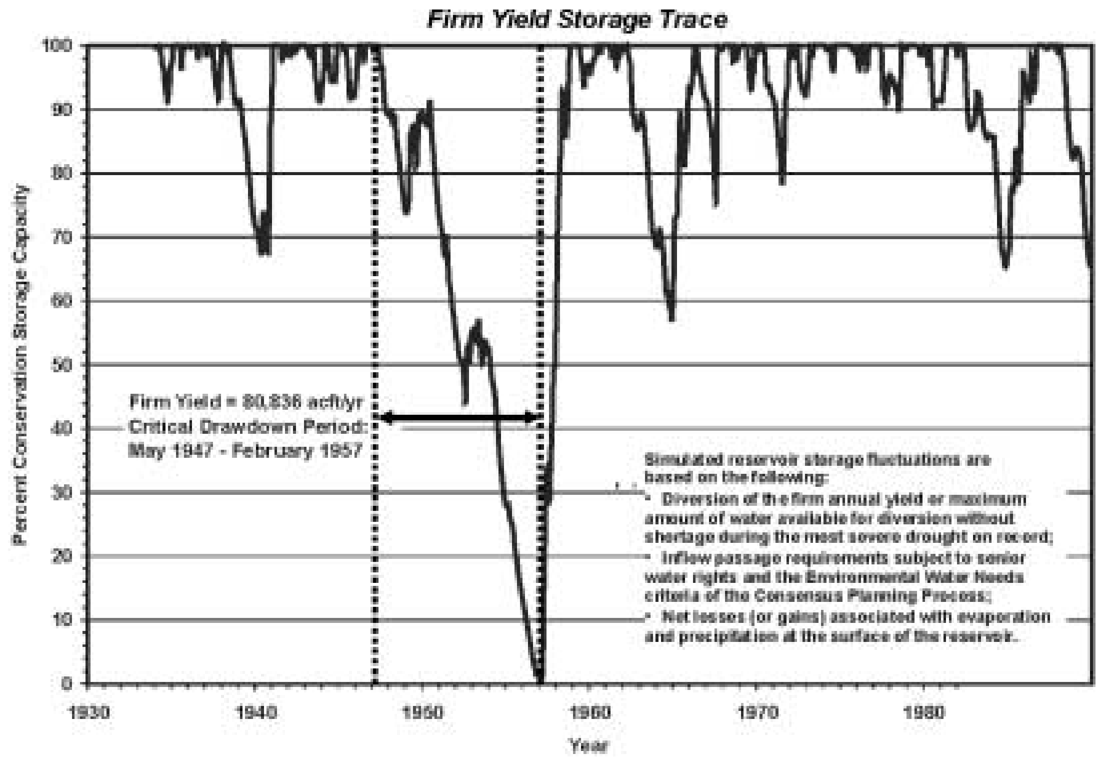
[2] The current TNRCC Water Quality Standard (7Q2) for this segment is 1,203 acft/day.

629 acft/day) at the Guadalupe River diversion location is 69,078 acft/yr, a reduction of more than 14 percent.

The Texas Water Development Board (TWDB) estimated the firm yield of this option to be about 80,000 acft/yr, assuming flows passed through the reservoir for environmental maintenance of 3,175 acft/yr.[6]

Figure 5.11-3 illustrates the simulated Sandies Creek Reservoir storage fluctuations for the 1934-1989 historical period, subject to the firm yield of 80,836 acft/yr based on delivery of Guadalupe River diversions via two parallel 120-inch pipelines. Simulated reservoir contents

[6] TWDB, "Water for Texas, A Consensus-Based Update to the State Water Plan, Volume II, Technical Planning Appendix," Document No. GP-6-2, August 1997.



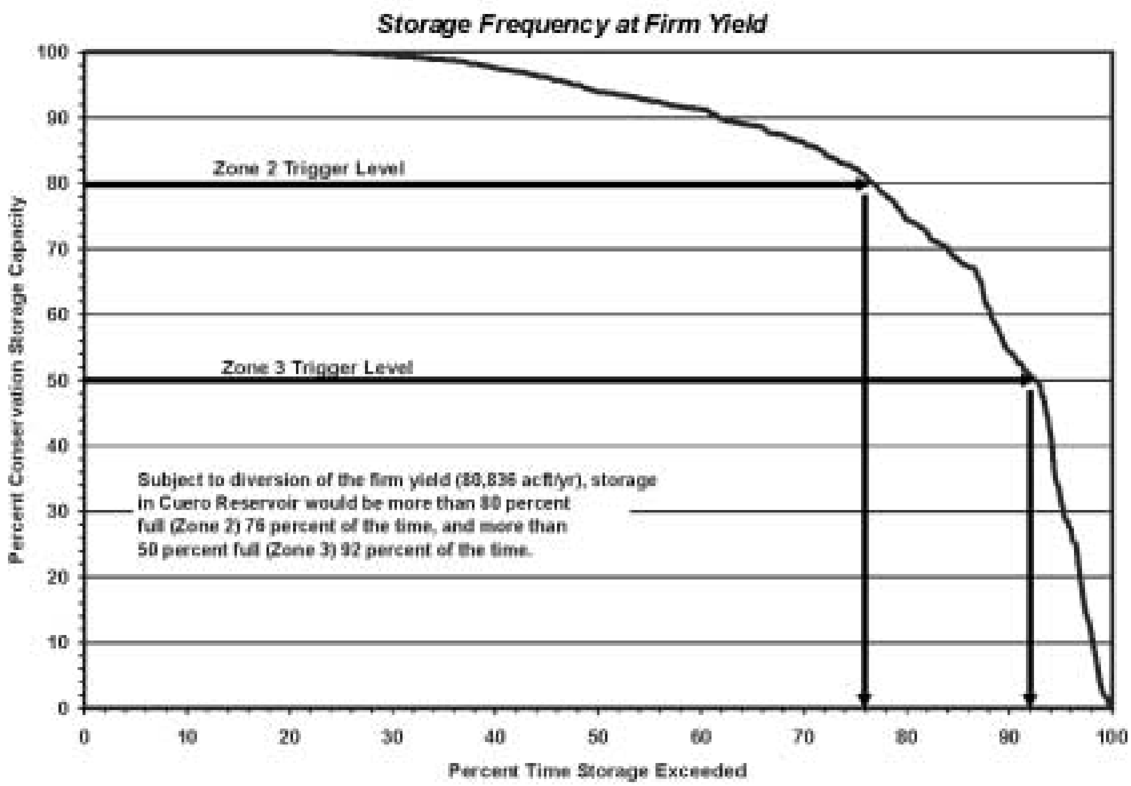


Figure 5.11-3. Sandies Creek Reservoir Storage Considerations

remain above the Zone 2 trigger level (80 percent capacity) about 76 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1934 to 1989 historical period. Figure 5.11-4 illustrates the changes in Guadalupe River streamflow medians and frequencies caused by the project as reflected at the Cuero gage downstream from the confluence of Sandies Creek and at the Guadalupe River Saltwater Barrier. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced about 17 percent.

5.11.3 Environmental Issues.

The Sandies Creek Reservoir project involves dam construction and inundation of approximately 26,875 acres along a 30-mile reach of Sandies Creek, a tributary of the Guadalupe River. The proposed reservoir spans portions of Gonzales and DeWitt Counties. It is located in the Texas Blackland Prairies ecoregion,[7] in the ecotonal region between the Post Oak Savannah and Blackland Prairie vegetational regions,[8] and within the Texan biotic province.[9]

Soils of the Meguin-Trinity association are found within the floodplains. These soils are somewhat poorly drained, calcareous loamy and clayey soils. They are well suited to range, improved pasture and crops. The Sarnosa-Shiner association is found on uplands. These are nearly level, well-drained, moderately permeable, calcareous loamy soils used for range and wildlife, but also suited to pasture.[10]

The upland forest community type comprises approximately 20 percent of the total woodland acreage within the reservoir boundaries. Dominant overstory species within the upland forest community type include post oak, cedar elm, honey mesquite, and live oak. In the understory and shrub layers, honey mesquite, acacias, cedar elm, and prickly pear (*Opuntia* spp.) occur. Grasses and forb species comprise the herbaceous stratum in this community type.[11]

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[7] Omernik, James M., “Ecoregions of the Conterminous United States,” Annals of the Association of American Geographers, 77(1). pp. 118-125, 1986.
[8] Gould, F.W., The Grasses of Texas, Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1975.
[9] Blair, W.F., "The Biotic Provinces of Texas,” Tex. J. Sci. 2:93-117, 1950.
[10] U.S. Department of Agriculture, Soil Conservation Service (SCS), “Soil Survey of DeWitt County, Texas,” in cooperation with the Texas Agricultural Experiment Station, Texas A&M University, College Station, 1978a.
[11] EH&A, Op. Cit., February 1986.

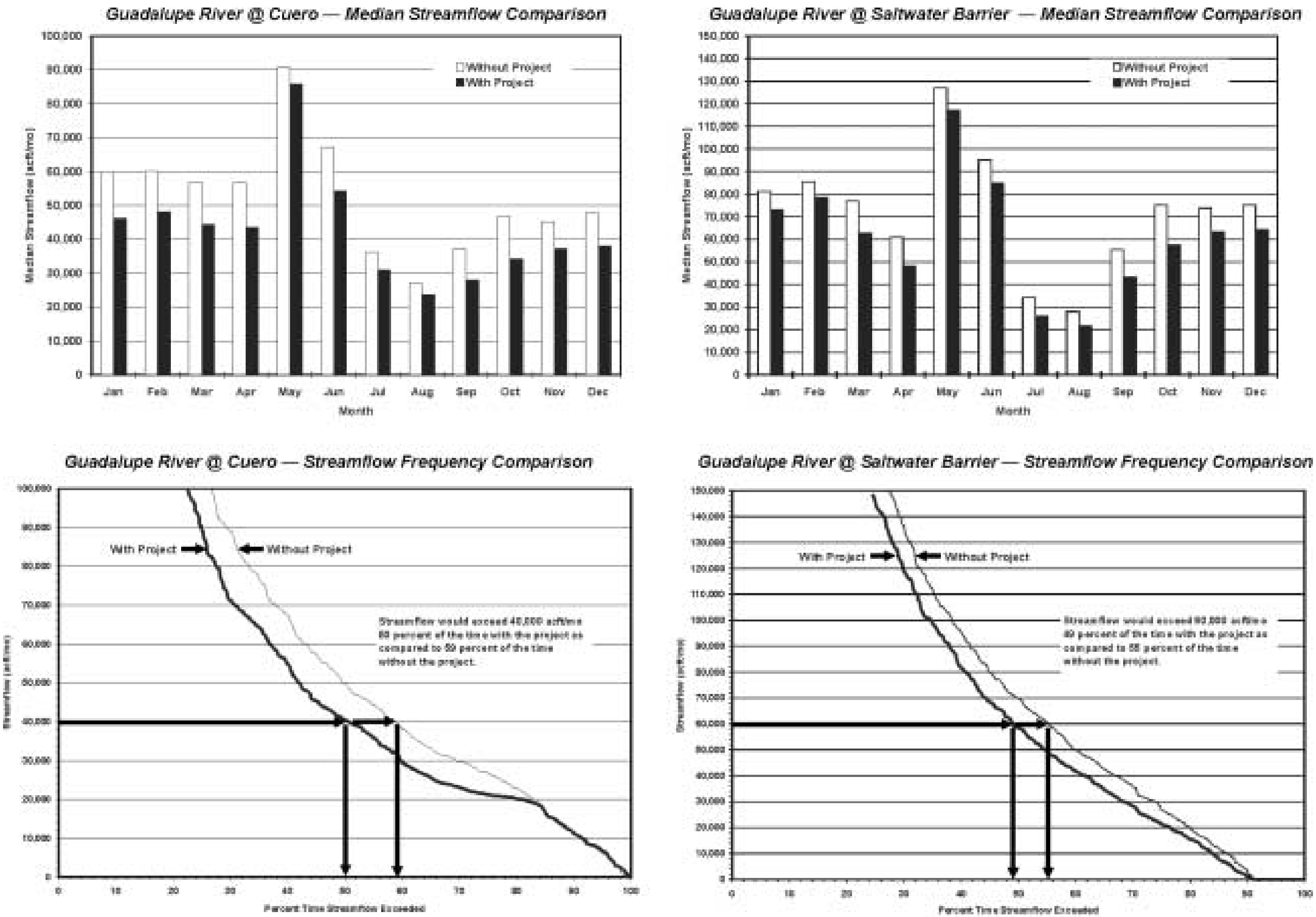

Figure 5.11-4. Sandies Creek Reservoir Streamflow Comparisons

Bottomland and riparian forests comprise approximately 80 percent (about 4,306 acres) of the wooded acreage within the proposed reservoir boundaries. A variety of reptiles, amphibians, mammals, and bird species rely on the bottomland/riparian forests for food and cover.[12]

Brushland, which occupies approximately 8,409 acres, is the dominant community type in the wooded upland portions of the proposed reservoir site, and is also present in some lowland areas. This community type occurs primarily as a result of overgrazing and fire suppression, which have allowed woody species to increase in areas that were formerly covered by grasslands or savannah community types. Brushlands are dominated by low trees and shrubs, with a ground cover of forbs and grasses.[13] The thick nature of the brushland vegetation makes this an excellent nesting habitat for a variety of bird species.

The grassland community types represent approximately 9,390 acres within the reservoir site, and include managed pastures, oilfields, and pipeline, utilities, and transportation rights-of-way. The majority of the grassland within the reservoir site is used as grazing land for livestock.[14] Woody species in the grassland habitats are either sparse or absent. Ground cover is occasionally thick, thus providing good cover for a variety of rodent species that in turn provide food for carnivores, such as the coyote, northern harrier, and common barn owl. A variety of reptiles, mammals, and birds also use grassland habitats for food and cover.[15]

Cropland is limited within the proposed reservoir site, occupying approximately 904 acres and occurring primarily within major floodplains. Principal crops grown in the region include grain sorghum, corn, cotton, wheat, and peanuts.[16]

Wetlands, which occupy approximately 2,789 acres (including 193 acres of riverine habitat) within the Sandies Creek Reservoir site, include riverine habitats; palustrine forested, scrub/shrub, emergent, and open-water wetlands; and limited areas of lacustrine open-water habitat. Forested wetlands (i.e., swamps) are limited to areas within major floodplains.[17]

The project area has a very dendritic creek system. Sandies Creek is the major aquatic habitat in the project area and is smaller than the Guadalupe River. Generally, the channel is no

[12] Ibid.
[13] Ibid.
[14] U.S. Department of Agriculture, Soil Conservation Service (SCS), "Soil Survey of Bandera County, Texas," in cooperation with Texas Agricultural Experiment Station, Texas A&M University, College Station, April 1977.
[15] EH&A, Op. Cit., February 1986.
[16] Ibid.
[17] Ibid.

more than 20 to 25 feet wide. Bank slope is gentler than the Guadalupe River. Vegetation generally reaches to the water's edge, even under low-flow conditions. The channel is more of a shallow V-shape than U-shape. Therefore, as flow increases, the creek quickly widens out. Several of the tributaries of Sandies Creek are perennial, and have marshy areas associated with them. Gravel bars occur in the channels of several tributaries.[18]

Salt flats occur within the Sandies Creek Reservoir site in poorly drained areas with loamy, highly saline sediments. The climax plant community in these areas is an open grassland composed of salt-tolerant herbaceous species. Dominant species include Gulf cordgrass (*Spartina spartinae*), switchgrass (*Panicum virgatum*), seashore saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), bushy sea-oxeye (*Borrichia frutescens*), devilweed aster (*Aster spinosus*), and wild buckwheat (*Eriogonum* sp.). Gulf cordgrass and switchgrass decrease as a result of heavy grazing by livestock and continuous burning, leaving bushy sea-oxeye and devilweed aster as the dominant components of the habitat.[19,20] Portions of the salt flats, which retain water for long periods of time due to low permeability and poor drainage, may be considered wetlands by some definitions.

The primary impacts that would result from construction and operation of the Sandies Creek Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Sandies Creek Reservoir would be permanently inundated to 232 ft-msl with a surface area of 26,875 acres. Approximately 9,390 acres of grassland, 8,409 acres of brushland, 5,383 acres of woodland, 904 acres of cropland, 2,596 acres of wetlands, and 193 acres of riverine habitat would be converted to open water.

Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime below the dam, and reduced freshwater inflows to the Guadalupe Estuary. As a large new

[18]Ibid.
[19] SCS, Op. Cit., 1978a.
[20] Thomas, G.W., "Texas Plants - An Ecological Summary. *In:* F.W. Gould Texas Plants - A Checklist and Ecological Summary," Texas Agricultural Experiment Station, MP-585/Rev., College Station, Texas, 1975.

reservoir without a current operating permit, Sandies Creek Reservoir would likely be required to meet environmental flow requirements determined by a site-specific study.

Subject to the firm yield of 80,836 acft/year, modeling results indicate that the monthly median streamflows on the Guadalupe River below the confluence with Sandies Creek (at Cuero) are reduced throughout the year relative to without project conditions, with the greatest reduction (approximately 14,000 acft/month) occurring during January. Low flows (those exceeded about 85 percent of the time) will be unchanged, largely due to the requirements of the Consensus Criteria.

The criteria for freshwater inflow to bays and estuaries are assumed to be met if the Consensus Criteria are met. The monthly median streamflow at the Guadalupe River Saltwater Barrier would be reduced by a maximum of 24 percent in July and October, with the reduction for other months ranging from 8 to 22 percent. Mean annual flows of the Saltwater Barrier (excluding ungaged runoff below the Saltwater Barrier) are projected to decline from 1,636,545 to 1,504,781 acft/yr (approximately 8 percent). The Texas Parks and Wildlife Department (TPWD) and Texas Water Development Board (TWDB) recently concluded that fisheries harvest for the Guadalupe Estuary is maximized at an annual freshwater inflow of 1,147,350 acft received in a seasonal pattern preferable to selected species of interest.[21]

Plant and animal species listed by the USFWS and TPWD and the Texas Organization for Endangered Species (TOES) as endangered or threatened, and those with candidate status for listing. Those species with potential habitat in the vicinity of the proposed reservoir and pipeline route are listed in Table 5.11-3. The Texas Natural Heritage Program records include reported occurrences of Texas meadow-rue (*Thalictrum texanum*), a USFWS candidate species for protection, in Gonzales County along the Guadalupe River just upstream of the town of Gonzales,[22] which is located near the Sandies Creek reservoir site. Of the species listed in Table 5.11-3, three are river dependent: Cagle's map turtle, blue sucker and the Guadalupe bass. The Cagle's map turtle has been observed within the proposed reservoir area.[23] The following

[21] TWDB, "Texas Bays & Estuaries Program Determination of Freshwater Inflow Needs," Texas Parks & Wildlife Dept., Texas Natural Resource Conservation Commission, September 1998.
[22] Texas Natural Heritage Program (TNHP), Unpublished data from element records, Austin, Texas, 1985 and 1994.
[23] Killebrew, F.C., "Habitat Characteristics and Feeding Ecology of Cagle's Map Turtle (*Graptemys caglei*) Within the Proposed Cuero and Lindenau Reservoir Sites," prepared for Texas Parks and Wildlife Department under interagency contract with the Texas Water Development Board, 15 pp., 1991.

Table 5.11-3. Important Species Known to Occur in the Study Area[1] Sandies Creek Reservoir

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3,4]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils			NL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/ Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident

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Table 5.11-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Meadow-rue	*Thalictrum texanum*	Coastal plains and savannah	C2	NL	WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information WL = Potentially Endangered/Threatened Blank = Rare, but no regulatory listing status
NL = Not Listed

Page 2 of 2

mapped Species of Concern have been reported within the vicinity of the pipeline route: Crown Coreopsis (*Coreopsis nuecensis*), Big Red Sage (*Salvia penstemonoides*), Parks' Jointweed (*Polygonelia parksii*) and Elmendorf's Onion (*Allium elmendorfii*). Two species listed as endangered by TPWD, the Jaguarundi (*Felis yagouaroudi*) and Ocelot (*Felis pardalis*) have been reported in Wilson and Karnes Counties. The Jaguarundi prefers thick brushlands near water. The blue sucker has not been recently reported in the lower Guadalupe River.[24] If the species is present, it would render this reach unsuitable for the construction of an impoundment. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

Although no cultural resource investigations have been conducted in the proposed Sandies Creek Reservoir, eleven sites were recorded adjacent to the upper reaches of Rocky Creek in Gonzales County. Located as a part of the University of Texas San Antonio Conquista Project,[25] all sites were reported as lithic scatter sites. One site revealed two *Angostura* fragments, suggesting a Paleo-Indian occupation. No other diagnostics were recorded.

One hundred eighty-five recorded cultural resources sites within Gonzales County have been listed by the Texas Archeological Research Laboratory. In addition, 258 sites are recorded in DeWitt County. Within the 26,875-acre study area encompassed by the 232 feet elevation of the proposed reservoir, no cultural resources sites have been recorded. The study area has not been subjected to a systematic cultural resources survey. It is probable that, if the area is surveyed, cultural resources sites will be located, some of which may exhibit the criteria necessary for nomination to the National Register of Historic Places (NRHP). A significant portion of the Sandies site is also within the Cuero I Archaeological District, whose boundaries were identified by latitude and longitude coordinates.

The NRHP lists six sites in Gonzales County and four sites in DeWitt County. There are no NRHP sites within the proposed reservoir area. The Guide to Official Texas Historical Markers lists 79 markers within Gonzales County and 64 markers within DeWitt County. One marker (Salt Flats) is located within the Sandies Creek Reservoir area. A second marker, located

[24]Academy of Natural Sciences (ANS), "A Review of Chemical and Biological Studies on the Guadalupe River, Texas," 1949-1989, Report No. 91-9, Acad. Nat. Sci. Phil. Philadelphia, PA., 1991.

[25]McGraw, A. Joachim, "A Preliminary Archaeological Survey for the Conquista Project in Gonzales, Atascosa and Live Oak Counties, Texas," Center for Archaeological Research, the University of Texas at San Antonio, Survey Report 76, 1979.

at 250 ft-msl in elevation, commemorates the town of Westhoff. A single State Historic Inventory Site, the Sandies Creek Bridge, is located within the Sandies study area. In the town of Westhoff, another Historic Inventory site, the First Baptist Church, is located at the 250 ft-msl contour. No previously recorded Historic Architectural Buildings Survey (HABS) structures, State Archeological Landmarks, Registered Log Cabins or Natural Landmarks are located within the proposed reservoir area. At least three cemeteries are located within the study site. Laws have been implemented by the Federal and Texas State governments to protect cemeteries. These resources should either be avoided or dealt with appropriately. Special procedures for handling cemeteries, as outlined in Vernon's Annotated Revised Civil Statutes of the State of Texas (Title 26, Article 912a-10 and 912a-11), will have to be followed for the Sandies Creek Reservoir site.

5.11.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.11-4. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate developed by EHA.[26] Intake, pipeline, pumping station, operation and maintenance, and right-of-way acquisition costs were developed in accordance with the standard costing methodology presented in Appendix A. Land was assumed to be purchased within the 100-year flood pool (elevation 240.5 ft-msl; 39,879 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest for the dam and reservoir; 30 years at 6 percent interest for transmission, treatment, and distribution system improvements) results in an annual expense of $50,226,000. Annual operation and maintenance and energy costs total $19,658,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $69,884,000. For an annual firm yield of 80,836 acft, the resulting annual cost of treated water delivered to the major municipal demand center of the South Central Texas Region is $865 per acft (Table 5.11-4).

5.11.5 Implementation Issues

Implementation of Sandies Creek Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-16C1, G-19, G-20, G-21, G-22, G-30, G-32, G-38C, G-40, S-15Db&c, S-15E, S-16C, SCTN-6, and/or SCTN-16b&c.

[26] EH&A Op. Cit., February 1986.

Table 5.11-4.
Cost Estimate Summary for Sandies Creek Reservoir (G-17C1)
Delivery of Treated Water to Edwards Region Major Municipal Demand Center
Second Quarter 1999 Prices

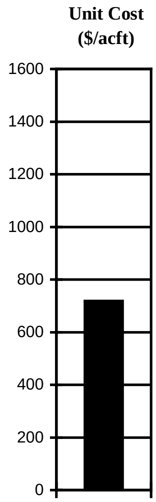
Item	***Estimated Cost***
Capital Costs	
Dam and Reservoir (Conservation Pool: 606,280 acft; 26,875 acres; 232 ft-msl)	$93,407,000
Intake and Pump Station (75.9 MGD)	8,144,000
Water Treatment Plant (75.9 MGD)	50,382,000
Transmission Pump Station(s) (2)	11,478,000
Transmission Pipeline (64-inch dia.; 73.7 miles)	88,112,000
Diversion Facilities (Intake, 510 mgd pump station, two 120-inch dia., 1.48 miles)	22,026,000
Distribution	78,527,000
Total Capital Cost	**$352,076,000**
Engineering, Legal Costs, and Contingencies	$116,739,000
Environmental & Archaeology Studies and Mitigation	70,816,000
Land Acquisition and Surveying (40,288 acres)	79,424,000
Interest During Construction (4 years)	99,050,000
Total Project Cost	**$718,105,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$29,346,000
Debt Service (6 percent for 40 years)	20,880,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	1,495,000
Dam and Reservoir	1,401,000
Water Treatment Plant	6,248,000
Pumping Energy Costs (175,235,321 kWh @ $0.06 per kWh)	10,514,000
Total Annual Cost	**$69,884,000**
Available Project Yield (acft/yr)	80,836
Annual Cost of Water ($ per acft)	$865
Annual Cost of Water ($ per 1,000 gallons)	$2.65

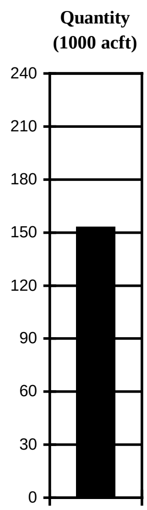
An institutional arrangement is needed to implement this project including financing on a regional basis.

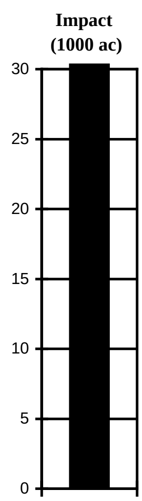
Reservoir Alternative

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads
   b. Other utilities
   c. Structures of historical significance
   d. Cemeteries
5. Other Coordination:
   a. The DeWitt-Gonzales River Association represents organized opposition to consideration of this reservoir option. Implementation of this option would require substantial coordination with this group and/or with others having specific local or regional interests.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET







OPTION NUMBER:
OPTION NAME: Cuero Reservoir — Firm Yield

OPTION DESCRIPTION:

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$718**	**per acft**[1]
QUANTITY OF WATER:	**152,606**	**acft/yr**[2]
LAND IMPACTED:	**44,502**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS				
UNIT COST OF WATER:	**N/A**	**of**	**57**	(1=lowest unit)
QUANTITY OF WATER:	**N/A**	**of**	**57**	(1=highest volume)
LAND IMPACTED:	**N/A**	**of**	**57**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** . Unit cost for raw water at the reservoir is $263 per acft.

[2]**QUANTITY OF WATER:**

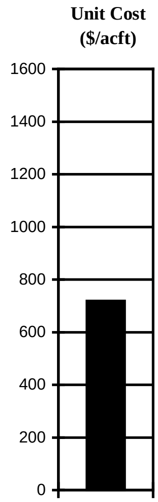
[3]**LAND IMPACTED:**

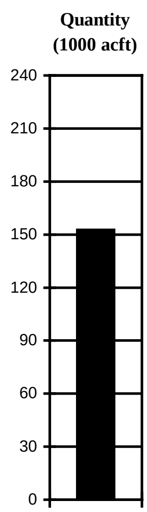
ENVIRONMENTAL ISSUES:

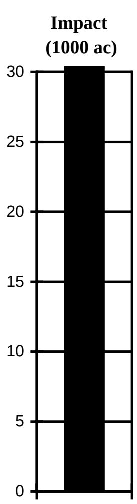
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and economic and social impacts in the local reservoir area.

ADDITIONAL FACTORS:

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET







OPTION NUMBER: G-16C1
OPTION NAME: Cuero Reservoir — Firm Yield

OPTION DESCRIPTION: *Firm yield of proposed Cuero Reservoir on Guadalupe River 4 miles north of Cuero, Texas would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region, via a 90-inch diameter, 79.6-mile pipeline.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$718**	**per acft**[1]
QUANTITY OF WATER:	**152,606**	**acft/yr**[2]
LAND IMPACTED:	**44,502**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**N/A**	**of**	**57**	(1=lowest unit)
QUANTITY OF WATER:	**N/A**	**of**	**57**	(1=highest volume)
LAND IMPACTED:	**N/A**	**of**	**57**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Dam and reservoir, intake and pump station, raw water pipeline and pump station, water treatment plant, finished water pipeline and pump station, and mitigation. Unit cost for raw water at the reservoir is $263 per acft.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, instream flow requirements, and level of hydropower subordination.

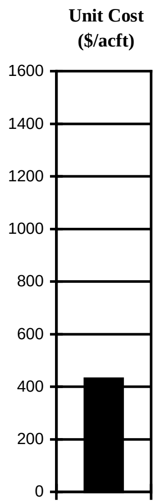
[3]**LAND IMPACTED:** Size of reservoir site, pipeline right-of-way, water treatment plant, and mitigation.

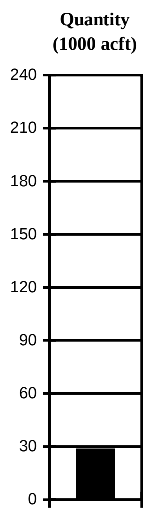
ENVIRONMENTAL ISSUES: Inundation of about 50 miles of Guadalupe River streambed, about 11,000 acres of wooded bottomland, 7,000 acres of brushland in the upland portion of the reservoir site, 6,700 acres of cropland, 2,400 acres of wetlands, and 14,000 acres of pastureland. Habitat for candidate species for protection, location of 82 possible significant historic resources and 257 archeological sites, and 7 cemeteries; streamflow below the dam would be modified, but sufficient flow to maintain bay and estuary sustenance would remain. In 1974, a large part of the site was nominated to the National Register of Historic Places and was accepted for review.

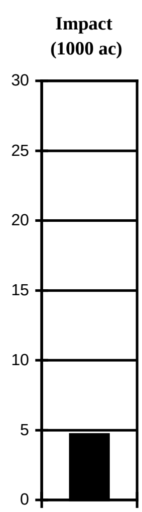
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and economic and social impacts in the local reservoir area.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Cuero Reservoir.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/31/99







OPTION NUMBER: SCTN-13
OPTION NAME: Palmetto Bend Stage II Reservoir

OPTION DESCRIPTION: *Delivery of water available from Palmetto Bend Stage II Reservoir to coastal areas in exchange for irrigation surface water rights now being met from streamflows and storage in the Guadalupe or Colorado Basins or delivery of water available from Stage II to Corpus Christi in exchange for surface water rights owned by Corpus Christi. Stage II Dam and Reservoir site is located in the Lavaca River Basin on the Lavaca River in Jackson County near Edna, Texas. The TWDB and the Lavaca-Navidad River Authority (LNRA) hold a TNRCC Certificate of Adjudication, #16-2096B, for Palmetto Bend Stage II Reservoir.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**431**	**per acft[1] Raw Water Delivered**
QUANTITY OF WATER:	**28,200**	**acft/yr[2]**
LAND IMPACTED:	**4,701**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST: Delivery to Corpus Christi:** $431 per acft represents the cost of delivering the firm yield of Stage II to Corpus Christi, which requires an intake pump station, a transmission line, an outlet structure, and upgrades the existing transmission facilities owned by LNRA and Corpus Christi. **Delivery to the Guadalupe River Basin:** The cost to deliver water to irrigation demands near the Saltwater Barrier is $585 per acft and requires an intake pump station, transmission line, and an outlet structure. **Delivery to the Colorado River Basin:** The cost to deliver water to irrigation demands near Bay City is $560 per acft and requires an intake pump station, transmission line, and an outlet structure.

[2]**QUANTITY OF WATER: Delivery to Corpus Christi:** 28,200 acft/yr represents the firm yield of Stage II if delivered to Corpus Christi. **Delivery to the Guadalupe River Basin:** The firm yield of Stage II delivered to the Saltwater Barrier is 28,100 acft/yr. **Delivery to the Colorado River Basin:** The firm yield of Stage II delivered to Bay City is 30,200 acft/yr.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity and transmission facilities right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation. The amount of land impacted by delivery to the Guadalupe River or Colorado River is 4,891 acres and 4,902 acres, respectively.

ENVIRONMENTAL ISSUES: Impacts of reservoir on downstream streamflows and freshwater inflows to Lavaca Bay. Selection of facility sites and pipeline routes to minimize impacts on endemic species and cultural resources.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Willingness of other parties to exchange Stage II water for their existing surface water rights or supplies.

ADDITIONAL FACTORS: Revision of Certificate of Adjudication #16-2096B to reflect the yields at the alternative site, development of reservoir release schedule for the bay and estuaries, and interbasin transfer authorization.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-14, S-16C, G-16C1, C-17A, C-17B, C-18, SCTN-11, SCTN-14a, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

5.13 Palmetto Bend Stage II Reservoir (SCTN-13)

5.13.1 Description of Option

The Texas Water Development Board (TWDB) and the Lavaca-Navidad River Authority (LNRA) hold a Texas Natural Resource Conservation Commission (TNRCC) Certificate of Adjudication, #16-2096B, for the completion of Palmetto Bend Stage II Dam and Reservoir (Stage II) on the Lavaca River. Stage I, now known as Lake Texana, was completed in 1981 and is located on the Navidad River. Lake Texana is operated by LNRA primarily for water supply purposes and has a firm yield of 79,000 acft/yr. In 1999, facilities were completed to deliver 41,840 acft/yr from Lake Texana to the City of Corpus Christi. Stage II could contribute to the South Central Texas Region water supply in one of the following ways:

- Exchanging Stage II water for coastal area surface water rights and/or options owned by Corpus Christi for Colorado River streamflow that might be diverted at an upstream point near Columbus;
- Exchanging Stage II water for coastal area irrigation surface water rights now being met from streamflow and upstream storage in the Guadalupe River (delivery to the Saltwater Barrier for supplying the Calhoun Canal Division); and
- Exchanging Stage II water for coastal area irrigation surface water rights now being met from streamflow and upstream storage in the Lower Colorado River (delivery to Bay City for local irrigators).

Originally, the U.S. Bureau of Reclamation proposed that Stage II would be located on the Lavaca River and share a common pool with Stage I (Lake Texana). However, recent studies have shown that Stage II could be constructed more economically if operated separately from Lake Texana and located further upstream at an alternative site on the Lavaca River.[1] At the original site with a separate pool from Lake Texana, the Certificate of Adjudication states:

> "Upon completion of the Stage 2 dam and reservoir on the Lavaca River, owner Texas Water Development Board is authorized to use an additional amount of 18,122 acft/yr, for a total of 48,122 acft/yr, of which up to 7,150 acft/yr shall be for municipal purposes, up to 22,850 acft/yr shall be for industrial purposes, and at least 18,122 acft/yr shall be for the maintenance of the Lavaca-Matagorda Bay and Estuary System. The entire Stage 2 appropriation remains subject to release of water for the maintenance of the bay and estuary system until a release schedule is developed pursuant to the provisions of Section 4.B of this certificate of adjudication."[2]

[1] HDR Engineering, Inc., "Regional Water Planning Study Cost Update for Palmetto Bend Stage II and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage II," February 1991.
[2] Texas Natural Resource Conservation Commission (TNRCC) Certificate of Adjudication No. 16-2096B, 1994.

For the purposes of this study, Stage II is assumed to be constructed at the alternative site located approximately 1.4 miles upstream of the original site. Since this site results in a different yield than stated in the certificate, the conditions in the certificate will need to be revised to account for the change in yield of Stage II. The revisions to the certificate should also reflect the impacts that joint operations of Lake Texana and Palmetto Bend Stage II could have on the releases necessary to maintain the bay and estuary system downstream of the projects. Recent studies of the Matagorda Bay[3] indicate the releases made from Lake Texana exceed the mitigation requirements and in some cases enhance the productivity of certain species in the bay and estuary. These results indicate that releases from Stage II for maintaining the bay and estuaries may be less restrictive than those called for in the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). However, in addition to the bay and estuary requirements, releases from Stage II might be required for the 3.5-mile reach of the Lavaca River downstream of the dam site to the confluence with the Navidad River.[4] Therefore, it is assumed that releases from Stage II will be in accordance with the Consensus Criteria for maintenance of the river reach just below the dam.

Figure 5.13-1 shows the location of Stage II and three potential pipelines that could be used to deliver raw water from Stage II. One option delivers water from Stage II to Lake Texana to be pumped to the City of Corpus Christi via LNRA's existing West Water Delivery System and Corpus Christi's Mary Rhodes Memorial Pipeline. The two other potential projects deliver water from Stage II to coastal irrigation areas either near the Colorado River at Bay City or the Guadalupe River near the Saltwater Barrier. Each option will require an intake station at the Stage II reservoir site, a transmission line, and an outlet structure. The Bay City and Saltwater Barrier options include storage at the pipeline outfalls to accommodate seasonal diversion patterns associated with irrigation.

5.13.2 Available Yield

At the alternative site, the reservoir has a drainage area of 830 square miles. Based on the topography of the site, the top of dam was selected at elevation 55 ft-msl and the conservation pool was set at elevation 44 ft-msl. The initial conservation storage capacity of the

[3] Lower Colorado River Authority, "Freshwater Inflow Needs of the Matagorda Bay System," December 1997.
[4] Personal communications with Gary Powell, Texas Water Development Board (TWDB), July 1999.

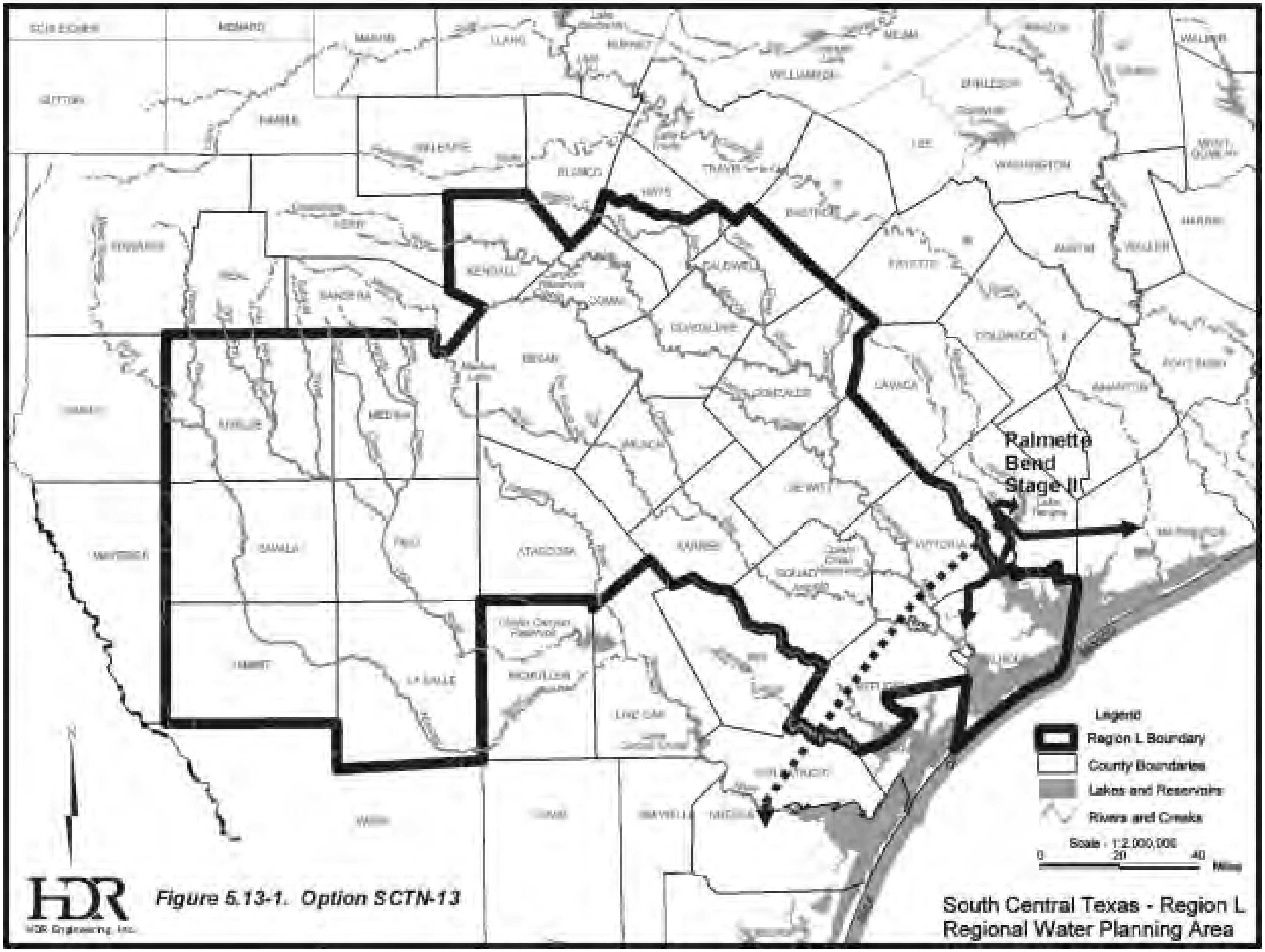


Figure 5.13-1. Option SCTN-13

reservoir would be 57,676 acre-feet (acft), and the reservoir area at elevation 44 ft-msl would be 4,679 acres. The reservoir area at the top of the dam would be approximately 8,200 acres.

The firm yield of Stage II operated separately from Lake Texana was calculated for each of the three potential projects and for a seasonal demand pattern used by the TWDB in determining the yield at the original Stage II site. The yield calculations required development of hydrologic data at the dam site, determination of release requirements in accordance with the Consensus Criteria, determination of seasonal demand factors for the three delivery options, and simulation of the Stage II reservoir operations.

A historical daily flow set for the Lavaca River was developed using naturalized monthly flows adjusted for senior upstream water rights. This monthly flow set was computed by the TNRCC using the Lavaca-Navidad River Basin Model and includes the period from 1940 through 1979. The monthly flows were adjusted using a drainage area ratio method to account for the location of the dam site in relation to the output points in the Lavaca-Navidad River Basin Model. The monthly flows were distributed to a daily time step using the flow pattern recorded at a nearby USGS gage on the Lavaca River near Edna, Texas. Evaporation was calculated utilizing the average of published[5] and supplemental monthly net evaporation rates developed by the TWDB.

The monthly median flows (Zone 1) and 25th percentile flows (Zone 2) used to define the Consensus Criteria release requirements were computed from the monthly naturalized flows from the Lavaca-Navidad River Basin Model distributed to a daily time step. The Zone 3 requirement (7Q2) was taken from TNRCC's published water quality standards.[6] Table 5.13-1 shows the daily release (inflow passage) requirements from Stage II.

Since the potential projects involve different types of usage in different geographic regions, different demand patterns were used for calculating the yield in each option. Table 5.13-2 displays the monthly demand factors used for each delivery point. The first demand pattern in the table reflects the City of Corpus Christi's municipal demand pattern and the second two patterns represent the seasonal irrigation demands at the Guadalupe River Saltwater Barrier and at Bay City, respectively. The fourth demand pattern is the generic seasonal pattern used by the TWDB in their determination of Stage II firm yield.

[5] TWDB, "Monthly Reservoir Evaporation Rates for Texas, 1940 through 1965," Report 64, October 1967.
[6] Texas Administrative Code, Chapter 307, Texas Surface Water Quality Standards.

Table 5.13-1.
Consensus Criteria Release Requirements (cfs) for Palmetto Bend Stage II

	Consensus Criteria Zone		
	1	***2***	***3***
Month	***>80% Capacity***	***<80% to >50% Capacity***	***<50% Capacity***
January	63.0	26.1	21.6
February	92.8	39.0	21.6
March	76.9	37.6	21.6
April	78.9	36.8	21.6
May	92.2	35.4	21.6
June	47.5	22.6	21.6
August	37.3	21.6	21.6
September	41.2	21.6	21.6
October	39.2	21.6	21.6
November	48.3	21.6	21.6
December	55.1	24.3	21.6

Reservoir operations were simulated on a daily basis using the SIMDLY model developed by the TWDB. The yields calculated for each option and the pipeline sizes necessary to deliver the different quantities of water are shown in Table 5.13-2. The yields range from 27,900 acft/yr using the TWDB seasonal demand pattern to 30,200 acft/yr for the Bay City option. Table 5.13-3 shows the Stage II yields if no inflows were passed to the bay and estuaries. The releases made in accordance to the Consensus Criteria reduce the firm yield by an average of 4,100 acft/yr for the four cases analyzed.

Figure 5.13-2 displays the firm yield storage traces for Stage II operating under Consensus Criteria and with Stage II making no releases. Both traces use the TWDB demand pattern and have a critical drawdown occurring from May 1953 to January 1957. The Consensus Criteria operations result in less water being stored in Stage II throughout the period. The firm yield storage traces for the other simulations are not plotted but exhibit similar behavior to that shown in Figure 5.13-2. Storage frequency plots for each of the simulations are shown in Figure 5.13-3. Each plot shows the storage frequency at the firm yield of Stage II under Consensus Criteria operations and storage frequency at the firm yield if no releases are made.

Table 5.13-2.
Firm Yield Estimates for Palmetto Bend Stage II[1]

Month	*To Lake Texana Yield = 28,200 acft/yr*		*To Saltwater Barrier Yield = 28,100 acft/yr*		*To Bay City Yield = 30,200 acft/yr*		*TWDB Yield = 27,900 acft/yr*	
	Municipal Demand Pattern[2]	*Quantity (acft/month)*	*Irrigation Demand Pattern[3]*	*Quantity (acft/month)*	*Irrigation Demand Pattern[4]*	*Quantity (acft/month)*	*TWDB Demand Pattern[5]*	*Quantity (acft/month)*
January	0.072	2,030	0.000	0	0.000	0	0.068	1,897
February	0.066	1,861	0.000	0	0.000	0	0.062	1,730
March	0.081	2,284	0.012	337	0.030	906	0.074	2,065
April	0.084	2,269	0.052	1,461	0.089	2,688	0.079	2,204
May	0.087	2,453	0.135	3,794	0.179	5,406	0.083	2,316
June	0.091	2,566	0.210	5,901	0.224	6,765	0.090	2,511
July	0.103	2,905	0.270	7,587	0.142	4,288	0.113	3,153
August	0.102	2,876	0.129	3,625	0.193	5,829	0.116	3,236
September	0.084	2,369	0.115	3,232	0.130	3,926	0.091	2,539
October	0.081	2,284	0.074	2,079	0.013	3,93	0.084	2,344
November	0.075	2,115	0.003	84	0.000	0	0.070	1,953
December	0.074	2,088	0.000	0	0.000	0	0.070	1,953
—	Pipe Size: 54-inch		Pipe Size: 64-inch		Pipe Size: 64-inch		—	

1 Dam at the alternative site for Stage II with conservation pool at 44 ft-msl.
2 Municipal Demand Pattern for the City of Corpus Christi.
3 Irrigation Demand Pattern for the Lower Guadalupe River.
4 Irrigation Demand Pattern for the Lower Colorado River.
5 Generic Demand Pattern used by TWDB to calculate Stage II firm yield.

Table 5.13-3.
Palmetto Bend Stage II Firm Yields
Consensus Criteria vs. No Releases

Option	Firm Yield (acft/yr)		
	Consensus Criteria	No Releases	Difference
Delivery to Lake Texana	28,200	32,300	4,100
Delivery to the Saltwater Barrier	28,100	32,000	3,900
Delivery to Bay City	30,200	34,700	4,500
TWDB Analysis	27,900	32,000	4,100

The Zone 2 and Zone 3 trigger levels dictated by the Consensus Criteria are shown for reference in each plot. For the simulation using the TWDB demand pattern, Stage II would be more than 80 percent full (Zone 2) about 72 percent of the time and more than 50 percent full (Zone 3) about 92 percent of the time when operated in accordance with the Consensus Criteria. When no releases are made under the same demands, Stage II would be more than 80 percent full about 82 percent of the time and more than 50 percent full about 95 percent of the time.

5.13.3 Environmental Issues (Being Completed by Paul Price)

Environmental issues associated with the construction of Stage II can be categorized as follows:

- Effects of the construction and operation of the reservoir;
- Effects on the Lavaca River downstream from the dam; and
- Effects on Lavaca Bay.

The proposed dam would create a 4,679-acre conservation pool area at 44 ft-msl, inundating about 22 miles of the Lavaca River channel. Although no federal or state protected species are known to be present within the reservoir area, important species may be present in the surrounding areas and are listed in Table 5.13-4. Suitable habitat for protected species may be present at the reservoir site. Several species of migratory birds, marine turtles, and mammals considered by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service to be endangered or threatened are believed to utilize the Lavaca Estuary.

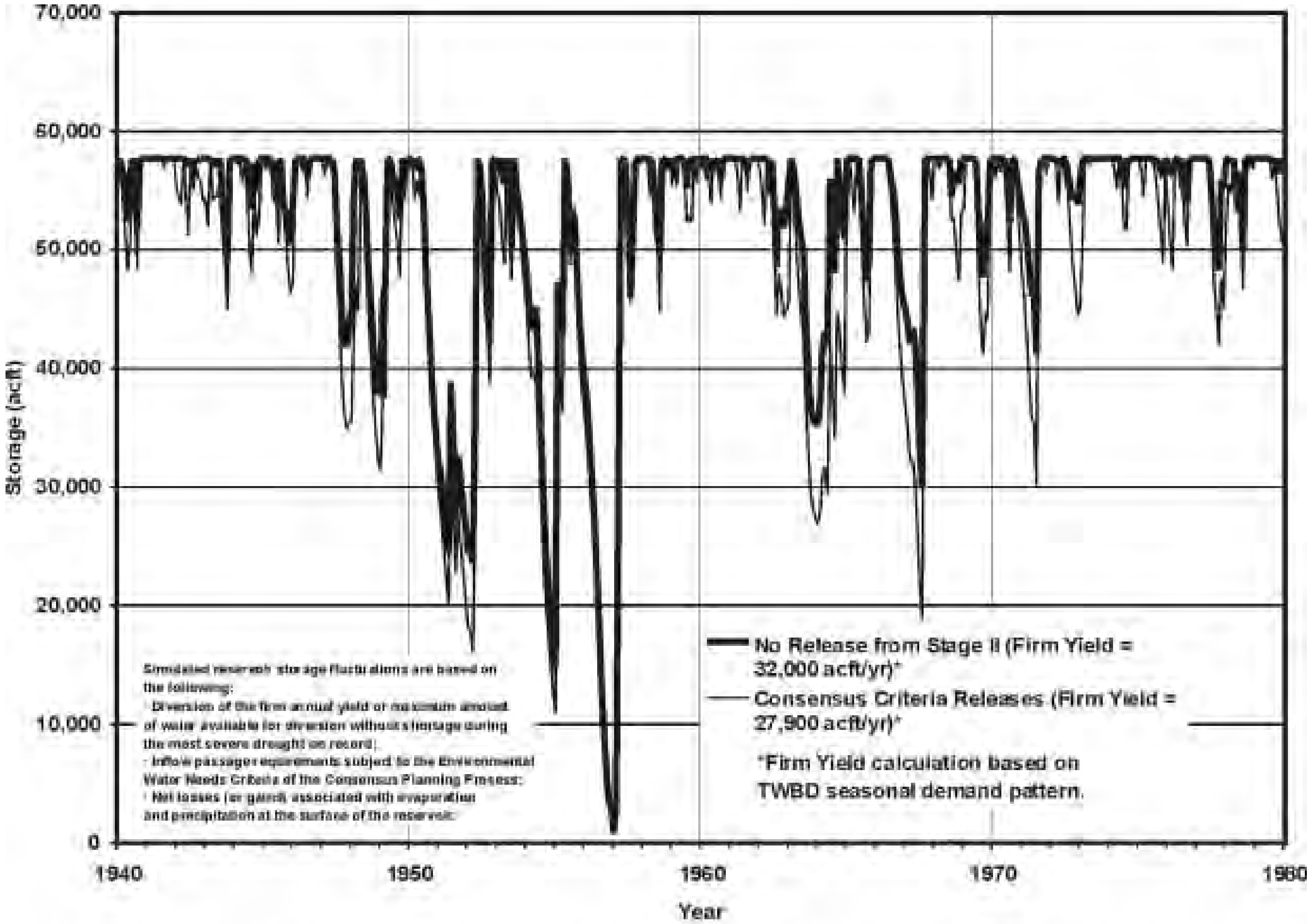


Figure 5.13-2. Palmetto Bend Stage II Reservoir Firm Yield Storage Trace

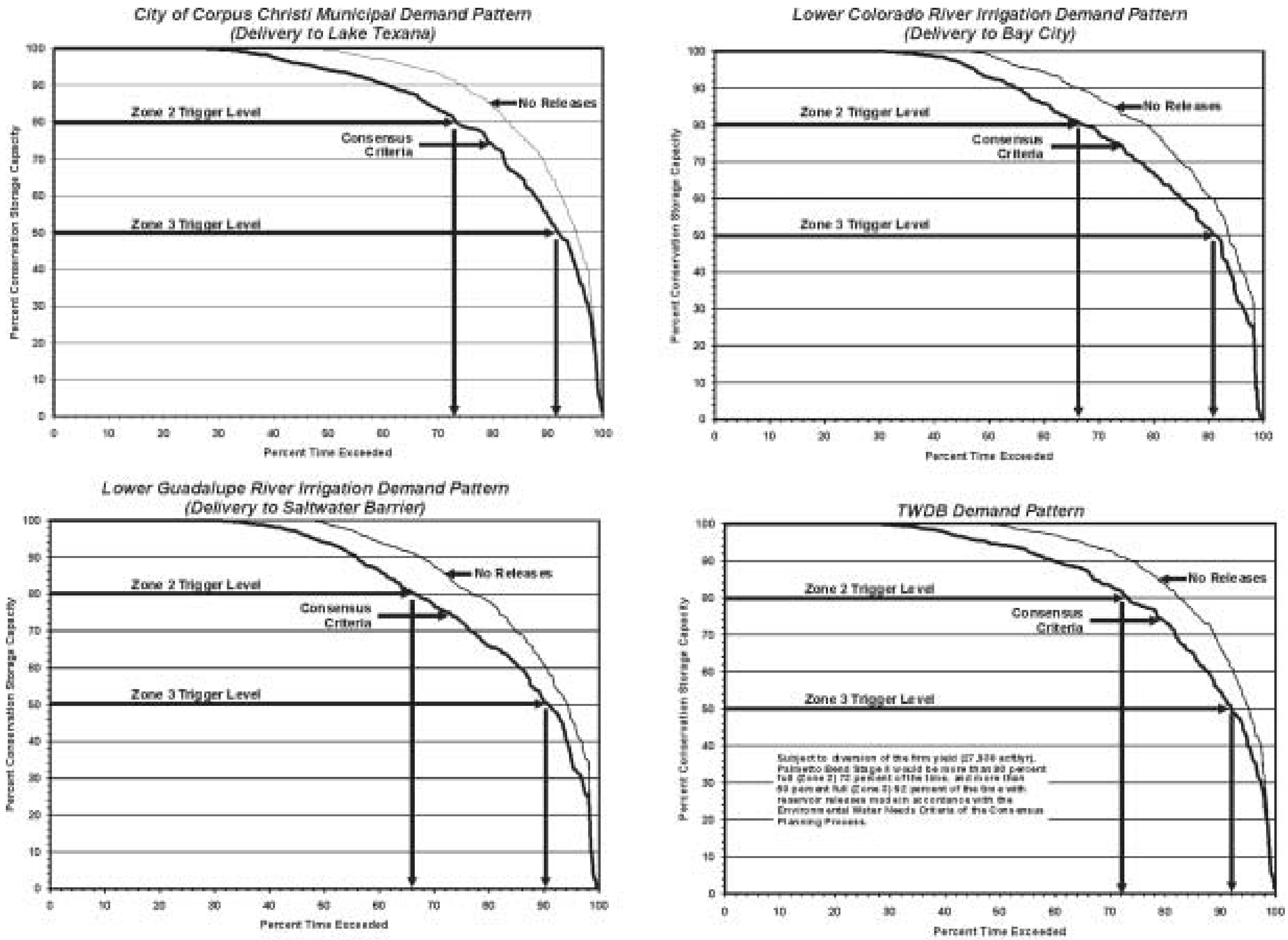


Figure 5.13-3. Palmetto Bend Stage II Reservoir Storage Frequency at Firm Yield

Table 5.13-4.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Palmetto Bend Stage II Reservoir (SCTN-13)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Coastal waters	E	E	E	Resident
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA	T	T	Resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Brown Pelican	*Pelecanus Occidentalis*	Coastal islands; shallow Gulf and bays	E	E	E	Resident
Coastal Gay-feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Resident
Eskimo Curlew	*Numenius borealis*	Coastal prairies	E	E	E	Migrant
Green Sea Turtle	*Chelonia mydas*	Gulf Coast	T	T	T	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T	NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Coastal waters; bays	E	E	E	Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Coastal and offshore waters	E	E	E	Resident
Loggerhead Sea Turtle	*Caretta caretta*	Coastal waters; bays	T	T	T	Resident
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Peregrine Falcon	*Falco peregrinus*	Open country, cliffs, occasionally cities[5]	E/SA	NL	NL	Nesting/Migrant
Piping Plover	*Charadrius melodus*	Beaches, flats	T	T	T	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T	NL	Nesting/Migrant
Scarlet Snake	*Cemophora coccinea*	Sandy soils	NL	T	WL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident

Table 5.13-4 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	Listing Agency: TPWD[1]	Listing Agency: TOES[2,3,4]	Potential Occurrence in County
Snowy Plover	*Charadrius alexandrus*	Beaches, flats, streamsides	NL		NL	Winter resident
Sooty Tern	*Sterna fuscata*	Coastal islands for nesting; deep Gulf for foraging	NL	T	WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin litoralis*	Bays and coastal marshes		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils of remnant coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
West Indian Manatee	*Trichechus manatus*	Warm, vegetated coastal waters	E	E	E	
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. pg. 86.

* E = Endangered T = Threatened C1 = Candidate Category, Substantial Information C2 = Candidate Category
C3 = No Longer a Candidate for Protection PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

The importance of the flow reductions to the bay and estuary system is a complex function of bay physiography (estuarine volume, area/depth ratio, substrate composition, constrictions or compartmentalization), regional climate, and the flushing energy provided by tidal action, the effects of multiple freshwater inflows, and the estuarine population examined. The operating regime for Stage II meets the Consensus Criteria for both streamflow and estuary requirements, based on the results of “Freshwater Inflow Needs of the Matagorda Bay System” (LCRA, 1997). The changes in streamflow in the Lavaca River and the inflows into Lavaca Bay resulting from Stage II operation are shown in Figure 5.13-4. Both plots display the reduction in flows downstream of Stage II when operating in accordance with Consensus Criteria and simulating the TWDB seasonal demands. The top chart shows the monthly median flows in the Lavaca River downstream of Stage II with and without the project, while the bottom plot shows the reduction in combined Lavaca-Navidad River flows into Lavaca Bay, with Lake Texana in full operation, and with or without Stage II.[7]

Freshwater inflows play an important role in determining the distribution and abundance of estuarine populations. Most importantly, inflows interact with the tidal regime to produce a range of salinity gradients that generally exhibit more or less predictable seasonal patters. Freshwater inflows may also be important in transporting sediments that play a role in maintaining tidal marsh elevations against subsidence and erosion, and nutrients that may support high levels of planktonic production and respiration.

Changes in streamflow in the Lavaca River and in the inflows to upper Lavaca Bay resulting from Stage II operating in accordance with the consensus criteria and the TWDB seasonal demand schedule are characterized in Figure 5.13-4. Monthly median flows with and without Stage Ii in place are presented for a location on the Lavaca River below the proposed dam site, and for combined Lavaca-Navidad River inflows to upper Lavaca Bay in the bar graphs on the top of the page. The frequencies of monthly streamflows with and without Stage Ii in operation are shown for the Lavaca River and for combined inflows are shown in the graphs on the bottom of the page.

The Lavaca River is tidally influenced at the proposed dam site; consequently, its biota is variable depending on its recent history of tidal stages and stream discharge, but is typically dominated by a brackish or salt-tolerant fauna. Following completion of the dam for Stage II, a continuous release requirement might prevent the development of adverse salinity and dissolved oxygen conditions below the dam that now accompany episodes of very low flow. Streamflows will tend to be more uniform over time than would be the case without the project, with most of the reduction occurring at flows above the median, while storage is taking place.

The characteristically large runoff events typical of this region have produced sufficient spills and releases from Lake Texana to maintain the Navidad River channel below the dam, and

[7] R.J. Brandes Company, "Analysis of Lavaca Bay Salinity Impacts of a Proposed Release Program from Lake Texana," Texas Parks and Wildlife Department, Austin, TX, November 1990.

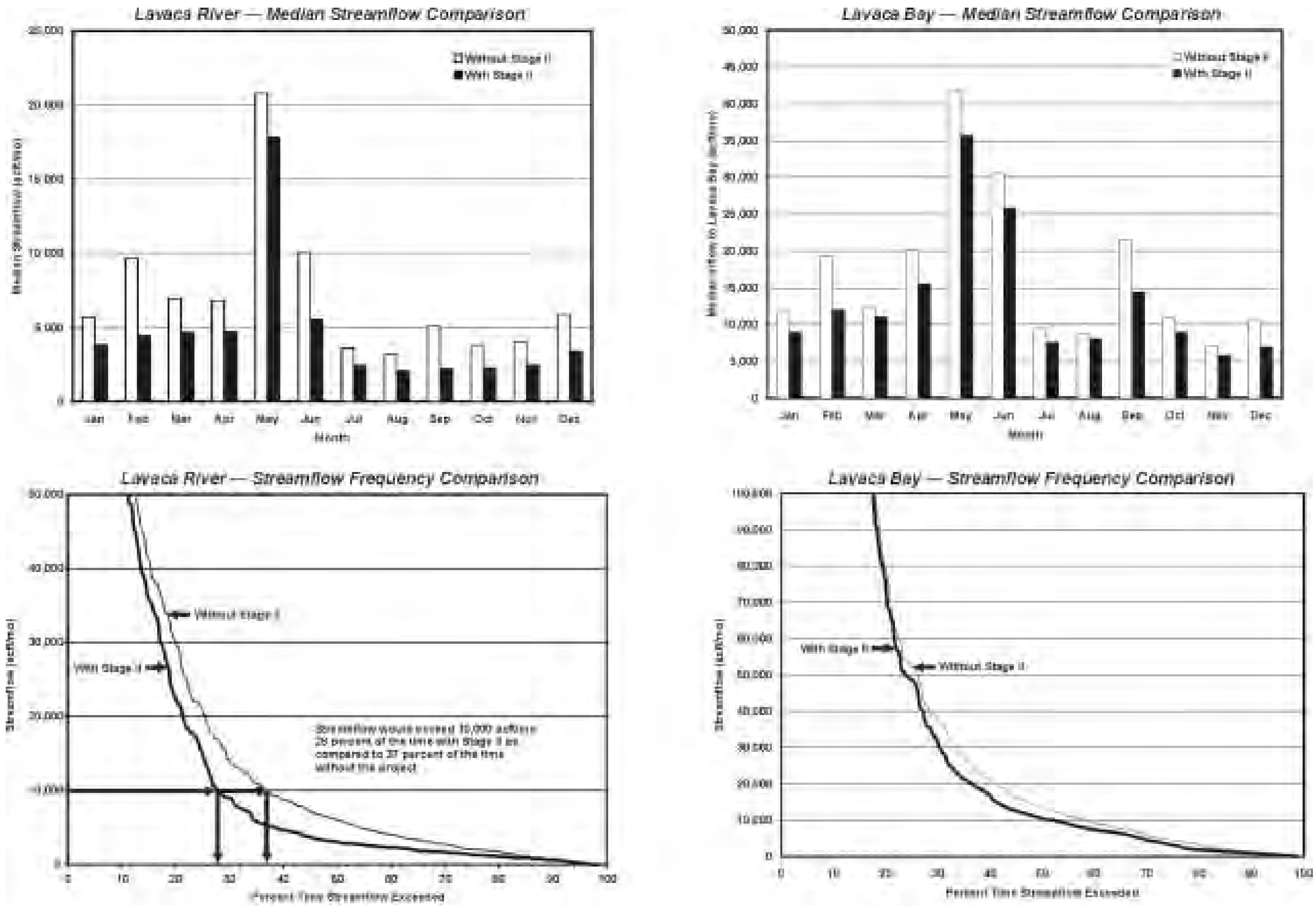


Figure 5.13-4. Palmetto Bend Stage II Reservoir Streamflow Comparisons

Stage II is expected to operate similarly. Migration will be blocked in the Lavaca River as it is in the Navidad River by Stage I, but strongly migratory species do not have any particular community importance in the present river-estuary system, and none are known that would be extirpated by construction of Stage II.

The slight decrease in estuarine inflows associated with implementation of Stage II (Figure 5.13-4) would have no net adverse effect on Lavaca Bay or the larger Matagorda Estuarine System. Inflows from the Lavaca-Navidad and Colorado Rivers, together with inflows from Tres Palacios and Garcitas Creeks and numerous, small local drainages are more than sufficient to maintain historic productivity levels with Stage II in place (LCRA, 1997).

In addition to the Palmetto Bend Stage II Reservoir, Option SCTN-13 includes three alternatives for the diversion of Stage II water. The alternative pipelines would divert water from Palmetto Bend to one of the three following areas: Lake Texana, the Guadalupe River near the Saltwater Barrier, or Bay City in Matagorda County. The reservoir and all three pipeline routes are in the gulf Prairies vegetational area, the Western Gulf Coastal Plan ecoregion, and the Texan biotic province. Post oak savannah and tall grass prairies dominated by oaks, mesquites (*Prosopis glandulosa*), acacias and prickly pears (*Opuntia spp*.) characterize the Gulf Prairies vegetational area. This vegetation is supported by acidic clays and clay loams interspersed by sandy loams.

Plant and animal species listed by TPWD, USFWS, and TOES that may be within the vicinity of the three pipeline routes or the reservoir are listed in Table 5.13-4. The Texas Natural Heritage Program (NHP) maps two plants, the Threeflower Broomweed (*Thurovia triflora*) and Welder Machaeranthera (*Psilactis heterocarpa*), on the pipeline route from Palmetto Bend to the Guadalupe River. The Threeflower Broomweed is found in black clay soils of remnant coastal prairie grasslands, while the Welder Machaeranthera thrives in shrub-invaded grasslands in clay and silt soils. This proposed route also passes through two rookeries, a wildlife management area, and ends near an area where endangered Attwater’s Greater Prairie Chickens have been sighted.

All three pipeline routes pass through or in the vicinity of Bald Eagle (in 1999, downgraded from endangered to threatened status) habitat. The NHP has mapped Bald Eagle habitat on the Guadalupe River near the Saltwater Barrier, which the proposed pipeline to this area would border for approximately 10 miles. A second Bald Eagle habitat, which extends south from Lake Texana along the Lavaca and Navidad Rivers, could be affected by the construction of Palmetto Bend Stage II Reservoir or the proposed pipelines to Lake Texana or Bay City. Bald Eagles usually inhabit areas around large bodies of water with nearby resting sites.

Other protected species that were not mapped in the project area but that could have habitat in the vicinity of the reservoir or one of the three proposed pipelines, include the Black Bear, Jaguarundi, Ocelot, and the Texas Tortoise. The animals depend on brushland and mesquite scrubland habitats in the coastal prairies. The Texas Tortoise occupies shallow depressions at the base of bushes and cacti and underground burrows. Another reptile, the Timber/Canebrake Rattlesnake is usually found in bottomland habitats that support hardwoods.

The White-tailed Hawk (*Buteo albicaudatus*), Interior Least Tern (*Sterna antillarum athalassos*), and Eskimo Curlew (*Numensis borealis*) also inhabit the coastal prairies. The White-tailed Hawk can be found in open prairies and mesquite/oak savannah, while the Interior Least Tern inhabits barren to sparsely vegetated sandbars along river, lake, and reservoir shorelines. The Eskimo Curlew has historically migrated through the coastal prairies in March and April.

Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and vegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

5.13.4 Engineering and Costing

The annual costs associated with constructing Palmetto Bend Stage II Dam and Reservoir at the site 1.4 miles upstream of the original site are shown in Table 5.13-5. With a total project cost of $124,414,000 financed over 40 years at 6 percent, the annual debt service of constructing Stage II is $8,269,000. Annual operation and maintenance costs are estimated at $1,019,000, resulting in a total annual cost of $9,288,000 for constructing and maintaining Stage II. For an

Table 5.13-5.
Cost Estimate Summary for
Palmetto Bend Stage II Dam and Reservoir
Second Quarter 1999 Prices

Item	*Estimated Costs*
Capital Costs	
Dam and Reservoir (Conservation Pool: 57,676 acft; 4,679 acres; 44 ft-msl)	$3,226,000
Mobilization	1,183,000
Care of Water	2,283,000
Spillway	32,428,000
Excess Excavation Disposal Berms & Drainage Channels	5,217,000
Upstream Slope Protection	1,135,000
Underdrain System	583,000
Channel Slope Protection	1,239,000
Revegetation	785,000
Clearing	1,312,000
Relocations	18,014,000
Total Capital Cost	**$67,967,000**
Engineering, Legal Costs, and Contingencies	$23,788,000
Environmental & Archaeological Studies and Mitigation	7,380,000
Land Acquisition and Surveying (8,200 acres)	8,118,000
Interest During Construction (4 years)	17,161,000
Total Project Cost	**$124,414,000**
Annual Costs	
Reservoir Debt Service (6 percent for 40 years)	$8,269,000
Operation and Maintenance	1,019,000
Total Annual Cost	**$9,288,000**
Available Project Yield (acft/yr)	**28,200**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$329**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$1.01**

estimated firm yield of 28,200 acft/yr, the annual cost of raw water at the reservoir would be $329 per acft. The facilities and costs involved with delivering Stage II raw water to the three potential usage locations are discussed below. Each option includes the total annual costs of constructing and maintaining Stage II.

In order to deliver Stage II water to Corpus Christi via the existing transmission facilities from Lake Texana to Corpus Christi, an intake pump station at Stage II, a 4.5-mile transmission line, and an outlet structure would be necessary to transfer water from Stage II to Lake Texana. The capital costs associated with these facilities are shown in Table 5.13-6. The total estimated capital cost of the new facilities is $7,097,000. An additional $1,639,000 of capital would be necessary to upgrade the existing pumping facilities to deliver the additional 28,200 acft/yr. The total project cost with the reservoir is $138,056,000. The annual debt service with the transmissions facilities financed over 30 years at 6 percent interest and the reservoir costs financed at 6 percent over 40 years comes to $9,260,000. The annual costs for operations and maintenance and power are estimated at $2,896,000, which includes $1,764,000 of annual power costs incurred at the existing facilities for delivering the additional water. The total annual cost of constructing Stage II and delivering the firm yield to Corpus Christi is $12,156,000. Dividing annual cost by the firm yield equates to an annual cost of $431 per acft (Table 5.13-6).

If Stage II raw water is delivered to coastal irrigation areas in the lower Guadalupe River, an intake pump station, a 44-mile transmission line, and an outlet structure will be necessary. The total capital costs of the facilities is estimated at $55,265,000. The annual debt service of the new transmission facilities is $6,328,000. The total annual cost, including the reservoir, equals $16,448,000. Dividing the annual cost of the transmission facilities and the reservoir by the firm yield of 28,100 acft/yr results in an annual raw water cost of $585 per acft (Table 5.13-6).

Delivering Stage II raw water to coastal irrigation areas near Bay City will require an intake and pump station, a 46-mile transmission line, and an outlet structure. The total capital cost of the facilities is estimated at $57,404,000. The annual debt service of the transmission facilities is $6,576,000. The total annual cost, including the reservoir, equals $16,910,000. Dividing the annual cost of the transmission facilities and reservoir by the firm yield of 30,200 acft/yr results in an annual raw water cost of $560 per acft (Table 5.13-6).

Table 5.13-6.
Cost Estimate Summary
Palmetto Bend Stage II Dam and Reservoir
Second Quarter 1999 Prices

Item	To Lake Texana	To Saltwater Barrier	To Bay City
Capital Costs			
Dam and Reservoir (Conservation Pool: 57,676 acft; 4,679 acres; 44 ft-msl)	$67,966,000	$67,966,000	$67,966,000
Intake and Pump Station (33 MGD; 85 MGD; 76 MGD)	3,286,000	9,748,000	9,422,000
Outlet Structure	139,000	1,668,000	1,668,000
Transmission Pipeline (54-inch 4.5-mile; 64-inch 44-mile; 64-inch 46-mile)	3,672,000	43,849,000	46,314,000
Improvements to Lake Texana System	1,639,000	0	0
Total Capital Cost	**$76,702,000**	**$123,231,000**	**$125,370,000**
Engineering, Legal Costs, and Contingencies	$26,491,000	$40,368,000	$41,009,000
Environmental & Archaeological Studies and Mitigation	7,493,000	8,528,000	8,585,000
Land Acquisition and Surveying (8,222 acres; 8,412 acres; 8,423 acres)	8,327,000	10,209,000	10,315,000
Interest During Construction (4 years)	19,043,000	29,175,000	29,646,000
Total Project Cost	**$138,056,000**	**$211,511,000**	**$214,925,000**
Annual Costs			
Debt Service (6 percent for 30 years)	$991,000	$6,328,000	$6,576,000
Reservoir Debt Service (6 percent for 40 years)	8,269,000	8,269,000	$8,269,000
Operation and Maintenance			
Intake, Pipeline, Pump Station	113,000	632,000	643,000
Dam and Reservoir	1,019,000	1,019,000	1,019,000
Pumping Energy Costs (294,000 MWh; 3,332 MWh; 4,247 MWh @ $0.06 per kWh)	1,764,000	200,000	403,000
Total Annual Cost	**$12,156,000**	**$16,448,000**	**$16,910,000**
Available Project Yield (acft/yr)	**28,200**	**28,100**	**30,200**
Annual Cost of Water ($ per acft) Raw Water Delivered[1]	**$431**	**$585**	**$560**
Annual Cost of Water ($ per 1,000 gallons) Raw Water Delivered[1]	**$1.32**	**$1.80**	**$1.92**

1 Reported Annual Cost of Water is for raw water delivered to specified location and does not include costs associated with treatment and distribution within municipal systems.

The option to deliver the water to Corpus Christi has a lower annual cost since there are existing facilities in place at Lake Texana that can be upgraded to deliver the Stage II raw water to Corpus Christi. It should be noted that the costs reported in this option only reflect the costs for Stage II and the delivery of raw water to specified locations. They do not include the additional costs necessary to deliver water to the South Central Texas Region in exchange for Stage II water.

5.13.5 Implementation Issues

Implementation of Palmetto Bend Stage Ii Reservoir with potential delivery of raw water to Corpus Christi (via Lake Texana), to the Guadalupe River Saltwater Barrier, or to the Bay city area could directly affect the feasibility of other water supply options under consideration, including L-14, S-16C, G-16C1, C-17A, C-17B, C-18, SCTN-11, SCTN-14a, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

Since the alternative site of Palmetto Bend involves a different yield than that stated in Certificate of Adjudication #16-2095B, the certificate would need to be amended to reflect the yield at the proposed site and release requirements necessary for the bay and estuary system. An interbasin transfer permit from TNRCC will also be required to implement any of the option discussed above.

Requirements Specific to Reservoirs

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits, including interbasin transfer authorization.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. General Land Office (GLO) Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. Texas Parks & Wildlife Dept. (TPWD) Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads.
   b. Petroleum pipelines.
   c. Other utilities.

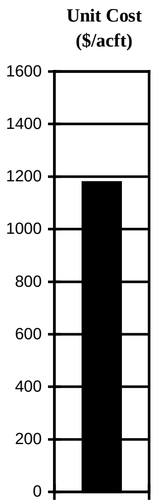
d. Structures of historical significance.

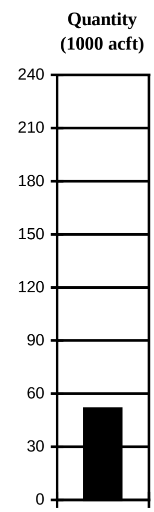
e. Cemeteries.

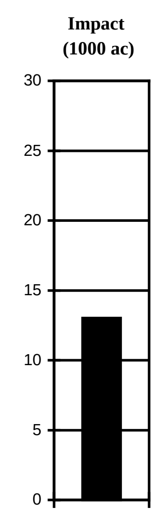
Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft – 12/13/99







OPTION NUMBER: C-18
OPTION NAME: Shaws Bend Reservoir — Firm Yield (Colorado River Basin)

OPTION DESCRIPTION: *The firm yield of the proposed Shaws Bend Reservoir, located 5 miles west of the City of Columbus, Texas, would be diverted through an intake and pumped at a uniform rate through a transmission pipeline to a water treatment plant at the major municipal demand center of the South Central Texas Region and distributed to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$1,178**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**51,576**	**acft/yr[2]**
LAND IMPACTED:	**13,023**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Large mainstem dam on Colorado River, river intake and pump station, 125-mile raw water pipeline and two transmission pump stations, water treatment plant, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** Firm yield of reservoir subject to water rights and environmental flow needs.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, water treatment plant site, and pipeline right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Up to approximately 5,700 acres of hardwood riparian forest and forested wetlands in the reservoir site. Numerous prehistoric and historic cultural resource sites. The Colorado River from Longhorn Dam in Travis County downstream to Matagorda Bay is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, mitigation requirements, and ability to incorporate into a regional plan that realizes economies of size that benefit all of the participants.

ADDITIONAL FACTORS:

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-13C, C-17A, C-17B, SCTN-11, SCTN-12b, and/or SCTN-15.

5.14 Shaws Bend Reservoir (C-18)

5.14.1 Description of Option

This water supply option involves the construction of a major dam and reservoir on the Colorado River between La Grange and Columbus in Fayette and Colorado Counties. This reservoir, known as Shaws Bend Reservoir, was proposed and studied by the U.S. Bureau of Reclamation (USBR), culminating in a 1986 report.[1] The site for the Shaws Bend Reservoir is shown in Figure 5.14-1. As originally proposed by the USBR, the dam would be located approximately 5 miles west of the City of Columbus. An earthfill embankment would form the reservoir and releases would be controlled through a gated spillway. The dam embankment would extend approximately 5,600 feet across the Colorado River valley, with a crest elevation of 241 feet-mean sea level (ft-msl). The reservoir would provide a conservation storage capacity of 132,220 acft at elevation 220 ft-msl and inundate 12,400 acres at this elevation. The reservoir would extend about 34.5 river miles upstream.

5.14.2 Available Yield

The 1986 USBR study found that Shaws Bend Reservoir would have a firm yield of 140,000 acft/yr, assuming that O. H. Ivie (Stacy) Reservoir would be in place upstream, although, at that time, it had not been constructed. However, this estimated firm yield did not consider requirements for instream flows or freshwater flows for the downstream estuary. Determining a new firm yield for this reservoir, subject to the applicable environment flow constraints of the Lower Colorado River Basin, was the major hydrological task for evaluating this water supply option.

There is a specific set of Instream Flow (IF) and Bay and Estuary (B&E) flow requirements for the Lower Colorado River Basin as opposed to the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). The Lower Colorado River Basin basin-specific criteria have been developed by the Lower Colorado River Authority (LCRA) and approved by the Texas Parks and Wildlife Department (TPWD) and the Texas Natural Resources Conservation Commission (TNRCC). While these criteria are specific to the LCRA's water rights, staff at TPWD and the Texas Water Development Board believe that

[1] U.S. Bureau of Reclamation, "Colorado Coastal Plains Project," July 1986, revised August 1986.

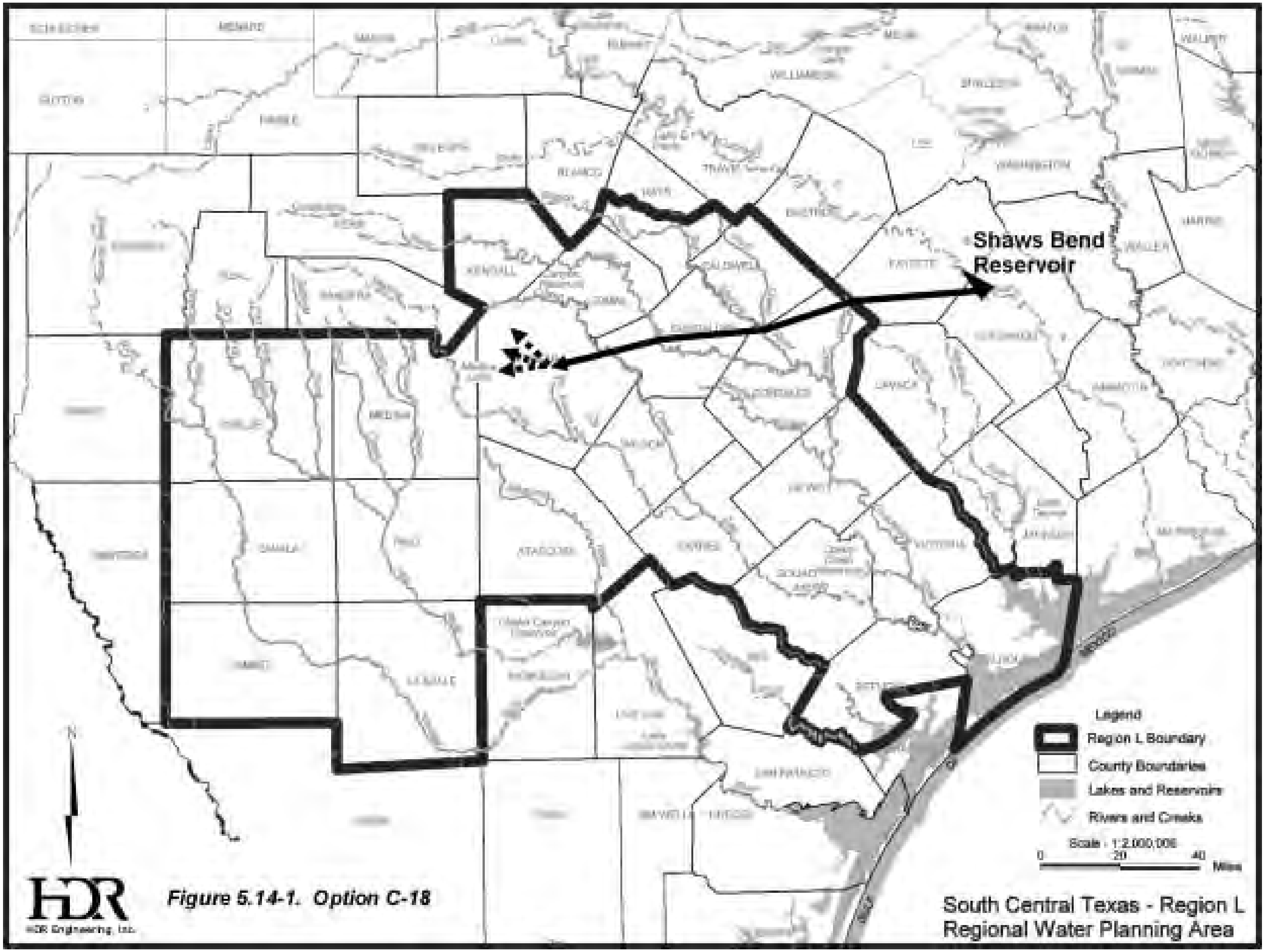


Figure 5.14-1. Option C-18

these criteria are the most applicable for planning a new project on the mainstem of the Colorado River.[2,3]

These Lower Colorado River Basin criteria include separate environmental criteria for instream flows and for bay and estuary flows. Furthermore, each of these sets of criteria are broken into a two-tiered system of "target" and "critical" flows, with the applicable criteria based on the beginning of the year storage in the Highland Lakes System. If stored water is above a certain trigger level at the beginning of the year, then the higher target flows are applicable. Below this trigger level, the lower critical flows are invoked. In either case, the applicable criteria is met "up to the extent of inflows," meaning that a flow up to the magnitude of the inflow to the Highland Lakes System would be passed downstream. The logic of the two-tiered approach to these criteria is similar to that of the general statewide criteria: as conditions become drier there is a "sharing of the adverse impact of drought by humans and the environment." The Lower Colorado River Basin instream flow criteria and bay and estuary flow criteria and the applicable trigger levels are summarized in Table 5.14-1 and Table 5.14-2, respectively.

To determine the unappropriated water in the Lower Colorado River Basin that the Shaws Bend Reservoir would be able to impound, the LCRA's RESPONSE model was utilized. The RESPONSE model determines what portion of the inflows to the Highland Lakes System must be passed to the senior downstream water rights listed in Table 5.14-3. The latest version of the RESPONSE model also will determine if extra inflows must be passed in order to meet the applicable instream flow and bay and estuary environmental criteria shown in Tables 5.14-1 and 5.14-2. In order to make this determination, the model must first determine what portion of the senior water rights demands could be met on a daily basis from run-of-river flows originating in the reaches of the Colorado River below the Highland Lakes.

One of the critical variables of the RESPONSE model is the level of assumed return flows from the City of Austin's wastewater treatment plants. This can be a considerable input volume, especially during the critical drought period, and is important for supplying downstream water rights demands. As a result of the 1987 agreement between the City of Austin and the LCRA, approximately 272,000 acft/yr of the City's Certificate of Adjudication 14-5471 (7 and 8

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[2] Personal communication with Cindy Loeffler of Texas Parks and Wildlife Department, August 9, 1999
[3] Personal communication with Gary Powell, Texas Water Development Board, August 6, 1999

Table 5.14-1.
Instream Flow Requirements for the Lower Colorado River Basin

	Target Flows (cfs)[1]			Subsistence/Critical Flows (cfs)[1]	
Month	**Bastrop**	**Columbus**	**Wharton**	**Austin**	**Bastrop**
January	370	300	240	46[3]	120
February	430	340	280	46[3]	120
March	560	500[2]	360	46[3]	500[4]
April	600	500[2]	390	46[3]	500[4]
May	1,030	820	670	46[3]	500[4]
June	830	660	540	46[3]	120
July	370	300	240	46[3]	120
August	240	200	160	46[3]	120
September	400	320	260	46[3]	120
October	470	380	310	46[3]	120
November	370	290	240	46[3]	120
December	340	270	220	46[3]	120

[1] Target flows apply when the beginning of year storage in the Highland Lakes is greater than 1,100,000 acft; otherwise, subsistence/critical flows apply.

[2] Since target flow at Columbus (based on overall community habitat availability) were insufficient to meet Blue Sucker (*Cycleptus elongatus*) spawning requirements during March and April, target flows were superceded by critical flow recommendations for this reach.

[3] LCRA will maintain a mean daily flow of 100 cfs at the Austin gage at all times, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, until the combined storage of Lakes Buchanan and Travis reaches 1.1 million acft of water. A mean daily flow of 75 cfs, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, will then be maintained until the combined storage of Lakes Buchanan and Travis reaches 1.0 million acft of water, then a subsistence/critical flow of 46 cfs will be maintained at all times, regardless of inflows.

In addition, if the subsistence/critical flow of 46 cfs should occur for an extended period of time, then operational releases will be made by LCRA to temporarily alleviate the subsistence/critical flow conditions. Specifically, should the flow at the Austin gage be below a 65-cfs daily average for a period of 21 consecutive days, LCRA will make operational releases from storage sufficient to maintain daily average flow at the Austin gage of at least 200 cfs for two consecutive days. If this operational release condition persists for three consecutive cycles (69 days), then a minimum average daily flow of at least 75 cfs will be maintained for the next 30 days.

[4] This flow should be maintained for a continuous period of not less than 6 weeks during these months. A flow of 120 cfs will be maintained on all days not within the 6-week period.

Source: LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

Table 5.14-2.
Bay and Estuary Requirements for the Lower Colorado River Basin

Month	Target Needs[1] (acft)	Critical Needs[1] (acft)
January	44,100	14,260
February	45,300	14,260
March	129,100	14,260
April	150,700	14,260
May	162,200	14,260
June	159,300	14,260
July	107,000	14,260
August	59,400	14,260
September	38,800	14,260
October	47,400	14,260
November	44,400	14,260
December	45,200	14,260
Total	1,033,100[2]	171,100

Note: Total commitments of the Combined Firm Yield from the Highland Lakes for bays and estuaries (estuarine inflows) will be an average of 3,090 acft/yr, with a maximum of 11,200 acft in any one year; 19,700 acft in any two consecutive years; 24,200 acft in any three or four consecutive years; 28,200 acft in any five consecutive years; and 30,900 acft in any six to ten consecutive years.

[1] Target needs apply when beginning of year storage in the Highland Lakes is above 1,700,000 acft; otherwise, critical needs apply.

[2] The sum of the monthly target needs is 1,032,900 acft. The slight difference from the published total value is presumably due to rounding.

Source: LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

in Table 5.14-3) is backed up by stored water in the Highland Lakes. Recent estimates of Austin's return flow percentages are in the range of 55 percent. In this analysis, it was assumed that this would be reduced to 44 percent, a 20 percent reduction in return flow due to reuse initiatives. This gives a future volume of 120,000 acft/yr at that point in time when the full 272,000 acft is utilized.

Table 5.14-3.
Summary of the Senior Water Rights in the Lower Colorado River Basin

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal
3	LCRA - Gulf Coast	14-5476	12/01/1900	228,570	Irrigation
4	LCRA - Lakeside	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403[2]	Municipal
9	City of Austin	14-5489	1945, 1965	36,456[3]	Municipal
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] These three water rights held by LCRA are subordinated to the 250,000 acft of the City of Austin's water right (no. 7).
[2] 22,403 acft/yr of this right are for municipal use, the balance is for steam-electric.
[3] These water rights are for steam-electric generation and cooling.

The REPONSE model was executed with all of the senior water rights in Table 5.14-3 attempting to divert their maximum permit amount each year. The environmental criteria of Table 5.14-1 and Table 5.14-2 were also utilized. The RESPONSE model first determines what portion of the water rights' demands are met on a daily basis. If these rights are not met, then inflows to the Highland Lakes are passed up to the amount necessary to satisfy the senior water rights. After this, the RESPONSE model checks to see if the applicable instream flow criteria of Table 5.14-1 are being met with the run-of-river flows below the lakes plus the Highland Lakes inflows passed thus far. If not, then additional Highland Lakes inflows are passed to attempt to satisfy the criteria. After this procedure is completed for a month, the model confirms that the sum of the daily flows that would have exited the river beyond the lowest gage at Bay City would meet the applicable bay and estuary criteria of Table 5.14-2. If not, then additional inflows may be passed to meet these criteria, but only subject to the multiple year constraints noted at the bottom of Table 5.14-2.

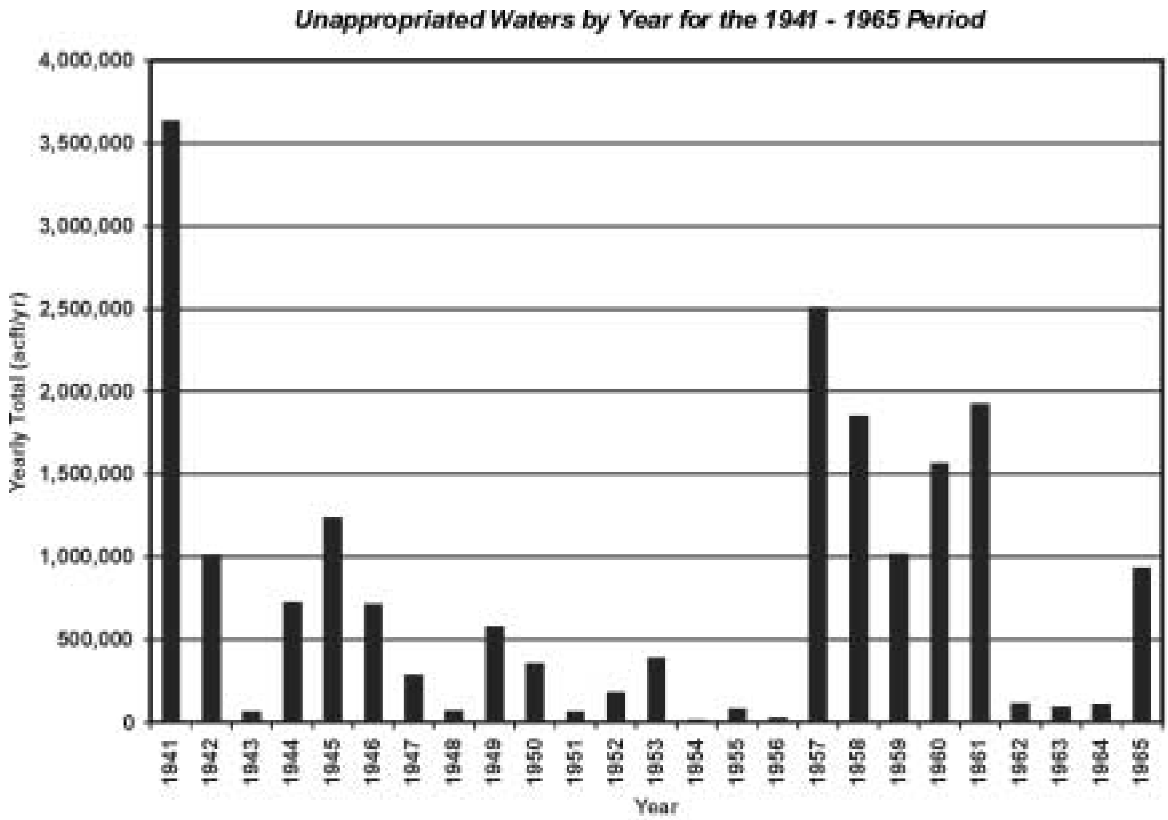
For this water supply option, the unappropriated water in the Lower Colorado River Basin was determined by utilizing the final predicted gage flows at Columbus from the REPONSE model which are given on a daily basis. Unappropriated water was determined subject to three constraints. The first criterion was that for any given day, the bay and estuary flows were met for the month containing that day. Next all senior water rights demands must have been met for that day, and finally, the instream flow needs were being met. Only the amount of water over and above that needed for senior water rights below Columbus and the instream flows at Columbus or Wharton was deemed unappropriated.

The upper panel of Figure 5.14-2 shows the total unappropriated flows on an annual basis for the 1941 to 1965 period. The large annual values such as those of 1941 or 1957, represent years in which large flood flow events occurred. The lower panel of Figure 5.14-2 shows the unappropriated water on an average monthly basis. Generally, there is little water available during the summer months due to the correspondence of low flows and high demands by the senior irrigation water rights (Table 5.14-3).[4] During 9 years of extended drought (1947 to 1956), no water would be available in the months of July or August. For the 1941 to 1965 period of record the July and August average unappropriated flows would be 23,444 acft/month and 744 acft/month, respectively. The winter months are much better on average, but even these months have much less water available during the critical drought period.

With the available water from the Colorado River quantified, subject to the senior water rights and applicable instream flow and bay and estuary criteria, it was then possible to make a new determination of the firm yield of the Shaws Bend Reservoir. This firm yield was computed with a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The reservoir was assumed full at the start of the SIMDLY simulation. It was assumed that water would be withdrawn from the reservoir with a uniform demand pattern. Under these assumptions, the firm yield to the Shaws Bend Reservoir was determined to be 51,576 acft/yr., which represents a reliable supply based on the 1941 through 1965 period of historical hydrologic record.

The upper panel of Figure 5.14-3 illustrates the simulated reservoir storage fluctuations for Shaws Bend Reservoir for the 1941 to 1965 historical period subject to diversion of the firm

[4] There is a strong seasonal concentration of the irrigation demand pattern during the late spring through summer period (May 15 to September 15), when 75 percent of the total irrigation demand is exercised.



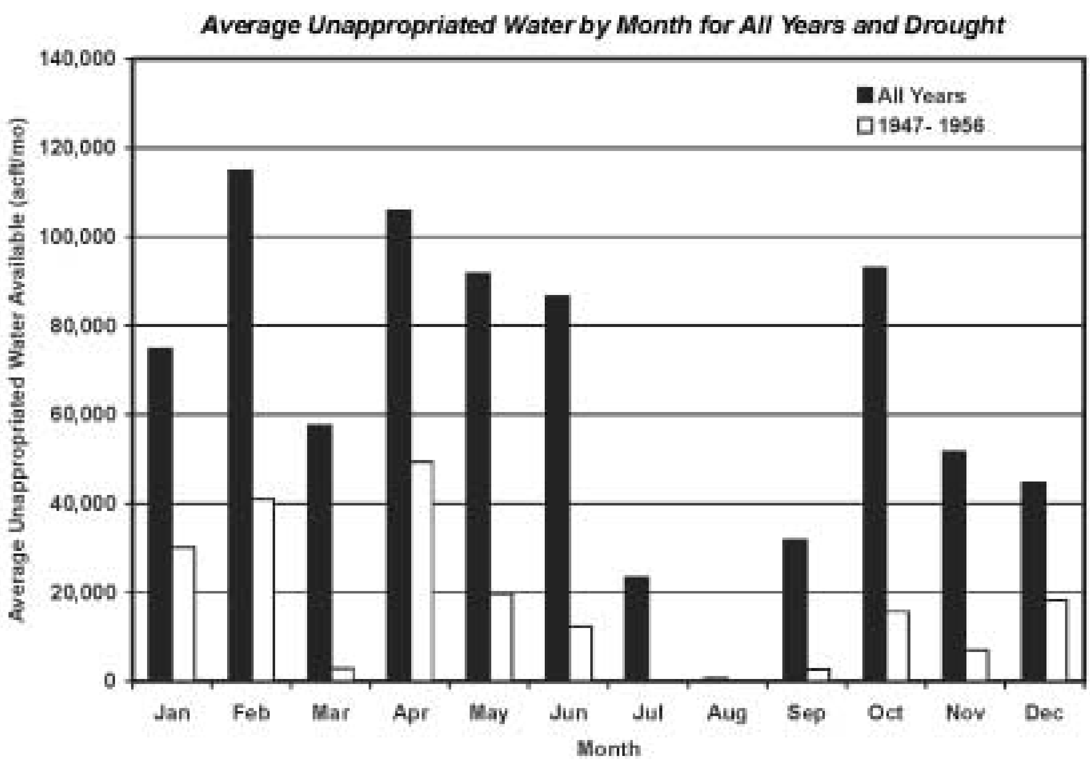
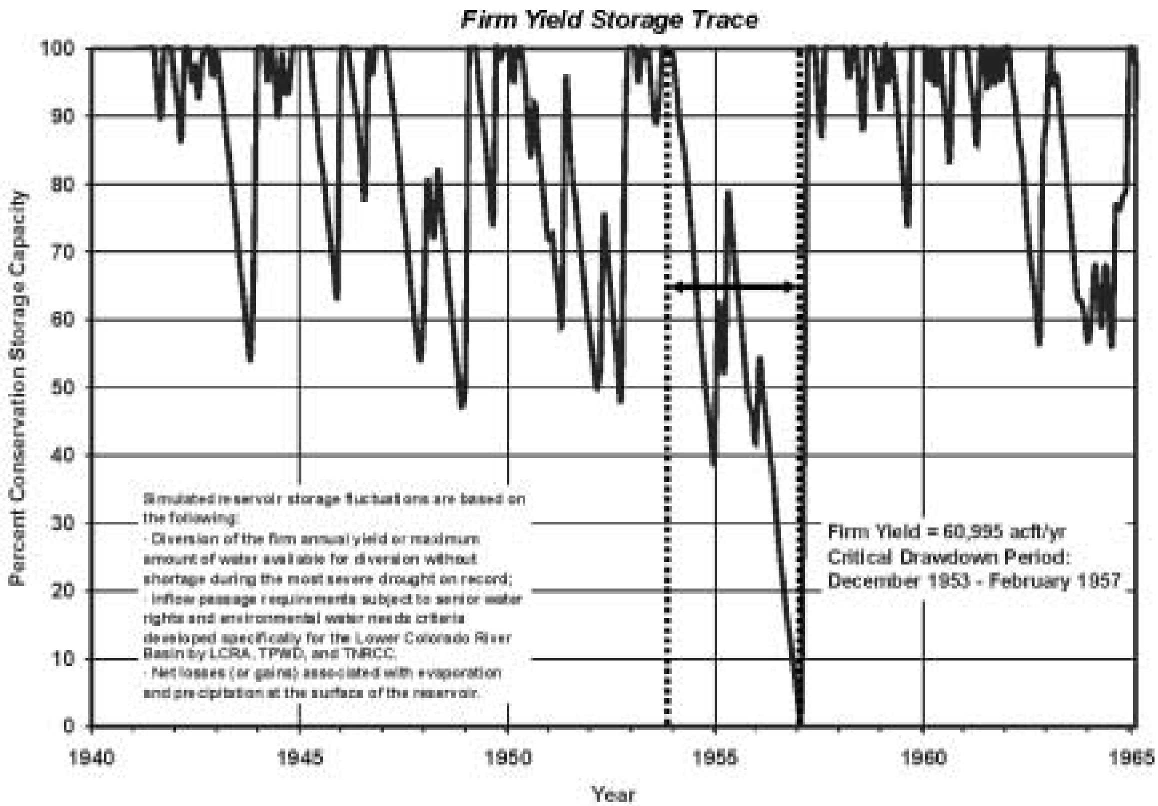


Figure 5.14-2. Availability of Unappropriated Waters of the Colorado River at Columbus



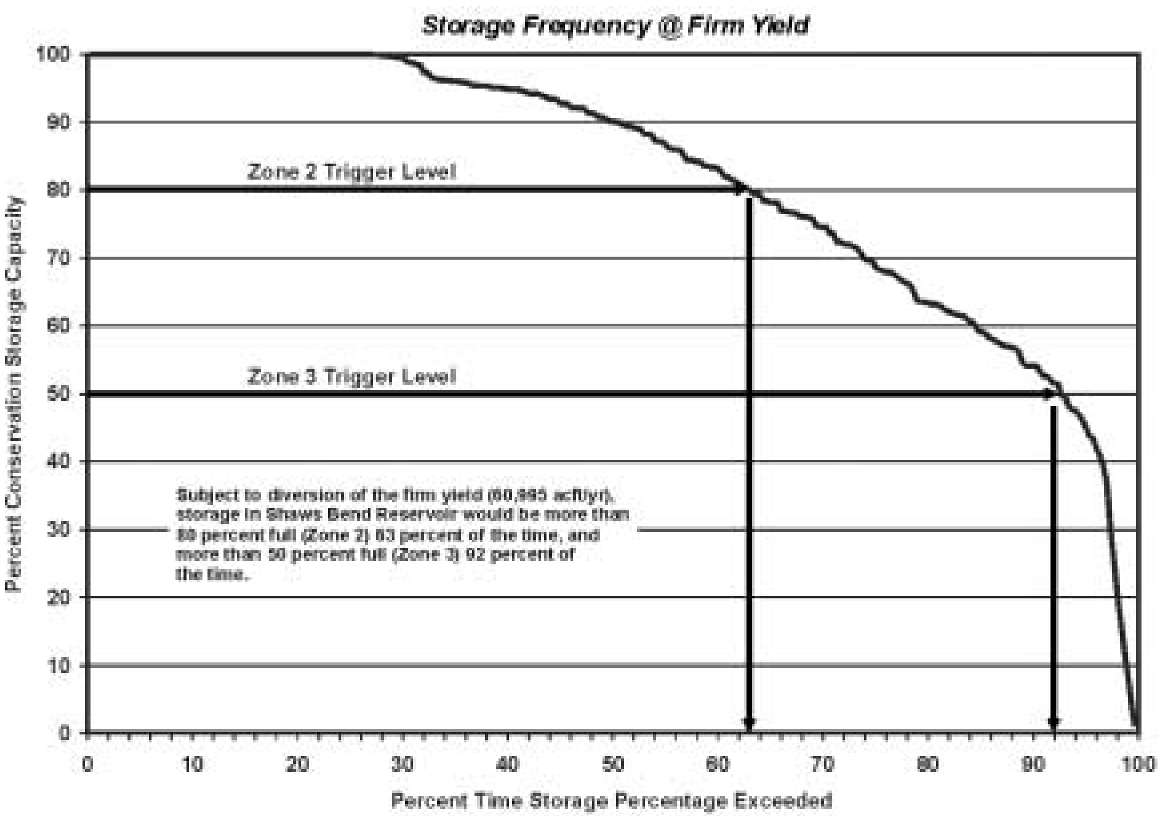


Figure 5.14-3. Shaws Bend Reservoir Storage Considerations

yield. The lower panel of Figure 5.14-3 illustrates storage behavior of the reservoir in a storage-frequency curve. Reservoir contents remain above the Zone 2 trigger level[5] (80 percent capacity) about 62 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1941 to 1965 simulation period.

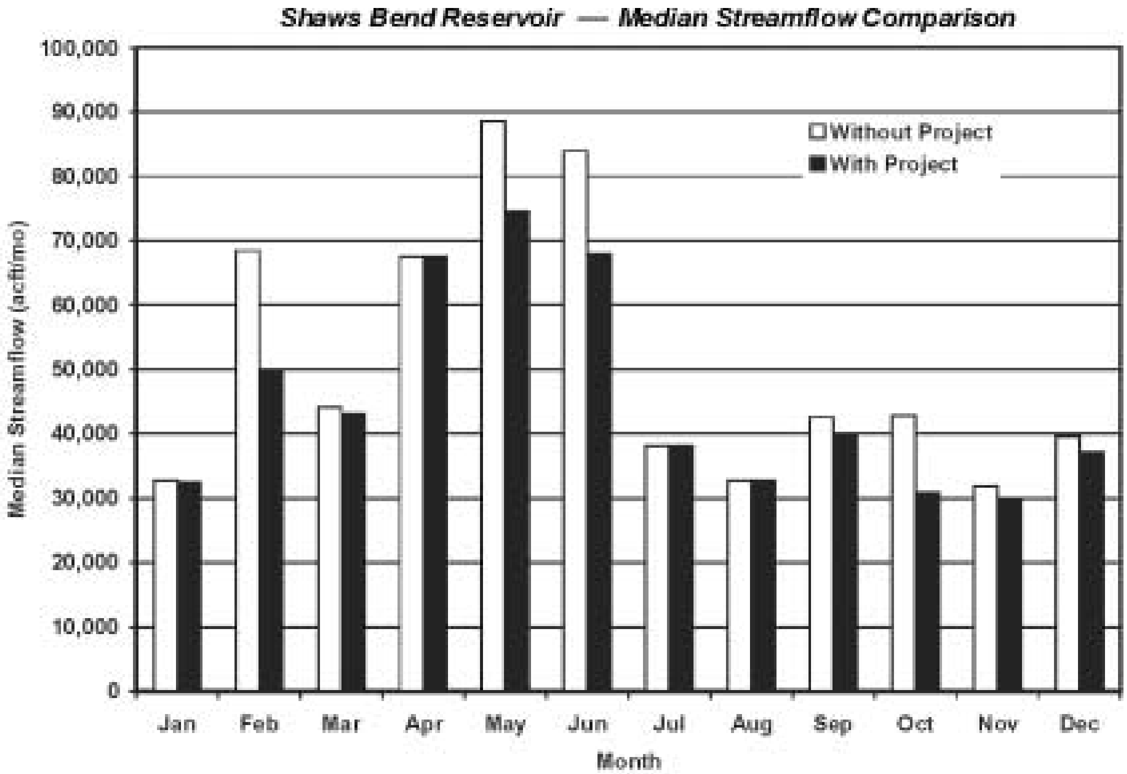
The upper panel of Figure 5.14-4 illustrates the changes in median streamflows that would occur at Columbus, with the Shaws Bend Reservoir impounding the unappropriated waters of the Colorado River just upstream. The largest change would be a decline in median streamflow of 18,694 acft/month (337 cfs) during February. Other significant declines would occur in May and June with declines in median streamflow of 13,910 acft/month (226 cfs) and 16,065 acft/month (267 cfs), respectively. During the summer months of July-September there would be little or no change in streamflow because the reservoir would only rarely be able to impound water in excess of that required for downstream senior water rights and environmental needs.

The lower portion of Figure 5.14-4 illustrates the streamflow frequency characteristics of the Colorado River at Columbus with the Shaws Bend Reservoir project in place. At low flows, there is little difference with the project because the reservoir would typically be passing all, or nearly all, inflows in order to satisfy senior water rights and/or environmental constraints. There is a more pronounced difference at higher Colorado River flows because, in this range, the reservoir would be able to impound water, since water rights and environmental needs would be satisfied more frequently.

5.14.3 Environmental Issues

The Shaws Bend Reservoir described in Option C-18 would impound the Lower Colorado River in Colorado and Fayette counties. The proposed dam site is located approximately 4.1 river miles above the U.S. Highway 71 bridge crossing near Columbus in Colorado County, Texas. The reservoir project description and much of the environmental characterization, is taken from two reports: the ECS Technical Services[6] April 1985 report to the

[5] Although the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B) are not applicable to this reservoir, these storage benchmarks are given for comparative purposes.
[6] ECS, "Environmental Resources Assessment, Colorado Coastal Plains Project, Texas," ECS Technical Services. 1985.



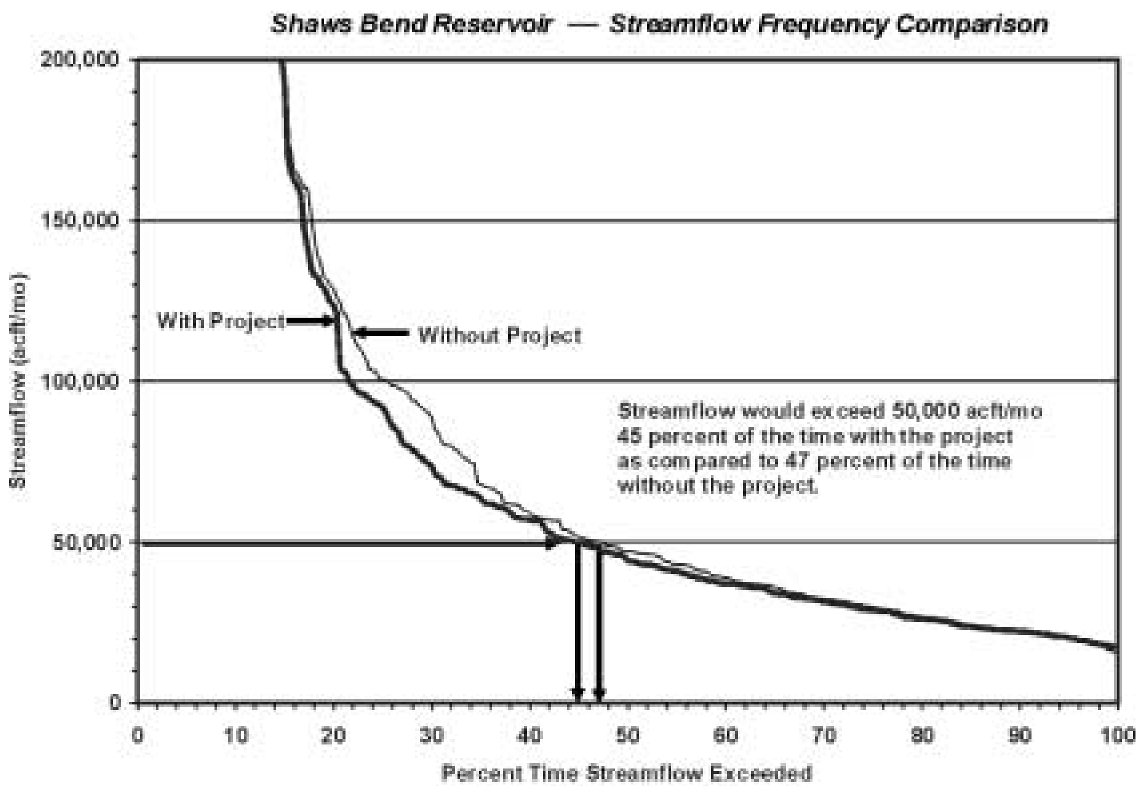


Figure 5.14-4. Shaws Bend Reservoir Streamflow Comparisons

U. S. Bureau of Reclamation (USBR) and the USBR[7] "Report Concluding the Colorado Coastal Plains Project." The ECS report was an environmental inventory and impacts assessment that compared Shaws Bend Reservoir with a series of small reservoirs. The 1986 USBR Report selected Shaws Bend as the preferred alternative for the Colorado coastal Plains Project.

The reservoir lies entirely within the Texas Blackland Prairie Ecoregion, and the Post Oak Savannah[8] vegetational area of Texas lies immediately to the north of the upper reservoir boundary. The Blackland Prairie vegetational area (Blair's[9] regional classification) places the reservoir in the Texan Biotic Province, a "broad ecotone" between western grasslands and eastern forests. Blair's biogeographical listing of wildlife fauna of this region, like the vegetation, is a mix of western grassland-associated and eastern forest-associated organisms.

The Post Oak Savannah is characterized by gently rolling to hilly terrain with an understory that consists typically of tall prairie grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*).[10] Most of the Post Oak Savannah has been converted to improved pastures and small farms. The Blackland Prairie's gently rolling to nearly level plain is largely under cultivation with a few areas in native hay meadows and improved pastures. The soils of the East Central Texas Plains are characteristically dry alfisols.[11] Within the reservoir site are clayey and loamy Brazoria–Norwood soils, typical of floodplains and river terraces.[12] Brazoria soils are poorly drained hydric soils[13] that support hydrophytic vegetation (i.e., they may be USCE jurisdictional wetlands).

The vegetation of the reservoir site is primarily influenced by its location in the Colorado River floodplain. The USBR study applied the U.S. Fish and Wildlife Service Habitat Evaluation Procedure cover type categories to evaluate the vegetation communities to be affected by the proposed reservoir[14] as shown in Table 5.14-4. The wetlands and river terrace are primarily forested with pecans, cottonwoods, sycamores, and willows. Live oak, post oak and

[7] Bureau of Reclamation, "Report Concluding the Study on Colorado Coastal Plains Project, Texas," Southwest Region, Amarillo, Texas, 1986.
[8] Gould, F.W., "The Grasses of Texas," Texas A & M University Press, College Station, Texas, 1975.
[9] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp.93-117, 1950.
[10] Correll, D.S., and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.
[11] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[12] SCS, General Soils Map, Colorado County, Texas, Sheet 4R36426, 1978.
[13] SCS, "Hydric Soils of the United States," Miscellaneous Publication No. 1491, U.S. Dept. of Agriculture, 1991.
[14] Bureau of Reclamation, "Report Concluding the Study on Colorado Coastal Plains Project, Texas," Southwest Region, Amarillo, Texas, 1986.

water oak cover the upper river terraces and upland areas. Grassland and pasture comprise about half of the reservoir area.

Table 5.14-4
Shaws Bend Reservoir
Habitats within Proposed Reservoir Conservation Pool[1]

Land Use Within Conservation Pool	*Acres*
Crop	0
Upland Woodland	3,092
Park	1,193
Brushland	0
Grassland and Pasture	5,781
Riverine (R2) Wetland	1,016
Forested Wetland	1,318
Total Acres	12,400

[1] Bureau of Reclamation 1986 report concluding the study on Colorado Coastal Plains Project, Texas. Southwest Region, Amarillo, Texas

The vegetation cover types of Table 5.14-4 have been grouped into categories corresponding to those used throughout this report[15] for comparison with other projects. As these acreages are based on U.S. Fish and Wildlife Service classification criteria, it is uncertain what proportion of the wetland categories will qualify as U.S. Army Corps of Engineers jurisdictional areas under the wetland determination criteria and procedures currently in use.[16] However, next to actual riverine and forested wetlands, riparian woodlands presently rank among the highest priorities for conservation among both state and federal regulatory agencies.

The with and without project changes in the monthly median streamflows in the Colorado River below the Shaws Bend impoundment shown in Figure 5.14-4, result from operations designed to meet the instream flow guidelines established by Lower Colorado river Authority and explained in Section 5.14.2. The annual hydrograph of the Colorado River has been disturbed for many years by the pattern of winter storage (normally a period of high flow) in the

[15] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas, Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[16] USCE. 1987. Corps of Engineers, "Wetlands Delineation Manual." Environmental Laboratory. Vicksburg, MS. ADA 176 734.

Highland Lakes and summer releases to meet downstream irrigation demand. It will continue to depart from pre-impoundment seasonal patterns as the Highland Lakes are operated to provide flood control and public water supply benefits.

The USBR[17] concluded that the continued existence of protected species or candidates for protection would not be affected by the project. Surveys for five protected or rare plant species failed to locate Texas meadow-rue, Navasota ladies'-tresses, blue-star, spikerush, or prairie dawn within the project area. Additional field studies revealed that the project area soils are unsuitable for populations of the endangered Navasota ladies'-tresses. However, the study recommended that the proposed dam site, adjacent uplands, and lands within the conservation pool should be thoroughly surveyed again for Texas meadow-rue prior to construction, since this plant adapts to prairie and oak forest with a shrub-grass understory. The USBR agreed to survey the reservoir for evidence of nesting American bald eagles prior to project construction. Important species proposed or listed for protection that may be present in the project vicinity are listed in Table 5.14-5. The Texas garter snake may be present in wetland habitats and grasslands. The timber rattlesnake is associated with dense bottomland woods. The Texas horned lizard and the western smooth green snake may be present in grassland areas. Two fish, the blue sucker and the Guadalupe bass, are known to inhabit this portion of the Colorado River. The implementation of Shaws Bend Reservoir (C-18) would require field surveys for protected species, vegetation and habitats.

Two environmentally unique areas, Harvey Creek woodlands and Horseshoe Bend woodlands, would be affected by the proposed reservoir. Harvey Creek is about 30 acres of relatively undisturbed mature oaks, elms, and hackberry trees. The creek provides a continuous water supply to the numerous pools and riffles along the reach above the confluence with the Colorado River. This pristine bottomland with pools and riffles would be totally inundated by the conservation pool. Horseshoe Bend woodlands, relatively undisturbed for more than 30 years, is approximately 100 acres dominated by an elm-ash-hackberry community with relatively homogeneous stands of cottonwood, hackberry, and other bottomland trees. The central portion of this woodland has a remnant oxbow lake that was cut off from the Colorado River during the 1940s. Other area oxbow lakes have generally been cleared for agricultural purposes. The Horseshoe Bend woodlands would be 70 percent inundated by the conservation pool.

[17] Bureau of Reclamation, Op. Cit., 1986.

Table 5.14-5
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option
Shaws Bend Reservoir (C-18)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-Capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-Spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling: hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen city and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Meadow-Rue	*Thalictrum texanum*	Outskirts of mesic woodlands or forests			WL	Resident
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident

Table 5.14-5 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows	C2	NL	NL	Resident
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]			NL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
Spot-Tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]			NL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

The USBR agreed to a mitigation plan with U.S. Fish and Wildlife Service for the habitat inundated. Mitigation included planting 4,000 acres of bottomland with native hardwoods to create a forested wetland within a 6,000-acre wildlife management area. Mitigation plans included the areas directly affected by the reservoir inundation, areas disturbed by construction, and an estimated 2,180 acres of pecan orchard adjoining the reservoir site that may be killed by the raised groundwater table. Results of a Habitat Evaluation Procedure conducted by the USFWS indicated that about 46,000 acres managed to encourage woodland development could be needed to compensate for terrestrial habitat losses.

With regard to cultural resources, about 200 to 250 prehistoric and historic sites were identified in the project area. Some sites would be destroyed by project construction and others would be less vulnerable to destruction as a result of inundation.[18] Burnham's Crossing, a historic ferry crossing and trade center, would be inundated regardless of conservation pool level since most of the site lies below the 200-foot contour. A site mitigation plan will be required to avoid loss of historically significant resources.[19] A systematic survey of the entire reservoir site would be required to search for surface indications of cultural deposits, while a geomorphic study to evaluate the potential for buried deposits is also a likely requirement. Sites located would have to be tested for archaeological or historic significance and for eligibility for listing on the National Register, and the need for additional study, salvage, or other mitigation determined prior to construction.

5.14.4 Engineering and Costing

This water supply option would require several major infrastructure items as summarized in Table 5.14-6. Obviously, the main item would be the construction of the Shaws Bend Dam itself. The dam would extend approximately 5,600 feet across the Colorado River valley with a crest elevation of 241 ft-msl. The reservoir would provide a conservation storage capacity of 132,220 acft. The cost for constructing this large dam is estimated to be approximately $83.25 million.

[18] Ibid.
[19] Ibid.

Table 5.14-6.
Cost Estimate Summary for
Shaws Bend Reservoir (C-18)
Second Quarter 1999 Prices

Item	***Estimate Costs***
Capital Costs	
Dam and Reservoir (Conservation Pool: 132,220 acft; 12,400 acres; 220 ft-msl)	$83,246,000
Intake and Pump Station (48.5MGD)	6,288,000
Water Treatment Plant (48.5 MGD)	33,909,000
Transmission Pump Stations (2)	9,205,000
Transmission Pipeline (60-inch dia.; 125 miles)	119,285,000
Relocations	1,808,000
Distribution	62,426,000
Power Connection Costs ($125/HP)	1,808,000
Total Capital Cost	**$317,975,000**
Engineering, Legal Costs, and Contingencies	$104,552,000
Land Acquisition and Surveying (13,023 acres)	87,402,000
Interest During Construction (4 years)	94,953,000
Environmental and Archaeology Studies, Mitigation, and Permitting	83,529,000
Total Project Cost	**$688,411,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$26,711,000
Debt Service (6 percent, 40 years)	21,317,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	1,580,000
Water Treatment Plant	3,865,000
Dam and Reservoir	1,249,000
Distribution Systems	624,000
Pumping Energy Costs (118,170,569 kWh @ $0.06 per kWh)	5,388,000
Total Annual Cost	**$60,734,000**
Available Project Yield (acft/yr)	**51,576**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$1,178**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$3.61**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Other major items include the approximately 125-mile transmission pipeline to convey the firm yield of the reservoir to the major municipal demand center of the south Central Texas Region as shown in Figure 5.14-1. The uniform delivery rate would be approximately 48.5 MGD requiring a 60-inch diameter transmission pipeline costing approximately $119.29 million.

Associated with the pipeline are the reservoir pump station and the two transmission pump stations along the length of the line. These pump stations are estimated to cost approximately $15.49 million. Another important capital cost is $62.43 million for distribution of water to municipal systems or to an aquifer for enhancement of recharge.

Another associated cost would be the purchase of the periodically inundated land of the reservoir. Although the normal conservation pool would be 12,400 acres, the total land area of the flood pool would be approximately 23,400 acres.[20] A general land cost of $2,000 per acre was used to value the land to be purchased. However, a 1,000-foot-wide corridor 34.5 miles in length along the Colorado River bottom was estimated to cost $10,000 per acre. The total land purchase cost for the reservoir area, including surveying, was $81.41 million. Land acquisition and surveying for the pipeline right-of-way and associated pump stations would be $5.99 million, for a total of $87.40 million.

With engineering, contingencies, legal costs, and other studies, the total project cost for the Shaws Bend Reservoir project would be $688.41 million.

The reservoir portion of the project would be financed for 40 years at 6 percent for a total annual payment of $21.32 million. The other portions of the project would be financed over 30 years at a 6 percent annual interest rate for an annual cost of $26.71 million. Operation and maintenance costs total $7.32 million annually.

Large annual costs are associated with the pumping of Colorado River water from the Shaws Bend Reservoir near Columbus to the major municipal demand center of the south Central Texas Region. The pumping costs for the conveyance of the Colorado River water, with the necessary vertical lift and friction losses along the pipeline, are estimated to be $5.39 million per year.

[20] U.S. Bureau of Reclamation, Op. Cit., 1986.

The total annual costs, including debt repayment, interest, and operation and maintenance, total \$60.73 million. For an annual supply of 51,576 acft the resulting cost of water of would be \$1,178 per acft/yr or \$3.61 per 1,000 gallons.

5.14.5 Implementation Issues

Implementation of Shaws Bend Reservoir on the Colorado River could directly affect the feasibility of other water supply options under consideration, including S-15 Dc, S-15 Eb, C-13C, C-17A, C-17B, SCTN-11, SCTN-12b, and/or SCTN-15. An institutional arrangement would likely be needed to implement this option with financing on a regional basis.

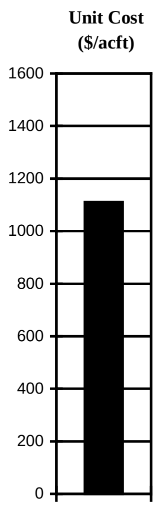
Requirements Specific to Reservoir

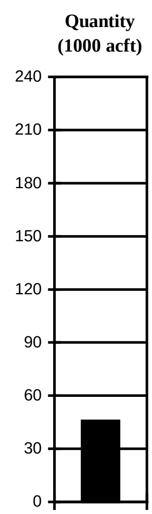
1. It will be necessary to obtain these permits for reservoir:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads
   b. Other utilities
   c. Structures of historical significance
   d. Cemeteries

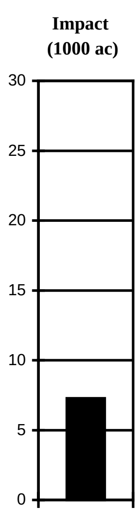
Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/13/99







OPTION NUMBER: **SCTN-15**
OPTION NAME: **Cummins Creek Reservoir (Colorado River Basin)**

OPTION DESCRIPTION: *Firm water supply would be delivered to a water treatment plant at the major municipal demand center of the South Central Texas Region and distributed to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$1,111**	**per acft**[1]
QUANTITY OF WATER:	**45,712**	**acft/yr**[2]
LAND IMPACTED:	**7,274**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:**

[2]**QUANTITY OF WATER:** (A) 15,453 acft/yr from just Cummins Creek Reservoir; and (B) 45,712 acft/yr from Cummins Creek Reservoir with Colorado River diversion.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Mitigation for inundation of approximately 6,600 acres in reservoir (including riparian woodlands) although no endangered or threatened species are known to occur there. Instream flows and freshwater inflows to bays and estuaries. Portions of the Colorado River and Cummins Creek potentially affected by this option are recommended for designation as Ecologically Unique River or Stream Segments by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY:

ADDITIONAL FACTORS:

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-13C, C-17A, C-17B, C-18, SCTN-11, and/or SCTN-12b.

5.15 Cummins Creek Reservoir (SCTN-15)

5.15.1 Description of Option

This option involves the development of an off-channel reservoir on Cummins Creek in Colorado County near Columbus. The off-channel reservoir could be used in two manners: a) to store waters derived solely from the Cummins Creek watershed, or b) to store a combination of water from the Cummins Creek watershed and unappropriated water diverted from the nearby Colorado River. The firm yield from the off-channel reservoir could then be conveyed through a pipeline to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or the Edwards Aquifer recharge zone. The approximate reservoir site, river diversion location, and transmission pipeline route are shown in Figure 5.15-1.

The Cummins Creek Reservoir has been investigated in prior studies by the U. S. Bureau of Reclamation (USBR)[1] and HDR.[2] The dam would be a 7,800-foot rolled earthfill structure, about 109 feet above the streambed at maximum height. The conservation pool elevation would be 256 feet-mean sea level (ft-msl) and would extend 12 miles upstream. The conservation storage capacity of the reservoir would be 132,700 acft, with a surface area of 6,600 acres. The flood pool of the reservoir would cover approximately 9,600 acres.

5.15.2 Water Potentially Available from Cummins Creek Reservoir

In order to evaluate the firm yield of Cummins Creek Reservoir, whether operated separately or in conjunction with the Colorado River diversion, it is necessary to know the inflows to the reservoir that originate in the watershed above the dam site. Since there is no streamflow gaging station on Cummins Creek, flows were estimated by using a similar nearby "partner" drainage basin. Streamflow data from the gaging station on the Lavaca River at Hallettsville (USGS #08163500), approximately 30 miles to the southwest, were utilized. This is the most upstream gaging station on the Lavaca River and the drainage above this point is similar in geology[3] and climate[4] to the Cummins Creek watershed. The desired streamflows were

[1] U.S. Department of the Interior, Bureau of Reclamation, "Colorado Coastal Plains Project - Texas," December 1981.
[2] HDR Engineering, Inc. (HDR) "Population, Water Demand Projections, and Water Supply Alternatives," Trans-Texas Water Program, North Central Study Area Phase II Report, Volume 2, 1998.
[3] Primarily the Tertiary-age Oakville Sandstone and Fleming Formations; see Bureau of Economic Geology, University of Texas, "Geologic Atlas Of Texas, Seguin Sheet," 1979.
[4] Bomar, George W., "Texas Weather," University of Texas Press, 1983.

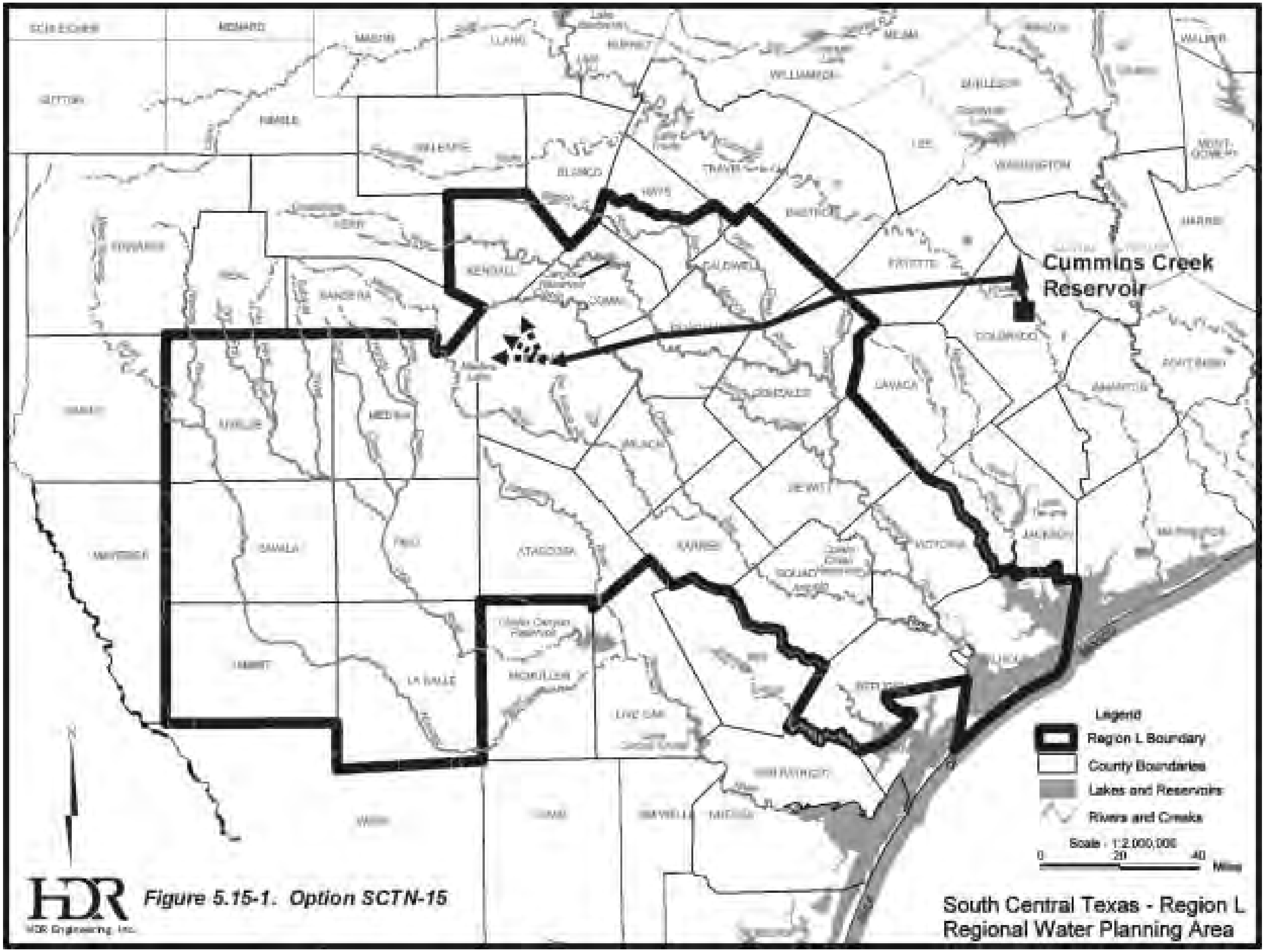


Figure 5.15-1. Option SCTN-15

estimated by using the ratio of the drainage area of Cummins Creek (293 square miles) to that of the Lavaca River at the gaging site (108 square miles).

Cummins Creek Reservoir would have to pass inflows originating in the Cummins Creek watershed subject to the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B)[5]. The streamflow data described above were used to compute the necessary statistics to quantify the Consensus Criteria pass-through requirements for Cummins Creek Reservoir. These pass-through requirement flows are summarized in Table 5.15-1.

Table 5.15-1.
Daily Natural Streamflow Statistics
for Cummins Creek

Month	*Median Flows – Zone 1 Pass-Through Requirement (acft/day)*	*25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)*
January	37.67	18.83
February	50.31	23.14
March	47.35	20.99
April	40.36	17.22
May	39.82	15.07
June	29.06	10.76
July	15.61	4.30
August	7.53	2.56[1]
September	11.84	3.90
October	13.45	5.38
November	20.99	8.07
December	29.06	15.61
Zone 3 Pass-Through Requirement[2] (acft/day)		3.52

[1] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[2] Water Quality Standard (7Q2).

In addition to passing inflows for environmental needs, the Cummins Creek Reservoir would also have to pass water to downstream senior water rights on the Colorado River. The

[5] Staff of Texas Water Development Board and Texas Parks and Wildlife Department indicate that Consensus Criteria would apply to tributaries of the Colorado River although there are specific criteria for instream flows and bay and estuary needs of the mainstem of the river (Section 5.14)

major existing water rights of the Lower Colorado River Basin are shown in Table 5.15-2. Those downstream from the proposed Cummins Creek Reservoir are underlined.

Table 5.15-2.
Summary of the Senior Water Rights in the Lower Colorado River Basin (rights below Cummins Creek Reservoir are underlined)

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation[1]
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal[3]
3	LCRA - Gulf Coast[2]	14-5476	12/01/1900	228,570	Irrigation
4	LCRA - Lakeside[2]	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch[2]	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403	Municipal
9	City of Austin	14-5489	1945, 1965	36,456	Municipal
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] Currently the use type of this right is for irrigation, but in this study it was assumed that it would be converted to a municipal pattern.
[2] These three water rights held by LCRA are subordinated to the 250,000 acft municipal portion of the City of Austin's water right (no. 7).

In order to determine the periods during which the Cummins Creek Reservoir would have to pass inflows to senior water rights, the Lower Colorado River Authority's (LCRA) RESPONSE model of the lower Colorado River was utilized. The results of the RESPONSE model indicate what portion of the senior water rights demands in Table 5.15-2 could be met on a daily basis over the 1941 to 1965 period from run-of-river flows[6] for the Colorado River below the Highland Lakes. Since the run-of-river flow values include the contribution of the Cummins Creek watershed, Cummins Creek Reservoir would be able to impound water only on days when all the downstream senior water rights (1 through 6, 10, 11 in Table 5.15-2) are satisfied.

[6] Derived by Texas Department of Water Resources, "Present and Future Surface-Water Availability in the Colorado River Basin, Texas," Report LP-60, June 1978.

Furthermore, on those days, the reservoir would be able to impound only an amount that would not cause a shortage to any of these water rights or a reduction in applicable instream flow or bay and estuary requirements (see Section 5.14).

5.15.2.1 Alternative A — Cummins Creek Reservoir without Colorado River Diversion

With the Cummins Creek flows and environmental and water rights pass-through requirements quantified, it was then possible to calculate the firm yield of Cummins Creek Reservoir. First, the firm yield was determined with just the inflows from the Cummins Creek watershed. This firm yield was computed with a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The reservoir was assumed full at the start of the SIMDLY simulation. It was assumed that water would be withdrawn from the reservoir with a uniform demand pattern. With only the inflows from its own watershed, and subject to environmental flows and senior water rights constraints, the firm yield of Cummins Creek Reservoir is 15,453 acft/yr.

The upper panel of Figure 5.15-2 illustrates the simulated reservoir storage fluctuations for the 1941 to 1965 historical period with just the waters derived from the Cummins Creek watershed. The lower panel of Figure 5.15-2 illustrates storage behavior of the off-channel reservoir in a storage-frequency curve. The reservoir contents are predicted to remain above the Zone 2 trigger level (80 percent capacity) about 52 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 75 percent of the time based on simulations for the 1941 to 1965 period.

The upper panel of Figure 5.15-3 illustrates the changes in median streamflows that would occur on the Colorado River at Columbus with the Cummins Creek Reservoir impounding just waters derived from its own watershed. There would be little change in flows associated with the project if configured in this way. The largest change would be a decline in median streamflow of 4,281 acft/month (77.1 cfs) during February. During the summer months, there would be no change in the median values. This is because the reservoir would only rarely be able to impound water derived from its own watershed in excess of senior water rights and environmental demands. The lower portion of Figure 5.15-3 illustrates the streamflow frequency characteristics of the Colorado River at Columbus with the Cummins Creek project impounding waters from only its own watershed. At low flows, there is little difference with the project

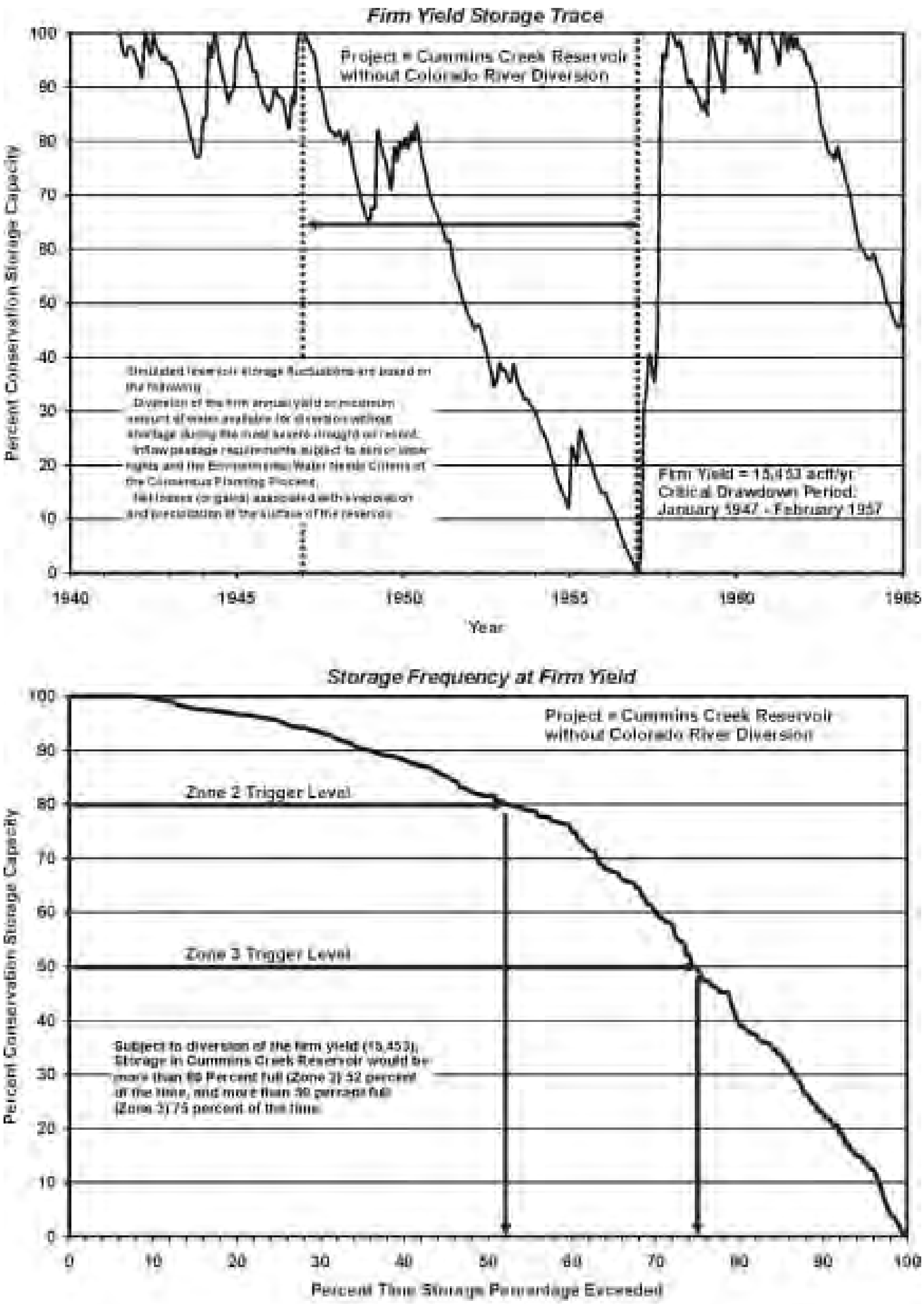
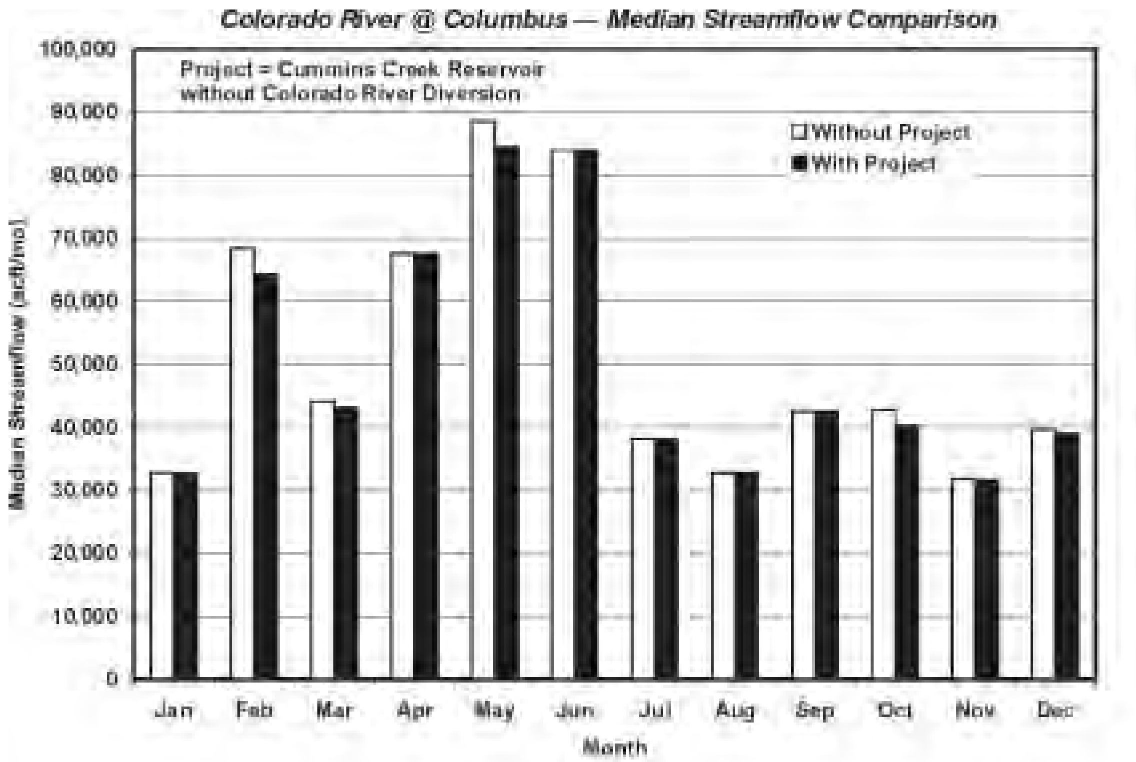


Figure 5.15-2. Cummins Creek Reservoir (Alternative A) Storage Considerations



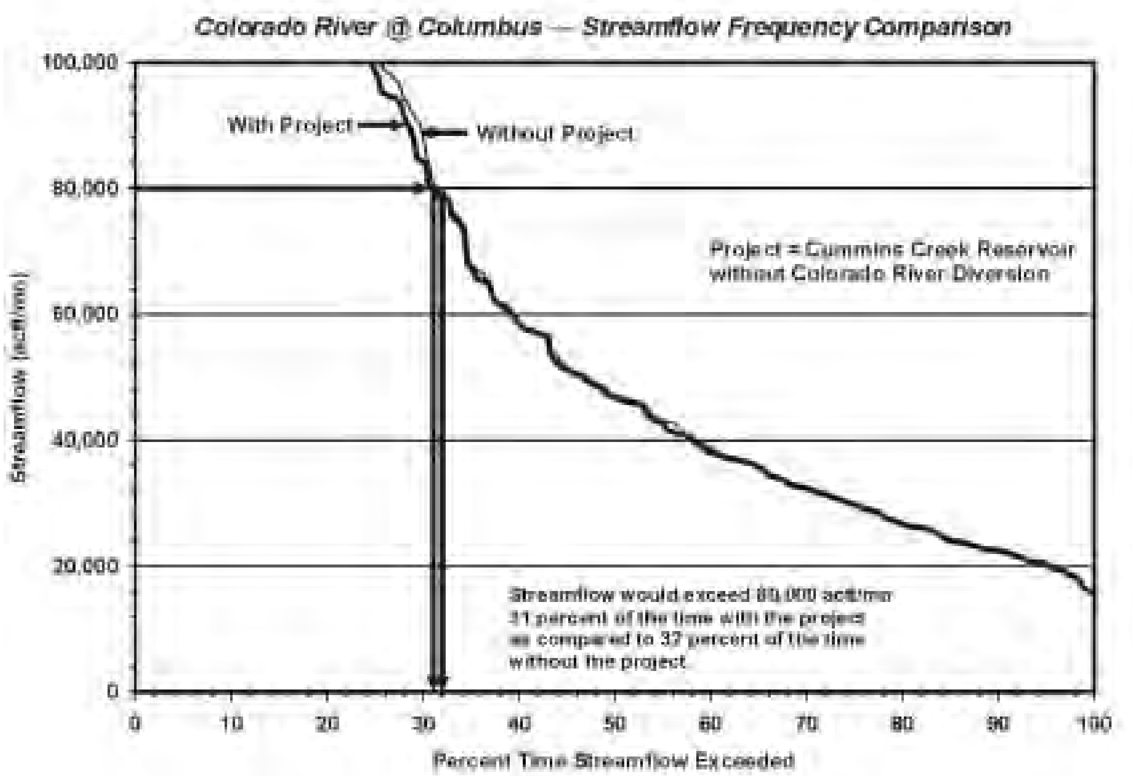


Figure 5.15-3. Cummins Creek Reservoir (Alternative A) Streamflow Comparisons

because the off-channel reservoir would typically be passing all, or nearly all, inflows in order to satisfy senior water rights and/or environmental constraints. There is a more pronounced difference at higher Colorado River flows because, in this range, Cummins Creek Reservoir would be able to impound more water, since water rights and mainstem environmental criteria would be satisfied more frequently.

5.15.2.2 Alternative B — Cummins Creek Reservoir with Colorado River Diversion

The second manner in which Cummins Creek Reservoir could be utilized is to pump unappropriated water from the nearby Colorado River into the reservoir and augment the firm yield. In order to determine the magnitude and time of occurrence of unappropriated streamflow in the Lower Colorado River Basin, the LCRA's RESPONSE model was utilized. Computations were performed to quantify water available after all senior water rights (Table 5.15-2) are honored and the specific environmental flow criteria of the Lower Colorado River Basin are met. This procedure is described more fully in Section 5.14, devoted to Shaws Bend Reservoir (Option C-18).

Figure 5.14-2 summarizes the results of the determination of unappropriated water in the Lower Colorado River Basin. In general, there is little or no unappropriated water in the Lower Colorado River Basin during summer months because of the coincidence of typically low streamflows and peak demands of the senior water rights, as listed in Table 5.15-1. The unappropriated waters of the Colorado River are generally available only during short periods of high flood flows or during late fall and winter months of reasonably wet years when senior water rights demands are low and streamflows are higher.

In order to make use of these short-term unappropriated waters, it is necessary to capture them quickly by utilizing a high diversion rate from the river. This requires a very large diversion facility and parallel 3.79-mile pipelines from the Colorado River to the off-channel reservoir. As in a previous study of the Cummins Creek Reservoir,[7] in this analysis it was assumed that the diversion facility on the Colorado River and the short pipelines would be sized to deliver approximately 800 cfs to the reservoir.

Figure 5.15-4 illustrates the average amount of water that could be diverted from the Colorado River by this diversion facility on a monthly basis. The pattern of water diverted

[7] HDR, Op. Cit. 1998.

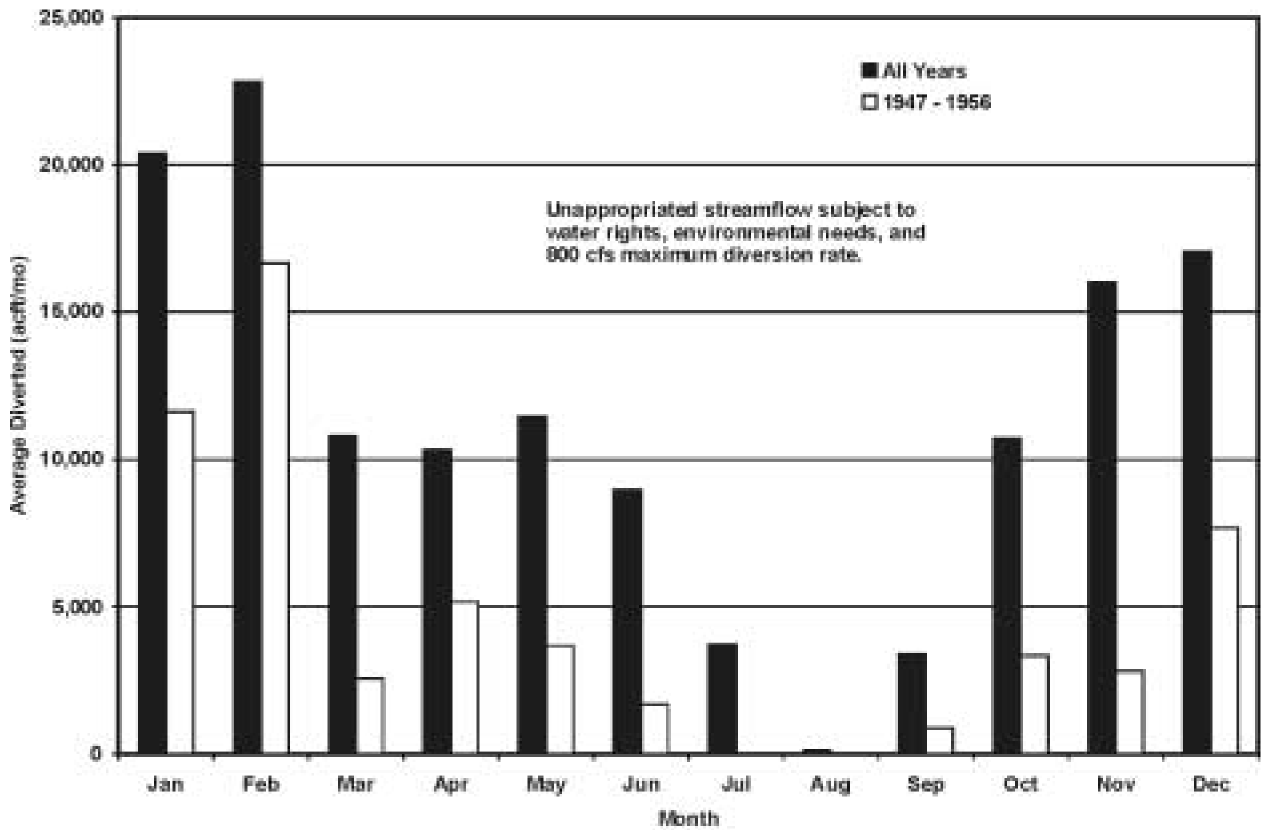


Figure 5.15-4. Average Availability of Unappropriated Steamflow, Colorado River at Columbus

reflects the pattern of unappropriated water availability: little or none in the summer and better availability in the late fall and winter months. Again, these diversions are only possible after all senior water rights and applicable environmental flow criteria have been met. The best month is February, during which an average of almost 23,000 acft could be diverted.

With the available water from the Colorado River quantified, it was then possible to make a new computation of the firm yield of Cummins Creek Reservoir. Cummins Creek Reservoir would have to pass inflows in accordance with Consensus Criteria, as shown in Table 5.15-1. With the addition of up to 800 cfs of unappropriated streamflow from the Colorado River, the firm yield of Cummins Creek Reservoir is increased to 45,712 acft/yr.

The upper panel of Figure 5.15-5 illustrates the simulated reservoir storage fluctuations for Cummins Creek Reservoir operated with the addition of the Colorado River diversion. The lower panel of Figure 5.15-5 illustrates the reservoir's storage-frequency curve. For the 1941 to 1965 period, reservoir contents are predicted to remain above the Zone 2 trigger level (80 percent

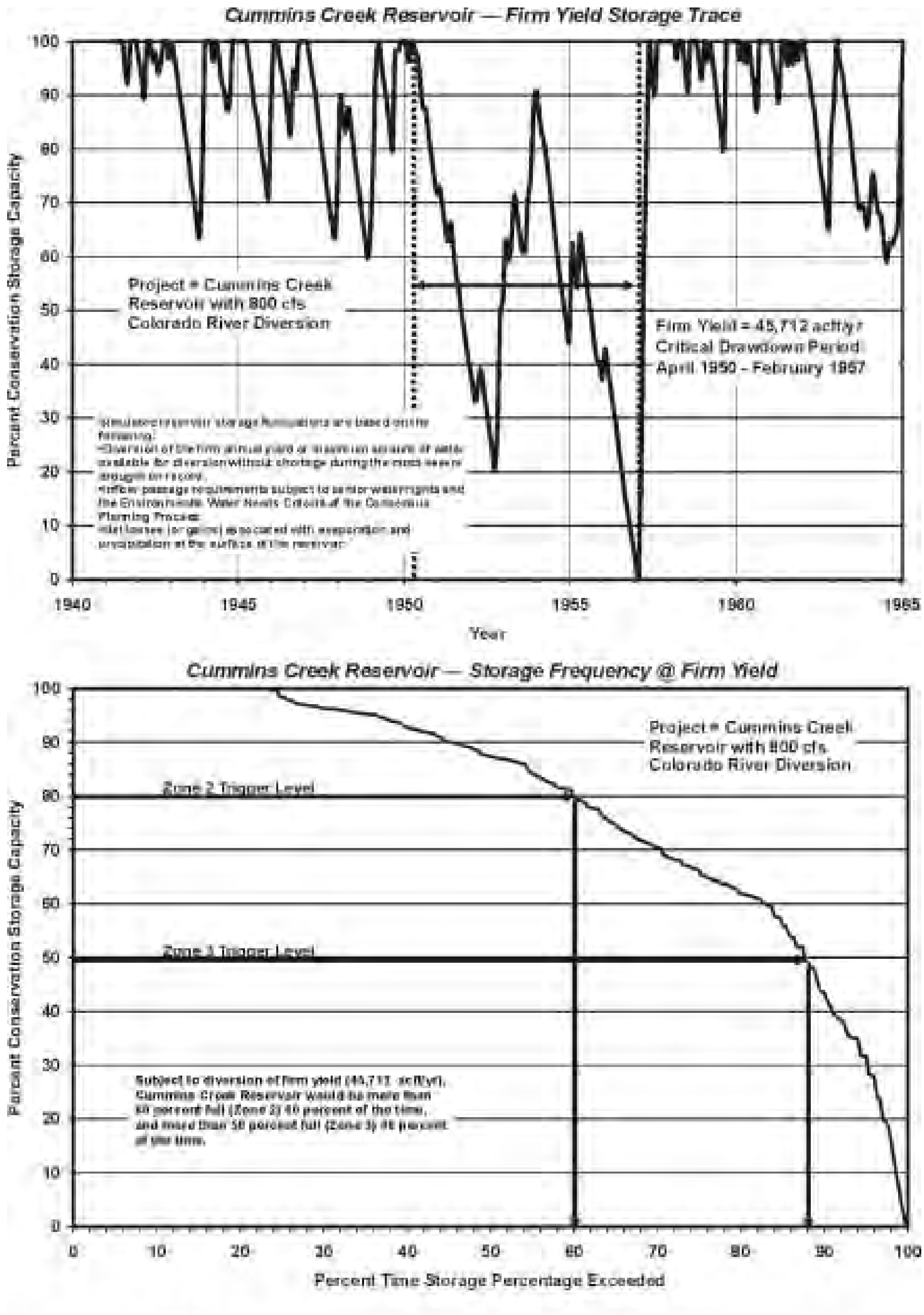


Figure 5.15-5. Cummins Creek Reservoir (Alternative B) Storage Considerations

capacity) about 60 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time.

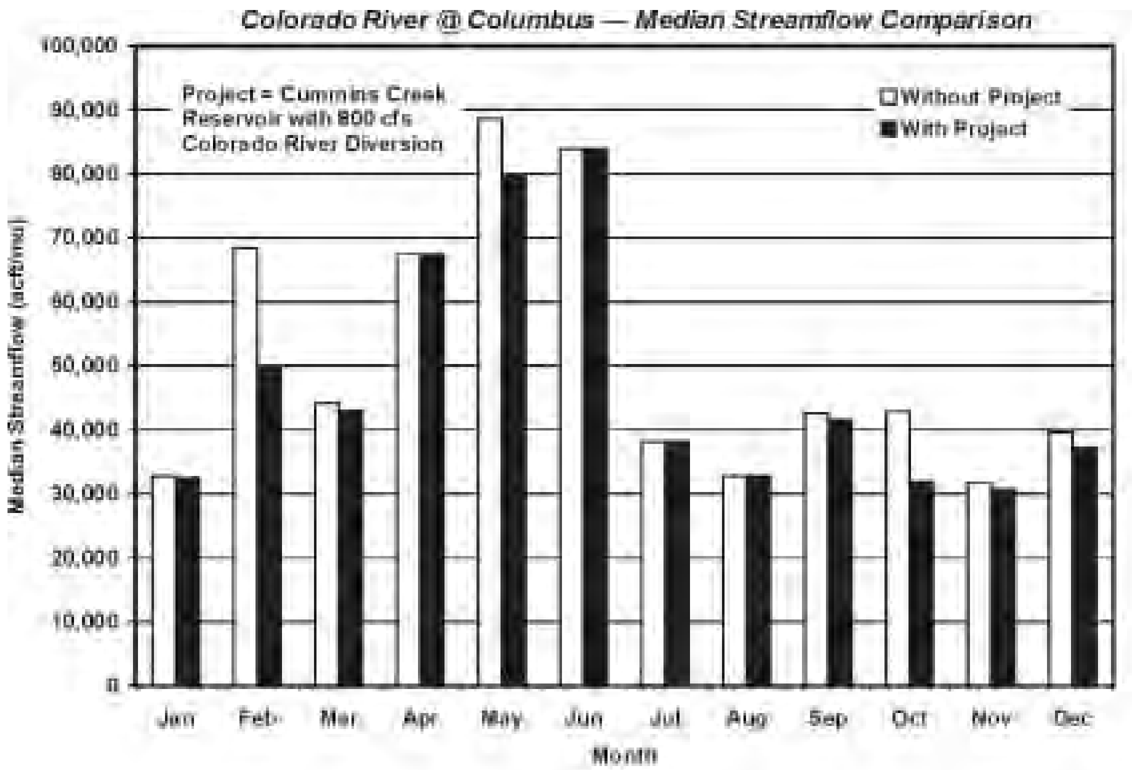
The upper panel of Figure 5.15-6 illustrates the changes in median streamflows that would occur on the Colorado River at Columbus with Cummins Creek Reservoir impounding waters derived from both its own watershed and from the Colorado River. The largest change, again in February, would be a decline in median streamflow of 18,387 acft/month (331 cfs). February is the month with the greatest availability of unappropriated streamflow (Figure 5.15-4). During the summer months, the changes in the median values would again be zero. In October, the median flow would decline 10,820 acft/month (176 cfs). These changes, however, would not cause any detrimental impact to senior water rights or environmental flows because these were accounted for in the derivation of the unappropriated flows (Section 5.14). The lower portion of Figure 5.15-6 illustrates the streamflow frequency characteristics of the Colorado River at Columbus with Cummins Creek Reservoir utilizing both the water from its own watershed and the Colorado River diversion.

5.15.3 Environmental Issues

This option includes the construction of a reservoir to impound the waters of Cummins Creek near Columbus. Included is a diversion of unappropriated water from the nearby Colorado River via 3.79-mile pipelines and conveying the water to major municipal demand center of the South Central Texas Region via an approximately 132-mile transmission pipeline. Option SCTN-15 includes the construction of Cummins Creek Reservoir in Colorado County and a corresponding transmission pipeline west through Colorado, Fayette, Gonzales, Guadalupe, and Bexar Counties. The proposed reservoir and transmission pipeline lie within Omernik's[8] Texas Blackland Prairie ecoregion and East Central Texas Plains ecoregion.

The Texas Blackland Prairie ecoregion and East Central Texas Plains ecoregion lie within Blair's[9] Texan Biotic Province and reach the northern border of the Tamaulipan Biotic Province. The Texan Province is an ecotone, or ecologically transitional region between the Austroriparian Biotic Province to the northeast and the Tamaulipan Province to the southwest.

[8] Omernik, J.M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers. 77:118-125.
[9] Blair, W. Frank. 1950. The Biotic Provinces of Texas. Texas journal of Science 2(1):93-117.



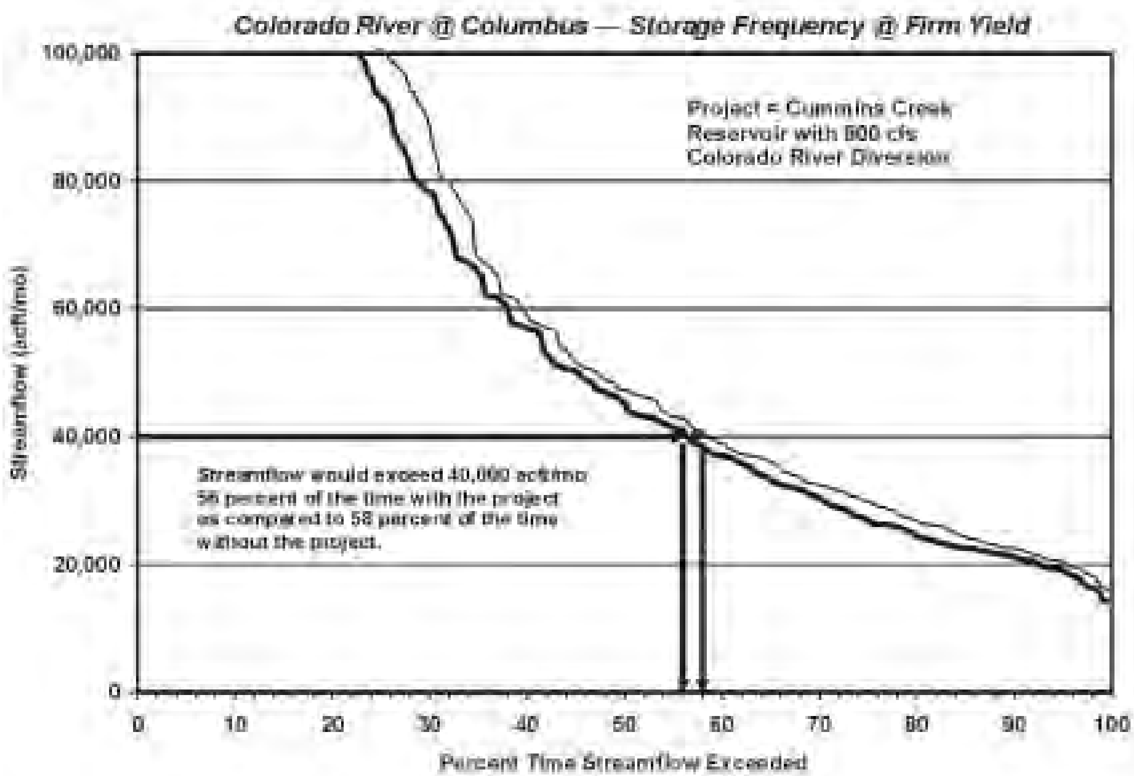


Figure 5.15-6. Colorado River at Columbus (Alternative B) Streamflow Comparisons

The plant and animal species of the Texan Province are a mixture of species characteristic of the Austroriparian and Tamaulipan Provinces. The raparian woodlands dissecting the Texas Province provide corridors for migration and an important habitat type in this predominately grassland region. The vegetation of these counties alternates between East Central Texas Plains species, mainly tall grasses, mesquite trees, oaks, and elms, and Texas Blackland Prairie flora, typically grassland species.[10]

The Texas Blackland prairies ecoregion includes the San Antonio and Fayette Prairies. Topography is gently rolling to nearly level, well dissected with rapid surface drainage. Blackland soils are fairly uniform dark-colored calcareous clays interspersed with some gray acid sandy loams. For the most part, this fertile area has been brought under cultivation, although a few native hay meadows and ranches remain. The Texas Blackland Prairies ecoregion is a true prairie with typically grassland species.[11] The predominant vegetation of the Texas Blackland Prairie vegetation include little bluestem (*Schizachyrium scoparium* var. *frequens*) as a climax dominant, sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), tall dropseed (*Sporoboulus asper*), silver bluestem (*Bothriochloa sacchariodes*), and Texas wintergrass (*Stipa hirsuta*).[12] Under heavy grazing, Texas wintergrass, buffalo grass (*Buchloe dactyloides*), Texas grama (*B. rigidiseta*), smutgrass and many annuals increase or invade. Mesquite (*Prosopis glandulosa*) also has invaded hardland sites of the southern portion of the Texas Blackland Prairies. Although classed as a true prairie, the Texas Blackland prairie has much timber, especially along the streams that traverse it. Common tree species include a variety of oaks, pecan, cedar elm (*Ulmus crassifolia*), bois d'arc (*Maclura pomifera*) and mesquite. Post Oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) increase on the medium- to light-textured soils. The soil types which support the vegetation types in this region include moderately well drained sandy to clayey soils over stream terraces or limestone.[13,14]

The East Central Texas Plains ecoregion lies immediately west of the primary forest region of Texas. The topography is also gently rolling to hilly. Soils on the uplands are light-

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[10] Clements, J., 1988, Texas Facts, Clements Research II, Inc. Dallas, Texas.
[11] Blair, W.F., Op. Cit., 1950.
[12] Gould, F. W., 1975, The Grasses of Texas, Texas A&M University Press, College Station, Texas.
[13] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1977. Soil Survey of Guadalupe County, Texas. USDA.
[14] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1991. Soil Survey of Guadalupe County, Texas. USDA.

colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the East Central Texas Plains is in native or improved pastures although small farms are common. Climax grasses include little bluestem, Indian grass, switchgrass, purpletop (*Tridens flavus*), silver bluestem, Texas wintergrass (*Stepa leucotricha*) and *Chasmanthium sessiliflorum.* The overstory is primarily post oak and blackjack oak. Many other brush and weedy species are also common. Some invading plants are red lovegrass, broomsedge, splitbeard bluestem (*Andropogon ternarius*), yankeeweed, bullnettle (*Cnidoscolus texanus*), greenbrier, yaupon (*Ilex vomitoria*), smutgrass and western ragweed.

The fauna present in areas where suitable habitat remains will be typically neotropical and grassland species.[15] On-site surveys will be necessary to determine the specific fauna of the corridor since the pipeline corridor is a mosaic of the East Central Texas Plains and the Texas Blackland Prairie ecoregions and could potentially include a wide variety of species.

The water transmission pipeline between Colorado and Bexar Counties would be about 132 miles long. A construction right-of-way 140 feet wide would affect a total area of approximately 2,240 acres. The construction of the pipeline would include the clearing and removal of woody vegetation. A 40-foot wide right-of-way corridor free of woody vegetation maintained for the life of the project would total 640 acres. Destruction of potential habitat could be avoided by diverting the corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impacts.

Although the Natural Heritage Program does not report any endangered or threatened species directly along the pipeline corridor, some have been reported in the vicinity (Table 5.15-3). Many of these appear to be dependent on shrubland or riparian habitat, such as the Texas tortoise, the Reticulated collared lizard, the Texas horned lizard, and the Indigo snake. The Texas garter snake may be present in wetland habitats and the Timber rattlesnake may be found in riparian woody vegetation. For approximately the first two miles of the pipeline corridor, construction would encroach on the northern portion of what is considered to be

[15] Op cit.

Table 5.15-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cummins Creek Reservoir (SCTN-15)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
BIRDS						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant in Bexar, Colorado, Guadalupe, Gonzales, Fayette
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	E	T	T	Nesting/Migrant in Bexar, Colorado, Guadalupe, Gonzales, Fayette
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant in Gonzales, Fayette, Guadalupe
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	Coastal Prairies of Gulf Coastal Plain	E	E	E	Nesting inColorado
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in Colorado, Bexar, Gonzales, Fayette, Guadalupe
Wood Stork	*Mycteria americana*	forages in prairie ponds, and shallow standing water formerly nested in TX		T	T	Migrant in Bexar, Colorado, Fayette
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	T	Nesting/Migrant in Colorado
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country, deciduous or pine-oak woodland; nests in various habitats		T	T	Nesting/Migrant in Bexar
Black-capped Vireo	*Vireo atricapillus*	oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces	E	E	T	Nesting/Migrant in Bexar
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant in Colorado, Fayette
Golden-cheeked Warbler	*Dendrpoica chrysoparia*	juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields	C2	T	T	Migrant in Bexar, Colorado
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant in Bexar, Colorado, Guadalupe
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas; bare ground for running and walking				Nesting/Migrant in Bexar, Colorado
REPTILES						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges	C1		C1	Bexar, GonzalesKnown to occur within 1 mile of pipeline route

Table 5.15-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush	C2	T	T	Bexar, Colorado, Gonzales, Fayette
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2			Bexar, Colorado
Spot-tailed Lizard	*Holbrookia lacerata*	central & southern Texas; oak-juniper woodlands and mesquite-prickly pear				Bexar
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass & bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Bexar
Western Smooth Green Snake	*Opheodrys vernalis blanchardi*	Coastal prairies of upper Texas coast		E	E	Colorado
Timber Rattlesnake	*Crotalus horridus*	floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Bexar, Colorado, Gonzales
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	wl	Bexar
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Bexar, Gonzales
AMPHIBIANS						
Houston Toad	*Bufo houstonensis*	endemic, ephemeral pools, water in pools, sandy substrate, stock tanks, associated with soils of the Recklaw, Weches, Sparta, Carrizo, Queen City, Goliad, Willis geologic formations	E	E	E	Colorado
Black-spotted newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	E	Bexar
FISH						
Blue Sucker	*Clycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River	C2	T	wl	
Guadalupe bass	*Micropterus treculi*	Clear flowing streams	C2		wl	Bexar, Gonzales
INSECTS						
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	found near slow-moving water, eggs laid on objects near water; larvae are aquatic, adults prefer shady areas; males bite, females feed on nectar and pollen	C1			Resident in Colorado
Maculated Manfreda Skipper	*Stallingsia maculosus*	fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			wl	Bexar
PLANTS						
Big Red Sage	*Salvia penstemonoides*	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade	C2		wl	Bexar
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			wl	Bexar
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			wl	BexarKnown to occur within 1 mile of pipeline route
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Bexar

Table 5.15-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tarnaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			wl	Bexar
Correll's false dragon-head	*Physostegiacorrellii*	wet soils including roadside ditches, irrigation channels			wl	Bexar
Glass Mountain coral root	*Hexalectrisnitida*	mesic woodlands in canyons, lower elevations, under oaks				Bexar
Sandhill woolywhite	*Hymenopappuscarrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Bexar
Navasota Ladies'-tresses	*Spiranthes parksii*	margins of post oak woodlands in sandy loams along intermittent tributaries of the Brazos and Navasota; often in areas where edaphic or hydrologic factors limit competition.	E	E	E	Fayette
MAMMALS						
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges			C2	Bexar, Colorado

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

essential habitat for the Attwater's prairie Chicken[16]; however, no Attwater's Prairie Chicken currently occupy the area, and effects of the construction on this habitat should be minimal. Implementation of this alternative is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts.

Some species of concern which are not endangered or threatened occur within a 1-mile corridor of the transmission pipeline. Cagle's map turtle (*Graptemys caglei*), is known to exist in the San Marcos River in Gonzales County near the point of junction with the proposed pipeline route. Cagle's map turtle is listed as a candidate species by both the U.S. Fish and Wildlife Department and the Texas Organization for Endangered Species (TOES). The range of Cagle's map turtle is scattered throughout the Guadalupe and San Antonio River systems in the slow-moving pools and impoundments with exposed rocks, cypress knees, and logs. One vascular plant on the TOES watch list is known to exist within the 1-mile corridor; Parks'

16 Attwater's Prairie Chicken Recovery Team, 1983, Attwater's Prairie Chicken Recovery Plan. U.S. Fish and Wildlife Service.

Jointweed (*Polygonella parksii*), which has been documented to occur within the corridor in Guadalupe County. This plant prefers deep loose sands for substrate. Three other rare plants occur within the pipeline corridor in Gonzales county: Smooth Blue Star (*Amsonia glaberrima*), Texas Taushia (*Taushia texana*), and Texas Pink-root (*Spigelia texana*). These plants are considered to be rare species of concern by the Natural Heritage Program, but do not have federal or state status.

Several species potentially affected by the project are associated with the rivers. The blue sucker (*Cycleputs elongatus*) and Guadalupe Bass (*Micropterus treculi*) may have habitat near the proposed reservoir near the Colorado River and transmission pipeline at the Guadalupe River. The Guadalupe Bass is listed as a candidate (C2) for protection by the U.S. Fish and Wildlife Department. The Natural Heritage Program identifies the occurrence of Guadalupe bass both upstream and downstream of the proposed location of the intake on the Colorado River. The blue sucker is listed as a candidate (C2) for protection by the U.S. Fish and Wildlife Department and threatened by the Texas Parks and Wildlife Department. A recent study conducted by the LCRA[17] states that "Downstream of Columbus, the potential impact of diversions on the instream flows becomes substantial." The rock outcrops of the Colorado River between the City of Columbus and the Gulf of Mexico appear to provide significant spawning habitat for the blue sucker.[18]

Stream impoundment can result in environmental changes (e.g., reduced mixing energy, increased depth) that interact to produce a cascade of effects within and downstream of a newly created reservoir. The actual nature and intensity of these effects are largely dependent on characteristics of the particular site (e.g., reservoir capacity, ratio of depth to surface area, rate of water exchange, nutrient and sediment loading, biological community type). Studies of the reaches to aid in determining the location of intake structures on the Colorado River near Columbus should be conducted in order to avoid critical habitats for spawning and early life stages of fish such as the Blue sucker and the Guadalupe bass.

The conservation pool of the Cummins Creek Reservoir would extend 12 miles upstream. The Natural Heritage Program does not identify the presence of any endangered, threatened or

[17] Mosier D. T. and R. T. Ray, "Instream Flows for the Lower Colorado River: Reconciling Traditional Beneficial Uses With the Ecological Requirements of the Native Aquatic Community," LCRA, Austin, Texas, 1992.
[18] Ibid.

rare species in the area of the flood pool of the Cummins Creek Reservoir which would cover approximately 9,600 acres.

When potential protected species habitat or significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use, or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, could be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

All areas to be disturbed during construction should first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL 96-515), and the Archaelogical and Historical Preservation Act (PL 93-291).

5.15.4 Engineering and Costing

For this option, an off-channel reservoir would be constructed on Cummins Creek in Colorado County near Columbus. The reservoir could be used to either: A) store waters derived solely from the Cummins Creek watershed; or B) store a combination of water from the Cummins Creek watershed and unappropriated streamflow diverted from the nearby Colorado River. The firm yield of the reservoir would then be conveyed to the major municipal demand center of the South Central Texas Region through a 132-mile transmission pipeline.

The facilities that would have to be constructed for this water supply option depend upon whether the reservoir is operated with or without the Colorado River diversion. Thus the facilities required and their associated costs are discussed in two parts. However, because the firm yield of the Cummins Creek Reservoir without the Colorado River diversion is only 15,453 acft/yr, this alternative (A) is only evaluated as a potential raw water supply at the reservoir site in Colorado County.

5.15.4.1 Alternative A — Cummins Creek Reservoir without Colorado River Diversion

The major facilities required for this alternative are itemized in Table 5.15-4. The primary capital cost item would be the off-channel reservoir itself. The dam would be a 7,800-

Table 5.15-4.
Cost Estimate for Option SCTN-15

Item	Alternative A (without Colorado River Diversion)	Alternative B (with Colorado River Diversion)
Capital Costs		
Reservoir (132,700 acft; 6,600 ac; 256 ft-msl)	$48,863,000	$48,863,000
Channel Dam (500 ft., 15-feet high)	N/A	3,038,000
River Intake and Pump Station (800 cfs peak capacity)	N/A	10,539,000
River Diversion Pipeline (3.8 miles; two 120-inch pipes)	N/A	22,353,000
Reservoir Intake and Pump Station	N/A	6,333,000
Transmission Pump Stations (2)	N/A	9,062,000
Transmission Pipeline (54-inch dia.; 132 miles)	N/A	114,008,000
Water Treatment Plant (43.0 MGD)	N/A	30,527,000
Distribution	N/A	55,329,000
Power Connection Costs ($125/HP)	N/A	3,655,000
Total Capital Cost	**$48,863,000**	**$303,707,000**
Engineering, Contingencies, Legal Costs	$17,102,000	$98,000,000
Environment & Archaeology Studies, Mitigation, and Permitting	24,715,000	28,446,000
Land Acquisition and Surveying ([9,567] 10,241 acres)	25,193,000	31,942,000
Interest During Construction (4 years)	18,540,000	73,935,000
Total Project Cost	**$134,413,000**	**$536,030,000**
Annual Costs		
Debt Service (6 percent, 30 years)	N/A	$28,814,000
Debt Service (6 percent, 40 years)	$8,933,000	$9,265,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	N/A	2,103,000
Water Treatment Plant	N/A	3,451,000
Dams and Reservoir	733,000	779,000
Distribution System	N/A	553,285
Pumping Energy Costs		
Reservoir and Pipeline (102.3 million kWh @ $0.06 per kWh)	N/A	5,325,000
Colorado River Div. (21.7 million kWh @ $0.06 per kWh)	N/A	480,000
Total Annual Cost	**$9,666,000**	**$50,770,000**
Available Project Yield (acft per year)	**15,453**	**45,712**
Annual Cost of Water ($/acft) Treated Water Distributed[1]	**$626**	**$1,111**
Annual Cost of Water ($/1,000 gallons)	**$1.92**	**$3.41**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

foot rolled earthfill structure rising about 109 feet above the streambed at maximum height. The cost of this structure is estimated to be $48.86 million.

Another associated cost would be the purchase of the land inundated by the reservoir, including the flood pool. The total land area of the flood pool would be 9,567 acres. A general land cost of $2,000 per acre was used to value the land to be purchased. However, a 1000-foot-wide corridor, 15.4 miles in length, along the Cummins Creek bottom and a primary tributary was estimated to cost $5,000 per acre. The total land purchase cost, including surveying, was $25.19 million.

Engineering, contingencies, legal costs, and other studies were estimated to cost a total of $41.82 million. This brings the total project cost for the Cummins Creek Reservoir without the Colorado River diversion to $134.41 million.

Financing the reservoir and associated reservoir cost would be done with a 40-year finance period and a 6 percent annual interest rate. This results in an annual cost of $8.93 million. Operation and maintenance for the dam and reservoir would cost an estimated $733,000 annually. The annual costs, including debt repayment, interest, and operation and maintenance, total $9.67 million. For an annual supply of 15,453 acft, the resulting annual cost of this raw water supply is $626 per acft at the reservoir.

5.15.4.2 Alternative B — Cummins Creek Reservoir with Colorado River Diversion

With this alternative, the addition of the Colorado River diversion increases the firm yield of the project to 45,712 acft/yr. However, several other major facilities would be required to deliver this water to the South Central Texas Region. The river intake and large pumping station are obviously necessary facilities for diverting water from the Colorado River. The river intake, pumping station, and short delivery pipelines (3.79 miles) are sized to divert up to 800 cfs from the Colorado River to the off-channel reservoir. The intake and pump station are estimated to cost a total of $10.54 million, while the short pipelines (two at 120 inches in diameter) would cost $22.35 million. Also required is a low-head channel dam for the pump intakes. The channel dam is estimated to cost $3.04 million.

The largest capital cost item would be for the approximately 132-mile pipeline that would deliver water from the Cummins Creek Reservoir at a uniform rate to the major municipal demand center of the South Central Texas Region, as shown in Figure 5.15-1. Delivery of 45,712 acft/yr would require a 54-inch diameter pipeline that costs approximately $114.01 million.

Associated with the pipeline are the initial reservoir transfer pump station and the transmission pump stations along the length of the pipeline. These pump stations are estimated to cost approximately $15.40 million. Another important capital cost is $55.33 million for distribution. Land acquisition and surveying for the pipeline right-of-way and associated pump stations would be another $6.75 million in addition to the $25.19 million for the Cummins Creek Reservoir. This brings the total land purchase and surveying cost to $31.94 million.

With engineering, contingencies, legal costs, and other studies, the total project cost for the Cummins Creek Reservoir utilizing the Colorado River diversion would be $536.03 million.

The reservoir portion of the project would be financed over 40 years at a 6 percent annual interest rate and the other portions of the project would be financed over 30 years at a 6 percent annual interest rate for an annual cost of $38.08 million. Operation and maintenance costs total $6.89 million annually. Large annual costs are associated with the pumping of Colorado River water to the off-channel reservoir and the subsequent delivery from Columbus to the South Central Texas Region. With the necessary vertical lift and friction losses along the pipeline, the annual pumping costs are estimated to be $5.81 million.

The total annual costs, including debt repayment, interest, and operation and maintenance, total $50.77 million. For an annual supply of 45,712 acft, the resulting cost of water of would be $1,111 per acft, or $3.41 per 1,000 gallons.

5.15.5 Implementation Issues

This option includes the construction of a reservoir to impound the waters of Cummins Creek near Columbus. Also included is a diversion of unappropriated water from the nearby Colorado River. This would require obtaining new water rights for the Cummins Creek Reservoir and the Colorado River diversion. The water pumped to the South Central Texas Region would also constitute an interbasin transfer.

An institutional arrangement is needed to implement the projects, including financing on a regional basis.

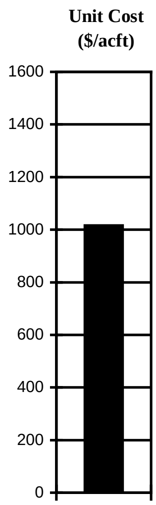
Requirements Specific to Reservoir and River Diversion

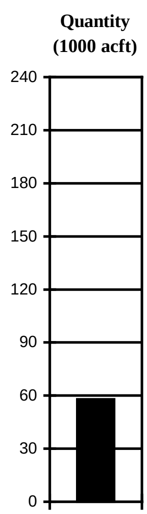
1. It will be necessary to obtain the following:
    a. TNRCC Water Right and Storage Permits.
    b. TNRCC Interbasin Transfer Approval
    c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and diversion pipelines.
    d. General Land Office (GLO) Sand and Gravel Removal review.
    e. GLO Easement for use of state-owned land.
    f. Coastal Coordination Council review.
    g. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
    a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
    b. Habitat mitigation plan.
    c. Environmental studies.
    d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoir could include:
    a. Utilities

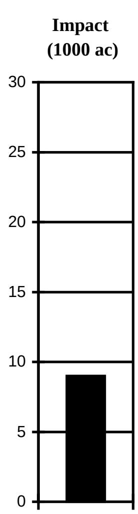
Requirements Specific to the Transmission Pipeline

1. Necessary permits:
    a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
    b. GLO Sand and Gravel Removal permits.
    c. TPWD Sand, Gravel and Marl permit for river crossings.
2. Right-of-way and easement acquisition.
3. Crossings:
    a. Highways and railroads
    b. Creeks and rivers
    c. Other utilities

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 11/16/99







OPTION NUMBER: B-10C
OPTION NAME: Allens Creek Reservoir — Firm Yield

OPTION DESCRIPTION:
TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$1,016**	**per acft[1] Treated Water Distributed**
QUANTITY OF WATER:	**57,800**	**acft/yr[2]**
LAND IMPACTED:	**9,036**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Allens Creek dam and reservoir, reservoir intake and pump station, river diversion, intake and pump station, raw water pipeline to Allens Creek Reservoir, raw water pipeline to water treatment plant, three transmission pump stations, water treatment plant, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** Unappropriated runoff from the 58.3 square mile Allens Creek watershed, diversions of unappropriated flood flows of the Brazos River, and stored water in Allens Creek Reservoir. Instream flow requirements could affect quantities available from Allens Creek and the Brazos River.

[3]**LAND IMPACTED:** Reservoir (conservation pool), water treatment plant sites, and pipeline right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Transfer of species not presently observed in the South Central Texas Region.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, mitigation requirements, and ability to incorporated into a regional plan that realizes economies of size and benefits all participants. Implementation of this option based on a greater quantity of water or in combination with other options may reduce the unit cost of water.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Brazos River Basin water to the South Central Texas Region. The 76th Texas Legislature passed SB1593 authorizing the TWDB to initiate project development and directing TNRCC to reissue abandoned permit and grant water rights to the TWDB.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None.

5.16 Allens Creek Reservoir — Firm Yield (B-10C)

5.16.1 Description of Option

Allens Creek Reservoir is a proposed 168,000 acft off-channel reservoir located on Allens Creek, a small tributary of the Brazos River in Austin County. The reservoir site is located 2 miles north of the town of Wallis, Texas. The location of the reservoir is shown in Figure 5.16-1. The project would impound water available from the Allens Creek watershed, as well as water diverted and pumped from the Brazos River during periods of flow in excess of downstream needs. In the 76th Texas Legislative Session, SB 1593 (sponsored by Senator J.E. Brown) was passed including the following provisions:[1]

a) Authorizes the Texas Water Development Board (TWDB) to use the state participation program to purchase up to 50 percent interest in the Allens Creek Reservoir project, including 100 percent of the reservoir site;

b) Directs the Texas Natural Resource Conservation Commission (TNRCC) to reissue the abandoned Allens Creek water rights permit upon application by the TWDB; and

c) Grants the TWDB additional water rights to the unappropriated flows of the Brazos River and Allens Creek.

The Allens Creek Reservoir project was originally proposed by Houston Lighting and Power Co. (HL&P) as a cooling lake for a nuclear power plant and the site was studied in 1974 by URS/Forrest and Cotton.[2] URS completed a second study in 1977 with a different dam alignment and smaller reservoir.[3] HL&P eventually abandoned plans for a power plant at the Allens Creek site and the Brazos River Authority (BRA) obtained an option to purchase the reservoir site from HL&P. In 1988, BRA retained Freese & Nichols to study the yield and cost of the proposed reservoir.[4] As part of the Trans-Texas Water Program, Freese & Nichols and Brown & Root reevaluated the firm yield of the reservoir with the application of the Trans-Texas Environmental Criteria.[5]

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[1] TWDB, "76th Texas Legislative Session Wrap-up Report," June 1999.
[2] URS/Forrest and Cotton, "Allens Creek Dam and Reservoir on Allens Creek, Brazos River Basin, Austin County, Texas" (prepared for Houston Lighting and Power Company), January 1974.
[3] URS/Forrest and Cotton, "Allens Creek Dam and Reservoir on Allens Creek, Brazos River Basin, Austin County, Texas" (prepared for Houston Lighting and Power Company), July 1977.
[4] Freese & Nichols, Inc., "Yield Analysis and Cost Estimate for Allens Creek Reservoir," Brazos River Authority, February 1989.
[5] Brown & Root, Inc. and Freese & Nichols, Inc., "Trans-Texas Water Program, Southeast Area Phase I Report", March 1994.

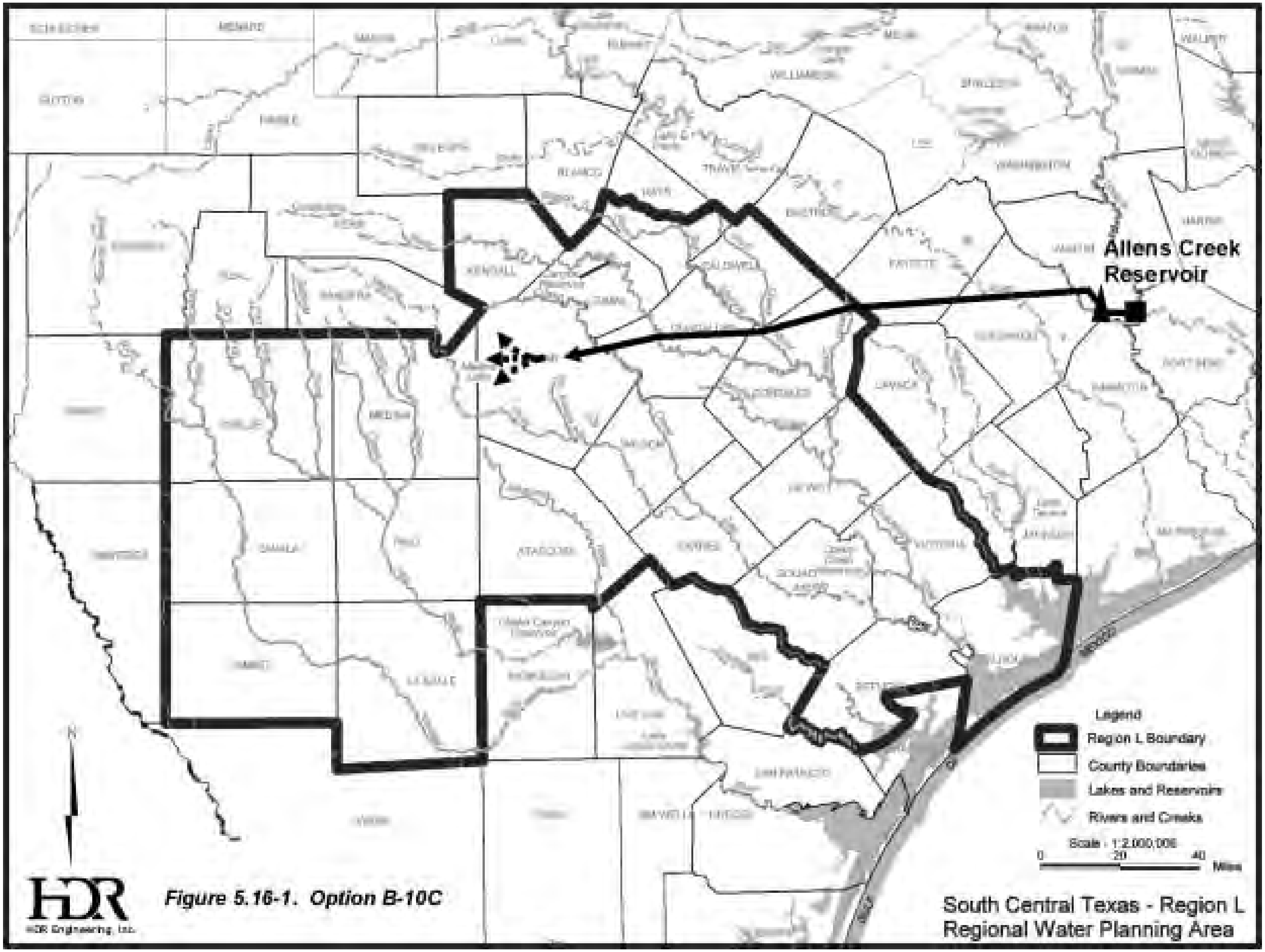

Figure 5.16-1. Option B-10C

The dam configuration studied by Freese & Nichols is the layout from the 1974 URS report, with minor changes. The dam would be a 26,200-foot earthfill embankment with a top width of 20 feet and 3-to-1 side slopes on both the upstream and downstream sides. The top of the embankment would be at elevation 136.5 feet-mean sea level (ft-msl); the probable maximum flood elevation in the reservoir would be 129.2 ft-msl; and the top of the conservation pool would be at elevation 118.0 ft-msl with a surface area of 8,250 acres. Approximately 6 miles of stream channel along Allens Creek would be inundated by the reservoir.

The outlet works would consist of a 60-inch diameter pipe in the spillway and a 500-foot uncontrolled concrete ogee spillway with a crest elevation of 118.0 ft-msl. Because the Brazos River would reach the embankment under high flow conditions, slope protection would be needed to protect the downstream face of the dam below elevation 120.0 ft-msl as well as the entire upstream face. The design flood on the Brazos River exceeds the spillway elevation and the spillway would be designed to accommodate flow from the river into the reservoir. Two small dikes of compacted earthfill on the southern shore of the reservoir would be needed to raise the shoreline above the elevation of the Allens Creek probable maximum flood.

Diversion facilities on the Brazos River would include a gated intake channel, pump station, two parallel pipelines to the reservoir, and a discharge structure in the reservoir.

5.16.2 Available Yield

The Allens Creek drainage area controlled by the reservoir would be 58.3 square miles and water available for storage from the watershed during the critical drought period was estimated to be 3,407 acft/yr. To create a more significant project yield, water must be pumped into the reservoir from the Brazos River during times when flow in the river is sufficient to satisfy senior downstream water rights. Freese & Nichols[6] reports that the Texas Water Commission estimated the volume of unappropriated water in the Brazos at the proposed diversion to be an average of 3,137,000 acft/yr, with a minimum annual volume of 40,800 acft (1956), and a maximum annual volume of 8,854,000 acft (1957). During the critical drought period from March 1954 through February 1957, an average of 174,756 acft/yr would be available. These estimates were computed on a monthly basis, using historical flows between

[6] Freese & Nichols, Inc., Op. Cit., February 1989.

1947 and 1976 adjusted to reflect watershed conditions and existing water rights as of June 30, 1986; no instream or bay and estuary inflow requirements were applied.

The volume of Brazos River water that can be diverted and stored is limited by the capacity of the diversion pumps and by the daily flow distribution in the Brazos River, as well as by the reservoir storage volume. In 1994, Freese & Nichols/Brown & Root[7] updated previous yield studies of Allens Creek Reservoir for application of the Trans-Texas Environmental Criteria and recent water rights granted. They estimated that for a diversion rate of 820 cfs, the project firm yield would be 57,800 acft/yr and for a diversion rate of 1,900 cfs, the firm yield would increase to 85,000 acft/yr. Substantially greater quantities of dependable water supply could be available at this location with the purchase of stored water available in upstream reservoirs from the Brazos River Authority (BRA). For purposes of this study, the river diversion rate was assumed to be 820 cfs resulting in a firm yield of 57,800 acft/yr.

Should this project become a component of an alternative regional water supply option for the South Central Texas Region, a reservoir operations study based on Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B) could be undertaken.

5.16.3 Environmental Issues

The proposed Allens Creek Reservoir will provide two benefits: 1) a uniform delivery rate regardless of Brazos River flows, allowing the transmission pipeline to be fully utilized year round, and 2) sedimentation of suspended material during storage, prior to placement in the cross-country transmission pipeline. This option includes a transmission pipeline from Allens Creek Reservoir to the crossing of IH-10 and the Colorado River, and would use the same transmission pipeline corridor from the IH-10 and Colorado River crossing to the major municipal demand center of the South Central Texas Region as that identified for Options C-17A, C-18, and SCTN-15. The transmission pipeline from the proposed Allens Creek Reservoir begins in Omernik's Western Gulf Coastal Plains Ecoregion[8] (southern Austin County). It then extends across the East Central Texas Plains (northern Austin County and

[7] Brown & Root, Inc. and Freese & Nichols, Inc., Op. Cit., March 1994.
[8] Ibid.

eastern Colorado County) and Texas Blackland Prairies Ecoregions (western Colorado County) before reaching the IH-10 and Colorado River crossing.

The proposed Allens Creek Reservoir is located in the Western Gulf Coastal Plain as described by Omernik.[9] This ecoregion is distinguished by its mosaic of bluestem and sacahuista grasses, croplands and grazing lands. Soils are primarily vertisols. Gould categorizes this area as being in the Gulf Prairies and Marshes vegetational region of Texas,[10] which is a prairie region extending inland from the Gulf of Mexico to elevations near 150 feet. It is a mosaic of grasslands and savannahs dissected by streams flowing into the Gulf. Live oak woodlands and narrow belts of low wet marsh occur immediately adjacent to the coast. Correll and Johnston described the climax vegetation as being tall grass prairie and post oak savannah, such as big bluestem, seacoast bluestem, Indian grass, eastern gama grass, gulf muhly, species of *Panicum* and others.[11] However the climax vegetation has generally been reduced to small areas and replaced with mesquite, oak, prickly pear, and several *acacias*.

Blair categorizes this area as being in the Texan Biotic Province.[12] The Texan Biotic Province as described by Blair is a broad ecotone between western grasslands and eastern forests. Blair's biogeographical listing of wildlife fauna for this province is a mix of western grassland-associated and eastern forest associated species.

The two dominant soil types found in the area to be inundated by the proposed reservoir consist mainly of Brazoria Clays. Brazoria Clay (BrA), 0 to 1 percent slopes, and the Brazoria Clay (Bs), depressional, are both deep level soils on flood plains adjacent to the Brazos River. Brazoria clays are moderately alkaline, calcareous, and poorly drained. Surface runoff and permeability are slow, the available water capacity is high and erosion hazard is slight. The BrA soil (0 to 1 percent slopes) is used mainly for pasture and crops, is well suited to corn, soybeans, and forage sorghums, and is poorly suited to urban uses. Brazoria depressional soil is slightly lower than surrounding soils and is subject to flooding for short periods. It is used mainly for pasture and range, with some areas in cropland. This soil is poorly suited to urban use because of the hazard of flooding.

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[9] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[10] Gould, F.W., "The Grasses of Texas," Texas A & M University Press, College Station, Texas, 1975
[11] Correll, D.S., and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.
[12] Blair, W. F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.

The Allens Creek Reservoir site is presently used primarily for farm land and pasture, but it still supports large stands of trees and associated vegetation.[13] The riparian vegetation consists of cedar, elm, black willow, hackberry, soapberry, pecan, ash, and poison oak. The area that would be inundated by the proposed reservoir is a complex mosaic of woodlands, grasslands and croplands that have a steady water supply and together provide a high quality habitat for a wide variety of species.[14]

Direct impacts of the proposed reservoir would include construction of the dam, inundation of 8,250 acres of primarily bottomland hardwoods and croplands, the withdrawal of water from the Brazos River, and the construction of a pipeline and right-of-way maintenance from Allens Creek to the major municipal demand center of the South Central Texas Region. The construction of the 157-mile pipeline would include the clearing and removal of woody vegetation and the pipeline right-of-way (763 acres) would be maintained for the life of the project. Locating the pipeline right-of-way in previously disturbed areas, such as crop and pasturelands can minimize impacts on wildlife habitats. A cleared pipeline right-of-way through a woodland or brushy habitat could be beneficial to some wildlife by providing edge habitat, except where fragmented habitat remnants do not suffer a shortage of edges.

The Natural Heritage Program reports occurrences of the Attwater's Prairie Chicken (*Tympanuchus cupido attwateri*) and White-tailed Hawk (*Buteo albicaudatus*), which prefer coastal prairies, on or near the transmission pipeline. Along with the mapped bird species, the protected Houston Toad (*Bufo houstonensis*), which was reintroduced into Colorado County and prefer to live in ponds that are surrounded by forest or grass, and the Smooth Green Snake (*Liochlorophus vernalis)* are found within the corridor and reservoir site. Plant species that are confirmed and located in the study area include Flatsedge (*Cyperus grayioides*), Crown Coreopsis (*Coreopsis nuecensis*), and the Sunflower (*Helianthus occidentalis*).

The Guadalupe Bass (*Micropterus treculi*) was located up and downstream from the pipeline corridor. The upstream species will not be affected by construction, while the others might incur adverse affects. The Toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) occupy the Edwards Aquifer under the City of San Antonio and are

[13] Freese & Nichols, Inc., Op. Cit., February 1989.
[14] Ibid.

found at the west end of the pipeline route. As a result of the potential increase in recharge to the aquifer by this option, these fish species may be affected if water quality diminishes.

In addition to the Attwater's Prairie Chicken and White-tailed Hawk, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Black-capped Vireo, Golden-cheeked Warbler, Interior Least Tern, Mountain Plover, White-faced Ibis, Whooping Crane, and Wood Stork) are reported to occur within the project counties. Several protected species occurrences have been confirmed in the vicinity, such as the Texas Tortoise (*Gopherus berlandieri*), Texas Horned Lizard (*Phrynosoma cornutum*), Indigo Snake (*Drymarchon corais erebennus*), and Texas Garter Snake (*Thamnophis sirtalis annectens*). These remnant communities and the habitat of those protected species should be avoided where practical. Other species that may inhabit the site are listed in Table 5.16-1.

The pipeline corridor will be traversing what is considered to be essential habitat for the Attwater's Prairie Chicken (APC).[15] The transmission line at Allens Creek Reservoir is approximately 2 miles east of the closest confirmed observation of APC, and is within 5 miles of 12 confirmed occurrences.[16] The APC is dependent on areas that are composed of more than 50 percent tall grass prairie climax species, such as big and little bluestem, Indian grass and brownseed paspalum. The effects of construction on this habitat would be minimal if a proper corridor is chosen. If appropriate revegetation and management procedures are employed within the transmission line right-of-way, the habitat could be managed for the benefit of the APC. Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize adverse impacts. Seasonal restrictions on construction may be imposed in APC habitat.

A 650-acre area of bottomland hardwood surrounding a pond, Alligator Hole, is located within the proposed conservation pool.[17] This bottomland hardwood community appears to be frequently inundated by flood flows and is considered to be wetland habitat (USGS, Wallis Quad) which would probably require mitigation. Wetland mapping has not been completed for this area, so a detailed inventory of wetland types is not available for this assessment. An on-site

[15] United States Fish and Wildlife Service, "Attwater's Prairie Chicken Recovery Plan," Albuquerque, NM. vii + 48 pp., 1992.
[16] Texas Parks and Wildlife Department, Resource Protection Division, Natural Heritage Program. 1994
[17] Freese & Nichols, Inc., Op. Cit., February 1989.

Table 5.16-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Allens Creek Reservoir (B-10C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	PE		NL	Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE		NL	Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T	T	E	Nesting/Migrant
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plain; 50% climax grass species composition	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T	E	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils			NL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Flatsedge	*Cyperus grayioides*	Pineywood regions[6]				
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodland canyons; usually under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	PE		NL	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	PE		NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident

Table 5.16-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency: USFWS[1]	Listing Agency: TPWD[1]	Listing Agency: TOES[2,3]	Potential Occurrence in County
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened with silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	PE		NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	PE		NL	Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	PE		NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]			NL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T	NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands; shallow sandy to clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Sunflower	*Helianthus occidentalis*	Blooms late summer-fall				Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]			NL	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident

Table 5.16-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	Listing Agency TPWD[1]	Listing Agency TOES[2,3]	Potential Occurrence in County
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	PE		NL	Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	PE		NL	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Checklist of Vascular Plants of Texas. Internet. Texas Parks and Wildlife Homepage. Online. www.tpwd.state.tx.us.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status

survey to delineate wetlands would likely be required in future phases of implementation of this water supply option.

There are several protected and candidate species listed for Austin and some of the surrounding counties that may have habitat in the vicinity of the proposed reservoir. Species of particular concern are the Attwater's Prairie Chicken, which prefer native prairie remnants, the Timber Rattlesnake, Black-spotted Newt, White-faced Ibis, Rio Grande Lesser Siren, Sheep Frog and Texas Meadow-Rue, which prefer bottomland hardwoods, marshes and other wetland areas. The species in Table 5.16-1 would require an on-site survey and possibly require mitigation if impacted by the proposed reservoir.

The water quality of natural runoff into the proposed Allens Creek Reservoir is not known. The Brazos River Basin's overall surface water quality is relatively good, with only localized areas of concern, such as natural and man-made salt pollution, and localized problems of low dissolved oxygen and elevated fecal coliform levels.[18] Specific water quality assessments will likely be completed in later phases of the implementation, if diversions from the Brazos River to the proposed Allens Creek Reservoir should continue to be considered as a viable water supply option.

The firm yield of Option B-10C was calculated without reference to the Consensus Environmental Criteria, as it is uncertain what flow criteria (in any) will be applied pursuant to the provisions of SB1593. Neither changes in instream flows nor freshwater inflows to the Gulf of Mexico are tabulated for this option. The Brazos River has already filled its Pleistocene river valley with sediments, so that its estuary consists only of the lower few miles of channel before it discharges into the Gulf of Mexico.

Cultural resources protection on public lands in Texas, or lands affected by projects regulated under Department of the Army permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided. Previous investigations have revealed large numbers of archaeological sites around the perimeter of the proposed reservoir.[19] It is probable that some further testing and mitigation in the reservoir pool would be needed.

5.16.4 Engineering and Costing

Pump station and transmission pipelines have been sized and costed for one annual delivery volume based on run-of-river diversions from the Brazos River and management of storage in Allens Creek Reservoir. This scenario produces a firm yield of 57,800 acft/yr. Additional firm supply could be obtained with the purchase and delivery of water stored in upstream reservoirs operated by BRA.

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[18] Texas Water Development Board (TWDB), "Water for Texas; Today and Tomorrow," TWDB, Austin, Texas, December 1990.
[19] Freese & Nichols, Inc., Op. Cit., February 1989.

For this option, the firm yield of the proposed reservoir would be diverted through an intake and pumped in a transmission line to the major municipal demand center of the South Central Texas Region (Figure 5.16-1). The diversion rate from the reservoir would be uniform throughout the year. The benefit from this project would be the addition of a new water supply source to the San Antonio distribution system, other municipal systems in the surrounding area, and/or the Edwards Aquifer (through enhancement of recharge). The major facilities required to implement this option are:

- River Diversion, Intake, and Pump Station
- Pipeline from River Pump Station to Reservoir
- Dam and Reservoir
- Reservoir Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Raw Water Pipeline Transmission Pump Stations, 3 required
- Water Treatment Plant (Level 3)
- Distribution

The river intake and pump station are sized to deliver up to 50,000 acft/month through two 120-inch diameter pipes. The reservoir intake and pump station is sized to deliver 54.3 MGD through a 60-inch diameter transmission pipeline. The operating cost was determined for an annual raw water delivery of 57,800 acft/year. Financing the reservoir costs over 40 years and the pipeline and other costs over 30 years at a 6 percent annual interest rate results in an annual expense of $41,955,000 (Table 5.16-2). Operation and maintenance and pumping energy costs total $16,756,000 per year. Hence, the total annual cost of the project is estimated to be $58,711,000. For an annual firm yield of 57,800 acft, the resulting annual cost of water is $1,016 per acft (Table 5.16-2).

Table 5.15-2.
Cost Estimate Summary for
Allens Creek Reservoir (B-10C)
(Second Quarter 1999 Prices)

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (Conservation Pool: 168,000 acft; 8,250 acres; 118 ft-msl)	$54,194,000
Diversion Facilities	$14,147,000
Intake and Pump Station (54.3 MGD)	$7,458,000
Water Treatment Plant (54.3 MGD)	$37,467,000
Transmission Pump Stations (3)	$20,411,000
Transmission Pipeline (60-inch dia., 157 miles)	$154,238,000
Distribution	67,675,000
Total Capital Cost	**$355,590,000**
Engineering, Legal Costs and Contingencies	$116,657,000
Environmental & Archaeology Studies and Mitigation	$19,980,000
Land Acquisition and Surveying (10,210 acres)	$23,847,000
Interest During Construction (4 years)	82,573,000
Total Project Cost	**$598,647,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$33,605,000
Reservoir Debt Service (6 percent for 40 years)	$8,350,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$3,129,000
Dam and Reservoir	$842,000
Water Treatment Plant	$4,362,000
Pumping Energy Costs (140,386,665 kWh @ 0.06 $ per kWh)	8,423,000
Total Annual Cost	**$58,711,000**
Available Project Yield (acft/yr)	57,800
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	$1,016
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	$3.12

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated, and distributed to municipal systems or the Edwards Aquifer recharge zone.

5.16.5 Implementation Issues

Implementation of Allens Creek Reservoir would not directly affect the feasibility of other water supply options under consideration, except to the extent that treated effluent from this imported supply may contribute to streamflow and water availability in the South Central Texas Region

An institutional arrangement is needed to implement this project, including financing, on a regional basis.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. Texas Parks and Wildlife Department (TPWD) Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired by negotiations or condemnation.
4. Relocations may include:
   a. Highways and railroads.
   b. Other utilities.
   b. Creeks and rivers.
   c. Other utilities.

6.1 Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (CZ-10C)

6.1.1 Description of Option

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa River, the aquifer has been extensively developed for many decades. East of the Atascosa River, the aquifer has had a moderate amount of development in Atascosa County and very limited development in Caldwell, Gonzales, Guadalupe, and Wilson Counties. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

The Evergreen Underground Water Conservation District (UWCD) includes Atascosa, Frio, Karnes, and Wilson Counties; the Gonzales County UWCD covers Gonzales County; the Wintergarden Groundwater Conservation District includes Dimmit, La Salle, and Zavala Counties; and the Live Oak UWCD covers Live Oak County. Each district has developed a water management plan and district rules and regulations that affect the export of groundwater.

Under this option, the development of a 40,000 and a 75,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the San Marcos and Frio Rivers (Figure 6.1-1) was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz/Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for a large municipal well field, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.

6.1.2 Available Yield

A review of existing reports,[1,2,3] the extent of other groundwater users in the area, and hydrogeologic data indicate that a well field(s) could be developed in a section of the Carrizo-

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[1] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[2] HDR Engineering, Inc. (HDR) and LBG-Guyton Associates (LBG), "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, August 1998.
[3] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

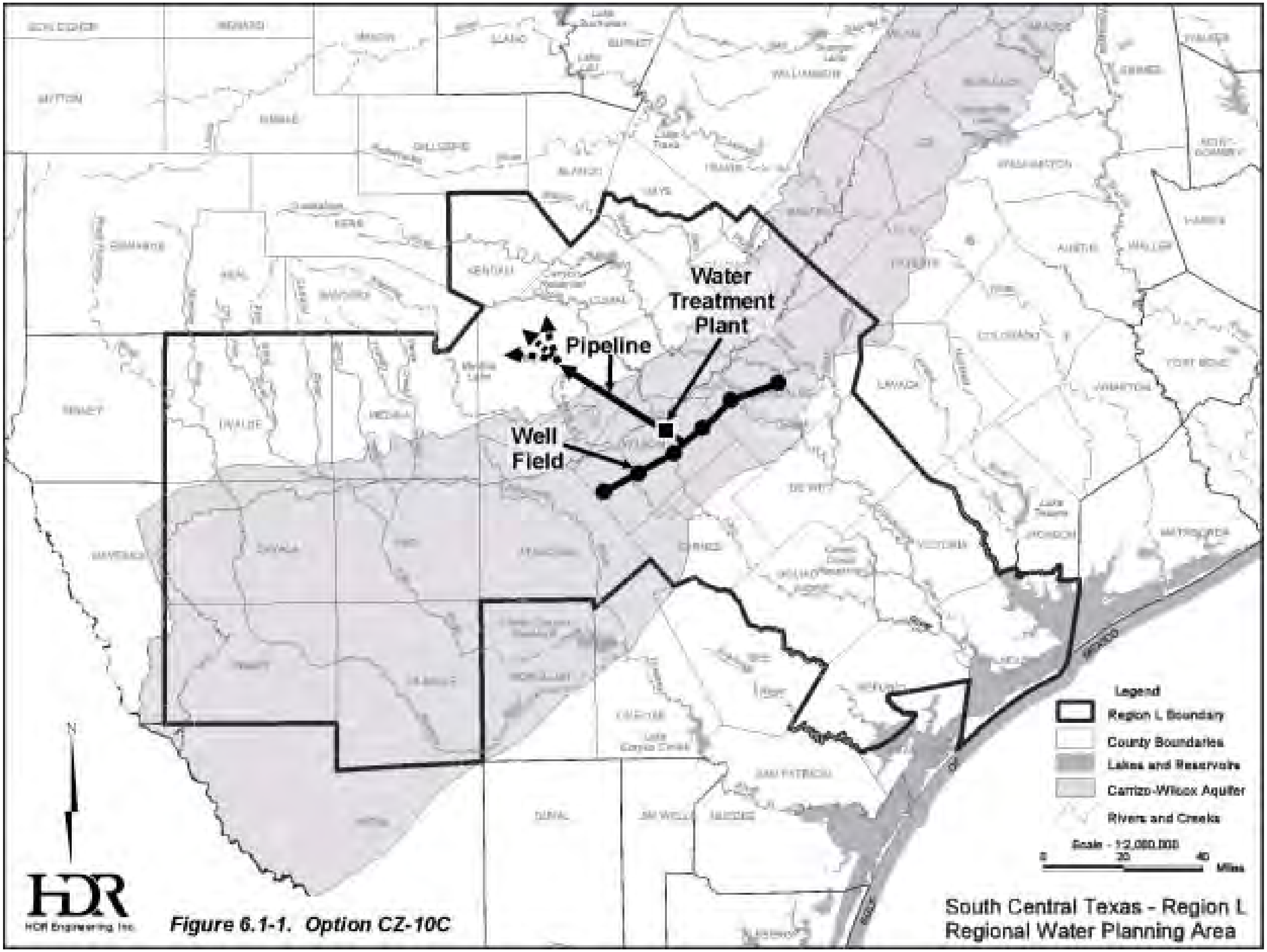


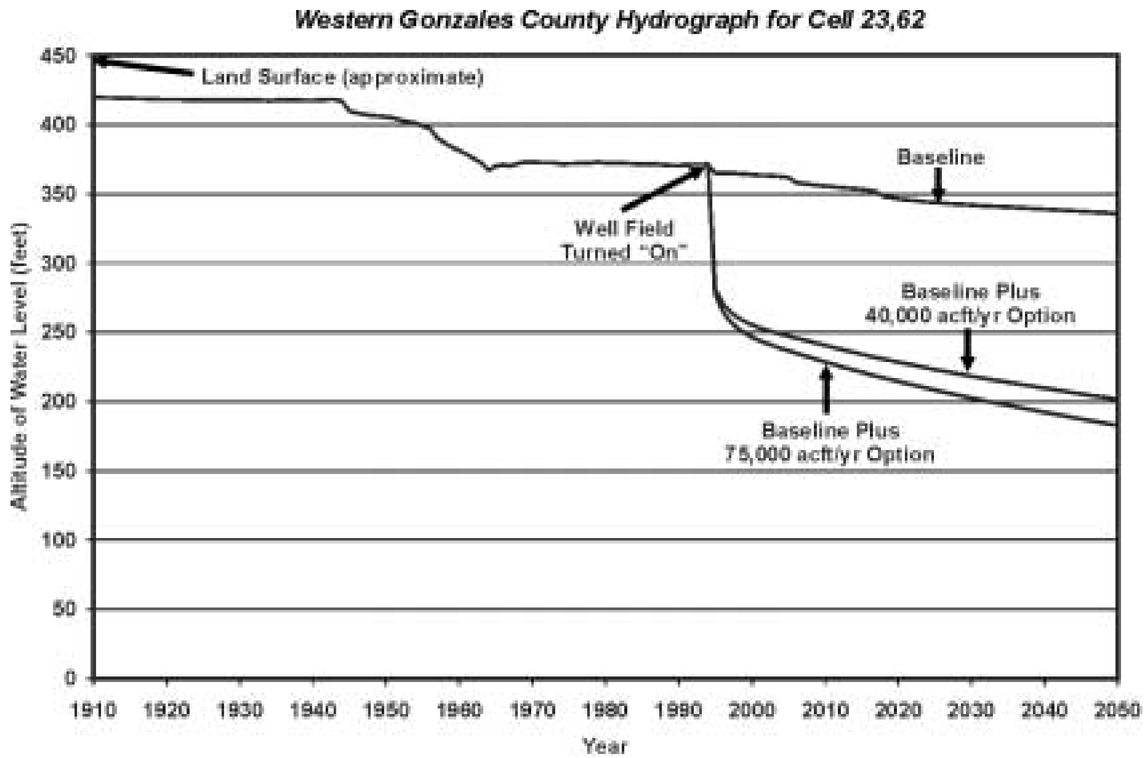
Figure 6.1-1. Option CZ-10C

Wilcox Aquifer that extends from southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County (Figure 6.1-1). This well field(s) would be separated at or "skip over" wells of the cities of Floresville and Stockdale. The projected needs of local entities and planned pumpages by Schertz and Seguin are included in the well field(s) being evaluated for this option.

Large capacity wells in the area typically produce 1,000 gallons per minute or more. With a contingency of 10 percent of the wells being out of service, the required number of wells would be 28 for the 40,000-acft/yr option and 52 for the 75,000-acft/yr option. Well spacings are planned to be about 1 mile.

To estimate the effects of the pumpage to meet projected local demands through 2050, planned pumpage by Schertz and Seguin, and Option CZ-10C pumpage (40,000 and 75,000 acft/yr), the "Interaction Between Groundwater and Surface Water in the Carrizo-Wilcox Aquifer" model was applied. The computer simulations indicate that pumpage to meet local needs to 2050 would result in water levels being drawn down between 30 and 40 feet in southwestern Gonzales and eastern Wilson Counties. With the additional pumpage of 20,000 acft/yr for Schertz/Seguin and 40,000 acft/yr for Option CZ-10C, water levels of the area would be drawn down an additional 120 feet for a total drawdown for local needs, Schertz/Seguin, and CZ-10C at 40,000 acft/yr of 150 to 160 feet. For the CZ-10C case of 75,000 acft/yr, water levels would be drawn down an additional 20 feet, for a drawdown of 170 to 180 feet when local, Schertz/Seguin, and CZ-10C (75,000 acft/yr) demands are considered. Southwest of the well field (Atascosa County), the drawdown would be about 120 feet and reflects the projected local Atascosa County pumpage, as well as the effect of the simulated pumpage in Wilson and Gonzales Counties.

To show the long-term change in water levels in the Carrizo Aquifer as a result of pumpage for historic conditions and CZ-10C options, water level hydrographs are shown for simulations from years 1910 to 2050 in Figure 6.1-2. Monitoring locations are cell 23,62 in western Gonzales County and cell 24,53 in west central Wilson County. These cell locations are in the well fields as outlined for this option. For the Gonzales County cell, the total drawdown from predeveloped conditions (1910) to end of the assessment (2050) is about 220 feet for the 40,000 acft/yr option and 245 feet for the 75,000 acft/yr option. The drawdowns are slightly less



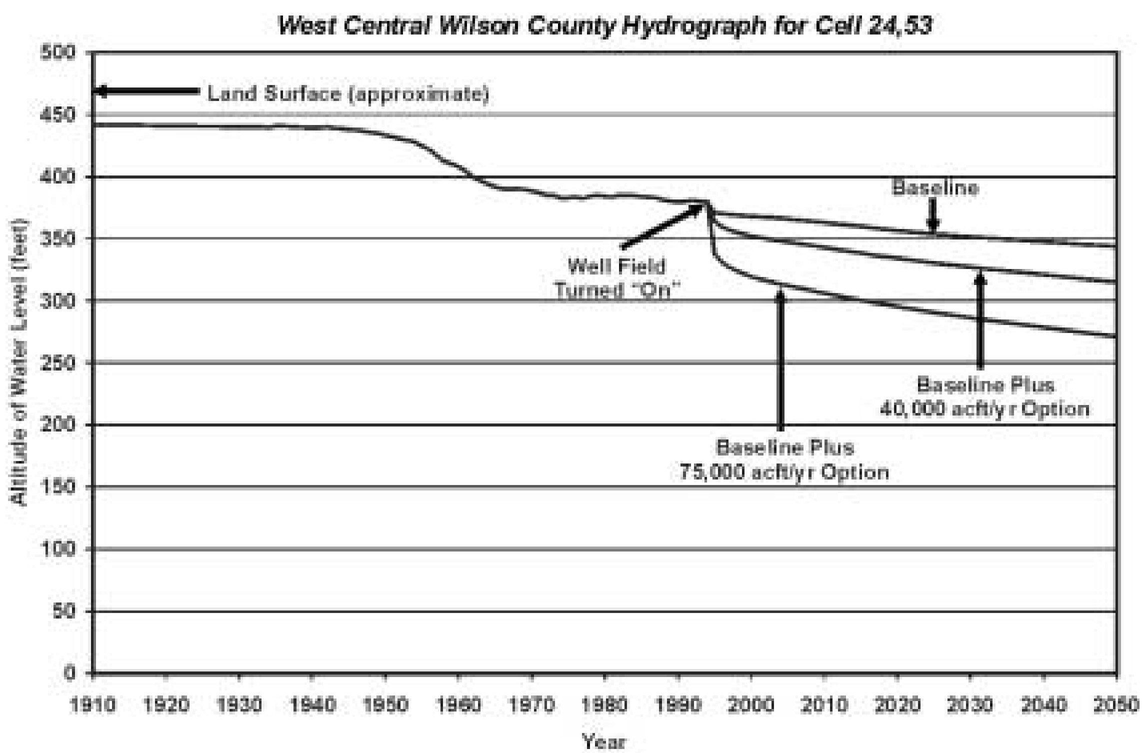


Figure 6.1-2. Hydrographs of Groundwater Levels

for the cell in Wilson County. For the Carrizo-Wilcox Aquifer, the TWDB calculated groundwater availability has two components, as follows. When water levels are less than 400 feet below land surface, groundwater availability is considered to be depletion from storage plus effective recharge. In Gonzales and Wilson Counties, the groundwater availability for the Carrizo-Wilcox Aquifer for both components is 47,033 and 43,391 acft/yr, respectively. For both projects, maximum depth of water levels below land surface is less than 400 feet in year 2050. As shown in Figure 6.1-2, the water levels are continuing to decline at a rate of about 1 foot per year in year 2050.

The combined effects of the development of groundwater under Option CZ-10C, the Schertz/Seguin plan, and local pumpage to meet projected local demands, are of importance at several locations on the Guadalupe and San Antonio Rivers. For comparative purposes, the streamflows at selected locations in the Guadalupe and San Antonio Rivers are computed by the Guadalupe-San Antonio River Basin Model (GSA Model)[4] for baseline and full development scenarios. The results are presented below.

As was done in previous studies,[5] to evaluate the impact of specified pumpage scenarios on surface water flows in the Guadalupe-San Antonio River Basin, changes in streamflows were extracted from the groundwater model runs and incorporated into the GSA River Basin Model based on comparison with historical streamflow. For this analysis, streamflows were compared at two locations: the San Antonio River at Falls City and the Guadalupe River at the Saltwater Barrier. As a baseline, the impacts due to expected local pumpage to meet local needs projected to 2050 on historical streamflows were computed and used as the baseline flow set for computing streamflow impacts due to additional pumpage scenarios.

As shown in Table 6.1-1, simulated average annual streamflows for the period of record simulated (1934 to 1989) on the San Antonio River at Falls city assuming baseline Carrizo-Wilcox Aquifer pumpage was computed to be 252,838 acft/yr. When the Schertz/Seguin pumpage of 20,000 acft/yr and the CZ-10C pumpage of 40,000 acft/yr are evaluated, average annual flows at Falls City would be reduced to 246,610 acft/yr (or a 2.5 percent reduction) (Table 6.1-1). Decreases in average annual flows during the historical drought of record (1947

[4] HDR, "Guadalupe-San Antonio River Basin Model Modifications and Enhancements," Trans-Texas Water Program, West Central Study Area, Phase II, San Antonio River Authority, et al., March 1998.
[5] HDR and LBG, Op. Cit., August 1998.

Table 6.1-1
Impacts to Streamflow Due to Additional Carrizo-Wilcox Pumpage
20,000 acft/yr for Schertz/Seguin plus 40,000 acft/yr for CZ-10C

Stream Location	Average Annual Streamflow (1934 to 1989) in acft			
	With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 60,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	246,610	-6,228	-2.5%
Guadalupe River at SWB[3]	1,591,727	1,575,249	-16,478	-1.0%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	80,818	-4,857	-5.7%
Guadalupe River at SWB[3]	507,563	496,796	-10,767	-2.1%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr of Schertz/Seguin and the 40,000 acft/yr of additional pumpage (CZ-10C).
[2] Additional pumpage taken from a well field in Wilson, and Gonzales Counties (20,000 acft/yr plus 40,000 acft/yr.)
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

to 1956) were computed to be 4,857 acft/yr (5.7 percent) with the additional (20,000 plus 40,000 acft/yr) Carrizo-Wilcox pumpage. Likewise, the simulated annual average streamflows at the Saltwater Barrier under baseline Carrizo-Wilcox Aquifer pumpage were computed to be 1,591,727 acft/yr and would be reduced to 1,575,249 acft/yr (or a 1.0 percent reduction) with additional 60,000 acft/yr pumpage of the aquifer (Table 6.1-1). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier would be reduced by 10,767 acft/yr (2.1 percent) with the additional pumpage (Table 6.1-1).

Figure 6.1-3 shows the impact of the additional 60,000 acft/yr (20,000 plus 40,000) pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at Falls City range from a minimum impact of 275 acft in January to a maximum of 717 acft in November. On an annual basis, annual median streamflows at Falls City would be reduced by 2.9 percent (5,667 acft/yr). Similarly, for the Guadalupe River at the Saltwater Barrier, the minimum impact to median monthly streamflows was computed to be 969 acft in September and

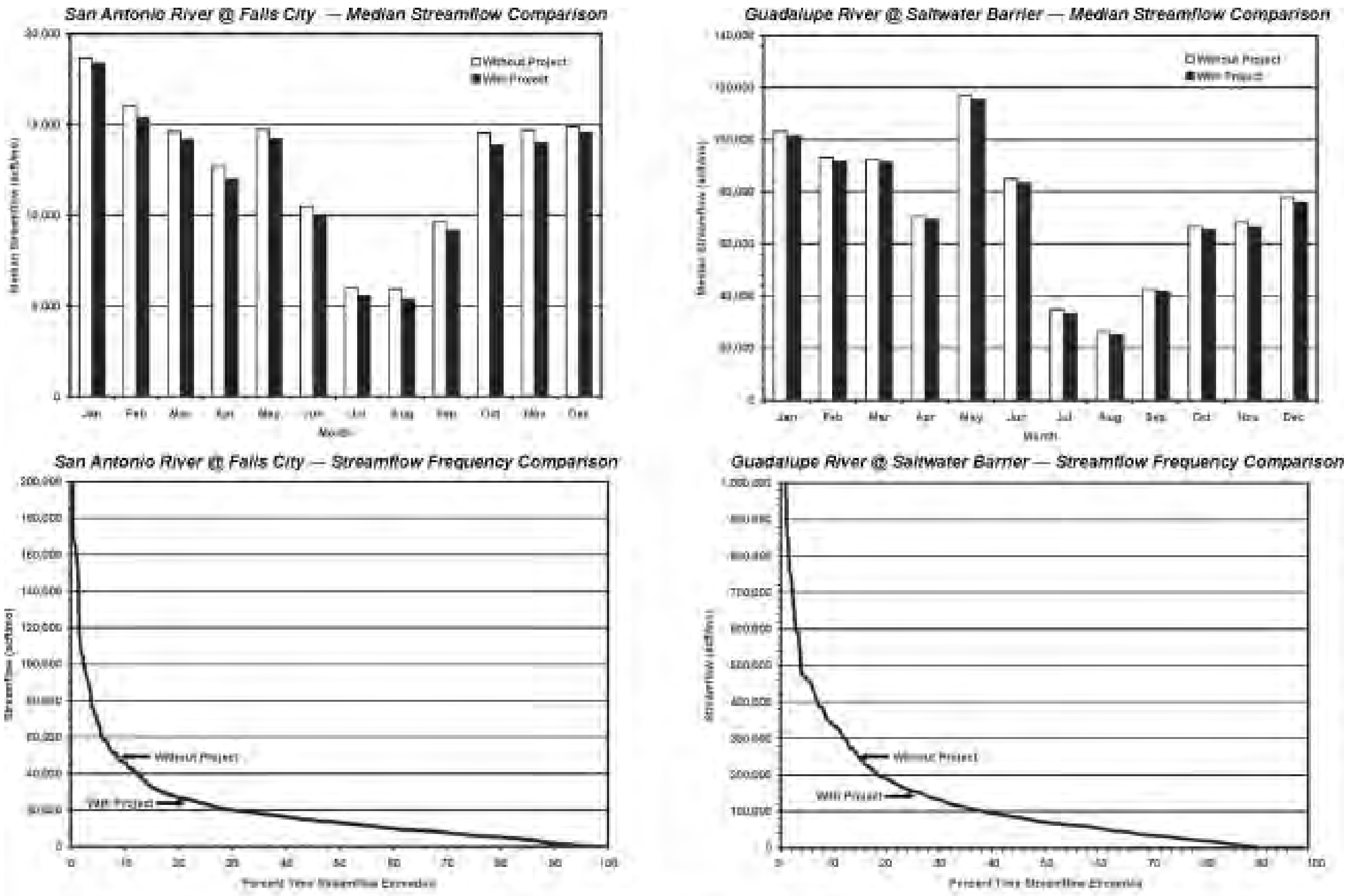


Figure 6.1-3. Changes in Streamflow for 40,000 acft/yr Option

the maximum impact was 1,953 acft in December. On an annual basis, median streamflows at the Saltwater Barrier were reduced by 1.2 percent (16,699 acft/yr).

Table 6.1-2 shows the impacts of additional pumpage of 95,000 acft/yr (20,000 plus 75,000) from the Carrizo-Wilcox Aquifer on average annual flows at Falls City (1934 to 1989). Under this pumpage scenario, average annual flows at Falls City would be reduced to 235,203 acft/yr, or a 7.0 percent reduction (Table 6.1-2). Decreases in average annual flows during the historical drought of record (1947 to 1956) were computed to be 14,225 acft/yr (16.6 percent) with the additional 95,000 acft/yr of Carrizo-Wilcox pumpage (Table 6.1-2). The simulated annual average streamflows at the Saltwater Barrier under this additional Carrizo-Wilcox Aquifer pumpage scenario were computed to be 1,565,848 acft/yr, or a 1.6-percent reduction over baseline flows (Table 6.1-2). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier would be reduced by 17,233 acft/yr (3.4 percent) with the additional pumpage. (Table 6.1-2)

Table 6.1-2
Impacts to Streamflow Due to Additional Carrizo-Wilcox Pumpage
20,000 acft/yr for Schertz/Seguin and 75,000 acft/yr for CZ-10C

Stream Location	Average Annual Streamflow (1934 to 1989) in acft			
	With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 90,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	235,203	-17,635	-7.0%
Guadalupe River at SWB[3]	1,591,727	1,565,848	-25,879	-1.6%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	71,450	-14,225	-16.6%
Guadalupe River at SWB[3]	507,563	490,330	-17,233	-3.4%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr of Schertz/Seguin and the 75,000 acft/yr of additional pumpage (CZ-10C).
[2] Additional pumpage taken from a well field in Wilson and Gonzales Counties (20,000 acft/yr plus 75,000 acft/yr.)
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

Figure 6.1-4 shows the impact of the additional 95,000 acft/yr (20,000 plus 75,000) pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at

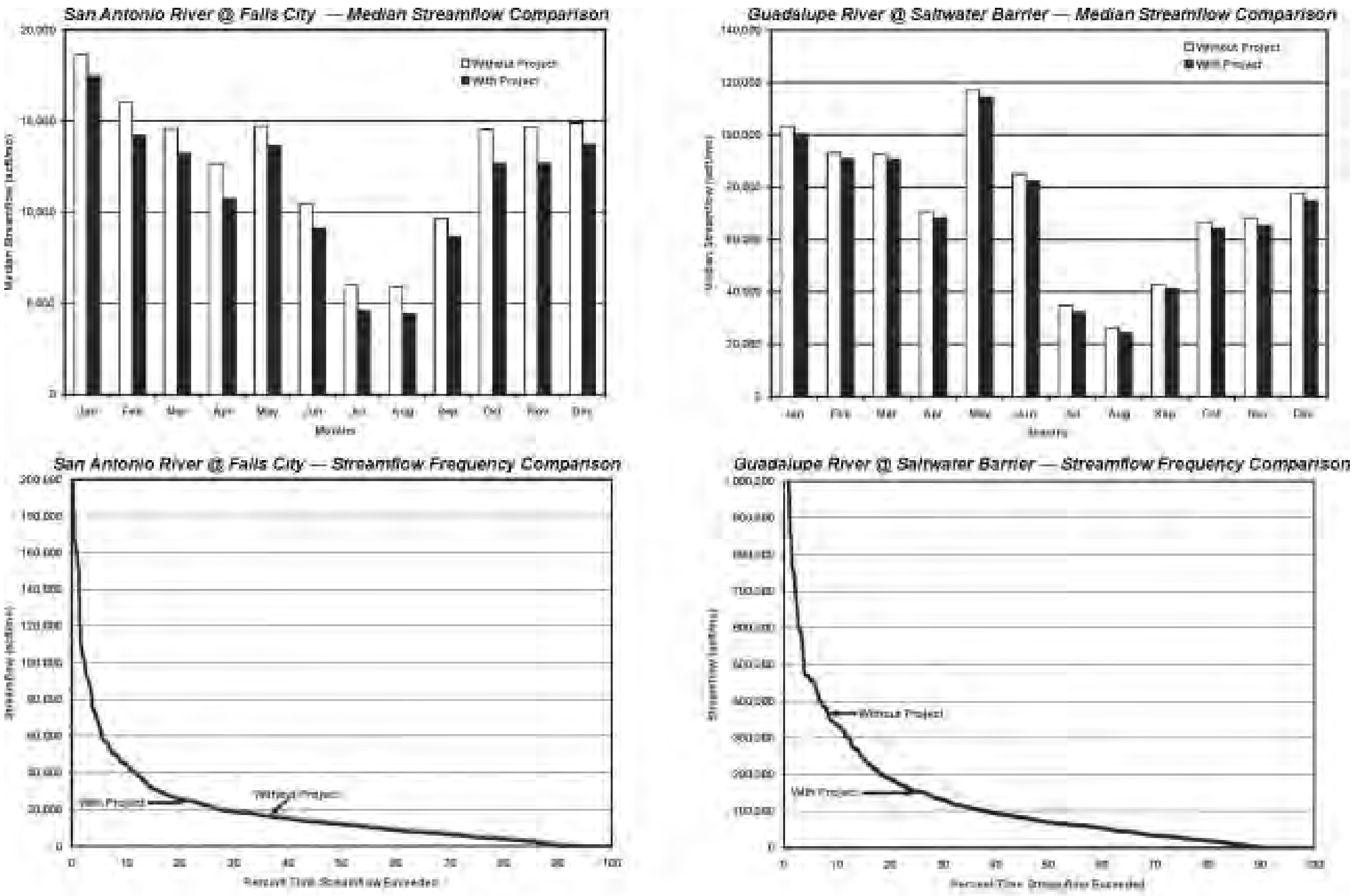


Figure 6.1-4. Changes in Streamflow for 75,000 acft/yr Option

Falls City range from a minimum impact of 976 acft in September to a maximum of 1,964 acft in November. On an annual basis, annual median streamflows at Falls City would be reduced by 8.5 percent (16,611 acft/yr) (Figure 6.1-4). Similarly, for the Guadalupe River at the Saltwater Barrier, the minimum impact to median monthly streamflows was computed to be 1,625 acft in September and the maximum impact was 3,102 acft in December. On an annual basis, median streamflows at the Saltwater Barrier would be reduced by 1.9 percent (26,436 acft/yr) (Figure 6.1-4).

6.1.3 Environmental Issues

The Carrizo-Wilcox Aquifer encompasses several formations of hydrologically connected cross-bedded sands interspersed with clay, sandstone, silt, and lignites (Wilcox Group) and overlying massive sands of the Carrizo formation. These formations outcrop in a southwest-northeast trending crescent near the inland margin of the Gulf Coastal Plain (Figure 6.1-1), and dip downward toward the coast. Aquifer recharge occurs over the general surface of the outcrop area.[6] The thickness of the Carrizo in the downdip artesian areas at the study site ranges from about 400 feet in Gonzales and Caldwell Counties to more than 1,000 feet in Atascosa County. The maximum thickness of the Carrizo Aquifer in this area is about 2,500 feet.

The project area for CZ-10C extends from southwestern Wilson County northeast to Gonzales County. It consists of all or parts of Wilson, Bexar and Gonzales Counties. The larger municipalities of the study area are: Floresville, Stockdale, Nixon and Gonzales. The project area includes land in the Blackland Prairies vegetational area in the northeast, and the south Texas Plains vegetational area in the south. The Blackland Prairies soils are fairly uniform, dark-colored calcareous clays interspersed with some gray acid sandy loams. Most of this fertile area has been cultivated, although a few native hay meadows and ranches remain. Little bluestem is the dominant grass of the native assemblage with other important grasses present including big bluestem, Indian grass, switchgrass, tall dropseed, silver bluestem and Texas wintergrass. Under heavy grazing, buffalo grass, Texas grama, smutgrass and many annuals

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[6] LBG, "Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program," prepared for HDR Engineering, Inc., Austin, Texas, 1994.

increase or invade native pastures. Mesquite, post oak and blackjack oak also invade or increase under these conditions.

The South Texas Plains is dissected by streams flowing into the Rio Grande and the Gulf of Mexico. Soils in this area range from clays to sandy loams, and vary in reaction from very basic to slightly acid. This wide range of soil types is responsible for great differences in soil drainage and moisture holding capacities within this region.[7,8] Wetlands in the project area consist of riverine habitats of Cibolo Creek, the San Antonio and Guadalupe Rivers and their tributaries, as well as associated palustrine habitats which are generally composed of narrow bands of wetlands along these watercourses.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer, and bobcat. The coyote and javelina are found mainly in brush/shrub areas and the red and gray fox in woodlands.[9] A wide variety of species of amphibians, reptiles and birds are also found throughout the region.[10,11]

The 70-mile well field/pipeline and the 25-mile transfer pipeline and water treatment plant in CZ-10C (Figure 6.1-1) would encompass approximately 1,762 acres. Cropland, together with shrub and brushland dominate the landscapes in which this option would lie.

The potential environmental effects resulting from the construction and operation of well pads and water transport pipelines depend to a large extent on the exact placement of the construction corridor. In general, habitats critical to the survival of important and protected species are locally restricted so that adverse impacts can often be avoided or minimized by site and alignment selection. More generally distributed habitats, although perhaps important to regional wildlife populations in some areas, may not be so easy to avoid, but the limited area affected by these corridors allows for insignificant impacts.

Plant and animal species listed by the USFWS and TPWD as endangered or threatened in the project area, and those with candidate status for listing are presented in Table 6.1-3. Because

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[7] Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962

[8] McMahan, C.A., R.G. Frye, K.L. Brown, “The Vegetation Types of Texas,” Texas Parks and Wildlife Department, Austin, Texas, 1984.

[9] Jones, K.J., et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, The Museum, Texas Tech University No. 119. May 1988

[10] McMahan, C.A., R.G. Frye, K.L. Brown, Op. Cit., 1984.

[11] Jones, K.J., et al, May 1988, "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, the Museum, Texas Tech. Univ. No. 119.

Table 6.1-3. Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (CZ-10C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant

Table 6.1-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	E	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

this option would extend through two ecoregions in three counties, all the species listed in Table 6.1-3 have habitat requirements or preferences that suggest they could be present within the project area. Surveys for protected species or other biological resources of restricted distribution, or other importance, would need to be conducted within the proposed construction corridors where preliminary studies have indicated that habitat may be present.

The primary impacts that would result from construction and operation of Option CZ-10C include temporary disturbance to soils and habitat during construction of wells, pipelines and other facilities; permanent conversion of existing habitats or land uses to maintained pipeline rights-of-way; disturbance of minor acreages for construction of water treatment plants, storage stations and well injection fields and mixing of treated aquifer water with waters of the Edwards Aquifer, if this water is to be used to recharge the Edwards Aquifer. Indirect effects of construction may include mitigation areas converted to alternate uses to compensate for losses of terrestrial habitat.

The Texas Natural Heritage Program maps several plant species of concern directly on the pipeline route for CZ-10C: Elmendorf's onion (*Allium elmendorfii*), Big Red Sage (*Salvia penstemonoides*), and Parks' jointweed (*Polygonella parksii*). Both Elmendorf's onion and Parks' jointweed are found in deep sands. The Big Red Sage usually grows along creek beds and seepage slopes of limestone canyons.

Because there are no known metazoan inhabitants present, withdrawing water from the Carrizo Aquifer would not impact an endemic fauna. These withdrawals may, however, lower the water table to some extent in the outcrop area, potentially affecting the water budgets of streams and ponds in the area (Section 6.1.2). Northeast of Atascosa County, the Carrizo Aquifer appears to be full and is discharging water to streams and rivers that cross the outcrop. It is expected that the proposed well field would lower water levels in outcrop areas and thereby additional storage space would be created in the aquifer, increasing infiltration of surface-water runoff.[12] As a result, it is expected that the base flows of streams crossing the recharge zone would be reduced, and that channel losses could increase on the outcrop. The rates of water loss from permanent ephemeral ponds could also increase. Because of limited groundwater storage capacity, the potential for significant losses of stream baseflow is probably not a major concern. Enhancement of seepage losses, however, may prove to be of more concern.

[12] Ibid.

Lowering the Carrizo Aquifer water table could possibly impact Houston toad habitat and the Texas garter snake, timber/canebrake rattlesnake, black-spotted newt, lesser siren and bracted twistflower populations, since the species inhabit wet areas in the project area (Table 6.1-3).

The transfer of Carrizo-Wilcox water could adversely affect two protected fish species within the Edwards Aquifer if the Carrizo water is used to recharge the Edwards Aquifer. The toothless blindcat (*Trogloglanis pattersoni*) and widemouth blindcat (*Satan eurystomus*) both inhabit the aquifer under the city of San Antonio. Both of these threatened species may incur negative impacts if the water quality of the aquifer is not maintained.

The endangered golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapillus*) may have habitat within the study area. The golden-cheeked warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The black-capped vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

It should be noted that the range of the golden-cheeked warbler and black-capped vireo only extend into Bexar County and not the other counties in this project area, while the two fishes mentioned above are endemic to the Edwards Aquifer. These species and others in Table 6.1-3, which are endemic to the Edwards Plateau region, would only be affected by the delivery pipeline of CZ-10C and not the well field.

Construction in brush/shrub habitat and maintenance activities would potentially impact populations of the Texas tortoise, Texas horned lizard, indigo snake, spot-tailed earless lizard, plains spotted skunk, jaguarundi, and ocelot. Since over half of the proposed well field corridor in Option CZ-10C consists of cropland, wildlife habitats tend to be small and fragmented, and may be disproportionately valuable to regional wildlife populations. Construction impact can generally be minimized or avoided, however, by locating project features in less sensitive cropland, pasture or upland woodland whenever possible. Construction across rivers and streams should be minimized, as riparian zones support wetlands and are valuable to wildlife. Mitigation may be required for impacts associated with the pump stations, water treatment plant, and pipelines identified for CZ-10C, and injection wells, and recharge structures, if any, if sensitive ecological or cultural resources are identified in the plan formulation phase of this study.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic

Preservation Act (PL 96-515), and the Archaeological and Historic Preservation Act (PL 93-291). All areas to be disturbed during construction would need to be surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

6.1.4 Engineering and Costing

For the 75,000 acft/yr scenario, groundwater would be developed by constructing wells along a line that extends from southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County, except for gaps for the cities of Floresville and Stockdale. (Figure 6.1-1). The well field for the 40,000 acft/yr scenario would be shortened by eliminating some of the wells at each end of the line. The wells would be connected by a collector pipeline, with pump station(s), a water treatment plant, and terminal storage near the center of the well field (Figure 6.1-1). The water would be treated for high iron and manganese concentrations and pumped through a pipeline to the major municipal demand center in the South Central Texas Region. The major facilities required for these options are:

- Water Collection and Conveyance System
  - Wells
  - Pipelines
  - Pump Station
  - Transmission System
- Storage
- Pipeline
- Pump Stations
- Water Treatment Plant (Iron and Manganese removal)

The approximate locations of these facilities were shown earlier in Figure 6.1-1.

Cost estimates were computed for capital and project expenses, annual debt service, operation and maintenance, power, land, and environmental mitigation. These costs are summarized in Tables 6.1-4 and 6.1-5 for the 40,000 and 75,000 acft/yr options, respectively. Because of the uncertainty in the acquisition of groundwater rights, estimates are based on land purchases to meet groundwater development requirements of the Evergreen and Gonzales underground water conservation districts. The annual costs, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, is estimated to

Table 6.1-4.
Cost Estimate Summary
Option CZ-10C — 40,000 acft/yr Scenario
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Well Costs (150 HP to 250 HP)	$15,147,000
Pipeline (12", 18", 24", 30", 36", 42", 48", & 54"; 422,000' total)	44,994,000
Transmission Pump Station (3,800 HP)	5,497,000
Water Treatment Plant (38 MGD) (Iron and Manganese Removal)	14,207,000
Total Capital Cost	**$79,845,000**
Engineering, Legal Costs and Contingencies (32% of capital costs)	$25,696,000
Environmental & Archaeology Studies and Mitigation	2,125,000
Land Acquisition and Surveying (36,302 acres) ($1,120/acre)	40,673,000
Interest During Construction (4 years)	23,735,000
Total Project Cost	**$172,074,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$12,501,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	723,000
Water Treatment Plant	2,725,000
Pumping Energy Costs (49,616,667kWh @ $0.06 per kWh	2,977,000
Water Export Fee - Wilson County 20,000 acft ($0.17 per 1,000 gallons)	1,108,000
Total Annual Cost	**$20,034,000**
Available Project Yield (acft/yr)	**40,000**
Annual Cost of Water ($ per acft)	**$501**
Annual Cost of Water ($ per 1,000 gallons)	**$1.54**

Table 6.1-5.
Cost Estimate Summary
Option CZ-10C — 75,000 acft/yr Scenario
(Second Quarter 1999 Prices)

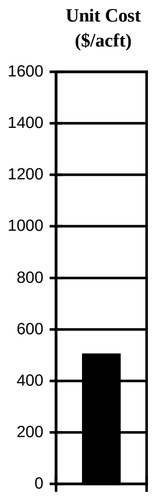
Item	*Estimated Costs for Facilities*
Capital Costs	
Well Costs (150 HP to 250 HP)	$29,807,000
Pipeline (12", 18", 24", 30", 36", 42", 48", 54" and 64"; 422,000' total)	70,675,000
Transmission Pump Station (8,800 HP)	8,298,000
Water Treatment Plant (71 MGD) (Iron and Manganese Removal)	22,334,000
Total Capital Cost	**$131,114,000**
Engineering, Legal Costs and Contingencies (32% of capital costs)	$42,356,000
Environmental & Archaeology Studies and Mitigation	3,215,000
Land Acquisition and Surveying (64,429 acres) ($1,106/acre)	71,296,000
Interest During Construction (4 years)	39,677,000
Total Project Cost	**$287,658,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$20,898,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	1,188,000
Water Treatment Plant	4,467,000
Pumping Energy Costs (912,666,667 kWh @ $0.06 per kWh	5,476,000
Water Export Fee - Wilson County 55,000 acft ($0.17 per 1,000 gallons)	3,047,000
Total Annual Cost	**$35,076,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft)	**$468**
Annual Cost of Water ($ per 1,000 gallons)	**$1.44**

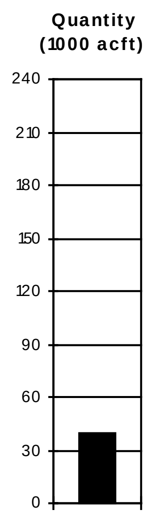
be $501 and $468 per acft/yr for the 40,000 and 75,000 acft/yr scenarios, respectively (Tables 6.1-4 and 6.1-5).

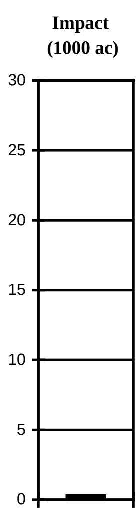
6.1.5 Implementation Issues

The development of groundwater in the Carrizo-Wilcox Aquifer in Wilson and Gonzales Counties for the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation, including test drilling and aquifer and water quality testing of prospective well fields, followed with more detailed groundwater modeling to confirm results of this preliminary evaluation.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.
- Regulations by the Evergreen and Gonzales County UWCDs, including the renewal of pumping permits at 5-year intervals in the Evergreen district.
- Water levels did not stabilize during the computer simulation of pumping for a period of 50 years, thereby indicating that the simulated withdrawals may be in excess of the effective recharge rates.







OPTION NUMBER: CZ-10C
OPTION NAME: Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (40,000 acft/yr))

OPTION DESCRIPTION: *Under this option, the development of a 40,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz-Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$501**	**per acft**[1]
QUANTITY OF WATER:	**40,000**	**acft/yr**[2]
LAND IMPACTED:	**302**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Land for groundwater rights and facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese, and connection to regional water distribution systems.

[2]**QUANTITY OF WATER:** The facilities are designed to supply 40,000 acft/yr and the analyses show that this quantity would be available through 2050.

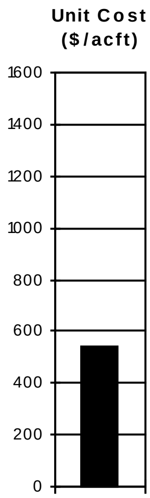
[3]**LAND IMPACTED:** The impacted land for wells, pipelines, pump stations, and a water treatment plant is about 302 acres. However, about 36,000 acres would need to be purchased or leased for groundwater rights.

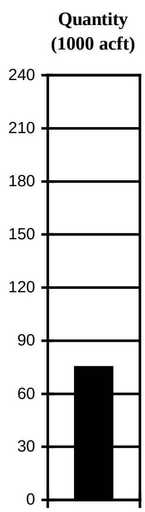
ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

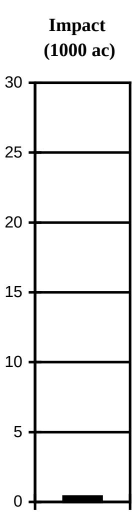
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: SCTN-12 and CZ-10D.







OPTION NUMBER: CZ-10C
OPTION NAME: Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (75,000 acft/yr))

OPTION DESCRIPTION: *Under this option, the development of a 75,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County was evaluated for major municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz-Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER	**$468**	**per acft**[1]
QUANTITY OF WATER:	**75,000**	**acft/yr**[2]
LAND IMPACTED:	**429**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Land for groundwater rights and facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese,, and connection to regional water distribution system.

[2]**QUANTITY OF WATER:** The facilities would be designed to supply 75,000 acft/yr and the analyses show that this quantity would be available through 2050.

[3]**LAND IMPACTED:** Impacted land is related to wells, pipelines, pump stations, and water treatment plants and totals 429 acres. However, about 64,000 acres would need to be purchased or leased for groundwater rights.

ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

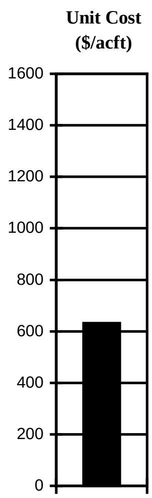
ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

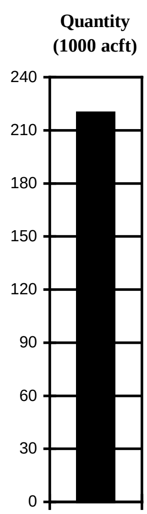
OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: SCTN-12 and CZ-10D.

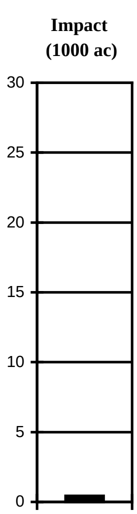
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/13/99







OPTION NUMBER: **CZ-10D**

OPTION NAME: **Carrizo-Wilcox Aquifer between Colorado and Frio Rivers**

OPTION DESCRIPTION: *Under this option, the development of a 220,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the Colorado River in Bastrop County to the Frio River in Frio County was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the 20,000 acft/yr of the Schertz/Seguin plan. The evaluation includes: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$632**	**per acft**[1]
QUANTITY OF WATER:	**220,000**	**acft/yr**[2]
LAND IMPACTED:	**1,437**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Land for groundwater rights, facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese, and connection to regional water distribution systems.

[2]**QUANTITY OF WATER:** The facilities are designed to supply 220,000 acft/yr, and the analyses show that this quantity would be available through 2050.

[3]**LAND IMPACTED:** About 1,437 acres of land would be needed for wells, pipelines, pump stations, and water treatment plants. However, about 131,000 acres would need to be purchased or leased for groundwater rights.

ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: CZ-10C, SCTN-1a.

6.2 Carrizo-Wilcox Aquifer between Colorado and Frio Rivers (CZ-10D)

6.2.1 Description of Option

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa-Frio county line, the aquifer has been extensively developed for many decades. Between this county line and the Colorado River, the aquifer has had limited development in Atascosa County and very limited development in Bastrop, Caldwell, Gonzales, Guadalupe, and Wilson Counties. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply except for elevated concentrations of iron and manganese in many areas.

The Evergreen Underground Water Conservation District (UWCD) includes Atascosa, Frio, Karnes, and Wilson Counties, the Gonzales County UWCD includes Gonzales County, the Wintergarden Groundwater Conservation District includes Dimmit, La Salle, and Zavala Counties, and Live Oak UWCD covers Live Oak County. Each district has developed a water management plan and district rules and regulations that affect the export of groundwater. The Lost Pines Groundwater Conservation District, which covers Bastrop County, was created in the 76th Texas Legislature, but requires ratification or authorization in the next legislative session before becoming permanent. Regulations on the export of groundwater from the new district have not been established.

Under this option, the development of a 220,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the Frio and Colorado Rivers (Figure 6.2-1) was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the projected local demands plus the 20,000 acft/yr demands of the Schertz/Seguin plan. The evaluation included: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well fields, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.

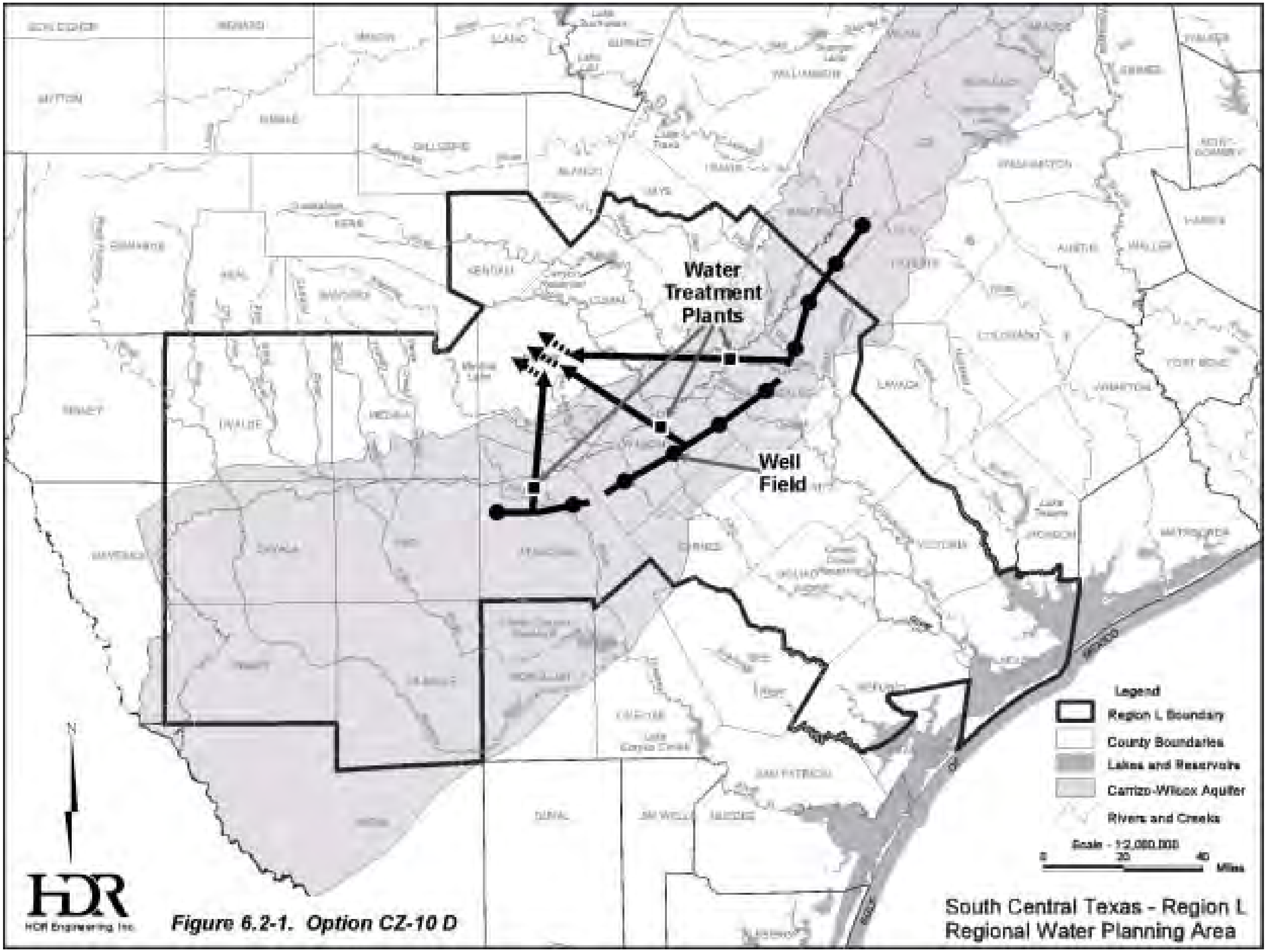


Figure 6.2-1. Option CZ-10 D

6.2.2 Available Yield

A review of existing reports,[1,2,3] the extent of other groundwater users in the area, and hydrogeologic data indicates that well fields can be developed in a section of the Carrizo-Wilcox Aquifer that extends from the Frio-Atascosa County line to a few miles south of the Colorado River in Bastrop County. These well fields would be separated or would "skip" across existing well fields for the cities of Jourdanton, Pleasanton, Floresville, Stockdale, and Gonzales.

Large capacity wells in the area typically produce 1,000 gallons per minute or more. With a contingency of 10 percent of the wells being out-of-service, about 150 wells would be required. Well spacings are planned to be about one mile.

To estimate the effects of the projected pumpage to meet local demands and the Schertz/Seguin plan through the year 2050, and Option CZ-10D pumpage (220,000 acft/yr), the "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer" model and a well image model for the well field north of the San Marcos River were applied. The computer simulations indicate drawdown in the well field in the year 2050 for pumping to meet local needs plus 20,000 acft/yr for Schertz/Seguin and an additional 220,000 acft/yr would be about 250 feet in Bastrop County, about 170 to 180 feet in Gonzales and Wilson Counties, and 120 to 150 feet in Atascosa County.

To show the long-term change in water levels in the Carrizo Aquifer as a result of pumpage to meet local demands plus the Schertz/Seguin and CZ-10D option, water level hydrographs are shown in Figure 6.2-2 for aquifer simulations from years 1910 to 2050. Monitoring locations are cell 23,62 in western Gonzales County, cell 24,53 in west-central Wilson County, and cell 20,43 in northwest Atascosa County. These cell locations are in the well fields as outlined for this option. For the Gonzales, Wilson, and Atascosa County cells, the total drawdown from predevelopment conditions (1910) to end of the assessment (2050) is about 245, 210 and 270 feet, respectively. For the Carrizo-Wilcox Aquifer, the TWDB calculated groundwater availability as having two components, as follows. When water levels are less than

[1] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[2] HDR Engineering, Inc (HDR) and LBG-Guyton Associates (LBG), "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, August 1998.
[3] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

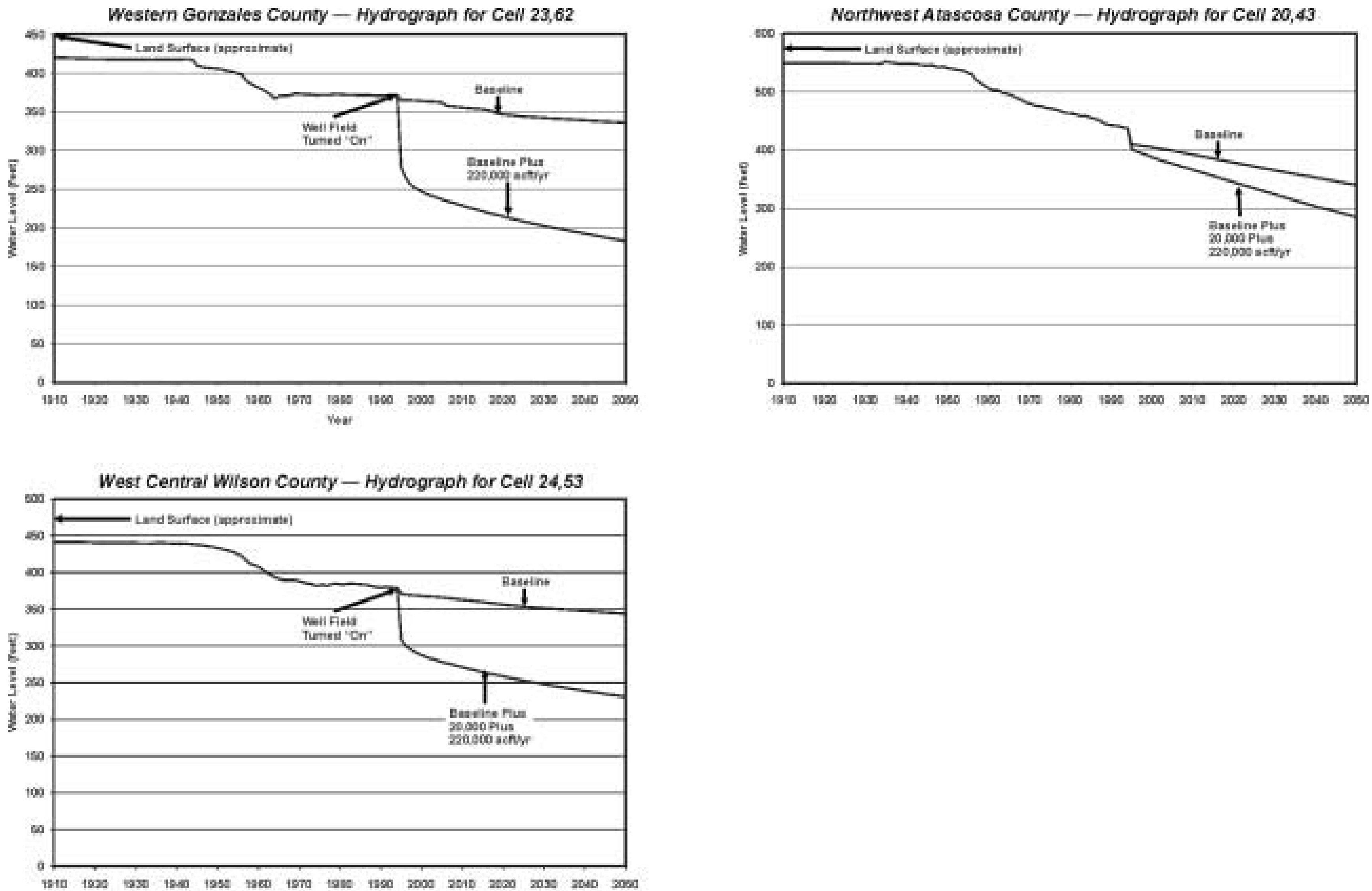


Figure 6.2-2. Hydrographs of Groundwater Levels

400 feet below land surface, groundwater availability is considered to be depletion from storage plus effective recharge. In Gonzales, Wilson, and Atascosa Counties, the groundwater availability for the Carrizo-Wilcox Aquifer for both components is 47,033; 43,391; and 30,824 acft/yr, respectively. For both projects, maximum depth of water levels below land surface is less than 400 feet in year 2050. As shown in Figure 6.2-2, the water levels are continuing to decline at a rate of about 1 foot per year in year 2050 in Gonzales County and about 2 feet per year in Atascosa County.

The combined effects of the development of groundwater under the Option CZ-10D and pumping to meet projected local demands are of importance at several locations on the Guadalupe and San Antonio rivers. For comparative purposes, the streamflow at several locations in these rivers are computed by using the Guadalupe-San Antonio Basin Model (GSA Model)[4] model for baseline and full development scenarios.

As was done in previous studies,[5] to evaluate the impact of specified pumpage scenarios on surface water flows in the Guadalupe–San Antonio River Basin, changes in streamflows were extracted from the groundwater model runs and incorporated into the GSA Model based on comparison with historical streamflow. For this analysis, streamflows were compared at two locations: the San Antonio River at Falls City and the Guadalupe River at the Saltwater Barrier. The impacts due to expected local pumpage to meet local needs projected to 2050 on historical streamflows were computed and used as the baseline flow set for computing streamflow impacts due to additional pumpage scenarios.

As shown in Table 6.2-1, simulated average annual streamflows for the period of record simulated (1934 to 1989) on the San Antonio River at Falls City assuming baseline Carrizo-Wilcox Aquifer pumpage was computed to be 252,838 acft/yr. Under an additional pumpage of 20,000 plus 220,000 acft/yr, average annual flows at Falls City would be reduced to 224,696 acft/yr, or a reduction of 11.1 percent (Table 6.2-1). Decreases in average annual flows during the historical drought of record (1947 to 1956) were computed to be 22,831 acft/yr (26.6 percent) with additional Carrizo-Wilcox pumpage of 240,000 acft/yr (Table 6.2-1). Likewise, the simulated annual average streamflows at the Saltwater Barrier under baseline

[4] HDR, "Guadalupe-San Antonio River Basin Model Modifications and Enhancements," Trans-Texas Water Program, West Central Study Area, Phase II, San Antonio River Authority, et al., March 1998.
[5] HDR and LBG, Op. Cit., August 1998.

Table 6.2-1.
Impacts to Streamflow Due to
20,000 Plus 220,000 acft/year of Additional Carrizo-Wilcox Pumpage

Stream Location	Average Annual Streamflow (1934 to 1989) in acft			
	With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 60,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	224,696	-28,147	-11.1%
Guadalupe River at SWB[3]	1,591,727	1,551,940	-39,787	-2.5%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	62,844	-22,831	-26.6%
Guadalupe River at SWB[3]	507,563	480,826	-26,737	-5.3%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr plus 220,000 acft/yr of additional pumpage (CZ-10D).
[2] Additional pumpage taken from a well field in Wilson, Atascosa, Gonzales, Caldwell, and/or Bastrop Counties.
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

Carrizo-Wilcox Aquifer pumpage were computed to be 1,591,727 acft/yr and were reduced to 1,551,940 acft/yr (or a 2.5 percent reduction) with 240,000 acft/yr additional pumpage of the aquifer (Table 6.2-1). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier were reduced by 26,737 acft/yr (5.3 percent) with the additional 240,000-acft/yr pumpage (Table 6.2-1).

Figure 6.2-3 shows the impact of the additional 20,000 plus 220,000 acft/yr pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at Falls City range from a minimum impact of 1,544 acft in September to a maximum of 2,879 acft in November. On an annual basis, annual median streamflows at Falls City were reduced by 12.6 percent, or 24,593 acft/yr (Figure 6.2-3). Similarly, for the Guadalupe River at the Saltwater Barrier, the minimum impact to median monthly streamflows was computed to be 2,265 acft in September and the maximum impact was 4,216 acft in December. On an annual basis, median streamflows at the Saltwater Barrier were reduced by 2.7 percent, or 36,792 acft/yr (Figure 6.2-3).

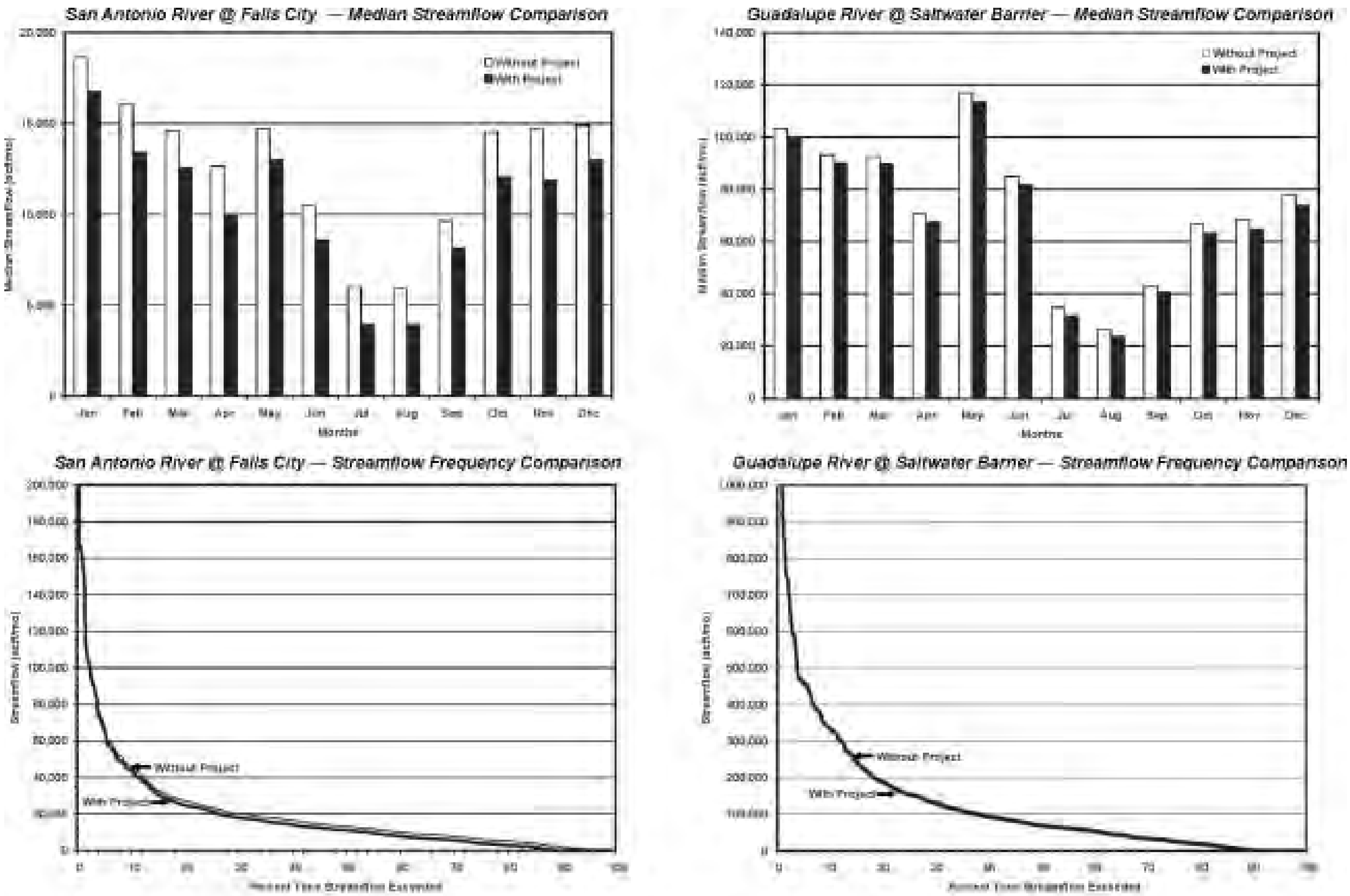


Figure 6.2-3. Changes in Streamflow for 20,000 Plus 220,000 acft/yr Option

6.2.3 Environmental Issues

The Carrizo-Wilcox Aquifer encompasses several formations of hydrologically connected cross-bedded sands interspersed with clay, sandstone, silt, and lignites (Wilcox Group) and overlying massive sands of the Carrizo formation. These formations outcrop in a southwest-northeast trending crescent near the inland margin of the Gulf Coastal Plain (Figure 6.2-1), and dip downward toward the coast. Aquifer recharge occurs over the general surface of the outcrop area.[6] The thickness of the Carrizo in the downdip artesian areas at the study site ranges from about 400 feet in Gonzales and Caldwell Counties to more than 1,000 feet in Atascosa County. The maximum thickness of the Carrizo Aquifer in this area is about 2,500 feet.

The project area for CZ-10D extends from Atascosa County northeast to Bastrop County. It consists of all or parts of Atascosa, Wilson, Bexar, Guadalupe, Gonzales, Caldwell, Bastrop, and Fayette Counties. The larger municipalities of the study area are Pleasanton, Floresville, Seguin, Gonzales, Luling, Lockhart, Smithville and Bastrop. The project area includes land primarily in the Post Oak Savannah vegetational area in the northeast, and the Blackland Prairies vegetational area in the south. Only a portion of the study area (Atascosa County) lies within the South Texas Plains vegetational area.[7] The Blackland Prairies soils are fairly uniform, dark-colored calcareous clays interspersed with some gray acid sandy loams. Most of this fertile area has been cultivated, although a few native hay meadows and ranches remain. Little bluestem is the dominant grass of the native assemblage with other important grasses present including big bluestem, Indian grass, switchgrass, tall dropseed, silver bluestem and Texas wintergrass. Under heavy grazing, buffalo grass, Texas grama, smutgrass and many annuals increase or invade native pastures. Mesquite, post oak and blackjack oak also invade or increase under these conditions.

The Post Oak Savannah upland soils are light-colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the Post Oak Savannah is still in native or improved pastures although small farms are common.

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[6] LBG, "Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program," prepared for HDR Engineering, Inc., Austin, Texas (also Appendix to this report), 1994.
[7] Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.

The South Texas Plains is dissected by streams flowing into the Rio Grande and the Gulf of Mexico. Soils in this area range from clays to sandy loams, and vary in reaction from very basic to slightly acid. This wide range of soil types is responsible for great differences in soil drainage and moisture holding capacities within this region.[8,9] Wetlands in the project area consist of riverine habitats of Cibolo Creek, the San Antonio, Guadalupe and Colorado Rivers and their tributaries, as well as associated palustrine habitats that are generally composed of narrow bands of wetlands along these watercourses.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer, and bobcat. The coyote and javelina are found mainly in brush/shrub areas and the red and gray fox in woodlands.[10] A wide variety of species of amphibians, reptiles and birds are also found throughout the region.[11,12]

The estimated area required for construction of Option CZ-10D encompasses 5,376 acres. Cropland, together with shrub and brushland dominates the landscape of the south Texas Plains and Blackland Prairies in which Option CZ-10D would lie, but Option CZ-10D also extends into the Post Oak Savannah in an area less impacted by ongoing agricultural activity.

The potential environmental effects resulting from the construction and operation of well pads and water transport pipelines depend to a large extent on the exact placement of the construction corridor. In general, habitats critical to the survival of important and protected species are locally restricted so that adverse impacts can often be avoided or minimized by site and alignment selection. More generally distributed habitats, although perhaps important to regional wildlife populations in some areas, may not be so easy to avoid, but the limited area affected by these corridors allows for insignificant impacts.

Plant and animal species listed by the USFWS and TPWD as endangered or threatened in the project area and those with candidate status for listing are presented in Table 6.2-2. Because this option would extend through three ecoregions in seven counties, all the species listed in Table 6.2-2 have habitat requirements or preferences that suggest they could be present within

[8] Ibid.

[9] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Austin, Texas, 1984.

[10] Jones, K.J., et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, The Museum, Texas Tech University No. 119, May 1988.

[11] McMahan, C.A., R.G. Frye, K.L. Brown, Op. Cit., 1984.

[12] Jones, K.J., et al, Op. Cit., May 1988.

Table 6.2-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Carrizo-Wilcox Aquifer between Colorado and Frio Rivers (CZ-10D)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquie savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident

Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	E	Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]			NL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Meadow-rue	*Thalictrum texanum*	Coastal plains and savannah	C2	NL	WL	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]			NL	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]			NL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

the project area. Surveys for protected species or other biological resources of restricted distribution, or other importance, would need to be conducted within the proposed construction corridors where preliminary studies have indicated that habitat may be present.

The primary impacts that would result from construction and operation of Option CZ-10D include temporary disturbance to soils and habitat during construction of wells, pipelines and other facilities; permanent conversion of existing habitats or land uses to maintained pipeline rights-of-way; disturbance of minor acreages for construction of water treatment plants and storage stations; and well injection fields, and mixing of treated aquifer water with waters of the Edwards Aquifer, if this water is to be used to recharge the Edwards Aquifer. Indirect effects of construction may include mitigation areas converted to alternate uses to compensate for losses of terrestrial habitat.

The Texas Natural Heritage Program maps several plant species on or in the vicinity of the pipeline route for CZ-10D; Elmendorf's onion (*Allium elmendorfii*), Parks' jointweed (*Polygonella parksii*), Sandhill Woolywhite (*Hymenopappus carrizoanus*), spikerush (*Eleocharis texana*), Texas Tauschia (*Tauschia texana*), smooth blue-star (*Amsonia glaberrima*), and Texas pink-root (*Spigelia texana*). Elmendorf's onion, Parks' jointweed, and Sandhill Woolywhite are found in deep sands usually derived from Eocene formations. The Texas Tauschia, smooth blue-star, and Texas pink-root grow in alluvial thickets or other wooded areas near water, while the spikerush thrives in fresh to moderately alkaline marshes. The aforementioned species are rare but not under regulatory status by TPWD or USFWS.

The Guadalupe Bass (*Micropterus treculi)*), which resides within streams of the Edwards Plateau, and Cagle's Map Turtle, which inhabits waters of the Guadalupe River Basin, were mapped near the pipeline corridor. Construction across streams and rivers might impact these two species of concern. The transfer of Carrizo-Wilcox water could also adversely affect two protected fish species within the Edwards Aquifer. The toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) both inhabit the aquifer under the City of San Antonio. Both of these threatened species may incur negative impacts if the water quality of the aquifer is not maintained.

The mountain plover (*Charadrius montanus*), designated a species of concern by TPWD, was mapped within 2 miles of the project area and may have essential habitat along the pipeline corridor. The mountain plover inhabits shortgrass plains, sandy deserts, and plowed fields.

Because there are no known metazoan inhabitants present, withdrawing water from the Carrizo Aquifer would not impact an endemic fauna. These withdrawals may, however, lower the water table to some extent in the outcrop area, potentially affecting the water budgets of streams and ponds in the area. Northeast of Atascosa County, the Carrizo Aquifer appears to be full and is discharging water to streams and rivers that cross the outcrop.[13] It is expected that the proposed well field would lower water levels in outcrop areas and thereby additional storage space would be created in the aquifer, increasing infiltration of surface-water runoff.[14] As a result, it is expected that the base flows of streams crossing the recharge zone would be reduced, and that channel losses could increase on the outcrop. The rates of water loss from permanent ephemeral ponds could also increase. Because of limited groundwater storage capacity, the potential for significant losses of stream baseflow is probably not a major concern. Enhancement of seepage losses, however, may prove to be of more concern.

Lowering the Carrizo Aquifer water table in Bastrop County could possibly impact Houston toad habitat (Table 6.2-2). The Houston toad uses the vernal pools (temporary ponds that typically contain water during the spring and dry completely during the summer) provided by the saturated sands of the Carrizo Aquifer as their breeding habitat.[15] The Texas garter snake, timber/canebrake rattlesnake, black-spotted newt, lesser siren and Bracted Twistflower populations could also be impacted as they inhabit wet areas in the project area (Table 6.2-2).

The endangered Golden-Cheeked Warbler (*Dendroica chrysoparia*) and Black-Capped Vireo (*Vireo atricapillus*) may have habitat within the study area. The Golden-Cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-Capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

Construction in brush/shrub habitat and maintenance activities would potentially impact populations of the Texas tortoise, indigo snake, spot-tailed earless lizard, plains spotted skunk, jaguarundi, ocelot and Texas horned lizard. Construction impact can generally be minimized or avoided, however, by locating project features in less sensitive cropland, pasture or upland woodland whenever possible. Construction across rivers and streams should be minimized, as

[13] LBG, Op. Cit., 1994.
[14] Ibid.
[15] Andrew H. Price, Personal Communication, Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas, 1994.

riparian zones support wetlands and are valuable to wildlife. Mitigation may be required for impacts associated with the pump stations, injection wells, recharge structures, water treatment plants, and pipelines identified for CZ-10D option if sensitive ecological or cultural resources are identified in the plan formulation phase of this study.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL 96-515), and the Archaeological and Historic Preservation Act (PL 93-291). All areas to be disturbed during construction would need to be surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

6.2.4 Engineering and Costing

Groundwater would be developed by constructing a line of wells in a section of the Carrizo-Wilcox Aquifer that extends from the Frio-Atascosa County line to a few miles south of the Colorado River in Bastrop County. These well fields would be separated in areas where well fields are located for the cities of Jourdanton, Pleasanton, Floresville, Stockdale, and Gonzales.

The well field is divided into three sections with each section being independent of the other. Each section would have a well field, collector pipeline, pump station(s), and terminal storage and Level 2 water treatment (iron and manganese removal) near the center of the well field. From there, the water would be pumped through a pipeline to the major municipal demand center in the South Central Texas Region.

The Atascosa, Wilson-Gonzales, and Gonzales-Bastrop segments are designed to supply 55,000, 75,000 and 90,000 acft/yr, respectively. The major facilities required for these options are:

- Water Collection and Conveyance System
  - Wells
  - Pipelines
  - Pump Station
  - Transmission System
- Storage
- Pipeline
- Pump Stations
- Water Treatment Plant (Iron and Manganese removal).

The approximate locations of these facilities were shown earlier in Figure 6.2-1.

Cost estimates were computed for capital and project expenses, annual debt service, operation and maintenance, power, land, and environmental mitigation. These costs are summarized in Table 6.2-3. Because of the uncertainty in the acquisition of groundwater rights, estimates are based on land purchases to meet groundwater development requirements of the Evergreen and Gonzales groundwater districts. The costs are estimated for the annual costs, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power. The cost of water is estimated to be $632 per acft/yr (Table 6.2-3).

6.2.5 Implementation Issues

The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling and aquifer and water quality testing, followed with more detailed groundwater modeling to confirm results of this preliminary evaluation.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others in the area for groundwater.
- Regulations by the Evergreen and Gonzales County UWCDs, including the renewal of pumping permits at 5-year intervals in the Evergreen District.
- Water levels did not stabilize during the 50-year evaluation and simulated pumping may be in excess of effective recharge.

Table 6.2-3.
Cost Estimate Summary
Option CZ-10D — 220,000 acft/yr Scenario
(Second Quarter 1999 Prices)

Item	***Estimated Costs for Facilities***
Capital Costs	
Well Costs	$86,890,000
Pipeline	255,681,000
Transmission Pump Station	33,108,000
Water Treatment Plants (Iron and Manganese Removal) (208 MGD)	70,177,000
Distribution	237,467,000
Total Capital Cost	**$683,323,00**
Engineering, Legal Costs and Contingencies (33% of capital costs)	$226,379,000
Environmental & Archaeology Studies and Mitigation	9,037,000
Land Acquisition and Surveying (132,437 acres @ $1,300-$1,600/acre)	205,714,000
Interest During Construction (4 years)	179,921,000
Total Project Cost	**$1,304,374,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$94,512,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	6,528,000
Water Treatment Plant	14,610,000
Pumping Energy Costs (@$0.06/KW hr, 286,550,000 kWh)	17,193,000
Water Export Fee ($0.17/1,000 gallons (Wilson & Atascosa Counties only)	6,094,000
Total Annual Cost	**$138,937,000**
Available Project Yield (acft/yr)	**220,000**
Annual Cost of Water ($ per acft)	**$632**
Annual Cost of Water ($ per 1,000 gallons)	**$1.94**

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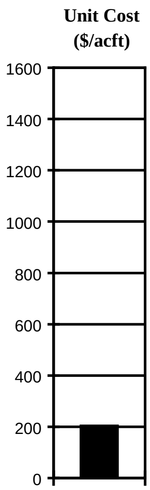

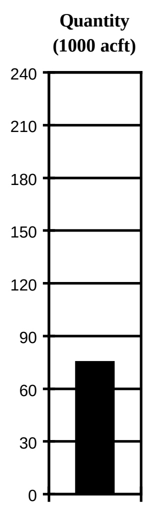

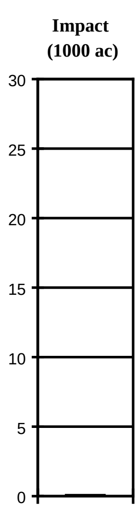

OPTION NUMBER: **SCTN-3a**
OPTION NAME: **Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to Colorado River**

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$203**	**per acft**[1]	**Raw Water Delivered**
QUANTITY OF WATER:	**75,000**	**acft/yr**[2]	
LAND IMPACTED:	**78**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, land acquisition, and mitigation.

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

ENVIRONMENTAL ISSUES: Concern exists about the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies. Losses of water in 'bed and banks' transport.

ADDITIONAL FACTORS: Negotiation of contracts with Lower Colorado River Authority for an exchange of water. Compliance with regulatory requirements in 'bed and banks' transport and water quality in Colorado River.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

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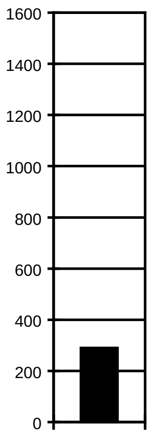
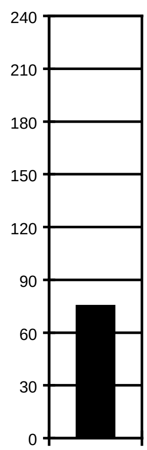
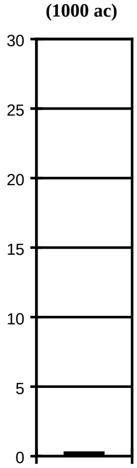
Unit Cost ($/acft)



Quantity (1000 acft)



Impact (1000 ac)



OPTION NUMBER: SCTN-3b
OPTION NAME: Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to Plum Creek

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$290**	**per acft**[1]	**Raw Water Delivered**
QUANTITY OF WATER:	**75,000**	**acft/yr**[2]	
LAND IMPACTED:	**269**	**acres**[3]	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, land acquisition, and mitigation.

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

ENVIRONMENTAL ISSUES: Concern exists about the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies. Losses of water in 'bed and banks' transport.

ADDITIONAL FACTORS: Negotiation of contracts with Guadalupe-Blanco River Authority for an exchange of water. Compliance with regulatory requirements in 'bed and banks' transport and water quality in streams in the Guadalupe River Basin.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

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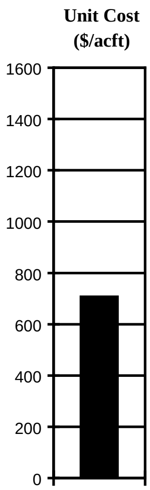
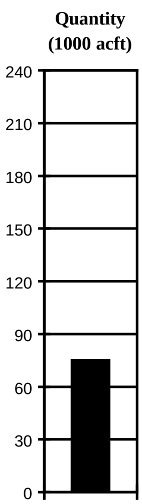
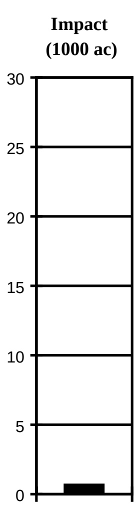






OPTION NUMBER: SCTN-3c
OPTION NAME: Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to a Major Municipal Demand Center

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$707**	**per acft[1]**	**Treated Water Delivered**
QUANTITY OF WATER:	**75,000**	**acft/yr[2]**	
LAND IMPACTED:	**671**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, mitigation, land acquisition, and water treatment

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

ENVIRONMENTAL ISSUES: Concern exists on the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies.

ADDITIONAL FACTORS: Water customer acceptability of Simsboro Aquifer water.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

6.3 Simsboro Aquifer – Bastrop, Lee, and Milam Counties (SCTN-3)

6.3.1 Description of Option

The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. The aquifer has primarily been used for domestic, livestock, and public supplies, except in southwestern Milam County where an ongoing lignite mining operation has found it to be necessary to depressurize the aquifer for mining operations in the overlying Calvert Bluff Formation. Since 1988, the mine operators have pumped about 30,000 acft/yr from the Simsboro Aquifer and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operators are planning to advance southwestward into western Lee and northern Bastrop Counties. A well field intended for depressurization purposes in these expanded mining operations, as well as additional water being pumped from wells in the vicinity of the present mining operations would result in a well field that extends from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles (Figure 6.3-1).

Under this option, the placement and operation of wells for supplies to be used in the South Central Texas Water Planning Region would be coordinated with mining operations, and would result in the water that is pumped to depressurize the mines being used for municipal and industrial purposes as opposed to being discharged into local streams for disposal. The water quality of the Simsboro Aquifer is suitable for use as a public water supply, except for elevated concentrations of iron and manganese.

Even though some of the supply wells may have to be abandoned and replaced at another location from time-to-time, for planning purposes, only one well field development scenario is studied. With a proposed transfer of 75,000 acft/yr to the South Central Texas Water Planning Region and average well yields from the Simsboro Aquifer of about 300 gpm in the proposed well field, 170 wells would be required, including a contingency of 10 percent for wells being out-of-service. The supply wells would be spaced about 1,000 feet apart and parallel the outcrop.

The delivery options for the water supply include transporting the water at a uniform rate for: (1) release into the Colorado River west of Bastrop, (2) release into Plum Creek east of Lockhart, and (3) use in the major municipal and industrial demand center of the South Central Texas Region. The first two options would only be considered in conjunction with an exchange

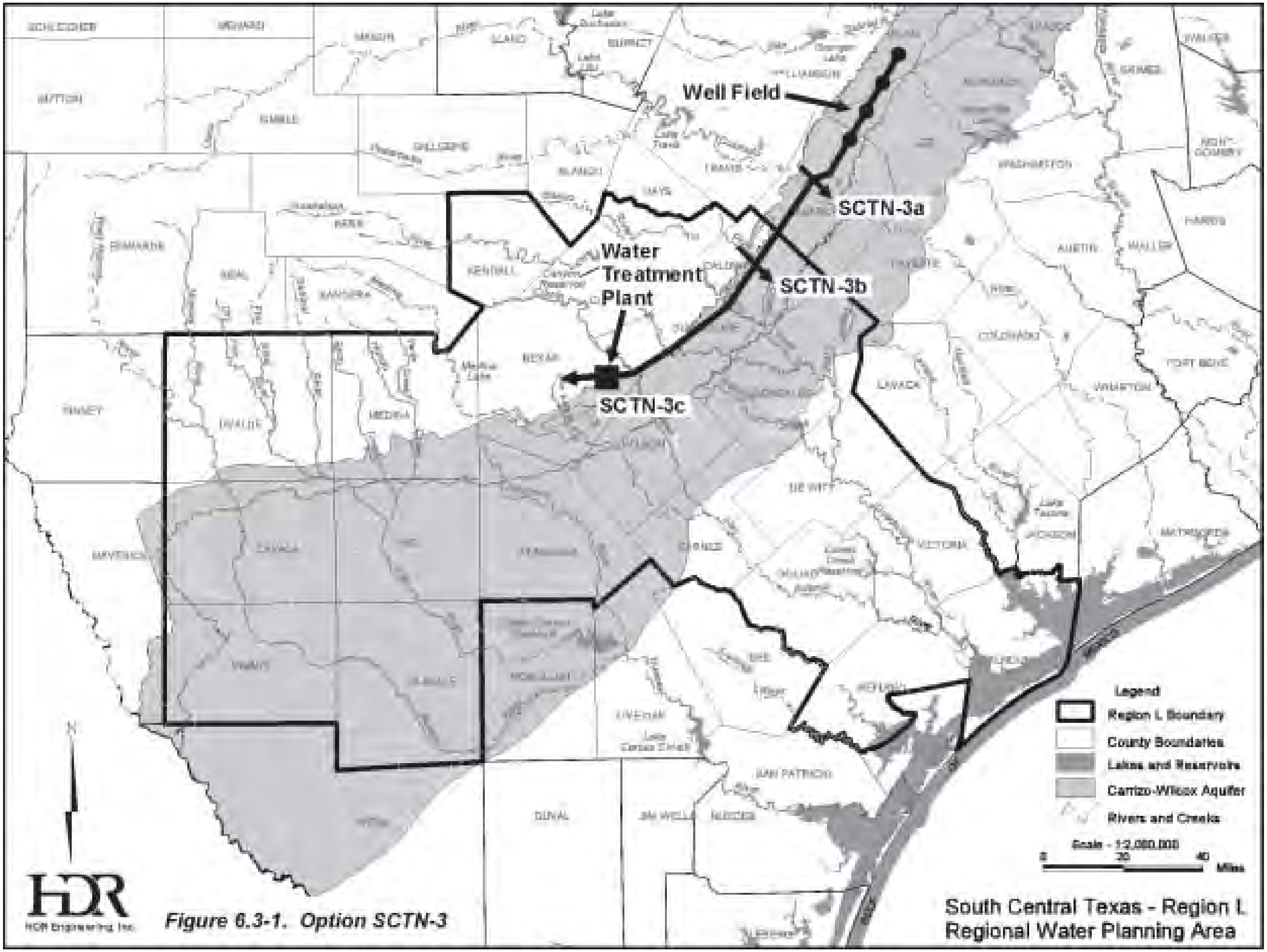


Figure 6.3-1. Option SCTN-3

for water in the Colorado and Guadalupe River Basins, which would then be transferred to the major municipal and industrial demand center of the South Central Texas Region. The third option would be to transport potable water to the major municipal and industrial demand center of the South Central Texas Region for direct use. The required facilities for all options include a Well Field and Conveyance System of pipelines, pump stations, and storage facilities. The third option requires a water treatment plant for removal of iron and manganese. Figure 6.3-1 indicates the location of the pipeline route, water treatment plant, and delivery points.

6.3.2 Available Yield

For an evaluation of this option, two recent groundwater availability studies[1,2] were reviewed. These studies indicate that in the project area, about 2,500 acft/yr of groundwater can be developed per mile along the outcrop of the Simsboro Aquifer. Considering a 32-mile section of the Carrizo-Wilcox Aquifer from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, about 80,000 acft/yr could be developed. After making an allowance for local groundwater use in the area, 75,000 acft/yr could be developed and transported to the South Central Texas Water Planning Region. Model simulations of the aquifer system indicate that drawdowns in the well field would be 100 to 150 feet in addition to drawdowns that are estimated to occur as a result of development for local use as reported in the TWDB's 1997 Water Plan.

6.3.3 Environmental Issues

Option SCTN-3 involves the construction of a 32-mile well field in Milam, Lee, and Bastrop Counties and a small portion of Williamson County, with three alternative extensions of a transmission pipeline that would deliver water to:

(3a) The Colorado River west of Bastrop,
(3b) Plum Creek east of Lockhart, or
(3c) A major municipal demand center in the Edwards Aquifer Region.

The northern part of the well field will be implemented to support lignite mining in the immediate future, and is presumed to be needed for that purpose regardless of whether the water is transferred to the South Central Texas Region.

[1] HDR Engineering, Inc., "Assessment of Groundwater Availability on CPS Property in Bastrop and Lee Counties, Texas", prepared for San Antonio Water System, San Antonio, Texas, July 1999.
[2] Dutton, Alan, R., "Assessment of Groundwater Availability in the Carrizo-Wilcox Aquifer in Central Texas—Results of Numerical Simulations of Six Groundwater Withdrawal Projections (2000-2050)," prepared for Texas Water Development Board, April 1999.

The majority of the well field and the extensions of the transmission pipeline lie in and along several borders of the Blackland Prairies and Post Oak Savannah vegetational areas.[3] The project area for SCTN-3a would lie in the Texas Blackland Prairies and East Central Texas ecoregions, while SCTN-3b and 3c would extend the proposed pipeline farther into the Texas Blackland Prairies.[4] All three options cross the Texan biotic province, except for SCTN-3c, which extends a small portion of the transmission line into the Tamaulipan biotic province.[5]

The dominant vegetation of the Blackland Prairies is mesquite, post oak, bluestems, switchgrass and blackjack supported by clay soils mixed with sandy loams. The Post Oak Savannah vegetational area is characterized by gently rolling to hilly terrain with an understory that is typically tall grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*). On-site surveys will be necessary to determine the specific fauna of the corridor since the pipeline corridor is a mosaic of the Post Oak Savannah and the Blackland Prairie ecoregions and could potentially include a wide variety of species.

Table 6.3-1 lists rare and protected species that may have habitat in the project area. The Texas Natural Heritage Program maps several species and essential habitat in the vicinity of the well field and transmission pipeline for SCTN-3. Houston Toad (*Bufo houstonensis*) habitat is mapped in Lee and Bastrop Counties along with several sightings of the species itself, and a portion of this habitat is less than a mile from the proposed project area. The well field and resulting watertable drawdown could potentially impact *Bufo houstonensis* in this area since the endangered Houston Toad uses the temporary pools provided by the saturated sands of the Carrizo aquifer as their breeding habitat. Another protected species, the Bald Eagle, was reported directly on the transmission pipeline route for SCTN-3a. The Bald Eagle prefers habitat near large bodies of water with nearby resting sites. In addition to the Houston Toad and Bald Eagle, Option SCTN-3c would pass in the vicinity of several mapped species of concern: Guadalupe Bass (*Micropterus treculi*), Mountain Plover (*Charadrius montanus*), Spikerush (*Eleocharis austrotexana*), and Bracted Twistflower (*Streptanthus bracteatus*).

[3] Omernik, James M., "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-135.
[4] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[5] Blair, W.F., "The biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.

Table 6.3-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Simsboro Aquifer – Bastrop, Lee, and Milam Counties (SCTN-3)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bone Cave Harvestman	*Texella reyesi*	Small, blind, cave-adapted harvestman endemic to a few caves in Travis and Williamson counties	LE		NL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Coffin Cave Mold Beetle	*Batrisodes texanus*	Resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson counties	LE		NL	
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Georgetown Salamander	*Eurycea sp. 5*	Endemic; known from springs and waters in/around town of Georgetown in Williamson County			NL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jollyville Plateau Salamander	*Eurycea sp. 1*	Known from springs and waters of some caves of Travis and Williamson counties north of the Colorado River			NL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident

Table 6.3-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer			NL	Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT		NL	Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WK	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Scarlet Snake	*Cemophora coccinea*	Sandy soils	NL	T	WL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texabama Croton	*Croton alabamensis var. texensis*	Deciduous/evergreen woodlands in duff-covered loamy clay soils on rocky slopes in mesic limestone ravines; flowering late Feb.-March			WL	Resident
Texas Fescue	*Festuca versuta*	Margins of Edwards Plateau[5]			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Tooth Cave Ground Beetle	*Rhadine persephone*	Resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson counties	LE		WL	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc. New York.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category
C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

Several protected species were not mapped along the proposed well field or pipeline route but may have essential habitat in the project area: Timber/Canebrake Rattlesnake, Texas Tortoise, and the Spot-tailed Earless Lizard. The Timber Rattlesnake and Spot-tailed Earless Lizard can be found in woodlands consisting of oak and other hardwoods, the Texas Tortoise prefers open brush with grass understory and usually occupies shallow depressions at the base of a bush or cactus. The endangered Navasota ladies' tresses (*Spiranthes parksii*), grows at the margins of post oak woodlands within sandy loams and may be affected by construction.

Protected bird species, which may have habitat within the study area, are the Golden-cheeked Warbler (*Dendroica chrysoparia*), Black-capped Vireo (*Vireo atricapillus*), and Zone-tailed Hawk. The Golden-cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories, while the Zone-tailed Hawk inhabits arid, open country including deciduous or pine-oak woodlands.

Two fish species that could only be affected by the delivery pipeline of Option SCTN-3c are the Toothless Blindcat (*Trogloganis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) which occupy the Edwards Aquifer under the City of San Antonio and are found at the end of the pipeline route. If this water is used to recharge the Edwards Aquifer, these fish species may be affected if water quality is changed.

Existing regulations would require that habitat studies and surveys for protected species be conducted at the proposed well field sites, construction activity sites, and along any pipeline routes. Monitoring saturated sands of the Carrizo for effects by pumping groundwater may be required to protect the Houston Toad habitat. When potential protected species habitat or other significant resources cannot be avoided, additional studies would be required to evaluate habitat use, permit requirements, and other mitigative measures. Eligibility for inclusion in the National Register for Historic Places would be considered for migration of cultural resources that could not be avoided. Wetland impacts, primarily pipeline stream crossings, can be minimized by ROW selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.3.4 Engineering and Costing

Groundwater would be developed by constructing wells along a line from U.S Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a collector pipeline, pump station(s), and terminal storage at the southern end of the well field. From here, the water would be pumped through a pipeline for release into either the Colorado River west of Bastrop (Option SCTN-3a), Plum Creek east of Lockhart (Option SCTN-3b), or to the major municipal and industrial demand center of the South Central Texas Region (Option SCTN-3c). Common to all the options is the Well Field and Collection System of wells, pipelines, and pump stations and a Transmission System of storage, pipelines, and pump stations to the Colorado River. For comparison purposes, estimates of cost include the construction of all wells. For options SCTN-3a and SCTN-3b, the wells would be constructed similar to irrigation wells. For SCTN-3c, the wells would be constructed to public water supply standards. For cost estimating purposes, the project is divided into segments with Option SCTN-3a extending from the well field to the Colorado River, Option SCTN-3b includes Option SCTN-3a plus the segment between the Colorado River and Plum Creek, and Option SCTN-3c includes Option SCTN-3b plus the segment from Plum Creek to the major demand center. The major facilities required for these options are:

- Well Field and Collection and Conveyance System (to U.S. Hwy 290):
  - Wells.
  - Pipelines.
  - Pump Station.
- Transmission System (from U.S. Hwy 290 to the three discharge points – Colorado River, Plum Creek, and the major demand center):
  - Storage.
  - Pipeline.
  - Pump Station.
  - Outlet Works (SCTN-3a and SCTN-3b).
- Water Treatment Plant:
  - Iron and Manganese removal (SCTN-3c only).

The approximate locations of the well field, pipeline, and water treatment plant are shown in Figure 6.3-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, land, and environmental mitigation. These costs are summarized in Tables 6.3-2 through 6.3-4. The annual costs, including debt service for a

Table 6.3-2.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to the Colorado River (SCTN-3a)
Second Quarter 1999 Prices

Item	*Estimated Cost*
Capital Costs	
Well Sites	$22,497,000
Water Conveyance System	23,611,000
Transmission Pump Station (1)	2,536,000
Transmission Pipeline (60-in dia., 12.3 miles)	10,199,000
Water Treatment Plant	0
Total Capital Cost	**$58,843,000**
Engineering, Contingencies and Legal Costs	19,455,000
Environmental & Archaeology Studies, Mitigation, and Permitting	314,000
Land Acquisition and Surveying (77 acres)	725,000
Interest During Construction (2.5 years)	7,934,000
Total Project Cost	**$87,271,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$6,340,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	715,000
Water Treatment Plant	0
Pumping Energy Costs (106,105,485 kWh @ $0.06 per kWh)	4,444,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$15,249,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft) Raw Water at Colorado River[1]	**$203**
Annual Cost of Water ($ per 1,000 gallons)	**$0.62**

[1] Near Bastrop.

Table 6.3-3.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to Plum Creek (SCTN-3b)
Second Quarter 1999 Prices

Item	***Estimated Cost***
Capital Costs	
Well Sites	$22,497,000
Water Conveyance System	23,611,000
Transmission Pump Stations (2)	12,756,000
Transmission Pipeline (60-in dia., 43.3 miles)	36,887,000
Water Treatment Plant	0
Total Capital Cost	**$95,751,000**
Engineering, Contingencies and Legal Costs	31,039,000
Environmental & Archaeology Studies, Mitigation, and Permitting	1,095,000
Land Acquisition and Surveying (269 acres)	2,534,000
Interest During Construction (2.5 years)	13,042,000
Total Project Cost	**$143,461,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$10,422,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	$1,214,000
Water Treatment Plant	0
Pumping Energy Costs (106,105,485 kWh @ $0.06 per kWh)	6,390,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$21,776,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft) Raw Water at Plum Creek[1]	**$290**
Annual Cost of Water ($ per 1,000 gallons)	**$0.89**

[1] Near center of Caldwell County.

Table 6.3-4.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to Major Municipal Demand Center of the
South Central Texas Region (SCTN-3c)
Second Quarter 1999 Prices

Item	Estimated Cost
Capital Costs	
Well Sites	$39,165,000
Water Conveyance System	23,611,000
Transmission Pump Stations (3)	22,839,000
Transmission Pipeline (60-in dia., 108.4 miles)	208,381,000
Water Treatment Plant (70.5 MGD)	9,145,000
Total Capital Cost	**$303,141,000**
Engineering, Contingencies and Legal Costs	99,047,000
Environmental & Archaeology Studies, Mitigation, and Permitting	2,745,000
Land Acquisition and Surveying (269 acres)	6,258,000
Interest During Construction (2.5 years)	41,120,000
Total Project Cost	**$452,311,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$32,860,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	3,324,000
Water Treatment Plant	3,302,000
Pumping Energy Costs (163,218,963 kWh @ $0.06 per kWh)	9,793,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$53,029,000**
Available Project Yield (acft/yr) Treated Water at Demand Center[1]	**75,000**
Annual Cost of Water ($ per acft)	**$707**
Annual Cost of Water ($ per 1,000 gallons)	**$2.17**

[1] Near center of Bexar County.

30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $15,249,000, $21,776,000, and $53,029,000 for options SCTN-3a, SCTN-3b, and SCTn-3c, respectively (Tables 6.3-2, 6.3-3, and 6.3-4). This option produces water at an estimated cost of $203, $290, and $707 /acft/yr, respectively. However, the cost estimates do not include potential fees that might be levied by underground water conservation districts, and the cost for SCTN-3c to the major demand center is for treated water, whereas the costs for SCTN-3a and 3b are for raw water at the Colorado River and Plum Creek discharge points.

6.3.5 Implementation Issues

Major issues of the development of groundwater in the Simsboro Aquifer in Bastrop, Lee, and Milam Counties for the South Texas Water Planning Region include:

- Need for additional hydrogeology and environmental data and analyses of the effects of pumping the aquifer at 75,000 acft/yr for an extended period of time.
- Impact on:
  - Endangered species;
  - Water levels in the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Potential regulations by the newly created groundwater district (Lost Pines Groundwater Conservation District).
- Development of agreements for the exchange of groundwater from the Simsboro Aquifer and surface water from the Colorado or Guadalupe Rivers and the cost of transporting the replacement surface water to the major demand center in the South Central Texas Region.
- Potential groundwater quality degradation from leakage of groundwater through the mine.
- Accounting for water losses in ‘bed and banks’ transport.
- Potential change in water quality in the Colorado and Guadalupe Rivers.
- The potential losses of water in options SCTN-3a and 3b where water is discharged to the Colorado River and Plum Creek, respectively. However, legally, such losses are not considered to be a waste of water, as decided by the Texas Supreme Court in City of Corpus Christi vs. City of Pleasanton, 276 s.w. 2d 798 (Tex, 1995).
- Future purchase price of water.
- Resistance to movement of water from one river basin to another and from one planning region to another.

6.4 Wintergarden Carrizo Recharge Enhancement (SCTN-7)

6.4.1 Description of Option

The Carrizo Aquifer is recharged through a relatively narrow outcrop extending across portions of Caldwell, Guadalupe, Gonzales, Wilson, Bexar, Atascosa, Medina, Frio, Uvalde, Zavala, and Dimmit Counties within the South Central Texas Region (Figure 6.4-1). Water is recharged where the aquifer outcrop occurs, generally travels downdip toward the south, and is available for pumpage in the counties listed above as well as La Salle, Karnes, and DeWitt Counties within the South Central Texas Region. Estimated average recharge to the Carrizo Aquifer is 13,000 acft/yr for Atascosa County; 10,000 acft/yr for Frio County; 25,000 acft/yr for Dimmit County; and 25,000 acft/yr for Zavala County.[1] The Carrizo Aquifer in the Wintergarden area is heavily pumped, with estimated pumpage in 1993 of 7,198 acft for Dimmit County; 66,440 acft for Zavala County; 350 acft for Frio County; 6,261 acft for La Salle County; and 54,078 acft for Atascosa County.[2] These counties are predominantly rural and the majority of the water pumped is used for irrigation.

This option includes evaluation of the potential for enhancing recharge of the Carrizo Aquifer in Dimmit, Zavala, Frio, and Atascosa Counties with available water from the Nueces, Frio, and Atascosa Rivers. Available flows from the Nueces, Frio, or Atascosa Rivers could be diverted into off-channel storage reservoirs, and released to facilities constructed to recharge the water to the aquifer using canals to convey water over the outcrop where infiltration would take place. Because injection of the water via wells would require some degree of treatment to remove suspended material that would otherwise clog aquifer pores and reduce well efficiency, this means of recharge is not considered herein. Water recharged under this option could be available for pumpage by local irrigators or for pumpage and transmission to a nearby municipality.

6.4.2 Water Availability

Water available for recharge enhancement from the Nueces, Frio, and Atascosa Rivers is limited by upstream and downstream water rights. Water for this option would be available

[1] LBG-Guyton Associates (LBG), "SCTN-7: Winter Garden Carrizo Recharge Enhancement," Draft Report to HDR Engineering, Inc., October 12, 1999.
[2] LBG and HDR Engineering, Inc. (HDR), "Interaction Between Groundwater and Surface Water in the Carrizo-Wilcox Aquifer," Texas Water Development Board (TWDB), August 1998.

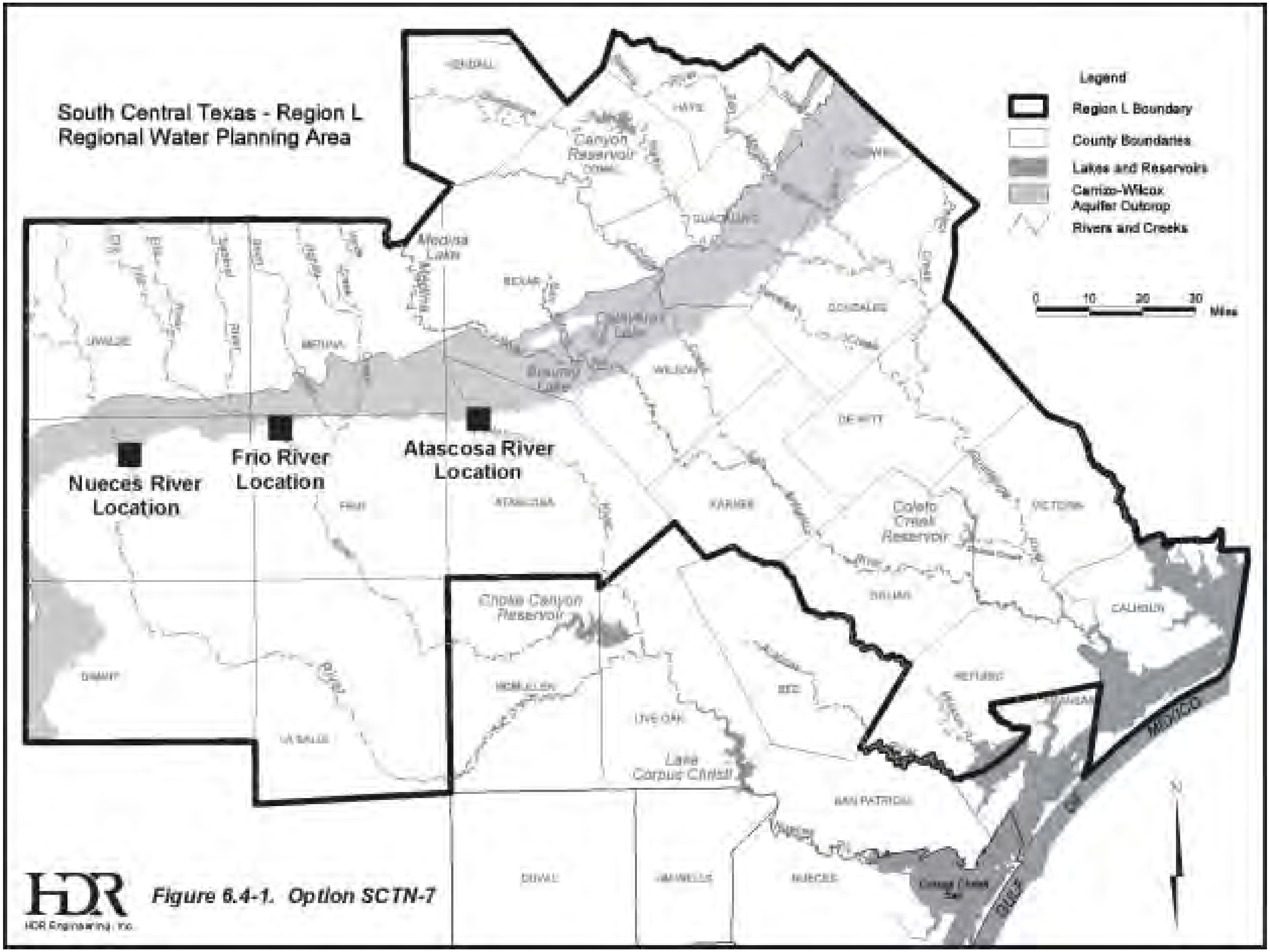


Figure 6.4-1. Option SCTN-7

sporadically, during periods of high flow when existing water rights are fully satisfied. The availability of water for recharge enhancement was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). Monthly regulated streamflows and unappropriated streamflows available from the Nueces, Frio, and Atascosa Rivers were estimated using the Nueces River Basin Water Availability Model (WAM),[3] developed for the Texas Natural Resource Conservation Commission (TNRCC) under the SB1 Water Availability Modeling Project. The current version of the Nueces River Basin WAM includes the 1934 to 1996 historical period. The input data files for the Nueces River Basin WAM were modified so as to match the general assumptions adopted by the South Central Texas Regional Water Planning Group and listed in the Introduction.

Water availability was estimated at three sites near the southern boundary of the Carrizo Aquifer outcrop in Zavala County (Nueces River, model control point 307901), Frio County (Frio River, model control point 9910), and Atascosa County (Atascosa River, model control point 321601). The approximate locations of these sites are shown in Figure 6.4-1. Daily streamflow available for diversion at these sites was estimated by distributing the monthly regulated and unappropriated streamflows to daily values using records for nearby streamflow gaging stations.

A computer program was developed to simulate daily diversion from a site into an off-channel storage facility, with subsequent diversion to the recharge canal system, or recharge field. Data inputs to the program include the monthly regulated and available streamflows estimated using the Nueces River Basin WAM, daily gaged flows used to distribute the monthly flows to daily values, the Consensus Criteria pass-through flow requirements, the transmission capacity of the diversion facility from the river to the off-channel reservoir, the storage capacity of the off-channel reservoir, and the recharge capacity of the recharge field. Monthly unappropriated or available flows for the three sites are summarized in Figure 6.4-2. As shown in the figure, available flows in the Frio River occur substantially less frequently than in the other two rivers. Hence, the Frio River site was eliminated from further analysis in this study. The streamflow statistics used in application of the Consensus Criteria pass-through requirements for the Nueces and Atascosa River sites are presented in Tables 6.4-1 and 6.4-2.

[3] HDR, "Water Availability in the Nueces River Basin," Texas Natural Resource Conservation Commission, October 1999.

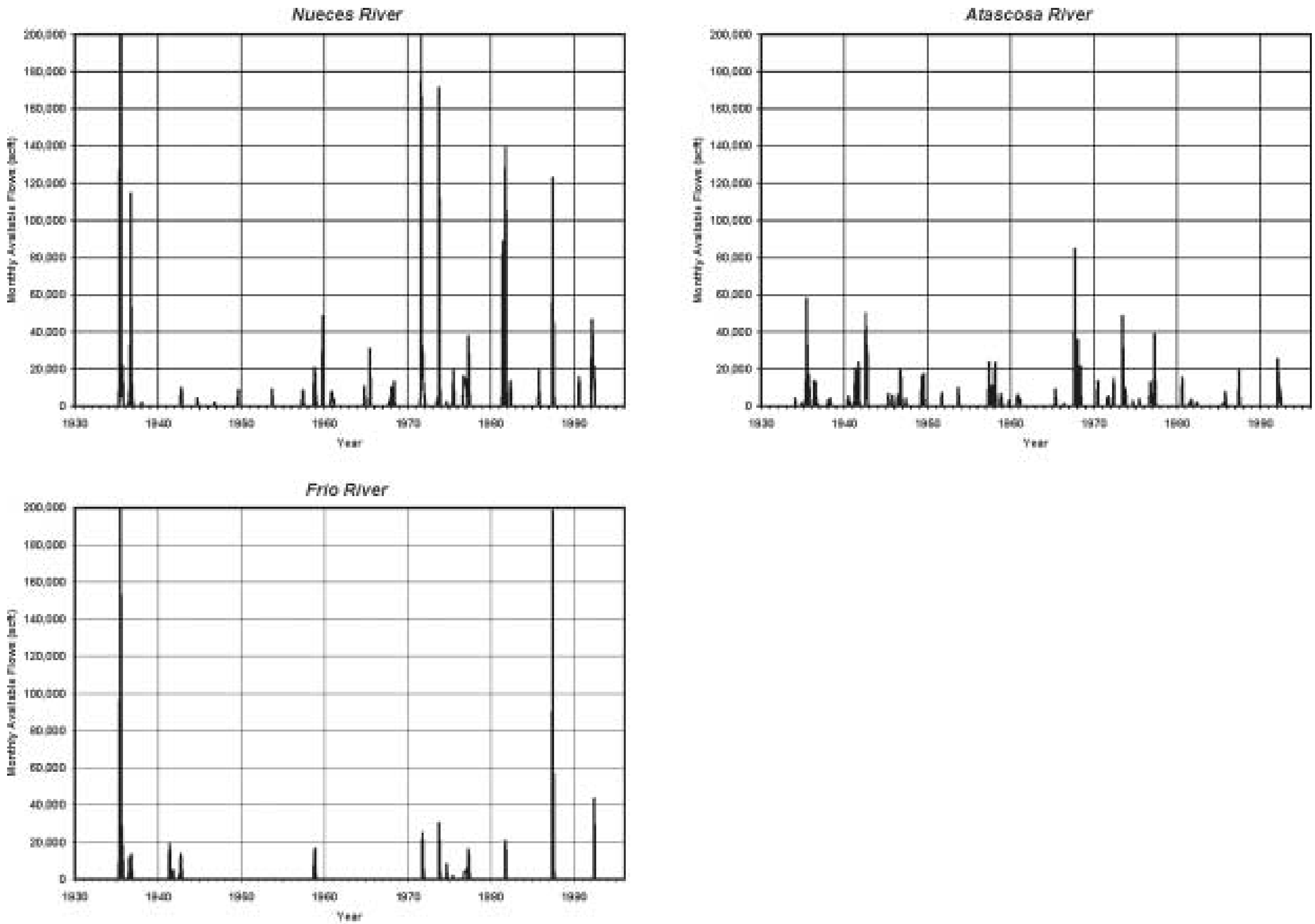


Figure 6.4-2. Monthly Available Flows at the Southern Boundary of the Carrizo Aquifer Outcrop

Table 6.4-1.
Daily Natural Streamflow Statistics for the Nueces River at the Downstream Boundary of the Carrizo Aquifer Outcrop

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	46	21[2]
February	43[1]	22[2]
March	41[1]	27[2]
April	45	28[2]
May	57	32[2]
June	53	30[2]
July	54	28[2]
August	53	23[2]
September	53	26[2]
October	59	27[2]
November	56	21[2]
December	50	21[2]
Zone 3 Pass-Through Requirement[3] (acft/day)		44

[1] When the Zone 3 pass-through requirement is greater than the median flow, the median flow is superceded by the Zone 3 pass-through requirement.
[2] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[3] Water Quality Standard (7Q2).

A system of recharge canals could potentially recharge an estimated 1,500 to 2,500 acft per acre per year, based upon the hydraulic conductivity of the aquifer and the permeability of overlying soils in the area.[4] A recharge rate of 2,000 acft per acre per year is equivalent to an infiltration rate of about 5.5 feet per day. Allowing for reductions in infiltration efficiency due to clogging of pore spaces or site-specific soil characteristics, an infiltration rate of 182 acft per acre per year (0.5 feet per day) was assumed. This rate generally agrees with, but is slightly lower than, permeability test data presented in soil surveys of Atascosa[5] and Zavala[6] Counties. The selected infiltration rate was assumed to occur uniformly over the land occupied by the recharge field.

[4] LBG, Op. Cit., October 12, 1999.
[5] U.S. Department of Agriculture, "Soil Survey of Atascosa County, Texas," August 1980.
[6] U.S. Department of Agriculture, "Soil Survey of Dimmit and Zavala Counties, Texas," November 1985.

Table 6.4-2.
Daily Natural Streamflow Statistics for the Atascosa River at the Downstream Boundary of the Carrizo Aquifer Outcrop

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	7	4
February	8	5
March	8	4
April	7	3
May	10	4
June	9	2
July	5	1
August	3	1
September	5	1
October	5	1
November	6	2
December	7	3
Zone 3 Pass-Through Requirement[1] (acft/day)		0.41

[1] Water Quality Standard (7Q2).

For the Nueces and Atascosa River sites, the average (mean) annual recharge available for multiple combinations of off-channel storage capacity and recharge field capacity was estimated. All combinations assumed a river diversion facility consisting of a channel dam, intake structure and pump station, and parallel 120-inch pipelines to divert flood flows to the off-channel reservoir at a maximum combined rate of about 800 cfs. Capital costs for the combined facilities were estimated and used to determine an approximate optimal configuration at each site. The optimal configuration for the Nueces River site would be the combination of a 10,000-acft capacity off-channel reservoir with a 1,000-acre recharge field, resulting in an average annual recharge enhancement to the Carrizo Aquifer of 11,000 acft. The optimal configuration for the Atascosa River site would be the combination of a 2,500-acft capacity off-channel reservoir with a 1,000-acre recharge field, resulting in an average annual recharge enhancement to the Carrizo Aquifer of 7,200 acft.

Recharge at both locations would occur sporadically, with water available only during flood events on the Nueces and Atascosa Rivers. Recharge facilities would be in operation only about 10 to 20 percent of the time. Estimated annual recharge enhancement over the 1934 to 1996 simulation period is shown for both alternatives in Figure 6.4-3. Limited additional recharge enhancement could occur from localized runoff adjacent to the recharge fields. While preliminary sites were identified for cost estimating purposes, numerous potential sites exist in the vicinity. Implementation of this option would require more detailed studies to select specific sites for recharge enhancement.

Figure 6.4-4 illustrates simulated changes in streamflow medians and frequencies near the Nueces and Atascosa River diversion locations. Monthly median streamflows would be reduced about three percent at the Nueces River location, and about 25 percent at the Atascosa River location. Reductions in inflow to the Nueces Estuary would be minimal, and would occur only during periods of high flow when Lake Corpus Christi would be spilling. There would be no change in the firm yield of the Choke Canyon Reservoir/Lake Corpus Christi System, located downstream of both projects, as the water diverted at both sites is unappropriated water.

6.4.3 Environmental Issues

Atascosa and Zavala Counties both fall within Blair's Tamaulipan biotic province[7] and the South Texas Plains vegetational area.[8] The South Texas Plains is comprised mainly of rangeland. The vegetation associated with this area has shifted from a grassland or savannah to shrubs characterized by mesquite, live oak (*Quercus virginiana*), acacia and post oak. Atascosa County lies equally within the Southern Texas Plains and East Central Texas Plains ecoregions. Zavala County lies almost entirely in the South Texas Plains, except for the southern tip, which penetrates the Central Texas Plateau ecoregion.[9]

Table 6.4-3 presents important plant and animal species as listed by the U.S. Fish and Wildlife Service (USFWS), Texas Parks and Wildlife Department (TPWD), and the Texas Organization for Endangered Species (TOES) for Atascosa and Zavala Counties. These species may be encountered during construction of the project. The endangered Jaguarundi (*Felis*

[7] Blair, W.F, "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[8] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[9] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.

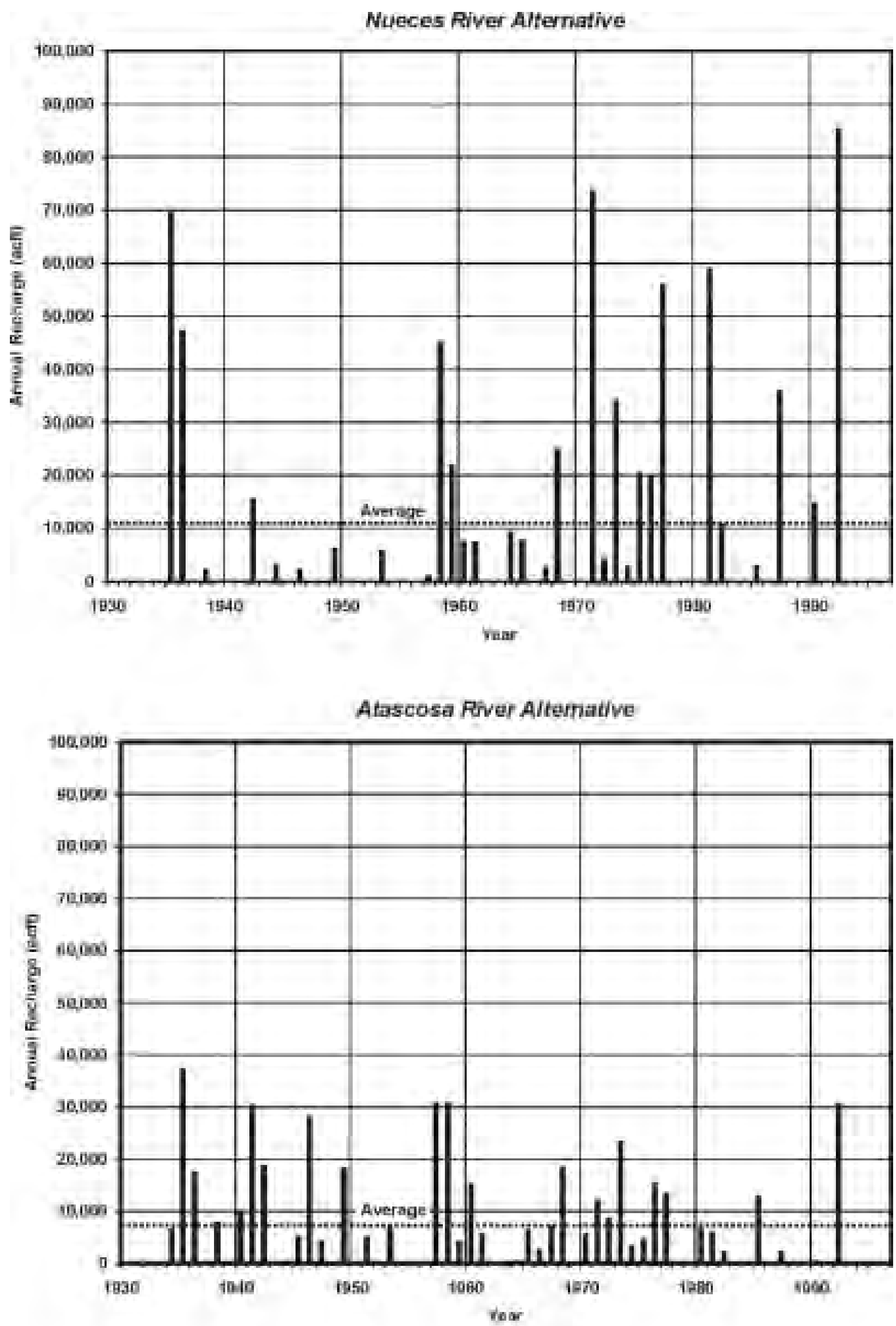


Figure 6.4-3. Carrizo Recharge Enhancement

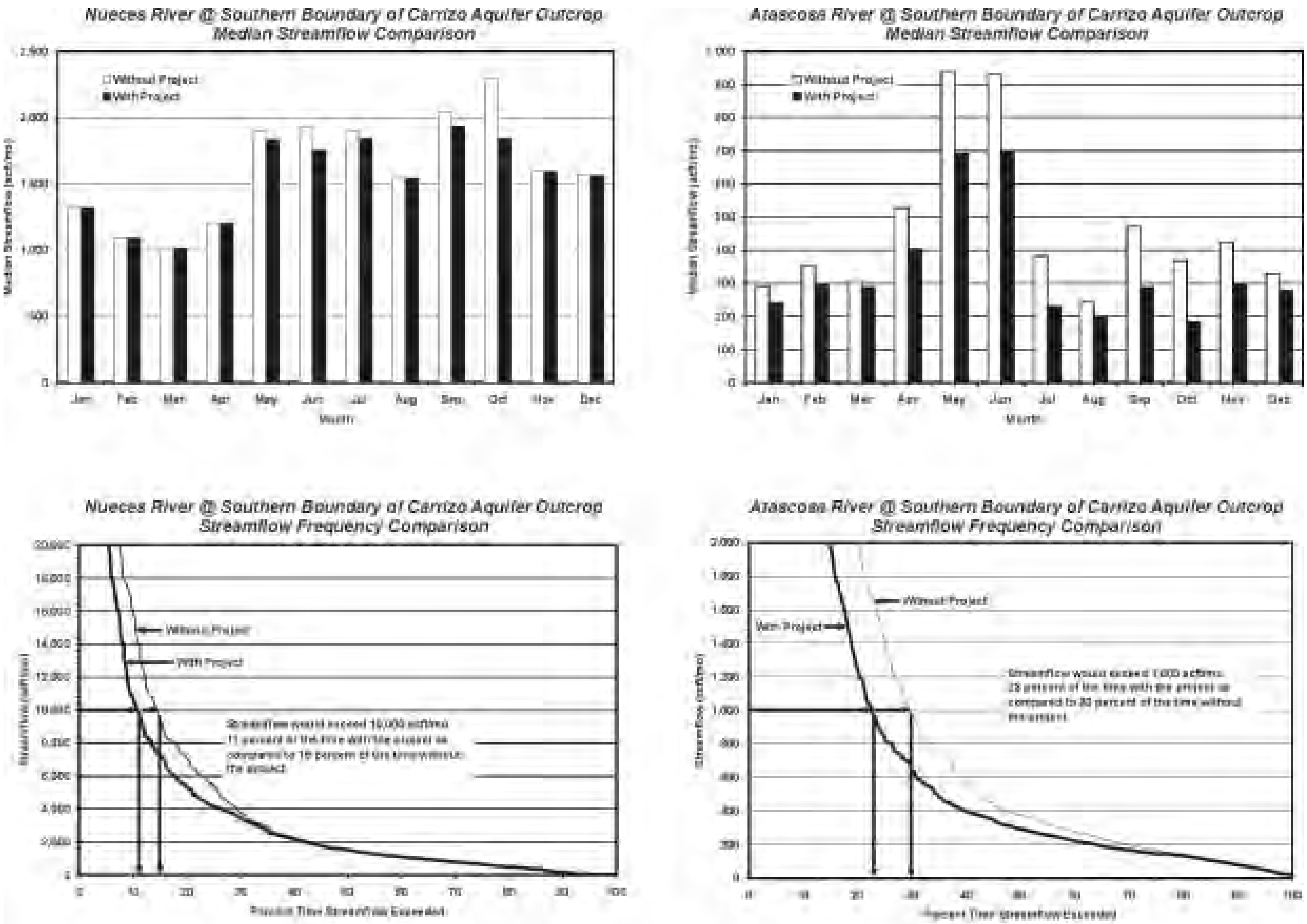


Figure 6.4-4. Carrizo Recharge Enhancement Streamflow Comparisons

Table 6.4-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Wintergarden Carrizo Recharge Enhancement (SCTN-7)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOE [2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	T/SA	T	T	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Frio Pocket Gopher	*Geomys texensis bakeri*	Sandy surface layers with loam going as deep as 2 meters			NL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking			NL	Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas			NL	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies			NL	Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbrush, mesquite-blackbrush		T	T	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations			NL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Yuma Myotis Bat	*Myotis yumanensis*	Desert regions, lowland habitats near open water, mines, tunnels, and buildings			NL	Resident
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C1 = Candidate Category, Substantial Information C2 = Candidate Category
C3 = No Longer a Candidate for Protection PE/PT = Proposed Endangered or Threatened
WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

yagouaroundi), which prefers thick brushlands, especially near water, and the Ocelot (*Felis pardalis*), which resides within mesquite-thorn scrubland and dense chaparral thickets, inhabit both Atascosa and Zavala Counties. Other species that may be encountered in the project area include the Texas Tortoise (*Gopherus berlandieri*), which inhabits open brush with a grass understory, the Plains Spotted Skunk (*Spilogale putorius interrupta*) found in both wooded and brushy areas, the Indigo Snake (*Drymarchon corais erebennus*), and Texas Garter Snake (*Thamnophis sirtalis annectens*). A survey of any potential project site may be required prior to construction to determine whether populations of, or potential habitat for, species of concern occur in the affected area.

Streamflows would be reduced as water is withdrawn from either the Atascosa or Nueces Rivers. However, streamflows up to the Consensus Criteria requirements would be passed at the project locations. As water will be diverted primarily during high flow periods, potential adverse affects should be minimal.

When potential protected species habitat cannot be avoided, additional studies would have to be conducted to evaluate habitat use. Sites of historic or prehistoric significance would be evaluated for possible inclusion in the National Register for Historic Places. Wetland impacts can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where such impacts are unavoidable.

6.4.4 Engineering and Costing

The site identified for the Nueces River diversion alternative would include a channel dam on the Nueces River near the town of Washer in Zavala County. Water would be diverted through parallel, 120-inch diameter, 1,000-foot pipelines to an off-channel storage reservoir. Water impounded in the storage reservoir would be released under gravity flow to the recharge field via a 96-inch diameter, 8,000-foot pipeline. The recharge field would consist of approximately 59 canals, 6,600 feet in length, with 12-foot bottom widths and 3:1 side slopes. Intake, pipeline, pumping station, operation and maintenance, and right-of-way acquisition costs were developed in accordance with the cost estimating procedures presented in Appendix A. Land was assumed to be purchased for the off-channel storage reservoir and the recharge field. Costs for development of the recharge field are based on costs for similar volumes of earthwork for recently completed projects. The cost estimate for the Nueces River alternative for this option is shown in Table 6.4-4

Financing the Nueces River alternative under TWDB guidelines (40 years at 6 percent annual interest for the off-channel reservoir and 30 years at 6 percent interest for all other facilities) results in an annual expense of $4,217,000. Annual operation and maintenance and energy costs total $1,400,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $5,617,000. For an average annual recharge enhancement of 11,000 acft, the resulting annual cost of water recharged to the Carrizo Aquifer from the Nueces River is $511 per acft (Table 6.4-4).

The site identified for the Atascosa River alternative would include a channel dam on the Atascosa River near the town of Rossville in Atascosa County. Water would be diverted through parallel, 120-inch diameter, 1,500-foot pipelines to an off-channel storage reservoir. The off-channel reservoir would be formed behind an earthen dam impounding an unnamed draw. Water impounded in the storage reservoir would be released under gravity flow to the recharge field via a 96-inch diameter, 14,000-foot pipeline. The recharge field would consist of approximately 84 canals, 4,700 feet in length, with 12-foot bottom widths, and 3:1 side slopes. Land was assumed to be purchased for the off-channel storage reservoir and the recharge field. Costs for development of the recharge field are based on costs for similar volumes of earthwork for recently completed projects. The cost estimate for the Atascosa River alternative for this option is shown in Table 6.4-5.

Financing the Atascosa River alternative results in an annual expense of $3,490,000. Annual operation and maintenance and energy costs total $1,029,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $4,519,000. For an average annual recharge enhancement of 7,200 acft, the resulting annual cost of water recharged to the Carrizo Aquifer from the Atascosa River is $627 per acft (Table 6.4-5).

6.4.5 Implementation Issues

Implementation of Option SCTN-7 could directly affect the feasibility of other water supply options under consideration, including L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.

Table 6.4-4.
Cost Estimate Summary for Carrizo Aquifer Recharge Enhancement (SCTN-7)
Recharge of Available Flows from the Nueces River
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (10,000 acft; 618 acres)	$10,945,000
Channel Dam	1,890,000
Intake and Pump Station (9,740 HP)	9,037,000
Recharge Canals (1,000 acres; 59 canals; 6,600 ft long)	9,995,000
Pipelines from Channel Dam to Reservoir (Two 120-inch dia.; 1,000 feet)	1,040,000
Pipeline from Reservoir to Recharge Zone (96-inch; 8,000 feet)	2,536,000
Highway and Stream Crossings	116,000
Power Connection Costs ($125/HP)	1,218,000
Total Capital Cost	**$36,777,000**
Engineering, Legal Costs and Contingencies	$12,080,000
Land Acquisition and Surveying (1,633 acres)	1,335,000
Interest During Construction (4 years)	8,220,000
Environmental & Archaeology Studies, Mitigation and Permitting	1,181,000
Total Project Cost	**$59,593,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$3,008,000
Reservoir Debt Service (6 percent for 40 years)	1,209,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	293,000
Dam and Reservoir	193,000
Recharge Field Maintenance and Cleaning	150,000
Pumping Energy Costs (28,006,971kWh @ $0.06 per kWh)	764,000
Total Annual Cost	**5,617,000**
Available Annual Recharge (acft/yr) Raw Water in Aquifer[1]	**11,000**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$511**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$1.57**

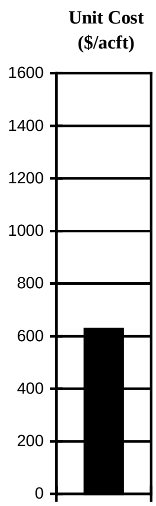
[1] Reported Annual Cost of Water is for additional water supply in the Carrizo Aquifer.

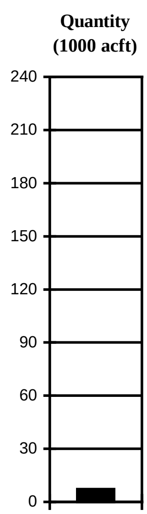
Table 6.4-5.
Cost Estimate Summary for Carrizo Aquifer Recharge Enhancement (SCTN-7)
Recharge of Available Flows from the Atascosa River
Second Quarter 1999 Prices

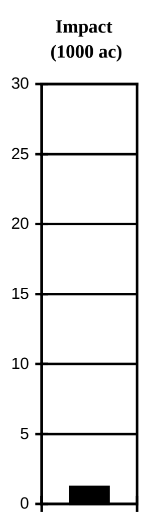
Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (2,500 acft; 210 acres)	$4,708,000
Channel Dam	1,890,000
Intake and Pump Station (21,429 HP)	9,037,000
Recharge Canals (1,000 acres; 84 canals; 4,700 feet long)	10,133,000
Pipelines from Channel Dam to Reservoir (Two 120-inch, 1,500 feet)	1,560,000
Pipeline from Reservoir to Recharge Zone (96-inch, 1,400 ft)	444,000
Highway and Stream Crossings	116,000
Power Connection Costs ($125/HP)	1,218,000
Total Capital Cost	**$29,106,000**
Engineering, Legal Costs and Contingencies	$9,474,000
Land Acquisition and Surveying (1,210 acres)	1,795,000
Interest During Construction (4 years)	6,719,000
Environmental & Archaeology Studies, Mitigation and Permitting	1,617,000
Total Project Cost	**$48,711,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$2,956,000
Reservoir Debt Service (6 percent for 40 years)	534,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	278,000
Dam and Reservoir	99,000
Recharge Field Maintenance and Cleaning	152,000
Pumping Energy Costs (18,331,835 kWh @ $0.06 per kWh)	500,000
Total Annual Cost	**$4,519,000**
Available Annual Recharge (acft/yr) Raw Water in Aquifer[1]	**7,200**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$627**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$1.93**

[1] Reported Annual Cost of Water is for additional water supply in the Carrizo Aquifer.

   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. General Land Office (GLO) Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Texas Parks and Wildlife Department Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Effects on bay and estuary inflows.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Recovery of the enhanced recharge would need to be coordinated and permitted through local groundwater conservation districts, including the Evergreen District for the Atascosa site and the Wintergarden District for the Nueces River site.







OPTION NUMBER: SCTN-7
OPTION NAME: Wintergarden Carrizo Recharge Enhancement—Atascosa River Alternative

OPTION DESCRIPTION: *Recharge to the Carrizo Aquifer would be enhanced through the operation of an off-channel reservoir and a system of recharge canals, supplied from the Atascosa River in Atascosa County. Enhanced recharge would be available for pumping by local irrigators or for pumpage and transmission to a municipality.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$627**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**7,200**	**acft/yr[2]**
LAND IMPACTED:	**1,210**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Channel dam, off-channel reservoir, Atascosa River diversion pump station and pipeline, reservoir intake, transmission pipeline to recharge canals, and recharge canals.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size of off-channel reservoir, and number and size of recharge canals.

[3]**LAND IMPACTED:** Off-channel reservoir site, pipeline right-of-way, and recharge canal field.

ENVIRONMENTAL ISSUES: Inundation of about 210 acres adjacent to the Atascosa River, and construction and operation of a 1,000-acre recharge canal field. Archeological and cultural resource surveys have not been conducted.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high for potential irrigation uses.

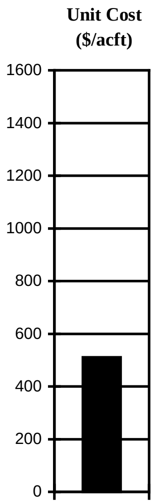
ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Atascosa River and recover enhanced recharge from the Carrizo Aquifer.

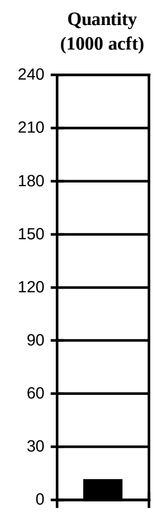
OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

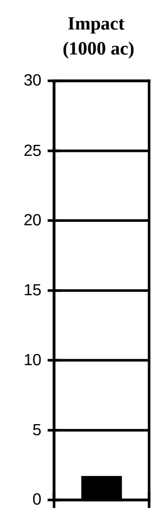
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft – 12/31/99







OPTION NUMBER: SCTN-7
OPTION NAME: Wintergarden Carrizo Recharge Enhancement—Nueces River Alternative

OPTION DESCRIPTION: *Recharge to the Carrizo Aquifer would be enhanced through the operation of an off-channel reservoir and a system of recharge canals, supplied from the Nueces River in Zavala County. Enhanced recharge would be available for pumping by local irrigators or for pumpage and transmission to a municipality.*

TIME NEEDED TO IMPLEMENT: ☐ **1-5 yr.** ☒ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$511**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**11,000**	**acft/yr[2]**
LAND IMPACTED:	**1,633**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Channel dam, off-channel reservoir, Nueces River diversion pump station and pipeline, reservoir intake, transmission pipeline to recharge canals, and recharge canals.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size of off-channel reservoir, and number and size of recharge canals.

[3]**LAND IMPACTED:** Off-channel reservoir site, pipeline right-of-way, and recharge canal field.

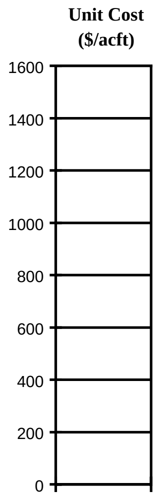
ENVIRONMENTAL ISSUES: Inundation of about 633 acres adjacent to the Nueces River on an unnamed tributary, and construction and operation of a 1,000-acre recharge canal field. Archeological and cultural resource surveys have not been conducted.

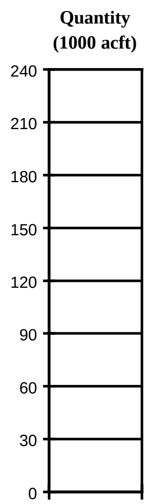
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high for potential irrigation uses.

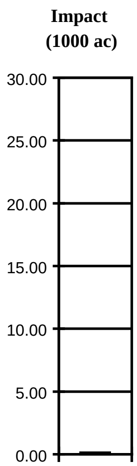
ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Nueces River and recover enhanced recharge from the Carrizo Aquifer.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
DRAFT – 12/13/99







OPTION NUMBER: **SCTN-2a**
OPTION NAME: **Groundwater Supplies for Municipal Water Systems in the Carrizo-Wilcox Aquifer**

OPTION DESCRIPTION: *Municipal water systems in the upper Coastal Plains area of the South Central Texas Water Planning Region commonly use the Carrizo-Wilcox Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to its ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**N/A**	**per acft**[1]
QUANTITY OF WATER:	**N/A**	**acft/yr**[2]
LAND IMPACTED:	**N/A**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** See Individual City Fact Sheet.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.5 Groundwater Supplies for Municipal Water Systems in the Carrizo-Wilcox Aquifer, South Central Texas Water Planning Region (SCTN-2a)

6.5.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the upper Coastal Plains area of the South Central Texas Water Planning Region commonly use the Carrizo-Wilcox Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050;
- If additional supplies are needed, identify a suitable area for new well fields; and
- If additional wells are needed or if the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;
2. Estimated the Texas Natural Resources Conservation Commission (TNRCC) required system capacity through the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and the Texas Water Development Board (TWDB);

4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.5.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheets provide information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the municipal water systems (Figure 6.5-1) is presented below.

6.5.2.1 Batesville, Charlotte, Crystal City, Dilley, Falls City, Floresville, Jourdanton, La Pryor, Nixon, Pearsall, Poteet, and Poth

The municipal systems servicing the communities of Batesville, Charlotte, Crystal City, Dilley, Falls City, Floresville, Jourdanton, La Pryor, Nixon, Pearsall, Poteet, and Poth have well fields that are not expected to encounter water supply problems or a need for expansion before the year 2050. However, regional water level declines in some areas may cause the system operators to lower pumps in some of their wells, and as growth in water demands occurs, it may be necessary to add wells to meet peak day demands.

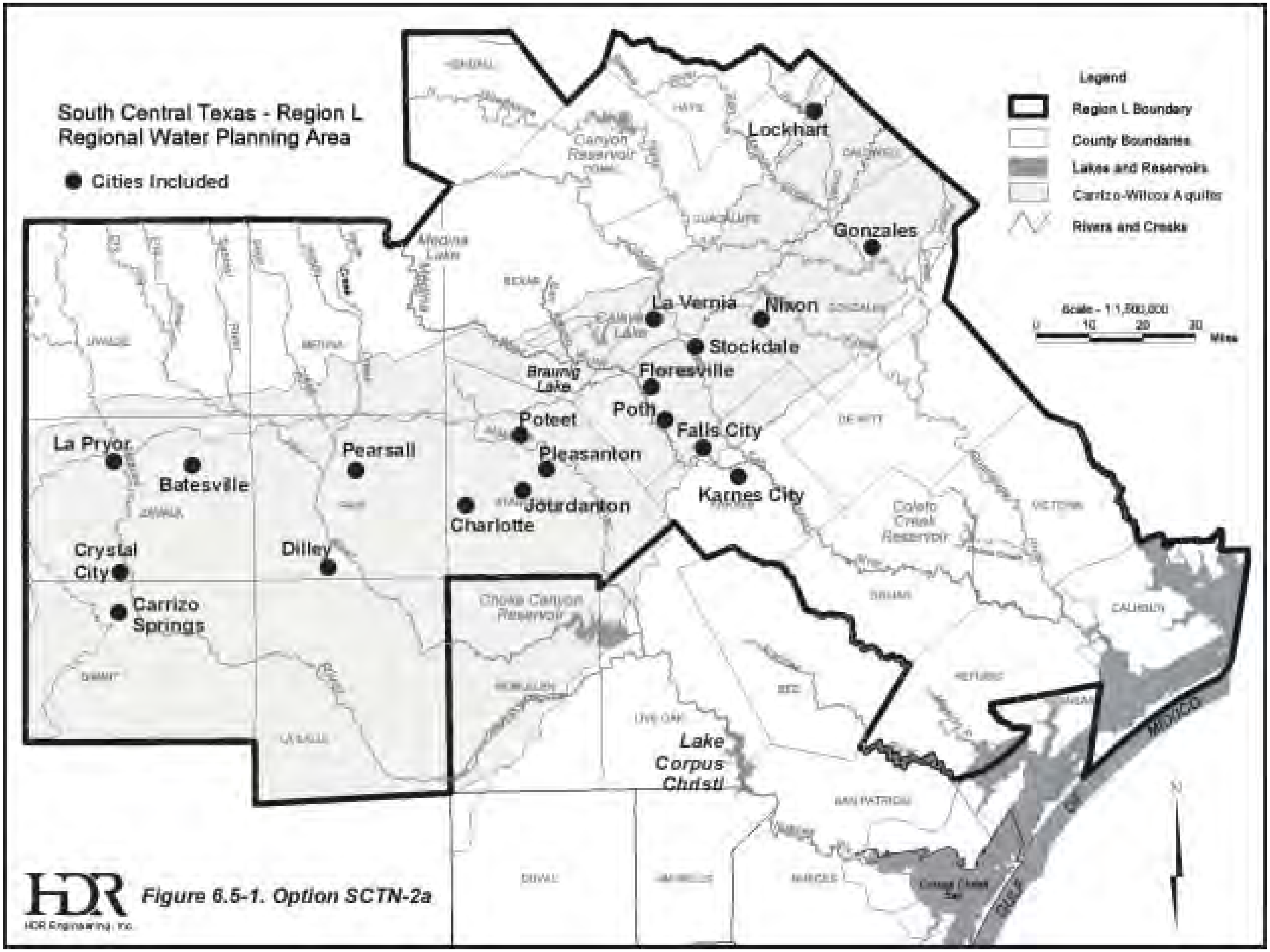


Figure 6.5-1. Option SCTN-2a

Water from the Carrizo-Wilcox Aquifer often has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. TNRCC field surveys report that these guidelines are exceeded in the cities of Charlotte, Dilley, Jourdanton, Nixon, and Pearsall. The cost of adding a water treatment plant for each of these cities is provided in the Fact Sheet.

Some of the well fields are located where the Carrizo Aquifer is very deep and produces relatively hot water.

6.5.2.2 LaVernia, Gonzales

The cities of LaVernia and Gonzales have a combined surface water and groundwater supply, and are not expected to encounter water supply problems.

6.5.2.3 Carrizo Springs, Lockhart, Pleasanton, and Stockdale

The cities of Carrizo Springs, Lockhart, Pleasanton, and Stockdale appear to have sufficient groundwater supplies in their well fields. However, projections indicate that additional well(s) will be required before the year 2050. The date or year when the wells are needed and the estimated costs are provided in each city's Fact Sheet.

For the City of Lockhart, groundwater in the well field typically has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. The cost of adding a water treatment plant is provided in the Lockhart Fact Sheet.

6.5.2.4 Karnes City

Karnes City is between the downdip limits of the Carrizo Aquifer and the freshwater formations of the Gulf Coast Aquifer. Karnes City has one Carrizo Aquifer well near Falls City that is the primary supply. Three wells in the Catahoula Formation of the Gulf Coast Aquifer are located in the city and produce slightly saline water. They are used for emergency supplies. Additional supplies can be acquired by expanding the well field near Falls City or using a desalinization process for the Catahoula Aquifer wells in Karnes City. (See Option SCTN-17 of Section 1.10).

6.5.3 Environmental Issues

In Option SCTN-2a existing municipal well fields in the upper Coastal Plains area, which use the Carrizo-Wilcox Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050.

Data from well fields in this area show declining trends in groundwater levels during the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels.

The pumping of groundwater from the Carrizo-Wilcox Aquifer could have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species should be considered when evaluating this option.

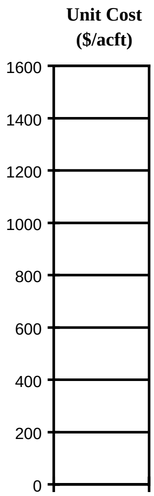
Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primary pipeline stream crossings, can be minimized by ROW selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

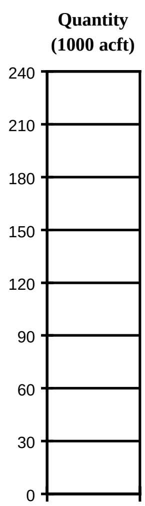
6.5.4 Engineering and Costing: See Individual City Fact Sheets

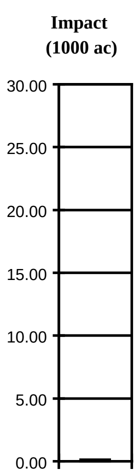
6.5.5 Implementation Issues

The development of additional wells and well fields in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling and aquifer water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.
- Regulations by Underground Water conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.







OPTION NUMBER: SCTN-2b
OPTION NAME: Groundwater Supplies for Municipal Water Systems in the Gulf Coast Aquifer

OPTION DESCRIPTION: *Municipal water systems in the lower Coastal Plains area of the South Central Texas Water Planning Region commonly use the Gulf Coast Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**N/A**	**per acft**[1]
QUANTITY OF WATER:	**N/A**	**acft/yr**[2]
LAND IMPACTED:	**N/A**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** See Individual City Fact Sheet.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.6 Groundwater Supplies for Municipal Water Systems in the Gulf Coast Aquifer, South Central Texas Water Planning Region (SCTN-2b)

6.6.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the lower Coastal Plains area of the South Central Texas Water Planning Region commonly use the Gulf Coast Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through year 2050;
- If additional supplies are needed, identify a suitable area for new well field(s); and
- If additional wells are needed or if the water needs to be treated, estimates are made as to when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;
2. Estimated the Texas Natural Resources Conservation Commission (TNRCC) required system capacity in the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and the Texas Water Development Board (TWDB);

4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.6.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheets provide information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

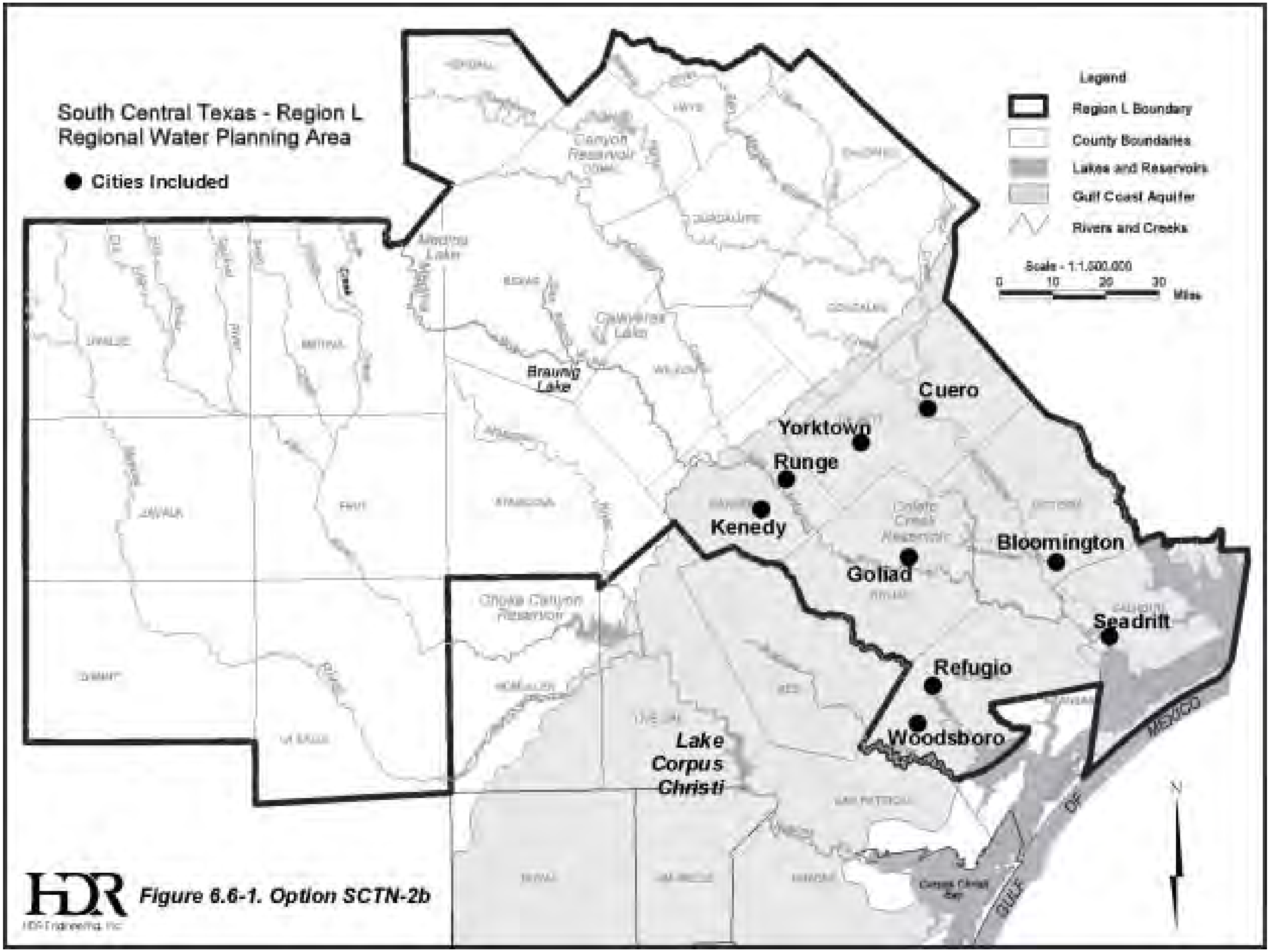
A discussion on the municipal water systems (Figure 6.6-1) is presented below.

6.6.2.1 Cuero, Goliad, Kenedy, Refugio, Runge, Yorktown, and Woodsboro

The municipal systems servicing the communities of Cuero, Goliad, Kenedy, Refugio, Runge, Yorktown, and Woodsboro have well fields that are not expected to encounter water supply problems or a need for expansion before the year 2050.

6.6.2.2 Bloomington

The City of Bloomington appears to have sufficient groundwater supplies in their well field. However, projections indicate that additional wells will be required. Details on when the additional supplies are needed and the estimated cost are provided in the City's Fact Sheet.



HDR Figure 6.6-1. Option SCTN-2b

6.6.2.3 Refugio

For the City of Refugio, the well field is not expected to encounter water supply problems or a need for expansion before the year 2050. However, TNRCC field survey notes that the chloride concentrations in their water supply exceeds the 250 milligrams per liter primary drinking water standard. The capital cost for a desalination water treatment plant is provided in the City's Fact Sheet.

6.6.2.4 Seadrift

The City of Seadrift is in an area where freshwater from the Gulf Coast Aquifer is very limited. As a result, the City's wells produce slightly saline water. Recently, a desalinization treatment process (reverse osmosis) has been added and demineralizes the water to drinking water standards. Sufficient supplies of slightly saline water are available through the year 2050.

6.6.3 Environmental Issues

In Option SCTN-2b existing municipal well fields in the lower Coastal Plains area, which use the Gulf Coast Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050. Data from well fields in this area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels and potential encroachment of poor quality groundwater should be considered when evaluating this option.

The pumping of groundwater from the Gulf Coast Aquifer could also have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools, as well as aquifers and springs. Possible negative effects in these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by ROW selection and appropriate construction methods, including erosion controls and revegeration procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.6.4 Engineering and Costing: See Individual City Fact Sheets

6.6.5 Implementation Issues

The development of additional wells and well fields in the Gulf Coast Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluations including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands
- Competition with others for groundwater in the area.
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
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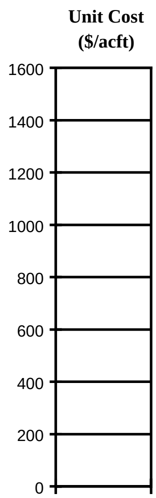
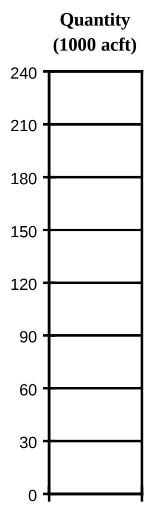
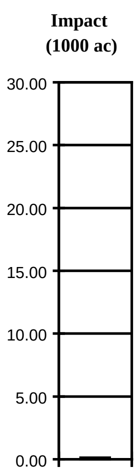






OPTION NUMBER: SCTN-2c
OPTION NAME: Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer

OPTION DESCRIPTION: *Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantities, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**N/A**	**per acft**[1]
QUANTITY OF WATER:	**N/A**	**acft/yr**[2]
LAND IMPACTED:	**N/A**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** See Individual City Fact Sheets.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.7 Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer, South Central Texas Water Planning Region (SCTN-2c)

6.7.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantity, inexpensive, and suitable for public water supplies with minimal treatment. However, a very rapid growth of population in the cities as well as the development of rural areas is clashing with the rather modest supply of groundwater. Two ongoing efforts to address the water supply issue are (1) the formation of the Cow Creek Groundwater Conservation District (Kendall County), and (2) the planned construction of the West Comal Water Supply Project by the Guadalupe-Blanco River Authority (GBRA).

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050;
- If additional supplies are needed, identify a suitable area for a new well field(s); and
- If additional wells are needed or if the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;
2. Estimated the Texas Natural Resources Conservation Commission (TNRCC) required system capacity in the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and the Texas Water Development Board (TWDB);
4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.7.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheet provides information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the evaluation of the systems (Figure 6.7-1) that are having difficulties or will be expected to have difficulties before the year 2050 is provided below.

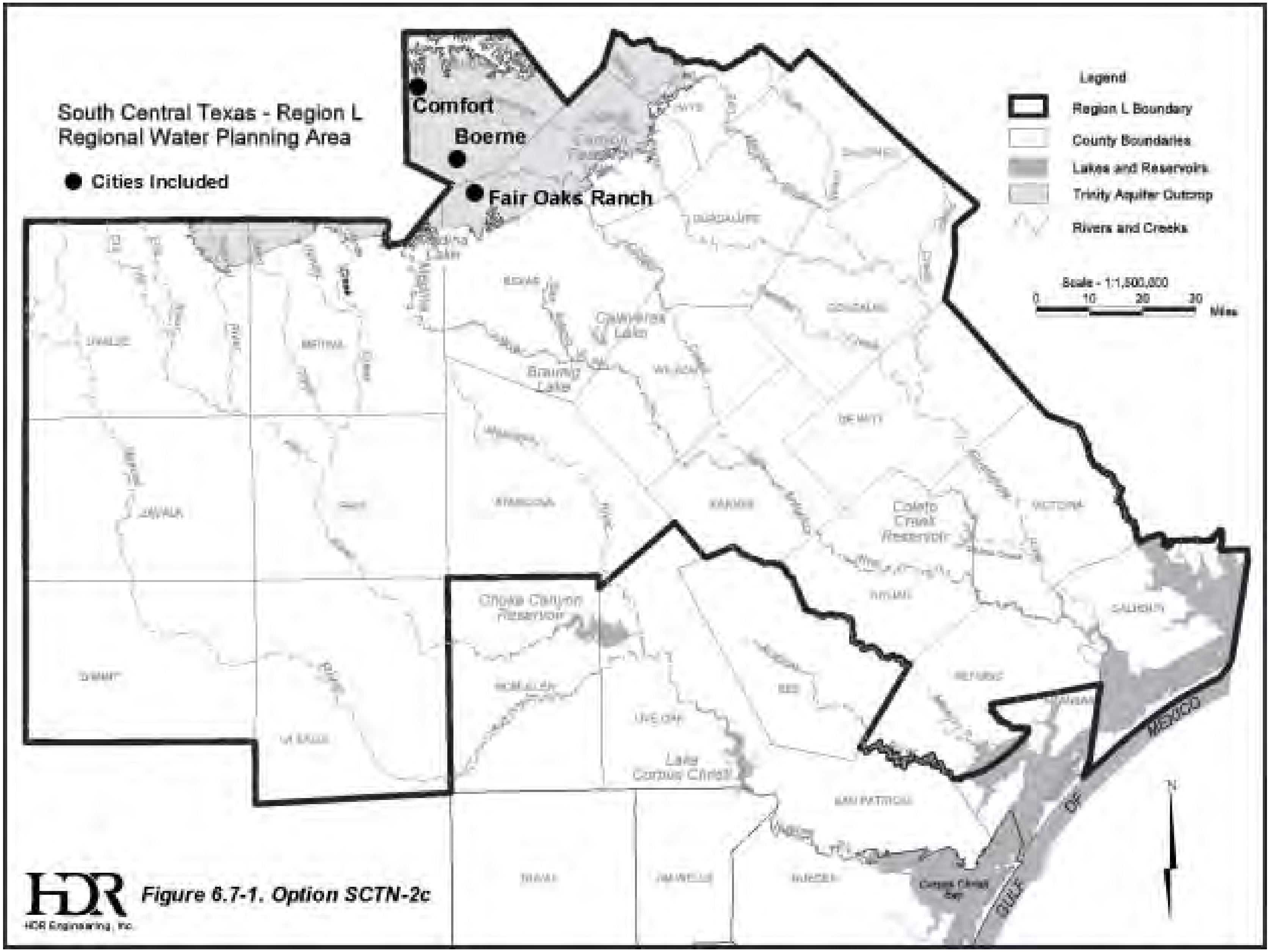


Figure 6.7-1. Option SCTN-2c

6.7.2.1 Boerne

Groundwater supplies from the Trinity Aquifer are inadequate and have been for many years. Consequently, Boerne has been drawing over 800 acre-feet/year from Cibolo Creek. In the near future these combined supplies will not be adequate. Consequently, Boerne has plans to connect to GBRA's West Comal Water Supply Project that draws water from Canyon Lake. Given these sources of supply, Boerne's projected demands can be met through 2040, but additional supplies will be needed for projected growth after 2040.

6.7.2.2 Comfort

Groundwater from the Trinity Aquifer in the vicinity of Comfort appears to be adequate to meet projected demands through the year 2050. However, TNRCC notes a Secondary Drinking Water violation for chlorides and total dissolved solids. One or two of Comfort's deeper wells probably are causing the salinity problem. Because the shallow formations of the Trinity Aquifer typically produces water somewhat better than the secondary drinking water standards, the salinity problem probably can be corrected by taking the problem well(s) out of service and replacing them with new, shallower wells. The new wells should be located at least .5 miles from the nearest large capacity well producing from the same formation. Another option is to add a desalinization water treatment process to the water system. The estimated cost for a replacement well is provided in the City's Fact Sheet.

6.7.2.3 Fair Oaks Ranch

With rapid growth in demands in and around Fair Oaks Ranch and decreasing well yields caused by declining water levels, more and more wells and/or well fields will be required. As a result, and given the fact that suitable supplies of groundwater are not readily available locally, the City of Fair Oaks is participating in GBRA's West Comal Water Supply Project for an outside water supply. With advanced water conservation, and use of small quantities of reclaimed water (less than 25 acft/yr), Fair Oaks would not need additional supplies during the 50-year planning horizon.

6.7.3 Environmental Issues

In Option SCTN-2c existing municipal well fields in the Hill Country area, which use the Trinity Aquifer for their water supply, are evaluated. Some municipalities will need additional wells or well fields or a supplemental water supply from other aquifers or surface sources to meet projected water supply needs to 2050. Data from wells in this area show a declining trend in groundwater levels. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels should be considered when evaluating this option.

The pumping of groundwater from the Trinity Group of aquifers could also have a negative impact on springflow in these areas. Some species inhabit or use the aquifers and springs of the area. Possible negative effects on these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by ROW selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.7.4 Engineering and Costing: See Individual City Fact Sheet

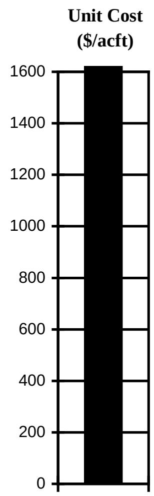
6.7.5 Implementation Issues

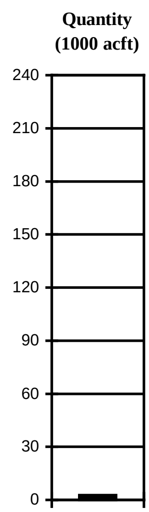
The development of additional wells in the Trinity Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

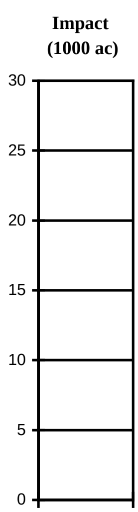
- Detailed feasibility evaluation including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.

- Competition with others for groundwater in the area,
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where underground water conservation districts have been organized.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft - 12/31/99







OPTION NUMBER: **SCTN-1a**
OPTION NAME: **Aquifer Storage and Recovery (ASR) – Regional Option**

OPTION DESCRIPTION: *Option SCTN-1a evaluates regional scale municipal and industrial utilities that would benefit from storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when demand exceeds supply or system capacity. A regional scale facility is considered to have a capacity of 10 to 20 million gallons per day. For this option, two facilities are evaluated. One of the facilities would use the Carrizo-Wilcox Aquifer to support water suppliers in the major municipal and industrial demand center. The other one would support utilities in the Victoria area and would use the Gulf Coast Aquifer.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15 yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF CAPACITY (average):	**$2,428 and $1,009**	**per acft**[1]
QUANTITY OF CAPACITY (each facility):	**2,792**	**acft/yr**[2] **(Capacity only)**
LAND IMPACTED (average):	**286**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get raw water to the water treatment plant and to the ASR facility are not included. Costs presented here are for installation and operation of an ASR facility.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 10 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce any new water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts will be well sites and transmission facilities. The facility for the major municipal and industrial demand center would impact about 278 acres in rural areas while the Victoria facility would impact about 8 acres of urban area.

ENVIRONMENTAL ISSUES: Considered to be minimal – well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of ASR water, suitability of local aquifer conditions, control of potential water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.8 Aquifer Storage and Recovery (ASR) – Regional Option (SCTN-1a)

6.8.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1a evaluates regional scale ASR facilities for municipal and industrial water supply management. A regional scale facility is considered to have a capacity of 10 to 20 million gallons per day (MGD), or 11,201 to 22,402 acft/yr, if operated continuously. For this option, three facilities are evaluated. Two of the facilities would support municipal and industrial utilities located in the major municipal and industrial demand center of the South Central Texas Region and would use nearby sites located over the Carrizo-Wilcox Aquifer. The other facility would support municipal and industrial water suppliers in the Victoria area and would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.8.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, Texas Natural Resource Conservation Commission (TNRCC) regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.8.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gallons per minute (gpm) (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gallons per minute (gpm).

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the Gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Regulations: The Texas Natural Resources Conservation Commission (TNRCC) regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.8.2 Available Capacity

For purposes of evaluating this option, regional size water supply facilities are considered in order to be useful to major municipal and industrial water utilities in the major municipal and industrial demand center of the South Central Texas Region and in the vicinity of Victoria. The Carrizo Aquifer, from northern Atascosa to southwestern Gonzales Counties, offers suitable characteristics for an ASR facility to serve the major municipal and industrial demand center in Bexar County. The Gulf Coast Aquifer is suitable for the City of Victoria. The locations are shown in Figure 6.8-1.

The development of an ASR facility requires use of water to sufficiently flush the formation and to create a bubble of injected water. This quantity of water used to flush the formation is lost, and varies from site to site. However, once the site of the projects identified in this option become fully operational, it is estimated that 90 to 95 percent of the injected water can be recovered.

6.8.2.1 Municipal and Industrial Utilities in Region

The selected conceptual application of an ASR facility to serve the major municipal and industrial demand center is based upon the long-term ASR approach. In this case, excess supplies form the Edwards Aquifer and treated surface water, either from local watersheds or the Guadalupe River, would be candidate water supplies. The location for the potential ASR facility is a section of the Carrizo where all or most all the guidelines listed above can be met (Figure 6.8-1). The ASR well fields should parallel the outcrop of the Carrizo Formation and be located about 5 to 7 miles southeast of the downdip limit of the outcrop.[2,3,4] In these locations,

[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998.
[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

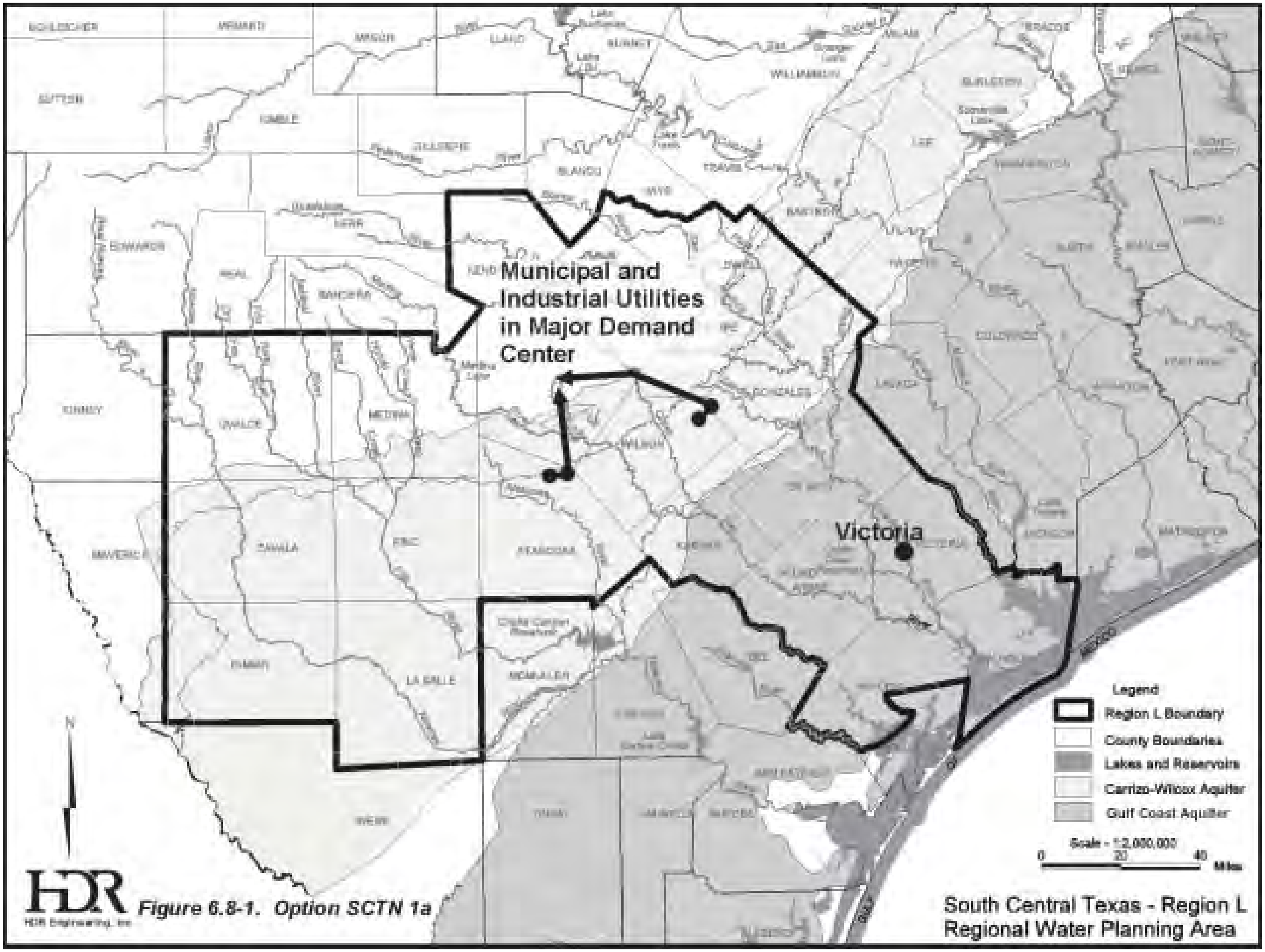


Figure 6.8-1. Option SCTN 1a

the Carrizo Sands are sufficiently permeable and thick so that well capacities can range from 1,000 to 2,000 gpm. For a 10-MGD facility, five to eight high capacity wells would be required, however, the facility should be sized and operated in an optimum configuration in order to balance injection and recovery cycles with respect to supplies available for injection, aquifer characteristics, and demand patterns of the utilities that are using ASR. To maintain continuity in depth and to prevent water levels from rising above the land surface (flowing at the surface), the wells would need to be in a line and spaced about 0.5 miles apart. Because of the extent of the Carrizo Aquifer in this area, well fields could be extended for several miles.

6.8.2.2 Victoria Area

The selected conceptual application of an ASR facility for a municipal and industrial water utility in the Victoria area uses the annual approach, as opposed to the long-term approach stated above for the municipal and industrial utilities in the region. In this case, treated surface water from the Guadalupe River would be a candidate water supply. The water could be diverted and treated during the fall, winter, and spring and injected into the Gulf Coast Aquifer for storage. The water could then be recovered during the summer months when water demands are high. This concept allows the selection and operation of smaller-sized water treatment facilities than are needed for peaking demands, with use of the water treatment facilities at near capacity throughout the year. ASR wells would be available for the injection cycle 8 to 9 months of the year and suitable to the recovery cycle for the remaining 3 to 4 months.

The site for the ASR facility would be the service area of municipal and industrial water suppliers in the vicinity of Victoria. A review of existing reports listed above and other reports[5,6,7] indicates that an ASR well field located within the City of Victoria would be satisfactory. In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range from 1,000 to 1,500 gpm. For a 10-MGD facility, six to nine high capacity wells would be required, however, as in the Carrizo example above, the facility should be sized for optimum operation with respect to injection and recovery cycles, taking into account supplies

[5] Marvin, R.F., et al., “Ground-Water Resources of Victoria and Calhoun Counties, Texas,” Texas Board of Water Engineers Bulletin 6202, 1962.
[6] Carr, J.E., et al., “Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers along the Gulf Coast of Texas,” Texas Department of Water Resources Report 289, 1985.
[7] Wood, L.A., et al., “Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas,” Texas Water Commission Bulletin 6305, 1963.

available for injection, aquifer characteristics, and needs of water suppliers using ASR. To maintain continuity in depth and to prevent water levels rising above the land surface, the wells would need to be distributed throughout the city and spaced about 0.5 mile apart. Locating the wells in the city of Victoria provides a means of controlling who can pump the stored water.

6.8.3 Environmental Issues

Option SCTN-1a involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support municipal and industrial utilities in the major demand center, and utilities in the Victoria area, respectively. These regional scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 10 to 20 MGD.

Well fields in this option that use local stream or river systems as the water supply would result in reduced streamflows, which would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the ASR location area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these new wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contributed to variations in aquifer levels, spring flow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.8.4 Engineering and Costing

Securing a water supply for the ASR option is beyond the scope of this option, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities, in case water supplies can be obtained and delivered to the sites. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any of groundwater).
- Transmission System from water treatment plant or Edwards wells (for major demand center) to ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the well fields, pipelines, and water treatment plants for the two areas are shown in Figure 6.8-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, power, and land. The costs are based on operating the facilities in the injection cycle 9 months per year and the pumping cycle 3 months per year. These costs are summarized in Tables 6.8-1 and 6.8-2. As shown, the annual costs for a 10 MGD facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $6,778,000 and $2,817,000 for the major municipal and industrial demand center and the Victoria area, respectively. The annual cost for storing and recovering the water is estimated at $2,428/acft, and $1,009/acft, respectively. It is reiterated, however, that these cost estimates do not include the cost of securing a water supply nor the transportation of water to the water treatment plant or the ASR facility. The ASR facility at Victoria is considerably less expensive per unit of capacity because of the shorter distance from the ASR

Table 6.8-1
Cost Estimate Summary
Municipal and Industrial Users in
Major Demand Center in the Region (SCTN 1a)
Second Quarter 1999 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,248,000
Transmission Pump Stations (3)	3,987,000
Transmission Pipeline (24 in dia., 48.9 miles)	14,272,000
Water Treatment Plant (10 MGD)	10,303,000
Distribution Connections	12,880,000
Total Capital Cost	**$45,690,000**
Engineering, Legal Costs and Contingencies	$15,079,000
Environmental & Archaeology Studies and Mitigation	2,303,000
Land Acquisition and Surveying (278 acres)	3,167,000
Interest During Construction (2 years)	5,300,000
Total Project Cost	**$71,539,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$5,197,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	225,000
Water Treatment Plant	973,000
Pumping Energy Costs (6,391,324 kWh @ $0.06 per kWh)	383,000
Total Annual Cost	$6,778,000
Project Capacity (acft/yr) (for 3 months of operation)*	**2,792**
Annual Cost of ASR ($ per acft)	**$2,428**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.45**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.8-2
Cost Estimate Summary
Municipal and Industrial Users
in Victoria Area (SCTN 1a)
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,432,000
Transmission Pipeline (24 in dia., 6 miles)	2,408,000
Water Treatment Plant (10 MGD)	10,303,000
Total Capital Cost	**$17,143,000**
Engineering, Legal Costs and Contingencies	$5,880,000
Environmental & Archaeology Studies and Mitigation	11,000
Land Acquisition and Surveying (8 acres)	15,000
Interest During Construction (2 years)	922,000
Total Project Cost	**$23,971,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$1,741,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	24,000
Water Treatment Plant	973,000
Pumping Energy Costs (1,321,333 kWh @ $0.06 per kWh)	79,000
Total Annual Cost	$2,817,000
Project Capacity (acft/yr)*	**2,792**
Annual Cost of ASR ($ per acft)	**$1,009**
Annual Cost of ASR ($ per 1,000 gallons)	**$3.10**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

wells to the distribution system than is the case for the major demand center. It is important to note, however, that neither the Carrizo nor the Gulf Coast cases presented are necessarily optimum in size nor injection/recovery cycles. Detailed optimization analyses will be required in order to consider ASR as a part of any water supply system.

6.8.5 Implementation Issues

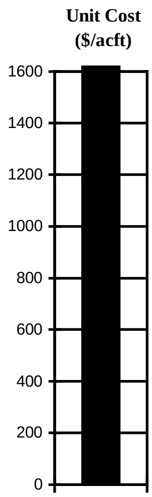
Implementation of the ASR concepts includes the following issues:

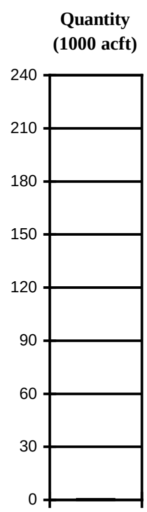
- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.

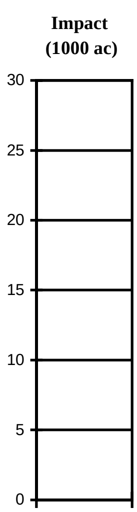
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

Draft - 12/31/99







OPTION NUMBER: SCTN-1b
OPTION NAME: Aquifer Storage and Recovery (ASR)—Local Option

OPTION DESCRIPTION: *Option SCTN-1b evaluates local-scale municipal and industrial water supply facilities that would benefit by storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when needed. A local-scale facility is considered to have a capacity of 0.5 to 1.0 million gallons per day. For this option, four facilities are evaluated. Two use the Carrizo-Wilcox Aquifer (Cities of Carrizo Springs and Luling) and the other two use the Gulf Coast Aquifer (Karnes City and City of Seadrift.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15 yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER (average):	**$2,089**	**per acft**[1]
QUANTITY OF WATER (each facility):	**279**	**acft/yr**[2]
LAND IMPACTED (average)	**3**	**acres**[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get the raw water to the water treatment plant and not included.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 1.0 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce additional water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts would be for water treatment plant, well sites, and transmission facilities within urban areas. Waterlines are considered to be located on city easements and are not included.

ENVIRONMENTAL ISSUES: Considered to be minimal—well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of water, water treatment, suitability of local aquifer conditions, control of water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.9 Aquifer Storage and Recovery (ASR) – Local Option (SCTN-1a)

6.9.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1b evaluates local scale ASR facilities for municipal and industrial water supply management. A local scale facility is considered to have a capacity of 0.5 to 1.0 million gallons per day (MGD), or 560 to 1,120 acft/yr, if operated continuously. For this option, four facilities are evaluated. Two of the facilities (Cities of Carrizo Springs and Luling) would use nearby sites located over the Carrizo-Wilcox Aquifer. The other two facilities (Karnes City and coastal area municipal and industrial water suppliers in Calhoun County) would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.9.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, Texas Natural Resource Conservation Commission (TNRCC) regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.9.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gallons per minute (gpm) (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gallons per minute (gpm).

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

Regulations: The Texas Natural Resources Conservation Commission (TNRCC) regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.9.2 Available Capacity

For purposes of evaluating this option, local size water supply facilities are considered to be typical of communities with less than 2,500 connections. The cities selected for evaluation include Carrizo Springs and Luling in the Carrizo-Wilcox Aquifer and Karnes City and coastal water suppliers in Calhoun County in the Gulf Coast Aquifer. The locations are shown in Figure 6.9-1.

6.9.2.1 City of Carrizo Springs

The selected conceptual application of an ASR facility to serve Carrizo Springs combines the annual and long-term ASR approach. In this case, a long-term basis refers to the injection of water from a supply that is considered to be available on an intermittent basis over the long-term, but not on an annual basis or during selected seasons. Candidate sources are a local watershed or the Nueces River. The annual basis refers to the recovery cycle to meet summer peak demands. This scenario is based on injecting water over many months, and perhaps years, and withdrawing some of the water each summer, as needed. Considering the variability in the availability of surface water and the peak demands, it is estimated that four wells would be needed for the injection and recovery cycle.

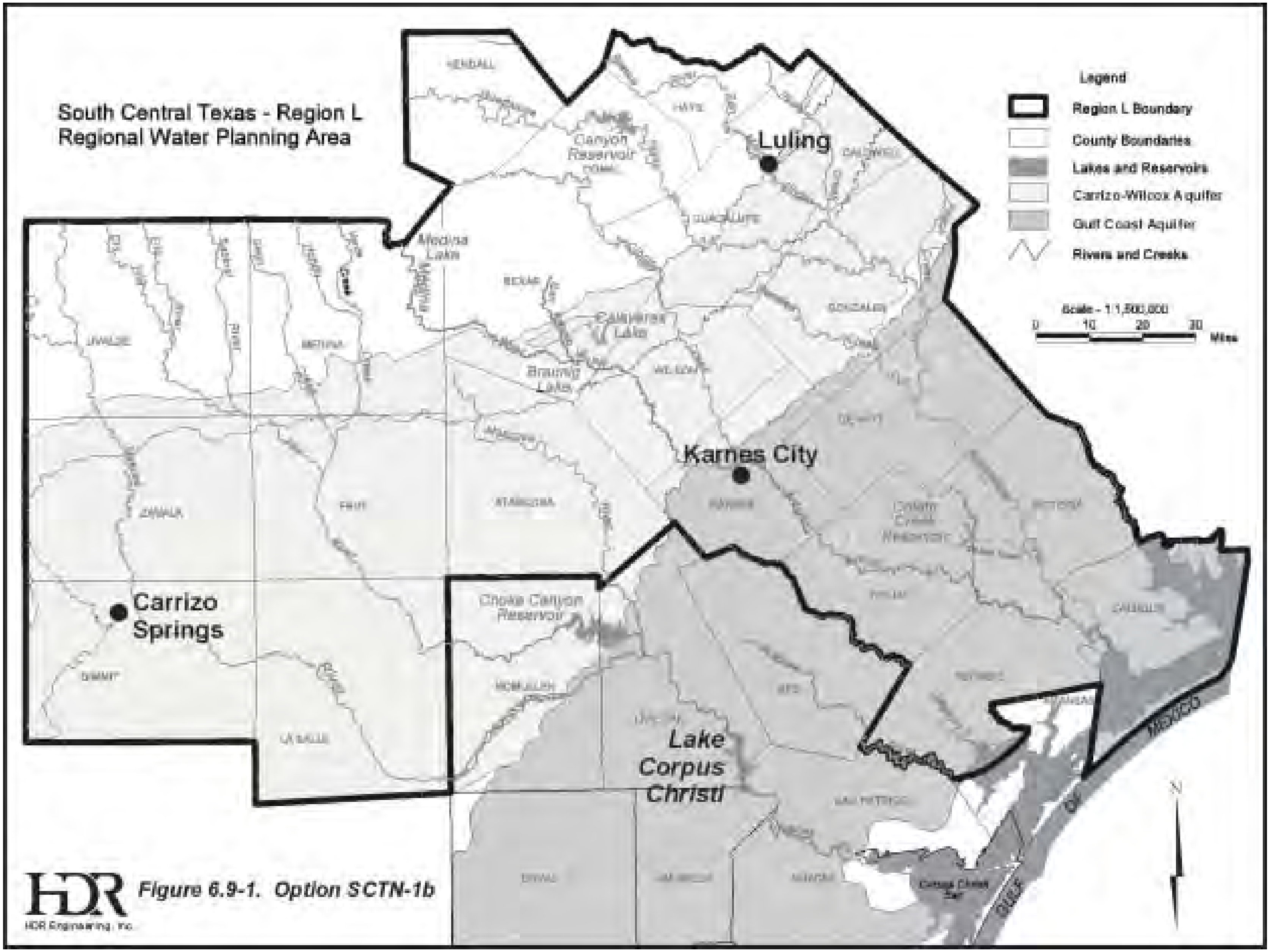


Figure 6.9-1. Option SCTN-1b

In the vicinity of the City of Carrizo Springs, the Carrizo Aquifer meets most all the guidelines listed above. A review of existing reports[2,3,4] and the extent of other groundwater users in the area indicates that an ASR well field could be located on the eastern side of the city. In this location, the Carrizo Sands are sufficiently permeable and thick so that well capacities can range from 200 to 300 gallons per minute (gpm). For a 1.0-MGD facility, three to five wells would be required. The wells would be located within the city to maintain control of the stored water. They would be spaced about 0.5 miles apart.

6.9.2.2 City of Luling

The selected conceptual application of an ASR facility to serve the City of Luling uses the annual approach. In this case, the application assumes treated surface water from the Guadalupe River would be the water source. The water would be diverted and treated during the fall, winter, and spring and injected into the Carrizo Aquifer for storage. The water would be recovered during the summer months when water demands are high. This concept allows using the water treatment facilities at near capacity throughout the year and reduces demand on supplies in the Guadalupe River during the summer when demands are high. ASR wells would be in the injection cycle 8 to 9 months a year and in the recovery cycle 3 to 5 months.

A review of existing reports listed above and a county groundwater report[5] indicates that an ASR well field in the City of Luling would be satisfactory. In this location, the Carrizo Aquifer is sufficiently transmissive so that well capacities can range from 400 to 500 gpm. For a 1.0-MGD facility, two to three wells would be required, and locating the wells in the City of Luling provides a means of controlling who can pump the stored water.

6.9.2.3 Karnes City

The selected conceptual application of an ASR facility to serve Karnes City uses the annual approach. In this case, the candidate supply is treated surface water from a local stream or the San Antonio River. The water would be diverted and treated during the fall, winter, and

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[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998
[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.
[5] Follett, C.R., "Ground-Water Resources of Caldwell County, Texas," TWDB, Report 12, 1966

spring and injected into the Catahoula Formation of the Gulf Coast Aquifer from which the city presently obtains a part of its water. The injected water could be recovered during the summer months when water demands are high. This concept would allow using the water treatment facilities at near capacity when a raw water supply is available. It would also provide emergency supplies when there is a malfunction of the existing system. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

In Karnes City, depth to the Catahoula Formation is about 100 feet; however, native water in the Catahoula Formation has total dissolved solids concentrations between 1,000 and 2,000 milligrams per liter. Water from the Carrizo Aquifer comes from a water-bearing zone over 3,000 feet deep and has total dissolved solids concentrations less than 1,000 milligrams per liter. However, the water temperature is over 150 degrees Fahrenheit. Thus, an ASR operation using the Catahoula Formation would be expected to improve the quality and increase the quantity of supply for Karnes City.

A review of existing reports listed above and other reports[6,7] indicates that an ASR well field in Karnes City would be satisfactory. In this location, the Catahoula Formation is sufficiently transmissive so that well capacities can range from 200 to 250 gpm. For a 1.0-MGD facility, three to four wells would be required, and locating the wells in Karnes City provides a means of controlling who can pump the stored water.

6.9.2.4 Coastal Area Water Suppliers of Calhoun County

The selected conceptual application of an ASR facility to serve the municipal and industrial suppliers of Calhoun County use the annual approach. In this case, groundwater from the Gulf Coast Aquifer in the northwestern part of Calhoun County about 12 miles from the Gulf Coast would be the water supply and would be pumped at a rather uniform rate throughout the year. During the fall, winter, and spring when water demands are low, the water in excess of demands would be injected into the Gulf Coast Aquifer for storage, which is slightly saline at about 10 miles inland. The water would be recovered during the summer months to meet water demands that exceed system capacity of the remote wells and pipeline. This concept allows using the remote wells and pipeline to operate at near capacity throughout the year and provides

[6] Wood, L. A., et al., "Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas," Texas Water Commission Bulletin 6305, 1963.
[7] Anders, R.B., "Ground Water Geology of Karnes County, Texas," TWDB Bulletin 6007, 1960.

emergency supplies close to the demands. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

A review of existing reports listed above and other reports[8,9] indicates that an ASR well field in the vicinity of the City of Seadrift would be satisfactory.[10] In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range up to 500 gpm. For a 1.0-MGD facility, two to three wells would be required.

6.9.3 Environmental Issues

Option SCTN-1b involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support local municipalities. These local scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 0.5 to 1 MGD.

In this option, the sources of water would probably be local stream or river systems and groundwater from aquifers. In the case of surface water sources, reduced streamflows would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the Carrizo Aquifer area show a variety of trends in groundwater levels over the past 30 years. The effects of ASR wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contribute to variations in aquifer levels, springflow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat

[8] Marvin, R.F., et al., "Ground-Water Resources of Victoria and Calhoun Counties, Texas," Texas Board of Water Engineers Bulletin 6202, 1962.
[9] Carr, J.E., et al., "Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers Along the Gulf Coast of Texas," Texas Department of Water Resources Report 289, 1985.
[10] It is important to note that the City of Seadrift has recently installed a reverse-osmosis desalination plant to meet its needs. Thus, it may become advantageous to use desalted water as a source of water for ASR.

or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.9.4 Engineering and Costing

Securing a water supply for the aquifer storage and recovery option and transporting the water to the ASR facility is beyond the scope of this evaluation, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities in case they are needed. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any for groundwater).
- Freshwater Supply Wells (Calhoun County).
- Transmission System to the ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the ASR facilities for the four sites are shown in Figure 6.9-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, and land. These costs are summarized in Tables 6.9-1, 6.9-2, 6.9-3, and 6.9-4 for the cities of Carrizo Springs, Luling, Karnes City, and Calhoun County, respectively. As shown, the annual costs for a 1.0 MGD size facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $763,000, $703,000, $756,000 and $111,000, respectively. The annual costs for the respective ASR facilities are estimated at $2,734/acft, $2,519/acft,

Table 6.9-1.
Cost Estimate Summary
SCTN-1b: City of Carrizo Springs
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,453,000
Environmental & Archaeology Studies and Mitigation	31,000
Land Acquisition and Surveying (3 acres)	43,000
Interest During Construction (2 years)	466,000
Total Project Cost	**$6,806,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$495,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (152,613 kWh @ $0.06 per kWh)	9,000
Total Annual Cost	**$763,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,734**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.39**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-2.
Cost Estimate Summary
SCTN-1b: City of Luling
Second Quarter 1999 Prices

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (3 wells, 1 MGD total)	$783,000
Transmission Pipeline (12-inch dia., 3 miles)	713,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,150,000**
Engineering, Legal Costs and Contingencies	$1,417,000
Environmental & Archaeology Studies and Mitigation	17,000
Land Acquisition and Surveying (3 acres)	23,000
Interest During Construction (2 years)	449,000
Total Project Cost	**$6,056,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$440,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	7,000
Water Treatment Plant	249,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$703,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,519**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.73**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-3.
Cost Estimate Summary
SCTN-1b: Karnes City
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,579,000
Environmental & Archaeology Studies and Mitigation	3,000
Land Acquisition and Surveying (3 acres)	4,000
Interest During Construction (2 years)	499,000
Total Project Cost	**$6,733,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$489,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (132,333 kWh @ $0.06 per kWh)	8,000
Total Annual Cost	**$756,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,708**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.31**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-4.
Cost Estimate Summary
SCTN-1b: Calhoun County near City of Seadrift
Second Quarter 1999 Prices

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (2 wells, 1 MGD total)	$470,000
Transmission Pipeline (12-inch dia., 2 miles)	475,000
Total Capital Cost	**$945,000**
Engineering, Legal Costs and Contingencies	$307,000
Environmental & Archaeology Studies and Mitigation	1,000
Land Acquisition and Surveying (1 acre)	2,000
Interest During Construction (2 years)	101,000
Total Project Cost	**$1,356,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$99,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	5,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$111,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$396**
Annual Cost of ASR ($ per 1,000 gallons)	**$1.21**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

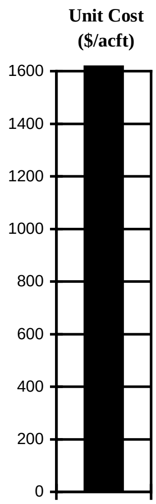
$2,708/acft, and $396/acft, respectively. The costs are based on operating the facilities in the pumping cycle 3 months each year. It is reiterated that these cost estimates do not include the cost of securing a water supply or the transportation of water to the ASR facility. The estimated cost of the ASR facility at the Calhoun County site is considerably less because no water treatment would be required.

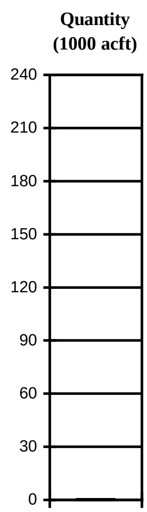
6.9.5 Implementation Issues

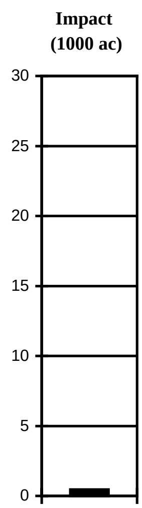
Implementation of the ASR concepts includes the following issues:

- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
Draft 12/13/99







OPTION NUMBER: SCTN-8
OPTION NAME: Trinity Aquifer Optimization

OPTION DESCRIPTION:

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**$1,886**	**per acft[1] Raw Water in Aquifer**
QUANTITY OF WATER:	**390**	**acft/yr[2] (Program of Five Structures)**
LAND IMPACTED:	**460**	**acres[3] (Program of Five Structures)**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]COST:

[2]QUANTITY OF WATER:

[3]LAND IMPACTED:

ENVIRONMENTAL ISSUES:

SIGNIFICANT ISSUES AFFECTING FEASIBILITY:

ADDITIONAL FACTORS:

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED:

6.10 Trinity Aquifer Optimization (SCTN-8)

6.10.1 Description of Option

Recharge to the Trinity Aquifer within the South Central Texas Region occurs primarily where the Lower Member of the Glen Rose Limestone outcrops in portions of Hays, Comal, Bexar, Kendall, Medina, and Uvalde Counties. The majority of Kendall County lies within this outcrop area, as indicated in Figure 6.10-1. Water recharged to the aquifer generally travels to the south and southeast.[1] The aquifer can be described as a generally "tight" formation, referring to a relatively low permeability. This low permeability limits the quantity of water that may be pumped by individual wells, and conversely, the quantity of water that can be recharged to the aquifer. Reported permeabilities range from 0.0012 to 0.108 feet per day for cores taken at depth, to 0.1 to 0.4 feet per day at the surface. This is extremely low in contrast to reported permeabilities of other aquifer formations investigated for water supply potential within the South Central Texas Region. For example, the Carrizo Aquifer has reported permeabilties ranging from 1.2 to 4 feet per day.

This option evaluates the potential for enhancing recharge of the Trinity Aquifer in Kendall County with available (unappropriated) water from tributaries of the Guadalupe River. With this option, available flows from these tributaries would be impounded in small to medium-sized recharge reservoirs, and allowed to percolate into the underlying aquifer formation. Water recharged in this fashion would then be available for pumpage by wells in the surrounding area. However, due to the low permeability and other characteristics of the formation, water recharged in this fashion would likely be available for pumpage only in the immediate geographic vicinity of the recharge project.

Water recharged by implementation of this option would be available for local domestic needs, or for transmission to a nearby municipality. Only costs for enhanced recharge of the Trinity Aquifer are considered in this analysis.

6.10.2 Water Availability

Water available for recharge enhancement from tributaries of the Guadalupe River in Kendall County is limited by upstream and downstream water rights. Water would be available

[1] Texas Department of Water Resources, "Report 273: Ground-Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas," January 1983.

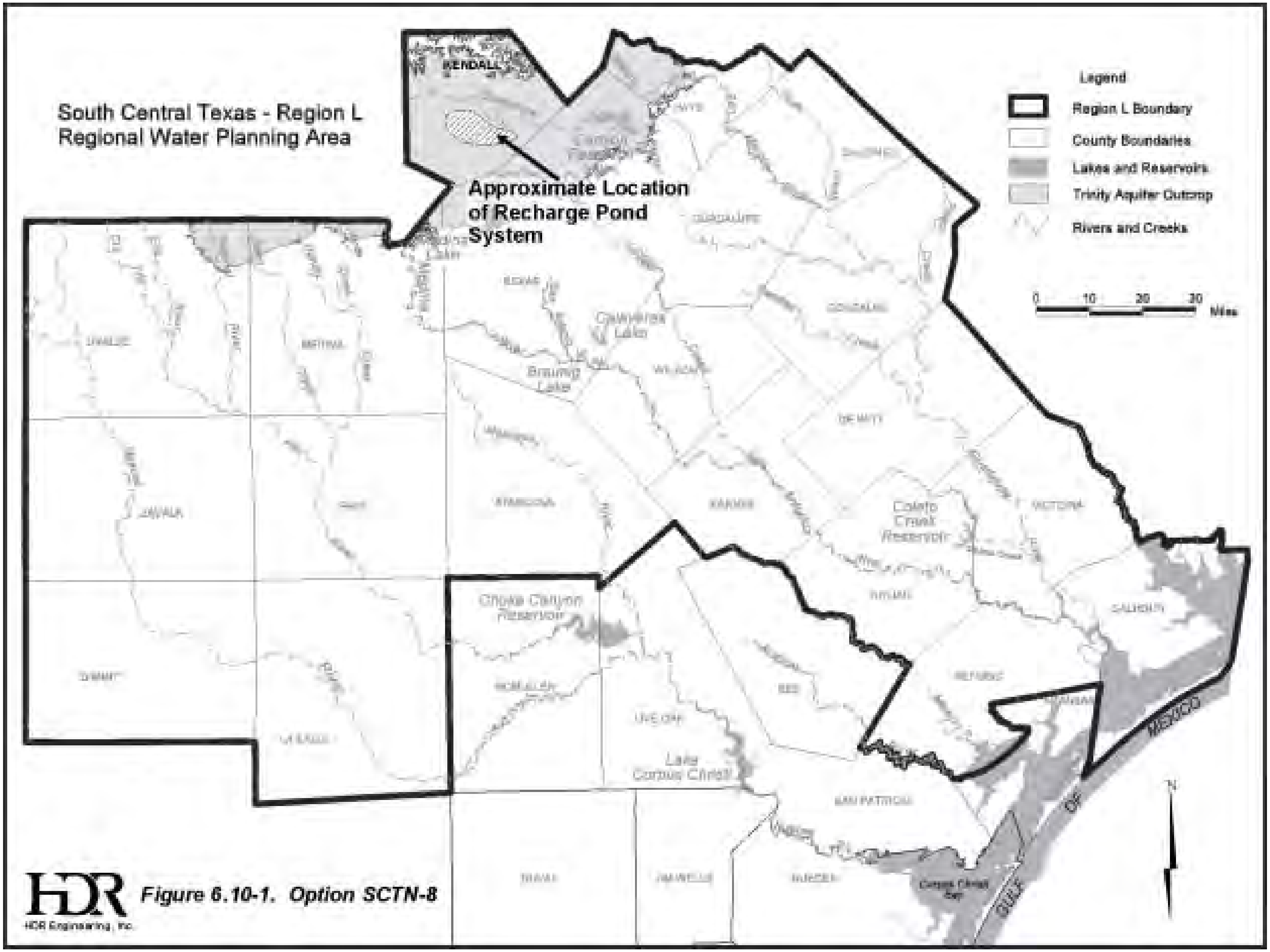


Figure 6.10-1. Option SCTN-8

sporadically, during periods of high flow when existing water rights (including priority hydropower) are fully satisfied, and Canyon Reservoir is full. The availability of water for recharge enhancement was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). Monthly regulated streamflow and unappropriated streamflow available from the Guadalupe River Basin were estimated using the Guadalupe-San Antonio River Basin Water Availability Model (GSA WAM),[2] developed for the Texas Natural Resource Conservation Commission (TNRCC) under the SB1 Water Availability Modeling Project. The current version of the GSA WAM includes the 1934 to 1989 historical period. Input data files for the GSA WAM were modified so as to match the general assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction. This "run" of the model is referred to as "Run 9" and is documented in a separately bound appendix to the GSA WAM report (Appendix IX, Regional Water Planning: Run 9).[3]

Water availability was estimated for one representative site in central Kendall County. The drainage area of this site (15 square miles) is representative of other sites in this area at which small-to-medium-sized recharge reservoirs could be constructed. Figure 6.10-1 shows a general outline of the vicinity within which one or more of these structures might be constructed. Daily streamflow available for diversion at a representative site was estimated by distributing the monthly regulated and unappropriated streamflows computed by the GSA WAM to daily values using nearby gaged streamflow records.

A computer program was developed to simulate daily impoundment of available streamflow and subsequent recharge of the water to the Trinity Aquifer. Data inputs to the program include the monthly regulated and available streamflows estimated using the GSA WAM, monthly evaporation rates, daily gaged flows used to distribute the monthly flows to daily values, the Consensus Criteria pass-through requirements, the storage capacity of the reservoir, and the infiltration (recharge) rate estimated for the site. As gaged flows for this small watershed are not available, the streamflow statistics used to determine the monthly Consensus Criteria pass-through requirements were prorated by drainage area from those for the Guadalupe

[2] HDR, "Water Availability in the Guadalupe-San Antonio River Basin-Draft Report," Texas Natural Resource Conservation Commission, September 1999.
[3] Ibid.

River near Comfort (USGS #08167000). Monthly unappropriated flows for the representative site are shown in Figure 6.10-2. As is apparent in the figure, available flows occur relatively infrequently. Note that additional water could be made available for impoundment (at additional cost) through negotiation of a hydropower subordination agreement with downstream water rights owners.

An infiltration rate of 0.01 feet per day was assumed. This rate is within the range reported by the Texas Department of Water Resources[4] for cores obtained from test wells, but is lower than permeability test data presented in a soil survey of Kendall County.[5] The lower rate would control recharge into the formation, and was adopted for this analysis. Recharge rates could be much greater in areas where the aquifer formation is highly fractured. However, the likelihood of rapid losses to proximate springs is also greater in these areas. A recharge reservoir capacity of 500 acft was assumed, based upon the area of land that might be controlled by the facility (15 square miles). Based upon a generalized area-capacity relationship for small reservoirs developed by Texas A&M University,[6] the land area within the recharge pool for this size reservoir would be approximately 92 acres. Estimated annual recharge over the 1934 through 1989 simulation period is shown in Figure 6.10-3. For the representative site, the long-term average (mean) annual recharge enhancement to the Trinity Aquifer is about 78 acft. Due to the relatively low rate of infiltration, such a reservoir would evaporate an average of 55 acft/yr, a volume equal to 71 percent of the recharge enhancement.

Figure 6.10-4 illustrates simulated storage fluctuations in the representative recharge reservoir. The reservoir would be more than 50 percent full approximately 16 percent of the time, as most inflows must be passed to satisfy downstream senior water rights and instream flow requirements of the Consensus Criteria, only high flows would be affected by the reservoir, and no significant change in median and low streamflows would occur.

Review of topographic mapping for the area of interest shown in Figure 6.10-1 indicates that five (or more) candidate sites for recharge enhancement reservoirs having drainage areas averaging about 15 square miles could be identified. The feasibility assessment of any specific

[4] Texas Department of Water Resources, Op. Cit., January 1983.
[5] U.S. Department of Agriculture, "Soil Survey of Kendall County, Texas," March 1981.
[6] Texas Water Resources Institute, "Hydrologic and Institutional Water Availability in the Brazos River Basin, TR-144," Texas A&M University, August 1988.

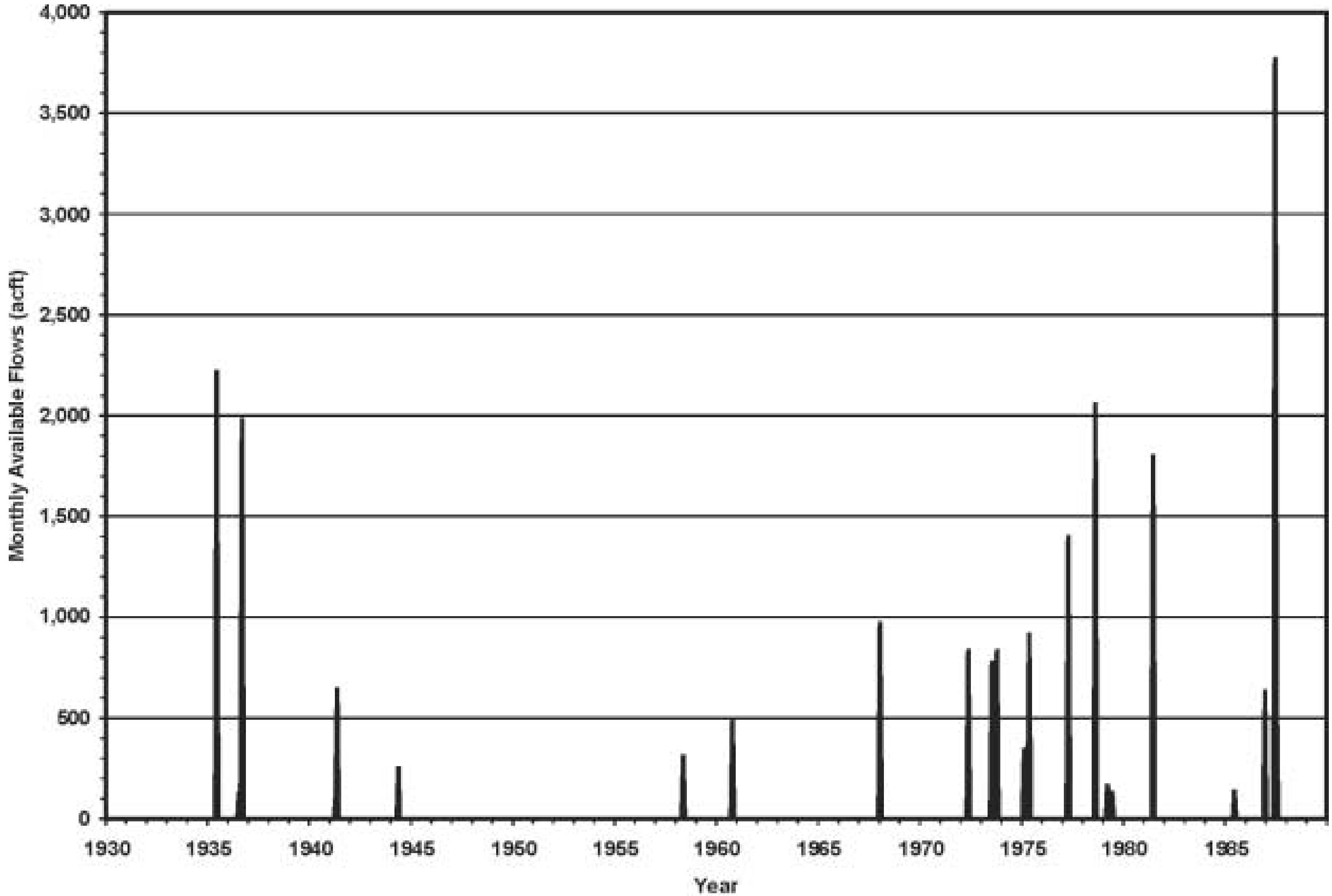


Figure 6.10-2. Monthly Available Flows for a Representative 15 Square Mile Watershed in Kendall County

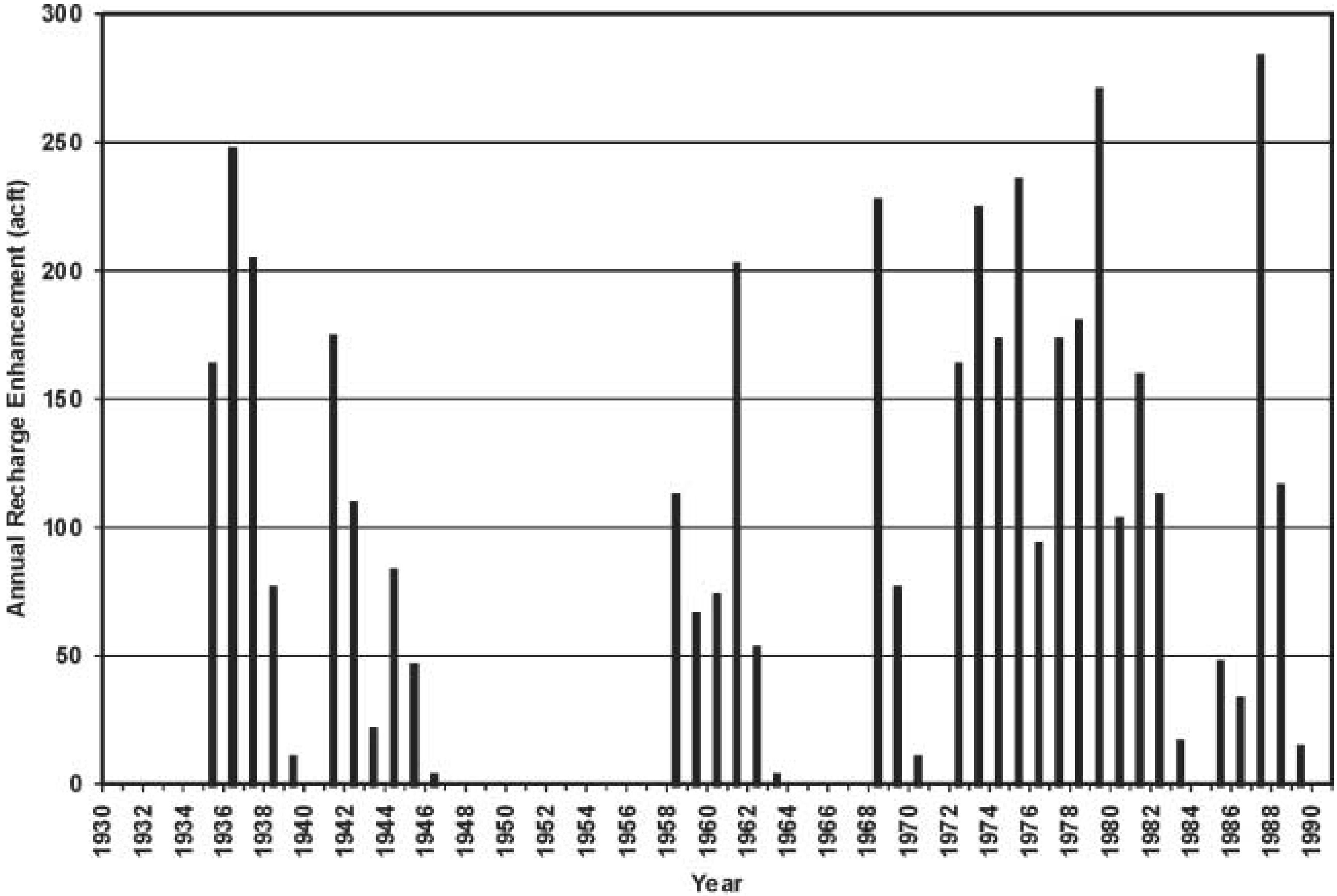


Figure 6.10-3. Trinity Aquifer Recharge Enhancement by a Representative Recharge Reservoir

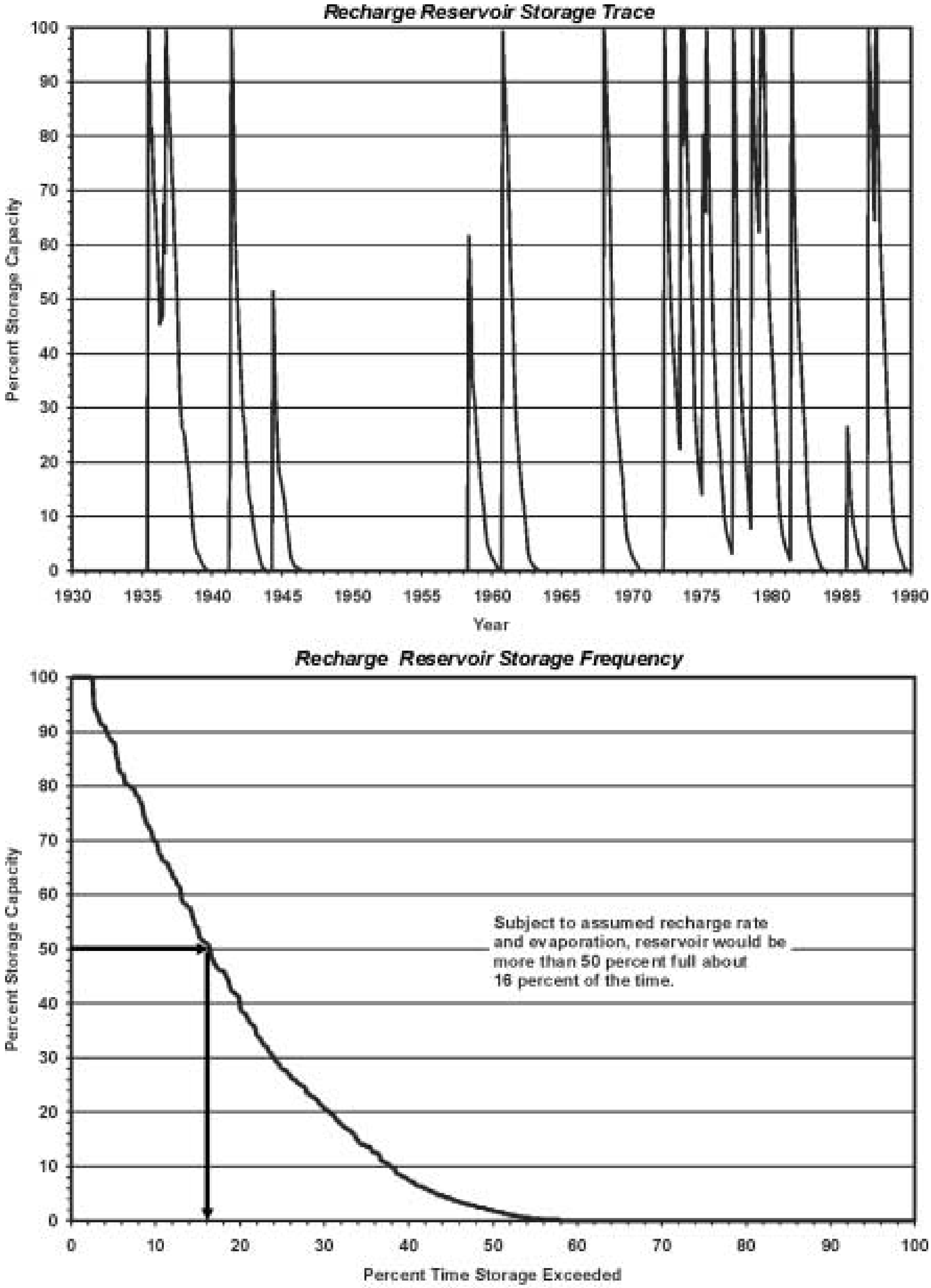


Figure 6.10-4. Recharge Reservoir Storage Considerations

site should include the evaluation of the potential for rapid loss to nearby springs. As water is available for impoundment only during high flow periods, it is reasonable to assume that recharge enhancement for multiple sites will be approximately additive. Hence, annual Trinity Aquifer average recharge enhancement associated with the development of five small to medium-sized reservoirs is estimated to be 390 acft/yr.

6.10.3 Environmental Issues.

Option SCTN-8 takes available flows from tributaries of the Guadalupe River and impounds them within recharge reservoirs in Kendall County. The relatively low permeability of the Trinity formation will result in the recharge reservoirs holding water for significant periods. Evaporation from the reservoirs and the need to control vector species and nuisance growths should be considered in overall management plans. Overall, construction of the reservoir will enhance the aquifer by increasing the amount of water available for pumping. Potential concerns involved with construction of this option include destruction of species habitat.

Table 6.10-1 presents the protected plant and animal species which are listed for Kendall County by the Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service (USFWS), and the Texas Organization for Endangered Species (TOES). Two protected bird species, which may have habitat within the study area, are the Golden-Cheeked Warbler (*Dendroica chrysoparia*) and Black-Capped Vireo (*Vireo atricapillus*). The Golden-Cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-Capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. Additional protected birds which may be found in the area are the American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Black-Capped Vireo, Golden-Cheeked Warbler, Interior Least Tern and Whooping Crane. A survey of any potential reservoir site may be required prior to construction to determine whether populations of, or potential habitat for, species of concern occur in the area to be impacted.

The Guadalupe River in Kendall County is recommended for designation as an Ecologically Unique River Segment by TPWD.

Table 6.10-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Trinity Aquifer Optimization (SCTN-8)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	DL	E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregtinus tundrius*	Open country; cliffs	DL	T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Basin Bellflower	*Campanula reverchonii*	Dry gravels and shallow sandy soils; open slopes			WL	Resident
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests	T/SA	T	T	Resident
Black-Capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River			NL	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1		NL	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau			NL	Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Edge Falls Anemone	*Anemone edwardsiana var petraea*	Woodlands in mesic canyons			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau			NL	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Headwater Catfish	*Ictalurus lupus*	Clear streams			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear			NL	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.

3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.

4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

5 Correll, Donovan S. and Marshall Johnston. 1979. Manual of the Vascular Plants of Texas. University of Texas at Dallas. Austin, Texas. pp 1201.

* E = Endangered T = Threatened 3C = No Longer a Candidate for Protection C2 = Candidate Category

C1 = Candidate Category, Substantial Information PE/PT = Proposed Endangered or Threatened

WL = Potentially endangered or threatened Blank = Rare, but no regulatory listing status NL = Not listed

6.10.4 Engineering and Costing

Construction costs for a representative 500-acft capacity recharge dam were estimated from detailed cost estimates for similarly sized recharge enhancement projects.[7,8] Operation and maintenance costs were developed in accordance with the cost estimation procedure presented in Appendix A. Land was assumed to be purchased for the recharge reservoir pool. The cost estimate shown in Table 6.10-3 is for a single 500-acft capacity recharge enhancement reservoir.

Financing a single recharge enhancement reservoir under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $131,000. Annual operation and maintenance costs total $16,000. The annual cost, including debt service and operation and maintenance, totals $147,000. For an average annual recharge enhancement of 78 acft per site, the resulting annual cost of water recharged to the Trinity Aquifer from tributaries of the Guadalupe River in Kendall County is $1,886 per acft per reservoir site (Table 6.10-2).

With the development of a program of five reservoirs, average annual recharge of the Trinity Aquifer in Kendall County could be enhanced by about 390 acft at an estimated annual cost of $1,886 per acft.

6.10.5 Implementation Issues

Implementation of this option for one or more sites could directly affect the feasibility of other water supply options under consideration, including G-19, G-30, SCTN-ZC, and/or SCTN-10.

1. It will be necessary to obtain these permits:
   a. Texas Natural Resource Conservation Commission (TNRCC) Water Right and Storage permits.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. General Land Office (GLO) Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.

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[7] HDR, et al., "Nueces River Basin Edwards Aquifer Recharge Enhancement project, Phase IV A," Edwards Underground Water District, June 1994.
[8] HDR, et al., "Trans-Texas Water Program, West Central Study area, Edwards Aquifer Recharge Analyses," San Antonio River Authority, et al., march 1998.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on instream flows.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

3. Land or easements will need to be acquired through either negotiations or condemnation.

4. Recovery of the enhanced recharge would need to be coordinated and permitted through local groundwater conservation districts.

Table 6.10-2.
Cost Estimate Summary for a
Representative Recharge Enhancement Reservoir
Trinity Aquifer Optimization (SCTN-8)
Second Quarter 1999 Prices

Item	***Estimated Costs for Facilities***
Capital Costs	
Dam and Reservoir (500 acft, 92 acres)	$1,054,000
Total Capital Cost	**$1,054,000**
Engineering, Legal Costs and Contingencies	$369,000
Land Acquisition and Surveying (92 acres)	147,000
Interest During Construction (4 years)	272,000
Environmental & Archaeology Studies, Mitigation and Permitting	133,000
Total Project Cost	**$1,975,000**
Annual Costs	
Reservoir Debt Service (6 percent for 40 years)	$131,000
Operation and Maintenance	16,000
Total Annual Cost	**$147,000**
Available Annual Recharge Enhancement (acft)	**78**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$1,886**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$5.79**

[1] Reported Annual Cost of Water is for additional water supply in the Trinity Aquifer.

Appendix A

Cost Estimating Procedures
South Central Texas Region

Appendix A
Cost Estimating Procedures
South Central Texas Region

The cost estimates of this study are expressed in three major categories: (1) construction costs or capital (structural) costs, (2) other (non-structural) project costs, and (3) annual costs. Construction costs are the direct costs incurred in constructing facilities, such as those for materials, labor, and equipment. "Other" project costs include expenses not directly associated with construction activities of the project, such as costs for engineering, legal counsel, land acquisition, contingencies, environmental studies and mitigation, and interest during construction. Capital costs and other project costs comprise the total project cost. Operation and maintenance (O&M), energy costs, and debt service payments are examples of annual costs. Major components that may be part of a preliminary cost estimate are listed in Table A-1. Cost estimating procedures employed in the technical evaluation of water supply options for the South Central Texas Region are summarized in the following sections.

Table A-1.
Major Project Cost Categories

Capital Costs (Structural Costs)	*Other Project Costs (Non-Structural Costs)*
1. Pump Stations	1. Engineering (Design, Bidding and Construction Phase Services, Geotechnical, Legal, Financing, and Contingencies)
2. Pipelines	2. Land and Easements
3. Water Treatment Plants	3. Environmental - Studies and Mitigation
4. Water Storage Tanks	4. Interest During Construction
5. Off-Channel Reservoirs	
6. Well Fields	***Annual Project Costs***
a. Injection	1. Debt Service
b. Recovery	2. Operation and Maintenance (excluding pumping energy)
c. ASR Wells	3. Pumping Energy Costs
7. Dams and Reservoirs	4. Purchase Water Cost (if applicable)
8. Relocations	
9. Water Distribution	
10. Other Items	

A.1 Capital Costs

Capital costs for elements of each water supply option are estimated from reliable cost information. Cost tables are the most useful reference for estimating the costs for a project element quickly and efficiently. The cost tables report all-inclusive costs to construct. For example, the pump station cost table values include the building, pumps, control equipment, all other materials, labor, and installation costs. Cost tables that have been created for planning cost estimates are discussed and presented throughout this section. The costs for a project element are typically computed by applying a unit cost from the cost tables to a specific unit quantity. Estimates are reported to the nearest thousand dollars. If previous cost estimates are used, a ratio of the Engineering News Record's Construction Cost Index (ENR CCI)1 values is applied to update the cost to Second Quarter 1999. For example, based on an average of the monthly index values for the second quarter of 1999 (6008, 6006, 6039) the representative Second Quarter 1999 index value would be 6018. The ENR CCI values are based upon construction costs, including labor and materials, averaged over 20 cities. The index measures how much it would cost to purchase a hypothetical package of goods and services compared to what it was in a base year. The index values are reported monthly from 1977 to present. Average annual index values are reported from 1908 to 1976.

A.1.1 Pump Stations

Anticipated intake and transmission pump station costs vary according to the discharge and pumping head requirements, and structural requirements for housing the equipment and providing proper flow conditions at the pump suction intake. The cost tables provided herein are based on the station size, or horsepower, necessary to deliver the peak flow rate. Pump station costs are listed as millions of dollars in Table A-2 for a range of horsepower requirements. The costs include those for pumps, housing, motors, electric control, site work, and all materials needed. The costs in Table A-2 were estimated using generalized cost data related to station horsepower from actual construction costs of equipment installed. The cost for an intake structure is included when pumping from a raw water source, such as a river or reservoir. Based on costs of actual projects, the intake structure cost is estimated as 45 percent of the intake pump

[1] ENR: Engineering News Record, Vol. 242, No. 25, June 1999, McGraw-Hill, http:\\www.enr.com\cost\costcci.asp.

Table A-2.
Pump Station Costs[1]
(With and Without Intake Structures)[2]

Pump Station (HP)	Pump Station Cost (dollars)	Pump Station (HP)	Pump Station Cost (dollars)
—	—	7,000	5,470,000
< 400	550,000	8,000	5,760,000
400	650,000	9,000	6,040,000
1,000	1,350,000	10,000	6,300,000
2,000	2,450,000	15,000	7,280,000
3,000	3,380,000	30,000	9,230,000
4,000	4,080,000	60,000	12,010,000
5,000	4,610,000	80,000	13,050,000
6,000	5,040,000	100,000	13,980,000

[1] Values are current as of Second Quarter 1999.
[2] Intake structure costs are estimated as an additional 45 percent to be added to the pump station cost shown.

station cost. The cost of bringing power to each pump station is estimated as $125/hp, with a minimum cost of $50,000. Power connection costs are calculated for each pump station and for well pumps. Costs for pump stations located at water treatment plants are accounted for in the capital cost table for water treatment plants (Table A-5).

A.1.2 Pipeline

Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. For technical evaluation of water supply options, pipeline costs are obtained from Table A-3, which shows unit costs based on the pipe diameters from 12-inches to 120-inches, soil type, and level of urban development. In the case of a high-pressure pipeline (>150 psi), the unit cost is increased by 13 percent for the length of pipe designated as high-pressure class pipe. The unit costs listed in Table A-3 represent the installed cost of the pipeline and appurtenances, such as markers, valves, thrust restraint systems, corrosion monitoring and control equipment, air and vacuum valves, blow-off valves, erosion control, revegetation of right-of-way, fencing, and gates.

Table A-3.
Pipeline Unit Cost for Various Soil Environments[1]

	Soil		Combination Rock and Soil		Rock	
Pipe Diameter (inches)	Rural ($/foot)	Urban ($/foot)	Rural ($/foot)	Urban ($/foot)	Rural ($/foot)	Urban ($/foot)
12	28	45	35	54	42	63
14	31	51	40	61	48	71
16	35	57	45	69	53	79
18	39	63	50	75	59	86
20	41	67	53	81	62	92
24	46	76	59	91	70	104
27	53	87	67	103	80	118
30	60	97	75	114	90	133
33	70	113	87	134	104	155
36	80	128	100	153	118	177
42	96	155	119	185	144	214
48	111	180	138	216	167	250
54	128	210	160	250	193	290
60	147	240	184	286	221	331
64	165	269	206	320	248	371
66	182	297	229	355	275	411
72	218	354	272	422	326	490
78	239	387	293	462	358	536
84	257	415	320	495	384	574
90	270	438	337	522	405	606
96	317	516	398	616	478	704
102	365	594	457	708	547	821
108	412	670	516	799	619	928
114	462	751	577	896	693	1,039
120	520	846	651	1,008	781	1,170

[1] Values as of Second Quarter 1999. Add 13 percent to unit price for length of pipe with pressure class >150 psi.

Table A-4.
Crossing Costs for
Tunneling and Pipe Jacking[1]

Pipe Diameter (inches)	*Tunneling Cost ($/inch diameter/ft)*
48	23
54	22
60	21
66	20
72	19
78	18
84	17

[1] Values current as of 2nd Quarter 1999.

Additional costs are included for pipeline installation when crossing roads, streams, or rivers. Some form of trenchless technology will likely be used to install the pipeline when obstructions (e.g., larger streams, major roads, railways, rivers, and structures) are encountered. The two trenchless technologies included herein are: (1) pipe jacking utilizing boring and/or tunnel techniques to excavate the soil, and (2) horizontal directional drilling. Table A-4 shows costs that are used to estimate pipeline borings.

A.1.3 Water Treatment Plants

Water treatment plant costs shown in Table A-5 are based on plant capacity for four different types or levels of treatment. It is not the intent of these cost estimating procedures to establish an exact treatment process, but rather to estimate the cost of a general process appropriate for bringing the source water quality to the required standard of the receiving system (i.e., potable water distribution system, a stream in an aquifer recharge zone, or an aquifer injection well). The process options presented include treatment of groundwater, simple filtration, conventional surface water treatment, and reclaimed wastewater treatment. Table A-6 gives a description of the processes involved in each treatment level. The costs in Table A-5 include costs for all processes required, site work, buildings, storage tanks, sludge handling and disposal, clearwell, pumps, and equipment. The costs assume pumping through and out of the

Table A-5.
Water Treatment Plant Costs[1]

Capacity (MGD)	Level 1[2]	Level 2[3]	Level 3[4]	Level 4[5]
	Capital Cost (dollars)	Capital Cost (dollars)	Capital Cost (dollars)	Capital Cost (dollars)
1	558,000	3,399,000	2,654,000	5,970,000
10	2,322,000	7,600,000	10,303,000	23,218,000
50	6,744,000	19,209,000	34,849,000	71,867,000
75	9,730,000	24,738,000	50,000,000	99,508,000
100	11,921,000	29,381,000	60,607,000	132,677,000
150	18,243,000	38,005,000	90,909,000	199,015,000
200	21,007,000	42,428,000	112,121,000	265,354,000

1 Values current as of 2nd Quarter 1999.
2 Level 1: Aquifer Treatment.
3 Level 2: Direct Filtration.
4 Level 3: Conventional.
5 Level 4: Reclaimed Wastewater.

plant as follows: Levels 2, 3, & 4 treatment plants include raw water pumping into the plant for a total pumping head of 100 feet, and finished water pumping for 300 feet of total head. Level 1 treatment includes only finished water pumping at 300 feet of head. O&M costs are included in the non-structural costs discussed in Section 3.

A.1.4 Storage Tanks

Ground storage tanks may be used for stand-alone storage, as part of a distribution system, or as part of a pumping station. The costs for storage tanks are listed in Table A-7 as cost per million gallons of capacity. A storage tank should be included at each transmission pump station along a pipeline. It is assumed that storage tanks at these stations will provide storage for 5 percent of the daily flow.

A.1.5 Off-Channel Reservoirs

An off-channel reservoir is a reservoir located away from a main river channel that receives little or no natural inflow. Off-channel reservoirs are built by placing a dam across a minor tributary or by constructing a ring dike that has no associated tributary. The capacity of

Table A-6.
Water Treatment Level Descriptions

Level 1:	Groundwater Treatment – This treatment process is used to disinfect and, if necessary, to lower the iron and manganese content of groundwater. The process includes application of chlorine dioxide for taste and odor control and addition of phosphate to sequester iron and manganese. Disinfection by chlorine is applied as the final treatment. With this treatment, the water is suitable for public water system distribution, aquifer injection, and/or delivery to an aquifer recharge zone.
Level 2:	Direct Filtration Treatment – This process is used for treating waters from sources with anticipated low turbidity and low color where turbidity and taste and odors levels are low. In the direct filtration process, low doses of alum and polymer are used and settling basins are not required, as filters remove all suspended solids. The process includes alum and polymer addition, rapid mix, flocculation, gravity filtration, and disinfection. Level 2 treatment costs were also used to estimate costs for iron and manganese removal from groundwater at levels in excess of 0.3 mg/L for iron and 0.05 mg/L for manganese. Water treated with either of these processes is suitable for aquifer injection or for delivery to an aquifer recharge zone, and for groundwater sources, is suitable for public water system distribution.
Level 3:	Conventional Treatment – This process is used for treating all surface water sources to be delivered to a potable water distribution system. The process includes alum and polymer addition, rapid mix, flocculation, settling, filtration, and disinfection with chlorine. In options where the source contains a large proportion of reclaimed water, this level may be modified to include GAC and pre-ozone treatment. This treatment produces water that is suitable for public water system distribution.
Level 4:	Reclaimed Water Treatment – This process is used for treatment where wastewater effluent is to be reclaimed and delivered to a supply system or injected to an aquifer. The concept includes renovation of wastewater plant effluent by phosphorous removal, storage in a reservoir, blending with surface runoff from the reservoir catchment, followed by conventional water treatment. Phosphorous is removed from the effluent by lime softening including lime feed, rapid mix, flocculation, settling, recarbonation, and gravity filtration. The final conventional treatment will include ozonation, activated carbon, addition of alum and polymer, rapid mix, flocculation, sedimentation, second application of ozone, filtration, and disinfection with chlorine. This treatment results in water that can be delivered to a public water system for distribution or injection to an aquifer.

these reservoirs is typically used for storing water that is pumped from another location, such as a nearby river. Because natural inflow is an insignificant factor, spillway requirements are minimal. The values in Table A-8 are referenced for a cost estimate for an off-channel reservoir. In this study, the cost of ring dikes is used for all off-channel reservoirs.

Table A-7.
Ground Storage Tank Costs[1]

Tank Volume (MG)	Cost (dollars)
0.01	86,400
0.05	146,400
0.10	209,300
0.50	393,600
1.00	679,100
2.00	1,129,300
4.00	1,768,600
6.00	2,408,000
7.50	2,926,600
9.00	3,299,200

[1] Values current to Second Quarter 1999.

Table A-8.
Off Channel Storage Costs[1]

Storage Volume (acft)	Ring Dike Capital Cost (dollars)[1]	Storage Volume (acft)	Ring Dike Capital Cost (dollars)[1]
500	1,390,000	15,000	12,111,000
1,000	2,781,000	17,500	12,869,000
2,500	5,203,000	19,000	13,323,000
4,000	6,782,000	20,000	13,626,000
5,000	7,709,000	22,000	14,233,000
10,000	10,440,000	25,000	15,142,000
12,500	11,353,000	—	—

[1] Values from Dr. N. Johns, Pierce Ranch ring dike storage reservoir study, current to June 1999 prices (ENR CCI June 1999 = 6039), also used as costs for dams on tributaries.

A.1.6 Well Fields

The costs for public water supply wells are summarized in Table A-9. These reconnaissance level values were estimated by the Wellspec Company and LBG-Guyton Associates, Inc. The costs include well completion, pumps, and other necessary facilities, such as access roads, fending, and site improvements. The cost for irrigation wells is assumed to be 55 percent of the well cost for public water supply wells. Aquifer storage and recover (ASR) well costs are estimated using the values represented in Table A-10.

A.1.7 Dams and Reservoirs

Construction costs for these projects were handled individually. Since each reservoir site is unique, costs were based on the specific project requirements. Items included in the estimate consist of the capital (structural) and "other" (non-structural) costs listed in Table A-1. Most dams and reservoirs under consideration in the South Central Texas Region have been studied in the past and previous cost estimates were updated to Second Quarter 1999 prices, using the ENR CCI.

A.1.8 Relocations

Large-scale projects, such as reservoirs, may require the use of lands that contain existing improvements or facilities such as utilities, roads, homes, businesses, and cemeteries. The cost estimating procedures include an accounting for either the cost of relocation or outright purchase of these types of improvements and facilities. Because the type of improvements and facilities that would need to be relocated vary significantly from project to project, estimating the costs for relocation items is addressed on an individual project basis.

A.1.9 Water Distribution System Improvements

The introduction of treated water to a city or other entity may require improvements to the entity's water distribution system, which is comprised of piping, valves, storage tanks, pump stations, and other equipment used to distribute water throughout the entity's service area.

Table A-9.
Public Supply Well Costs

Well Depth (feet)	Well Capacity (gpm)				
	200	400	700	1,000	1,500
Static Water Levels Less Than 200 Feet Below Land Surface					
150	$156,000	$157,000	—	—	—
300	$190,000	$191,000	$209,000	—	—
500	$214,000	$217,000	$238,000	$337,000	—
700	$233,000	$235,000	$257,000	$359,000	$383,000
1,000	$270,000	$274,000	$296,000	$391,000	$415,000
1,500	$328,000	$331,000	$348,000	$446,000	$470,000
Static Water Levels Between 200 and 400 Feet Below Land Surface					
300	$194,000	—	—	—	—
500	$215,000	$ 221,000	$ 250,000	—	—
700	$233,000	$ 237,000	$ 269,000	$ 376,000	$ 398,000
1,000	$277,000	$ 278,000	$ 312,000	$ 395,000	$ 417,000
1,500	$320,000	$ 323,000	$ 352,000	$ 453,000	$ 475,000
Static Water Levels Between 400 and 600 Feet Below Land Surface					
500	$221,000	—	—	—	—
700	$238,000	$238,000	$272,000	$384,000	$400,000
1,000	$277,000	$296,000	$306,000	$394,000	—
1,500	$324,000	$342,000	$376,000	$455,000	$475,000
Static Water Levels Between 600 and 800 Feet Below Land Surface					
1,000	$283,000	$334,000	$347,000	$426,000	—
1,500	$328,000	$362,000	$382,000	$468,000	—

Table A-10.
ASR Well Costs
(Static Water Levels = 200 Feet Below Land Surface)

Well Depth (Feet)	ASR Well Capacity (gpm)			
	400	700	1,000	1,500
300	$235,000	$268,000	—	—
500	$261,000	$292,000	$389,000	—
700	$288,000	$323,000	$420,000	$508,000
1,000	$323,000	$349,000	$446,000	$531,000
1,500	$380,000	$434,000	$526,000	$554,000

Previous cost estimate guidelines were developed specifically for distribution system improvements for the City of San Antonio during the Trans-Texas Water Program. These costs were obtained from a 1991 report to the City Water Board by Black and Veatch entitled "Report on Master Plan for Water Works Improvements" and include estimated costs for improvements to San Antonio's distribution system to convey treated water from the proposed Applewhite project. Using Applewhite Phase 1 capacity of 50 MGD and water distribution cost of $51,750,000 (1991 costs) results in a mid-1991 cost of $1,035,000 per MGD for the first 50-MGD increment. For alternatives producing up to 50-MGD the annual costs were estimated at $1,288,000 per MGD of capacity (Second Quarter 1999). Above 50-MGD capacity, the unit cost is $758,000 per MGD (Second Quarter 1999). (Note: The cost of distribution system improvements is assumed applicable to taking the same quantity of water from the demand center to the nearby aquifer recharge locations.)

A.1.10 Stilling Basins

If an option involves discharging into a water body or perhaps into a recharge structure, it may require the use of a stilling basin. Stilling basin costs, when applicable, were estimated as $2,764 per cfs discharge.

A.2 Other Project Costs

As previously mentioned, "other" (non-structural) project costs are costs incurred in a project that are not directly associated with construction activities. These include costs for engineering, legal counsel, financing, contingencies, land, easements, surveying and legal fees for land acquisition, environmental and archaeology studies, permitting, mitigation, and interest during construction. These costs are added to the capital costs to obtain the total project cost. The major components of these costs are described below.

A.2.1 Engineering, Legal, Financing, and Contingencies

A percentage applied to the capital costs is used to calculate a combined cost that includes engineering, financial, legal services, and contingencies. The contingency allowance accounts for unforeseen costs and for variances in design elements. In accordance with TWDB guidelines, the percentages used are 30 percent of the total construction costs for pipelines and 35 percent for all other facilities.

A.2.2 Land Acquisition and Easements

Land related costs for a project can typically be divided into two categories: (1) land purchase costs and (2) easement costs. Land areas acquired for various facility types are considered based upon previous project experience. Two types of easements are usually acquired for pipeline construction – temporary and permanent. Permanent easements are those in which the pipeline will reside once constructed. These permanent easements provide access for maintenance and protection from other parallel underground utilities. Temporary easements provide extra working space during construction for equipment movement, material storage, and related construction activities. Pipeline easement costs are estimated using a value of $8,712 per acre ($0.20 per ft^2), based in large part on recent experience with the Mary Rhodes Pipeline extending from Lake Texana to Corpus Christi. The pipeline area considered in the acquisition cost includes a permanent easement width of 30 to 50 feet, depending upon the pipe size. This value includes costs for the temporary easement.

Land costs vary significantly with location and economic factors. Land costs in Texas are estimated using Rural Land Values in the Southwest, by Charles E. Gilliland, published biannually by the Real Estate Center at Texas A&M University, College Station, Texas. Other sources of land values, such as county appraisal district records, are also utilized. The land acquisition area estimated for reservoirs includes the acreage inundated by the 100-year or standard project flood.

A.2.3 Surveying and Legal Fees

Ten percent (10 percent) is added to the total land and easement costs to account for surveying and legal fees associated with land acquisition, except for reservoirs and large well fields. The surveying cost for reservoirs is estimated at $50 per acre of inundation, and for large well fields is computed at $50 per acre purchased.

A.2.4 Environmental and Archaeology Studies, Permitting, and Mitigation

Costs for environmental studies, permitting, and mitigation, as well as archaeological recovery, are project-dependent and were estimated on an individual basis using information available and the judgement of qualified professionals. In the case of reservoir options, environmental studies and mitigation costs were generally based on 100 percent of the land value for the acreage purchased. The environmental studies and mitigation costs for pipelines were estimated at $25,000 per mile of pipeline.

A.2.5 Interest During Construction

Interest during construction (IDC) is calculated as the cost of interest on the borrowed amount less the return on the proportion of borrowed money invested during construction. In accordance with TWDB guidelines, IDC is calculated as the total of interest accrued at the end of the construction period using a 6 percent annual interest rate on total borrowed funds, less a 4 percent rate of return on investment of unspent funds.

A.3 Annual Costs

Annual costs are those that the project owner can expect to incur if the project is implemented. These costs include repayment of borrowed funds (debt service), operation and maintenance costs of the project facilities, pumping power costs, and water purchase costs, when applicable.

A.3.1 Debt Service

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost (present worth), an assumed finance rate, and the finance period in years. As specified in TWDB Exhibit B, Section 1.71, debt service for all projects was calculated assuming an annual interest rate of 6 percent and a repayment period of 40 years for reservoir projects and 30 years for all other projects. The debt service factor of

0.06646 or 0.07265 for 40- or 30-year repayment periods is applied, respectively, to the total estimated project costs.

A.3.2 Operation and Maintenance

Operation and maintenance (O&M) costs for dams, pump stations, pipelines, and well fields (excluding pumping power costs) include labor and materials required to operate the facilities and provide for regular repair and/or replacement of equipment. In accordance with TWDB guidelines, O&M costs are calculated at 1 percent of the total estimated construction costs for pipelines, distribution, facilities, tanks and wells, at 1.5 percent of the total estimated construction costs for dams and reservoirs, and at 2.5 percent for intake and pump stations.

Water treatment plant O&M is estimated using Table A-11. The O&M costs listed in Table A-11 include labor, materials, replacement of equipment, process energy, building energy, chemicals, and pumping energy.

Table A-11.
Operation and Maintenance Costs for Water Treatment Plants[1]

Capacity (MG)	Level 1[2] O&M Cost (dollars)	Level 2[3] O&M Cost (dollars)	Level 3[4] O&M Cost (dollars)	Level 4[5] O&M Cost (dollars)
1	111,000	199,000	249,000	387,000
10	619,000	829,000	973,000	2,875,000
50	2,322,000	3,538,000	3,980,000	12,715,000
75	3,538,000	5,307,000	6,192,000	19,902,000
100	4,367,000	6,744,000	7,739,000	26,535,000
150	7,076,000	9,951,000	11,056,000	39,803,000
200	8,292,000	13,268,000	14,373,000	53,071,000

1 Values current as of 2nd Quarter 1999.
2 Level 1: Aquifer Treatment.
3 Level 2: Direct Filtration.
4 Level 3: Conventional.
5 Level 4: Reclaimed Wastewater.

A.3.3 Pumping Energy Costs

In accordance with TWDB guidelines, power costs are calculated on an annual basis using the appropriate calculated power load and a power rate of $0.06 per kWh. The amount of energy consumed is based upon the pumping horsepower required.

A.3.4 Purchase of Water

The purchase cost, if applicable, is included if the water supply option involves purchase of raw or treated water from an entity. This cost varies by source.

A.4 Cost Estimate Presentation

Each individual option is presented with total capital costs, total project costs, and total annual costs. The level of detail is dependent upon the characteristics of each option. Additionally, a summary is calculated, showing the cost per unit of water involved in the option, reported as costs per acft and cost per 1,000 gallons of water developed. The individual option cost tables specify the point within the region at which the cost applies (e.g., raw water at the lake, treated water at the municipal and industrial demand center, or elsewhere as appropriate).

Appendix B

Environmental Water Needs Criteria of the Consensus Planning Process

Environmental Water Needs

PLANNING CRITERIA OF THE CONSENSUS STATE WATER PLAN

CONSENSUS PROCESS

The consensus-based state water planning process joins the three primary State water or natural resource agencies, the Texas Water Development Board (TWDB), the Texas Natural Resource Conservation Commission (TNRCC), and Texas Parks and Wildlife Department (TPWD) with other stakeholders in a major effort to update the State Water Plan. This effort is addressing the long-range, multi-purpose water needs of Texas through broad-based involvement, negotiation, and consensus-building among key parties.

The overall goals of these consensus efforts are summarized in Exhibit 1. This effort involves planning for the water needs of Texas' citizens for the next fifty years, while trying to ensure adequate flows to maintain ecosystems and protect water quality.

Exhibit 1
Consensus Goals

The consensus-based water planning process was initiated by the State water agencies to address the following management goals:

★ To promote consistent planning, policy, regulation, management, and wise use of the State's water resources.

★ To minimize or avoid any needless and unproductive conflict in the planning and management of these resources.

★ To provide an on-going, cooperative planning and policy process for orderly and responsible water conservation, development, and management.

PLANNING GOALS

To accomplish this balancing between competing purposes, environmental water needs criteria have been developed consisting of:

(1) *philosophical planning goals* for environmental water needs that the consensus process is trying to achieve, and

(2) *specific numerical planning criteria* that can serve as desk-top, reconnaissance-level planning guidance, or possibly as regulatory default values where detailed field studies are not required. The numerical criteria outlined below can provide early planning

guidance for developing applications for new or amended water rights permits. They not intended to be used as an exact formula for determining specific environmental requirements that may be conditioned to new or amended water right permits.

Since water development projects, such as river impoundments and diversions, can alter the natural flow regime of streams and rivers, assessment of fish and wildlife maintenance needs in the affected downstream segments is an important project activity. The primary objective is to minimize development impacts on living resources by managing for environmental flow needs through watershed management. This can best be done on a regional basis. Also, decreasing the flow in streams below a certain threshold can affect the assimilative capacity or dilution ability of streams, thereby leading to increased costs associated with higher levels of wastewater treatment and nonpoint source pollution prevention activities. Therefore, multi-stage rules for environmentally safe operation of these necessary water projects over the normal range of weather conditions experienced in Texas, which is extreme, are needed.

The environmental criteria have generally been accepted by State water agencies for use in planning and for use as "default" values in the permitting of certain small projects in the absence of site-specific information. However, they are not intended to replace site-specific information in the permit process, and the TNRCC is charged by law with the final ~~decision in all~~ permit matters.

As part of the State Water Plan process, a team of instream flow and aquatic biology specialists was asked to develop guidelines to be used in planning for water resource projects. The general consensus planning methods developed by the State water agencies attempt to balance human and environmental water needs. These criteria provide instream flow recommendations that serve as initial "placeholders" for instream flow needs until more site-specific assessments can be performed.

ECOLOGICAL FLOW AND WATER SUPPLY GOALS

In developing the criteria, general *ecological goals* were specified to provide adequate water to maintain instream flows and freshwater inflows to bays and estuaries. Identified environmental flows should represent an estimate of full ecological water needs and how those ecological targets might be met or altered in balancing them with human needs. The methods developed should help ensure the *long-term health* of the aquatic environment, realizing that periodic dry conditions are a natural part of the climate, hydrology, and ecosystem development in Texas. Also, ecological water need targets would be based on "naturalized" stream flow conditions to address slowing the degradation of the natural, pre-development environment, and to provide a more stable streamflow record that would not change with each new water development project, which would be the case if gaged flow records were used in the analyses.

Conditioning these environmental goals, *water supply goals* were identified. To acknowledge the priority of human needs during dry periods and drought, the relative share of water provided for the environment will be successively reduced to protect water supplies. Also, ecological flow needs will be based on inflows to water project sites and will not be provided from the project's water supply storage. Further, all downstream water right needs will be honored at all times.

To address these goals, a three-zone approach, summarized in Exhibit 2 and described in detail below, was formulated to ensure instream environmental maintenance during normal flow periods, while protecting human water supply needs during times of low flows and drought. Regional or watershed-specific differences are inherent in these criteria, since pass-through flows are based on the specific, "on-site" hydrology of each river system.

Exhibit 2
Three-Zone Concept for the Provision of Instream Flow Environmental Water Needs

Zone 1. During normal or higher flow periods, promote the *long-term health* of the natural environment with the pass-through provision of the most-common flow regime, identified by an appropriate central tendency value such as median, mode, or geometric mean of naturalized flows.

Zone 2. During drier periods, provide pass-through flows for *minimum ecological maintenance* where the aquatic species are impacted by lower flows, but can survive for a short period.

Zone 3. During severe drought conditions, provide pass-through flows sufficient to maintain *water quality*.

As a planning place-holder value, the Zone 1 reservoir pass-throughs or direct diversion by-passes will also provide freshwater inflow to the bays and estuaries (B&E). However, where inflow values adequate to meet the beneficial inflow needs as described in Texas Water Code §11.147 have been established, those inflow volumes will be used for projects within 200 river miles of the coast, commencing from the mouth of the river, as the basis for calculating the relative contributions of fresh water from the associated rivers and coastal basins during Zone 1 conditions. No other special provisions would be made for B&E purposes in Zone 2 or 3 conditions for either new reservoirs or large direct diversions. These inflow values may be determined by TPWD until a regulatory determination is made in accordance with Texas Water Code Section 11.1491.

It is the intent of the consensus-based water planning process that the goals of these environmental flow criteria be met with the *best information possible*. The numerical values given below are for default purposes only, given the lack of more detailed, site-specific investigations at many locations around the State. Where more site-specific or better data can be obtained, this information should replace the default values, but still remain consistent with the overall policy goals and general structure of the criteria.

REGULATORY GOALS AND PROVISIONS

A primary regulatory goal of the environmental water needs planning criteria is to reasonably predict the ultimate regulatory outcome so that future applicants will have increased certainty concerning the way environmental issues will generally be addressed in their applications. An overall structure for regulatory consideration should be established that defines general performance standards that an applicant would be expected to meet, but also allows the applicant considerable flexibility to conduct field work and technical analyses to devise an application that best meets their needs and those of the State. Finally, regulatory flexibility in the joint consideration for providing downstream water rights and environmental flows should be allowed. There may be some instances where "stacking" of environmental flows on top of downstream rights may not be a necessary provision of the water right, especially where a release or pass-though for one purpose can fully satisfy both.

When the results of intensive fresh water inflow or instream flow studies are available and criteria have been established regulatorily, those criteria will be used in the Water Plan in lieu of any generic rule. For example, the instream flow requirements for the Colorado River have been approved by TNRCC in the LCRA Management Plan. When established criteria are available and agreed to by TPWD and TNRCC, bay and estuary inflow requirements would be apportioned to each new project identified in the plan according to its proportional share, based on its contribution to the total hydrology of the estuary. Where possible, this process will seek to restore seasonal flow patterns and minimize cumulative impacts from water development projects.

AMENDMENTS TO EXISTING PERMITS

The scope of environmental review and permit consideration of an amendment to an existing water right is limited by law. Because of the many varied conditions around the State, and the fact that an applicant may propose a project different than that identified in the Plan, the TNRCC can only provide general guidance as to how the Commission would evaluate applications for water rights and amendments to existing permits.

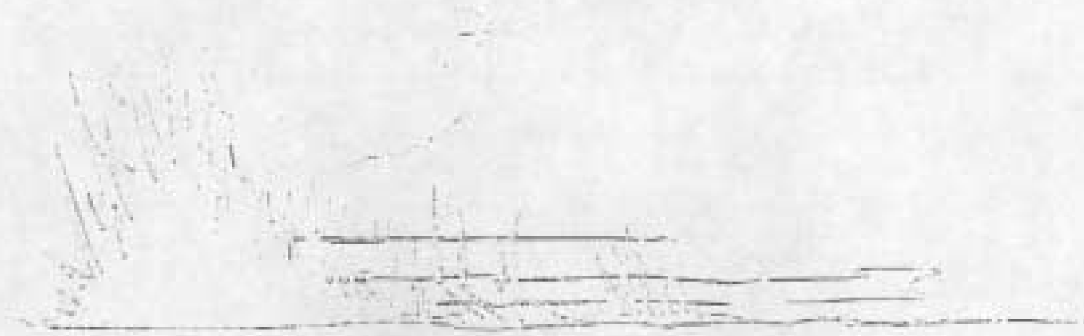
In general, evaluation of impacts to instream or estuarine ecosystems will occur when there is a *significant* change in the point of diversion from downstream to upstream, to an adjoining tributary, to an area with endangered species habitat, increase in the amount and/or rate of diversion, or if there is a change of purpose of use from non-consumptive to consumptive. Other changes in place or type of use and changes made by SB 1 to sections 11.122 and 11.085, Texas Water Code, may have limited or no further environmental review. This limited scope of review for proposed amendments to existing water rights was codified by SB 1. Section 11.122 of the Water Code now expressly provides that, except for an amendment that increases the amount of water authorized to be diverted or the authorized rate of diversion, an amendment shall be authorized if the requested change will not cause any greater adverse impact on other water right holders or the environment than the full legal exercise of the water right prior to its amendment. An exception to this is provided by changes made by SB 1 to Section 11.085 of the Water Code relating to interbasin transfers. If the water right sought to be transferred is currently authorized to be used under an existing water right, potential environmental impacts shall only be considered in relation to that portion of the right proposed for transfer and shall be based on the historical use of the water.

For planning purposes, proposed amendments, such as conversion from non-consumptive to consumptive use (having the effect of a new appropriation) would have the appropriate environmental considerations described for new projects. For other types of amendments where only the intervening river or stream would be affected, the appropriate reservoir or direct diversion instream flow criteria would be applied. Where applicable, environmental flow criteria would only affect that portion of the existing water right subject to change. A summarization and categorization of the TNRCC's general guidance for determining potential adverse impact to the environment for types of possible water right amendments likely to be considered in the consensus planning process is shown in Exhibit 3.

Exhibit 3
Water Rights Permit Amendments and Scope of Environmental Review for Planning

Type of Amendment	Environmental Assessment	Application of Environmental Criteria
Interbasin Transfer with no change in *permitted* purpose of use, appropriative amount, point of diversion, and rate of diversion.	No additional environmental impacts considered with respect to the originating basin. Consideration of potential changes in water quality and/or migration of nuisance species, and excessive freshwater inflows to maintain proper salinity levels for B&E's may be made for receiving basin. An impact statement may be required to be submitted.	Not applicable for originating basin.
Significant change in point of diversion from downstream to upstream, to adjoining tributary, or to endangered species habitat	Evaluation of impacts to intervening instream or site-affected environmental resources.	Case-by-case basis where level of significance is evaluated as per TNRCC's guidance.
Change of purpose of use from non-consumptive to consumptive use	Evaluation of impacts to instream and B&E environmental resources.	Three-zone planning criteria described previously.
Change in purpose of use where there is no increase in the consumption of water from that legally authorized in the existing water right	No environmental review.	Not applicable.

Where applicable, the "environmental planning criteria" would only affect that portion of the existing water right subject to change. Also, where regional or local planning efforts may specify higher environmental goals than those provided by the existing minimum legal or regulatory requirements, such alternate goals may be requested by the applicant and may ultimately be provided in the water right permit.



DEFAULT NUMERICAL VALUES
AND OPERATIONAL GUIDELINES OF THE
ENVIRONMENTAL WATER NEEDS PLANNING CRITERIA

OVERVIEW

The following discussion is intended as planning guidance to help water planners and engineers meet the goals of the environmental flow criteria, while protecting water supply yield during low flow conditions. The concepts described are intended as guidelines for planning, or in some cases, to be used as "default" values for permitting in situations where site-specific information from detailed field studies is not required. For larger projects, the intent of these guidelines is that they be used as a basic structure for providing environmental flows, with the actual numerical values determined by site-specific studies. A daily reservoir operations model (e.g., SIMDLY-B&E) should be used to simulate performance of potential future water impoundment projects over a multi-year period that includes the drought-of-record. Similarly, a daily diversion operations model (e.g., DIVERT) should be used to simulate performance of potential future direct diversion projects over a multi-year period that includes the drought-of-record. Results will provide estimates of the amount of water produced by the project and the amount that must be passed downstream to protect environmental resources.

NEW PROJECT ON-CHANNEL RESERVOIRS

As illustrated in Figure 1, the conservation storage of new-project, on-channel water supply reservoirs would be divided into three zones for the provision of environmental flows as follows:

Zone 1

In Zone 1 of a reservoir, when reservoir water levels are greater than 80% of storage capacity, inflows to the reservoir will be passed downstream in amounts up to the monthly median value, as calculated from naturalized daily streamflow estimates.[1] Depending on the hydrology of the basin, it may be appropriate to pass the "most common" or central tendency flow frequency which historically occurred, whether it be the median or some other more appropriate expression of central tendency value, such as modal or geometric mean.

Periodic flushing flows for channel and habitat maintenance are beneficial both for the hydraulic properties of the water course itself, and for maintaining the habitat of the aquatic ecosystem.

[1] Naturalized streamflow is the estimated amount of water that would have been present in a watercourse with no direct man-made impacts in the watershed. It is calculated by taking values of historically measured streamflow, adding amounts of estimated man-made losses from the upstream watershed caused by water diversion and lake evaporation, then subtracting amounts of estimated man-made gains to the upstream watershed caused by return flows.

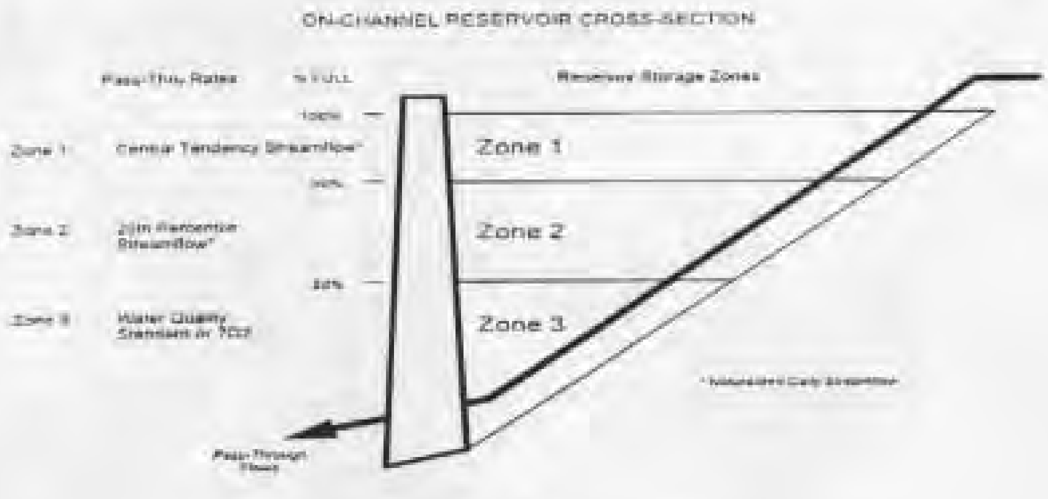


Figure 1
New Project, On-Channel Reservoir Criteria for Passing Environmental Flows

Flushing events appear to occur naturally with enough frequency that planning criteria requiring them may be unnecessary. However, the feasibility of providing flushing flows should be explored during site-specific investigations, and may be required as a condition of obtaining State or Federal permits.

Zone 2

When dry conditions develop and reservoir water levels decline into Zone 2, between 50 and 80% storage capacity, the amount of inflows passed would be reduced to rates up to the monthly 25th percentile flows, as calculated from the naturalized daily streamflow estimates.

Zone 3

As more severe drought conditions develop and reservoir water levels decline into Zone 3, below 50% storage capacity, environmental pass-throughs would be reduced further, and inflows would be passed up to a level determined adequate for the protection of water quality in the downstream segment. In lieu of any site-specific data, the 7Q2 low-flow value, as published in the TNRCC's State Water Quality Standards, would be used as the default criterion for Zone 3 pass-throughs. If in Zones 1 and 2, the value necessary to maintain downstream water quality is higher than the monthly medians or 25th percentiles, respectively, then the value necessary to maintain downstream water quality will be used instead of the other target flow values.

The goal of Zone 3 is to protect water quality. Water quality standards consisting of specific numerical and general narrative criteria are established to protect designated uses based on *current* law and policy. In effluent dominated stream segments, it may difficult to justify any water quality flow value other than the seven-day, two-year, low-flow value (7Q2). In non-effluent dominated or high base flow segments, other analytical methods that address dissolved oxygen (DO) and toxicity may be more appropriate for defining water quality flows than the 7Q2 value used here for planning purposes. More detailed analyses, such as QUALTEX modeling, may be required in a permit application for a large project.

All Reservoir Zones

In all zones, it is the intent of the planning criteria that flows passed for instream purposes also contribute to meeting the ecological needs of the associated bay and estuary system. In addition to passage of environmental flows, adequate flows will be passed through for protection of downstream water rights.

Also in all zones, water that can be captured by reservoirs in excess of the environmental provisions is available for water supply storage, and no water will be released from storage to meet environmental targets when inflows are below these limits. However, since most future reservoir projects and direct diversions are anticipated to be designed solely for water supply rather than flood control, then most floods can't be captured by the reservoirs, but will pass (spill) downstream anyway. These high flow events increase the amount of water available for instream flow maintenance and estuarine needs beyond the levels that would be provided by the environmental criteria alone.

NEW PROJECT DIRECT DIVERSIONS

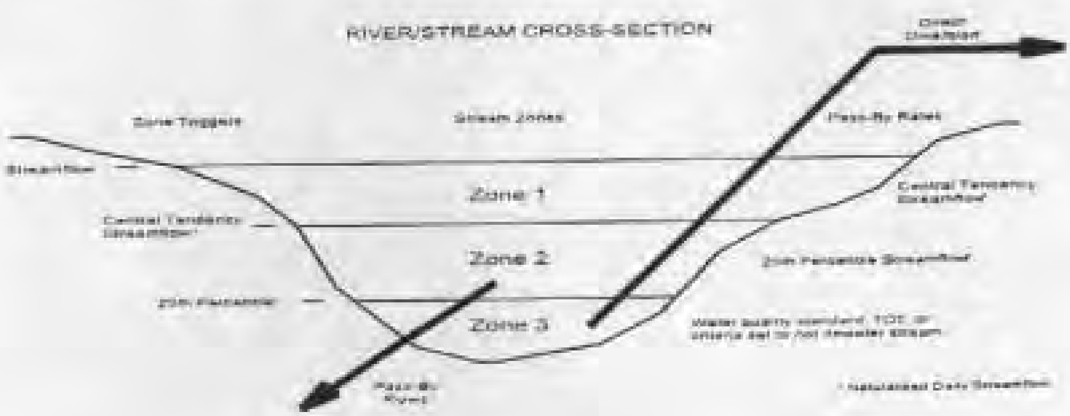


Figure 2
New Project, Direct Diversion Criteria
for Passing Environmental Flows

As illustrated in Figure 2, the criteria for direct diversions from a river or stream that are recommended in the Water Plan, would be based on streamflow conditions just upstream of the diversion point, and would also be divided into three zones as follows.

Zone 1

Zone 1 occurs when actual streamflow is greater than the monthly central tendency values calculated from naturalized daily streamflow estimates. When streamflow is within Zone 1, minimum flows passed will be up to the monthly median or other appropriate central tendency value calculated from naturalized daily streamflow estimates.

Zone 2

Zone 2 occurs when actual streamflow is less than or equal to the central tendency value, but greater than the monthly 25th percentile value. When streamflow is within Zone 2, minimum flows passed will be the monthly 25th percentile values calculated from naturalized daily streamflow estimates.

Zone 3

Zone 3 occurs when actual streamflow is less than or equal to monthly 25th percentile values. During Zone 3, minimum flows passed will be the greater of: (1) the value necessary to maintain downstream water quality or (2) a continuous-flow threshold (e.g., 15th percentile) to be determined by consensus planning staff that will not allow the diversion by itself, to dry up the stream.

For all river and stream segments, the amount of flow necessary to protect water quality downstream will be used as the by-pass target. Where such a rate has not been determined from site-specific or other data, the default planning criterion is the 7Q2 value as published in the TNRCC's <u>State Water Quality Standards</u>. For Zones 1 and 2, if the value necessary to maintain downstream water quality is higher than the medians or 25th percentiles, respectively, then the value necessary to maintain downstream water quality will be used instead of the other target flow values.

All Zones

The streamflow values which trigger different zonal operations will be calculated from naturalized daily streamflow estimates. The above procedure, because it provides a specific quantity of flow for environmental uses in each zone, does not have smooth transitions between zones for diversion projects, and the State water agencies agree that the procedure should be improved to make smoother transitions.

NEW DIRECT DIVERSIONS INTO LARGE OFF-CHANNEL STORAGE

As illustrated in Figure 3, in those cases where a large water supply project would divert its water from a river or stream into off-channel storage, a combination of the direct diversion and reservoir criteria would apply. The direct diversion criteria will govern the ability to divert water into the off-channel project. The reservoir criteria will address the ability of the reservoir to capture water from its own watershed, define the reservoir's multi-stage operations to pass environmental flows, and to ensure flows for protection of downstream water rights.

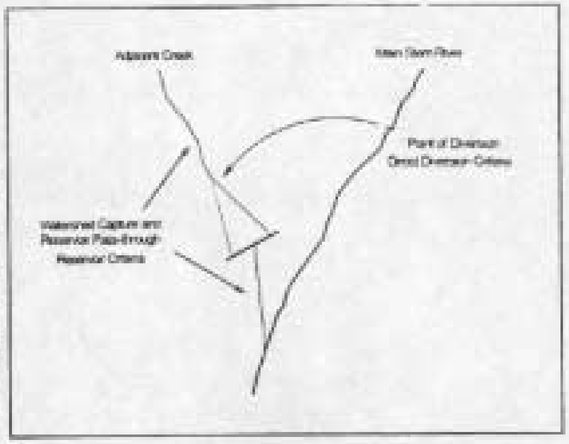


Figure 3
Combined Criteria for Diversion into Off-channel Reservoir

BAY AND ESTUARY CONSIDERATIONS

As a planning place-holder value, the Zone 1 reservoir pass-throughs or direct diversion by-passes described previously will also provide freshwater inflows to the bays and estuaries. However, where inflow values adequate to meet the beneficial inflow needs as described in Texas Water Code §11.147 have been established, those inflow volumes will be used for projects within 200 river miles of the coast, commencing from the mouth of the river, as the basis for calculating the relative contributions of fresh water from the associated rivers and coastal basins during times of Zone 1 conditions. No other special provisions would be made for B&E purposes in Zone 2 or 3 conditions for either new reservoirs or large direct diversions. These inflow values may be determined by TPWD until a regulatory determination is made in accordance with Texas Water Code Section 11.1491.

The target flows in Zone 1 of the reservoir operating procedure should be established to provide the "beneficial flows" defined in Section 11.147(a) of the Texas Water Code as providing a "salinity, nutrient, and sediment loading regime adequate to maintain an ecologically sound environment in the receiving bay and estuary system that is necessary for the maintenance of productivity of economically important and ecologically characteristic sport or commercial fish and shellfish species and estuarine life upon which such fish and shellfish are dependent."

In practical terms, that means it is not necessarily the MinQ or MaxQ value produced by TxEMP, the fresh water inflow optimization model, but a point along that curve between these values that allows some margin of safety in providing sufficient flows in Zone 1 to maintain the ecological health and historic productivity of the fisheries. The fresh water inflow target is validated in part by comparing the seasonal distribution of salinity regimes in the estuary with the density distribution of selected estuarine flora and fauna.

B&E pass-through requirements for a new water development project will be based on a pro-rata share of that location's contribution of flow to the estuary in question. Once the target amount of water reaches an estuary during a month, no additional flows need to be provided for bay and estuary purposes during that month. For the remainder of the month, environmental flows revert to the instream criteria.

When the results of intensive fresh water inflow or instream flow studies are available and criteria have been established in the regulatory process, those criteria will be used in the Water Plan rather than any generic rule. The instream flow requirements for the Colorado River have been approved by TNRCC in the LCRA Management Plan. When established criteria are available and agreed to by TPWD and TNRCC, bay and estuary inflow requirements would be apportioned to each new project identified in the plan according to its proportional share, based on its contribution to the total hydrology of the estuary. Where possible, this process seeks to restore seasonal flow patterns and minimize cumulative impacts from water development projects.

In order to facilitate the timely completion of the determination of the inflow conditions necessary for the (remaining) bays and estuaries, TPWD and TNRCC will each designate an employee under Section 11.1491of the Texas Water Code to share equally in the oversight of the effort to review the studies jointly prepared by TWDB and TPWD under Section 16.058 (bay and estuary inflow studies) to determine inflow conditions necessary for the bays and estuaries. The three agencies will continue to work together as they have in the past to develop target flows to meet the needs of each principal bay and estuary system for a salinity, nutrient, and sediment loading regime at or above the identified needs.

Fresh water optimization curves are available for (1) San Antonio Bay and the Guadalupe Estuary, (2) Matagorda Bay and the Lavaca-Colorado Estuary; (3) Corpus Christi Bay and the Nueces Estuary; and (4) Galveston Bay and the Trinity-San Jacinto Estuary. The remaining Texas bays and estuaries are currently under study. A summary of the study protocol, the completion schedule, and results to date are attached to this briefing document.

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Appendix C

Technical Evaluation Procedures for Edwards Aquifer Recharge Enhancement Options

Appendix C
Technical Evaluation Procedures
for Edwards Aquifer Recharge Enhancement Options

C.1 Introduction

Several of the water supply options under consideration in the South Central Texas Region involve the enhancement of recharge to the Edwards Aquifer. Such recharge enhancement is intended not only to increase springflows protecting endangered species and downstream water uses, but also to enhance the reliability of the Edwards Aquifer as a regional water supply. With regard to enhanced water supply, the Edwards Aquifer Authority (EAA) is in the process of formulating rules regarding recharge recovery permits,[1] which could define the amount of additional authorized pumpage to which the developer of a recharge enhancement project might be entitled. It is not yet known whether such recharge recovery would be authorized on an annual ("put and take") basis[2] or on a long-term ("sustained yield") basis similar to that for surface water reservoirs. More specifically, annual "put and take" refers to a management policy suggested by a provision in SB1477 that may be interpreted as requiring that waters artificially recharged to the aquifer (less an adjustment for springflow) must be recovered during the following 12-month period. "Sustained yield," on the other hand, refers to an alternative management policy under which a fixed or firm annual amount of recharge recovery could be authorized based on the long-term operations of a recharge enhancement project. Hence, recharge recovery would not be limited by actual recharge enhancement in the preceding year, but would be limited to the increase in reliable supply from the Edwards Aquifer during the drought of record. Adoption of a "sustained yield" basis for the issuance of recharge recovery permits could require modification of the referenced provision in SB1477.

For the purposes of regional water supply planning under rules set forth by the Texas Water Development Board (TWDB), recharge enhancement options are evaluated herein based on the reliable supply available during the drought of record. In this way, recharge enhancement options may be considered by the South Central Texas Regional Water Planning Group on the same basis as surface water supply options, such as reservoirs and run-of-river diversions. While

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[1] HDR Engineering, Inc. (HDR), "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.
[2] Senate Bill 1477, Section 1.44(c).

numerous studies quantifying recharge enhancement on both long-term and drought average bases have been completed in recent years, the quantification of additional reliable supply based on maintenance of springflows during the drought of record was not a part of these studies. Hence, the TWDB's model of the Edwards Aquifer is used in this regional water supply planning effort to simulate aquifer performance subject to recharge enhancement, quantify the associated increase in reliable supply, and allow for more direct comparisons between recharge enhancement and other water supply options. The following paragraphs provide a brief summary of the technical procedures used for evaluation of Edwards Aquifer recharge enhancement options.

C.2 Edwards Aquifer Model

In order to simulate aquifer response to a recharge enhancement option, the TWDB GWSIM4 Edwards Aquifer groundwater flow model (Figure C-1) is used to make the necessary calculations. It is designed to simulate aquifer response in terms of water levels and springflows for specified recharge and pumping rates. The model was developed by the TWDB in the 1970s[3] as a tool for use in developing a water resources management program for the Nueces, San Antonio, and Guadalupe River Basins. Originally, the model operated on an annual timestep and was calibrated to data collected from 1947 to 1971. Major assumptions in the model include: (1) no lateral movement of water from the Glen Rose formation in the Hill Country (Trinity Aquifer-Edwards Plateau); (2) no water movement across the so-called 'bad-water line'; and (3) no leakage from underlying or overlying formations except in an area southeast of Uvalde near Leona Springs.

The TWDB recalibrated the model in the early 1990s[4] with information compiled between 1971 and 1989 and refined the timestep to monthly intervals. The recalibration was based on comparisons of water levels and springflows for 1947 to 1959 and "verified" with 1978 to 1989 data. During the process of adjusting the aquifer parameters for recalibration, the model developers gave special emphasis to minimum flow periods at Comal and San Marcos Springs

[3] Klemt, W.B., Knowles, T.R., Elder, G.R., and Sieh, T.W., "Ground-water Resources and Model Applications for the Edwards (Balcones Faulty Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 239, 88p., 1979.
[4] Thorkildsen, D. and McElhaney, P.D.., "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 340, 33p., 1992.

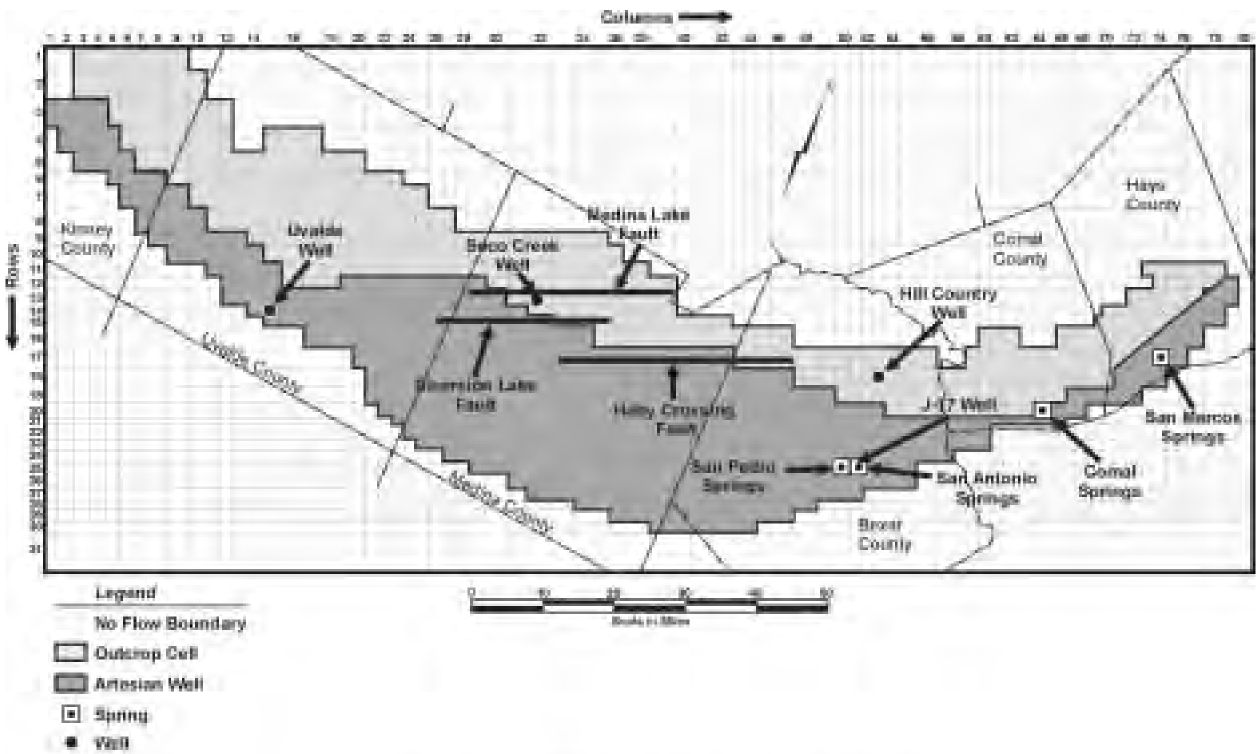

Figure C-1. GWSIM 4 Model for Edwards Aquifer

and water levels at observation well J-17 in San Antonio. The recalibration did not revise any of the major assumptions used in the original model.

At the request of the Texas Natural Resource Conservation Commission (TNRCC) and the South Central Texas Regional Water Planning Group, the TWDB made additional modifications to GWSIM4 and performed a simulation for use in surface water availability and water supply options in the Nueces, San Antonio, and Guadalupe River Basins.[5] As part of this effort, the TWDB modified GWSIM4 to simulate implementation of the EAA's original Critical Period Management rules by separating pumpage by category and location. These categories and locations include: domestic and livestock use, municipal and industrial use in Kinney County, irrigation use by county, industrial use by county and by San Antonio Water System (SAWS), and municipal by county and SAWS. Application of the EAA's original Critical Period Management rules does not, however, force a reduction in overall pumpage during critical aquifer conditions. Hence, the original Critical Period Management rules were turned OFF in all

[5] Kabir, N., Bradley R.G., and Chowdury, A., "Summary of a GWSIM4 Model Run Simulating the Effects of the Edwards Aquifer Authority's Critical Period Management Plan for the Regional Water Planning Process," Texas Water Development Board, July 1999.

simulations. The EAA is in the process of developing new Critical Period Management rules at the time of this report.

All model simulations for this study are for the 1934 through 1989 historical period and have monthly timesteps. The simulation period includes a severe drought in the 1950s (1947 to 1956) and wetter than normal conditions in much of the 1970s and 1980s, except for short, intense droughts in 1984 and 1989.

Historical recharge to the Edwards Aquifer is based upon monthly estimates developed by HDR.[6,7] For the most recent application of GWSIM4, the TWDB used estimates of baseline recharge, developed by HDR, that reflect full utilization of current water rights and recharge enhancement associated with all existing projects as if they existed throughout the 1934 to 1989 historical period. The distributions to specific cells in GWSIM4 were made by the TWDB. The annual estimates of baseline recharge are shown in Figure C-2.

[6] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[7] HDR, "Nueces River Basin Regional Water Supply Planning Study," Nueces River Authority, et al., May 1991.

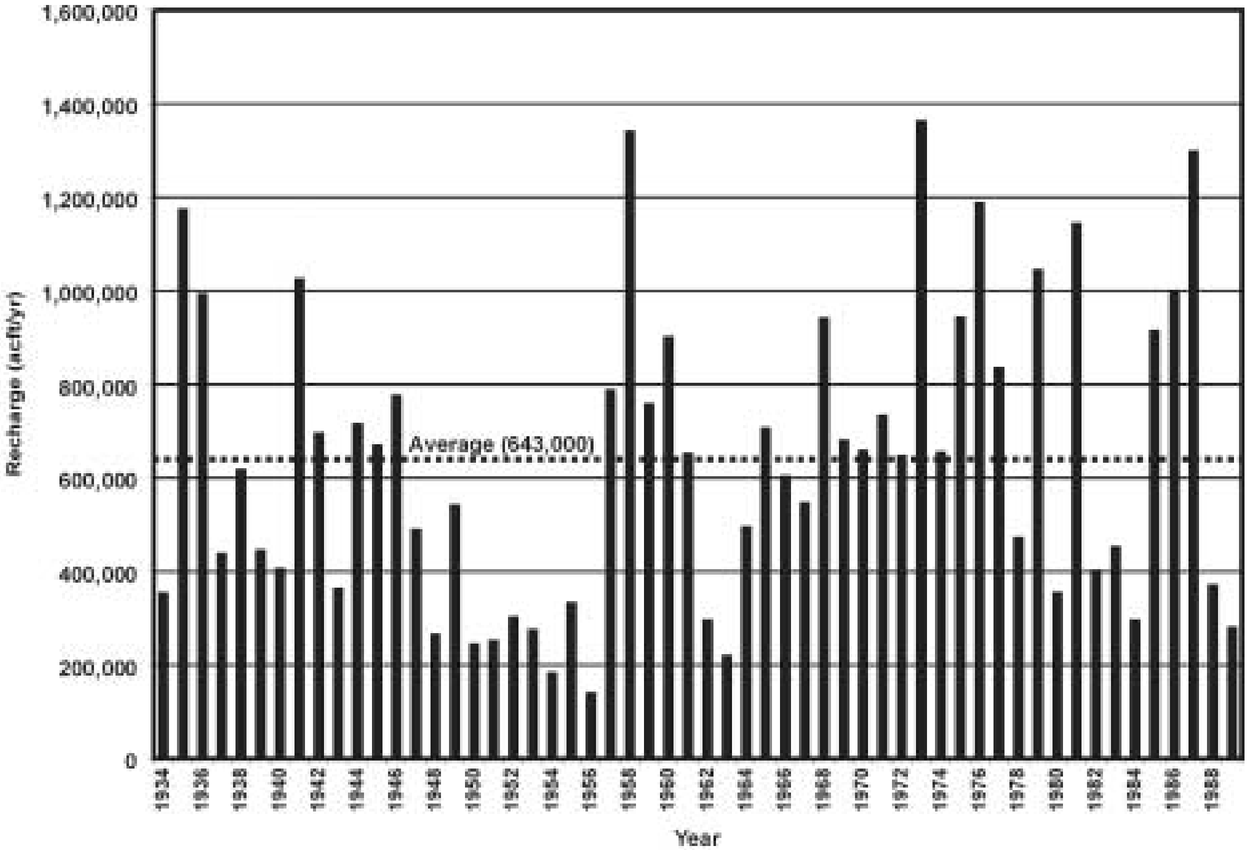

Figure C-2. Edwards Aquifer Recharge

Natural water losses from the Edwards Aquifer model are springflow at Leona, San Pedro, San Antonio, Comal, and San Marcos Springs. Springflow is calculated from aquifer heads at the spring and an aquifer head-springflow rating curve for each spring. Another natural loss is cross-formational leakage in an area southeast of Uvalde. This loss is calculated similarly to springflow. The current version of GWSIM4 includes an estimate of discharge to the Guadalupe River (largely associated with Hueco Springs) and is considered a negative (rejected) recharge by the model. The discharge is estimated from a regression equation of streamflow gains and water levels in observation well J-17.

Pumpage is assigned by category to specific cells in the model by the TWDB, based on the locations of permitted wells. For the baseline permitted pumpage, the total pumpage for irrigation, industrial, and municipal purposes in Kinney, Uvalde, Medina, Bexar, Atascosa, Comal, and Hays Counties, is adjusted to 400,425 acft/yr. Domestic and livestock pumpage does not require permits and totals 12,312 acft/yr. Thus, the total annual pumpage used in the model is 412,737 acft/yr. Annual pumpage is distributed to monthly pumpage values by multiplying the annual pumpage for each category by a monthly distribution factor. The distribution of pumpage, by category and month, is shown in Figure C-3.

C.3 Technical Evaluation Procedure

The technical evaluation procedure used in determining the increase in water supply attributable to a recharge enhancement option is based on the definitions, assumptions, and steps summarized in the following paragraphs.

Definitions:

- *Baseline Pumpage:* The sum of the regular permitted industrial, municipal, and irrigation pumpage categories adjusted to 400,425 acft/yr plus the unpermitted domestic and livestock pumpage. The total is 412,737 acft/yr.
- *Baseline Sustained Yield:* The portion of baseline pumpage that will maintain a minimum monthly flow at Comal Springs of 60 (cfs) in one and only one month of the simulation period. This simulation is performed merely to obtain a baseline estimate of aquifer yield for the "no enhanced recharge" case.
- *Sustained Yield with Recharge Enhancement Project(s)*: The sum of the pumpages for the baseline sustained yield scenario plus an across the board increase in municipal pumpage such that the minimum monthly flow at Comal Springs is 60 cubic feet per second (cfs) in one and only one month of the simulation period.
- *Recharge Recovery Permit Pumpage:* The increase in sustained yield that is attributable to the recharge enhancement project(s).

Assumptions:

- The GWSIM4 Model provides a reasonable simulation of Edwards Aquifer response (in terms of springflow and water levels) to enhanced recharge and various pumpage rates. Note that the EAA, in cooperation with regional, state, and federal interests, has undertaken the development of a new model of the Edwards Aquifer.
- Minimum Comal Springs discharge of 60 cfs (in one and only one month of the 56-year simulation period) provides a reasonable point of reference for assessment of potential changes in sustained yield of the Edwards Aquifer associated with recharge enhancement. Note that the selection of 60 cfs as a minimum discharge simply provides a point of reference for consistent computations and does not necessarily imply acceptability under the law.
- The increase in sustained yield of the Edwards Aquifer during the drought of record provides a reasonable basis for consideration of recharge enhancement options in a manner consistent with other water supply options in the regional water planning process. Note that the EAA is in the process of formulating rules governing recharge enhancement and recovery.

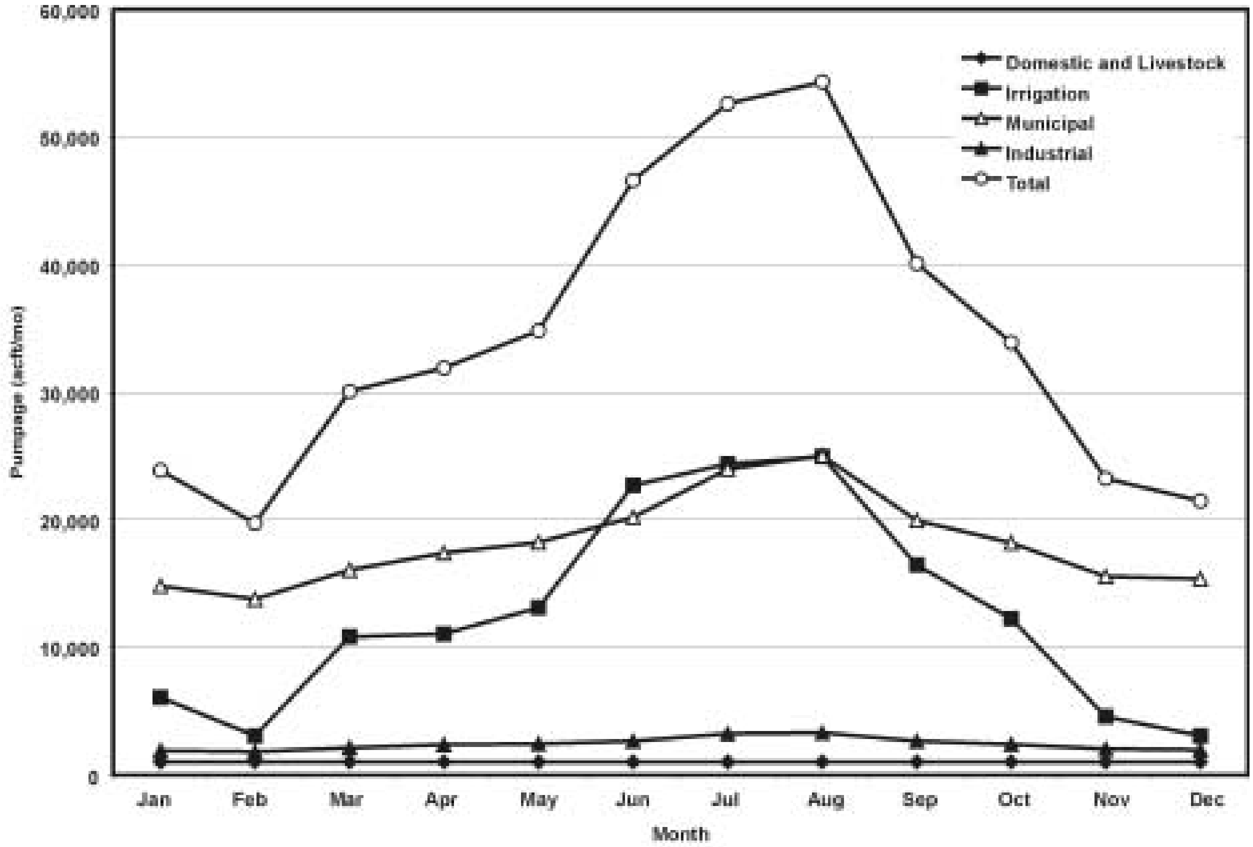

Figure C-3. Summary of Baseline Pumpage — Edwards Aquifer

Steps:

1. Make a baseline GWSIM4 simulation with baseline pumpage and baseline recharge. Count the number of months when flow at Comal Springs (Figure C-4) is less than specified values of interest (200 cfs, 150 cfs, and 60 cfs) and when J-17 levels fall below specified values of interest (650, 642, 636, 632, and 628 ft-msl).
2. Make a series of trial and error GWSIM4 simulations with reductions in baseline pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the baseline sustained yield of the Edwards Aquifer (Figure C-4).
3. Calculate the enhanced recharge provided by the water supply option using a surface water model.
4. Add the baseline recharge and the enhanced recharge.
5. Make a series of trial and error GWSIM4 simulations (including enhanced recharge) with the baseline sustained yield pumpage plus across the board increases in municipal pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the sustained yield with the recharge enhancement option.

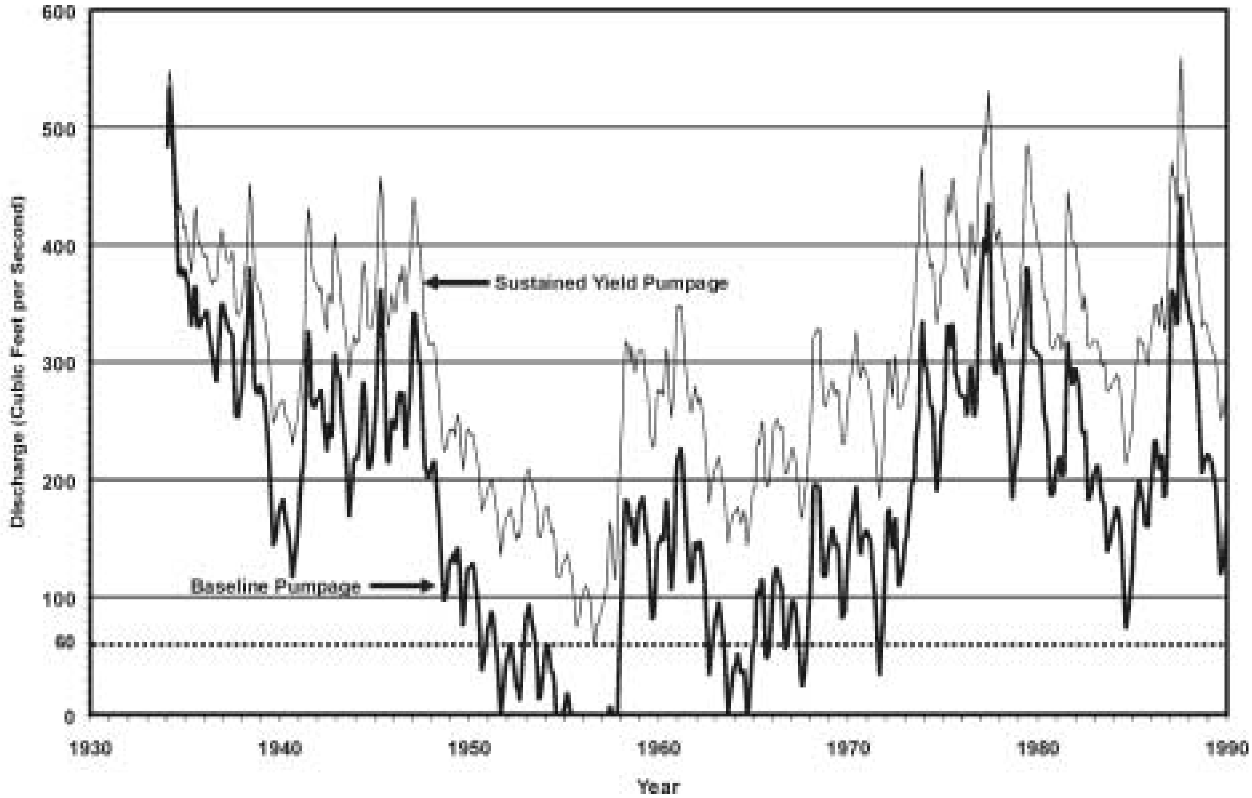

Figure C-4. Comal Springs Discharge Subject to Pumpage Scenarios

6. Calculate the amount of annual pumpage for a recharge recovery permit by subtracting the baseline sustained yield from the sustained yield with recharge enhancement.
7. Add the recharge recovery permit pumpage to the baseline pumpage.
8. Run GWSIM4 with the pumpage calculated in Step 7 and the combined baseline and enhanced recharge. Count the number of months when flow at Comal Springs is specified values of interest (200 cfs, 150 cfs, and 60 cfs) and when J-17 levels fall below specified values of interest (650, 642, 636, 632, and 628 ft-msl).
9. Compare the number of months below specified values of interest for the baseline pumpage simulation (Step 1) with the combined baseline and recharge recovery permit pumpage (Step 8).
10. Prepare a summary of the water balance in the Edwards Aquifer, with and without recharge enhancement, as shown in Figure C-5.

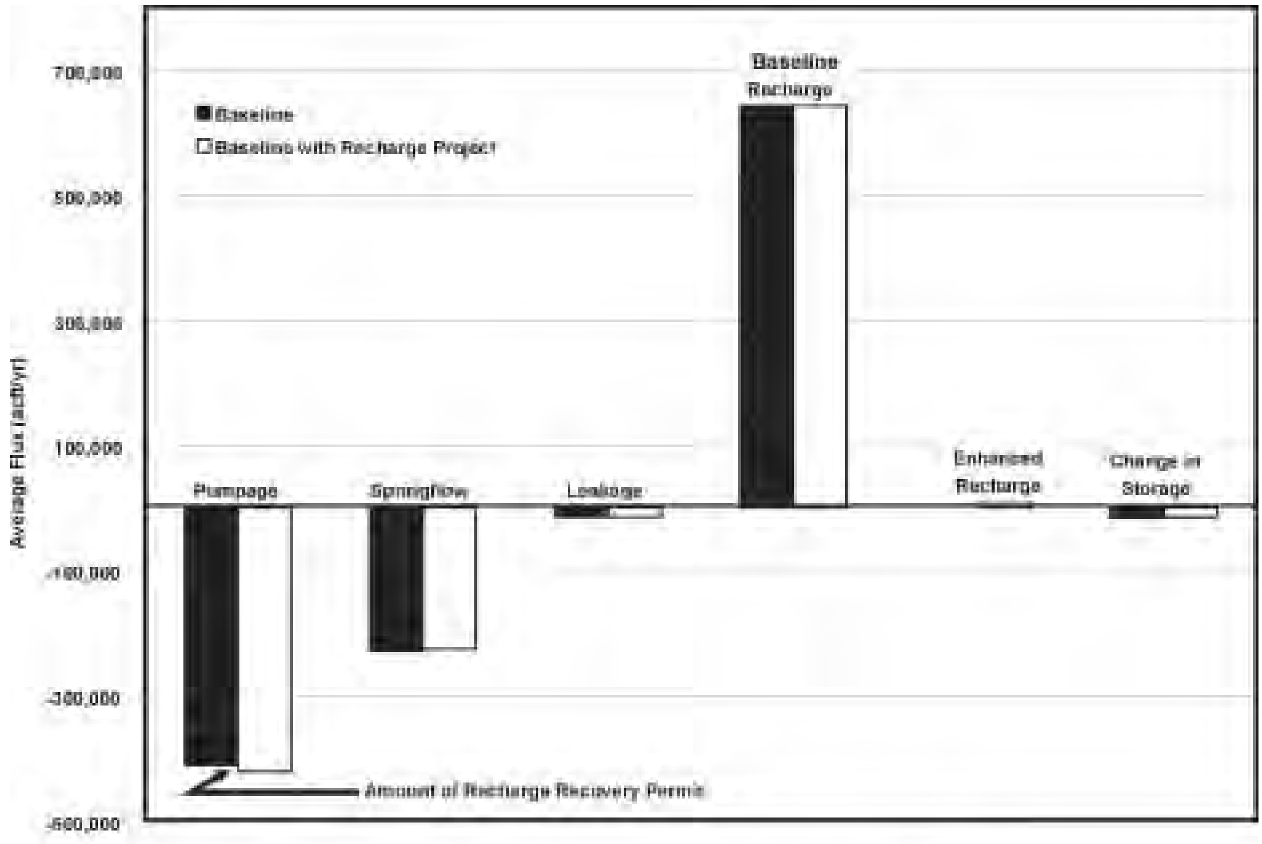

Figure C-5. Water Balance of the Edwards Aquifer (1934 - 1989)

Appendix D

Endangered Species by County

TABLE 1

THREATENED, ENDANGERED, AND RARE SPECIES OF ATASCOSA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T

TABLE 1 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF ATASCOSA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-May		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Atascosa County, 8/26/99.

TABLE 2				
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Black Spotted Newt	*Notophthalmus meridionalis*	Can be found in wet or sometimes wet areas, such as arroyos, canals, ditches, or even		T
		shallow depressions; aestivates in the ground during dry periods; Gulf Coastal Plain south of		
		the San Antonio River		
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal counties		T
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under		
		rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Government Canyon Cave Spider	*Neoleptoneta micops*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar	PE	
		County		
Madla's Cave Spider	*Cicurina madla*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar	PE	
		County		
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Small, eyeless harvestman; karst features in north and northwest Bexar County	PE	
Veni's Cave Spider	*Cicurina venii*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar	PE	
		County		
Vesper Cave Spider	*Cicurina vespera*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar	PE	
		County		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered;	DL	T
		potential migrant		
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with	LE	E
		open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to		
		same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees		
		provide insects for feeding; species composition less important than presence of adequate		
		broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer		
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark	LE	E
		strips, only available from mature trees, used in nest construction; nests placed in various trees		
		other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide		
		the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late		
		March-early summer		
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch		
		grasses occur along with vines and branches; a key component is bare ground for running/		
		walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts;	PT	
		primarily insectivorous		
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and		T
		saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on		
		floating mats		
Whooping Crane	*Grus americana*	Potential migrant	LE	E

TABLE 2 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water,		T
		including salt-water; usually roosts communally in tall snags, sometimes in association with		
		other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and		
		other wetlands, even those associated with forested areas; formerly nested in Texas, but no		
		breeding records since 1960		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country,		T
		often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of		
		desert mountains; nests in various habitats and sites, ranging from small trees in lower desert,		
		giant cottonwoods in riparian areas, to mature conifers in high mountain regions		
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T
Widemouth Blindcat	*Satan eurystomus*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T
A Ground Beetle	*Rhadine exilis*	Small, essentially eyeless ground beetle; karst features in north and northeast Bexar County	PE	
A Ground Beetle	*Rhadine infernalis*	Small, essentially eyeless ground beetle; karst features in north and northeast Bexar County	PE	
Helotes Mold Beetle	*Batrisodes venyivi*	Small, eyeless mold beetle; karst features in north and northwest Bexar County	PE	
Maculated Manfrede Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most		
		skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head		
		and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon		
		made of leaves fastened together with silk		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges,		
		and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to		
		thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave		
		of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands;prefers		
		wooded, brushy areas and tallgrass prairie		
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; only known from two wells penetrating the Edwards Aquifer		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate	C1	
		flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a		
		silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially		
		within ca. 30 feet of water's edge		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral		T
		woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and		
		Irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such		
		As rodent burrows, for shelter		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small		
		invertebrates; eggs laid underground March-September (most May-August)		

TABLE 2 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Correll's false dragon-head	*Physotegia correllii*	Wet soils including roadside ditches and irrigation channels; flowering June-July		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-May		
Glass Mountain coral root	*Hexalectris nitida*	Mostly in mesic woodlands in canyons, but also in various lower elevations farther east; usually under oaks; flowering July-August		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas, flowering spring-summer		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		
South Texas rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on very shallow sandy to clayey soil over calcareous rock outcrops and caliche hills; flowering in spring		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Bexar County, 8/26/99.

TABLE 3

THREATENED, ENDANGERED, AND RARE SPECIES OF CALDWELL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	LT-PDL	T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T

TABLE 3 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF CALDWELL COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak		
		woodlands; flowering April-May		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations,		
		including disturbed areas; flowering late spring-fall		
LE, LT - Federally Listed Endangered/Threatened				
PE, PT - Federally Proposed Endangered/Threatened				
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance				
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened				
DL, PDL - Federally Delisted/Proposed Delisted				
E, T - State Endangered/Threatened				
"blank" - Rare, but with no regulatory listing status				
Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.				
Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Caldwell County, 8/26/99.				

TABLE 4

THREATENED, ENDANGERED, AND RARE SPECIES OF CALHOUN COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Snowy Plover	*Charadrius alexandrinus*	Gulf coastal beaches in Texas, avoids thick vegetation and narrow beaches; found worldwide		
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	LT	T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered;	DL	T
		potential migrant		
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near	LT-PDL	T
		water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food		
		from other birds		
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water,		T
		including salt-water; usually roosts communally in tall snags, sometimes in association with		
		other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and		
		other wetlands, even those associated with forested areas; formerly nested in Texas, but no		
		breeding records since 1960		
Eskimo Curlew	*Numenius borealis*	Coastal fields	LE	E
Brown Pelican	*Pelecanus occidentalis*	Gulf, salt bays and coastal areas	LE	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and		T
		saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on		
		floating mats		
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Sooty Tern	*Sterna fuscata*	Coastal wetland islands		T
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	LE	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in	LE	E
		March and August		
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	LT	E
Scarlet Snake	*Cemophora coccinea*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-		T
		September		
Green Sea Turtle	*Chelonia mydas*	Gulf coast, bay waters and beaches	LT	T
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Gulf coast, bay waters and beaches	LE	E
Kemp's RidleySea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	LE	E
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		

TABLE 4 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF CALHOUN COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered		T
		brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters		
		rodent burrows, or hides under rocks when inactive; breeds March-September		
LE, LT - Federally Listed Endangered/Threatened				
PE, PT - Federally Proposed Endangered/Threatened				
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance				
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened				
DL, PDL - Federally Delisted/Proposed Delisted				
E, T - State Endangered/Threatened				
"blank" - Rare, but with no regulatory listing status				
Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.				
Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Calhoun County, 4/24/98.				

TABLE 5

THREATENED, ENDANGERED, AND RARE SPECIES OF COMAL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cascade Cavern Salamander	*Eurycea latitans*	Endemic; subaquatic; springs and caves in Comal, Kendall, and Kerr Counties		T
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal		T
Comal Springs Salamander	Eurycea sp. 8	Counties Endemic; Comal Springs		
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides		
		under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed	DL	T
		Endangered;potential migrant		
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer	LE	E
		with open, grassy spaces; requires foliage reaching to ground level for nesting cover;		
		Return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs		
		& trees provide insects for feeding; species composition less important than presence of		
		adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid		
Golden-cheeked Warbler	*Dendroica chrysoparia*	April-late summer Juniper-oak woodlands; dependent on Ashe juniper (also known as	LE	E
		cedar) for long fine bark strips, only available from mature trees, used in nest construction;		
		nests placed in various trees other than the Ashe juniper; only a few mature junipers or		
		nearby cedar brakes can provide the necessary nest material; forage for insects in broad-		
		leaved trees & shrubs; nests late March-early summer		
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of		
		bunch grasses occur along with vines and branches; a key component is bare ground for r		
		running/walking; likely to occur, but few records within this county		
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain		T
		country, often near watercourses, and wooded canyons and tree-lined rivers along		
		middle-slopes of desert mountains; nests in various habitats and sites, ranging from small		
		trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		
Peck's Cave Amphipod	*Stygobromus pecki*	Small, aquatic crustacean; lives underground in the Edwards Aquifer; collected at Comal	LE	
		Springs and Hueco Springs		
Fountain Darter	*Etheostoma fonticola*	Known only from the San Marcos and Comal Rivers; springs and spring-fed streams in		T
		dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding		
		mostly diurnal; spawns year-round with August and late winter to early spring peaks		
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on	LE	
		stream bottoms or along shores; adults may leave the stream and fly about, especially at		
		night; most dryopid larvae are vermiform and line soil or decaying wood		
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	LE	
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from an artesian well in Hays County		

TABLE 5 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF COMAL COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under		
		bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in		
		clusters of up to thousands of individuals; hibernates in limestone caves of Edwards		
		Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands;		
		Prefer wooded, brushy areas and tallgrass prairie		
Horseshoe Liptooth	*Polygyra hippocrepis*	Terrestrial snail known only from the steep, wooded hillsides of Landa Park in New Braunfels		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to	C1	
		moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow		
		Rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and		
		Pools and especially within ca. 30 feet of water's edge		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly		
		pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily		
		restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus,		T
		scattered o scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil,		
		enters rodent burrows, or hides under rocks when inactive; breeds March-September		
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-		
		oak woodlands; flowering April-May		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons,		
		usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May,		
		Fruit maturing in September		
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands		
		associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-		
		May, fruit persisting until midsummer		
Lindheimer's tickseed	*Desmodium lindheimeri*	Known in Texas only from a specimen collected in 1850 by Ferdinand Lindheimer from an		
		undetermined location presumed to by in Comal County; presumably flowering in mid-summer		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in		
		shade of mostly deciduous sloped forest; flowering April-May		

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DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Comal County, 10/5/99.

TABLE 6

THREATENED, ENDANGERED, AND RARE SPECIES OF DE WITT COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C1	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. DeWitt County, 3/23/98.

TABLE 7

THREATENED, ENDANGERED, AND RARE SPECIES OF DIMMIT COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
South Texas Siren	*Siren sp 1*	Wet or temporally wet areas, arroyos, canals, ditches and shallow depressions; requires moisture		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and Irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Dimmit Sunflower	*Helianthess praecos spp. Hirtus*	Known only to sands in Dimmit County, Rio Grande Plains		

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C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Dimmit County, 4/22/98.

TABLE 8				
THREATENED, ENDANGERED, AND RARE SPECIES OF FRIO COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered;	DL	T
		potential migrant		
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch		
		grasses occur along with vines and branches; a key component is bare ground for running/		
		walking; likely to occur, but few records within this county		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country,		T
		often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of		
		desert mountains; nests in various habitats and sites, ranging from small trees in lower desert,		
		giant cottonwoods in riparian areas, to mature conifers in high mountain regions		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges,		
		and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to		
		thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave		
		of Panhandle during winter; opportunistic insectivore		
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface		
		layers with loam extending to as deep as two meters		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in	LE	E
		March and August		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds	LE	E
		and raises young June-November		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers		
		wooded, brushy areas and tallgrass prairie		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands		T
		of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated		
		croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent		
		burrows, for shelter		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small		
		invertebrates; eggs laid underground March-September (most May-August)		
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain		T
		of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or		
		isolated rock outcrops among scattered clumps of prickly pear and mesquite		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly		
		pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily		
		restricted to them; hibernates underground or in or under surface cover; breeds March-August		

TABLE 8 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF FRIO COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered		T
		brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters		
		rodent burrows, or hides under rocks when inactive; breeds March-September		
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided;		T
		when inactive occupies shallow depressions at base of bush or cactus, sometimes in		
		underground burrows or under objects; longevity greater than 50 years; active March-		
		November; breeds April-November		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations,		
		including disturbed areas; flowering late spring-fall		
LE, LT - Federally Listed Endangered/Threatened				
PE, PT - Federally Proposed Endangered/Threatened				
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance				
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened				
DL, PDL - Federally Delisted/Proposed Delisted				
E, T - State Endangered/Threatened				
"blank" - Rare, but with no regulatory listing status				
Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.				
Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Frio County, 8/26/99.				

TABLE 9

THREATENED, ENDANGERED, AND RARE SPECIES OF GOLIAD COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	LT-PDL	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	LE	E
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Goliad County, 4/27/98.

TABLE 10

THREATENED, ENDANGERED, AND RARE SPECIES OF GONZALES COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C1	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Gonzales County, 3/24/98.

TABLE 11

THREATENED, ENDANGERED, AND RARE SPECIES OF GUADALUPE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Guadalupe County, 3/24/98.

TABLE 12

THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Blanco Blind Salamander	*Eurycea robusta*	Troglobitic; water-filled subterranean caverns; may inhabit deep levels of the Balcones aquifer to the north and east of the Blanco River		T
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; springs and caves in the Blanco River drainage in Blanco, Hays, and Kendall Counties		
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
San Marcos Salamander	*Eurycea nana*	Headwaters of the San Marcos River downstream to ca. 1/2 mile past IH-35; water over gravelly substrate characterized by dense mats of algae (*Lyng bya*) and aquatic moss (*Lyeptodictym riparium*), and water temperatures of 21-22C; diet includes amphipods, midge larvae, and aquatic snails	LT	T
Texas Blind Salamander	*Eurycea rathbuni*	Troglobitic; water-filled subterranean caverns along a six mile stretch of the San Marcos Spring Fault, in the vicinity of San Marcos; eats small invertebrates, including snails, copepods, amphipods, and shrimp	LE	E
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	LE	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	LE	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Texas Cave Shrimp	*Palaemonetes antrorum*	Subterranean sluggish streams and ponds		
Ezell's Cave Amphipod	*Stygobromus flagellatus*	Known only from artesian wells		
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		

TABLE 12 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Fountain Darter	*Etheostoma fonticola*	Known only from the San Marcos and Comal Rivers; springs and spring-fed streams in dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding mostly diurnal; spawns year-round with August and late winter to early spring peaks	LE	E
San Marcos Gambusia	*Gambusia georgei*	Endemic; formerly known from upper San Marcos River; restricted to shallow quiet, mud-bottomed shoreline areas without dense vegetation in thermally constant main channel	LE	E
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Very poorly known species with habitat description limited to "a spring"		
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from an artesian well in Hays County		
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	LE	
San Marcos Saddle-case Caddisfly	*Protoptila arca*	Known from an artesian well in Hays County; locally very abundant; swift, well-oxygenated warm water about 1-2 m deep; larvae and pupal cases abundant on rocks		
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night; most dryopid larvae are vermiform and line soil or decaying wood	LE	
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C1	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertabrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

TABLE 12 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Warnock's coral root	*Hexalectris warnockii*	Leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May, fruit maturing in September		
Texas wild-rice	*Zizania texana*	Perennial, emergent aquatic grass known only from the upper 2.5 km of the San Marcos River in Hays County	LE	E

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Hays County, 10/5/99.

TABLE 13

THREATENED, ENDANGERED, AND RARE SPECIES OF KARNES COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Maculated Manfrede Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Karnes County, 3/27/98.

TABLE 14				
THREATENED, ENDANGERED, AND RARE SPECIES OF KENDALL COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Cascade Cavern Salamander	Eurycea latitans	Endemic; subaquatic; springs and caves in Comal, Kendall, and Kerr Counties		T
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; springs and caves in the Blanco River drainage in Blanco, Hays, and Kendall Counties		
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal counties		T
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	LE	E
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	LT-PDL	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	LE	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C1	
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		

TABLE 14 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF KENDALL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Edge Falls Anemone	*Anemone edwardsiana var. petraea*	Shallow to moderately deep clays and clay loams over limestone in grasslands associated with plateau live oak, on rolling uplands		
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May, fruit maturing in September		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Kendall County, 4/21/98.

TABLE 15

THREATENED, ENDANGERED, AND RARE SPECIES OF LA SALLE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Silvery Wild Mercury	*Argythamnia argyraea*	South Texas Plains, perennial herb, also in Atascosa, Kinney, and Maverick Counties		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. La Salle County, 4/27/98.

TABLE 16

THREATENED, ENDANGERED, AND RARE SPECIES OF MEDINA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	Isolated, intermittent pools of a subterranean stream; sinkhole located in Medina County		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less importatn than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	LE	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; depedent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest contruction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	LE	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open decidious or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		

TABLE 16 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF MEDINA COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Medina County, 8/26/99.

TABLE 17

THREATENED, ENDANGERED, AND RARE SPECIES OF REFUGIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and		T
		marshes		
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions;		T
		aestivates underground during dry periods		
South Texas Siren	*Siren sp 1*	Wet or temporally wet areas, arroyos, canals, ditches and shallow depressions; requires		T
		moisture		
Mexican Treefrog	*Smilisca baudinii*	Rio Grande valley, vegetation in wet areas		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	LT	T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered;	DL	T
		potential migrant		
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near	LT-PDL	T
		water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food		
		from other birds		
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water,		T
		including salt-water; usually roosts communally in tall snags, sometimes in association with		
		other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and		
		other wetlands, even those associated with forested areas; formerly nested in Texas, but no		
		breeding records since 1960		
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	LE	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and		T
		saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on		
		floating mats		
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	LE	E
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds	LE	E
		and raises young June-November		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in	LE	E
		March and August		
Scarlet Snake	*Cemophora coccinea*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-		T
		September		

TABLE 17 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF REFUGIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned		T
		farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands		T
		of south Texas, in particular dense riparian corridors; can do well in suburban irrigated		
		croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent		
		burrows, for shelter		
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided;		T
		when inactive occupies shallow depressions at base of bush or cactus, sometimes in		
		underground burrows or under objects; longevity greater than 50 years; active March-		
		November; breeds April-November		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly		
		pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small		
		invertebrates; eggs laid underground March-September (most May-August)		
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf Coast shoreline		
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered		T
		brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters		
		rodent burrows, or hides under rocks when inactive; breeds March-September		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-		
		May		
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants; also		
		roadsides, with coastal prairie endemics is slightly saline soils in bare areas around pimple		
		mounds		
Black Lace Cactus	*Echinocerus reichenbachii var albertii*	Brushy, grassy areas with huisache, mesquite, blackbrush, retama, shrubs; South Texas Plains	LE	E
Plains Gumweed	*Grindelia oolepis*	Tight black clay-gumbo soils in coastal part of Rio Grande Plains		
Welder Machaeranthera	*Machaeranthera heterocarpa*	Shrub invaded grasslands; grows on mostly clayey to silty soils over Beaumont-Lissie		
		Formations		

LE, LT - Federally Listed Endangered/Threatened

PE, PT - Federally Proposed Endangered/Threatened

E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance

C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened

DL, PDL - Federally Delisted/Proposed Delisted

E, T - State Endangered/Threatened

"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Refugio County, 3/27/98.

TABLE 18				
THREATENED, ENDANGERED, AND RARE SPECIES OF UVALDE COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Edwards Plateau Spring	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides		
Salamanders		under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain		T
		county, often near watercourses, and wooded canyons and tree-lined rivers along		
		middle-slopes of desert mountains; nests in various habitats and sites, ranging from		
		small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine	LE	E
		bark strips, only available from mature trees, used in nest construction; nests placed in		
		various trees other than the Ashe juniper; only a few mature junipers or nearby cedar		
		brakes can provide the necessary nest material; forage for insects in broad-leaved		
		trees & shrubs, nests late March-early summer		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed	DL	T
		Endangered, potential migrant		
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow		T
		standing water, including salt-water; usually roosts communally in tall snags,		
		sometimes in association with other wading birds; breeds in Mexico and birds move		
		into Gulf States in search of mud flats and other wetlands, even those associated with		
		forested areas; formerly nested in Texas, but no breeding records since 1960		
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer	LE	E
		with open, grassy spaces; requires foliage reaching to ground level for nesting cover;		
		return to same territory, or one nearby, year after year; deciduous & broad-leaved		
		shrubs & trees provide insects for feeding; species composition less important than		
		presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer		
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually		T
		consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults		
		winter in deep pools and move upstream in spring to spawn on riffles		
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Very poorly known species with habitat description limited to "a spring"		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds	LE	E
		and raises young June-November		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in	LE	E
		March and August		
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface		
		layers with loam extending to as deep as two meters		

TABLE 18 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF UVALDE COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
White-nosed Coati	*Nasua narica*	Arid open plains; Rio Grande plains in woodlands		T
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March- November; breeds April-November		T
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Tobusch Fishook Cactus	*Ancistrocactus tobuschii*	Gravel terraces along drainages, limestone ledges, ridges, and rocky hills in openings of live oak-juniper woodland	LE	E
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Sabinal Prairie Clover	*Dalea sabinalis*	Edwards Plateau, isolated local		
Sonora Fleabane	*Erigeron mimegletes*	Grasslands in shallow clay soils over limestone, possibly more frequent in areas poorly drained during spring		
Texas Grease Bush	*Forsellesia texensis*	Dry limestone ledges and chalk bluffs above Nueces River; isolated		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		

LE, LT - Federally Listed Endangered/Threatened
PE, PT - Federally Proposed Endangered/Threatened
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened
DL, PDL - Federally Delisted/Proposed Delisted
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Uvalde County, 4/30/98.

TABLE 19

THREATENED, ENDANGERED, AND RARE SPECIES OF VICTORIA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	LT-PDL	T
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Eskimo Curlew	*Numenius borealis*	Coastal fields	LE	E
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	LE	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	LE	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	LE	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	LE	E
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf Coast shoreline		
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		

TABLE 19 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF VICTORIA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Welder Machaeranthera	*Machaeranthera heterocarpa*	Shrub invaded grasslands; grows on mostly clayey to silty soils over Beaumont-Lissie Formations		

LE, LT - Federally Listed Endangered/Threatened

PE, PT - Federally Proposed Endangered/Threatened

E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance

C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened

DL, PDL - Federally Delisted/Proposed Delisted

E, T - State Endangered/Threatened

"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Victoria County, 3/27/98.

TABLE 20

THREATENED, ENDANGERED, AND RARE SPECIES OF WILSON COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered; potential migrant	DL	T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Whooping Crane	*Grus americana*	Potential migrant	LE	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Maculated Manfrede Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	LE	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	LE	E
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

TABLE 20 (CONTINUED)				
THREATENED, ENDANGERED, AND RARE SPECIES OF WILSON COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided;		T
		when inactive occupies shallow depressions at base of bush or cactus, sometimes in		
		underground burrows or under objects; longevity greater than 50 years; active March-		
		November; breeds April-November		
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of		
		limestone canyons; flowering June-October		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-		
		May		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas;		
		flowering spring-summer		
LE, LT - Federally Listed Endangered/Threatened				
PE, PT - Federally Proposed Endangered/Threatened				
E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance				
C1 - Federal Candidate, Category 1; information supports proposing to list as endangered/threatened				
DL, PDL - Federally Delisted/Proposed Delisted				
E, T - State Endangered/Threatened				
"blank" - Rare, but with no regulatory listing status				
Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.				
Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Wilson County, 8/26/99.				

TABLE 21				
THREATENED, ENDANGERED, AND RARE SPECIES OF ZAVALA COUNTY				
			Federal	State
Common Name	Scientific Name	Habitat Preference	Status	Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas	DL	E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons as federal listed Endangered;	DL	T
		potential migrant		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country,		T
		often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of		
		desert mountains; nests in various habitats and sites, ranging from small trees in lower desert,		
		giant cottonwoods in riparian areas, to mature conifers in high mountain regions		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges,		
		and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to		
		thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave		
		of Panhandle during winter; opportunistic insectivore		
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface		
		layers with loam extending to as deep as two meters		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in	LE	E
		March and August		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds	LE	E
		and raises young June-November		
Yuma Myotis Bat	*Myotis yumanensis*	Desert regions; most commonly found in lowland habitats near open water, where forages;		
		roosts in caves, abandoned mine tunnels, and buildings; season of parts is May to early June;		
		usually only one young born to each female		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands		T
		of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated		
		croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent		
		burrows, for shelter		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small		
		invertebrates; eggs laid underground March-September (most May-August)		
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain		T
		of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or		
		isolated rock outcrops among scattered clumps of prickly pear and mesquite		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly		
		pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily		
		restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered		T
		brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters		
		rodent burrows, or hides under rocks when inactive; breeds March-September		

TABLE 21 (CONTINUED)

THREATENED, ENDANGERED, AND RARE SPECIES OF ZAVALA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

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Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Zavala County, 8/26/99.

Appendix E

Endangered Species Related to Edwards Aquifer

TABLE 1

EDWARDS AQUIFER DEPENDENT SPECIES AND KARST GEOLOGY ASSOCIATED SPECIES

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Blind Salamander	*Eurycea rathbuni*	Edwards Aquifer springs and caves, thermally stable; troglobitic	LE	E
Blanco Blind Salamander	*Eurycea robusta*	Blanco River; subterranean; gravel bed of Dry Blanco only occurrence; troglobitic		T
Comal Blind Salamander	*Eurycea tridentifera*	Honey Creek and limestone caves		T
Cascade Cavern Salamander	*Eurycea latitanus*	Cascade Caverns		T
San Marcos Salamander	*Eurycea nana*	San Marcos River and springs; under rocks and matted stream vegetation	LT	T
Fountain Darter	*Etheostoma fonticola*	San Marcos River to confluence with Blanco River; associated with San Marcos Salamander and San Marcos Gambusia	LE	E
San Marcos Gambusia	*Gambusia georgei*	San Marcos River to confluence with Blanco River, large clear spring fed river	LE	E
Widemouth Blindcat	*Satan eurystomus*	Edwards Aquifer; from artesian wells in Bexar Co.; troglobitic		T
Toothless Blindcat	*Trogloglanis pattersoni*	Edwards Aquifer; from artesian wells in Bexar Co.; troglobitic		T
Texas Cave Shrimp	*Palaemonetes antrorum*	Ezells's Cave and Edwards Aquifer subterranean caverns		
Robber Baron Cave Harvestman	*Texalla cokendolpheri*	Karst features in north and northwest Bexar County	PE	
Helotes Mold Beetle	*Bartrisodes venyivi*	Karst features in north and northwest Bexar County	PE	
A Ground Beetle	*Rhadine exillis*	Karst features in north and northwest Bexar County	PE	
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	PE	
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal Springs	LE	
Comal Springs Dryopid Beetle	*Stigoparnus comalensis*	Comal Springs	LE	
Ezell's Cave Amphipod	*Stigobromus flagellatus*	Ezells's Cave and Edwards Aquifer subterranean caverns		
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Honey Creek		
Peck's Cave Amphipod	*Stygobromus pecki*	Comal Springs	LE	
San Marcos Saddle-case Caddisfly	*Protoptila arca*	San Marcos River		
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Edwards Aquifer subterranean caverns		
Texas Wildrice	*Zizania texana*	San Marcos River to confluence with Blanco River	LE	E

LE, LT - Federally Listed Endangered/Threatened

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E/SA, T/SA - Federally Endangered/Threatened by Similarity of Appearance

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