TRANS-TEXAS WATER PROGRAM

Corpus Christi Study Area

Phase II Report

Volume 3- Appendix

City of Corpus Christi

Port of Corpus Christi Authority

Corpus Christi Board of Trade

Texas Water Development Board

Lavaca-Navidad River Authority

September, 1995

HDR

HDR Engineering, Inc.
in association with
Naismith Engineering, Inc.
Paul Price Associates, Inc.

TRANS-TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA

PHASE II
REPORT

VOLUME 3

APPENDIX REPORT

Prepared For
City of Corpus Christi
Port of Corpus Christi Authority
Corpus Christi Board of Trade
Texas Water Development Board
Lavaca-Navidad River Authority

by
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Corpus Christi Service Area
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APPENDIX A

Previous Studies on Water Supply in South Central Texas

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Previous Studies on Water Supply in South-Central Texas

1. Bureau of Reclamation, "Nueces River Basin: A Special Report for the Texas Basins Project," U.S. Dept. of the Interior, December, 83.

This report updated and reanalyzed the potential for economically developable water sources in the Nueces Basin. As an appraisal of potential development projects, this report does not contain detailed design or cost information. The report does contain a sizable (in number and time) bibliography.

The report took a comprehensive look at the Basin's problems and needs, from social inequities to water related considerations and from recreational issues to environmental quality, to develop a picture of the water situation. Tables and figures accompany each specific area of discussion with projections to the year 2030 where appropriate.

A listing and discussion of present resource capacities from the Nueces Basin was followed by an in-depth evaluation of alternative concepts for development. The Resource Capacity chapter was divided by type of resource, then area of location, whereas the Alternative Concept chapter was divided by location, then type of resource. Each chapter included specific data on each resource or alternative. These alternatives included: Cotulla Dam and Reservoir; Cotulla Diversion Dam and Canal; Zavala Dam and Reservoir; Caimanche Dam and Reservoir; Goliad Dam, Reservoir, and Conveyance System; and R/O Desalting.

The environmental factors and topics in the basin were identified, with particular interest given to river bank and estuary habitats as well as those alternatives which directly affect Corpus Christi.

This report provided an excellent reference for data associated with alternative water resource development strategies. The report concluded that surface water development above Lake Corpus Christi was not feasible, and the importation of water from the Guadalupe and San Antonio River Basins was the best option.

2. **Bureau of Reclamation, "Nueces River Project, Texas: Feasibility Report, July 1971," U.S. Dept of the Interior, July 1971.**

This report was an in-depth study of the proposed R&M Dam and Reservoir on the Nueces River just downstream from Lake Corpus Christi. The R&M Reservoir was designed to provide M&I water for the 10-county Coastal Bend area, as well as recreation and sport fishing.

The report reviewed the general geography, previous studies, and problems and needs of the study area before defining its development plan. The development plan included discussion of design, schedule and cost of construction, O&M costs, and project organization. The report then discussed the resulting water supply issues and the associated social and economic effects of the project. A benefit-cost analysis was included in the report, as is an environmental effects analysis.

The water supply section reviewed stream flow data from 1914-18 and 1941-67 to help approximate the effects of the R&M Reservoir on water supply to the Lower Nueces and Coastal Bend region. This approximation included the estimated inflows, losses, spills, sedimentation, storage, and yields of the reservoir.

A sense of necessity and expediency, in light of projected water shortage in the Coastal Bend region, added to the report's recommendation to build the Dam. Unmitigateable losses of freshwater inflows to the estuary were seen as an undesirable, but not a deciding, factor.

3. **Bureau of Reclamation, "Texas Basins Project," Vol.s I & II. U.S. Department of the Interior, Amarillo, TX, February 1965.**

The first comprehensive study on interbasin water transfers in Texas, The Texas Basins Project recommended the development of a 418-mile interbasin canal from the Sabine River to the Lower Rio Grande Valley. This recommendation included the construction of 18 major reservoirs, three regulating reservoirs, distribution and drainage facilities for 785,500 acres of new irrigation in six units, and recreation facilities at the reservoirs and along the interbasin canal. Flood control capacity was included in plans for seven reservoirs.

The proposed reservoirs were divided into two groups. The first group comprised the interbasin portion of the project. The second group was designed to provide water to the basins in which they were located. The following is a list of the two groups of projects and their costs in January 1962 dollars.

Group 1 works:

Interbasin Canal	$418,650,000
Baffin Bay Regulatory Reservoir	8,141,000
Sinton Regulating Reservoir	8,932,000
Valley Regulating Reservoir	8,391,000
Confluence Reservoir	63,261,000
Goliad Reservoir	46,888,000
Liberty Reservoir	52,000,000
Ponta Reservoir	27,900,000
Sabine Diversion Reservoir	23,633,000
Tenaha Reservoir	22,336,000
Voth Reservoir	36,755,000
Baffin Bay Unit	50,048,000
Lower Rio Grande Valley Unit	108,488,000
Sinton Unit	36,941,000
Recreation facilities	10,290,000
Subtotal	$922,654,000

Group Two Works:

Caimanche Reservoir	$13,253,000
Choke Canyon Reservoir	22,703,000
Cibolo Reservoir	20,581,000
Cotulla Reservoir	21,063,000
Cuero Reservoir (Stage 2)	44,807,000
Fowlerton Reservoir	15,844,000
Garcitas Reservoir	20,462,000
La Grange Reservoir	50,571,000
Lockhart Reservoir	6,974,000
San Saba Reservoir	26,262,000
Zavala Reservoir	21,804,000
Cotulla Unit	4,953,000
Fowlerton Unit	4,794,000
San Saba Unit	6,187,000
Recreation facilities	2,602,000
Subtotal	$282,860,000
Total construction costs	$1,205,514,000

The Texas Basins Project was a detailed study of Texas' geography, population, business, agriculture, municipal growth, water demands and the water supply projects listed above. The information in the report was organized into the respective river basins included in the study while maintaining the regional view necessary for the interbasin transfer of water.

The 1965 Bureau report laid the groundwork for surface water development in Texas. Whether or not the projects designed and analyzed in the report were considered, the information contained in this report was referenced; i.e.; the Texas Basins Project report is the "Mother of All Water Plans" for Texas. Each of the Group One and Two projects has been addressed individually and in several other reports since 1965. Several of the Reservoirs have been approved and built while others have been found to be infeasible in subsequent studies.

4. Bureau of Reclamation, Texas Water Development Board, and the Lavaca-Navidad River Authority, "Palmetto Bend Project: Contractual Documents, includes 1976 Amendments," 1976.

This document was a compilation of legal resolutions and contracts concerning the responsibilities for the Palmetto Bend Project between the TWDB and the LNRA. The document included costs, allocations, responsibilities, amendments, changes, resolutions, repayment schedules, and financing strategies.

5. Bureau of Reclamation, "Palmetto Bend Project (Stage 1), Texas: Definite Plan Report," U.S. Dept. of the Interior, Sept 1971, Revised April, 1972.

As a specification of the final plans for constructing Palmetto Bend Dam and Reservoir Stage 1, this report was a culmination of previous reports. These reports included, but were not limited to, the original Palmetto Bend Project - 1963, House Document No. 279, and Reevaluation Statements from 1964 and 1967.

The report included material on general background, plan development, water supply, economic and financial analysis, and environmental analyses. Corrections to previously published data included figures for reservoir area, capacity, and sediment capacity which were all initially overestimated. Dependable yield estimates from 1963 were verified by interim data (i.e., rainfall from 1961 through 1968 were higher than previous drought of record).

The decision to build the Palmetto Bend Dam and Reservoir Stage 1 had been made prior to the issuance of this report.

6. Bureau of Reclamation, "Summary of Special Report, San Antonio-Guadalupe River Basins Study: Texas Basins Project," U.S. Dept. of the Interior, Amarillo, TX, November, 1978.

This report evaluated four proposed water management, or development, alternatives for the study area with emphasis on meeting demands and quantifying impacts. The report began with a description of the basins' geography, including water resources and human population data. These data were followed by a discussion of the area's problems and needs. The four water management/development alternatives proposed to address these issues were: 1) No Additional Development; 2) Minimum Additional Development; 3) Full Surface Water Development; 4) and Full Surface Water Development with Environmental Emphasis.

The environmental impacts were listed and contrasted for each alternative, taking into account the natural, archeological, recreational, and social considerations of the study area. A brief listing of these impacts by Plan was as follows:

Plan A - Lower groundwater levels would curtail flows from the major springs in the basin. This, in turn, would drastically decrease flows in the Guadalupe River, since 75% of the river's flow is due to spring discharges. Two plant species would also be endangered by reduction or cessation in flow at these springs.

Plan B - Similar to Plans C and D; however, due to the allowed over-development of the Edward's Aquifer under this plan, environmental effects take on the same characteristics as Plan A.

Plans C and D - Loss of some habitat area to inundation, modification of habitat due to new reservoirs, gain in aquatic reservoir habitat, improvement of wildlife habitat on certain lands, transfer of habitat from private to public ownership. Plans C and D also result in a large decrease of inflows to the San Antonio Bay Estuary system, with Plan C providing zero flow and Plan D providing 150,000 acre-feet from an historical flow of 1,970,000 acre-feet and a recommended minimum of 1,300,000 acre-feet.

Detailed maps were included for each alternative, which gave proposed and existing reservoir locations and capacities. There were also maps which showed historic and projected flows at various locations in the study area.

The report concluded that Plans C and D were preferred due to their ability to meet water supply demands and protect the Edward's Aquifer from overdevelopment, among other shared beneficial characteristics. The differences between Plans C & D were Plan D's better environmental features and its 25% higher cost.

7. **City of San Antonio and the Edwards Underground Water District, "San Antonio Regional Water Resource Study: Summary," April, 1986.**

This report evaluated the ability of the Edward's Aquifer to provide water to its five-county region through the year 2040. Past, present, and projected water supply and demand situations were discussed to show the need for alternatives to aquifer dependency. Population estimates, water use quantities, with quantity by type of use, and from each source were used to support this premise.

Three alternatives were presented, defined, and discussed: 1) Construct reservoirs where needed and possible; 2) Revise laws and institutions; and 3) Combine I & II.

Discussion included decision strategies and cost recovery plans (not necessarily feasible options). The reservoirs considered include: Cloptin Crossing, Goliad, Cibolo, Applewhite, Cuero, and Lindenau. Proposed filter plants include: San Marcos, New Braunfels, and South San Antonio.

Each of the options presented in the three alternatives can be considered individually or in groups, depending on budget or other limiting factors. Alternative three provides the best yields, but at the highest cost.

8. **City Water Board, San Antonio, TX, "Discussion of Surface Water Alternatives for the City Council," August 10, 1977.** *(Note: This report is primarily based on the Texas Basins Project report reviewed above as article 6.)*

This report evaluated four alternative plans for surface water supply to San Antonio using Canyon, Clopton Crossing, Cuero I, Cuero II, Applewhite, Cibolo, and Mason Reservoirs and the Guadalupe and San Antonio Rivers for supply sources.

After a review of population and water use projection methods and values, the report reviewed different plans by the Bureau of Reclamation for the area. It was determined that Plan C (from study no. 6 above) would be used as a guideline to develop four more alternatives. These four alternatives were designed by scheduling the use or development of the different water sources above in varying sequences. However, Plan C only considers Applewhite, Cibolo, Canyon, and Cuero I reservoirs in detail, having eliminated the other three through preliminary review. The other three plans are covered above in study no. 6.

Each plan ran similarly high capital costs due to the large physical structures. However, due to the scheduling of the projects, costs varied across the four alternatives. Plan 4 appeared to have the lowest cost through the year 2020.

9. Edwards Underground Water District Technical Review Panel, "Report of the Technical Data Review Panel on the Water Resources of the South Central Texas Region," organized and funded by the Edwards Underground Water District, November, 1992.

This report was a very detailed literature review which created a forum by assembling those communities, agencies, and organizations which relied on and were affected by decisions made about the Edwards Aquifer. The review panel drafting this report was comprised of the technical representatives of each of the above-mentioned communities, agencies, and organizations. The goal behind the establishment of this forum was the unbiased review and communication from the relevant participants about the availability, reliability, accuracy, and limitations of existing water quality, use, and supply data. The information derived from this review and report, as well as the resultant process, are envisioned as future area planning, policy, or decision-making tools.

However, this report focused strictly on the technical potential and does not address policy questions, nor does it make qualitative decisions about specific proposed projects. The study area included the Nueces River Basin through the Lavaca-Navidad River Basin, as well as the adjacent coastal basins. The report presented water demands and needs, sources of water supply, reductions and use of supplies, natural recharge, and water quality, and includes a section on suggestions for further technical study. At the end of each topic and subtopic, there was a panel discussion and conclusion section. These consisted mainly of comments about the method of data collection and a determination as to which agency's numbers were more acceptable.

The water demands and needs section of this report included data from the USGS, TWDB, and the TWC on historic groundwater pumping, historic surface water diversions, population and water use projections, and water needs for natural systems. The panel felt that the USGS data were most accurate and raised questions about the possibility of a consistent data gathering method. There were 112 pages of tables and figures for this section alone. The tables included data on groundwater pumpage by county, specific use, and source of water per aquifer. In addition, projections of municipal, and agricultural use by county and general supply source were given. There were several tables showing data from the different agencies "back to back" for easier comparison.

The supply source section of this report was divided into potential sources, i.e., surface water, water reuse, groundwater storage and recovery, recharge, and desalination. Data on costs were also included at the end. This section relied on 23 technical studies for its data. As of April 1, 1993, the current literature review included 10 of these 23 studies. Of the 13 not included, 11 were prepared by private consulting firms and may be difficult to obtain. The existing surface water sites included in the report were: Canyon Lake, Medina Lake, Lake Corpus Christi, Choke Canyon Reservoir, Lake Texana, Upper Guadalupe Reservoir, Coleto Creek Reservoir, Calaveras Lake, and Victor Braunig Lake. The potential undeveloped reservoir projects are: Cloptin Crossing, Cuero I, Cuero I and Lindenau (combined), Cibolo, Simmons, Indian Creek, R&M Dam and Reservoir, Cotulla Diversion Dam, Lake Texana-Palmetto Bend Stage 2 (combined), Lockhart, Lindenau (Cuero II), Applewhite, Goliad, Harris, Bluntzer, Cotulla Reservoir, and Palmetto Bend Stage 2.

The information provided for each project included firm yields for different operating scenarios as a major focus. The data were presented first by Basin, second by project, and third by report.

The existing water reuse projects included in the report are as follows:

- Southwest Texas State University - Gray water reuse system
- City of Uvalde - Wastewater reuse for golf course and park
- Kelly AFB - Wastewater reuse for golf course
- Cibolo Creek Mun. Auth. - Wastewater reuse for golf course, Randolph AFB
- Cibolo Creek Mun. Auth. - Wastewater reuse for golf course, Selma
- San Antonio River Authority - Recycling through flood control tunnel for San Antonio River and Rivercenter Mall.

The report stated that no underground storage and recovery projects were operating in the study area. However, four recharge reservoirs exist in Medina County: San Geronimo Creek, Verde Creek, Parker Creek, and Seco Creek. The total recharge from the four facilities averaged 5,000 acre-feet per year.

The existing recharge structures included: Dry Comal Creek, York Creek, and the Upper San Marcos watershed (these structures control 1/6th of the runoff in the San Antonio and Guadalupe River basins). The potential undeveloped recharge facilities consisted of the structures discussed in the HDR report "Regional Water Supply Planning Study Phase III Recharge Enhancement-Nueces River Basin."

Six desalination projects from the TWDB report included in the current review were listed in tabular form in this report (Table 3.6-1, pg 211). The process was seen as increasingly more feasible as cost for proven technologies are driven down and the cost of water supply options continues to rise.

Existing sources costs were found in Table 3.7-1, pg 167, with Canyon at $53.03/acre-foot of annual yield, Choke Canyon/Lake Corpus Christi at $34.52/acre-foot of annual yield, and Lake Texana at $45.00/acre-foot of annual yield (changing to $65.00 by year 2004). The price for Medina Lake water was $10.00 tax per acre irrigated plus $8.00 per acre-foot of water used for irrigation.

Tables 3.7-2 and 3.7-3 compared the potential undeveloped project costs; however, the report cautioned the reader in the use of the data for comparison due to the varying levels of detail and accuracy in the cost calculations used within the different reports.

Water reuse program costs included: (1) San Antonio multiphase reuse development estimated at $350 to $200/acre-foot with a target of 20,000 acre-feet per year reused by the year

2000; (2) Corpus Christi tertiary wastewater treatment (lime softening) for $635 to $215/acre-foot for 2,240 to 17,920 acre-feet per year, respectively; and (3) San Antonio wastewater treated and cycled through Calaveras and Braunig Lakes and treated to potable standards for $425 to $345/acre-foot for 48,000 to 84,000 acre-feet per year.

The underground storage and recovery system reported by CH2M Hill (1991) reported $464/acre-foot for 15,000 acre-feet per year in the Carrizo Aquifer in Atascosa County or $717/acre-foot for 15,000 acre-feet per year using wells for recharge. Both options obtain the source water from the Medina Lake irrigation system. The recharge facilities studied by HDR for the Edwards Aquifer range in cost from $145 to $4,434/acre-foot. However, the desalination study by Stone and Webster quotes a price range of $782 to $352/acre-foot for 1,120 to 22,400 acre-feet per year, respectively.

Tables 3.7-6 and 3.7-7 compared the costs for existing projects and potential projects, respectively (pg.s 170 - 171).

Two types of measures are defined within water use reduction: conservation measures and drought measures. Drought measures are the more stringent in terms of levels and enforcement. All information in this section is based on projections and target goals. There is no program listed which will provide meaningful data that would provide expected conservation savings applicable to the region.

The natural recharge section of this report provided comparisons between the methods of recharge calculation and results for the USGS, TWDB, and EUWD. The USGS method used Lowry (1955), Garza (1962-66), and Puente (1978), and estimated recharge to the Edwards Aquifer based on recharge to the Edwards Plateau Aquifer catchment area upstream of the Edwards Aquifer recharge area. The USGS believed that the range of accuracy for the estimates was from 20% to 50%.

Developed by HDR, the TWDB method used a modified Soil Conservation Service method to compute the estimated flow in the recharge area. Updated precipitation and drainage areas, as well as basin-by-basin accounting of soil cover complexes, topography, and land use characteristics were all used to calculate the recharge for the TWDB method. This was a more detailed method with a range of uncertainty of 15% to 20% for dry years and 25% for wet years.

Developed by Espey, Huston, the EUWD method developed elevation versus monthly recharge volume curves for the Medina Lake and Diversion Lake similar to Lowry (1953). However, the recharge rates estimated by Espey, Huston were significantly lower than Lowry. The difference between the two methods was in Espey, Huston's use of historic data for Medina Lake and the Diversion Lake while USGS did not use these data. In both cases, the USGS estimates were higher than those of the TWDB and the EUWD.

The USGS and several other agencies test water quality in the Edwards Aquifer; however, the USGS has the most consistent and longest running records. Although there were more extensive tests run, these were only done for specific projects and have no predictability associated with their results. Table 6.1-2, pg 290, listed levels of tested water constituents for the years 1987 through 1990 with the associated maximum constituent level (MCL) established by the USEPA in compliance with PL 93-523. The only violations of the MCL occurred in 1987; selenium and silver were present in levels of 300 and 10 times to MCL limit, respectively (MCL limit for selenium = 0.01 mg/l and silver = 0.05 mg/l).

Four localized problems were mentioned:

- Taylor Slough, Uvalde, Texas. Tetrachloroethylene contaminated several private wells in a several square mile area, but no public wells were contaminated. A monitoring program is still in effect in the affected area.

- West Ave. Landfill, San Antonio, Texas. Volatile organic carbon migrated into the Edwards Aquifer from an out-of-use landfill, which has since been capped. The immediate surroundings have been contoured to minimize water infiltration, and leachate recovery wells were installed. No public or private wells were contaminated.

- Thousand Oaks Blvd. and Jones-Maltsberger Rd., San Antonio, Texas. Ten thousand gallons of gasoline leaked from an underground storage tank. "The most soluble components of gasoline have been found at low levels in the Edwards Aquifer in the vicinity. No public wells were affected. Some private well owners switched to public supplies."

- Recharge Zone. Bacteriological contamination of the water is prevalent in the recharge zone and to a lesser extent in the artesian zone. It is stated that chlorination of the public supplies will cure this problem where it exists.

The freshwater/saline-water interface was defined in this report as the line where the TDS equals 1,000 mg/l. The normal TDS of the Edwards Aquifer was reported as 250-300 mg/l. The concern was for the tendency of saline-water to intrude when freshwater levels were low. One test in the San Antonio freshwater region yielded water from the bottom of the aquifer with a TDS concentration of 4800 mg/l; however, this was not seen as an immediate problem since there was still a sizable transition zone. In New Braunfels and San Marcos, the saline water (greater than 1000 mg/l of dissolved solids) was found to be closer to the freshwater springs than had previous been thought. One case in San Marcos had determined there was no transition zone between the saline and fresh water with the saline water only 300 feet from the spring.

This report identified several technical areas requiring further study or improvement, as follows:

Water Demands and Needs

1. Regulate use of underground water for irrigation;
2. Attach underground water use rates to applications;
3. Regulate use of underground water for industry;
4. Measure all unreported underground water use for better management purposes;
5. Relative accuracies, either with measurements or estimations, should be noted with the data;
6. Record all underground water use by aquifer to help maintain better management;
7. Standardize water use reporting;
8. A call for studies on the needs of the natural systems; and
9. Define the boundaries of the Edwards Aquifer better, especially in the west near Brackettville and Uvalde.

Sources of Supply

1. Interbasin water sourcing as a solution;
2. Recharge enhancement;
3. Storage of freshwater in the saline zone of the Edwards Aquifer for later recovery;
4. Desalination potential should be explored more;
5. Better understanding of the Knippa Gap;
6. Environmental limitations of reservoirs for those proposed projects where the work has not yet been done;
7. Study the potential for controlling flow from the Springs; and
8. Water transfer from below the Springs back to San Antonio for municipal use or recharge.

Reductions in Use

1. Water market development among users of the Edwards Aquifer;
2. Conservation incentive development;

3. Better definition of the GPCD measure, especially if used extensively for regulatory purposes; and
4. Reduce seasonal demands.

Natural Recharge

1. Improve and standardize methods of calculating recharge.

10. Espey, Huston and Associates, Inc., "Water Availability Study for the Guadalupe and San Antonio River Basins," for San Antonio River Authority, Guadalupe-Blanco River Authority, and the City of San Antonio, Vol. 1 and Appendices, February, 1986.

This report identified and presented preliminary evaluations of six reservoir sites: Cuero I, Cuero II (Westhoff), Cuero II (Lindenau), Cibolo (Upper), Cibolo (Lower), and Goliad, for their surface water supply potential within the San Antonio and Guadalupe River Basins. A detailed analysis was applied to only four of the reservoirs due to preliminary yield and cost estimates. The pertinent factors considered in the evaluation include: permitting, environmental analysis, hydrology, hydraulic design, engineering, recreation, right-of-way requirements, costs, and system operating analysis.

To accomplish these evaluations, each of the factors listed above provided a focus for review of potential. Extensive attention was given to the environmental analyses (five chapters). A detailed "state-of-the-art" model of the combined Guadalupe and San Antonio Rivers was developed as the major tool for the study. The model was used for preliminary site selection and for in-depth analyses of firm yields and different operating strategies.

Water supply data were given for each proposed site individually and in combination with other sites. These combinations comprised five alternative scenarios which were reviewed for their effects on groundwater use, present and proposed reservoir utilization, return flow policy, and bay and estuary inflows. These scenarios included: "Future Baseline" Scenario; Single Reservoir Scenarios; Combination of Reservoirs Scenarios; Full Development Scenario; Subordination of Water Rights Scenarios; and a review of the CH2M-Hill Regional Water Resource Study performed for the City of San Antonio, which outlined four alternatives.

Upstream reservoirs, both existing and proposed, were reviewed for their effects on the reservoirs under study. Also considered were San Antonio's water demands and return flows as they affect the Guadalupe and San Antonio River Basins. No recommendations were made; however, the level of detail provided in the report would allow enough information to support decisions based on desired levels of outcomes.

11. Freese and Nichols, Inc., "Report on Availability of Additional Surface Water Supply from the Nueces River Between Uvalde and Three Rivers," for the Nueces River Authority, Dec 1982.

Commissioned by the Nueces River Authority, the report analyzed the extent of available surface water from the Balcones Fault zone to the confluence of the Nueces, Frio, and Atascosa Rivers. Given that the Choke Canyon Reservoir-Lake Corpus Christi (CCR-LCC) system accounted for 87% of the existing water rights in the Nueces Basin and that the system's firm yield only produces 50% of that volume, the idea that there was a developable water supply seemed plausible.

The report analyzed three projects in three subareas of the upstream reaches of the River Basin: (1) Indian Creek Reservoir - northwest of Uvalde; (2) Harris Reservoir - west of Cotulla; and (3) Simmons Reservoir - at Simmons. The three reservoirs were chosen for their geographic spread, and their storage capacities relative to other proposed projects in the respective areas of the basin. The estimated high storage capacities for the three reservoirs were reported to be: Indian Creek - 165,000 acre-feet, Harris - 400,000 acre-feet, and Simmons - 450,000 acre-feet.

The reservoirs were analyzed under different operating scenarios to determine the effect they would have on the overall surface water system in the basin. The different scenarios used included: (1) holding all inflow; (2) holding only water that would spill at Lake Corpus Christi; (3) operate as 3-part reservoir system with CC/LCC; and (4) operate with overdraft. Scenarios 1 and 2 were applied to all three reservoirs, while scenario 3 was used only for Harris and Indian Creek, and scenario 4 for Harris Creek only.

A major consideration throughout the report was the water losses through the "braided" section of the Nueces River. Using Robert L. Lowry's loss curves (1958) for that stretch of the river, there were typical water losses of 35% to 45%, on average. However, controlled releases were estimated to cut losses to approximately 20% by keeping the river within the main channel and not allowing it to spread out into the various braids where the stream losses were exacerbated.

The potential mitigation of stream loss drove the use of scenario 3 for the Harris and Indian Creek projects. That is, the reservoirs could be used to control the flow in the braided section by impounding any flood-induced excess flows, then releasing the water at rates consistent with the constraints of the main channel in the braided section. Simmons reservoir was not considered for this plan due to its location below the braided section and, therefore, its inability to affect the flow to that section.

Each of the reservoirs produced a substantial firm yield. However, in each case, there is a corresponding loss to the CC/LCC system resulting in total yields which do not justify the construction of the projects. The following table provides the highlights of the yields of the proposed reservoirs and their overall effect on the surface water system. (Note: Basin water rights are accounted for in the data provided in the following tabulation.)

Projects	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Indian Creek	13,300 AFA	--	13,300 AFA	--
w/CC/LCC	2,300 AFA	--	5,300 AFA	--
Harris	51,700 AFA	4,400 AFA	51,700 AFA	99,000 AFA
w/CC/LCC	9,700 AFA	--	18,000 AFA	65,000 AFA
Simmons	124,900 AFA	14,400 AFA	--	--
w/CC/LCC	4,900 AFA	--	--	--

It appears that operating the Harris Reservoir with an overdraft produces the highest yield. The success of this project depends upon: 1) A type of use that will be able to tolerate periodic shortages, and 2) There is a backup supply such as groundwater that can be utilized as needed.

The conclusions drawn on the availability of surface water development in the Nueces Basin in this report included:

1. Indian Creek and Simmons Reservoir sites did not seem likely to produce yields without substantially negative effects on the CC/LCC system yield.

2. Harris Reservoir operated in a three reservoir system with CC/LCC would produce a net gain of 18,000 acre-feet per year.

3. Harris Reservoir operated with an average overdraft of 10% would produce a net gain of 65,000 acre-feet per year.

4. Operating with an overdraft as small as 10% would still result in severe shortages in some years. The recommendation was to use this plan with irrigation since it does not require a totally dependable yield.

12. Freese, Nichols and Endress, "Inter-basin Transfer of Water: Comparison of Costs of Transportation," for the TWDB, April, 1966.

This report provided estimated construction and operating costs for various inter-basin transfer routes and capacities from Northeast Texas to Palmetto Bend Reservoir. Nine routes were identified, then subdivided and analyzed in manageable segments. The routes shown in bold in the table below represent transfers with the least cost impact on the South Central Texas study area.

From	To	Flow Capacities Analyzed (10^5 AFA)
Texoma Reservoir	Lock & Dam No. 20	1, 2
Texoma Reservoir	White Rock Creek	2, 6
Trinity River	Richland Reservoir	6, 12
Tehuacana Reservoir	Brazos River via Cottonwood Creek	6, 16, 28, 40
Tehuacana Reservoir	Navasota River	6, 16, 28
Millikan Reservoir	Brazos River	6, 16, 28
Navasota River	Brazos River	6, 16, 28
Brazos River	**Colorado River at Altair**	**6, 16, 28, 40**
Brazos River	**Somerville Reservoir**	**6, 16, 28**
Somerville Reservoir	**LaGrange Reservoir**	**6, 16, 28**
Somerville Reservoir	**Columbus Bend Reservoir**	**6, 16, 28**

Colorado River	**Palmetto Bend Reservoir**	**6, 16, 28, 40**
Sulphur Bluff Reservoir	Lake Fork Reservoir	6, 10, 16
Lake Fork Reservoir	Mineola Reservoir	2, 12, 20
Mineola Reservoir	Blackburn Crossing Reservoir	2, 6, 12, 20
Blackburn Crossing Res.	Tennessee Colony Reservoir	2, 6, 16, 20
Tennessee Colony Res.	Richland Reservoir	6, 12, 20, 40
Mineola Reservoir	Cedar Creek Reservoir	2
Cooper Reservoir	Lavon Terminal	6, 12, 20, 40
White Rock Terminal	White Rock Creek	4, 6
Marshall Reservoir	Lake o' the Pines	2
Black Cypress Reservoir	Lake o' the Pines	2
Lake o' the Pines	Titus Reservoir	7, 8
Titus Reservoir	Naples Reservoir	5, 8, 9
Carthage Reservoir	Marshall Reservoir	3, 4

Different flow capacities and canal characteristics were applied to obtain a range of costs and operating procedures. Future water demand estimates were used to determine the water flow rates to review in the analyses described above. No conclusions were drawn due to the nature of the report.

13. Guadalupe-Blanco River Authority, "Alternative Source Water Supply Study," February, 1987.

This report defined and evaluated water source and supply system alternatives for San Marcos, Kyle, Lockhart, Creedmor-Maha, Goforth, Maxwell, Crystal Clear, and Springs Hill's water supply corporations. These cities are located in Hays, Caldwell, and Guadalupe counties.

Seventeen alternatives were identified using a combination of eight water sources and five plant sites. The water sources included both raw and treated water deliveries. The study was conducted in four phases: (I) Capacity Requirements; (II) Delivery Systems; (III) Design and Cost Estimates; and (IV) Unit Costs.

Within Phase II, each of the eight alternative water sources and five delivery systems were identified by status (planned or existing), location, and also sustainability and capacity, where obtainable. The 17 alternatives were then tabulated, giving MGD values for each serviceable city in terms of initial delivery and plant capacity. The 17 alternatives included:

Water Source	Plant Site	Initial Delivery (MGD)	Plant Capacity (MGD)	Unit Cost $/1000 Gal
1. San Marcos River	San Marcos	2.94	5.10	1.68
2. Canyon Reservoir	San Marcos	2.94	5.10	2.12
3. Cloptin Crossing	San Marcos	2.94	5.10	3.38
4. City of Austin	Austin	2.94	5.10	3.54
4A. Colorado River	Pilot Knob	2.94	5.10	2.63
5. Canyon Reservoir	Guadalupe R.	2.94	5.10	2.30
6. Lockhart Reservoir	Lockhart	2.94	5.10	2.69
7. City of Austin	Austin	0.68	1.46	3.86
7A. Colorado River	Pilot Knob	0.68	1.46	4.37
7B. Canyon Reservoir	Guadalupe	2.26	3.64	2.19
8. Wilcox Aquifer	Well location	0.25	0.86	6.74
9. Luling Water Pl.	Luling	0.08	0.21	4.74
10. Canyon Reservoir	Guadalupe R.	0.16	0.37	2.30
11. Canyon Reservoir	Guadalupe R.	0.38	0.79	2.54
12. Canyon Reservoir	Guadalupe R.	0.22	0.42	2.99
13. Canyon Reservoir	San Marcos	1.88	2.85	2.04
14. Canyon Reservoir	San Marcos	1.64	2.43	1.91

The Initial Delivery was defined as 30% of the 1985 water use for the area, while the Plant Capacity was defined as the larger of either 50% of growth for the 1985-2000 period or 25% of the projected total water use in the year 2000. After considering the demands, supplies, logistics, and specific costs, unit costs were calculated to help determine relative merits of the alternatives.

The San Marcos River Supply using the San Marcos treatment plant was seen as the best option, even though the imminent cessation of flow was known to be a factor. The fall-back plan was to construct a raw water line from the Guadalupe River (Canyon Lake) to the treatment plant in San Marcos. The other alternatives were mentioned and ranked. The results confirmed the expected benefits of economies of scale when using regional or multi-system approaches.

14. HDR Engineering, Inc., Naismith Engineering, Inc., and University of Texas, Marine Science Institute, "Nueces Estuary Regional Wastewater Planning Study - Phase II," for the City of Corpus Christi, Port of Corpus Christi Authority, Corpus Christi Board of Trade, South Texas Water Authority, and the Texas Water Development Board, June, 1993.

This report studied the potential for the planned usage of a combination of releases, spills, diversions of wastewater, return flows, river flows, and stormwater to increase biological productivity in the bays and estuaries. The reasons for this study are found in two provisions included in the March 9, 1992 TWC Agreed Order for scheduled CC/LCC releases to Nueces Bay. These two provisions are: 1) the establishment of procedures for relief from releases under specified salinity and drought conditions, and 2) the recognition that increased biological productivity from diversions to the Nueces Delta could justify inflow credits greater than the volumes actually transferred.

Following the recommendations made in the Phase I study in 1991, the Phase II study objectives were:

1) Continue biological monitoring and productivity evaluations of river and waste water diversions to the Nueces Delta and Estuary;
2) Prepare the discharge location cost estimates and scheduling information needed to implement the river and wastewater diversion demonstration projects;
3) Evaluate stormwater and locally available brackish groundwater to meet estuary needs;
4) Update the Lower Nueces River Basin and Estuary Model (NUBAY2); and
5) Evaluate the impact of river, wastewater, and stormwater diversions upon the yield of the CC/LCC System.

The first objective was achieved through the continued monitoring of soil cores, salinity, temperature, dissolved inorganic nitrogen (DIN), sediment ammonium, water levels, and other chemical and physical properties of the marsh and bay. The data collected in 1992 were compared with the Phase I data from 1991. Given information from the continued monitoring efforts, the other four objectives were achieved through a straight-forward detailed analysis of the factors affecting each objective.

The data from 1992 supported the conclusions drawn in the Phase I study. The conclusion was that greater primary productivity occurred with freshwater and return flows diverted into the delta rather than allowing such flows to enter Nueces Bay via the Nueces River. The 1992 data differed from the 1991 data in that it showed even higher levels of primary production for similar inflows. Productivity for freshwater inflow to the Delta was found to have three times the rate of productivity as flows via the Nueces River to Nueces Bay and the productivity of wastewater return flows diverted to the Delta were five times that of such flows released into the Nueces River which discharges into Nueces Bay. The 1992 data also showed that the rates of primary production were not strongly influenced by the salinity concentrations of Nueces Bay.

Several alternatives were considered which would provide water to the Delta. The alternatives were individually analyzed for feasibility by reviewing their yield, water quality, likelihood of obtaining a permit, and cost. Several of the alternatives were rejected before complete analysis was performed. The local groundwater option was found to be infeasible since the volume available was determined to be inadequate given the costs. The diversion of stormwater was also rejected due to a lack of volume given the high costs, as was the installation of more gages and meters to determine the amount of run-off entering the Delta.

The goals of the Phase II study were to evaluate biological productivity of a river and wastewater diversions to Nueces Delta and to estimate the costs of diversion projects that would restore as much of the Choke Canyon/Lake Corpus Christi system yield as possible. The system yield lost due to the Agreed Order was determined to be 30,954 AFA. As none of the 18 individual alternatives that were studied could recover the full 30,954 acre-feet of yield, combinations of options were developed. The combinations were created by maximizing the productivity for each wastewater return flow option proposed while minimizing the necessary river diversions. The combinations were divided into two groups: 1) Those which use municipal wastewater, and 2) those which use municipal and industrial wastewater. The most cost effective options were those which used the industrial return flows. However, these options were not recommended due to the expected difficulty in obtaining permits to discharge industrial wastewater into the Delta.

The Phase II study recommends a river and wastewater diversion that restores 83% of the system yield at a unit cost of $53 per acre-feet. The individual diversions included in this combination were:

> Allison, Broadway, and a part of Westside WWTP's Discharge to the Delta; and Nueces River Diversion to the Delta.

The report makes five recommendations.

1) Establish a Municipal WW Diversion Demonstration Project from Allison WWTP to the South Lake area of the Delta
2) Establish a Nueces River Diversion Project from Calallen pool to Upper Rincon Bayou
3) Establish a Nueces River Diversion Project through existing facilities of the O.N. Stevens Plant
4) Explore the potential of rerouting wastewater within the Corpus Christi wastewater collection system given the results of the Allison Demonstration Project.
5) Continue the scientific data collection and monitoring of the Nueces Delta and Bay.

Projects which were found to be infeasible in the Phase II study were not recommended for further study. A variation of the Phase II recommended diversion project is one of the alternatives included in this Trans-Texas Study.

15. HDR Engineering, Inc., and Guadalupe-Blanco River Authority, "Regional Water Plan for the Guadalupe River Basin," for the Guadalupe-Blanco River Authority, January, 1991.

This report presented projections of population and water demands and identified and evaluated regional water supply alternatives (including conservation and return flows, storage and management, water rights subordination, and various structural alternatives) to meet future water needs of the basin.

The report provided projections of water requirements by type of use, section of basin, and county, from 1980 to 2040 in 10-year increments. General public and out-of-basin needs were also considered. Ground water use and supply and surface water permit holders and quantities permitted were also tabulated.

The various water supply alternatives were discussed separately, with consideration given to yields, costs, and quality. These alternatives included: Canyon, Cuero I, Cuero II, Cuero I and II combined, Cloptin Crossing, Lockhart, Port O'Connor pump expansion, and an alternative pipeline to Boerne.

Recommendations were made in reference to the pertinent issues surrounding each alternative, i.e., a course of action was identified for each case, but the exact form each action should take was not specified.

16. HDR Engineering, Inc., "Regional Water Planning Study: Cost Update for Palmetto Bend Stage 2 and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage 2," for LNRA, Alamo Conservation and Reuse District, and the City of Corpus Christi, May, 1991.

This report reviewed and estimated the potential water supply, feasibility, and costs to San Antonio and Corpus Christi associated with the development and utilization of Palmetto Bend Stage 2 and Garwood irrigation water sources.

Estimated costs and yields were considered, along with legal issues connected with water rights and inter-basin transfers. Along with these factors, the report reviewed the hydrology, economics, and environmental impacts of the project for a range of water volumes that might be obtained from the Lower Colorado Basin. Area drought and conservation plans were also addressed. The options reviewed were: Palmetto Bend Stage 2; Garwood irrigation water; unappropriated Colorado River water; and a combination of Garwood and unappropriated Colorado River water.

It was found that Garwood irrigation water was the least expensive option for supplying water to Corpus Christi and/or San Antonio through Lake Texana, and therefore should be utilized as much as possible. Garwood had expressed a willingness to sell 30,000 acre-feet of their 168,000 acre-feet total water right. The analysis within the report sought to determine the optimal amount of Garwood and unappropriated water to use given the constraints of costs and flow in the canals. For Garwood, the optimal flow is 50,000 to 60,000 acre-feet per year.

However, given the limitation of 30,000 acre-feet stated above, development of unappropriated water would appear to be needed to meet long-term demands.

For San Antonio and Corpus Christi needs that exceed the Garwood irrigation water quantity, unappropriated Lower Colorado River water was seen as the next best option. However, if the combined municipal need greatly exceeds the amount that can be obtained from Garwood, then the development of Palmetto Bend Stage 2 is the only other nearby option. Environmental and legal factors associated with water supply development using Garwood water rights and/or Palmetto Bend 2 were identified and described. Future water shortages in the LNRA basin may tend to cause out-of-basin transfers to be couched as temporary agreements.

17. HDR Engineering, Inc. and Geraghty and Miller, Inc. "Regional Water Supply Planning Study - Phase I: Nueces River Basin Volume I Executive Summary for the Nueces River Authority, City of Corpus Christi, Edwards Underground Water District, South Texas Water Authority, and Texas Water Development Board, May, 1991.

This report evaluated the potential effects of two types of recharge-enhancing structures -- catch and release (Type 1) and immediate recharge (Type 2) -- over the Edwards Aquifer, within the Nueces River Basin. The evaluation considered potential recharge enhancements, and satisfaction of demands through the year 2040, and emphasized the Choke Canyon and Lake Corpus Christi (CC/LCC) service area, as well as inflows to the Nueces Estuary. These analyses were accomplished through the development of a Nueces River Basin Model, which was compared with the USGS projections for Edwards Aquifer recharge originating from the Nueces River Basin.

The effects of the two types of recharge-enhancing structures upon the yield of the CC/LCC System were considered separately (at 100% conservation capacity), then measured against each other and against a base case scenario of no new structures. It was found that Type 1 structures, when measured against Type 2, provided greater recharge enhancement, less reduction of firm yield in the CC/LCC system, marginally more reduction of inflows to the Nueces Estuary, and less inflow reduction to the CC/LCC reservoirs.

Type 1 Reservoirs considered were: Montell, Upper Dry Frio, Concan, Upper Sabinal, Upper Seco, Upper Hondo and Upper Verde, and Type 2 Reservoirs considered were: Indian Creek, Lower Dry Frio, Lower Frio, Leona, Blanco, Lower Sabinal, Little Blanco, Lower Seco, Lower Hondo, Lower Verde, Elm Creek, and Quihi Creek.

In contrast to the model's findings, the USGS estimates of Edwards Aquifer recharge in wet periods appear high due to soil differences across the recharge zone, and the fact that pertinent water rights downstream were not taken into consideration by the USGS. The Nueces Basin Model developed by HDR honors all existing water rights.

This report warned of potentially high estimates of recharge enhancement due to unaccounted-for or unforeseeable economic, environmental, and structural effects. Storage capacity estimates may vary due to geologic or man-made features.

18. HDR Engineering, Inc. and Paul Price Assoc., Inc. "Regional Water Supply Planning Study - Phase III: Recharge Enhancement Nueces River Basin Final Report for the Nueces River Authority, City of Corpus Christi, Edwards Underground Water District, South Texas Water Authority, and Texas Water Development Board, November, 1991.

This report presented an in-depth analysis of recharge enhancement potential, as described in the Phase I report. The two types of structures were considered in light of their optimal capacities with respect to minimizing unit costs (annual cost/unit of recharge enhancement). These optimal capacities were contrasted with 100% conservation capacity. A comprehensive set of estimates on recharge enhancements, as well as yield reductions to the CC/LCC system and inflows to the Nueces Estuary, are provided for each recharge structure. It is estimated that recharge enhancement potential to the Edwards Aquifer from within the Nueces Basin could be increased, on the average, by 26 percent or 85,000 acre-feet per year, with a maximum effect upon the yield of the CC/LCC System of 5,800 acre-feet or 2.6 percent.

Cost components considered included conceptual dam design, road relocation, land acquisition, environmental mitigation, water rights mitigation, and miscellaneous project costs. With these cost components, the Type 2 structures, at optimal capacity, were considered to be the most cost-effective, mainly due to location and evaporation effects.

With either Type 1 or Type 2 structures, slight (less than 3%) reductions to the CC/LCC System yield and inflows to the Nueces Estuary would occur. It was suggested that owners of the CC/LCC System be compensated by those who would benefit from the Edwards Aquifer recharge structures. If mitigation was not feasible, it was recommended that Type 1 structures be utilized due to increased recharge enhancements.

19. Naismith Engineering, Inc., "Subcommittee Report on Desalination for Potable Water," For Mayoral Advisory Committee on Water Issues - Subcommittee for Water Sources and the Environment, November, 1992.

This report presented a summary of current technology and utilization of desalination in the United States. A brief background for the study led directly into a list and discussion of the various desalination technologies (including diagrams and schematic presentations). These technologies included: three Distillation Processes; 1) Multi-Stage Flash (MSF), 2) Multi-Effect Distillation (MED), 3) Vapor Compression (VC), and three Electrodialysis Processes; 1) Electrodialysis (ED), 2) Electrodialysis Reversal (EDR), and 3) Reverse Osmosis (RO).

Economic considerations were reviewed with specific reference to ongoing and planned projects in Florida, California, and Texas. California was reported to use desalination as a municipal water source in three communities. The Texas Coastal Bend water conditions were then reviewed for their various total dissolved solids (TDS) concentrations as a means of determining the efficacy of the desalination process for the region. That is to say, the TDS concentration of raw water in a desalination process is the prime factor affecting the feasibility of desalination as a water supply option. In the Coastal Bend Region, namely, Nueces Bay, Corpus Christi Bay, and the Gulf of Mexico, the TDS was seen to be too high for cost-effective development. A price of $4.00 to $6.00 per 1,000 gallons is estimated to desalt the water from these areas.

20. Rauschuber and Associates, Inc., "Potential for Development of Additional Water Supply from the Nueces River Between Simmons and Calallen Diversion Dam," for Subcommittee on Additional Water Supply from the Nueces River Watershed, December, 1985.

The report reviewed existing and proposed in-basin water supply options for the lower Nueces River Basin study area. The study area extended from Calallen Dam to just above Three Rivers. The report was designed as a preliminary step toward in-basin water supply decisions and therefore does not consider out-of-basin water supply options. The in-basin projects investigated were: (1) enlargement of Lake Corpus Christi; (2) Bluntzer Dam and Reservoir; (3) R&M Dam and Reservoir; and (4) Simmons Pump Facility. The report also considered the potential for maximizing the firm yield of the CC/LCC System as an option.

The analysis of the four options listed above were considered separately as a third leg to the CC/LCC System, each using year 2010 stream flow projections and sediment loads. A base yield for the CC/LCC System was indicated to be 249,000 acre-feet per year, using the Bureau of Reclamation data set from the years 1941 to 1980. The results were:

1. CC & Enlarged LCC . . . . . 271,000 AFA
2. CC, LCC, & Bluntzer . . . . . 276,250 AFA
3. CC, LCC, & R&M . . . . . . 317,300 AFA
4. CC, LCC, & Simmons I . . . 255,000 AFA
5. CC, LCC, & Simmons II . . . 263,000 AFA

Simmons I & II represented two operating strategies. The first option was to divert water from the Nueces River at Simmons to CC only when LCC was spilling and CC was not. This was found to be impractical and infeasible since the pumping capacity would need to be as high as one million gallons per minute. The second option provided for five 20 MGD pumps for a total of 100 MGD capacity. The operating strategy evaluated was to pump when the CC conservation pool was down more than a foot from its normal 220.5 ft-msl, and there was sufficient flow in the Nueces River to feed at least one pump.

System	Increased Yield (AFA)	Total Cost (million $)	Cost ($/1000 Gal)
CCR- ENLG. LCC	23,000	408.00	5.79
CCR-LCC-Bluntzer	27,250	173.00	2.02
CCR-LCC-R&M	68,300	236.00	1.09
CCR-LCC-Simmons	14,000	6.38	0.33

The report recommended the combination of the R&M Reservoir site with the Simmons pump facility as providing the best ratio of water supply to unit cost. However, a closer look at the hydrology of the basin was necessary to determine the extent of the losses in the reach of the Nueces River under study.

The environmental impacts of the two programs were reviewed; however, detailed analyses of the proposed sites were beyond the scope of the report. The threat to wildlife habitat was raised as a potential issue, as was the possibility of increased wildlife habitat. The Simmons Pump Facility was reported to have no adverse environmental impacts due to the site and the nature of the facility. The R&M site, or any site on the Nueces River, was reported to reduce flows to the estuary from 477,000 acre-feet per year to 386,000 acre-feet per year. The difference was proposed to be made up from return flows. This would not stop increased salinity in the estuary, but it would increase the nutrient inflow.

Using the year 2010 projections, there appeared to be enough water in the Nueces Basin to meet demands through the year 2020. However, it was recommended that steps be taken to acquire land and plan routing options so that when these projects were needed the costs would be reasonable.

21. Stone and Webster Engineering Corporation, "Report on the Feasibility of Desalination and Waste Water Reuse for the City of Corpus Christi, Texas," with DSS Engineers, Inc., Nov 1984.

According to the Texas Department of Water Resources, Corpus Christi's 1984 surface water supply would provide sufficient quantities of water only through the year 2030. This was viewed as a real threat to development in the region. This study, conducted for the City of Corpus Christi, reviewed the potential for developing alternate water supply sources to satisfy municipal and industrial demands. The alternate sources for water reviewed in the report included: (1) reuse of treated municipal wastewater; and (2) desalination of brackish groundwater and seawater sources.

The report was completed in three phases: (1) identification of major users, both potable and industrial; (2) description of the Desalt and Treatment Processes; and (3) development of Capital and O&M costs for both processes. The study reviewed institutional, technical, and economic factors which affect the decision to reuse wastewater or to engage in the desalination of brackish or sea water.

The first and second phases of the report focused on the question of project viability. Both phases of the study showed that the tertiary treatment of municipal wastewater and the desalination of brackish water were viable alternatives for municipal and industrial water supplies.

The third phase of the study compared the economics of the different water supply alternatives being considered by the City at that time. The unit costs for desalting brackish groundwater for potable use ranged from $2.40 to $1.08 per 1,000 gallons. These costs were calculated for a reverse osmosis plant with a capacity ranging between one and 20 million gallons per day. The unit costs for the tertiary treatment of municipal wastewater, using lime softening, for industrial use were estimated at a range of $1.95 to $0.66 per 1000 gallons. The reuse figures assumed the use of a system producing between two and 16 million gallons per day.

The report recommended that each alternative be compared by unit cost of production to determine the best choice for implementation. A major benefit cited for the two supply alternatives analyzed in the report was their independence from future climatic events.

22. Texas Department of Water Resources, "Ground-Water Availability in Texas: Estimates and Projections Through 2030," Report 238, September, 1979.

This report provided a comprehensive reference for groundwater availability in Texas on an average annual basis to the year 2030. (The report also updated the data on available groundwater supplies presented in the 1968 Texas Water Plan.)

The report began by defining groundwater terminology, and explained data collection and analysis techniques (to include steady state and non-steady state flow methods). Each major and minor aquifer was described in terms of geologic origin and composition, location, size, recharge characteristics, water quality, water yield, and degree of utilization in 1979. The numbers provided were given for river basins and zones, and the dangers involved in overdeveloped use were also discussed theoretically and historically. The report provided estimates of recharge and total and recoverable storage for the different aquifers of Texas.

23. **Texas Water Development Board, "Coastal Canal Project Reconnaissance Cost Estimate," no date available.**

This report provided a summary of cost estimates for water delivered from Toledo Bend Reservoir to the Lower Rio Grande Valley of Texas under three operating strategies and four amortization rates. The deliverable quantity of water was chosen by defining the high and low estimates as 150% and 75% of the middle estimate, respectively. The middle estimate was simply the year 2020 projected water requirement, without new irrigation development, from The 1969 Texas Water Plan. The amortization rates were set at values ranging from 0 to 7%, over 50 years, as per various federal and state operating procedures.

Costs for conveyance were calculated with and without peaking capacities. With peaking capacity considered, capital costs increased by 51% and O&M costs increased by 56%.

The report recommended the development of a storage capacity of 110,000 acre-feet per year below Palmetto Bend to eliminate the need to allow for peaking capacities. Options were developed and costed beyond the peaking consideration. Relevant options included: (1) Palmetto Bend to the Guadalupe River; (2) Guadalupe River to Copano Creek; (3) Copano Creek to Melon Creek; (4) Melon Creek to the Nueces River.

24. **Texas Water Development Board, "Desalting in Texas: A Status Report," May, 1992.**

This report listed, briefly defined, and analyzed the economics of the different technologies available for water desalinization. The different methods available were grouped generally as either distillation or membrane as follows. Distillation included Multi-Stage Flash (MSF), Multi-Effect Distillation (MED), and Vapor Compression (VC). Membrane included Electrodialysis (ED), Electrodialysis Reversal (EDR), and Reverse Osmosis (RO).

Each technology was then evaluated according to its operating and maintenance costs, capital costs, necessary level of labor, output capacity, and raw water condition requirements. Advantages and limitations were also discussed for each technology, along with associated considerations. The report also included a list of desalt plant locations within Texas, operators, capacities, and types of projects.

The desalinization process was viewed as effective but expensive and the decision as to which technology to use would be driven by external conditions, which precluded recommendation without specific knowledge of a particular project. The report predicted that desalinization most likely would not be used to produce drinking water in Texas until legislation demands it.

25. "Ground-Water Resources of Nueces and San Patricio Counties, Texas," Report 73, May 1968, Reprinted by the TDWR, Aug. 1982.

This study was conducted to determine the occurrence, availability, dependability, quality, and quantity of groundwater in the study area. More specifically, the study's goals were to map the location and size of the sands containing fresh to slightly saline water, determine water quality, hydrology of the sands, level of pumpage, and the effect of the pumpage on the sands. The purpose of the study was to develop information useful to protecting and maximizing the benefits obtainable from the groundwater supplies within the study area.

The study was methodical in its investigation of the factors affecting groundwater pumping. An inventory was made of water wells and oil tests, as well as all groundwater pumpage at the time of the study. Above- and below-ground geology and topography were cataloged, while climate, and stream flows were chronicled to produce a clearer picture of the available groundwater in the area. The report also addressed the various problems related to the development and protection of groundwater supplies.

The principle aquifers in the two counties are the Goliad Sands, the Lissie Formation, and the Beaumont Clay (the Gulf Coast aquifer), each running roughly parallel to the coast. The water in the aquifers moves southeastward from the recharge areas to the discharge points.

It was determined that a few million gallons per day were available for development in the two county area without depleting the aquifers. The most favorable area identified for additional groundwater development was north and northwest of Sinton in San Patricio County, with potential well yields of as much as 1,700 gallons per minute. Elsewhere in the study area, only small quantities of water would be available on a perennial basis. The water stored within the aquifers was estimated at a few million acre-feet, which could be developed given sufficient knowledge of the potential effects depletion would have on the aquifers.

Large quantities of moderately saline water were reported. The development of this water would depend upon economically competitive demineralization technology to produce potable water. More information is called for concerning the interface of the fresh water with the saline water.

26. Texas Water Development Board, "Summary of Current Reconnaissance-Level Design and Cost Studies of Water Storage and Conveyance Systems Between Red River and Lower Rio Grande Valley, Texas," 1973.

This report summarized the design and cost studies of reservoir and conveyance systems for the transfer of water from Northeast Texas to the Lower Rio Grande Valley (LRGV) of Texas. The report considered three potential water sources: A) Diversion and transfer of water from the Mississippi River to Toledo Bend, and surpluses from Sam Rayburn and Rockland Reservoirs; B) Same as A, except that no Mississippi River water would be used; and C) Assumed only diversions from the Sabine and Neches River Basins. The relevant information from the report included transportation of water from Toledo Bend Reservoir, in the Sabine Basin, westward to Palmetto Bend and on to the LRGV. Plan A could provide 3.438 million acre-feet per year, while Plan B could provide 1.731 million acre-feet per year. The cost under Plan B for water from Toledo Bend to Palmetto Bend was estimated at $46.09/acre-foot (1973 prices).

Costs for diversion and conveyance systems were expressed in terms of mid-1973 dollars. These costs were calculated as total cost per leg, accumulated cost per delivery point, and unit cost per delivery point. Three delivery sizes were used to provide a range of alternatives. The high estimate met all requirements below Palmetto Bend, the low estimate met all requirements except bay and estuary, and the middle estimate was an arbitrary value.

27. Texas Water Development Board, "Water For Texas: Today and Tomorrow - 1990," Dec 1990.

This report provided a general overview of present water use and of future Texas water needs. It considers water supply, demand, availability (proximity and cost), use (municipal, industrial, agricultural, and natural), and quality.

Groundwater supply projections of the Texas Water Plan were based on safe yield of aquifers, the presence of a management plan (especially where "most needed"), and the use of groundwater in conjunction with surface water (especially where the combination results in lower costs). Projections of surface water supply were based on firm yield calculations from reservoirs or scaled-down values of the same, depending on the reservoir's characteristics. Water conservation was included for all projections in the document.

The report provided proposed water supply plans for each area of Texas. The plans included date supply would be needed, and their costs, from a straightforward water conservation plan to new physical structures. For south-central Texas, these structures included: Applewhite, Lindenau, Allens Creek, Cuero, Goliad, Cibolo, Palmetto Bend II, and Shaw's Bend Reservoirs (pg. 3-13).

The report also listed various projects that have been studied as potential alternative or long-term reservoir sites and water conveyance systems. The sites for south-central Texas included: R&M, Cotulla, Montell, Concan, Sabinal, Falls City, Mission, Confluence, Garcitas, Cummins Creek, Gonzales, Plum Creek, Lockhart, Cloptin Crossing, Ingram, Dam 7, Baylor Creek, Wilbarger Creek, Clearview, Pedernales, Mason, San Saba, and Upper Pecan Bayou Reservoirs (pg. 3-14).

Conveyance systems were included for the following: Texana to Point Comfort, Texana to Corpus Christi, Goliad to San Antonio, Lindenau/Cuero to San Antonio, Medina to San Antonio, Canyon to San Marcos, Stillhouse Hollow to Round Rock, and Cibolo to San Antonio (pg. 3-16).

The report gave detailed, basin-by-basin projections of water usage for the years 2000 and 2040. The information provided included projections of use from each aquifer and reservoir in the basin. The aggregate basin projections considered a breakdown of demands against surface and ground water supplies and water imports and exports. The aggregate data were also displayed in pie charts showing percentage distribution among the various water uses.

28. Texas Water Development Board, "Water for Texas - Today and Tomorrow 1992," November, 1992.

This document is an update to the 1990 document of the same title. The document reviewed the implementation status of the policy recommendations made in the 1990 version, it also updated the policy recommendations. For the most part, the policy recommendations which have yet to be implemented from the 1990 document were retained for future consideration.

The 1992 update of the 1990 water plan concerned itself less with water availability and demand in the various river basins of the State and more with planning, policy issues, regional concerns and trends, and specific projects which are either under immediate consideration or whose specifications have changed within the last two years. These projects include: Applewhite Reservoir, Bosque Reservoir-Lake Waco, Brazos River Chloride Control, Canadian River Chloride Control, Cooper Reservoir, Cuero Reservoir, Eastex Reservoir, Gilmer Reservoir, Goliad Reservoir, Ivie Reservoir Conveyance Systems, Lake o' the Pines, Lindenau Reservoir, Little Cypress Reservoir, Medina Reservoir, Natural Dam Chloride Control, Neches Chloride Control, New Bonham Reservoir, Palo Duro Reservoir, Paluxy Reservoir, Red River Chloride Control, Site A Channel Dam Reservoir, Tehuacana Reservoir and Trinity River Diversion, Texana Reservoir, Toledo Bend/Houston Conveyance System, and Trinity River Chloride Project (Wallisville).

The updates to those projects with direct relevance to Trans-Texas South Central area were as follows:

Applewhite - Construction stopped in 1991 due to referendum election. The reservoir was seen as both a proximate terminal storage facility for any additional water supplies as well as a source of water. It is recommended that the City keep its options open pending further investigation, including completion of Applewhite, springflow augmentation, Edwards Recharge options, and other major water supply options.

Cuero - U.S. Fish and Wildlife Service was evaluating a request for a higher endangered classification for a turtle whose critical habitat was claimed to lie within the project area. It was recommended that no change be made to previous recommendations, but it was noted that the environmental evaluation underway could be resolved by the next update of the Texas Water Plan.

Goliad - Studies were underway to determine which of three water supply options would be best to construct: Goliad, Lindenau, and/or diversions from the San Antonio River to the Cibolo Reservoir (Wilson County). No change was recommended.

Lindenau - Revised pool elevation to 232 ft (from 250.1) to avoid inundating valuable upland environmental habitat. The new elevation reduced firm supply to 107,000 acre-feet per year (from 220,000); however, if springflows were guaranteed at 100 cfs and 50 cfs at Comal and San Marcos Springs , respectively, then Lindenau yield could be increased 100,000 to 207,000 acre-feet per year.

Medina - A recent Bureau of Reclamation study showed a yield of 29,000 acre-feet per year in the vicinity of the dam. However, high channel losses downstream were attributed to aquifer recharge.

Texana - There were no substantial effects on permitted water rights by the environmental releases pending approval by the TWC. Corpus Christi Port Authority entered into an option contract for 41,000 acre-feet per year (sic). However, 9,000 acre-feet per year (sic) of the option was available to LNRA, if needed. The option was awaiting the necessary state and federal permits (sic). Pipeline construction was anticipated in the 1996 time frame which was earlier than previous reports (sic).

The report included information on regions of the South-Central study area, as follows:

Coastal Bend Region (Nueces and Neighboring Counties) - The CC/LCC Reservoir System was estimated to be able to develop 196,000 acre-feet per year without consideration for bay and estuary releases. The most recent TWC Order for these releases reduced the available supply to 154,000 acre-feet per year. The TWC order required 97,000 acre-feet per year be discharged into Nueces Bay by any combination of releases and spills. Assuming that the supply of 154,000 acre-feet per year held, the Corpus Christi area would need additional water supplies by the year 2000.

The Texas Hill Country area from which aquifer recharge and stream flow relevant to the Trans-Texas South Central Study area are concerned, was designated critical with respect to groundwater supply by the TWC, due to severe current and future water supply problems. It was recommended that conjunctive surface and groundwater use be explored as a means of mitigating the problem.

North American Free Trade Agreement (NAFTA) - This section recognized a controversy as to exactly how much growth will be stimulated by NAFTA and where such growth might occur. The report assumed some growth in all sectors, with no specific data presented.

Southern Edwards Aquifer Region (Bexar and Neighboring Counties) - After recognizing legal actions pertaining to efforts to protect flows of springs fed by the Edwards Aquifer, the 1992 Texas Water Plan update specified that a 425,000 acre-feet per year pumping level was too high to protect springflow because the model used to estimate flow used only a yearly time step. The Plan called for increased conservation savings of 100,000 acre-feet per year for M&I, 60,000 acre-feet per year for irrigation, and 40,000 acre-feet per year of water reuse by the year 2010. Even with the increased conservation and reuse and the high-end pumping limit, additional water supplies would be needed for the area.

Trans-Texas Regional Water Issues - In the 1992 Texas Water Plan, the Trans-Texas Water Programs was identified in order to meet the needs of areas experiencing continued growth. The existence of natural resources, trade corridors, transportation and other infrastructure, skilled labor forces, and other factors were straining water supplies on the one hand and on the other these same elements provided resources with which to develop additional water supply sources. The study period was listed at approximately three to four years.

29. United States Geological Survey, Sergio Garza, "Water-Delivery Study, Lower Nueces River Valley, Texas," TWDB Report 75, in cooperation with the Lower Nueces River Water Supply District, May 1968.

The purpose of this report was to determine the cause of the losses and increased mineralization found to occur in the lower Nueces River. Data were collected at more than 20 points along the 35-mile stretch of the Nueces River between Lake Corpus Christi and the Calallen Diversion Dam. Groundwater was also tested by sampling water from 37 test holes on both sides of the river over the 35-mile study area. Data were gathered twice over several days in February and August of 1966 in order to gain seasonal differentiation in the data.

The study showed that, depending on the river stage and elevation of the water table in areas adjacent to the river, the river would either gain or lose water, from or to, the surrounding alluvium. When the river flow was 150 cfs, the river lost 8 cfs. However, the typical release for that time of year was only 86 cfs. At 86 cfs, the records show an increase in flow to the river. Conversely, at the end of the rainy season, the river was shown to gain 4 cfs even though it was flowing at 146 cfs. This was due to the raised water table resulting from recent heavy rains. From these results, the river was determined to be in hydraulic continuity with the alluvium. Therefore, the only permanent losses to the system were found to be from evaporation from the river and evapotranspiration from the plants along the river and flood plain.

The analysis of the water quality was not as straightforward. Although the groundwater around the river was shown to be of very poor quality, the volumes of water transferred could not account for the increases in concentrations measured downstream at Calallen. It was also found that several tributaries were delivering high concentrations of minerals (chlorides, TDS, and sulfates) to the river, but again in very small volumes (1 to 2 cfs). The highest increases to the mineral concentrations were found to occur in the Calallen channel lake. The intrusion of groundwater was ruled out since the stage of the lake was found to be higher than the surrounding water table. No further explanation was sought for this increase since the overall concentrations of the constituents were well below the regulatory limits in 1967 (72 ppm).

The 1992 Reports Mandated by Senate Bill - 818:

As a specialized and basically similar series of reports, the Senate Bill - 818 (SB-818) Water Quality Assessment reports for river basins of the study area are presented here in a group. The water quality assessments were performed by individual river authorities for their respective basins. Since SB-818 was a new law, most of the 1992 water quality assessment reports mention a lack of time to properly prepare an in-depth study. However, each river authority expressed plans to address the water quality problems each perceives within their respective basins.

SB-818 lists 26 elements to be addressed by each report. The 26 elements are:

1) Review of Historic and Current Water Quality Monitoring Data;

2) Citizen Monitoring Goals and Objectives;
3) Public Awareness about Water Quality Issues;
4) Population;
5) Surface Water Base Map (digital);
6) Ground Water Base Map (digital);
7) Water Wells Inventory;
8) Municipal Wastewater Discharge Permits;
9) Industrial Wastewater Discharge Permits;
10) Storm Water Discharge Permits;
11) Water Rights Permits;
12) Solid Waste Management Facilities and Superfund Sites;
13) Petroleum Storage Tanks (AST's and UST's regulated by TWC);
14) On-Site Disposal Facilities;
15) Water Quality Problems Caused by Toxic Chemicals;
16) Pollution Sources Affecting Aquatic Life;
17) Nonpoint Source Pollution Sources;
18) Excessive Growth of Aquatic Plants Affecting Water Quality;
19) Water Quality Problems Caused by Pollution to Receiving Waters;
20) Solid Waste Management Program;
21) Water Quality Regulatory Role of Red River Authority of Texas;
22) Federal, State, and Local Water Quality Programs;
23) Water Quality Problems not Previously Identified;
24) Waters That Present a Water Quality Concern;
25) Bibliography of Water Quality Studies; and
26) Water Conservation.

The following summaries focus on the information that is relevant to the Corpus Christi area Trans-Texas project, i.e., those segments of the rivers where identified water supply options for Corpus Christi are located. The Water Quality Assessment reviews are ordered west to east by river basin.

Nueces River Basin

30. Alan Plummer and Associates, Inc., "Regional Assessment of Water Quality: Nueces River Basin, San Antonio-Nueces Coastal Basin, and the Nueces-Rio Grande Coastal Basin," in cooperation with the TWC, NRA, LRGVDC, and the CBCOG, October, 1992.

Thirty-three of the 38 segments of the Nueces Basin had water that was generally considered good, and 35 of the 38 segments had either high or exceptional quality for aquatic habitat. The three most persistent problem constituents in the basin were found to be Fecal Coliform, Dissolved Oxygen, and Copper. However, the literature reviewed for the report included several other constituents and water quality issues as potential problems, i.e.; nutrient loadings, excessive aquatic vegetation, chlorides, and total dissolved solids.

The following is a summary of the segment specific assessments. The segments included in this review were those which are within the 12-county study area. Any water quality concerns found in segments upstream of those located in the study area are assumed to be either incorporated in the downstream segments quality assessments, or mitigated. The TWC had two water quality designations pertinent to the segments of interest: effluent limited and water quality limited. Effluent limited water was defined to be treatable by conventional wastewater methods to maintain the existing water quality in the stream. Water quality limited water was such that conventional wastewater treatment methods were not adequate to maintain the existing water quality in the stream.

The summary of the report listed several conclusions which were drawn by the steering committee:

1. Consult the steering committee on quality monitoring issues for the 93-94 work plan.
2. Develop process for the specification of basin-wide objectives for education and involvement programs in water quality.
3. Begin monitoring sediment quality concurrently with the biota.
4. Monitor non-classified segments receiving discharge from municipal wastewater treatment facilities.
5. Review the applicability of the TWC default standards to the Nueces Basin.
6. Include the steering committee in the review process of the publications, Water Quality Inventory and Nonpoint Source Pollution Assessment.
7. Include information in the next report on the benefits of nutrient discharge into the bays and estuaries.
8. Include adequate set-backs from public drinking water supplies in the permit applications for solid waste disposal.

The list emphasized the need for more public input into water quality issues in the region, which was within the legislative intent of Senate Bill 818.

Segment 2101- Nueces River Tidal Location: From the mouth of Nueces Bay to Calallen Dam 1.7 km upstream of U.S. 77/IH-37					
Excursions		No. of Measurements	No. of Excursions	Est. Standard	Range of Excursions
Location	Parameters				
2101.01	DO (mg/l)	47	5	5	0.68 - 4.43
2101.01	FC (#/100ml)	17	4	200	217 - 525
2101.01	pH (SU)	46	3	9.1	6.5 - 9.0
Summary: Water quality - good, TWC - "effluent limited"					

Segment 2102- Nueces River Below Lake Corpus Christi Location: From Calallen Dam to Wesley E. Seale Dam					
Excursions		No. of Measurements	No. of Excursions	Est. Standard	Range of Excursions
Location	Parameters				
2102.01	DO (mg/l)	11	1	5	4.4 - 4.4
2102.01	FC (#/100ml)	51	12	200	260 - 1600
2102.02	FC (#/100ml)	44	11	200	210 - 2590
Summary: Water quality - good, TWC - "effluent limited"					

Segment 2103- Lake Corpus Christi Location: From Wesley E. Seale Dam to a point 100 meters upstream of U.S. 59 in Live Oak County					
Excursions		No. of Measurements	No. of Excursions	Est. Standard	Range of Excursions
Location	Parameters				
2103.01	DO (mg/l)	146	25	5	0.2 - 4.9
2103.01	FC (#/100ml)	16	1	200	333 - 333
2103.016	DO (mg/l)	94	7	5	0.5 - 4.6
2103.018	DO (mg/l)	55	1	5	2.5 - 2.5
Summary: Water quality - good, TWC - " water quality limited"					

Segment 2104-Nueces River above the Frio River Location: From the confluence of the Frio River in Live Oak County to Holland Dam to LaSalle County					
Excursions		**No. of Measurements**	**No. of Excursions**	**Est. Standard**	**Range of Excursions**
Location	**Parameters**				
2104.02	DO (mg/l)	15	2	5	2.7 - 3.73
2104.02	FC (#/100ml)	29	14	200	210 - 16200
2104.02	Temp (F)	15	1	90	92.34 - 92.34
2104.03	FC (#/100ml)	7	1	200	260 - 260
Summary: Water quality - good, TWC - "effluent limited"					

Segment 2106-Nueces/Lower Frio River Location: From a point 100 meters upstream of U.S. 59 in Live Oak County to Choke Canyon Dam in Live Oak County					
Excursions		**No. of Measurements**	**No. of Excursions**	**Est. Standard**	**Range of Excursions**
Location	**Parameters**				
08210000	Cadmium (ug/l)	18	1	1.608250	5.0 - 5.0
08210000	FC (#/100ml)	29	6	200	220 - 660
08210000	Lead (ug/l)	18	2	5	10 - 15
08210000	Mercury (ug/l)	18	1	2	2.2 - 2.2
2106.0025	DO (mg/l)	23	2	5	4.3 - 4.7
2106.0025	FC (#/100ml)	56	15	200	220 - 13100
2106.006	DO (mg/l)	16	2	5	3.4 - 4.4
2106.006	FC (#/100ml)	45	14	200	210 - 8000
2106.11	DO (mg/l)	24	2	5	2.9 - 4.0
2106.011	FC (#/100ml)	55	19	200	220 - 22000
Summary: Water quality - good, TWC - "effluent limited"					

Segment 2107-Atascosa River Location: From the confluence with the Frio River in Live Oak County to the confluence of the West Prong Atascosa River and the North Prong Atascosa River in Atascosa County					
Excursions		No. of Measurements	No. of Excursions	Est. Standard	Range of Excursions
Location	Parameters				
2106.0025	DO (mg/l)	24	16	5	3.72 - 4.99
2106.0025	FC (#/100ml)	26	23	200	290 - 35000
2106.006	DO (mg/l)	21	3	5	3.8 - 4.5
2106.006	FC (#/100ml)	15	4	200	360 - 850
2106.11	NO_3-N (mg/l)	21	9	10	11.6 - 34.2
Summary: Water quality - good, TWC - "water quality limited" Some part of the segment are unswimmable due to elevated levels of fecal coliform.					

Segment 2116-Choke Canyon Reservoir Location: From Choke Canyon Dam in Live Oak County to a point 4.2 kilometers downstream of SH 16 on the Frio River arm in McMullen County and to a point 100 meters upstream of the confluence of the Mustang Branch on the San Miguel Creek arm in McMullen County					
Excursions		No. of Measurements	No. of Excursions	Est. Standard	Range of Excursions
Location	Parameters				
2116.003	DO (mg/l)	179	50	5	0 - 4.98
2116.003	FC (#/100ml)	13	1	200	4283 - 4283
2116.003	pH (SU)	179	3	6.5 - 9.0	6.2 - 6.4
2116.0045	DO (mg/l)	124	72	5	0 - 4.91
2116.0045	pH (SU)	124	2	6.5 - 9.0	6.3 - 6.4
2116.005	FC (#/100ml)	35	5	200	250 - 8700
2116.006	FC (#/100ml)	16	10	200	210 - 16500
Summary: Water quality - good, TWC - "water quality limited"					

San Antonio River Basin

31. San Antonio River Authority, Environmental Services Division, "Regional Assessment of Water Quality: San Antonio River Basin," in cooperation with the TWC, Sept.9, 1992.

The problems found in the San Antonio River Basin were typically elevated levels of FC, Sulfates, and Chlorides. Although these problems had been decreasing since the installation of San Antonio's Dos Rios Water Treatment Plant in 1987, occasionally violations still occur.

The area of the basin relevant to the Trans-Texas project was designated as segment 1901. The segment was defined as that portion of the river from 600 meters downstream of F.M. 791 at Mays Crossing near Falls City in Karnes County to the confluence of the San Antonio River with the Guadalupe River. This segment contained four monitoring stations: Falls City, Hobson, Runge, and Goliad. The two most important sites to the Trans-Texas project were the Falls City and Goliad sites. This was due to their proximity to potential water diversion points. Falls City is just eight miles downstream from the closest point on the San Antonio River to the Nueces River with no other tributary inputs. The Goliad monitoring site is nearest to the proposed Goliad Reservoir -- a potential source of water for Trans-Texas. The Goliad site is also the most southern data gathering point and therefore is also relevant to the McFaddin reservoir.

The report contained the raw data from the monitoring stations and included the average, minimum, and maximum values for each constituent.

Goliad Monitoring Station - (data from 87-92)									
	DO	**Cond**	**TOC**	**NH_3**	**NO_3**	**NO_2**	**Cl**	**SO_4**	**FC**
Max	11.4	1345.0	26.2	0.91	9.03	1.06	167.0	311.0	7700.0
Avg	8.1	990.9	7.3	0.13	3.88	0.20	86.0	85.1	632.6
Min	5.2	247.0	0.0	0.00	0.70	0.00	12.6	10.4	70.0

The report did not include the data for the Falls City monitoring station. The next most northern station is near Hobson. However, the data from Hobson was very sporadic in its number of observations. Therefore, the Runge monitoring station data was presented. There were graphs for each constituent comparing the average, maximum, and minimum values for two periods of time, 1982-1987 and 1987-1992. These graphs showed a general trend of increasing water quality. The biggest improvement was seen in FC and DO measurements. The average FC for the periods decreased from 1212.9 to 295.3 (colonies/100 ml) and the DO increased from 6.9 up to 8.01 (mg/l). Even with these improvements, the levels for these constituents and others (chlorides, sulfates, and nutrients) frequently exceeded TWC criteria and at times rise to an

Runge Monitoring Station - (data from 87-92)									
	DO	Cond	TOC	NH_3	NO_3	NO_2	Cl	SO_4	FC
Max	11.0	1480.0	14.5	0.26	9.87	1.50	208.0	198.0	1180.0
Avg	7.4	916.0	8.1	0.04	4.32	0.37	93.7	87.5	209.1
Min	4.8	7.7	3.4	0.00	0.77	0.00	12.5	19.0	0.0

unswimmable state. The report also mentions the possibility of a problem with the presence of heavy metals.

The San Antonio Basin Water Quality Assessment concluded that the major source of water quality problems was the wastewater effluent discharge from the City of San Antonio. However, viewing the data in the tables above seems to provide conflicting information. That is, the FC, NH, and Conductivity measurements are worse in Goliad than in Runge, which is closer to San Antonio. Therefore, it is important not to assume that the further downstream from San Antonio one is, the better the water quality will be.

Guadalupe River Basin

32. Espey, Huston & Associates, Inc., "Regional Assessment of Water Quality: Guadalupe River Basin and the Lavaca-Guadalupe Coastal Basin," in cooperation with the TWC, GBRA, and the UGRA, October 1, 1992.

This report addressed nine of the 26 elements required by SB 818. Newness of the law, and therefore shortage of time were cited as the reasons for limiting the 1992 assessment to nine elements. The nine elements addressed are either filed data like measured water quality data, water rights permits, disposal permits, a bibliography of previous studies, and community-oriented program information to promote citizen monitoring and public awareness and involvement.

The report made a strong call for citizen participation in the problem definition phase. To that end, a linear correlation model was developed to help citizens understand how water quality is affected by natural processes. The results of this model showed there was a positive relationship between the river flow and TSS, and flow was negatively related to conductivity.

There were no other significant correlations between the flow and the other water quality constituents (DO, FC, Total P, etc.).

The report included water quality data from specific measurement sites. The sites that were relevant to the Trans-Texas project included the following:

Station	River Mile	Location Description
1803.0025	10.2	Guadalupe River at Lower Guadalupe Diversion Dam & Salt Water Barrier
1803.0100	47.8	Guadalupe River SH175 South of Victoria
1807.0100	36.2	Coleto Creek at US77 South of Victoria

The data published in the report included the minimum and maximum for the period of record as well as the average, geometric mean, standard deviation, and number of observations. The following was a listing of the average values reported for each of these three stations, respectively.

Flow-cfs	Temp - °C	TSS-mg/l	Cond-umhos/cm	DO-mg/l	FC-col/cl	Tot P mg/l	NH_3-N-mg/l	NO_3-N mg/l
--	22.4	158.8	671	6.98	369	0.529	0.089	1.531
1678.28	22.7	72.1	582	7.99	1571	0.274	0.171	0.800
4.93	23.5	33.5	838	8.70	332	0.151	0.117	0.103

Lavaca-Navidad River Authority

33. HDR Engineering, Inc., "Regional Assessment of Water Quality: Lavaca River Basin of Texas," in cooperation with the TWC, and the LNRA, October, 1, 1992.

Water quality in the Basin was generally satisfactory. There are two segments in the Lavaca-Navidad River Basin that are pertinent to the Trans-Texas project. These are the segments 1601 and 1604, which are defined to be the stretch of the Lavaca River which incorporates the Palmetto Bend Reservoir site, and the segment of the Navidad River which is Lake Texana, respectively.

For the period September 1, 1987 to August 31, 1991, segment 1601 had no violations of stream standards according to the TWC. Segment 1604 (Lake Texana), however, had one DO violation (4.2 mg/l versus the standard 5.0) and two slight sulfate violations (26 and 27 mg/l versus the standard 25) (sic). However, since 1988, the data show that dissolved oxygen has not been below 5.0 mg/l and sulfates have not exceeded 14.0 mg/l. (Note: The water quality data for the period of record is not included in the report.)

There were no TWC data on heavy metals, but the USGS data showed possible chronic aquatic states for lead, and definite chronic aquatic states for cadmium and mercury, respectively. The USGS data also showed the presence of minute quantities of DDD, DDE, 2, 4, 5-T, 2, 4-D, and PCBs in sediment samples while showing no presence of same in the water samples.

The major concerns for segments 1601 and 1604 were the presence of elevated FC, elevated average nutrient levels, and periodically low levels of DO in the bottom layers of Lake Texana. No solutions were proposed for dealing with these problems in this first assessment report; however, future assessments will include proposed solutions with budget projections and time-lines.

Colorado River Basin

34. Lower Colorado River Authority, "1992 Water Quality Assessment of the Colorado River Basin," in cooperation with the TWC, Upper Colorado River Authority, and the Colorado River Municipal Water District, Oct 1, 1992.

Like each of the other river basin reports, the amount of time allowed for the first report was less than one year, resulting in less-than-complete information for some parts of the basin. The major water quality issues and recommendations identified by the Lower Colorado River Authority (LCRA), Upper Colorado River Authority (UCRA), and the Colorado River Municipal Water District (CRMWD) as needing attention or further study included:

- <u>Citizen monitoring</u> - Participate with other agencies in the Joint Water Quality Monitoring Committee in Austin and investigate potential for similar coordination in other parts of the basin.

- <u>Steering Committees, public hearings</u> - continue to hold meetings and follow-up with responsible individuals.

- Municipal wastewater discharges - provide support for more aggressive enforcement of treatment violations by the TWC, and pursue policy alternatives to discharging directly into the Highland Lakes.

- Solid waste/hazardous waste management - Investigate feasibility of remediation programs, and expand household hazardous waste disposal program.

- Aquatic habitat - Design and implement biological monitoring program.

- Non-point source pollution - as the health impacts at the receiving end of municipal and agricultural NPS pollution.

- Depletion/degradation of major springs - evaluate impacts on major and historical springs.

- TSS, oil, and grease from sand and gravel mining - evaluate impacts of specific constituents on water quality and water use.

- Salinity, nutrient balance in West Matagorda Bay - design and implement data collection programs to evaluate the impacts of the Corps of Engineers' diversion, sedimentation, and nutrient loading.

The TWC classified each segment of the river as either water quality limited (WQL), or effluent limited (EL). The WQL designation signified either that the segment had been found to exceed the limits of the Texas Surface Water Quality Standards and required advanced waste treatment to bring it back to acceptable levels, or that the segment was a domestic water supply reservoir. The EL designation signified that conventional waste water treatment was adequate to protect existing water quality standards.

As of April, 1993, the segments of the Colorado that were of interest to the Trans-Texas project included:

- 1401 - Colorado River Tidal - WQL
- 1402 - Colorado River Below Smithville - EL
- 1305 - Caney Creek Above Tidal - WQL

Element 17.B listed the nonpoint source (NPS) pollutants for each river segment. Segments 1401 and 1402 were combined due to agricultural similarity. The pollutants found to be in excess of state or federal water quality standards were: chromium, lead, phosphorus, nitrate, sulfate, and TDS. Other NPS pollutants identified in these segments were arsenic, DDT,

Water Quality Criteria for Colorado River, 1991						
Segment	**Chlorides (mg/l)**	**D.O. (mg/l) min**	**Ph range (s.u.)**	**Temp. °C [a]**	**TDS (mg/l)**	**Fecal Coliform (#/100ml)[b]**
1401	**N.A.**	**4.0**	**6.5-9.0**	**95**	**N.A.**	**200**
1402	**90**	**5.0**	**6.5-9.0**	**95**	**450**	**200**

[a] annual avg not to exceed
[b] minimum for thirty day geometric mean

DDE, DDD, chlordane, mercury, sediment, and fecal coliform. As a result of the presence of these pollutants, the pH levels fluctuated above and below the segment standard. The high algae metabolism in the segment also contributed to the pH level fluctuation. The possible sources of NPS pollution were agricultural return flows, and urban runoff from Bay City, Wharton, Columbus, and La Grange.

Element 26 required a description of the water conservation goals and objectives of the river basin. For segments 1401 and 1402, the LCRA had a four-pronged plan, as follows:

- Canal rehabilitation - In its fifth year in 1992 at the Gulf Coast Irrigation District, this project involved the removal of undesirable vegetation, reshaping the banks for improved flow, and replacing control and delivery structures. The project was scheduled to be completed at the end of fiscal year 1996.

- On-farm water conservation research - Commonly referred to as "less water, more rice," this program was established to create a database of irrigation and farmer management practices to reduce on-farm water use and production costs. Results showed that the use of 25% to 30% less water could improve crop yield by an average of 17%.

- Water measurement - Initially tested in 1991, the measurement of water flow both in the canals and that delivered to individual farmers had been expanded to all LCRA-served acreage in 1992. The technique was being incorporated with a conservation incentive rate structure (Commissioners were still deciding on this issue in late Dec. 1992).

- Farmer education - Activities included the distribution of fact sheets, videos with practical information on better management practices, seminars and workshops, field demonstrations, and one-on-one consultations with farmers.

Brazos River Basin

35. Brazos River Authority, "Regional Assessment of Water Quality: Brazos River Basin including the Oyster Creek Watershed," in cooperation with the TWC, October 1, 1992.

The Brazos River Authority (BRA) concluded that the Brazos River has generally good quality water. This conclusion was reached by reviewing available historical water quality data, compiling citizen complaints and other sources of data, and tabulating the results by river segment and concern. The BRA also scored the various segments for water use impairment potential. From this process, the BRA identified six segments of the river to be of either high action priority or moderate-high action priority.

The Trans-Texas project was potentially concerned with Segment 1202, a moderate-high action priority segment defined as the Brazos River below the Navasota River. Segment 1245, Upper Oyster Creek, located in the coastal basin just east of the Brazos, was a high action priority segment. Although not directly affecting the South-Central part of Trans-Texas, its proximity to segment 1202 merits its recognition.

The Action Priority assessments by segments were used to address specific problems, and to develop general strategies for the mitigation of potential problems in the future which are shown to be trends now. The four general strategies developed were increased monitoring, quantifying specific source load impacts (e.g., confined animal industries), development of nutrient standards for each segment of the river, and calling for solutions to the natural salt loading from a shallow aquifer in the Panhandle.

One problem with the Action Priority designations acknowledged by the BRA was the disparity of observations per segment. Attempts are made to weight certain observations; however, this does not always remove the discrepancy. The BRA stresses the "starting point" nature of the Action Priority technique of problem identification. Modifications to the structure of the problem identification process would be made when adequate data are obtained.

The specific problems identified for segment 1202 included: elevated fecal coliform (FC) levels; elevated nutrients; elevated total dissolved solids (TDS); and toxic substances -pesticides and chemicals. The sources of information for these problems included:

- TWC Water Quality Inventory, 10th Edition;
- TWC Water Quality Data;
- TWC Complaint Data;
- TWC Fish Kill Data;
- Texas Watch, Citizen Monitoring Data;
- 1990 Update to NPS report; and
- E.P.A. Recommended Criteria.

The specific problems for segment 1245 include: elevated FC levels; does NOT meet swimmable standard; low dissolved oxygen (DO) levels; fish kills; elevated chlorides; elevated nutrients; and elevated sulfates. The sources of information for these problems included the same as above for Segment 1202, with one addition: personal communications with the City of Sugarland.

The BRA also reported its Citizen Steering Committee to be an invaluable source of information to the water quality assessment process, as well as helpful in communicating with the public on issues of water quality status and control.

The report included specific attention to the relevant segments 1201, 1202, and 1245, as summarized below.

<u>Segment 1201 - Brazos River Tidal</u>:

- Contains one classified sampling site under both TWC and USGS systems.

- City of Jackson performs monitoring in this watershed.

- Designated biological resource for striped bass spawning and migration and also designated as protected species habitat.

- Subsidence of land due to overdraft of groundwater.

- Pesticides in fish tissue.

- Elevated FC levels with 13% of the observations above the criteria.

- Numerous oil and chemical spills.

- Occasional elevated nutrient levels, ammonia, and phosphate.

- Over 50 percent of the complaints received by TWC concerned hazardous waste.

- Six fish kills have been reported; causes vary from red tide to suspected ammonia and toxic releases.

Segment 1202 - Brazos River below Navasota River:

- Contains five classified and six unclassified TWC sites, and the USGS monitors five sites.

- Two citizen monitoring groups are active.

- Designated as biological resource for striped bass spawning and migration and also designated as protected species habitat. Milk Creek is designated as a unique community for rare prairie and Big Creek is designated as a unique state holding.

- 25% of the TDS measurements exceeded limits.

- Elevated nutrient level, ammonia, and phosphates.

- Elevated FC; averages from all five stations were above criteria.

- Toxic substances; pesticides and chemicals have been listed as possible sources of concern.

- At least one low DO level recorded.

- Two documented fish kills are thought to be caused by either depressed DO levels, or low DO levels in one case and acid layer in the sediment in the other

Segment 1245 - Oyster Creek Watershed:

- Contains 20 classified and 12 unclassified sampling sites under the TWC with no USGS sites.

- A citizen monitoring group is active .

- A portion of the segment does not meet swimmable standards due to elevated FC; 50% of the observations were above the 200 cfu/Ml criteria and average values from three different stations were also above criteria.

- Four fish kills documented; attributable to DO depletion and unknown sources.

- Over 50% of the citizen complaints concerned hazardous wastes.

- Toxic substances (none listed) are affecting water quality.

- Low DO levels are reported from over 90% of the stations with levels less than 5.00 mg/l.

- Elevated chloride and sulfate levels with 25% of the samples exceeding TWC standards.

- Elevated nutrient levels with chronic high ammonia and phosphates reported along with occasional elevated nitrates.

- 33% of Ph levels were found to exceed standards.

The report did not include raw data (at least not for the three relevant segments). The information was given as percentage of observations above the specified criteria, and ranges of values were not provided. No relation was drawn in the report to the effect of flow on certain water quality elements. The Appendices of the report included the EPA and TWC criteria in a concise and easily understandable format.

36. Lower Colorado River Authority, "Water Supply and Demand Assessment of Matagorda County", 1990.

This report was prepared at the request of the Commissioner's Court of Matagorda County and the City Council of Bay City. The report includes a detailed county-wide assessment of available and potential water supplies to Matagorda County and examines availability though the year 2030. The report describes high, low, and base case population projections for the county. The base case population for the county in 2030 is 53,091. The study projects annual municipal water use for the county in 2030 of 7,963 acft/yr. Base case irrigation, mining, manufacturing, and steam electric water use is projected to be 238,594 acft/yr, 227 acft/yr, 38,200 acft/yr, and 2,600 acft/yr respectively. Total projected base water use for the county in 2030 is 287,584 acft/yr.

Water in the county is obtained from the Gulf Coast Aquifer and the Colorado River. The estimated annual groundwater availability from the Gulf Coast Aquifer is 18,222 acft/yr. Because of limited dependable groundwater supplies, ground water irrigation demand supply shortages ranging from 36,749 to 37,928 acft/year are forecasted from 1990 through 2030. Computer simulations of the Colorado River using the base case demands reveal that all projected firm surface water demands can be met through year 2030 with existing firm water supplies.

The report concludes that there are sufficient surface water supplies to meet projected base case surface demands and sufficient groundwater supplies to meet all non-irrigation groundwater demands. Five recommendations are presented to improve water quality, provide for additional supplies, and reduce the county's dependence on ground water for municipal systems.

37. Lower Colorado River Authority, "Water Supply and Demand Assessment of Colorado County", 1990.

This report was prepared at the request of the Colorado County Water Council. The report includes a detailed county-wide assessment of available and potential water supplies to Colorado County and examines availability through the year 2030. The study developed high, low, and base case population projections for the county. The base case population for the county in 2030 is 22,183. The study projects annual municipal water use for the county in 2030 of 3,339 acft/yr. Base case irrigation, mining, manufacturing, and steam electric water use is projected to be 192,435 acft/yr, 17,120 acft/yr, 3,838 acft/yr, and 5,249 acft/yr respectively. Total projected base water use for the county in 2030 is 221,981 acft/yr.

Surface water in the county is obtained primarily from Eagle Lake and the Colorado River. Computer simulations using the base case demand levels reveal that all projected firm surface water demands can be met through year 2030. Demands other than Garwood and Lakeside Irrigation are projected to experience shortages under base case conditions starting in 1990. Under high case demand projections, shortages are predicted for all irrigation demands.

Groundwater in the county is obtained from the Gulf Coast Aquifer. Currently, withdrawals from this aquifer are reportedly exceeding estimated annual availability. Shortages in groundwater availability are projected because of the limited groundwater availability within the county.

The report concludes with strategies for meeting future water quality and supply needs, and six recommendations to improve water quality, provide for additional supplies, and reduce the county's dependence on ground water for municipal systems.

38. Lower Colorado River Authority, "Water Supply and Demand Assessment of Wharton County", 1991.

This report was prepared at the request of the Wharton County Water Council. The report includes a detailed county-wide assessment of available and potential water supplies to Wharton County and examines availability through the year 2030. The study developed high, low, and base case population projections for the county. The base case population for the county in 2030 is 54,115. The study projects annual municipal water use for the county in 2030 of 7,792 acft/yr. Base case irrigation, mining and livestock, and manufacturing water use is projected to be 335,349 acft/yr, 6,948 acft/yr and 595 acft/yr respectively. Total projected base water use for the county in 2030 is 350,684 acft/yr.

Surface water in the county is obtained from two principle sources, the Highland Lakes and the Colorado River. Numerous other small sources supply a significant amount of water. Computer simulations using the base case demand levels reveal that all projected firm surface water demands can be met through year 2030. However, under high case conditions, major irrigation demands would experience shortages.

Groundwater in the county is obtained from the Gulf Coast Aquifer. Currently, withdrawals from this aquifer are reportedly exceeding estimated availability. Shortages in groundwater availability are projected because of the limited groundwater availability within the county.

The report concludes with strategies for meeting future water quality and supply needs and six recommendations to improve water quality, provide for additional supplies, and reduce the county's dependence on ground water for municipal systems.

39. Lower Colorado River Authority, Water Management Plan, Draft, July 11, 1990.

This report defines LCRA's water management principles, programs, and policies. Section One presents the Water Management Plan, Section Two presents the Drought Management Plan, and Section Three explains the determination of combined firm yield. The Water Management Plan establishes 15 key elements. The Drought Management Plan is defined through year 2000. The plan establishes criteria for the curtailment of stored water that is committed by contract or LCRA Board resolution and for interruptable water. The plan establishes a reserve storage pool and provides for gradual curtailment in order to protect the full demand of irrigation demand for the first rice crop in all years of the critical drought. Section Three describes the river modeling methodologies and the reservoir operation procedures of the LCRA.

APPENDIX B

12/7/92 HDR Memo on Channel Loss Study, Trans-Texas Project

APPENDIX B

To	Emmett Gloyna, Lavaca-Navidad River Authority James Dodson, City of Corpus Christi
From	Ken Choffel and Kelly Payne
Date	December 7, 1992
Subject	Trans-Texas Project Channel Loss Study - Pinoak and Sandy Creeks

HDR

Memorandum

A study was conducted from October 8th through October 16th, 1992 to determine channel losses in Pinoak and Sandy Creeks for the water being drained from rice fields in the Garwood Irrigation Co.'s service area. These are the creeks under consideration for delivery of Colorado River water into Lake Texana. The study area was broken into three reaches as delineated on the attached figure. The reaches cover the area beginning near the southern limits of Garwood Irrigation Co.'s (Garwood) service area to the upper limits of Lake Texana. The weather throughout the course of the study was warm and dry with the exception of the last day of the study when significant rainfall occurred. Streamflows during the study varied from a low of 32 cfs (cubic feet per second) to a high of 111 cfs. The most accurate and reliable data for each reach was obtained by field crew canoeing each reach and making discharge measurements of the main stem and all tributary inflows. Channel losses were then calculated by adding the streamflow at the upstream end of the reach to the tributary inflows, subtracting the flow at the downstream end of the reach, and adjusting for small changes in storage and estimated evaporation within the reach. The results obtained for each reach are discussed below:

Reach #1 runs approximately 7.0 miles from the intersection of Pinoak Creek and a county road crossing to four tenths of a mile upstream of the intersection of Pinoak Creek and FM 2546. The reach runs through the lower limits of Garwood's service area and is full of fallen trees and brushy debris that obstruct the channel in numerous places. The channel bottom was typically sandy throughout the reach. This reach was measured on October 13th. Total inflow to this reach was approximately 100.2 cfs with total losses measured and estimated at 5.1 cfs. The channel loss in this reach averaged 5.1 percent for the reach or 0.72 percent per mile.

Reach #2 runs approximately 6.8 miles beginning at the end of Reach #1 and ends at the intersection of Sandy Creek and FM 1300. The upper portion of this reach is characterized by wide and slow moving pools that exist between the FM 2546 bridge and Meek's Camp approximately one mile downstream. From Meek's Camp downstream the channel is relatively uniform with average widths of 35 feet on the Pinoak section and 60 feet in the Sandy section. The channel bottom in this reach was typically sandy throughout. This reach was measured in it's entirety on October 15th. Total inflow to this reach was approximately 152.9 cfs with total losses measured and estimated at 41.9 cfs. The loss in the reach was 27.4 percent or 4.0 percent per mile. A majority of this loss, over 80 percent, was confirmed by partial measurements taken on October 16th. This second day of reconnaissance was only partially completed due to rain.

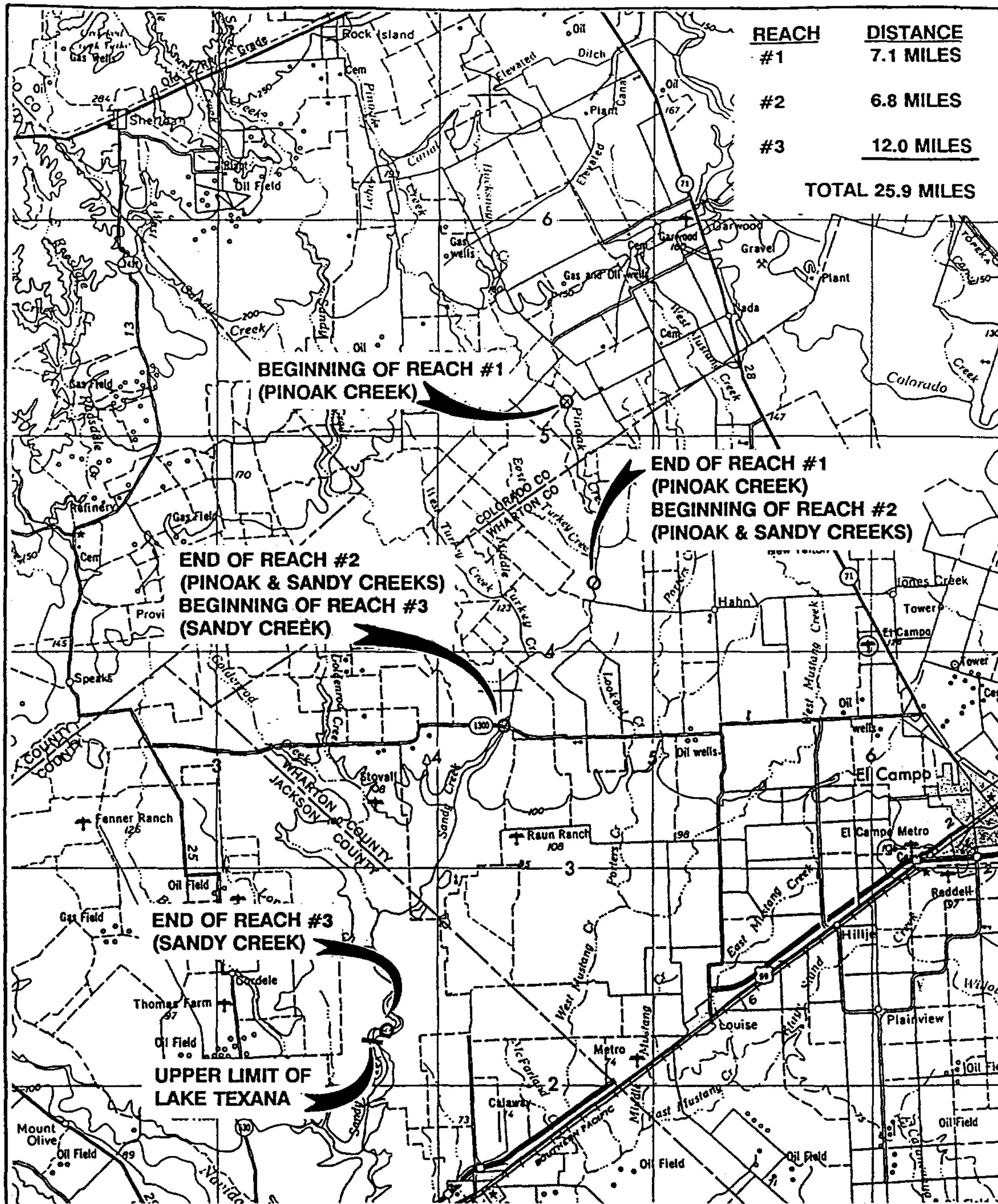
Reach#3 runs approximately 12.0 miles beginning at the end of Reach #2 to just above the upper limits of Lake Texana. This reach is characterized by a relatively uniform, clean channel with a sandy bottom and an average width of 63 feet. This reach was measured on October 8th. Total inflow to this reach was approximately 77.9 cfs with total losses measured and estimated at 5.9 cfs. The loss in this reach was 7.6 percent for the reach or 0.63 percent per mile.

The calculated channel loss rates for the three reaches are plotted along with the results of other channel loss studies conducted by the USGS for other Texas streams. The upper line represents the curve of relation for channel loss rates measured by the USGS on small watersheds. The lower line represents the curve of relation for channel loss rates measured by the USGS in water delivery studies. This relationship was developed based on actual data for some larger Texas streams such as the Colorado and Brazos Rivers. This relationship likely represents a lower limit of expected channel loss rates. As shown on the figure, Reaches #1 and #3 fall between the two USGS relationships signifying that these two reaches have reasonable loss rates as compared to the USGS data. Reach #2, however, is above the upper curve boundary, exhibits a high loss rate, and would not be a good candidate for use as a water delivery channel.

Conclusions: The relatively large loss rate in Reach #2 would discourage the use of Reach #1 or Reach #2 for water delivery purposes. The loss rate in Reach #3 is reasonable, when compared to the USGS channel loss studies at just over one half of a percent per mile. The use of Reach #3 to deliver water from the Colorado River to Lake Texana will probably be economically attractive and will be considered in the Trans-Texas project.

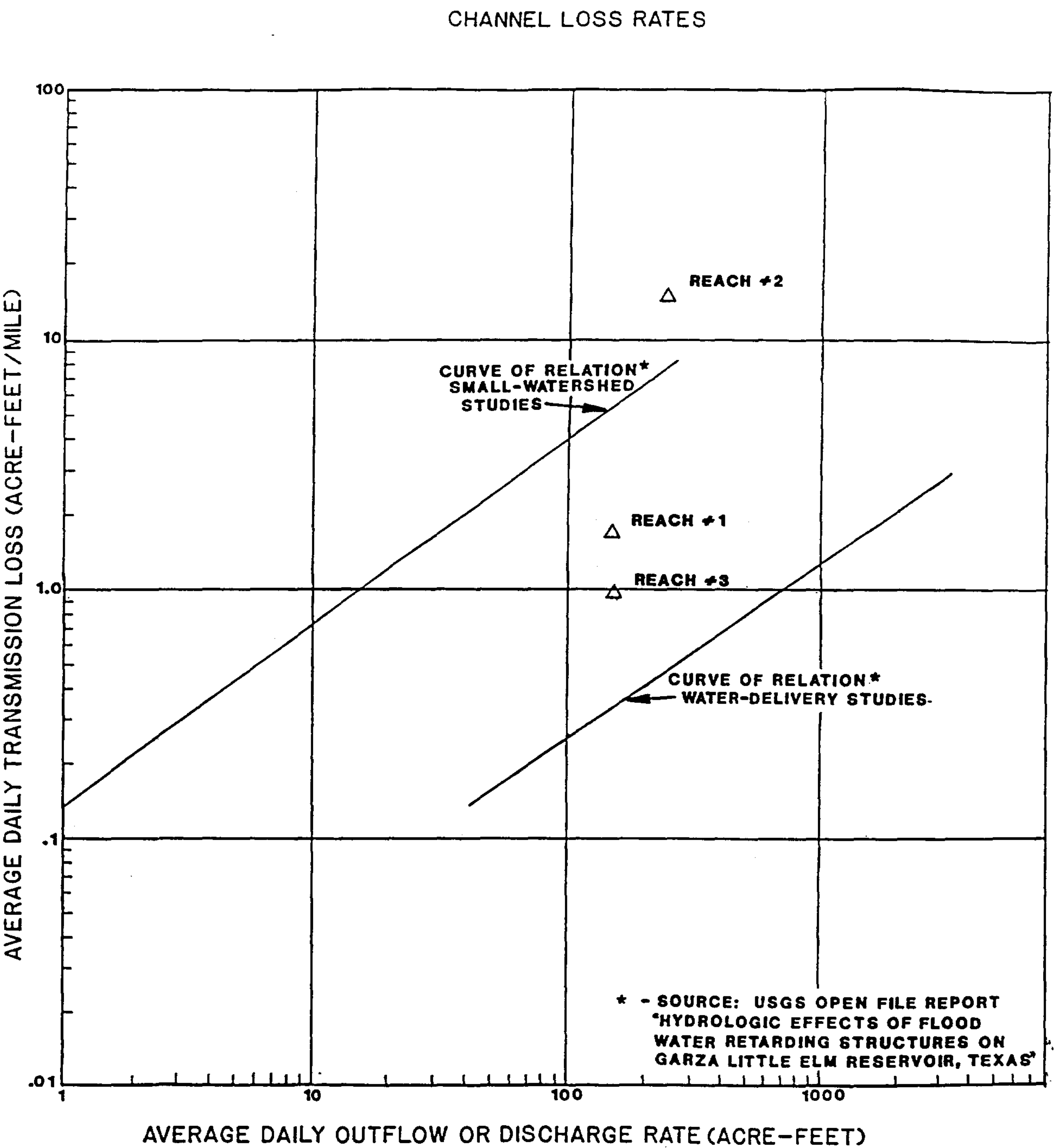
Estimated loss rates for Reach #3 at various delivery rates are as follows:

Delivery Rate		Channel Loss in Reach #3	Percent Loss
(cfs)	(ac-ft/day)	(ac-ft/day)	(%)
50	99.2	8.9	9.0
75	148.8	11.4	7.7
100	198.4	13.2	6.7
125	248.0	15.6	6.3
150	297.6	17.4	5.9



HDR Engineering, Inc.

CHANNEL LOSS STUDY



CHANNEL LOSS RATES
100
10
1.0
.1
.01
1
10
100
1000
AVERAGE DAILY TRANSMISSION LOSS (ACRE-FEET/MILE)
AVERAGE DAILY OUTFLOW OR DISCHARGE RATE (ACRE-FEET)
REACH #2
REACH #1
REACH #3
CURVE OF RELATION*
SMALL-WATERSHED
STUDIES
CURVE OF RELATION*
WATER-DELIVERY STUDIES
* - SOURCE: USGS OPEN FILE REPORT
"HYDROLOGIC EFFECTS OF FLOOD
WATER RETARDING STRUCTURES ON
GARZA LITTLE ELM RESERVOIR, TEXAS"

APPENDIX C

Protected Endangered and Threatened Species

APPENDIX C --TABLE 1
PROTECTED ENDANGERED AND THREATENED SPECIES, ARANSAS COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 &17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Aplomado Falcon	*Falco femoralis*	Grasslands and coastal prairies; open terrain with scattered trees; nests in yuccas and mesquite	E	E	[1] Possible; transient/ historic
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	wintering / transient
Becard, Rose-throated	*Pachyramphus aglaiae*	Wooded canyons, forests, riversides, large trees; nests in Rio Grande Valley south of Falcon Dam	NL	T	wintering / transient possible endemic
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast waters and bays	E	E	endemic
Eskimo Curlew	*Numenius borealis*	Coastal plains	E	E	[1] Possible; at periphery migratory
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	E	E	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Sooty Tern	*Sterna fuscata*	Coastal wetland islands during breeding season; offshore and Gulf of Mexico at other times	NL	T	wintering / transient
Swallow-Tailed Kite	*Elanoides forficatus*	Open forested areas	NL	T	[1]confirmed / transient
Tyrannulet, Breadless -, Northern	*Camptostoma imberbe*	Extreme Southern Rio Grande Valley	NL	T	rare
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Desert grasslands, prairie brushlands	NL	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migratory
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] confirmed
Zoned-tailed Hawk	*Buteo albonotatus*	Desert Mountains and western rivers	NL	T	[1]possible / migratory
Coati	*Nasua nasua*	Arid open plains, Rio Grande plains	NL	E	[1]possible endemic
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	[1] probable

*USFWS DOES NOT LIST ENDANGERED IN TEXAS

APPENDIX C -- TABLE 1 (CONTINUED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland, live oak mottes; primarily extreme south Texas	E	E	[1] Probable
Dolphin, Rough-Toothed	*Steno bredanensis*	Offshore waters; usually off edge of continental shelf	NL	T	[1] Possible; at periphery
Dolphin, Spotted, Atlantic	*Stenella plagiodon*	Offshore waters 5mi ; seasonally may approach shore	NL	T	[1] Possible; at periphery
Whale, Black Right	*Balaena glacialis*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Blue	*Balaenoptera musculus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Dwarf Sperm	*Kogia simus*	Gulf of Mexico and coastal bays	NL	T	[1] Possible; at periphery
Whale, False Killer	*Pseudorca crassidens*	Gulf of Mexico and coastal bays	NL	T	[1] Possible; at periphery
Whale, Fin	*Balaenoptera physalus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Gervais' Beaked	*Mesoplodon europaeus*	Probably warm temperate offshore waters	NL	T	[1] Possible; at periphery
Whale, Goose-Beaked	*Ziphius cavirostris*	Gulf of Mexico	NL	T	[1] Possible; at periphery
Whale, Killer	*Orcinus orca*	Gulf of Mexico and occasionally large rivers	NL	T	[1] Possible; at periphery
Whale, Pygmy Killer	*Feresa attenuata*	Gulf of Mexico	NL	T	[1] Possible; at periphery
Whale, Pygmy Sperm	*Kogia breviceps*	Deep Gulf waters; close to shore during calving season	NL	T	[1] Possible; at periphery
Whale, Short-Finned	*Globicephala macrorhynchus*	Deep offshore waters; sometimes close to shore	NL	T	[1] Possible; at periphery
Whale, Sperm	*Physeter macrocephalus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Green Turtle, Atlantic	*Chelonia mydas mydas*	Gulf coast and bay waters and beaches	T	T	endemic
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1]confirmed occurrence
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E	[1] confirmed occurence
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	T	E	[1] confirmed occurence
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E	[1] confirmed occurence

APPENDIX C -- TABLE 1 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING AGENCY USFWS	LISTING AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Cat-eyed Snake, Northern	*Leptodeira s. septentrionalis*	Coastal thorn thicket; principal microhabitat is dense vegetation bordering ponds and watercourses	NL	E	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Racer, Specked	*Drymobius margaritiferus*	Dense thickets heavily littered with plant debris; generally near water	NL	E	possible
Texas Scarlet Snake	*Cemophora coccinea lineri*	Sand floored thicket immediately adjacent to the Gulf	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic
Opposum Pipefish	*Microphis brachyurus*	Gulf of Mexico south coastal bays in various habitats, *Spartina* marshes or *Sargassum*	NL	T	confirmed
Black Lace Cactus	*Echinocereus reichenbachii albertii*	Grows in extremely heavy brush and very localized	E	E	possible
Lila de los Llanos / Chandlers Crag Lily	*Anthericum chandleri*	Lower Rio Grande Valley; South Coastal Texas	C2	NL	endemic
Roughseed Sea-purslane	*Sesuvium trianthemoides*	Dunes of coastal South Texas	C2	NL	possibly extinct
Slender Rush-pea	*Hoffmannseggia tenella*	Gulf Coast prairies and marshes; clayey soils near creeks with buffalo grass, spear grass, mesquite and prickly pear	E	E	endemic
South Texas Ragweed	*Ambrosia cheiranthiflora*	Open prairie, various shrublands on deep clay soils	C1	NL	endemic
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants; also roadsides and with coastal prairie edemics in slightly saline soils in bare areas around pimple mounds	C2	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED[1]

SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPENDIX C -- TABLE 2
PROTECTED ENDANGERED AND THREATENED SPECIES, ATASCOSA COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1995
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	winter transient
Black-capped vireo	*Vireo atricapillus*	Semi-open Broad-leaved shrublands	E	E	nesting/migratory
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast waters and bays	E	E	transient
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oak and old juniper	E	T	nesting
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas; southern U.S. coastal plains	NL	T	transient
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	migratory
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] confirmed occurrence
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas Islands	E	E	[1]migratory
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and wooded river bottoms in Southwest U.S.A.	NL	T	[1] probable
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	[1] confirmed occurrence
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	C2	T	[2]probable

* LISTED ENDANGERED BUT NOT IN TEXAS

APPENDIX C -- TABLE 2 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2	NL	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]probable
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	[1]probable
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer	3C	NL	endemic
Silvery Wild Mercury	*Argythamnia argyraea*	South Texas Plains, perennial herb, also in Kinney, LaSalle and Maverick Counties	3C	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED

[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 94 & MARCH 1995

[2] DIXON , 1987

APPENDIX C --TABLE 3
PROTECTED ENDANGERED AND THREATENED SPECIES, BEE COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1994) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	nesting; wintering
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Red Wolf	*Canis rufus*	Southern riparian and pine forests; may only remain in Liberty Chambers and Jefferson Co.s [2]	E	E	historic range
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	C2	T	[2]probable
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation ;grass, cactus, scattered brush; soil may vary from sandy to rocky, burrows in soil, rodent burrow, or hides under rocks			[1]probable endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies, sand hills; thorn brush woodland and mesquite savannah coastal plain	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of Rio Grande Valley, lower South Texas Plains, South Coastal Prairie and marshes	NL	T	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.
SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995; [1] TPWD MAY, 1988.; [2]ARMSTRONG ET AL, 1986* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C -- TABLE 4
PROTECTED ENDANGERED AND THREATENED SPECIES, BEXAR COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING AGENCY		POTENTIAL OCCURRENCE IN COUNTY
			USFWS	TPWD	
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	[1]winter transient
Black-capped vireo	*Vireo atricapillus*	Semi-open Broad-leaved shrublands	E	E	nesting/migratory
Golden-cheeked Warbler	*Dendroica chrsoparia*	Woodlands with oaks and old juniper	E	E	nesting/migrant
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	[1]migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	[1]migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	[1]migratory
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas; southern U.S. coastal plains	NL	T	[1]transient
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	[1]migratory
Wood Stork	*Mycteria americana*	Post-breeding; in wetlands of the coastal plain, major waterways, and lower Mississippi valley	E[2]	T	dispersal
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas Islands	E	E	[1]migratory
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and wooded river bottoms in Southwest U.S.A.	NL	T	endemic
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1	NL	[3]endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[1]probable
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	[1]endemic
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2	NL	[3]endemic

APPENDIX C -- TABLE 4 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Timber Rattlesnake	*Crotalus horridus*	Bottomland hardwoods	NL	T	[1]possible
Blind Texas Salamander	*Typhlomolge rathbuni*	Edwards Aquifer springs and caves, thermally stable; troglobitic	E	E	[3]endemic
Toothless Blindcat	*Trogloglanis pattersoni*	Edwards Aquifer; subterranean; from artesian wells in Bexar Co., TX; troglobitic [4;6]	C2	T	endemic
Widemouth Blindcat	*Satan eurystomus*	Edwards Aquifer; subterranean; from artesian wells in Bexar Co., TX; troglobitic [4;5]	C2	T	endemic
Texas Cave Diving Beetle	*Haideoporus texanus*	Edwards Aquifer subterranean caverns[7;8;9;10]	C2	NL	endemic
Balcones Cave Amphipod	*Stygobromus balconis*	Limestone caves [10]	C2	NL	endemic
Bifurcated Cave Amphipod	*Stygobromus bifurcatus*	Spring openings [10]	C2	NL	endemic
Texas Cave Shrimp	*Palaemonetes antrorum*	Ezell's Cave and Edwards Aquifer subterranean caverns [7;8]	C2	NL	endemic
Mimic Cave Snail	*Phreatodrobia imitata*	Edwards Aquifer subterranean caverns; from artesian wells in Bexar Co., TX; troglobitic [11]	C2	NL	endemic
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer	3C	NL	endemic
Silvery Wild Mercury	*Argythamnia argyraea*	South Texas Plains, perennial herb, also in Kinney, LaSalle and Maverick Counties	3C	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED

[1] SOURCE: TPWD, 05/09/88

[2] ENDANGERED POPULATIONS ALABAMA, FLORIDA, GEORGIA, NORTH CAROLINA, SOUTH CAROLINA

[3] DIXON, 1987

[4] LONGLEY & KARNEI 1979A,

[5] LONGLEY & KARNEI 1979B,

[6] LONGLEY, 1979;

[7] W.R. ELLIOT, PERS. COM. JANUARY 1993;

[8] SISSOM & DAVIS 1979;

[9] YOUNG & LONGLEY, 1976;

[10] J. R. REDDELL, PERS. COM. JANUARY 1993;

[11] HERSHLER & LONGLEY, 1986

SOURCE FOR ALL OTHER OCCURRENCES IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPENDIX C -- TABLE 5

PROTECTED ENDANGERED AND THREATENED SPECIES, BROOKS COUNTY, TEXAS

LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering transient
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic/ nesting
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Gulf Coast hog-nosed Skunk	*Conepatus leuconotus texensis*	Gulf Coast from Aransas Co. to Cameron; brushlands; usually nocturnal and secretive	C1	NL	potential
Red Wolf	*Canis rufus*	Oak-hickory -pine forest, southern riparian forest; may still exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	[1] historic
Texas Tortoise	*Gopherus berlandieri*	Open brush - grass understory; open grass and bare ground are avoided; occupies shallow depression at base of bush/cacti; active Mar.-Nov.	NL	T	[1]possible endemic
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	endemic
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic

* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C --TABLE 5 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-September	NL	T	[3] endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988. OCCURENCE SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994, MARCH 1995;

[2] ARMSTRONG ET.AL., 1986

[3] DIXSON, 1987

APPENDIX C -- TABLE 6
PROTECTED ENDANGERED AND THREATENED SPECIES, CALHOUN COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Attwater's Prairie-Chicken	*Typanuchus cupido attwateri*	Short grass prairies of the Texas coastal plain	E	E	endemic
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites; nesting in riparian forests near water	E	E	wintering / nesting
Becard, Rose-throated	*Pachyramphus aglaiae*	Wooded canyons, forests, riversides, large trees	NL	T	[1]possible endemic
Brown Pelican	*Pelecanus occidentalis*	Gulf, salt bays and coastal areas	E	E	[1]confirmed endemic
Eskimo Curlew	*Numenius borealis*	Coastal fields	E	E	[1] confirmed migratory
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	E	E	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Sooty Tern	*Sterna fuscata*	Coastal wetland islands	NL	T	[1]probable; wintering/ transient
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded areas	NL	T	[1]probable endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] probable
Dolphin, Rough-Toothed	*Steno bredanensis*	Offshore waters, usually off edge of continental shelf	NL	T	[1] possible; at periphery
Dolphin, Spotted, Atlantic	*Stenella plagiodon*	Generally offshore 5 mi. or 100 fathoms deep; seasonally may approach very close to shore	NL	T	[1] possible; at periphery
Whale, Black Right	*Balaena glacialis*	Gulf of Mexico and coastal bays	E	E	[1] possible; at periphery
Whale, Blue	*Balaenoptera musculus*	Gulf of Mexico and coastal bays	E	E	[1] possible; at periphery

* LISTED ENDANGERED BUT NOT IN TEXAS

APPENDIX C -- TABLE 6 (CONTINUED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Whale, Finback	*Balaenoptera physalus*	Gulf of Mexico and coastal bays	E	E	[1] possible; at periphery
Whale, Sperm	*Physeter macrocephalus*	Gulf of Mexico and coastal bays	E	E	[1] possible; at periphery
Whale, Dwarf Sperm	*Kogia simus*	Gulf of Mexico and coastal bays	NL	T	[1] possible; at periphery
Whale, Pygmy Sperm	*Kogia breviceps*	Deep offshore waters; close to shore when calving	NL	T	[1] possible; at periphery
Whale, False Killer	*Pseudorca crassidens*	Tropical and temperate seas; Gulf of Mexico; occasionally stranded in bays or estuaries	NL	T	[1] possible; at periphery
Whale, Killer	*Orcinus orca*	Gulf of Mexico; occasionally large rivers	NL	T	[1] possible; at periphery
Whale, Pygmy Killer	*Feresa attenuata*	Warm offshore waters	NL	T	[1] possible; at periphery
Whale, Gervais' Beaked	*Mesoplodon europaeus*	Warm temperate offshore waters	NL	T	[1] possible; at periphery
Whale, Goose-Beaked	*Ziphius cavirostris*	Gulf of Mexico	NL	T	[1] possible; at periphery
Whale, Short-Finned	*Globicephala macrorhynchus*	Deep offshore waters; sometimes close to shore	NL	T	[1] possible; at periphery
Green Sea Turtle	*Chelonia mydas mydas*	Gulf coast, bay waters and beaches	E	T	[1]confirmed
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches	E	E	[1]probable
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1] probable
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast and bay waters and beaches; scattered beach nesting	T	E	[1] confirmed
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1] confirmed
Texas Diamondback Terrapin	*Malaclemys terrapin*	Gulf coast shoreline	C2	NL	endemic

APPENDIX C – TABLE 6 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov.	NL	T	endemic
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 in soil, rodent burrow, or hides under rocks when inactive	C2	T	endemic
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows	C2	NL	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grassy prairies to sand hills, usually thorn brush woodland and mesquite savannah of coastal prairies	NL	T	endemic
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-Sept.	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods	C2	E	[1] possible; at periphery
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]confirmed
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	[1]confirmed

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER OF CONCERN; NC-USFWS NOT OF CONCERN; NL-TPWD NOT LISTED; E-ENDANGERED; T-THREATENED.

[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994 & MARCH 1995

APPENDIX C --TABLE 7
PROTECTED ENDANGERED AND THREATENED SPECIES, COLORADO COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1994) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Coastal prairie; native grassland with diverse habitat of short-, mid-, and tallgrass prairie	E	E	endemic
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering, nesting
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Swallow-tailed Kite, American	*Elanoides forficatus*	forests in water, Southern US coastal plains	NL	T	[1]probable endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic/nesting
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Red Wolf	*Canis rufus*	Southern riparian and pine forest; may exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	historic
Houston Toad	*Bufo Houstonensis*	Loamy soils temporary rain pools, flooded field, ponds surrounded by forest or grass; reintroduced Colorado Co. Texas	E	E	endemic
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic

* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C --TABLE 7 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Timber Rattlesnake	*Crotalus horridus*	Riparian woods, in dense vegetation	NL	T	endemic
Western Smooth Green Snake	*Opeodrys vernalis blanchardi*	Coastal grasslands	NL	E	[1]probable endemic
Blue Sucker	*Cycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major freshwater streams of Texas to Rio Grande River	C2	T	[1]possible, at periphery
Guadalupe Bass	*Micropterus treculi*	Rivers of the Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio River Basins; also the lower Colorado River and introduced in the Nueces River system	C2	NL	endemic
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows in Texas, Louisiana, Illinois	C2	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.
[1] TPWD MAY, 1988.
[2] ARMSTRONG ET.AL.,1986
SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994, MARCH 1995

APPENDIX C --TABLE 8
PROTECTED ENDANGERED AND THREATENED SPECIES, DUVAL COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Common Black Hawk	*Buteogallus anthracinus*	Nesting in trees on floodplains of the Lower Rio Grande; wintering in Mexico and south Texas	NL	T	[1] possible,wintering
Gray Hawk	*Buteo nitidus*	Nesting in trees on floodplains of the Lower Rio Grande; wintering in Mexico and south Texas	C2	T	[1] possible,wintering
Golden-checked Warbler	*Dendroica chrysoparia*	Nesting in about 31 counties in central Texas; ashe juniper-oak woodlands of the Edward's Plateau ; adjacent areas with similar geology; Brazos and Colorado River basins	E	T	migratory
Interior Least Tern	*Sterna antillarum athalassos*	Nesting on large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Swallow-tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas near water; tall trees for nesting; southern U.S. coastal plains	NL	T	transient
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic/nesting
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and wooded river bottoms in Southwest U.S.A.	NL	T	[1] probable
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	[1] confirmed occurrence

* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C --TABLE 8 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Red Wolf	*Canis rufus*	Southern riparian and pine forest; may exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	[1] possible, historic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[2]probable
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	[1]probable resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	resident
Texas Scarlet Snake	*Cemophora coccinea lineri*	Sand floored thicket immediately adjacent to the Gulf	NL	T	resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	resident
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	resident
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	resident
Black Lace Cactus	*Echinocereus reichenbachii* var. *albertii*	Openings in dense brush on sandy soils on South Texas Plains	E	E	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988.

[2] ARMSTRONG ET.AL.,1986

SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994 & MARCH 1995

APPENDIX C --TABLE 9
PROTECTED ENDANGERED AND THREATENED SPECIES, GOLIAD COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1995) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1995)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Attwater's Prairie-Chicken	*Typanuchus cupido attwateri*	Short grass prairies of the Texas coastal plain	E	E	endemic
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering / nesting
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oak and old juniper	E	T	[1] possible; periphery
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	[1]confirmed occurrence
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	[1] confirmed occurrence
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	endemic
Texas Scarlet Snake	*Cemophora coccinea lineri*	mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-Sept.	NL	T	endemic

* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C --TABLE 9 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988.

SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , MAY, 1993

APPENDIX C -- TABLE 10

PROTECTED ENDANGERED AND THREATENED SPECIES, JACKSON COUNTY, TEXAS

LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites; nesting in riparian forests near water	E	E	wintering / nesting
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	resident
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	resident
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	resident
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	resident
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Texas Diamondback Terrapin	*Malaclemys terrapin*	Littoral zone and coastal waters of Gulf of Mexico	C2	NL	
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation (grass, cactus, scattered brush , scrubby trees);when inactive burrows in soil (various rocky to sandy), rodent burrow, or hides under rocks	C2	T	resident
Marshelder Dodder	*Cuscuta attenuata*	Parasitic; only collected on Marsh-Elder *Iva annua* in Texas[2]	C2	NL	[2]endemic

* LISTED ENDANGERED BUT NOT IN TEXAS

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED

[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

[2] PERS. COMM. TPWD, RESOURCE PROTECTION DIV., 1993.

APPENDIX C -- TABLE 11
PROTECTED ENDANGERED AND THREATENED SPECIES, JIM WELLS COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	transient/winter
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	migratory
White-tailed Hawk	*Buteo albicaudatus*	Desert grasslands, prairie brushlands	NL	T	migratory
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migratory
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] possible
Zoned-tailed Hawk	*Buteo albonotatus*	Desert Mountains and western rivers	NL	T	[1]possible / migratory
Coati	*Nasua nasua*	Arid open plains, Rio Grande plains	NL	E	[1]possible
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	[1] probable
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland, live oak mottes; primarily extreme south Texas	E	E	[1] probable
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic
Black Lace Cactus	*Echinocereus reichenbachii albertii*	Grows in extremely heavy brush and very localized	E	E	endemic
South Texas Ragweed	*Ambrosia cheiranthiflora*	Open prairie, various shrublands on deep clay soils	C1	NL	endemic
Lila de los Llanos / Chandlers Crag Lily	*Anthericum chandleri*	Lower Rio Grande Valley; South Coastal Texas	C2	NL	endemic

* LISTED ENDANGERED BUT NOT IN TEXAS
SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED
[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88
SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPE... ...C—TABLE 12

PROTECTED ENDANGERED AND THREATENED SPECIES, KARNES COUNTY, TEXAS

LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering/transient
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Red Wolf	*Canis rufus*	Southern riparian and pine forest; may exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	[1] possible, historic
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[2]probable
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation grass, cactus, scattered brush or scrubby trees; soil may vary from sandy to rocky, burrows in soil, enters rodent burrow, or hides under rocks	C2	T	[1]probable endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic

* NOT LISTED ENDANGERED IN TEXAS

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988.

SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994 & MARCH 1995

APPENDIX C -- TABLE 13
ENDANGERED AND THREATENED SPECIES, KLEBERG COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND LISTED FOR PROTECTION BY TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

COMMON NAME	SCIENTIFIC NAME	SUMMARY OF HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Gulf Coast Hog-nosed Skunk	*Conepatus leuconotus texensis*	Central and West Texas rocky foothills, partly timbered and brushlands; usually nocturnal	C1	NL	potential
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	possible; habitat buffer zone
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	area is habitat buffer zone; possible endemic
Audubon's Oriole	*Icterus graduacauda audubonii*	South Texas dense woods, midlevel in trees foraging in pairs	C2	NL	potential
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby roosting/resting sites	E	E	wintering / transient
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	E	E	[1]possible endemic
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Loggerhead Shrike	*Lanius ludovicianus migrans*	South Texas	C2	NL	potential
Mountain Plover	*Charadrius montanus*	arid plains, short grass prairies and arid plains	C2	NL	potential
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	E	E	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Sennett's Hooded Oriole	*Icterus cucullatus sennetti*	South Texas; dense palm frons, cotton woods and willows in riparian areas	C2	NL	potential
Sooty Tern	*Sterna fuscata*	Pantropical, nesting on offshore islands Florida, historically bred on Louisiana and Texas shore	NL	T	transient/ nesting
Texas Botteri's Sparrow	*Aimophila botterii texana*	South Texas in dense tall grass; very secretive	C2	T	potential
Texas Olive Sparrow	*Arremonops rufivirgatus rufivirgatus*	South Texas in brushy thickets; secretive	C2	NL	potential

APPENDIX C -- TABLE 13 (CONTINUED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
Wood Stork *	*Mycteria americana*	Coastal wetlands	NL *	T	dispersal
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and forested rivers of the Southwest U.S.A.	NL	T	trainsient
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods	C2	E	endemic
Green Turtle, Atlantic	*Chelonia mydas mydas*	Gulf coast and bay waters and beaches	T	T	endemic
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1]good potential
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	T	E	[1]confirmed occurence
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E	good potential
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic
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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	good potential
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Northern Cat-eyed Snake	*Leptodeira s. septentrionalis*	Coastal thorn thicket; principal microhabitat is dense vegetation bordering ponds and watercourses	NL	E	endemic

*LISTED ENDANGERED BUT NOT IN TEXAS

APPENDIX C -- TABLE 13 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Texas Scarlet Snake	*Cemophora coccinea lineri*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-September	NL	T	endemic
Speckled Racer	*Drymobius margaritiferus*	Far South Texas; dense thickets near water, Texas palm groves, riparian woodlands; often areas with much vegetation litter on ground	NL	E	potential
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic
Opposum Pipefish	*Microphis brachyurus*	Gulf of Mexico south coastal bays in various habitats, *Spartina* marshes or *Sargassum*	NL	T	confirmed
Bailey's Ballmoss	*Tillandsia baileyi*	South Texas, Rio Grande Valley on trees	C2	NL	good potential
Black Lace Cactus	*Echinocereus reichenbachii* var. *albertii*	Openings in dense brush on sandy soils on South Texas Plains	E	E	endemic
Chandler Craig-lily (lila de los llanos)	*Anthericum chandleri*	Remnant native grasslands; grasslands and openings in subtropical woodlands and brush on clay soils; common in windblown saline clay on lomas near mouth of Rio Grande	C2	NL	endemic
Slender Rush-pea	*Hoffmannseggia tenella*	In grasslands on heavy clay soils of coastal plain, can occur in disturbed areas	E	E	endemic
South Texas Ragweed (Ambrosia)	*Ambrosia cheiranthifolia*	Open prairie, various shrublands on deep clay soils	C1	NL	endemic

SYMBOLS UNDER LISTING AGENCY: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED

[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88.

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995; AND PRICE ASSOCIATES, 1993.

APPENDIX C --TABLE 14
PROTECTED ENDANGERED AND THREATENED SPECIES, LIVE OAK COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering/transient
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	possible; habitat buffer zone
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[2]probable
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 in soil, enters rodent burrow, or hides when inactive	C2	T	[1]probable endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; thorn brush woodland, mesquite savannah of coastal plain	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground in dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions;	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie	NL	T	endemic

* NOT LISTED ENDANGERED IN TEXAS

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988.

SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPENDIX C --TABLE 15
PROTECTED ENDANGERED AND THREATENED SPECIES, MCMULLEN COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1995) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	wintering\ transient
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Red Wolf	*Canis rufus*	Oak-hickory -pine forest, southern riparian forest; may still exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	[1] historic
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[2]probable
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation, grass, cactus, scattered brush or scrubby trees; soils vary sandy to rocky; burrows, enters rodent burrow, or hides under rocks	C2	T	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]probable
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	[1]probable

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.

[1] TPWD MAY, 1988. SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994 & MARCH 1995

* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C --TABLE 16
PROTECTED ENDANGERED AND THREATENED SPECIES, NUECES COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1995) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Aplomado Falcon	*Falco femoralis*	Grasslands Prairies	E	E	[1] Possible; at periphery/migratory
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	wintering / transient
Becard, Rose-throated	*Pachyramphus aglaiae*	Wooded canyons, forests, riversides, large trees; nests in Rio Grande Valley south of Falcon Dam	NL	T	wintering / transient possible endemic
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast waters and bays	E	E	endemic
Eskimo Curlew	*Numenius borealis*	Coastal plains	E	E	[1] Possible; at periphery migratory
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	E	E	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Sooty Tern	*Sterna fuscata*	Coastal wetland islands during breeding season; offshore and gulf at other times	NL	T	wintering / transient
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open forested areas	C3	T	[1]confirmed / transient
Tyrannulet, Breadless -, Norther	*Camptostoma imberbe*	Extreme Southern Rio Grande Valley	NL	T	rare
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Desert grasslands, prairie brushlands	NL	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migratory
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] confirmed
Zoned-tailed Hawk	*Buteo albonotatus*	Desert Mountains and western rivers	NL	T	[1]possible / migratory
Coati	*Nasua nasua*	Arid open plains, Rio Grande plains	NL	E	[1]possible endemic
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	[1] probable

*USFWS DOES NOT LIST ENDANGERED IN TEXAS

APPENDIX C -- TABLE 16 (CONTINUED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland, live oak mottes; primarily extreme south Texas	E	E	[1] Probable
Dolphin, Rough-Toothed	*Steno bredanensis*	Offshore waters; usually off edge of continental shelf	NL	T	[1] Possible; at periphery
Dolphin, Spotted, Atlantic	*Stenella plagiodon*	Offshore waters 5mi. or 100 fathoms; seasonally may approach close to shore	NL	T	[1] Possible; at periphery
Whale, Black Right	*Balaena glacialis*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Blue	*Balaenoptera musculus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Dwarf Sperm	*Kogia simus*	Gulf of Mexico and coastal bays	NL	T	[1] Possible; at periphery
Whale, False Killer	*Pseudorca crassidens*	Gulf of Mexico and coastal bays	NL	T	[1] Possible; at periphery
Whale, Fin	*Balaenoptera physalus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Whale, Gervais' Beaked	*Mesoplodon europaeus*	Probably warm temperate offshore waters	NL	T	[1] Possible; at periphery
Whale, Goose-Beaked	*Ziphius cavirostris*	Gulf of Mexico	NL	T	[1] Possible; at periphery
Whale, Killer	*Orcinus orca*	Gulf of Mexico and occasionally large rivers	NL	T	[1] Possible; at periphery
Whale, Pygmy Killer	*Feresa attenuata*	Gulf of Mexico	NL	T	[1] Possible; at periphery
Whale, Pygmy Sperm	*Kogia breviceps*	Deep Gulf waters; close to shore during calving season	NL	T	[1] Possible; at periphery
Whale, Short-Finned	*Globicephala macrorhynchus*	Deep offshore waters; sometimes close to shore	NL	T	[1] Possible; at periphery
Whale, Sperm	*Physeter macrocephalus*	Gulf of Mexico and coastal bays	E	E	[1] Possible; at periphery
Green Turtle, Atlantic	*Chelonia mydas mydas*	Gulf coast and bay waters and beaches	T	T	endemic
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1]confirmed occurrence
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E	[1] confirmed occurence
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	T	E	[1] confirmed occurence
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E	[1] confirmed occurence

APPENDIX C -- TABLE 16 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Cat-eyed Snake, Northern	*Leptodeira s. septentrionalis*	Coastal thorn thicket; principal microhabitat is dense vegetation bordering ponds and watercourses	NL	E	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Racer, Specked	*Drymobius margaritiferus*	Dense thickets heavily littered with plant debris; generally near water	NL	E	possible
Texas Scarlet Snake	*Cemophora coccinea lineri*	Sand floored thicket immediately adjacent to the Gulf	NL	T	endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic
Opposum Pipefish	*Microphis brachyurus*	Gulf of Mexico south coastal bays in various habitats, *Spartina* marshes or *Sargassum*	NL	T	confirmed
Black Lace Cactus	*Echinocereus reichenbachii albertii*	Grows in extremely heavy brush and very localized	E	E	possible
Lila de los Llanos / Chandlers Crag Lily	*Anthericum chandleri*	Lower Rio Grande Valley; South Coastal Texas	C2	NL	endemic
Roughseed sea-purslane	*Sesuvium trianthemoides*	Dunes of coastal South Texas	C2	NL	possibly extinct
Slender Rush-pea	*Hoffmannseggia tenella*	Gulf Coast prairies and marshes; clayey soils near creeks with buffalo grass, spear grass, mesquite and prickly pear cactus	E	E	endemic
South Texas Ragweed	*Ambrosia cheiranthiflora*	Open prairie, various shrublands on deep clay soils	C1	NL	endemic
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants; also roadsides and with coastal prairie edemics in slightly saline soils in bare areas around pimple mounds	C2	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE FOR PROTECTION, HOWEVER, CONCLUSIVE DATA ON BIOLOGICAL VULNERABILITY IS NOT AVAILABLE TO USFWS; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPENDIX C --TABLE 17
PROTECTED ENDANGERED AND THREATENED SPECIES, REFUGIO COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Attwater's Prairie-Chicken	*Typanuchus cupido attwateri*	Short grass prairies of the Texas coastal plain	E	E	endemic
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites; nesting in riparian forests near water	E	E	wintering / nesting
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	E	E	[1]possible endemic
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oak and old juniper	E	T	[1] possible; periphery
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	E	E	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas	NL	T	transient
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] confirmed occurrence
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	[1]confirmed occurrence
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	[1] confirmed occurrence

* THE WOOD STORK IS LISTED ENDANGERED, BUT NOT IN TEXAS.

APPENDIX C --TABLE 17 (CONTINUED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Red Wolf	*Canis rufus*	Oak-hickory -pine forest, southern riparian forest; may still exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	historic range
Green Turtle, Atlantic	*Chelonia mydas mydas*	Gulf coast and bay waters and beaches; scattered beach nesting	T	T	[1]probable
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1]probable
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast and bay waters and beaches; scattered beach nesting	T	E	[1]probable
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1] probable
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf coast shoreline	C2	NL	endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov.	NL	T	confirmed endemic
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation (grass, cactus, scattered brush, scrubby trees); when inactive burrows in soil (various texture, sandy to rocky), rodent burrow, or hides under rocks	C2	T	confirmed endemic
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries and beaches; crayfish and fiddler crab burrows	C2	NL	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grassland Prairie to sand hills; usually thorn brush woodland and mesquite savannah of coastal plains	NL	T	endemic

[2] ARMSTRONG ET.AL., 1986

APPENDIX C -- TABLE 17 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Texas Scarlet Snake	*Cemophora coccinea lineri*	mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-Sept.	NL	T	endemic
Timber rattlesnake	*Crotalus horridus*	Bottomland woodlands	NL	T	[1]confirmed endemic
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods	C2	E	[1]probable
Mexican Treefrog	*Smilisca baudinii*	Rio Grande Valley, vegetation in wet areas	NL	T	[2]confirmed
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]probable
Black Lace Cactus	*Echinocerus reichenbachii var. albertii*	Brushy, grassy areas with huisache, mesquite, blackbrush, retama, shrubs; South Texas Plains	E	E	[3]endemic
Plains Gumweed	*Grindelia oolepis*	Tight black clay-gumbo soils in coastal part of Rio Grande Plains	3C	NL	endemic
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants; also roadsides and with coastal prairie edemics in slightly saline soils in bare areas around pimple mounds	C2	NL	endemic
Welder Machaeranthera	*Machaeranthera heterocarpa*	Shrub invaded grasslands and rights-of-way on mostly gray colored clayey to silty soils over Beaumont and Lissie Formations	C2	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; 3C-USFWS NO LONGER UNDER REVIEW FOR PROTECTION; E-ENDANGERED; T-THREATENED; NL- NOT LISTED FOR PROTECTION.

[1] SOURCE: TPWD, MAY, 1988

[2] POSSIBLE ACCIDENTAL INTRODUCTION (DIXON, 1987)

[3] SOURCE: 1991. TPWD, ENDANGERED RESOURCES ANNUAL STATUS REPORT (E.R.A.S.R.) APPENDIX G SPECIAL PLANT LIST.

SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES , JANUARY 1994 & MARCH 1995

APPENDIX C -- TABLE 18

PROTECTED ENDANGERED AND THREATENED SPECIES, SAN PATRICIO COUNTY, TEXAS

LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1995) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1995)

AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Brown Pelican	*Pelecanus occidentalis*	Ocean, bays and coastal	E	E	endemic
Interior Least Tern	*Sterna antillarum athalassos*	Large river sand bars	E	E	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Piping Plover	*Charadrius melodus*	Coastal beaches and mudflats	T	T	wintering / transient
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-Faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
White-Tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	migratory
Black -Spotted Newt	*Notophthalmus meridionalis*	Wet or temporarily wet areas such as arroyos, canal, ditches and shallow depressions; aestivates underground during dry periods	C2	E	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporarily wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture to remain	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]possible

*USFWS DOES NOT LIST ENDANGERED IN TEXAS

APPENDIX C --TABLE 18 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Littoral zone and coastal waters of Gulf of Mexico	C2	NL	endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush - grass understory; open grass and bare ground are avoided; occupies shallow depression at base of bush/cacti; active Mar.-Nov.	NL	T	[1]possible endemic
Timber Rattlesnake	*Crotalus horridus*	Prefers dense extensive forest; also open upland pine and deciduous woods and second growth pasture of unused farmland; botomland woodlands	NL	T	[1]possible endemic
Indigo Snake	*Drymarchon corais erebennus*	Grassland prairies to coastal sandhills; prefers woodland and mesquite savannah of coastal plain	NL	T	endemic
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 in soil, rodent burrow, or hides under rocks when inactive	C2	T	endemic
Mathis Spiderling	*Boerhavia mathisiana*	Open thorn shrublands in shallow sandy to gravely soils over limestone or on bare limestone or caliche outcrops; vicinity of Lake Corpus Christi	C2	NL	endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE FOR PROTECTION WITH SUBSTANTIAL INFORMATION TO SUPPORT APPROPRIATENESS OF LISTING IN USFWS FILES; C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER OF CONCERN; NL-TPWD NOT LISTED; E-ENDANGERED; T-THREATENED.
[1] SOURCE OF OCCURRENCE IN COUNTY: TPWD, 05/09/88
SOURCE FOR ALL OTHER OCCURRENCE IN COUNTY: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995

APPENDIX C -- TABLE 19
PROTECTED ENDANGERED AND THREATENED SPECIES, VICTORIA COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1995)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Attwater's Prairie-Chicken	*Typanuchus cupido attwateri*	Short grass prairies of the Texas coastal plain	E	E	endemic
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites; nesting in riparian forests near water	E	E	wintering / nesting
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays and coastal areas	E	E	possible
Eskimo Curlew	*Numenius borealis*	Coastal Prairie	E	E	[1] possible; at periphery
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open forested areas	NL	T	migratory
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] probable
Red Wolf	*Canis rufus*	Varied, Coastal Prairie and sandhills	E	E	historic range
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	[1]probable
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporally wet areas, arroyos,canals,ditches and shallow depressions; requires moisture to remain	C2	E	endemic

* Not listed endangered in Texas

APPENDIX C --TABLE 19 (CONCLUDED)

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Green Sea Turtle	*Chelonia mydas mydas*	Gulf coast and bay waters and beaches; scattered beach nesting	NL	T	probable
Hawksbill Sea Turtle	*Eretmochelys imbricata imbricata*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1]possible
Indigo Snake	*Drymarchon coralis*	Grassland Prairie to coastal sand hills; preferswoodland and mesquite savannah of Coastal Plain	NL	T	endemic
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast and bay waters and beaches; scattered beach nesting	E / T[3]	E	possible
Ridley, Kemp's, Sea Turtle	*Lepidochelys kempi*	Gulf coast and bay waters and beaches; scattered beach nesting	E	E	[1] possible
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf coast bays and beaches; littoral zones	C2	NL	endemic
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 in soil, rodent burrow, or hides under rocks when inactive	C2	T	endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov.	NL	T	endemic
Timber Rattlesnake	*Crotalus horridus*	Bottomland woodlands	NL	T	[1] endemic
Texas Scarlet Snake	*Cemophora coccinea lineri*	mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-Sept.	NL	T	probable
Guadalupe Bass	*Micropterus treculi*	Rivers of the Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio River Basins; also the lower Colorado River and introduced in the Nueces River system	C2	NL	[1] possible
Welder Machaeranthera	*Machaeranthera heterocarpa*	shrubland invaded grasslands, rights-of-way, and open mesquite - huisache woodlands on mostly grey colored clayey to slity soils over Beaumont and Lissie formations on the coastal prairie	C2	NL	endemic

Symbols under listing agency are as follows: C1-USFWS Candidate for protection with substantial information to support appropriateness of listing in USFWS files; C2-USFWS Candidate Category for protection; 3C-USFWS no longer under review for protection; E-Endangered; T-Threatened; NL- not listed

[1] Source: TPWD, 05/09/88

[2] Source: 1991. TPWD, Endangered Resources Annual Status Report (E.R.A.S.R.) Appendix G Special Plant List.

Source for all other occurrence in county: Texas Natural Heritage Program Files , January 1994 & March 1995

[3] Threatened in Texas, Endangered in breeding colony populations in Florida and along the Pacific coast of Mexico

APPENDIX C --TABLE 20
PROTECTED ENDANGERED AND THREATENED SPECIES, WHARTON COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

COMMON NAME	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Near large water bodies with near by resting sites, nesting in forested river bottoms	E	E	nesting/ wintering
Brown Pelican	*Pelecanus occidentalis*	Ocean, salt bays, and coastal areas	E	E	endemic
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	endemic
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	[1] migratory
Red Wolf	*Canis rufus*	Southern riparian and pine forest; may exist in Liberty, Chambers, Jefferson Counties,TX [2]	E	E	historic
Black-spotted newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	C2	E	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic
Reticulated Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	endemic
Rio Grande Lesser Siren	*Siren intermedia texana*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; requires moisture	C2	E	endemic
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes	NL	T	endemic

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 in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	[1]probable endemic

SYMBOLS UNDER LISTING AGENCY ARE AS FOLLOWS: C1-USFWS CANDIDATE CATEGORY C2-USFWS CANDIDATE CATEGORY FOR PROTECTION; C3-USFWS NO LONGER A CANDIDATE FOR PROTECTION; NL- NOT LISTED FOR PROTECTION; E-ENDANGERED; T-THREATENED.
[1] TPWD MAY, 1988.
SOURCE: TEXAS NATURAL HERITAGE PROGRAM FILES, JANUARY 1994 & MARCH 1995
* NOT LISTED ENDANGERED IN TEXAS

APPENDIX C -- TABLE 21

PROTECTED ENDANGERED AND THREATENED SPECIES, WILSON COUNTY, TEXAS

LISTED BY THE U.S. DEPARTMEMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994) AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	winter transient [1]
Black-capped vireo	*Vireo atricapillus*	Semi-open Broad-leaved shrublands	E	E	nesting/migratory [1]
Golden-cheeked Warbler	*Dendroica chrsoparia*	Woodlands with oaks and old juniper	E	E	nesting/migrant
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory [1]
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory [1]
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory [1]
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas; southern U.S. coastal plains	NL	T	transient [1]
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	migratory [1]
Wood Stork *	*Mycteria americana*	Coastal wetlands, dispersal	E *	T	migratory [1]
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas Islands	E	E	migratory [1]
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and wooded river bottoms in Southwest U.S.A.	NL	T	endemic [1]
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic [1]
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[2]probable
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 in soil, enters rodent burrow, or hides or under rocks when inactive.	C2	T	endemic [4]
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	endemic [1]
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2	NL	endemic [3]
Big Red Sage	Salvia penstemonoides		C2		endemic, historical [4]

Parks Jointweed	Polygonella parksii	3C	NL	endemic

* LISTED ENDANGERED BUT NOT IN Texas

[3] Dixson, 1987

[4] TPWD, NHP, Special Plant List, last observed or collected prior to 1930

APPENDIX C TABLE 22

Summary of Environmental Effects by Alternative

Alternative	N-1 Modify Existing Reservoir Operating Policy (Variable Target)	N-2 Diversion from Nueces River to Coke Canyon	N-3 R&M Reservoir
New Additional Water Supply (acft/yr)	11,000	900	A) 92,000 B) 57,500
Interbasin Water Transfer	no	no	no
Flow to Estuary Change (median)	+3% to +10% (monthly range)	-0.2%	A) -16.5% B) -10.3%
River Flow Change	change below CC increase below LCC	minor reduction below diversion	much of lower Nueces River inundated
Land Use and Vegetation Types Affected by Construction[1]			
Woodland (acres)		2	6,642
Park (acres)			2,781
Brushland (acres)			3,398
Grass / Cropland (acres)		85	16,219
Wetland (acres)		<1	446
Long term Impacts (acres)[2]		25	31,340
Known Occurrence of Federal and State Protected Species Within Project Area		no	no
Possible Habitat for Federal and State Protected Species Within Project Area		yes	yes

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Recorded Cultural Resources in Project Area	no	yes
National Register of Historic Places in Project Area	no	yes

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	N-4 Purchase of Existing Water Rights in Nueces Basin	N-5 Pipeline from Choke Canyon to Lake Corpus Christi	N-6 Pipeline from Lake Corpus Christi to Calallen
New Additional Water Supply (acft/yr)	lower) 3,260 upper) 4,000	18,000	6,500
Interbasin Water Transfer	no	no	no
Flow to Estuary Change (median)	-0.5% - 2.7% (monthly range)	+2%	+1%
River Flow Change	increase Nueces River (minor)	-15% - -25% (monthly range) below CCR	-20%- -40% (monthly range) below LCC
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)			
Park (acres)			
Brushland (acres)		431	260
Grass / Cropland (acres)		78	130
Wetland (acres)		1	1
Long term Impacts (acres)		145	113
Known Occurrence of Federal and State Protected Species Within Project Area		yes	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes
Recorded Cultural Resources in Project Area	yes	yes
National Register of Historic Places in Project Area	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	N-7 Dredging Lake Corpus Christi	L-1 Desalination	L-2A Local Ground-water Options (Gulf Coast Aquifer
New Additional Water Supply (acft/yr)	7,200-23,000	>100,000	8,330
Interbasin Water Transfer	no	no	no
Flow to Estuary Change (median)	no	+15.9%	+1.3%
River Flow Change	no	no	increase below LCC
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)			
Park (acres)			
Brushland (acres)			
Grass / Cropland (acres)			
Wetland (acres)			
Long term Impacts (acres)	2,000-20,000	hypersaline discharge	
Known Occurrence of Federal and State Protected Species Within Project Area	no	no	no
Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes	no

?ENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Recorded Cultural Resources in Project Area	no	no	no
National Register of Historic Places in Project Area	no	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	L2-B Local Ground-water Options (Gulf Coast Aquifer)	L2-C, D & E Local Groundwater Options (Gulf Coast Aquifer)	L2-F & G Local Groundwater Options (Gulf Coast Aquifer)
New Additional Water Supply (acft/yr)	8,960	11,200	
Interbasin Water Transfer	no	no	no
Flow to Estuary Change (median)	+1.4%	+1.8%	
River Flow Change			
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)			
Park (acres)			
Brushland (acres)			
Grass / Cropland (acres)			
Wetland (acres)			
Long term Impacts (acres)	201	207	115
Known Occurrence of Federal and State Protected Species Within Project Area	no	no	
Possible Habitat for Federal and State Protected Species Within Project Area	yes	no	

APPENDIX C TABLE 22

Summary of Environmental Effects by Alternative

Recorded Cultural Resources in Project Area	no	no
National Register of Historic Places in Project Area	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	L-3 Use of Ground-water from Campbellton Wells (Carrizo Aquifer)	L-4 Municipal Wastewater Reuse (Nueces Delta)	L-5 Industrial Water Use Evaluation
New Additional Water Supply (acft/yr)	4,800	5,500	
Interbasin Water Transfer	no	no	
Flow to Estuary Change (median)	+0.8%	increase to Delta	
River Flow Change	no	no	
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)			
Park (acres)			
Brushland (acres)	249		
Grass / Cropland (acres)	43		
Wetland (acres)	1		
Long term Impacts (acres)	84	74	
Known Occurrence of Federal and State Protected Species Within Project Area	no	yes	
Possible Habitat for Federal and State Protected Species Within Project Area	no	yes	

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Recorded Cultural Resources in Project Area	no	yes
National Register of Historic Places in Project Area	no	

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	L-6 Accelerated Municipal Water Conservation	L-7 Groundwater re-charge and Recovery (Carrizo/WilcoxAquifer)	S-1 Goliad Reservoir
New Additional Water Supply (acft/yr)	6,300	40,300	60,000
Interbasin Water Transfer	no	no	yes
Flow to Estuary Change (median)		+6.4%	-6.4 (average)[5] +9.5%[10]
River Flow Change			-3% - 50% (monthly medians)
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)			3,028
Park (acres)			
Brushland (acres)			850
Grass / Cropland (acres)			24,807
Wetland (acres)			556
Long term Impacts (acres)		1,190	29,000
Known Occurrence of Federal and State Protected Species Within Project Area		yes	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes
Recorded Cultural Resources in Project Area	yes	no
National Register of Historic Places in Project Area	yes	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	GS-1 Diversion from Guadalupe and San Antonio Rivers (McFaddin Reservoir)	LN-1 Lake Texana Pipeline to Corpus Christi	LN-2 Palmetto Bend (Phase II) Reservoir
New Additional Water Supply (acft/yr)	37,200	31,440-41,840	30,000
Interbasin Water Transfer	yes	yes	yes
Flow to Estuary Change (median)	<-1%[5] +6.0%[10]	-2.8%[6] +5.0 - 6.7%[10]	-5.1%[6] +4.8%[10]
River Flow Change		-5.0%[7]	-8.3%[7]
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)	12	20	1,100
Park (acres)	27	65	300
Brushland (acres)	76	235	
Grass / Cropland (acres)	390	1,478	4,150
Wetland (acres)	182	140	450
Long term Impacts (acres)	902	504	7,000
Known Occurrence of Federal and State Protected Species Within Project Area	no	yes	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes	yes
Recorded Cultural Resources in Project Area	no	yes	no
National Register of Historic Places in Project Area	no	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	LN-3 Diversion from Lavaca River to Lake Texana[1]	C-1A Purchase and Diversion of Water Rights to Corpus Christi	C-1B Purchase and Diversion of Water Rights to Corpus Christi
New Additional Water Supply (acft/yr)	<3,000	29,000	32,000
Interbasin Water Transfer	yes	yes	yes
Flow to Estuary Change (median)		-2%[8] +4.6%[10]	-2%[8] +5.1%[10]
River Flow Change		-2%[9]	-2%[9]
Land Use and Vegetation Types Affected by Construction			
Woodland (acres)		24	24
Park (acres)			
Brushland (acres)			
Grass / Cropland (acres)		248	248
Wetland (acres)		2	2
Long term Impacts (acres)	19	78	78
Known Occurrence of Federal and State Protected Species Within Project Area		no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes
Recorded Cultural Resources in Project Area	no	no
National Register of Historic Places in Project Area	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Alternative	C-2 Purchase of Colorado River Water	B-3 Purchase of Brazos River Water
New Additional Water Supply (acft/yr)	29,000	29,000
Interbasin Water Transfer	yes	yes
Flow to Estuary Change (median)	-2%[8] +4.6%[10]	+4.6%[10]
River Flow Change	-2%[9]	<-1%[11]
Land Use and Vegetation Types Affected by Construction		
Woodland (acres)	34	712
Park (acres)		
Brushland (acres)		
Grass / Cropland (acres)	373	7,600
Wetland (acres)	2	255
Long term Impacts (acres)	116	8,591
Known Occurrence of Federal and State Protected Species Within Project Area	no	no

APPENDIX C TABLE 22
Summary of Environmental Effects by Alternative

Possible Habitat for Federal and State Protected Species Within Project Area	yes	yes
Recorded Cultural Resources in Project Area	no	no
National Register of Historic Places in Project Area	no	no
1 Vegetation Types from TPWD (1984) 2 Area affected by reservoir inundation, maintained ROW, etc. 3 Environmental studies not pursued for reasons other than environmental issues 4 San Antonio River includes 63,435 acft/yr net evaporation 5 Guadalupe-San Antonio Estuary	6 Lavaca Estuary 7 Lavaca-Navidad River, median 8 Colorado Estuary 9 Colorado River, median 10 Nueces Estuary	11 Brazos River, average

APPENDIX D

Summary of Water Quality Data

APPENDIX D: SUMMARY OF WATER QUALITY DATA

This Appendix presents analyses of the water quality conditions at seven locations in south-central Texas. These locations coincide with the more significant surface water alternatives included in this study. The water quality assessment is designed to provide a general perspective of water quality in the lower Nueces River Basin as well as the potential effects of blending Nueces River water with water from other sources, i.e.; San Antonio River at Goliad, Guadalupe River at Victoria, Lake Texana, Colorado River at Wharton, and Brazos River at Richmond. Specifically, this section addresses the following issues:

- Present quality of the raw feed-water at the O. N. Stevens Treatment Plant (Stevens) at Calallen;
- Water quality at Stevens after blending with water from each of the five alternative sources; and
- Comparison of water quality for each of the five alternative sources, before and after blending, with drinking water standards.

In Texas, the Texas Natural Resource Conservation Commission (TNRCC) is responsible for setting standards to assure the safety of public drinking water supplies. The TNRCC Drinking Water Standards are divided into two groups, Primary and Secondary. The 1986 Federal Safe Drinking Water Act (SDWA) Amendments directed the U.S. Environmental Protection Agency (EPA) to regulate concentrations of 83 Primary Constituents (23 inorganics, 14 volatile organics, 35 other organics, 6 related to microbiology or turbidity, and 5 radionuclides) for all public drinking water supplies. The 1986 SDWA was to have been phased in over a period of three years with all 83 constituents regulated by 1989. Congress also directed the EPA to add 25 new constituents to the regulated list every three years with no limit on the number of additions. In addition to the list of 83 SDWA constituents, the TNRCC maintains a list of Secondary Drinking Water (SDW) Standards which is comprised of common water quality characteristics and constituents, i.e.; Chloride, Color, Copper, Corrosivity, Fluoride, Foaming agents, Hydrogen sulfide, Iron, Manganese, Odor, pH, Sulfate, Total Dissolved Solids, and Zinc. The SDW Standards are recommended limits for existing water supplies. For new water system developments, any excursion of the SDW Standards must have the written approval of the TNRCC. However, written approval will not be granted if there is an alternate water supply available which will meet all of the SDW Standards at a reasonable cost.

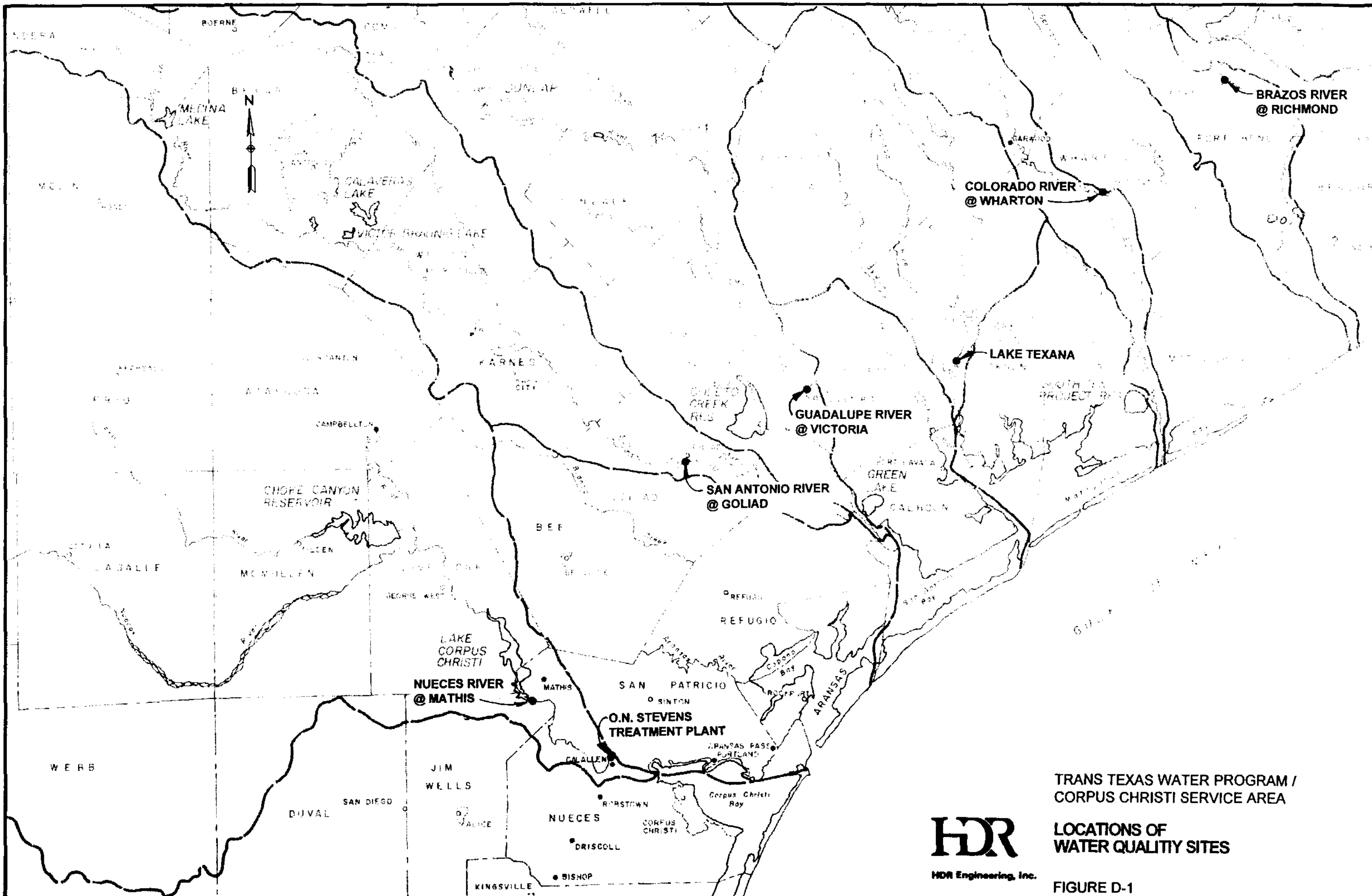
There are three secondary water quality constituents, for which data are available, that have historically presented problems in the Corpus Christi Service Area. Data for these three constituents, as well as data on hardness, were available at the seven sites (see Figure D-1). These constituents include:

- Chlorides (mg/l);
- Sulfates (mg/l);
- Total Dissolved Solids (TDS) (mg/l); and
- Hardness (mg/l).

The present study does not consider the primary water quality standards for three reasons: 1) In south Texas, the primary water quality constituents have not presented major problems in surface water sources, 2) If a problem exists, treatment is possible and in most cases conventional treatment will be all that is required, and 3) Data for primary standards are not readily available since the laboratory analyses are very costly. As a matter of precaution, there is a chance that other water quality constituents, either primary or secondary, may be present in isolated instances. In this case, it is recommended that in later phases of the Trans-Texas study more comprehensive water quality assessments be made of the raw water sources for Corpus Christi. This would include testing the water for primary and secondary constituent levels as well as a sanitation survey of the watershed area to ascertain the potential for spills in the proximity of the water source. It should be stressed that chances for detecting a problematic constituent are minimal as water from the six surface water sources being considered are currently being used for drinking water by communities in the respective river basins.

Although not directly used for comparison, conductivity was also used in estimating missing values of the other constituents. Conductivity, which is dependent upon the dissolved solids content of water, is closely correlated with the four constituents listed above.[1] Use of

[1] Once a relationship is established between conductivity and a constituent for a given location, it is generally assumed that the relationship will remain constant, barring significant changes in the system. The R^2 values for the USGS data sets were all greater than 0.98 with the majority greater than 0.99.



TRANS TEXAS WATER PROGRAM /
CORPUS CHRISTI SERVICE AREA

LOCATIONS OF
WATER QUALITIY SITES

FIGURE D-1

conductivity to calculate estimates of constituent levels was utilized in estimating data for Lake Texana as well as filling in missing data for several of the other water sources.

The calculation of the four constituents at Lake Texana required information from two sources. The LNRA provided monthly conductivity data for the period of record on Lake Texana (11/1980 to 5/1993 from station 8b). The conductivity regression coefficients for Lake Texana, calculated by the United States Geological Survey (USGS), were then used to determine the levels of the four constituents.[2]

Several agencies provided the monthly water quality data for the period of record for the other six locations. The Texas Natural Resources Information System (TNRIS) supplied the following five sets of USGS station data:

Nueces River at Mathis	1967 to 1993
San Antonio River at Goliad	1967 to present
Guadalupe River at Victoria	1967 to present
Colorado River at Wharton	1967 to present
Brazos River at Richmond	1976 to present

The City of Corpus Christi provided data from the Stevens intake at Calallen Dam, which covers the period from 1976 to the present. However, the Stevens data includes only values for two of the four constituents chosen for the analysis; chlorides and hardness. This lack of complete data at Stevens limits the blended water quality analysis to two constituents. However, the data for the other two constituents at the five sites can be compared in relative terms, since the water to be blended is well below the drinking water standards limit.

In the five USGS data files obtained through TNRIS, a few of the years from the 25 years of data were missing one or two months. Three procedures were used to fill in these missing data points. The first was to calculate the constituent value given the conductivity values and the USGS regression equation for that specific location. If there were no USGS coefficients available, then the second procedure was to develop a regression equation using the conductivity values available for that location along with the corresponding constituent values. If there were no conductivity values available, then the third procedure was to take an average

[2] The statistical significance of the linear regressions were as follows: chlorides - R^2 = 99, TDS - R^2 = 98, hardness - R^2 = 88.8, and sulfates - R^2 = 35. Although the R^2 for sulfates is quite low, so are the levels of sulfates at each of the five other locations resulting in little cause for concern.

of the data points immediately preceding and following the missing value.[3]

Of the four constituents, chloride concentrations present the biggest threat to water quality standards in the lower Nueces River Basin. The Secondary Drinking Water (SDW) Standard for chlorides is 300 mg/l. Although there has not been a SDW Standard excursion since 1979, the variability of the constituent in the basin, and its as yet unexplained increase in the 35-mile river reach from Lake Corpus Christi to the O.N. Stevens Treatment Plant give some cause for concern (Figures D-2 and D-3).

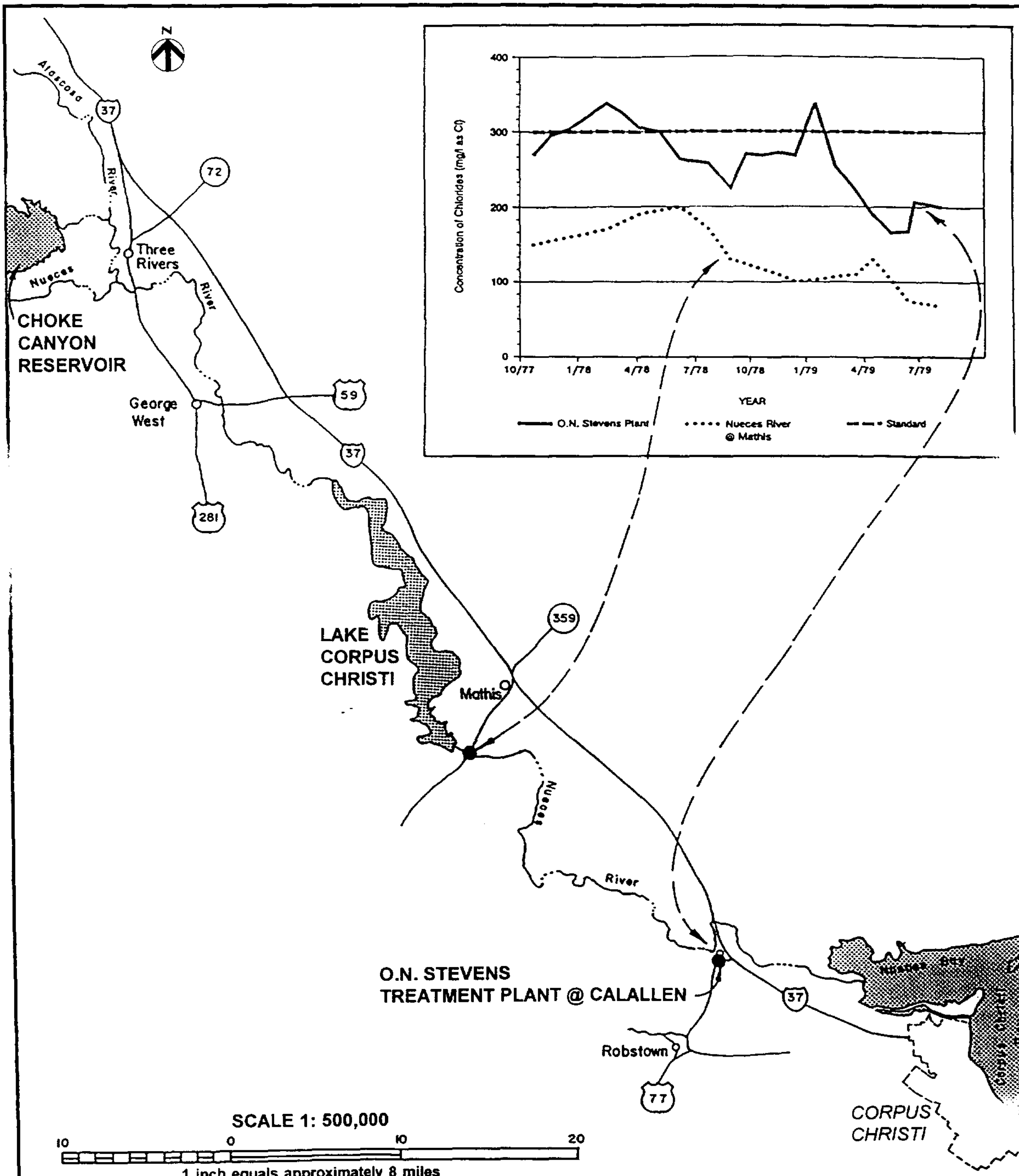
D.1 Water Quality for the Nueces River (at Mathis and O.N. Stevens)

The Nueces River Basin plays the strongest role in determining the water quality of the Coastal Bend region. Water quality in the Nueces River Basin is generally considered to be good. However, there is some cause for concern given the atypical rise in chlorideconcentration over the 35-mile stretch of the Nueces River between Lake Corpus Christi and Calallen Diversion Dam.

Since 1977, the chloride concentration, as measured at Mathis, has ranged from 25 to 225 mg/l lower than at Stevens (Figures D-2 and D-3). Although there have been no SDW Standard excursions (the horizontal dashed line at 300 mg/l in Figures D-2 and D-3) since the spring of 1979, the chloride levels threaten to exceed the SDW Standard. During the early 1980's drought, the chloride level at Stevens increased above 270 mg/l five separate times (Figure D-3).

The cause of the increase in the level of chlorides in the river reach between Mathis and Calallen was the subject of a number of studies through the 1960's. The May 1968 report, "Water-Delivery Study, Lower Nueces River Valley, Texas," written by the USGS in cooperation with the TWDB and the Lower Nueces River Water Supply District (LNRWSD) provided an overview of these studies. The report found that the increased mineralization was due to a combination of groundwater inflow, and deliveries of oil field and gravel washing waste from several tributaries. The report also determined the level of groundwater inflow from the surrounding alluvium was dependent upon the stage of the river. The flows from the tributaries,

[3] Except for Lake Texana, the majority of the values used in the analyses were measured values.



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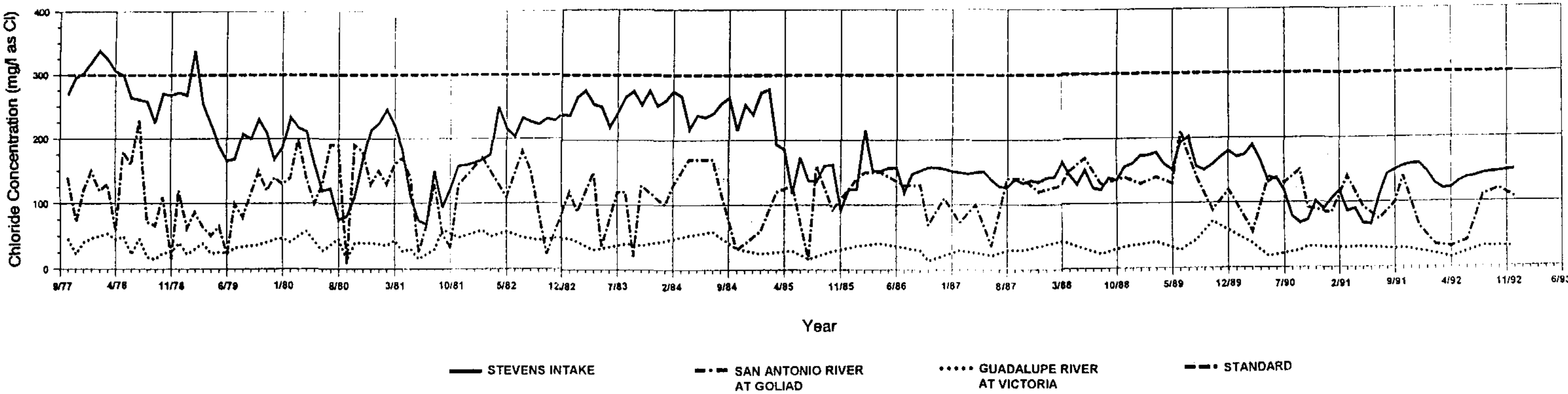
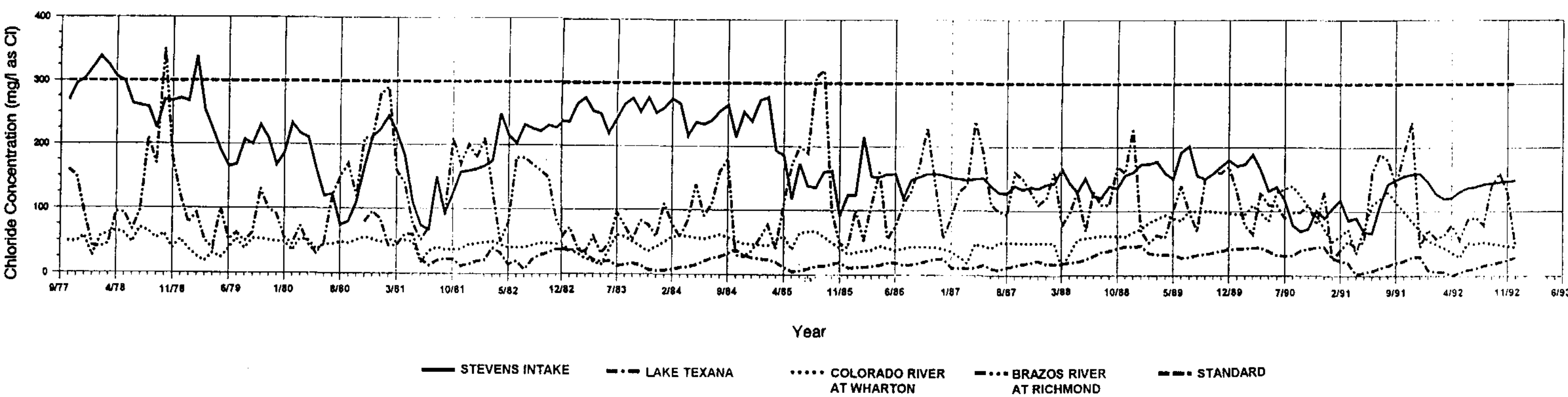
CORPUS CHRISTI SERVICE AREA

HISTORICAL CHLORIDE CONCENTRATIONS IN LOWER NUECES RIVER

FIGURE D-2





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COMPARISON OF CHLORIDE CONCENTRATIONS AT SELECTED SITES

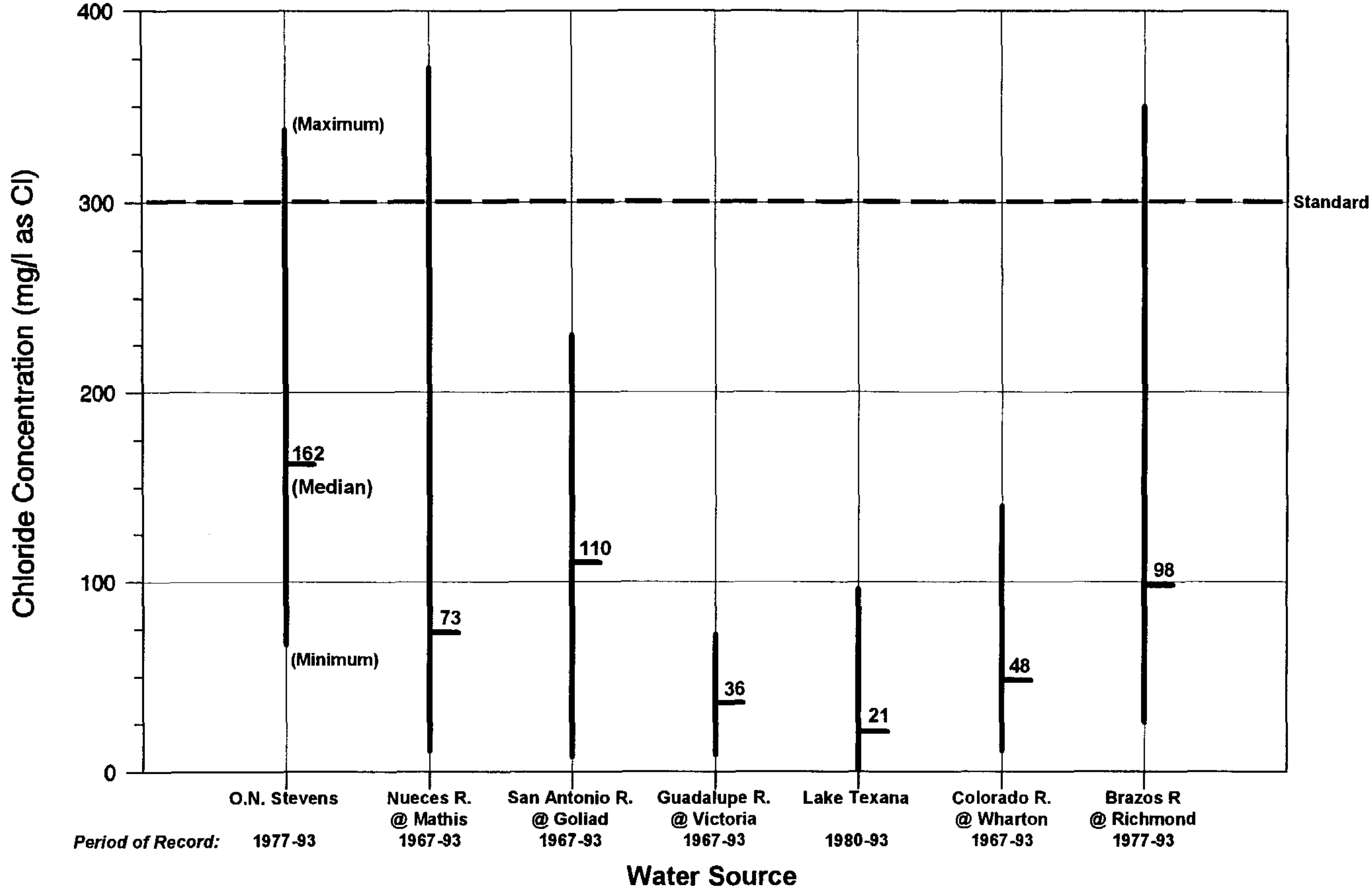
FIGURE D-3

although containing high concentrations of chlorides and TDS (880 ppm and 2120 ppm), were found to be too small to explain the increases in minerals down stream. The largest increases in chlorides were found to occur just above Calallen Diversion Dam in the area where a majority of the large water supply pumping stations are located. It was proposed that the groundwater adjacent to the river which had high levels of salinity (from 1700 ppm to 12,000 ppm) was entering the stream. However, according to the report, the top of the channel dam was approximately 4 to 5 feet higher in elevation than the surrounding water table thus ruling out groundwater intrusion. The report concluded that there were no definite explanations to the atypical mineralization of the river. The report did not attempt to quantify the contributions of the different contamination sources since the water quality was within the regulatory limits. The water at Stevens is still within the SDW standards, however, the level has increased from 72 mg/l of chloride in 1968, to 150 mg/l in 1993 (Figure D-3).

The chloride data show two atypically high concentrations at Mathis (370 mg/l in April, 1977 and 270 mg/l in March, 1977, while the next highest concentration is only 205 mg/l in February, 1977) (Figure D-4). However, with just over 300 values for chloride at Mathis, these two high concentrations have negligible impact on long-term water quality.

Hardness, the only other water quality constituent data obtained at the Stevens intake, represents the total poly-valent ion content of the water (i.e. Ca, Mg, Fe, Mn, Sr, Ba, Z, and Al) measured in mg/l as $CaCO_3$, Calcium Carbonate. Although hardness is an unregulated constituent, it presents its own constraints to both industrial and residential users in terms of the scaling of precipitants on equipment as well as home plumbing fixtures. As reuse of water increases, the significance of hardness increases as each cycle of reuse tends to increase mineral concentrations and hardness. At the Stevens intake, the hardness varies within a range of about 170 mg/l around a median of 220 mg/l (Figure D-5). The hardness concentrations at Mathis are more variable, with a range of 270 mg/l; however, the median at Mathis is 180 mg/l or about 18% lower than the median at Stevens.

As with the chloride concentration at Mathis, the hardness concentration also contains two outliers in the same two months. Without these two values, the hardness concentration at Mathis would have a maximum 270 mg/l instead of 360 or 320 mg/l. The fact that these two



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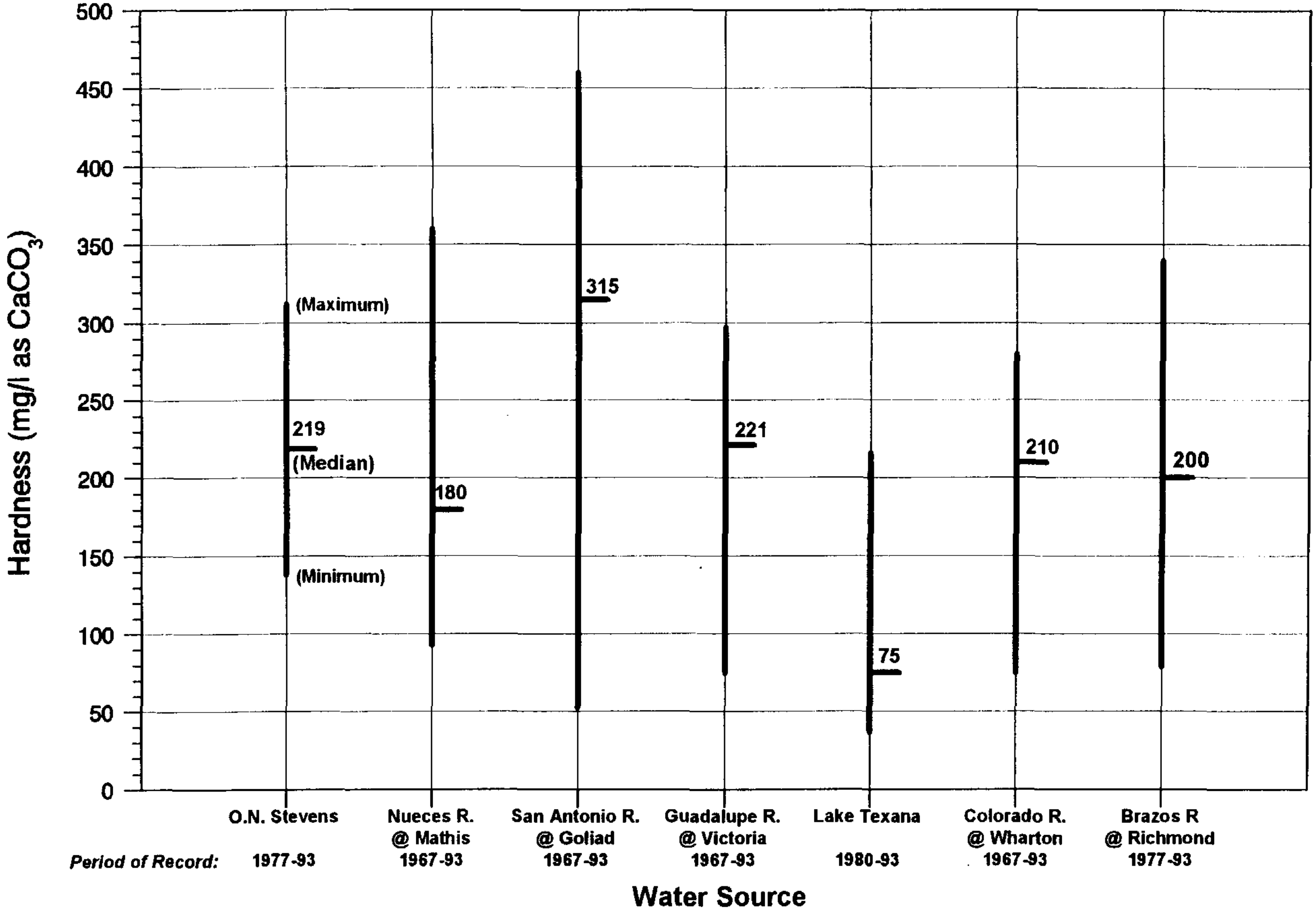
COMPARISON OF CHLORIDE CONCENTRATIONS AT POTENTIAL WATER SUPPLY SOURCES

FIGURE D-4



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COMPARISON OF HARDNESS CONCENTRATIONS AT POTENTIAL WATER SUPPLY SOURCES

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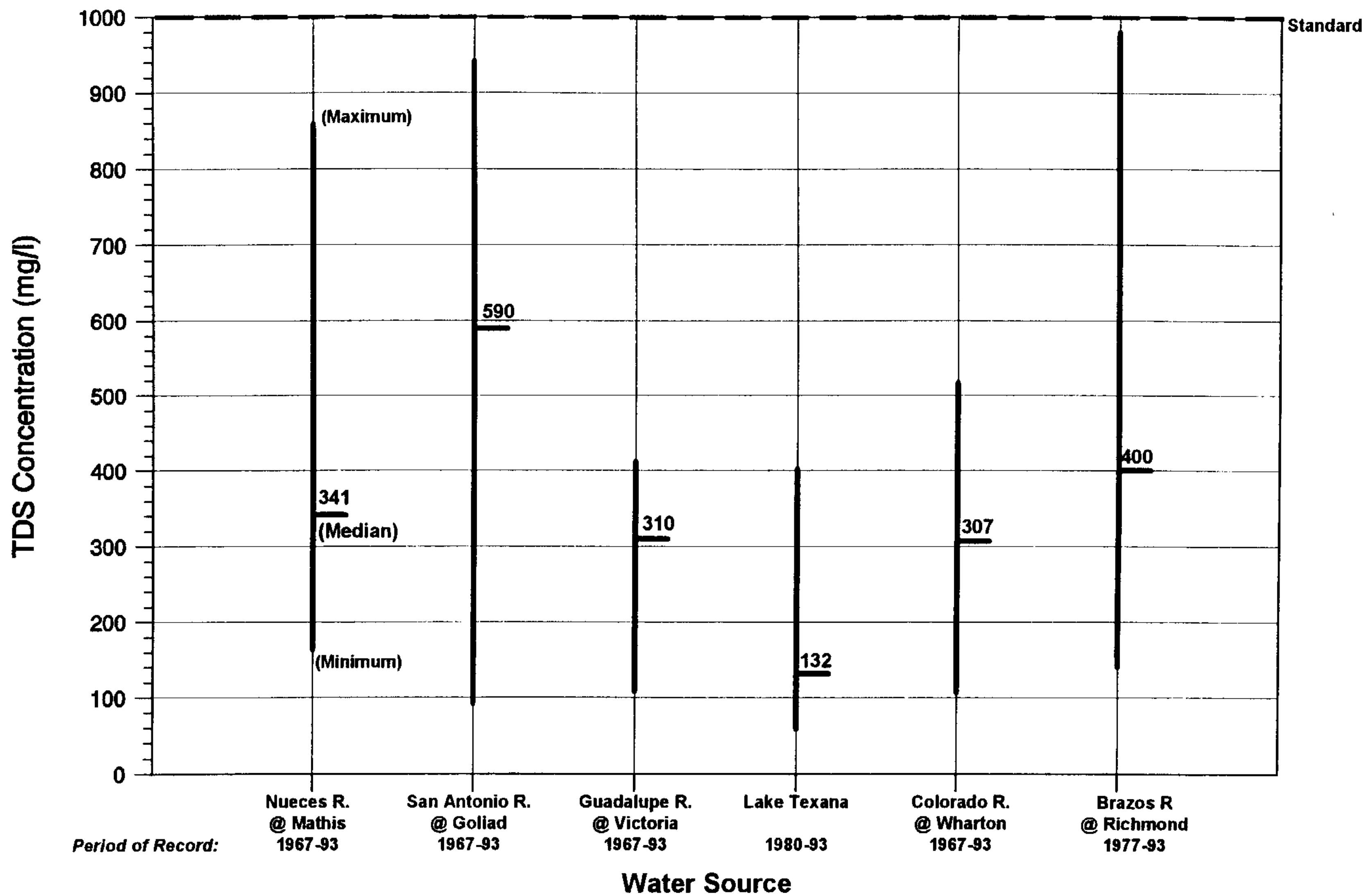
FIGURE D-5



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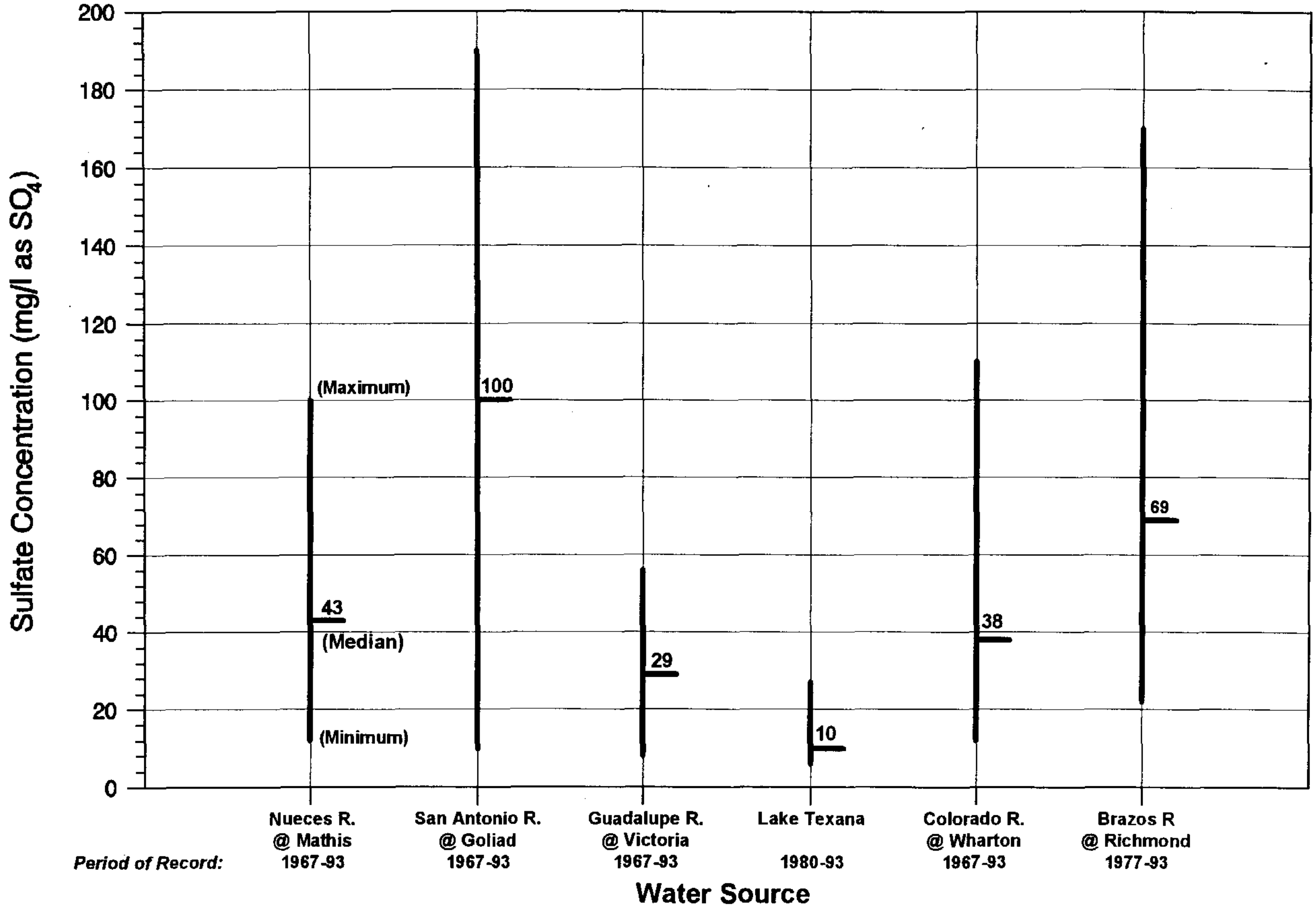
COMPARISON OF TDS CONCENTRATIONS AT POTENTIAL WATER SUPPLY SOURCES

FIGURE D-6



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COMPARISON OF SULFATE CONCENTRATIONS AT POTENTIAL WATER SUPPLY SOURCES

FIGURE D-7

below the standard, and hardness concentrations are equivalent to the Colorado River at Wharton. The Brazos River exhibits the highest maximum TDS concentration and the second highest median TDS (second to San Antonio River at Goliad), although in all cases the TDS concentrations are below TNRCC standards.

D.5 Water Quality at Stevens with Blending

In this section, the impact of blending various water sources with the raw water at the Stevens intake is addressed and the resulting water quality calculations are presented. The blending ratio used in the following analyses was determined by taking an average annual quantity from the Nueces River of 130,000 AF, and blending it with a volume of 30,000 AF of imported water. The resulting blend ratio was 81% Nueces River water and 19% imported water. It was assumed that blending would be evenly distributed over the year and that neither significant chemical reactions nor phase changes would take place during the blending process (Table D-2).

Table D-2 and Figures D-8 and D-9 show the maximum, minimum, and median values of chloride and hardness concentrations after blending out-of-basin water with Nueces River water at the Stevens intake. Figure D-10 shows chloride concentrations during the worst period of record at the O.N. Stevens plant both with and without blending with Lake Texana water. Four observations are apparent from a review of Table D-2 and Figures D-8, D-9, and D-10:

1) Blending Nueces River water with out-of-basin water decreases the median value of chloride concentrations in all cases;

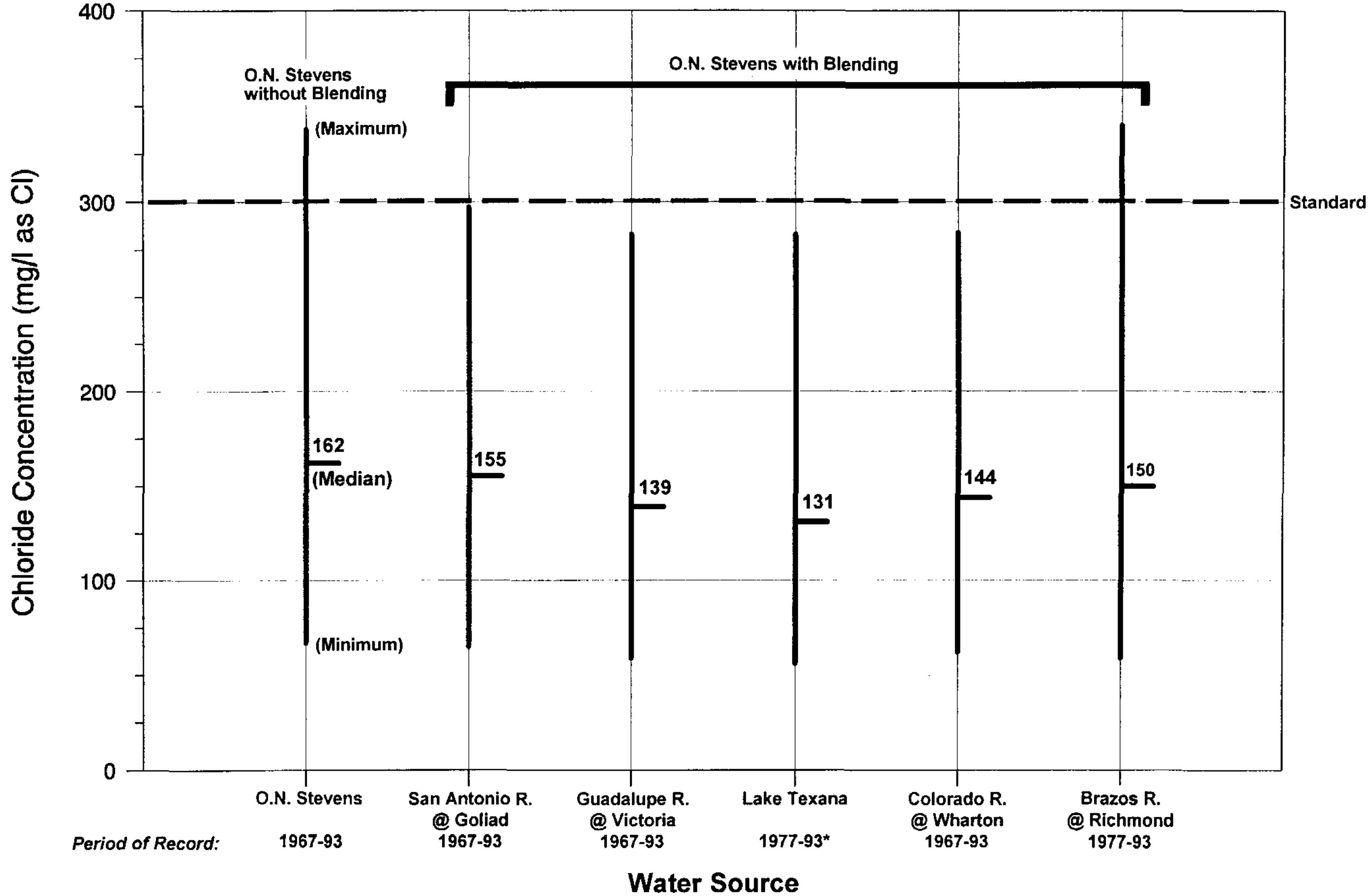
2) Blending Nueces river water with out-of-basin water would eliminate SDW Standard excursions for chlorides for all basins except the Brazos;

3) With respect to hardness, blending with either the Guadalupe, Colorado, or Brazos River water results in very little change, however, blending with San Antonio River water would result in a 10% increase in hardness. The greatest reduction in hardness is 19%, which would be achieved through blending with Lake Texana water.

4) Blending Nueces River water with Lake Texana water gives the lowest chloride and hardness values.

Table D-2 General Statistics on Blended Water Quality			
Location		**Chloride**	**Hardness**
Nueces without Blending	Max	338	312
	Med	162	219
	Min	67	138
Nueces Blended w/ San Antonio*	Max	297	324
	Med	155(-4%)**	240(+10%)**
	Min	65	122
Nueces Blended w/ Guadalupe*	Max	283	300
	Med	139(-14%)**	225(+3%)**
	Min	59	126
Nueces Blended w/ Lake Texana*	Max	283	276
	Med	131(-19%)**	175 (-19%)**
	Min	56	135
Nueces Blended w/ Colorado*	Max	284	300
	Med	144(-11%)**	221 (+1%)**
	Min	62	139
Nueces Blended w/ Brazos*	Max	340	317
	Med	150 (-7%)**	219 (0%)**
	Min	59	127

*Blending ratio used: 81% Nueces River water at Stevens and 19% from each out-of-basin option.
**Percentage decrease (-) or increase (+) in concentration.



* Estimated for 1977-1981

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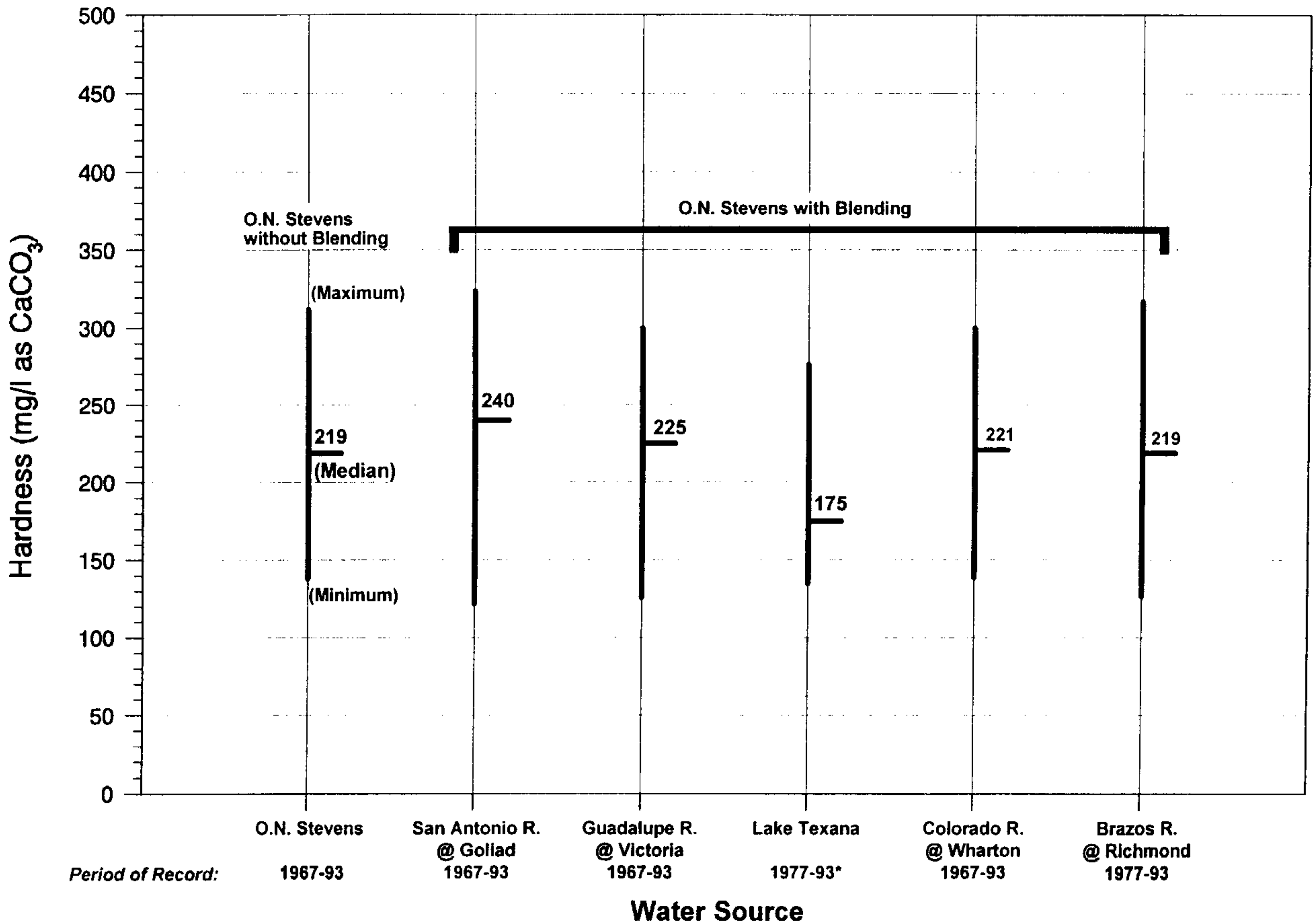
COMPARISON OF CHLORIDE CONCENTRATIONS CONSIDERING BLENDING

FIGURE D-8



* Estimated for 1977-1981

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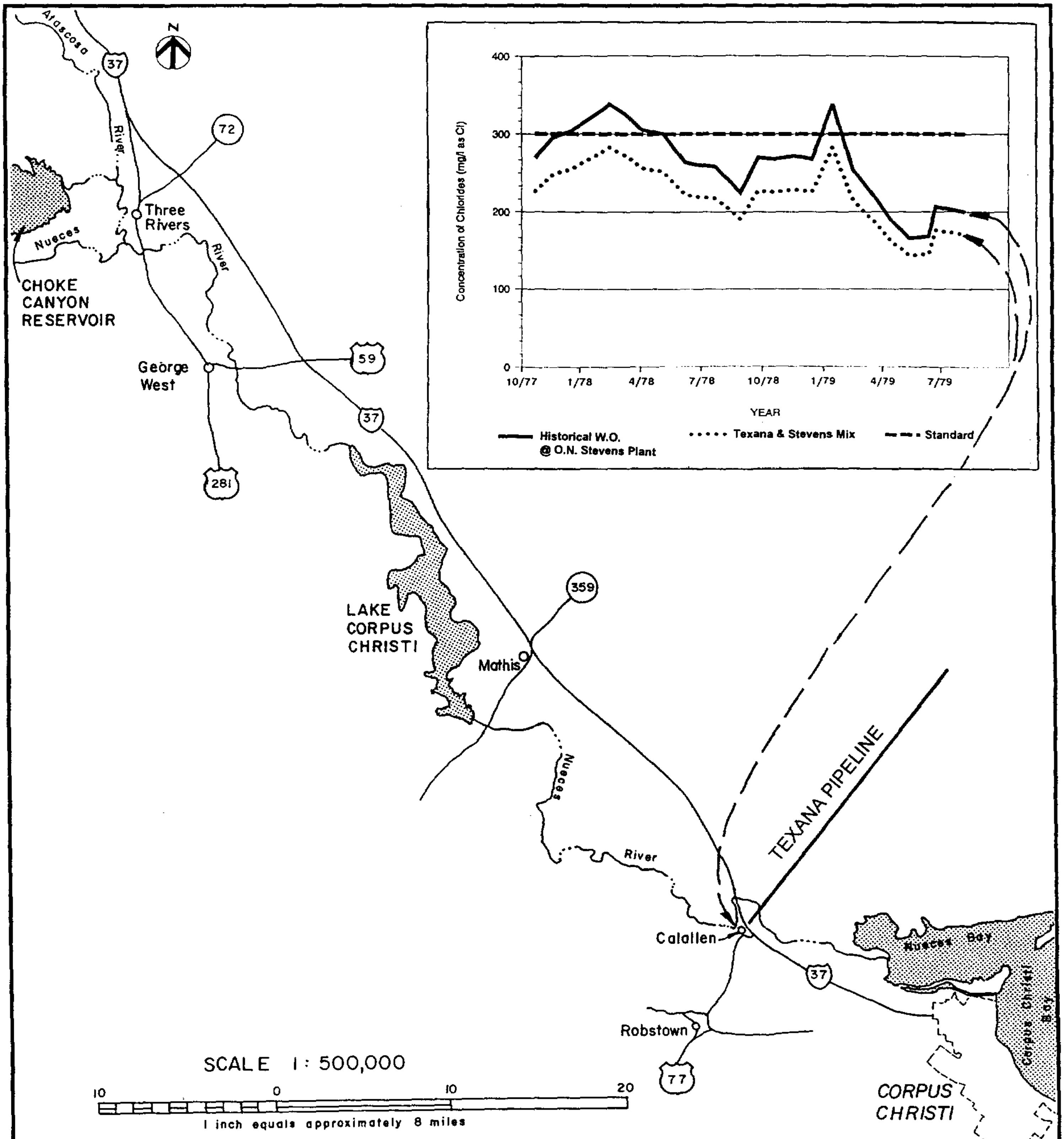
COMPARISON OF HARDNESS CONCENTRATIONS CONSIDERING BLENDING

FIGURE D-9



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CHLORIDE CONCENTRATIONS AFTER BLENDING WITH TEXANA WATER

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FIGURE D-10

APPENDIX E

Water Treatability

APPENDIX E - WATER TREATABILITY

E.1 Water Treatment Processes

Water treatment is generally classified either as conventional treatment or as demineralization. Conventional treatment is the most common process, and it is the process currently used at Corpus Christi's O.N. Stevens treatment plant. Conventional treatment typically consists of disinfection, coagulation, sedimentation/clarification, and filtration processes. The disinfection step inactivates any disease-causing microorganisms present, while the coagulation, sedimentation, and filtration steps remove suspended materials from the water. Conventional treatment can also remove some dissolved chemical constituents. However, precipitation of dissolved constituents depends on the coagulation chemical, the process used, water pH, and the valence of the constituent in solution.

In contrast to conventional treatment, demineralization processes can remove almost all impurities, both dissolved and suspended, and provide a higher degree of treatment than a conventional process. As a result, demineralization processes are usually significantly more expensive. Demineralization is achieved by forcing water through semi-permeable membranes which allow pure water to pass through, with impurities remaining behind. The most common demineralization processes are Reverse Osmosis (RO), which uses pressure to drive water through the membranes, and Electrodialysis/Electrodialysis Reversal (ED/EDR), which uses electric potential to drive the water. These processes are used primarily to treat brackish waters and have been used in lieu of distillation processes for desalination of sea water. Sections 3.7 and 3.8 of this report discuss Desalination, as would be needed to treat Local Groundwater Sources, and present specific demineralization process applications which would be required if these sources are utilized to supplement Corpus Christi's water supply.

From the water quality analysis presented in Appendix D, it appears that conventional treatment will be adequate for water imported from the San Antonio, Guadalupe, Lavaca/Navidad, or Colorado Basins. The analysis in Appendix D indicates that blending imported water from these locations with Nueces Basin water will result in a raw water quality which will meet the TNRCC Secondary Drinking Water Standards for the parameters investigated.

E.2 Factors Influencing Conventional Treatment Processes

E.2.1 Organic Loading

Water disinfection is typically achieved by the addition of chemicals, such as chlorine, which oxidize and inactivate microorganisms in the water. The chemicals also react with organic material in the water. Raw water with high levels of organic matter will require high levels of disinfectant, which results in increased treatment costs. In addition, some disinfection processes can create substantial disinfection by-products, such as trihalomethanes (THM's), which are known carcinogens. THM's are currently regulated by the TWC; however, the EPA is now formulating a Disinfectant-Disinfection By-Products Rule which will regulate THM's, as well as other by-products. The exact extent of the regulation is unknown at this time, but indications are that by-product limits will be lowered significantly. Since the existing process at O.N. Stevens plant results in a much lower formation of by-products than disinfection by free chlorine, it is unclear if the new requirements will require modification of the existing disinfection methods at the plant. Organic matter can also compound taste and odor problems normally experienced with treated surface water. Taste and odor problems are usually caused by microorganisms such as algae, decayed vegetation, reaction of treatment chemicals with organic matter, and man-made chemicals. High levels of organics can react to cause tastes and odors and can also promote algae growth in the raw water. Although taste and odor events are difficult to predict, such problems can be handled with treatment. Again, special treatment will increase the cost of treated water.

One common source of organic matter found in surface water is wastewater treatment plant return flows. Of the water sources considered in this study, it appears that the San Antonio Basin could have higher levels of organics than the other sources due to the City of San Antonio's wastewater return flows. The Colorado River also receives return flows from the City of Austin, but return flows to the Colorado are a much smaller percentage of the river's base flow than in the San Antonio, thus, the organics are diluted to lower levels. In addition, Colorado River water would be transferred through Lake Texana on its way to Corpus Christi and any organics from wastewater return flows would be further diluted.

E.2.2 Suspended Solids Loading

As mentioned earlier, suspended solids can impact the coagulation, sedimentation, and filtration processes. Suspended solids found in surface water usually result from overland storm water runoff. The soils present and the type of land development in the watershed can substantially impact the amount of suspended matter which enters a stream. Wastewater return flows can also add trace amounts to the suspended solids load.

Water taken from a reservoir typically contains lower suspended solids than water secured directly from a river because residence time in a reservoir reduces suspended matter as the solids settle out. Therefore, water taken from reservoirs such as Lake Texana, R & M, or McFaddin, will likely have less suspended matter than water taken directly from a rivers, respectively. However, water from a reservoir still requires coagulation, sedimentation, and filtration treatment because local conditions in the reservoir or at the water intake structure can cause significant suspended matter.

High levels of suspended solids can normally be removed by conventional treatment, but result in higher cost as more coagulation chemicals are needed and filter backwashing increases. Since suspended solids concentrations are linked to storm runoff, problems can occur in systems where water quality changes rapidly, such as a direct river intake. In these situations, finished water quality from the treatment facility can be degraded if modifications to the treatment process are not completed promptly in response to changes in raw water quality.

E.2.3 Other Contaminants

Other contaminants regulated by the EPA and TWC, such as pesticides, volatile organic compounds, and various inorganic compounds, cannot be removed by a conventional treatment process. These contaminants usually result from leaking chemical storage facilities, chemical spills, chemical processes, or runoff from agricultural areas and are normally found in isolated locations. If these types of contaminants are found in any of the sources, special treatment will be required for their removal. However, it does not appear that any such contaminants exist in any of the options considered in this study. In fact, five of the surface water sources under consideration are currently used for drinking water by communities in the respective river basins. If a contaminant problem does occur, treatment by granular activated carbon, powdered activated carbon, ion exchange, or demineralization by membranes are some of the processes which are used to remove these types of contaminants. The exact nature of the contaminant will determine the best technology for treatment.

E.3 Water Hardness

Appendix D indicates that the hardness of the blended water using any of the sources studied will range between 130 to 325 mg/l, which is considered to be hard water. The range for the Nueces/Lake Texana blend is 130 to 227 mg/l, with a median of 175 mg/l. Hardness can cause operational problems in the water distribution system and in plumbing fixtures due to scale which can form on exposed surfaces. Hardness can be reduced by a softening process which chemically removes dissolved minerals, usually calcium and magnesium. Water can also be softened utilizing membranes similar to a demineralization process. Since the existing Stevens plant does not currently utilize a softening process, Corpus Christi may wish to evaluate the need for softening in its treatment process, especially if the blended water will have a higher resulting hardness (blends using San Antonio, Guadalupe, or Colorado water would be higher in hardness than the present Nueces source), in order to reduce any operational problems that may arise. Water softening does increase chemical costs or power costs and does increase the quantity of sludge or other waste streams generated at a plant; thus, treatment costs are increased.

E.4 Impacts of Future Regulations

The EPA is continuing to add contaminants to the list of regulated contaminants and to set Maximum Contaminant Levels (MCL's) for these newly added contaminants. As mentioned previously, EPA is now formulating a Disinfectant-Disinfection By-Product Rule which could significantly impact all surface water treatment systems. EPA will continue to tighten regulations on surface water treatment facilities. Future regulations could have significant impacts on the cost of water if different treatment techniques are mandated which require capital improvements or increased operational costs.

E.5 Anticipated Impacts on Treatment Costs

Since it appears that conventional treatment can continue to be used with any of the potential water supply sources identified, significant impacts to water treatment cost are not anticipated. Treatment costs may vary somewhat due to changes in organic or suspended solids loading, but it is not possible to quantify their effects without conducting a comprehensive water quality screening of the source. In addition, if regulated contaminants such as pesticides or volatile organic compounds are found in significant concentrations, specialized treatment will be required. Such treatment could impact treatment costs substantially. For these reasons, it is recommended that comprehensive water quality assessments and watershed surveys be completed in later phases of the study to determine specific impacts on water treatment costs.

APPENDIX F

Letter Report on Campbellton Well Field

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May 25, 1993

Mr. Ken Choffel
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Austin, Texas 78704-6536

Dear Ken:

This letter and the enclosed graph are in response to your telephone conversation with Mervin Klug on May 14, 1993. The discussion was in regard to whether 6 million gallons per day (mgd) or more of ground water might be developed from the Campbellton well field in Atascosa County, and if so what the effects might be.

As requested, we have reviewed readily available data for Corpus Christi's Campbellton wells and the surrounding area. The results from this review and preliminary calculations indicate that 6 mgd of ground water can be produced from the four existing city wells. It also appears that an even larger quantity of water can be developed from the Carrizo aquifer in the Campbellton area; however, additional wells will be required.

Pumping will be required to produce 6 mgd on a reasonably continuous basis because artesian heads, which presently range from 50 to 60 feet above ground level, are not sufficient to sustain this amount of natural flow for more than a few weeks. Pumping levels in the wells after pumping a total of 6 mgd continuously are expected to be greater than 150 feet below land surface after about a year and probably on the order of 200 to 300 feet below land surface after 50 years. The above pumping levels are based on a specific capacity of 6.4 gallons per minute per foot of drawdown that is indicated for the city's Well No. 1, static water-level measurements obtained from the Texas Water Development Board, and a computer simulation using aquifer coefficients reported for pumping tests made of the Campbellton wells in 1951. These future pumping levels assume that areal water levels will decline at an average rate of 2 feet per year as a result of pumping from the Carrizo by others. Based on the above analysis and a review of the well construction records, we feel 6 mgd is a practical 50-year water availability limit.

The enclosed figure is a series of graphs illustrating how water levels in the Carrizo will be lowered in the Campbellton area as a result of producing 6 mgd. The water-level decline in the general vicinity of Campbellton due to this amount of pumping is calculated to be about 75 to 100 feet after 1 year and on the order of 120 feet after 50 years. The water-level declines shown by the graphs are believed to be conservative for those areas north of Campbellton because the transmissivity of the aquifer generally improves in that direction.

Nicholas A. Rose, a ground-water consultant from Houston in the early 1950's, also computed the effect withdrawals from the Campbellton wells would have on the Carrizo wells in the Pleasanton and Poteet areas. As a basis for his computations, an average of the aquifer coefficients obtained from pumping tests at Campbellton and Pleasanton was used. The results of his computations, which are based on a coefficient of transmissibility of 96,700 gallons per day per foot, indicate that a continuous withdrawal of 10 mgd from the Campbellton well field for a period of 1 year would cause a decline in artesian pressure in wells at Pleasanton and Poteet of approximately 8 feet and 5 feet, respectively. This compares with declines of 15 and 8 feet, respectively, that are indicated by the accompanying graphs for a pumping rate of 6 mgd.

Ground-water quality data obtained from the Texas Water Development Board indicate total dissolved solids in water from the Campbellton wells generally range from 500 to 700 milligrams per liter (mg/l), and chlorides and sulfates are generally on the order of 50 and 60 mg/l, respectively. The water is hot (reported to range from 100 to 140 degrees Fahrenheit) and primarily a sodium bicarbonate type. The sodium content of the water, which is reported to be as much as 270 mg/l, might present a problem with people having high blood pressure. Blending the Carrizo ground water with a low sodium content water will help mitigate this problem. Also, there is the possibility that with long-term production of the Campbellton wells, the chemical quality of the ground water might become somewhat poorer over time.

The above discussion is based on readily available information and should be updated if consideration is given to placing the wells into operation. This should include checking the mechanical integrity and the performance of the wells to be sure they are in good enough condition to be used for the long-term production of water.

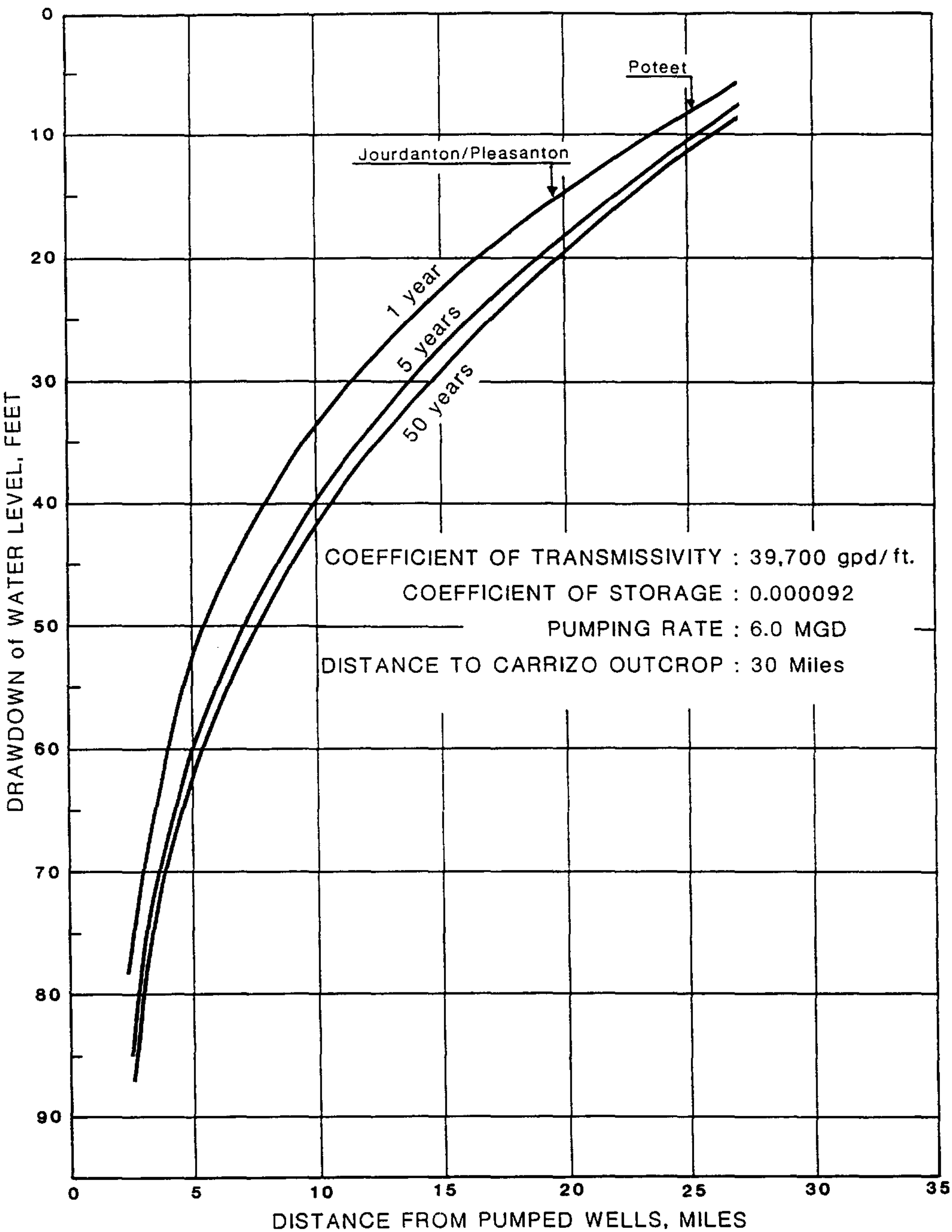
If you have any questions, please feel free to let us know, and we will be glad to discuss them with you.

Very truly yours,

LBG-GUYTON ASSOCIATES

William B. Klemt

WBK:klm
Enclosure



DRAWDOWN OF WATER LEVELS CAUSED BY PUMPING AT CAMPBELLTON

APPENDIX G

Trans-Texas Water Program Environmental Criteria

Water Quality

Preliminary water quality impact assessment of affected State waters must include evaluation of water quality standards attainment, chemical and biological compatibility of mixed waters, coastal salt water intrusion, and nutrients for compliance with drinking water standards. The recommended methodology, if any, for each analysis is given as follows:

1. Water Quality Standards Attainment

   A. Chloride, Sulfate, Total Dissolved Solids--Mass balance these constituents under a 7-day, 2-year, low flow (7Q2) condition to insure that the Standards are not violated.

   B. Dissolved Oxygen--If any interbasin transfer scenarios result in a reduction of a river's 7Q2, or if the baseflow is significantly reduced during spring spawning months [defined as the first half of the year when water temperatures are 63°-73°F in TWC Rule 307.7.(b)3. Aquatic Life], then simplified mathematical modeling must be performed to evaluate compliance with the Standard. Basic modeling assumptions are listed below:

   - Summer Analysis
     Headwater--7Q2 flow conditions
     Temperature--average of the three hottest months, plus one standard deviation, from the closest USGS station with water temperature data
     Discharges--full permitted effluent flow and quality
     BOD--compute BODu = $BOD_{5\ day} \times 2.3$
     K_n--nitrification rate = 0.30/day
     K_d--BOD oxidation rate = 0.10/day
     Reaeration--use Texas equation

   - Spring Spawning Analysis
     Same as above, except
     Headwaters--10th percentile monthly low flow conditions
     Temperature--90th percentile monthly high temperature conditions

   C. pH--No recommended method.

   D. Temperature--Mass balance temperature to insure compliance with the maximum temperature criteria, as well as the "rise over ambient" Standard.

   E. Fecal Coliform--No recommended method.

2. Chemical and Biological Compatibility of Waters

A. Formation of precipitates, etc.--No recommended method.

B. Introduction of exotic plants and animals--No recommended method.

3. Salt Water Intrusion

A. Migration of coastal salt wedge and effect of intrusion up tidal rivers--No recommended method.

B. Effect on water supply operations--No recommended method.

C. Effect on freshwater marshes/wetlands--No recommended method.

4. Nutrients

A. Potable water limits--Determine compliance with Drinking Water Standards.

B. Potential for nuisance aquatic vegetation--No recommended method.

Instream Flows

A relatively rapid assessment of instream flow needs to maintain downstream fish and wildlife habitats affected by the TransTexas Water Program can be performed by using the TPWD-modified Tennant's Method (Lyons 1979), which is based on a fixed percentage of median (50th percentile) monthly flows. At any point in a river basin intercepted by the TransTexas Water Program, streamflows must be passed downstream in an amount up to 60% of the median monthly flows from March through September, and 40 % of the median monthly flows from October through February. Streamflows above these monthly flow limits are to be considered available for other beneficial uses and interbasin transfer. Water stored in existing reservoirs will not be allocated to instream uses and released downstream to make up for normal flows below the specified limits.

Freshwater Inflows to Bays and Estuaries

For preliminary planning purposes, the freshwater inflow needs of the bays and estuaries can be conservatively estimated as a function of selected central tendency values. The typical bi-modal distribution of monthly rainfall runoff during the historical period is enhanced by requiring the pass through of normal inflows up to the mean (arithmetic average) monthly flow in May-June and September-October, while the minimum maintenance needs are satisfied with inflows up to the median (50th percentile) monthly flow in the remaining months of the year. Water stored in existing reservoirs will not be allocated to bay and estuary uses and released downstream to make up for normal flows below the specified limits.

New Reservoirs

Existing reservoirs that could potentially contribute to the TransTexas Water Program will be evaluated as to the effects on downstream flows and freshwater inflows to bays and estuaries under their existing state and federal permits which authorize their current operations, while any new reservoirs involved in the Program's future water storage and distribution system will be considered to operate such that they pass through impounded streamflows up to the mean (arithmetic average) monthly flow in April-June and August-October, and median (50th percentile) streamflows in the remaining months of the year, as long as reservoir capacity is above 60%. When reservoir capacity is below 60%, the water management operations will recognize drought contingency by passing through up to the median daily flow of the stream observed during the historical drought of record. The analysis will be repeated at 40% and 80% capacity thresholds to demonstrate a range of feasible solutions for operating any new reservoirs.

APPENDIX H

Water Development Board Population and Water Demand Projections

Apendix H. Table 1

Population Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

County	Population Projections /1													
	Census	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	17,892	20,202	21,203	22,820	25,158	25,281	29,667	27,505	34,984	29,578	39,888	----	44,792
Atascosa	30,533	36,053	37,785	40,810	44,108	44,574	49,394	48,163	54,480	49,434	59,580	----	64,680
Bee	25,135	27,128	28,402	28,575	30,519	30,032	32,686	32,148	35,485	34,366	38,532	----	41,579
Brooks	8,204	7,814	8,359	8,397	9,190	8,945	10,008	9,446	10,806	10,029	11,712	----	12,618
Duval	12,918	13,657	14,137	13,823	14,599	14,029	14,934	14,565	15,512	15,238	16,230	----	16,948
Jim Wells	37,679	40,989	41,411	41,111	43,231	41,232	43,757	41,354	44,314	41,477	44,666	----	45,018
Klegerg	30,274	32,526	33,370	35,886	36,904	38,064	39,315	40,729	42,324	42,698	44,739	----	47,154
Live Oak	9,556	10,158	10,579	10,757	11,317	10,793	11,537	10,787	11,674	10,756	11,714	----	11,754
McMullen	817	921	998	973	1,063	915	1,041	883	1,030	858	1,013	----	996
Nueces	291,145	334,255	339,413	374,451	386,134	406,471	427,119	440,158	472,085	473,552	518,667	----	565,249
Refugio	7,976	7,457	7,939	7,904	8,415	8,147	8,780	8,440	9,096	8,609	9,278	----	9,460
San Patricio	58,749	68,628	70,933	78,033	83,176	86,153	94,530	92,921	103,216	98,010	109,421	----	115,626
Regional Total	530,878	599,788	614,529	663,540	693,814	714,636	762,768	767,099	835,006	814,605	905,440	----	975,874

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 2

Municipal Water Demand Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	2,614	3,007	4,192	3,241	4,730	3,401	5,347	3,641	6,222	3,832	7,021	----	7,820
Atascosa	5,670	5,412	6,949	5,777	7,657	5,974	8,157	6,325	8,808	6,371	9,465	----	10,122
Bee	3,569	3,821	7,687	3,801	4,774	3,775	4,855	3,911	5,124	4,083	5,432	----	5,740
Brooks	1,150	1,132	1,568	1,149	1,637	1,155	1,694	1,189	1,794	1,230	1,905	----	2,016
Duval	2,090	1,928	2,426	1,858	2,384	1,973	2,324	1,807	2,358	1,839	2,409	----	2,460
Jim Wells	6,535	7,057	9,229	6,878	9,287	6,660	9,123	6,594	9,175	6,487	9,133	----	9,091
Kiegerg	6,261	5,887	7,383	6,137	7,758	6,204	7,903	6,449	8,305	6,619	8,633	----	8,961
Live Oak	1,796	1,486	1,983	1,489	2,013	1,427	1,961	1,392	1,949	1,347	1,919	----	1,889
McMullen	109	156	217	159	222	147	211	145	211	141	208	----	205
Nueces	76,521	63,719	81,634	68,728	89,206	72,234	95,643	76,707	104,119	81,358	113,094	----	122,069
Refugio	1,227	1,083	1,359	1,092	1,372	1,067	1,363	1,079	1,382	1,070	1,380	----	1,378
San Patricio	7,931	8,306	10,378	8,866	11,452	9,247	12,350	9,690	13,175	9,974	13,739	----	14,303
Regional Total	115,493	102,994	132,035	109,175	142,492	113,264	150,931	118,929	162,622	124,351	174,338	----	186,054

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 3

Industrial Water Demand Projections-Corpus Christi 12-County Area
Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	283	404	416	474	521	541	638	602	771	668	877	----	983
Atascosa	0	0	0	0	0	0	0	0	0	0	0	----	0
Bee	1	2	2	2	2	2	3	2	3	3	4	----	5
Brooks	0	0	0	0	0	0	0	0	0	0	0	----	0
Duval	0	0	0	0	0	0	0	0	0	0	0	----	0
Jim Wells	0	0	0	0	0	0	0	0	0	0	0	----	0
Kiegerg	0	0	0	0	0	0	0	0	0	0	0	----	0
Live Oak	943	929	986	875	959	878	967	880	971	882	974	----	977
McMullen	0	0	0	0	0	0	0	0	0	0	0	----	0
Nueces	34,949	39,409	41,993	39,452	44,323	41,471	48,143	43,439	51,578	45,638	55,144	----	58,710
Refugio	0	0	0	0	0	0	0	0	0	0	0	----	0
San Patricio	7,435	12,118	14,379	14,406	19,143	16,631	24,503	19,586	29,822	22,991	34,689	----	39,556
Regional Total	43,611	52,862	57,776	55,209	64,948	59,523	74,254	64,509	83,145	70,182	91,688	----	100,231

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.
/2 No extrapolation made for 2050 low case.

Apendix H. Table 4

Steam Electric Power Water Demand Projections-Corpus Christi 12-County Area
Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	0	0	0	0	0	0	0	0	0	0	0	----	0
Atascosa	3,622	12,000	12,000	12,000	12,000	12,000	17,000	17,000	22,000	17,000	27,000	----	32,000
Bee	0	0	0	0	0	0	0	0	0	0	0	----	0
Brooks	0	0	0	0	0	0	0	0	0	0	0	----	0
Duval	0	0	0	0	0	0	0	0	0	0	0	----	0
Jim Wells	0	0	0	0	0	0	0	0	0	0	0	----	0
Kiegerg	0	0	0	0	0	0	0	0	0	0	0	----	0
Live Oak	0	0	0	0	0	0	0	0	0	0	0	----	0
McMullen	0	0	0	0	0	0	0	0	0	0	0	----	0
Nueces	2,404	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	----	3,500
Refugio	0	0	0	0	0	0	0	0	0	0	0	----	0
San Patricio	0	0	0	0	0	0	0	0	0	0	0	----	0
Regional Total	6,026	15,500	15,500	15,500	15,500	15,500	20,500	20,500	25,500	20,500	30,500	----	35,500

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 5

Irrigation Water Demand Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	0	0	0	0	0	0	0	0	0	0	0	----	0
Atascosa	47,208	48,000	50,000	30,000	42,500	30,000	40,000	30,000	40,000	30,000	40,000	----	40,000
Bee	3,474	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	2,250	----	2,250
Brooks	350	225	371	225	371	225	371	225	371	225	371	----	371
Duval	2,586	2,063	3,095	2,063	3,095	2,063	3,095	2,063	3,095	2,063	3,095	----	3,095
Jim Wells	1,189	1,250	1,748	1,250	1,748	1,250	1,748	1,250	1,748	1,250	1,748	----	1,748
Kiegerg	461	375	578	375	578	375	578	375	578	375	578	----	578
Live Oak	3,333	1,500	2,000	1,500	2,000	1,500	2,000	1,500	2,000	1,500	2,000	----	2,000
McMullen	0	0	0	0	0	0	0	0	0	0	0	----	0
Nueces	1,734	1,500	2,632	1,500	2,632	1,500	2,632	1,500	2,632	1,500	2,632	----	2,632
Refugio	0	25	83	25	83	25	83	25	83	25	83	----	83
San Patricio	1,110	1,750	2,558	1,750	2,558	1,750	2,558	1,750	2,558	1,750	2,558	----	2,558
Regional Total	61,445	58,938	65,315	40,938	57,815	40,938	55,315	40,938	55,315	40,938	55,315	----	55,315

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 6

Mining Water Demand Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	0	113	113	85	85	57	57	29	29	14	14	----	0
Atascosa	664	1,444	1,444	1,554	1,554	2,680	2,680	3,806	3,806	4,931	4,931	----	6,056
Bee	20	40	40	30	30	23	23	16	16	12	12	----	8
Brooks	145	117	117	103	103	88	88	74	74	62	62	----	50
Duval	3,049	3,036	3,036	2,673	2,673	2,529	2,529	2,494	2,494	2,484	2,484	----	2,474
Jim Wells	393	339	339	238	238	175	175	124	124	94	94	----	64
Klegerg	1,221	950	950	844	844	739	739	633	633	542	542	----	451
Live Oak	2,385	2,737	2,737	2,794	2,794	2,864	2,864	2,943	2,943	3,027	3,027	----	3,111
McMullen	239	330	330	358	358	364	364	373	373	382	382	----	391
Nueces	50	136	136	93	93	57	57	28	28	16	16	----	4
Refugio	77	28	28	14	14	7	7	4	4	1	1	----	0
San Patricio	57	101	101	100	100	100	100	99	99	99	99	----	99
Regional Total	8,300	9,371	9,371	8,886	8,886	9,683	9,683	10,623	10,623	11,664	11,664	----	12,708

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 7

Livestock Water Demand Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	52	93	93	93	93	93	93	93	93	93	93	----	93
Atascosa	1,613	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	1,945	----	1,945
Bee	1,088	1,314	1,314	1,314	1,314	1,314	1,314	1,314	1,314	1,314	1,314	----	1,314
Brooks	816	1,133	1,133	1,133	1,133	1,133	1,133	1,133	1,133	1,133	1,133	----	1,133
Duval	1,177	2,306	2,306	2,306	2,306	2,306	2,306	2,306	2,306	2,306	2,306	----	2,306
Jim Wells	907	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	1,419	----	1,419
Kiegerg	1,745	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	1,470	----	1,470
Live Oak	1,170	1,105	1,105	1,105	1,105	1,105	1,105	1,105	1,105	1,105	1,105	----	1,105
McMullen	484	1,237	1,237	1,237	1,237	1,237	1,237	1,237	1,237	1,237	1,237	----	1,237
Nueces	373	352	352	352	352	352	352	352	352	352	352	----	352
Refugio	563	673	673	673	673	673	673	673	673	673	673	----	673
San Patricio	747	794	794	794	794	794	794	794	794	794	794	----	794
Regional Total	10,735	13,841	13,841	13,841	13,841	13,841	13,841	13,841	13,841	13,841	13,841	----	13,841

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 8

Total Water Demand Projections-Corpus Christi 12-County Area

Trans-Texas Water Program

(Projections in acre-feet) /1

County	Water Use	2000		2010		2020		2030		2040		2050	
	1990	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case	High Case	Low Case /2	High Case
Aransas	2,949	3,637	4,814	3,893	5,429	4,092	6,135	4,365	7,115	4,607	8,005	----	8,896
Atascosa	58,777	68,300	72,338	51,276	65,656	52,599	69,782	59,076	76,559	60,247	83,341	----	90,123
Bee	8,152	6,153	11,293	7,397	8,370	7,364	8,445	7,493	8,707	7,662	9,012	----	9,317
Brooks	2,461	1,591	3,189	2,610	3,244	2,601	3,286	2,621	3,372	2,650	3,471	----	3,570
Duval	8,902	10,063	10,863	8,900	10,458	8,871	10,254	8,670	10,253	8,692	10,294	----	10,335
Jim Wells	9,024	8,985	12,735	9,785	12,692	9,504	12,465	9,387	12,466	9,250	12,394	----	12,322
Klegerg	9,688	8,162	10,381	8,826	10,650	8,788	10,690	8,927	10,986	9,006	11,223	----	11,460
Live Oak	9,627	9,389	8,811	7,763	8,871	7,774	8,897	7,820	8,968	7,861	9,025	----	9,082
McMullen	832	816	1,784	1,754	1,817	1,748	1,812	1,755	1,821	1,760	1,827	----	1,833
Nueces	116,031	108,400	130,247	113,625	140,106	119,114	150,327	125,526	162,209	132,364	174,738	----	187,267
Refugio	1,867	1,164	2,143	1,804	2,142	1,772	2,126	1,781	2,142	1,769	2,137	----	2,134
San Patricio	17,280	22,376	28,210	25,916	34,047	28,522	40,305	31,919	46,448	35,608	51,879	----	57,310
Regional Total	245,590	249,036	296,808	243,549	303,482	252,749	324,524	269,340	351,046	281,476	377,346	----	403,649

/1 Texas Water Development Board low and high case for 2000 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April, 1992, Austin Texas.

/2 No extrapolation made for 2050 low case.

Apendix H. Table 9

Historical Population Growth and Comparison of 1990 Population Projections-Corpus Christi 12-County Area
Trans-Texas Water Program

	HISTORICAL POPULATION GROWTH						TWDB POPULATION PROJECTIONS for 1990				
COUNTY	1980	1984	1986	1988	1990	1993	1975 SERIES	1981/82 SERIES		1987/88 SERIES	
								LOW	HIGH	LOW	HIGH
Aransas	14,260	17,264	17,700	17,500	17,892	18,545	15,400	19,522	20,838	18,844	18,992
Atascosa	25,055	27,997	28,900	29,800	30,533	31,982	20,600	31,932	33,652	31,369	31,567
Bee	26,030	27,953	26,500	26,400	25,135	27,875	31,600	30,059	31,066	27,389	27,479
Brooks	8,428	9,242	9,200	9,300	8,204	8,264	7,900	9,368	9,604	9,553	9,592
Duval	12,517	13,325	13,500	13,000	12,918	12,859	10,200	13,609	13,881	13,116	13,289
Jim Wells	36,498	40,047	40,400	38,400	37,679	38,082	36,200	40,838	41,924	38,939	39,550
Kleberg	33,358	35,030	33,300	31,700	30,274	31,173	44,400	34,546	34,843	32,015	32,166
Live Oak	9,606	9,625	9,500	9,000	9,556	9,894	5,800	11,288	11,709	9,094	9,284
McMullen	789	932	900	1,000	817	725	900	550	686	976	984
Nueces	268,215	295,689	301,400	297,900	291,145	302,479	316,800	306,390	315,933	307,637	309,530
Refugio	9,289	8,856	9,000	8,600	7,976	8,050	8,800	9,473	9,473	8,550	8,570
San Patricio	58,013	61,921	61,600	60,100	58,749	61,835	57,300	69,949	72,936	62,537	63,090
Regional Total	502,058	547,872	551,900	542,700	530,878	551,763	555,900	577,524	596,545	560,019	564,093
Lavaca Basin	43,931	44,221	44,827	42,629	43,597	NA	40,701	47,695	48,890	43,418	43,971
State Total	14,229,200	16,082,700	16,685,000	16,682,820	16,986,500	18,031,000	15,594,000	16,808,600	17,846,100	17,295,700	17,562,500

APPENDIX I

Public Involvement

APPENDIX I

PUBLIC INVOLVEMENT THROUGH CITIZENS ADVISORY COMMITTEE

A Trans-Texas Desalination Citizens Advisory Committee was established to assist in the task of developing information necessary to evaluate seawater desalination as a water supply option.

Individuals from throughout the study area were invited to participate, provide input, raise relevant questions and comment on information developed by the consultants. More than 60 individuals volunteered to be participants in the public involvement process.

Monthly meetings were held and comments and questions were encouraged. Additionally, the committee was part of an "Ask The Experts" public desalination workshop attended by more than 100 people on December 17, 1994. A panel, including recognized national desalination experts, explained the current state of the art in desalting technology, environmental considerations and costs. The panel fielded numerous questions from the audience.

Citizens Advisory Committee participants made a substantial contribution to the overall Trans-Texas II study, raising questions and providing comments, not only on desalination, but also on other water supply options that are addressed in various sections of this report. Some of those comments and questions dealt with industrial water use, groundwater, additional reservoir sites and application of net present value of all inputs in calculating the comparative cost of each water supply option.

During each monthly meeting, information compiled by the consultants was presented. All questions and comments from committee participants were recorded. Written responses were prepared and mailed along with meetings agendas to all committee participants and to area news media. Participants were encouraged to offer comments and ideas in writing. All of these recorded comments, questions and responses have been compiled in a supplemental report which documents committee activities and participation (Record of Public Involvement, Trans-Texas Desalination Advisory Committee, 1994-1995).

Individuals, who participated in the committee sessions and offered comments, represented a broad cross-section of the community. Several had some experience in water supply issues and with various desalting technologies.

A step-by-step process was employed during which committee participants reviewed desalination technologies, applications around the world, considerations in selecting a desalination process, environmental and institutional issues, energy demand and the specific capital and operating costs of plants that have been studied or built in the U.S. in recent years.

In the end, committee participants were divided in their opinions about the feasibility of desalting.

Several committee participants believed that there may be technological breakthroughs in the years ahead that may make the cost of desalted seawater competitive with other new water supply sources under consideration in the Coastal Bend region. They argued for patience and planning so that desalting can be used to meet demand during the later portions of the 50-year Trans-Texas planning window. They suggested further that desalination can be accomplished incrementally with additional capacity being added in modules as needed. They also argued that an investment in desalting would be an appropriate drought management strategy with equipment kept on inactive standby during years when rainfall in the Nueces Basin is plentiful, thereby eliminating significant operating costs in those periods. These areas were all addressed by the consultant, although not to a degree acceptable to a few of the participants.

Other committee participants said they did not believe a single-purpose desalting plant could be cost competitive in the foreseeable future. However, a committee participant developed a proposal he believed could be economically viable immediately. It would involve building a publicly-owned dual purpose plant to generate electric power and make desalted water. A key to this proposal would be the use of high-efficiency gas turbines to generate power and multiple effect distillation to desalt seawater. He argued that this approach has not been seriously reviewed, perhaps because of institutional constraints, and that such a facility deserves further study.

Still other committee participants believed that the data collected by the consulting team strongly suggested that the desalting cost estimate being used in the Trans-Texas evaluation of water supply options ($1,400 per acft for desalt) was too low by as much as a factor of two.

They expressed a much higher degree of confidence in the economic calculations associated with a pipeline from Lake Texana than for those of a desalting plant.

Several other committee participants argued that the issue of brine concentrate disposal could be the fatal flaw in any large-scale desalting plant design for the Coastal Bend.

Some committee participants expressed the belief that while desalting does not appear to be economically feasible at this time, it should not be permanently rejected. Rather, this option should be carried forward for periodic re-evaluation in future years, particularly once all relatively low cost water supply options have been implemented.

The Trans-Texas Desalination Citizens Advisory Committee provided a significant forum for public involvement in the process of evaluating the complete list of water supply options being investigated in the Trans-Texas Phase II.

APPENDIX J

Review/Comment Letters

Trans-Texas Water Program
South Central Study Area

APPENDIX J
PHASE I INTERIM REPORT COMMENTS

APPENDIX J
PHASE I INTERIM REPORT COMMENTS (continued)

APPENDIX J
PHASE II REPORT COMMENTS

Trans-Texas Water Program
South Central Study Area

APPENDIX J
PHASE II REPORT COMMENTS (continued)

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

ANDREW SANSOM
Executive Director

August 11, 1993

Dr. Herb Grubb
HDR Engineering, Inc.
3000 IH 35 South, #400
Austin, Texas 78704

Dear Dr. Grubb:

I very much appreciate receiving the Trans-Texas South Central Phase I Interim Report Summary before the meetings on August 12 and 13. Unfortunately, I cannot attend this set of meetings, but I would like to provide some questions that came to mind as I reviewed this document. I hope the final report will address them.

Why are only the high population growth projections presented? To place this most basic and important statistic in perspective it would be proper to show the average or median growth rate for all U.S. cities, U.S. coastal cities, Texas Cities, and Texas coastal cities over 100,000. This would permit a more reliable evaluation to be made as to whether it is reasonable to assume that Corpus Christi and surrounding area will continue to grow at this rate for the next 50 years. If the city and urban area surrounding the city grow at a lower rate it means less water is needed and less of a tax burden for existing residents. It also means more water is available to support aquatic ecosystems.

What is meant in the report "with conservation"? Does this involve water saving measures during droughts? Does it include a definition of drought (even by implication of reservoir contents)? Does it include installation of efficient plumbing for new construction and incentives for retro-fitting old construction?

What is the basis for projecting that industrial use of water will increase from 18 to 25 percent of total water use? Is this a result of municipal use becoming more efficient or considerably more industry moving into the area? Maybe a combination of both?

Page 6. Table 2. What data does footnote 3 go with?

Page 8. Table 3. How would water surpluses or shortages compare if projections were based on mean and low growth assumptions and listed in the table? Could logic be developed to support favoring one assumption of growth over another (i.e. based on past performance which projection has come closest to actual census figures)?

Page 9. Figure 3. Could new lines(curves) be added representing demands based on assumptions of mean or low population growth?

Page 12. Table 4. Are unit costs per ac-ft/yr construction or enabling costs only, or do they have some unit of operation costs associated with them? If no operation costs are included, it would be beneficial to show a column that has 30 year projected operation costs associated with each project.

Page 12. Table 4. Are costs available for construction and operation of new desalinization plants in California or other places? Can operation costs be associated with a fuel type (i.e. coal, nuclear, oil, natural gas, etc.)?

What is the cost and feasibility of dredging silt from the reservoirs to regain yield lost to siltation?

Again, thank you for the opportunity to review the summary, I look forward to seeing the final report.

Sincerely,

Albert W. Green, Chief
Aquatic Studies Branch
Resource Protection Division

AWG/bls

cc: Dick Harrington
Larry McKinney
David Meesey
Randy Moss
Warren Pulich
Andy Sipocz

Reviewer:	08/11/93 letter from Albert W. Green, Chief, Aquatic Studies Branch Resource Protection Division, Texas Parks and Wildlife Department	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
1-1	Section 2.0 Population Projections	*Comment: Why are only the high population growth projections presented? To place this most basic and important statistic in perspective it would be proper to show the average or median growth rate for all U.S. cities, U.S. coastal cities, Texas Cities, and Texas Coastal cities over 100,000. This would permit a more reliable evaluation to be made as to whether it is reasonable to assume that Corpus Christi and surrounding area will continue to grow at this rate for the next 50 years. If the city and urban area surrounding the city grow at a lower rate it means less water is needed and less of a tax burden for existing residents. It also means more water is available to support aquatic ecosystems.*
		Response: The Texas Water Development Board's high case population and water demand projections, with conservation, dated April 1992 were specified by the Texas Water Development Board for use in all Trans-Texas Phase I studies. The high case projections are typically used in water supply planning in order to have sufficient quantities of water available to meet the water needs of the planning area during drought conditions. With respect to growth rates, the Corpus Christi high case projections are based upon the area's vital statistics (birth and death rates) and recent trends of migration into and out of the area. In comparison to rates for Texas and other coastal areas of Texas, Corpus Christi projected high case average annual growth rate of 1.02 percent per year for the period 1990 to 2050 is significantly below the projected Texas statewide rate of 1.27 percent. The Corpus Christi area rate of 1.02 percent is less than the Houston-Galveston area projected rate of 1.25 percent, and is slightly above the Victoria area projected rate of 1.00 percent. In addition, it should be noted that the TWDB "Consensus Water Planning" most likely population projections for the 12-county South Central Trans-Texas Study area are 979,922, which is 4,048 higher than the high case projections of 975,874 that were specified for use in the Phase I study.
1-2	Section 2.0 Water Demand Projections	*Comment: What is meant in the report "with conservation"? Does this involve water saving measures during droughts? Does it include a definition of drought (even by implication of reservoir contents)? Does it include installation of efficient plumbing for new construction and incentives for retro-fitting old construction?*
		Response: The term "with conservation" means the effects that the installation of low flow plumbing fixtures would have upon per capita water use. For purposes of making projections of future municipal water demands, TWDB has conducted an annual survey of cities, and public and private water districts and authorities since the mid-1960's. In the annual survey, each respondent reports the quantities of water that have been obtained from each respective water source and supplied to municipal-type customers. From the water use reports of the cities, TWDB has computed an annual per capita water use, in gallons per person per day, for each city. For the high case projection, the per capita use for the year with the highest computed value of the 1977-1986 period was chosen as the projection starting point (1990) per capita municipal water use rate for the city.

		The effects of water conservation were used to adjust the per capita water use rates of each city as follows. In 1991, the Texas Legislature enacted legislation which allows only the sale of low-flow rate plumbing fixtures in Texas after January 1, 1993. As of April, 1992, when the projections used in the Phase I study were made, TWDB had estimated that by 2020, the effects of this legislation will have reduced per capita water use by 18 gallons per person per day. This 18 gallons per person per day was phased into the projection methodology by reducing the computed per capita water use rate of each city by six gallons per decade between 1990 and 2020; i.e., if per capita water use for City A, in 1990, as explained above, was computed at 190 gallons per day, then the rate used for the year 2000 would be 184 gallons per day, the rate used for 2010 would be 178 gallons per day, and the rate used for 2020 and the following decades would be 172 gallons per day. High case, with conservation projections of annual municipal water demand for each city for the 1990-2050 planning period were made by multiplying the projected per capita water use of the city, as adjusted for conservation, at the decadal point in time, times 365 days, times the high case projection of the number of people projected for that city at the corresponding point in time. In this way, the effects of conservation that can be accomplished with low-flow plumbing fixtures are included in the high case, with conservation municipal water demand projections.
1-3	Section 2.0 Water Demand Projections	*Comment: What is the basis for projecting that industrial use of water will increase from 18 to 25 percent of total water use? Is this a result of municipal use becoming more efficient or considerably more industry moving into the area? Maybe a combination of both?*
		Response: In the Phase I report (Table 2.3-8) the quantities of water used in the study area for each water using purpose (municipal, industrial, steam-electric power, irrigation, mining, and livestock water) in 1990 is shown along with the percentage that each was of the total for 1990. Likewise, the projected quantities and percentages of totals are shown for the year 2050. The projections for 2050 show that industry would increase, as a percent of total, from 18 percent in 1990 to 25 percent in 2050. In the case of irrigation, the percent of total declines from 25 percent in 1990 to 14 percent in 2050. The reasons for these changes are that industrial water use is projected to increase at a faster rate than other uses; for example, irrigation water use is projected to decline from 61 thousand acre-feet in 1990 to 55 thousand acre-feet in 2050.
1-4	Section 2.0 Water Demand Projections (Summary Pg. 6)	*Comment: What data does footnote 3 go with?*
		Response: Footnote 3 pertains to Nueces County and the Region Total rows.
1-5	Section 2.0 Water Demand Projections (Pg. 8. Table 3.)	*Comment: How would water surpluses or shortages compare if projections were based on mean and low growth assumptions and listed in the table? Could logic be developed to support favoring one assumption of growth over another (i.e., based on past performance which projection has come closest to actual census figures)?*

<table>
<tr><td></td><td></td><td>Response: See response to comment Number 1-1 above. Note that the TWDB low projection, which is computed for the low population growth rate and the average as opposed to the high per capita water use has been included as Appendix H of the Phase II report. At year 2050, the low population projection for the 12-county study area is 862,111; the high projection is 975,874.

TWDB population projections for the Nueces River Basin and for Texas for 1990 are listed below. The projections were made in 1995, 1981/82, and 1987/88.

<table>
<tr><th>Date Projection Made</th><th>12-County Study Area</th><th>Texas</th></tr>
<tr><td>1975</td><td>555,900</td><td>15,594,000</td></tr>
<tr><td>1981/82 Low</td><td>577,524</td><td>16,808,600</td></tr>
<tr><td>1881/82 High</td><td>596,545</td><td>17,846,100</td></tr>
<tr><td>1987/88 Low</td><td>560,019</td><td>17,295,700</td></tr>
<tr><td>1987/88 High</td><td>564,093</td><td>17,562,500</td></tr>
<tr><td>1990 Census</td><td>530,878</td><td>16,986,500</td></tr>
</table>

In the case of the 12-county study area the projections made in 1975 for 1990 were 4.7 percent higher than the 1990 census showed; the 1981/82 high projection for 1990 was 12.4 percent higher than the 1990 census. In the case of Texas, the 1975 projection for 1990 was 8.2 percent lower than the 1990 census for Texas, while the 1981/82 high projection for 1990 for Texas was 5.1 percent higher than the 1990 census.</td></tr>
<tr><td>1-6</td><td>Section 2.0
Water Demand
Projections
(Pg. 9. Figure 3.)</td><td>Comment: Could new lines (curves) be added representing demands based on assumptions of mean or low population growth?

Response: Other projections curves for mean or low projections could be added. However, the high case with conservation, as explained in response 1-1 above, was the projection case, specified for the Phase I study.</td></tr>
<tr><td>1-7</td><td>Summary
Table
(Page 12. Table 4.)</td><td>Comment: Are unit costs per ac-ft/yr construction or enabling costs only, or do they have some unit of operation costs associated with them? If no operation costs are included, it would be beneficial to show a column that has 30 year projected operation costs associated with each project.

Response: Unit costs (i.e., $ per acft/yr) reported in the summary table include engineering, permitting, environmental studies, construction, and operation and maintenance costs (O&M). Typically, the O&M costs include labor and materials required to maintain the project and periodic replacement of equipment, power costs for pumping, and purchase of water.</td></tr>
<tr><td>1-8</td><td>Summary
Table
(Page 12. Table 4.)</td><td>Comment: Are costs available for construction and operation of new desalinization plants in California or other places? Can operation costs be associated with a fuel type (i.e., coal, nuclear, oil, natural gas, etc.)?

Response: Yes, please refer to Section 3.7 containing information on desalination plant costs gathered in Phase II studies. The cost information presented in Section 3.7 does not associate operation costs with a particular fuel type.</td></tr>
</table>

1-9	Section 3.19	*Comment: What is the cost and feasibility of dredging silt from the reservoirs to regain yield lost to siltation?*
		Response: Please refer to Section 3.19, Dredging of Lake Corpus Christi in the Phase II report.

City of Austin

Founded by Congress, Republic of Texas, 1839
Municipal Building, Eighth at Colorado, P.O. Box 1088, Austin, Texas 78767 Telephone 512/499-20

August 14, 1993

Mr. Emmett Gloyna, P.E.
PMC Chairman, South Central Portion Trans-Texas Study
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

RE: Trans-Texas Phase I Study for the City of Corpus Christi

Dear Mr. Gloyna,

I appreciate the opportunity to discuss the above Phase I Study findings with you, Mr. Jack Nelson, and Mr. James Dodson this past Thursday. Per our conversation, you indicated that you will be asking the Trans-Texas Policy Management Committee at the PMC meeting on September 22 to declare the Phase I Project for Corpus Christi complete and seek authorization to continue with Phase II, further evaluation of selected alternatives.

As I stated in our meeting, we will not object to your proceeding with Phase II of the study and further evaluation of the alternatives selected in Phase I, which includes the alternative of interbasin transfer of water from the Lower Colorado River Basin to Lake Texana and then on to Corpus Christi. We would however object to any prior activities leading to authorization to transfer any water out of the Lower Colorado River Basin prior to completion of the study for the remainder of the participants in the South Central group. I believe it is very important to develop the entire Trans-Texas picture before seeking actual authorizations to transfer water out of the Colorado River Basin.

Please contact me if you have any questions. We look forward to seeing you at the next meeting.

Sincerely,

Randy J. Goss, P.E., Director
Water and Wastewater Utility

xc: James Dodson, City of Corpus Christi
Tommy Knowles, TWDB

RG:JC::slb

Reviewer:	(Letter No. 2) 08/14/93 letter from Randy J. Goss, Director, Water and Wastewater Utility, City of Austin
Comment:	*Noted. No response necessary.*

UNITED STATES DEI .ATMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat Conservation Division
4700 Avenue U
Galveston, Texas 77551-5997

August 31, 1993 F/SE022/WJ/DM:op
409/766-3699

Mr. Emmett Gloyna
General Manager
Lavaca-Navidad River Authority
Post Office Box 429
Edna, Texas 77957-0429

Dear Mr. Gloyna:

At the Technical Advisory Committee Meeting for the Southern Portion, South-Central Area of the Trans-Texas Water Program, hosted by your agency on August 13, 1993, in Corpus Christi, Texas, it was requested that comments on the Draft Trans-Texas Water Program Corpus Christi Phase I - Interim Report Summary be forwarded to your office. We offer the following comments.

The Draft report is well organized and the data succinctly presented, especially summary Table 4. We are concerned about several proposed alternatives that would reduce freshwater, nutrient, sediment and detritus inflows to the Matagorda, San Antonio and Corpus Christi estuarine systems. Some major concerns are highlighted sequentially down the coast.

The Garwood Transfer (C-1), utilizing Colorado River flows, could reduce the total amount of fishery enhancement for which the Mouth of Colorado River, Texas project diversion features were justified in its benefit/cost ratio of 20:1.

The Palmetto Bend Phase II Reservoir (LN-2), proposed across the Lavaca River, would essentially eliminate the sediment renourishment of the Lavaca River delta. The sediment flows have already been greatly reduced by Phase I (Lake Texana), constructed across the primary Lavaca River tributary, the Navidad River. Construction and subsequent utilization of Phase II could cause significant further reduction in the inflows of freshwater, nutrients and detritus to Lavaca Bay and the rest of the Matagorda estuarine system.

The Texas Water Development Board component of the then Texas Department of Water Resources,[1] and biologists of the Fish and Wildlife Service and National Marine Fisheries Service,[2,3] determined that virtually all of the average historic freshwater flows would be necessary to maintain the fish- and shellfisheries harvests and the shrimp fishery productivity, respectively. We therefore believe that future significant decreases of freshwater, nutrient, detritus and sediment flows to the

Matagorda complex including Lavaca Bay, would be very detrimental to the estuarine fisheries. In addition, if Palmetto Bend Phase II (LN-2) were not constructed, some of the existing loss of sediment flowing into the Lavaca River delta could be eliminated by implementing a reverse of the proposed Diversion from Lavaca River to Lake Texana (LN-3). A diversion of Navidad River flows from the Lake Texana headwaters to the Lavaca River during floods would by-pass most of the in-stream sediment to the delta and also should extend the life of the existing Lake Texana.

The proposed Goliad Reservoir (S-1) and Diversion from Guadalupe and San Antonio Rivers (GS-1) would reduce inflows of freshwater, nutrients, detritus and sediment to San Antonio Bay. Also, a significant loss of sediment flow would reduce the nourishment of the Guadalupe River delta. The Texas Water Development Board, of the then Texas Department of Water Resources,[4] indicated that an average of nearly nine-tenths of the historic average annual freshwater inflows would be needed to maintain the average annual fish- and shellfisheries harvests in the San Antonio estuarine system. In another study, Texas Parks and Wildlife Department biologists[5] determined that any major deviation in annual amount of freshwater inflows from the historic average range would cause a major alteration in the ecology of the San Antonio estuarine system. It therefore appears that any significant reduction of freshwater inflows would significantly reduce the productivity of the estuarine fisheries.

Of the Alternatives presented in Table 4 - for the Nueces River watershed, the R&M Reservoir (N-3), the Pipeline from Choke Canyon to Lake Corpus Christi (N-5), and the Pipeline from Lake Corpus Christi to Calallen (N-6), do not appear to be viable alternatives due to their environmental impact of reduction of Nueces estuary freshwater inflow. The Choke Canyon/Lake Corpus Christi (CC/LCC) System is presently operating under a mandatory minimum freshwater release program to the Nueces estuary as required by the Phase II Operating Permit issued by the Texas Water Commission Order of March 1992. Any proposed water retention or transport alteration project that would reduce the minimum amount of CC/LCC Phase II freshwater inflow to the Nueces Bay estuary is not an acceptable alternative.

Of the three Nueces River watershed alternatives discussed above, the R&M Reservoir (N-3) is of greatest concern. Table 5 - Summary of Environmental Effects by Alternative shows a 6.4 percent decrease in historical median freshwater inflow to the Nueces estuary. This would be an additional loss of inflow, over and above what was lost when Choke Canyon was built, and this would cause serious degradation and loss to the Nueces estuary and related marine habitats of particular concern. The Final Environmental Impact Statement (FEIS) Nueces River Project, Choke Canyon Dam and Reservoir Site,[6] discussed the R&M reservoir site only as an alternative to the Choke Canyon reservoir site. It stated at page H-1, first, fourth, and seventh paragraphs, respectively, that: "A project at the R&M site on the Nueces

River . . . is considered the most desirable reservoir alternative to Choke Canyon."; "There would be losses to sport and commercial fishing in the Corpus Christi estuary that would result from reductions in freshwater inflow to the estuary caused by storage and diversion of currently unregulated Nueces River flows."; and "The project and a similar project at the Choke Canyon site on the Frio River are included as alternative projects in the Texas Water Plan published by the Texas Water Development Board in November 1968. In that plan, the board stated that the choice of which reservoir would be built would depend on plans of the local interests." Constructing reservoirs at both the R&M <u>and</u> Choke Canyon sites was not presented.

In a summary comparison of R&M and Choke Canyon sites (FEIS[6] Table 17, page H-7), annual estuary fishing losses for R&M were shown to be 184,000 man days of sport fishing and 4,490,000 pounds from commercial fishing. Both amounts are just over one-third more than those shown for the Choke Canyon site, and they do not estimate the impact on Gulf fishing for fishery resources reared in that estuary. Also, the Bureau of Reclamation predicted in a Nueces River Project, Texas Feasibility Report[7] (Table D-40, page D-124), that inflow to the estuary with full diversion of dependable yield of Lake Corpus Christi and R&M Reservoir under year 2010 conditions would not occur during 14 of 25 years, whereas, with Choke Canyon instead of R&M, it would not occur in 2 of 25 years.

In addition, the Texas Water Rights Commission on October 16, 1972, determined the Choke Canyon Reservoir as the more feasible and the more justifiable of the alternatives by reason of its engineering practicability, including cost of construction and operation and maintenance, thus essentially eliminating the R&M reservoir site from project consideration by the Bureau of Reclamation. We have found no current research data from any state or federal agency that would alter the above conclusions regarding R&M Reservoir impacts. As far as we know, the cumulative impacts of Choke Canyon Reservoir/Lake Corpus Christi plus R&M Reservoir have not been determined.

The invitation to provide these comments is appreciated and if we can provide further information please let us know.

Sincerely,

Donald Moore, Chief
Galveston Field Branch

Literature Cited

1. Texas Department to Water Resources. 1980 a. Lavaca-Tres Palacios Estuary: a study of the influence of freshwater inflows. TX Dept. of Water Res., LP-106. Austin, TX. 325 p.

2. Matthews, G. A. and A. J. Mueller. 1987. Freshwater inflow requirements of a Texas estuary. pp. 852-866 in Coastal Zone '87, WW Div./ASCE, Seattle, WA, May 26-29, 1987.

3. Mueller, A. J., and G. A. Matthews. 1987. Freshwater inflow needs of the Matagorda Bay System with focus on penaeid shrimp. U.S. Dept. of Comm. Nat'l Oceanic and Atmospheric Admin. National Marine Fisheries Svc. SE Fisheries Center Galveston Lab. NOAA Tech. Mem. NMFS-SEFC-189, 97 p. and 66 Append. p.

4. Texas Department of Water Resources. 1980 b. Guadalupe estuary: a study of the influence of freshwater inflows. TX Dept. of Water Res., LP-107. Austin, TX. 284 p.

5. Childress, R., E. Bradley, E. Hagen, and S. Williamson. 1975. The effects of freshwater inflows on hydrological and biological parameters in the San Antonio Bay System, Texas. Coastal Fisheries Branch, Texas Parks and Wild. Dept. 190 p.

6. Bureau of Reclamation. 1975. Final Environmental Impact Statement. Nueces River Project, Texas. Department of Interior, Southwest Region. FES 75-102. 97 p.

7. Bureau of Reclamation. 1971. Feasibility report on the Nueces River Project, Texas. Appendixes Vols. I and II. July 1971.

Reviewer:	08/31/93 letter from Donald Moore, Chief, Galveston Field Branch, U.S. Department of Commerce, National Marine Fisheries Service	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
3-1	C-1 (3-179)	*Comment: The Garwood Transfer (C-1), utilizing Colorado River flows, could reduce the total amount of fishery enhancement for which the Mouth of Colorado River, Texas project diversion features were justified in its benefit/cost ratio of 20:1.*
		Response: The proposed diversion of Colorado River Water considered under alternative C-1 concerns a permitted diversion under an existing water right. The volume of the proposed diversion is within Trans-Texas criteria for the maintenance of fisheries and for the health of the bay and estuary (see Appendix G).
3-2	LN-2 (3-167)	*Comment: The Palmetto Bend Phase II Reservoir (LN-2), proposed across the Lavaca River, would essentially eliminate the sediment re-nourishment of the Lavaca River delta. The sediment flows have already been greatly reduced by Phase I (Lake Texana, constructed across the primary Lavaca River tributary, the Navidad River. Construction and subsequent utilization of Phase II could cause significant further reduction in the inflows of freshwater, nutrients and detritus to Lavaca Bay and the rest of the Matagorda estuarine system.*
		Response: The proposed diversion of Lavaca River Water considered under alternative LN-2 concerns the permitted diversion of an existing water right. Recently it has been determined that 80 percent of the sediment entering Lake Texana passes through to the Lavaca River. An investigation (Ward, G.E., J.M. Wiersema, and N.E. Armstrong. 1982. Matagorda Bay: A Management Plan. USFWS) indicated that operation of the combined Palmetto Bend projects (an estimated diversion of 131,000 acft/yr) would have no substantial adverse impact on bay salinities or estuarine populations. Nonetheless, this project is not proposed to move forward in the integrated plans. As projects move forward through the various stages of study and permitting it is expected that concerns such bay and estuary inflows would be addressed at the appropriate level of investigation and permitting.
3-3	LN-2 (3-167)	*Comment: The Texas Water Development Board component of the then Texas Department of Water Resources, and biologists of the Fish and Wildlife Service and National Marine Fisheries Service, determined that virtually all of the average historic freshwater flows would be necessary to maintain the fish- and shellfisheries harvests and the shrimp fishery productivity, respectively. We therefore believe that future significant decreases of freshwater, nutrient, detritus and sediment flows to the Matagorda complex including Lavaca Bay, would be very detrimental to the estuarine fisheries. In additional, if Palmetto Bend Phase II (LN-2) were not constructed, some of the existing loss of sediment flowing into the Lavaca River delta could be eliminated by implementing a reverse of the proposed Diversion from Lavaca River to Lake Texana (LN-3). A diversion of Navidad River flows from the Lake Texana headwaters to the Lavaca River during floods would by-pass most of the in-stream sediment to the delta and also should extend the life of the existing Lake Texana.*
		Response: These comments are similar to Comment No 3-2 and are addressed above. Additionally, the diversion of flood flows from Lake Texana in order to pass sediments downstream of the dam would require further investigation in order to determine how much sediment the reservoir traps during floods and how much benefit, if any, could be achieved by diverting water from above Lake Texana to the Lavaca River. Water passing through the dam during flood stages is quite turbid.

3-4	G-1 & GS-1	*Comment: The proposed Goliad Reservoir (S-1) and Diversion from Guadalupe and San Antonio Rivers (GS-1) would reduce inflows of freshwater, nutrients, detritus and sediment to San Antonio Bay. Also, a significant loss of sediment flow would reduce the nourishment of the Guadalupe River delta. The Texas Water Development Board, of the then Texas Department of Water Resources, indicated that an average of nearly nine-tenths of the historic average annual freshwater inflows would be needed to maintain the average annual fish- and shellfisheries harvests in the San Antonio estuarine system. In another study, Texas Parks and Wildlife Department biologists determined that any major deviation in annual amount of freshwater inflows from the historic average range would cause a major alteration in the ecology of the San Antonio estuarine system. It therefore appears that any significant reduction of freshwater inflows would significantly reduce the productivity of the estuarine fisheries.*
		Response: The diversions proposed under these alternatives are within Trans-Texas criteria for maintaining healthy fisheries, bays, and estuaries (Appendix G). Recent investigations indicate that perturbations to bays and estuaries in Texas caused by reservoir operation are very difficult to detect against the background of variation characteristic of Texas bays and estuaries (Longley, W.L. ed. 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin, TX. 386 pp.).
3-5	N-3, N-5, N-6	*Comment: Of the Alternatives presented in Table 4 - for the Nueces River watershed, the R&M Reservoir (N-3), the Pipeline from Choke Canyon to Lake Corpus Christi (N-5), and the Pipeline from Lake Corpus Christi to Calallen (N-6), do not appear to be viable alternatives due to their environmental impact of reduction of Nueces estuary freshwater inflow. The Choke Canyon/Lake Corpus Christi (CC/LCC) System is presently operating under a mandatory minimum freshwater release program to the Nueces estuary as required by the Phase II Operating Permit issued by the Texas Water Commission Order of March 1992. Any proposed water retention or transport alteration project that would reduce the minimum amount of CC/LCC Phase II freshwater inflow to the Nueces Bay estuary is not an acceptable alternative.*
		Response: In the present investigations Trans-Texas criteria for maintaining fisheries, bays, and estuaries are incorporated into the proposed diversions. Actually, with respect to the pipelines (N-5 and N-6), flows to Nueces Bay would decrease due only to N-5 during periods of high flow. As a result of reduced evaporation, N-6 and N-5 during average or low flow periods, would slightly increase freshwater inflows to Nueces Bay.
3-6	N-3	*Comment: Of the three Nueces River watershed alternatives discussed above, the R&M Reservoir (N-3) of the greatest concern. Table 5 - Summary of Environmental Effects by Alternative shows a 6.4 percent decrease in historical median freshwater inflow to the Nueces estuary. This would be an additional loss of inflow, over and above what was lost when Choke Canyon was built, and this would cause serious degradation and loss to the Nueces estuary and related marine habitats of particular concern. The Final Environmental Impact Statement (FEIS) Nueces River Project, Choke Canyon Dam and Reservoir Site, discussed the R&M reservoir site only as an alternative to the Choke Canyon reservoir site. It stated at page H-1, first, fourth, and seventh paragraphs, respectively, that: "A project at the R&M site on the Nueces River. . .is considered the most desirable reservoir alternative to Choke Canyon."; "There would be losses to sport and commercial fishing in the Corpus Christi estuary that would result from reductions in freshwater inflow to the estuary caused by storage and diversion of currently unregulated Nueces River flows."; and "The project and a similar project at the Choke Canyon site on the Frio River are included as alternative projects in the Texas Water Plan published by the Texas Water Development Board in November 1968. In that plan, the board stated that the choice of which reservoir would be built would depend on plans of the local interests." Constructing reservoirs at both the R&M and Choke Canyon sites was not presented.*

		Response: These comments raise valid concerns. Detailed studies would be warranted in the event that plans to construct R&M reservoir moved forward. However, the construction of R&M reservoir is not expected to move forward in this study at this time. It is not being recommended as part of the integrated plan of alternatives to supply water for Corpus Christi.
3-7	N-3	*Comment: In a summary comparison of R&M and Choke Canyon sites (FEIS Table 17, page H-7), annual estuary fishing losses for R&M were shown to be 184,000 man days of sport fishing and 4,490,000 pounds from commercial fishing. Both amounts are just over one-third more than those shown for the Choke Canyon site, and they do not estimate the impact on Gulf fishing for fishery resources reared in that estuary. Also, the Bureau of Reclamation predicted in a Nueces River Project, Texas Feasibility Report (Table D-40, page D-124), that inflow to the estuary with full diversion of dependable yield of Lake Corpus Christi and R&M Reservoir under year 2010 conditions would not occur during 14 of 25 years, whereas, with Choke Canyon instead of R&M, it would not occur in 2 of 25 years.*
		Response: These comments raise valid concerns. Detailed studies would be warranted in the event that plans to construct R&M reservoir moved forward. However, the construction of R&M reservoir is not expected to move forward in this study at this time. It is not being recommended as part of the integrated plan of alternatives to supply water for Corpus Christi.
3-8	N-3	*Comment: In addition, the Texas Water Rights Commission on October 16, 1972, determined the Choke Canyon Reservoir as the more feasible and the more justifiable of the alternatives by reason of its engineering practicability, including cost of construction and operation and maintenance, thus essentially eliminating the R&M reservoir site from project consideration by the Bureau of Reclamation. We have found no current research data from any state or federal agency that would alter the above conclusions regarding R&M Reservoir impacts. As far as we know, the cumulative impacts of Choke Canyon Reservoir/Lake Corpus Christi plus R&M Reservoir have not been determined.*
		Response: HDR has updated engineering data for R&M reservoir using Trans-Texas criteria (see Appendix G). Nonetheless, constructing R&M reservoir is not being recommended as part of the integrated plan.

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

ANDREW SANSOM
Executive Director

September 7, 1993

Dr. Herb Grubb
HDR Engineering, Inc.
3000 IH 35 South, #400
Austin, Texas 78704

Dear Dr. Grubb:

I have only had time to partially review the draft interim Trans-Texas Report for the Corpus Christi Area, but in the interest of providing comment by September 7, I am forwarding my first impressions as preliminary comments. At the same time I am providing a copy of this report to other members of the TPWD staff for a more in-depth review and will provide their comments as they are provided to me.

Demands are ultimately a function of population. Therefore, having a valid population projection is the most important factor in determining whether new water projects are needed. Would it be possible to enlarge the discussion of population to develop a logic of how valid the current population projection is, given past abilities to accurately predict populations. Including discussion as to how much of the population growth in this area is net migration-in along with comparisons of population growth in other coastal and non-coastal areas of Texas and the rest of the United States might provide information as to whether current growth rates will be sustained? This information could have a great impact in determining which projects should be developed first and how many projects will be needed by certain dates.

Increases in municipal water demand will be driven by increases in population of the service area. I can appreciate the importance of conservativism in projecting population, but projections by definition must bear a relationship with historical trends. As populations change, demand patterns change as well. Changes in demand due to sociodemographic changes must be recognized and accounted for.

Water demand, especially municipal demand, should be broken down into at least two different types: base demand, which is primarily indoor water use, and peak seasonal demand, which is predominately outdoor water use. Different water conservation and demand management practices affect each to varying degrees. Additionally, peak demands, because they are temporary in nature, can be met with interim supplies. A substantial percentage of surface water storage, treatment capacity, and distribution capacity across Texas is dedicated to satisfy peak demands. Reductions in peak demands could reduce the need for infrastructure that is used only some of the time, thereby eliminating some costs and environmental impacts.

Extrapolation of per capita municipal use rates from the early 1980's produces use trends for most counties that rise after 1990, peak in 2000, and then decline due to anticipated adoption of conservation measures. However, there is no discussion of which water conservation practices are presently in place, which practices might be adopted in the future, and the effectiveness of either at reducing water use. Given the costs and impacts of expanding supply, reducing demand should be given much greater emphasis and attention now.

Can a discussion as to what "with conservation" actually means with regards to water conservation actions be included? If this does not include installation of efficient water-use plumbing or use of a cost gradient scale (i.e. $1.00 for first 1000 gallons, 2.00 for next 1000 gallons, etc.) to encourage conservation practices, then these ought to be presented as options to reduce demands thus decreasing future needs.

If this plan is to be a water plan for the region, I do not understand why the population is divided into that which is dependent upon CC/LCC and that portion which is not (i.e. Fig. 2.1-1). Where does the rest of the population get their water from and will their supplies be sufficient until 2050? If not, how is the state supposed to assist in addressing their needs?

I find the discussions of environmental issues to be superficial and of limited use for making preliminary decisions about which projects will have the greatest impacts on fish and wildlife resources. In Chapter 1 a claim is made that costs to do environmental studies and to mitigate adverse impacts were made, I do not find any presentation of these cost estimates.

It does not appear that any first level research such as site visitations or use of available mapped data on endangered resources has been done so that preliminary statements about actual effects can be addressed by project. It should be possible to get some actual locations of endangered species or special natural communities and note proximity and probable occurance on a proposed project site.

Page 3-10. Last sent. There may be controversy from an anthropogenic view as to which environment is adverse or beneficial, but from the view of a lotic dependent species there is no controversy. Changing its environment to a lentic environment is ultimately deadly.

Most of the discussion having to do with fish and wildlife resource concerns is limited to endangered or threatened species. My understanding was that environmental concerns would be addressed on a level of other demands on water uses and would include evaluations of impacts on all fish and wildlife resources.

Although the Texas Parks and Wildlife Department staff has in the past and may continue to introduce fish species and other organisms from one basin to another, that does not mean there has been no adverse impacts or that if conditions change (as they are likely to with large and persistent transfers) that additional impacts will not occur. The continual exchanges made by fisherman and recreationists cited in the report (pg 3-139) are extremely small compared with the magnitude of transfers suggested in most Trans-Texas projects.

Obviously, any exchange of organisms having several individuals of a species no matter how few could result in the establishment of a population in a new location, but the probability is smaller that it will happen. This is no excuse for justifying any transfer. However, there is a substantial difference that should be addressed. Introductions of small organisms (i.e. viruses, bacteria, even zooplankton) into habitat in which they have not been in before presents a number of problems which usually result in their failing to survive as a population, however, when large persistent introductions occur repeatedly, the probability that a population will become self sustaining is increased.

A good case study of concerns about biological problems that could develop from inter-basin transfers might be the Lake Texoma-Lake Lavon near Dallas. This study is not done yet, but it could be used to describe many of the past concerns dealing with inter-basin transfers and possible studies to provide answers if those concerns have merit. The movement of dangerous exotic species, such as the zebra mussel, may be greatly increased through major inter-basin transfers and must be examined in detail.

Sincerely,

Albert W. Green, Chief
Aquatic Studies Branch
Resource Protection Division
OFF.(512)448-4313
FAX (512)707-1358

AWG/bls

cc: Larry McKinney
Tommy Knowles
James Dodson
Warren Pulich
Randy Moss
Phil Durocher
Gen McCarty

Reviewer:	09/07/93 letter from Albert W. Green, Chief, Aquatic Studies Branch Resource Protection Division, Texas Parks and Wildlife Department	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
4-1	Section 2.0 Population Projections	*Comment:Would it be possible to enlarge the discussion of population to develop a logic of how valid the current population projection is, given past abilities to accurately predict populations. Including discussion as to how much of the populations. Including discussion as to how much of the population growth in this area is net migration-in along with comparisons of population growth in other coastal and non-coastal areas of Texas and the rest of the United States might provide information as to whether current growth rates will be sustained?*
		Response: See Response to Comment Number 1-1. The purpose of the Phase I study was to show the water supply of the area in relation to the high case, with conservation projection of water demand, as specified by the Texas Water Development Board (TWDB). The data used by the TWDB with which to make the projections were derived from the history of population growth, including migration, of each respective county of the study area. The Phase I study was not an analysis of migration nor a comparison of growth rates for coastal or other areas. It is important to note, however, that the projected population growth rate for the 12-county study area is only 1.02 percent per year, while the rate for the State for the period 1990 to 2050 is 1.27 percent. The historic rate for the 12-county area for the past 60 years (1930 through 1990) was 1.90 percent. Therefore, it appears that the high case population projections for the 12-county area are based on much lower rates than the historic experience of the area; i.e.; the projections are on the low side, when compared to growth rates of the past.
4-2	Section 2.0 Water Demand Projections	*Comment: Water demand, especially municipal demand, should be broken down into at least two different types: base demand, which is primarily indoor water use, and peak seasonal demand, which is predominately outdoor water use. Different water conservation and demand management practices affect each to varying degrees. Additionally, peak demands, because they are temporary in nature, can be met with interim supplies. A substantial percentage of surface water storage, treatment capacity, and distribution capacity cross Texas is dedicated to satisfy peak demands. Reductions in peak demands could reduce the need for infrastructure that is used only some of the time, thereby eliminating some costs and environmental impacts.*
		Response: The municipal water demand projections are not based upon peak summertime demands except to the extent that summer daily use rates are included in the computation of daily per capita use that is used in making the projections of municipal water demands. For example, the high case per capita water use rates for the cities and rural areas of the study area are the average daily water use per person for the driest year of the 1977-1986 period of record; i.e., the computation of the high case dry year per capita water use rate is (total quantity of municipal water use for the dry year) ÷ (365) ÷ (population for the dry year). This per capita water use rate (adjusted for conservation) is multiplied by the projected population in years 2000, 2010, 2020, 2030, 2040 and 2050 in order to obtain the projected quantities of municipal water demands for each year, respectively. Therefore, the projection shows the quantity of water that is needed to meet the needs of the population of the area at each projection date, including summertime peak demand days and wintertime low demand days for dry year conditions. As is stated in the comment, storage, treatment, and conveyance facilities are sized to meet peak day and peak hour demands, as appropriate.

4-3	Section 2.0 Water Demand Projections	*Comment: Extrapolation of per capita municipal use rates from the early 1980's produces use trends for most counties that rise after 1990, peak in 2000, and then decline due to anticipated adoption of conservation measures. However, there is no discussion of which water conservation practices are presently in place, which practices might be adopted in the future, and the effectiveness of either at reducing water use. Given the costs and impacts of expanding supply, reducing demand should be given much greater emphasis and attention now.*
		Response: The projections of municipal water demands are based upon the effects of low-flow, water efficient plumbing fixtures specified in 1991 Texas legislation which allows only the sale of low-flow rate plumbing fixtures (toilets, urinals, faucet aerators, and shower heads) after January 1, 1993 (see text of Section 2.3, Municipal Water Demand). Accelerated conservation is evaluated in the Phase II study as a potential to reduce municipal water demand. See response to Comment No. 1-2.
4-4	Section 2.0 Water Demand Projections	*Comment: Can a discussion as to what "with conservation" actually means with regards to water conservation actions be included? If this does not include installation of efficient water-use plumbing or use of a cost gradient scale (i.e., $1.00 for first 1000 gallons, 2.00 for next 1000 gallons, etc.) to encourage conservation practices, then these ought to be presented as options to reduce demands thus decreasing future needs.*
		Response: See response numbers 1-2 and 4-3 above. Also, see text of Section 2.3 of the Phase II Study report where "with conservation" is further explained.
4-5	Section 2.0 Water Demand Projections	*Comment: If this plan is to be a water plan for the region, I do not understand why the population is divided into that which is dependent upon CC/LCC and that portion which is not (i.e., Fig. 2.1-1). Where does the rest of the population get their water from and will their supplies be sufficient until 2050? If not, how is the state supposed to assist in addressing their needs?*
		Response: In the study area there are two major sources of water, as follows: 1) surface water from Choke Canyon/Lake Corpus Christi (CC/LCC) and 2) ground water from the Gulf Coast and Carrizo Aquifers. As is explained in the text in sections 2.4 and 2.5 some cities and rural areas that now use groundwater are expected to be able to continue to meet their needs from local groundwater sources, if quality does not deteriorate to the extent that the water does not meet regulatory standards for public supply. That is to say that groundwater quantities appear to be adequate to meet the needs of some cities and rural areas. However, for those cities and rural areas that depend upon the CC/LCC system, the projections of demand exceed the projections of supply in the near future. Thus, the division of the area into the two groups mentioned, and the focus upon securing supply for the entities that are facing shortages during the 50-year planning horizon.
4-6	Section 3.0 Cost Estimating Procedures	*Comment: I find the discussions of environmental issues to be superficial and of limited use for making preliminary decisions about which projects will have the greatest impacts on fish and wildlife resources. In Chapter 1 a claim is made that costs to do environmental studies and to mitigate adverse impacts were made, I do not find any presentation of these cost estimates.*

		Response: Generally, the level of effort in the environmental studies is coordinated with and appropriate to the level of planning type studies. Environmental studies early in the planning stages are conducted at a level commensurate with the screening process. Because it would be unproductive and prohibitively expensive to expend great effort on an alternative with little or no likelihood of being developed, environmental studies are designed to assist in sorting out the relative problems and merits of each alternative as they proceed through the planning process. Alternatives that continue on through the planning process receive greater scrutiny. Costs for environmental studies, mitigation, and permitting were estimated on an individual project basis utilizing available information and judgment of qualified professionals. These costs are summarized in a line-item entry in the cost estimate table for each alternative. For reservoirs, the mitigation costs are based on the cost to purchase an equal land area. In the case of pipelines, studies and mitigation, costs are estimated on a unit cost per foot of pipeline. For other types of projects, studies and mitigation costs were estimated individually.
4-7	Section 3.0	*Comment: It does not appear that any first level research such as site visitations or use of available mapped data on endangered resources has been done so that preliminary statements about actual effects can be addressed by project. It should be possible to get some actual locations of endangered species or special natural communities and note proximity and probable occurrence on a proposed project site.*
		Response: Land uses, habitat types and values, and wetland occurrences have been identified and evaluated using available literature and a variety of other sources, including the Texas Parks and Wildlife Department, Resource Protection Division's Texas Natural Heritage Program data and mapping files for endangered, protected and sensitive resources, the U.S. Fish and Wildlife Service' National Wetland Inventory (NWI) maps and U.S. Geological Survey (USGS) EROS Data Center black and white and infrared photographs. A records search for cultural resources using existing data of reported cultural resources identified from Texas Archaeological Research Laboratory (TARL) files was performed. This data base, including archaeological sites of record, natural resources, protected species, and potential wetland areas is on 7.5 minute quadrangles maintained at Paul Price Associates, Inc. Natural Heritage Program files and literature concerning specific species range has been used to develop the county by county threatened and endangered species tables included in Appendix C. Several alternatives that had previously been studied extensively included more focused tables of protected species that may have habitat present within the impact area of the alternative considered. As stated above, the specific site locations of these species and other important species and communities are located on 7.5 minute quadrangles. These specific locations are not reported in this document to protect the resource. Due to the sensitive nature of the occurrence information, Texas Parks and Wildlife Department requests that the location information not be published or disseminated without contacting the Natural Heritage Program office first. Without the type of detailed survey data collected in a field reconnaissance, exact location information could be inaccurate and misleading. For many species, where sufficient amounts of appropriate habitat is available, the species will be present. Since site reconnaissance was beyond the scope of the Phase I study, information concerning the habitats was assembled from aerial photographs, maps, and existing reports. Important vegetation communities data and possible presence of important resources were considered in the report sections and alternatives evaluations. Viable alternatives, that is those alternatives that were not eliminated in the fatal flaw analysis and evaluation matrix , will be studied in greater detail in later phases.

4-8	Section 3.0	*Comment: Most of the discussion having to do with fish and wildlife resource concerns is limited to endangered or threatened species. My understanding was that environmental concerns would be addressed on a level of other demands on water uses and would include evaluations of impacts on all fish and wildlife resources.*
		Response: The objectives of the Phase I environmental study were to provide a general assessment of the water supply alternatives advantages and disadvantages so that decisions can be made as to which options should be pursued in more detail in Phase II (see report section 1.2). The screening level and comparative analysis discussions targeted effects on protected species as an indication of the impacts to the most sensitive species. General evaluations of the impacts to fish and wildlife are addressed in section discussions concerning instream flow and inflow to the bays.
4-9	Section 3.0	*Comment: Although the Texas Parks and Wildlife Department staff has in the past and may continue to introduce fish species and other organisms from one basin to another, that does not mean there has been no adverse impacts or that if conditions change (as they are likely to with large and persistent transfers) that additional impacts will not occur. The continual exchanges made by fisherman and recreationists cited in the report (pg 3-139) are extremely small compared with the magnitude of transfers suggested in most Trans-Texas projects.* *Obviously, any exchange of organisms having several individuals of a species no matter how few could result in the establishment of a population in a new location, but the probability is smaller that it will happen. This is no excuse for justifying any transfer. However, there is a substantial difference that should be addressed. Introductions of small organisms (i.e., viruses, bacteria, even zooplankton) into habitat in which they have not been in before presents a number of problems which usually result in their failing to survive as a population, however, when large persistent introductions occur repeatedly, the probability that a population will become self sustaining is increased.* *A good case study of concerns about biological problems that could develop from inter-basin transfers might be the Lake Texoma-Lake Lavon near Dallas; This study is not done yet, but it could be used to describe many of the past concerns dealing with inter-basin transfers and possible studies to provide answers if those concerns have merit. The movement of dangerous exotic species, such as the zebra mussel, may be greatly increased through major inter-basin transfers and must be examined in detail.*
		Response: Currently, there are at least 41 permitted interbasin transfers of raw water in Texas and 14 interbasin transfer of treated water. The Texas Water Development Board, in cooperation with the U.S. Army Corps of Engineers, is sponsoring a study of the potential risks associated with interbasin water transfers being considered in the Trans-Texas Water Program. HDR is providing information to the study consultants specific to the water supply alternatives being considered for the Corpus Christi Study Area. The results of this study will probably not be available until after Phase II is complete. However, the findings of the study will be available for use in later phases of Trans-Texas.

THE POWER TO MAKE A DIFFERENCE.

September 14, 1993

Mr. Jack Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, TX 77957-0429

Dear Jack:

We have reviewed the Phase I Interim Report for the Southern Portion of the South Central Trans-Texas Water Program and offer the following comments.

- Page 2-33 through 34 and Table 2.7-1

The water supply and demand information for Wharton, Colorado, and Matagorda Counties is seriously flawed. The most severe problem is the assumption that water supply and maximum authorized permitted withdrawals are the same. In Table 2.7-1, the year 2050 projected water supply is set equal to the 1992 surface water permits. This is a gross overestimation of dependable water supplies in the lower Colorado River Basin.

The dependable water supplies available from the Colorado River cannot be calculated according to the water use permits since these permits are simply the authorization to capture water in the river when water is available. None of these permits include significant storage capacity. Water diverted under these permits must be supplemented with water stored in the LCRA Highland Lakes to provide a dependable supply, therefore, it is not proper to indicate a surplus of 571,247 acre-feet in 2050 from the designated ten-counties.

Concerning the projected 2050 water demands, the estimated water demands for irrigation from the Colorado River seem significantly lower that those projected by LCRA. In Wharton, Matagorda, and Colorado Counties, the estimated 2050 annual demand for irrigation and livestock totals 438,600 acre-feet, with the overwhelming majority certainly for irrigation. The surface water demands for irrigation are not explicitly indicated in the report, therefore, similar data are used for comparison. The TWDB projected for year 2000 that the four major irrigation districts supplied by LCRA would have an annual demand of 330,000 acre-feet. This compares to an annual demand projection of 480,000 acre-feet by LCRA for the LCRA Drought Management Plan. This difference in projected demands remain about the same in years after 2000. The TWDB projection assumes far fewer acres of rice cultivated than does LCRA.

LOWER COLORADO RIVER AUTHORITY P.O. BOX 220 AUSTIN, TX 78767-0220 (512) 473-3200 (512) 473-3298 FAX

Appendix A lists previous studies on water supply in South-Central Texas. Absent from this listing are the recent Water Supply and Demand Assessment Studies for Colorado, Wharton, and Matagorda Counties completed by LCRA as well as LCRA's Water Management and Drought Management Plans.

- Page 3-181 thru 3-187

The report concludes that because a portion of Garwood Irrigation Company's (Garwood) water use under its permit has been for the irrigation of land in the Lavaca-Navidad watershed the diversion of 35,000 acre-feet per year for municipal and industrial purposes by Corpus Christi would not be a new interbasin transfer. This seems to imply that a permit for the interbasin transfer from the Texas Natural Resources Conservation Commission (TNRCC) will not be necessary. We do not believe this conclusion is within the scope of this study and should be removed.

The report also concludes that because 35,000 acre-feet has always been available from run-of-the-river flows the sale of 35,000 acre-feet per year for municipal purposes could be achieved entirely from run-of-the-river flows. This conclusion presumes that the sale of 35,000 acre-feet for municipal purposes to Corpus Christi has priority over the remainder of Garwood's irrigation right and would have first call on run-of-the-river water. We do not believe that is the intent of the option agreement between Corpus Christi and Garwood. This type of priority diversion would impact the Highland Lakes through the required release of more stored water to support Garwood's irrigation operations. It would also subject Garwood's irrigators to additional curtailment of available water during extreme droughts under the terms of LCRA's Drought Management Plan.

Thank you for the opportunity to comment on the Phase I report.

Sincerely,

Gene Richardson, Manager
Water Resources

Reviewer:	09/14/93 letter from Gene Richardson, Manager, Water Resources, Lower Colorado River Authority	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
5-1	Section 2.0 Water Supply	*Comment: The water supply and demand information for Wharton, Colorado, and Matagorda Counties is seriously flawed. The most severe problem is the assumption that water supply and maximum authorized permitted withdrawals are the same. In Table 2.7-1, the year 2050 projected water supply is set equal to the 1992 surface water permits. This is a gross overestimation of dependable water supplies in the lower Colorado River Basin.* *The dependable water supplies available from the Colorado River cannot be calculated according to the water use permits since these permits are simply the authorization to capture water in the river when water is available. None of these permits include significant storage capacity. Water diverted under these permits must be supplemented with water stored in the LCRA Highland Lakes to provide a dependable supply, therefore, it is not proper to indicate a surplus of 571,247 acre-feet in 2050 from the designated ten-counties.*
		Response: The comment is well taken. The permit data were included in the Phase I report for information purposes only. Additional attention is given to this question in the Phase II report and in the West Central Trans-Texas report (see Section 3.16).
5-2	Section 2.0 Water Demand Projections	*Comment: Concerning the projected 2050 water demands, the estimated water demands for irrigation from the Colorado River seem significantly lower than those projected by LCRA. In Wharton, Matagorda, and Colorado Counties, the estimated 2050 annual demand for irrigation and livestock totals 438,600 acre-feet, with the overwhelming majority certainly for irrigation. The surface water demands for irrigation are not explicitly indicated in the report, therefore, similar data are used for comparison. The TWDB projected for year 2000 that the four major irrigation districts supplied by LCRA would have an annual demand of 330,000 acre-feet. This compares to an annual demand projection of 480,000 acre-feet by LCRA for the LCRA Drought Management Plan. This difference in projected demands remain about the same in years after 2000. The TWDB projection assumes far fewer acres of rice cultivated than does LCRA.*
		Response: The comment is noted and has been referred to the Texas Water Development Board (TWDB) for their consideration. It is anticipated that these differences will be resolved in the TWDB 1995 "Consensus Water Planning Projections".
5-3 (DCW)	Appendix	*Comment: Appendix A lists previous studies on water supply in South-Central Texas. Absent from this listing are the recent Water Supply and Demand Assessment Studies for Colorado, Wharton, and Matagorda Counties completed by LCRA as well as LCRA's Water Management and Drought Management Plans.*
		Response: These references have been added to the Appendix A listing.
5-4	C-1 Page 3-181 thru 3-187	*Comment: The report concludes that because a portion of Garwood Irrigation Company's (Garwood) water use under its permit has been for the irrigation of land in the Lavaca-Navidad watershed the diversion of 35,000 acre-feet per year for municipal and industrial purposes by Corpus Christi would not be a new interbasin transfer. This seems to imply that a permit for the interbasin transfer from the Texas Natural Resources Conservation Commission (TNRCC) will not be necessary. We do not believe this conclusion is within the scope of this study and should be removed.*

		Response: The diversion of water by the Garwood Irrigation Company from the Colorado River Basin to the Colorado-Lavaca Coastal Basin has occurred since the early 1900's. This interbasin transfer is discussed in Section 3.16.2 to point out that the water proposed for transfer is not a new demand on the Colorado River, but has occurred for many years. The need to obtain a TNRCC permit for interbasin transfer of this water is discussed in Section 3.16.6 Implementation Issues.
5-5	C-1 (3-181)	*Comment: The report also concludes that because 35,000 acre-feet has always been available from run-of-the-river flows the sale of 35,000 acre-feet per year for municipal purposes could be achieved entirely from run-of-the-river flows. This conclusion presumes that the sale of 35,000 acre-feet for municipal purposes to Corpus Christi has priority over the remainder of Garwood's irrigation right and would have first call on run-of-the-river water. We do not believe that is the intent of the option agreement between Corpus Christi and Garwood. This type of priority diversion would impact the Highland Lakes through the required release of more stored water to support Garwood's irrigation operations. It would also subject Garwood's irrigators to additional curtailment of available water during extreme droughts under the terms of LCRA's Drought Management Plan.*
		Response: This comment has been addressed in Section 3.16 of the Phase II report.

SAN ANTONIO RIVER AUTHORITY

1.11-3.6 GC

September 15, 1993

Mr. Jack C. Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

RE: Trans-Texas Water Program
South Central Phase I Interim Report
Corpus Christi Study Area

Dear Mr. Nelson:

We have reviewed the Interim Report and offer the following comments:

1. If the executive summary is bound separately from the main report, please include the summary tables comparing the alternatives in the main report.

2. Page 1-5 of the report states that if adequate water supplies can not be identified in the 12 county study area, only then will potential water supplies in the lower Brazos and Sabine River basins be considered.

   The purpose of Trans-Texas is to more effectively utilize existing water supplies instead of developing new water supplies if it is more feasible to use the existing water supplies. In order to have a complete comparison, the water supply options identified in the 12 county study area must be compared to the cost and feasibility of utilizing the existing water supplies in the eastern river basins. Will this comparison be done in Phase I or Phase II?

We hope these comments are helpful to you in completing your report. Please contact us if you have questions concerning the comments.

Sincerely,

STEVEN J. RAABE, P.E.
Chief, Engineering Division

cc: Tommy Knowles, TWDB

Reviewer:	09/15/93 letter from Steven J.Raabe, Chief, Engineering Division, San Antonio River Authority	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
6-1	Section 3.21	*Comment: The purpose of Trans-Texas is to more effectively utilize existing water supplies instead of developing new water supplies if it is more feasible to use the existing water supplies. In order to have a complete comparison, the water supply options identified in the 12 county study area must be compared to the cost and feasibility of utilizing the existing water supplies in the eastern river basins. Will this comparison be done in Phase I or Phase II?*
		Response: Water supply alternatives considering the use of Colorado River Water (Alternatives C-1 and C-2) and Brazos River Water (Alternatives B-3) are contained in the Phase II report. These sections include the cost and implementation issues associated with these potential supplies.

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE • P. O. BOX 7555 • TELEPHONE AREA CODE 817 776-1441
WACO, TEXAS 76714-7555

September 16, 1993

Mr. Jack Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957

Subject: Review Comments on South Texas Trans-Texas Phase I Interim Report (Corpus Christi Service Area)

Dear Jack:

I appreciate the opportunity to review the referenced report. HDR, Inc. has done their usual good job of correlating water demand and water supply data for both the 12 county study area and the ten county potential water supply area. In the draft report that I received, the page numbering in the table of contents did not correspond with the text, but overall the report presented an excellent compilation of pertinent data and a perceptive selection of water supply alternatives for the City of Corpus Christi.

It would be useful if the report contained a separate section to discuss the overall findings. This section would not only compare water demands to potential water supplies but would also discuss the merits and problems of the various water supply alternatives examined in the report. This may simply involve an expansion of Section 2.7 or perhaps Section 3.

I look forward to our meeting on September 22, 1993.

Sincerely,

Tom

J. TOM RAY, P.E.
Planning and Environmental
Division Manager

JTR:rp
q:\transtx.nelson.909

Reviewer:	09/16/93 letter from J. Tom Ray, Planning and Environmental Division Manager, Brazos River Authority	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
7-1	Section 4.0 Cost and Financing Analysis	*Comment: It would be useful if the report contained a separate section to discuss the overall findings. This section would not only compare water demands to potential water supplies but would also discuss the merits and problems of the various water supply alternatives examined in the report. This may simply involve an expansion of Section 2.7 or perhaps Section 3.*
		Response: The Executive Summary and also Section 4.0, Integrated Water Supply Programs (Phase II report), contain comparisons of cost, water supply potential, water quality, and environmental impact of water supply alternatives.

COASTAL BEND
SIERRA CLUB
P.O. Box 3512, Corpus Christi, Texas 78404

September 17, 1993

Mr. Jack Nelson
Lavaca-Navidad River Authority
Box 429
Edna, TX 77957-0429

Dear Mr. Nelson:

Here are our comments (a little late) on the South Central Trans-Texas Phase I Interim Report. In general, we believe that the study is progressing well. We await the results of some sedimentation investigations which are going on in the Choke Canyon and Lake Corpus Christi areas. That will give us all a better handle on just what the so-called firm yields are.

We would like to add another study to the list of 16 which are delineated in the Interim Report. This would be a serious look into the feasibility of deepening the reservoir at the Wesley Seale Dam. Geologists and resource people assure us that it is possible to increase the storage capacity in the immediate vicinity of the dam and that the sediment could be released gradually to mimic the former natural conditions of the river. Two things might be accomplished by this. One, more capacity to retain flood waters. Two, replenishing the sediment and nutrients normally carried by the river. We envision that more or less constant dredging would be needed and so a dredge would be an expense. One geologist also told us that by deepening the hole at the dam, the sediment now in the upper reaches of Lake Corpus Christi should gradually sift down to the lower level and then could be added to the dredged sediment being released there. If this is true, even more capacity would be created. If sedimentation is a problem at Choke Canyon, then the same argument applies.

Sincerely,

Patricia H. Suter, Chairman

Reviewer:	09/17/93 letter from Patricia H. Suter, Chairman, Coastal Bend Sierra Club	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
8-1	Section 3.19	*Comment: We would like to add another study to the list of 16 which are delineated in the Interim Report. This would be a serious look into the feasibility of deepening the reservoir at the Wesley Seale Dam. Geologists and resource people assure us that it is possible to increase the storage capacity in the immediate vicinity of the dam and that the sediment could be released gradually to mimic the former natural conditions of the river. Two things might be accomplished by this. One, more capacity to retain flood waters. Two, replenishing the sediment and nutrients normally carried by the river. We envision that more or less constant dredging would be needed and so a dredge would be an expense. One geologist also told us that by deepening the hole at the dam, the sediment now in the upper reaches of Lake Corpus Christi should gradually sift down to the lower level and then could be added to the dredged sediment being released there. If this is true, even more capacity would be created. If sedimentation is a problem at Choke Canyon, then the same argument applies.*
		Response: Conceptually, a program to release accumulated sediment from a reservoir could be implemented by (1) construction of an outlet structure which includes gates at the reservoir bottom that can be used to periodically sluice out silt, or (2) dredging portions of the reservoir immediately upstream from the dam and pumping the dredged material downstream, directly into the river. The feasibility of designing outlet structures that include gates at the reservoir bottom, to allow periodic sluicing of accumulated sediment, may have been considered for other reservoirs, however, construction of such an outlet structure at the existing Wesley Seale Dam may be possible, but would not create a cost effective source of additional water supply. At Lake Corpus Christi, the conservation storage volume that could be restored is above elevation 55.5 ft, which is the elevation of the existing lower sluice gates. The volume below that elevation is not useful for water supply. Based on the 1972 sedimentation survey, the lake bottom near the dam, and especially between the old and new dams (approximately 1500 feet upstream from the new dam), is below elevations 55.5 ft. Siltation in these areas does not affect the conservation storage. The feasibility of a dredging program to incorporate the release of accumulated sediment from the reservoir downstream to the Nueces River, instead of disposal of sediment into dredge disposal sites, would require that several major issues be addressed, including:

		1. Economic Feasibility - The cost of a dredging program that includes disposal of sediment in dredge disposal sites was estimated to range between \$5 - \$10 per cubic yard. A program that eliminates the disposal site cost will still include costs for: mobilization of dredging equipment; dredging; installation of discharge piping and intermediate booster stations. It is estimated that only approximately 15% to 25% of the total unit cost would be saved by eliminating the disposal site costs. 2. Water Quality Concerns - It is anticipated that a Corps of Engineers Section 404 permit would be required for such a sediment release program. Water quality concerns in the Nueces River downstream from the dam would require evaluation of the possible detrimental effect of additional sediment on parameters such as dissolved oxygen and toxicity to aquatic species. 3. Water Treatment Concerns - Increased turbidity resulting from the release of sediment would negatively impact the City's water treatment process and result in higher chemical usage and treatment costs. 4. Sediment Control - Release of sediment downstream from the dam may result in the need to periodically dredge areas of the Nueces River to prevent excessive deposition.

September 17, 1993

Mr. Emmett Gloyna
General Manager
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957

Dear Emmett:

Board staff have completed a preliminary review of the draft Phase I Interim Report for the Corpus Christi area. Overall, the report appears to satisfy the intent of Phase I, that is, to conduct a preliminary assessment of the technical, economic, and environmental feasibility of various alternatives such that decisions can be made on which alternatives to carry forward for more detailed evaluation in Phase II. For the alternatives considered, Board staff believe sufficient information is provided in the draft report to support the decision-making process by the Trans-Texas Policy Management Committee. However, as discussed, other alternatives, such as enhanced or accelerated water conservation, may need to be evaluated.

Board staff have identified a number of issues or questions in the draft report which may need to be considered by HDR or by the PMC during Phase II deliberations. Attached for your consideration are comments from individual Board staff on the draft report.

If you have any questions, please call me at (512)463-8043.

Sincerely,

Tommy Knowles
Deputy Executive Administrator
Office of Planning

CC: James Dodson, City of Corpus Christi
Mark Jordan, Texas Natural Resources Conservation Commission
Larry McKinney, Texas Parks and Wildlife Department
Herb Grubb, HDR Engineering

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Telefax (512) 475-2053 • 1-800-RELAY TX (for the hearing impaired)

Reviewer:	09/17/93 letter from Tommy Knowles, Deputy Executive Administrator Office of Planning, Texas Water Development Board	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
9-1	Section 2.0 Water Demand Projections	*Comment: A better reference for "drought" would be to "periods of below average rainfall".*
		Response: This has been addressed and further explained in Section 2.3 of the Phase II report.
9-2	Section 2.0 Water Demand Projections	*Comment: Second paragraph - This explanation could be strengthened by adding discussion about how the industries have reduced water use and provide quantitative information.*
		Response: This has been done in Section 3.6 of the Phase II report.
9-3	Section 2.0 Water Demand Projections	*Comment: The impacts of the North American Free Trade Agreement on the Corpus Christi area are unknown and this report does not provide sufficient information to prove that the Agreement will increase industrial growth of the area as implied in this sentence. The sentence could be re-written to say that the NAFTA may significantly change industrial activity in the area.*
		Response: This point is noted and recognized as suggested.

TEXAS WATER DEVELOPMENT BOARD

MEMORANDUM

To: Dennis Crowley, Regional Planning Section

From: Tommy Knowles, Assistant Executive Administrator for Planning

Date: September 10, 1993

Subject: Comments on Trans-Texas Draft Phase I Report for the Corpus Christi area

As requested, I have the following comments on the Trans-Texas Draft Phase I Report for the Corpus Christi area:

<u>Page 2-7:</u>

Sentence: ...upon municipal supplies during droughts.

A better reference for "drought" would be to "periods of below average rainfall"

<u>Page 2-9:</u>

Second paragraph: This explanation could be strengthened by adding discussion about how the industries have reduced water use and provide quantitative information.

<u>Page 2-11:</u>

Sentence: ... understated in terms of the effects of NAFTA upon industrial growth of the area.

The impacts of the North American Free Trade Agreement on the Corpus Christi area are unknown and this report does not provide sufficient information to prove that the Agreement will increase industrial growth of the area as implied in this sentence. The sentence could be re-written to say that the NAFTA may significantly change industrial activity in the area.

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TEXAS WAT ER DEVELOPMENT BOARD

MEMORANDUM

TO: Dennis Crowley

FROM: Tom Brown, Deputy Executive Administrator, Water Resources Development

DATE: September 10, 1993

SUBJECT: Comments on the Trans-Texas Draft Phase I Report for the Corpus Christi Area

Per your request, I had the following comments on the Trans Texas Phase I report for the Corpus Christi Area:

Page 3-14:

Sentence: ...Corpus Christi shows that on the average, the lake level would be approximately two feet lower under the Phase IV policy.

Comments: This statement will be challanged by the Save the Lake Coalition

Page 3-18:

Sentence: However, there is not information available on the potential effects of the CC/LCC reservoir operating policy on the water quality within Lake Corpus Christi and ultimately at Stevens. The reduced volume of water within Lake Corpus Christi (at elevation 76 feet-msl the ...

Comments: There should be data from the '83 drought. (Talk to Herbert Hall)

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Page 3-19:

Sentence: Specific water quality assessments should be completed in later phases of the Trans-Texas study, if the Modification of Reservoir Operating Policy should continue to be considered as an alternative water supply. (Refer to Appendix E for more detailed consideration of treatment issues.)

Comments: Item for study on Phase II study.

Page 3-29:

Sentence: The time step used in NUTEXAS averages the flood flows over a month, and these flood volumes are the major source of water for diversion

Comments: They focused on Three Rivers diversion. The Simmons diversion was only 108/ac. ft. (w/o O&M) for 14,000 ac. ft.

Page 3-37:

Sentence: Direct operational effects of the R&M alternative will include permanent inundation of 31,340 acres in the conservation pool, changes in the streamflow regime below the dam, and reductions in inflows to Nueces Bay equal to the amount of water diverted and not returned to the Nueces Delta, plus the net increase in evaporation resulting from impoundment.

Comment: Need greater detail on how the streamflow changes, since it will be kept bank full for diversion.

Page 3-43:

Sentence: Mitigation area management costs can be expected to average $5-10 per acre per year (plus inflation) over the life of the project.

Comment: There needs to be greater discussion on land acquisition costs since oil & gas, pipelines, easements etc. are present. Also, there needs to be investigation if any landfill or superfund sites would be impacted. R&M site. Also needs greater discussion on effect to Nueces Estuary. Effect on cattle etc.

Page 3-59:

Sentence: ...acre-feet per year of additional system yield represents the water currently lost to seepage and evaporation during transport to Lake Corpus Christi following release from Choke Canyon.

Comments: Could this pipeline be used for Beeville and if so, what impact would it have? Could this pipeline be tied into the Simmons diversion?

Page 3-67:

Comments: Need to add Three Rivers diversion in addition to 2,000 cfs requirement.

Page 3-70:

Sentence: However, there could actually be some improvement in the overall quality of water at the City's O.N. Stevens Water Treatment Plant since the portion of the water delivered via the pipeline will not be exposed to the water quality degradation which occurs in the natural river channel downstream of Lake Corpus Christi.

Comments: Previous studies indicated a pretty significant quality improvement with significantly less chlorides and solids.

Page 3-81:

Sentence: The report indicates that the water-bearing beds under both counties contain slightly saline to saline water and speculates that individual brackish well yields of 1,000 to 2,000 gpm could be attained.

Comments: Did the desalination option include the costs of a pipeline system to collect the source waters?

Page 3-97:

Sentence: The stand-by groundwater system was developed during the drought of the mid-1980's. The City commissioned a study by Reed and Associates to determine areas favorable for development of groundwater which could be utilized quickly to augment the water supply

Comments: They didn't reference the 1985 USGS study which studied this issue. Why not?

Page 3-98:

Table 3.8-1: Kleberg County Conversion dates:

Kingsville - 1983
Ricardo WSC - 1985
U.S. Naval Air Station - Kingsville - 1983

Nueces County Conversion dates:

Bishop - 1983
Driscoll - 1983
Nueces Co. WCID #5 - Banquette Area - 1984

Reviewer: Texas Water Development Board, Water Resources Development Division, September 10, 1993.		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
10-1	N-1 (3-14)	*Comment: This statement will be challenged by the Save the Lake Coalition: ". . . Corpus Christi shows that on the average, the lake level would be approximately two feet lower under the Phase IV policy."*
		Response: Comment is noted. Additional analyses on lake level changes under alternative operating policies are included in the Phase II report.
10-2	N-1 (3-18)	*Comment: There should be data from the '83 drought (Talk to Herbert Hall).*
		Response: The data used to develop Appendix D-Summary of Water Quality Data, includes the raw water quality (chlorides and hardness) of the raw water at the O.N. Stevens Water Treatment Plant for the period 1976 to 1993. This data included water quality during the drought years of the early 1980's.
10-3	N-1 (3-19)	*Comment: Item for study on Phase II study. (ie. "Specific water quality assessments should be completed in later phases of the Trans-Texas study, if the Modification of Reservoir Operating Policy should continue to be considered as an alternative water supply.")*
		Response: So noted.
10-4	N-2 (3-29)	*Comment: They (flood flow diversions) focused on Three Rivers diversion. The Simmons diversion was only $108/acft (w/o O&M) for 14,000 acft.*
		Response: Updated hydrologic analyses have been performed which show that the Three Rivers or Simmons Diversion will yield less than 1,000 acft/yr during the drought. Therefore, the unit cost of Simmons would be at least 14 times the cost estimated in previous studies which was based on a yield of 14,000 acft/yr.
10-5	N-3 (3-37)	*Comment: Need greater detail on how the streamflow changes, since it will be kept bank full for diversion.*
		Response: Comment is noted. See flow statistics presented in Phase II report.
10-6	N-3 (3-43)	*Comment: There needs to be greater discussion on land acquisition costs since oil & gas, pipelines, easements, etc. are present. Also, there needs to be investigation if any landfill or superfund sites would be impacted. R&M site. Also needs greater discussion on effect to Nueces Estuary. Effect on cattle, etc.*
		Response: This concern is addressed under Comments 3-6 and 3-7. Also, the question of landfill and waste sites has been updated in the Phase II report (Section 3.3).
10-7	N-5 (3-59)	*Comment: Could this pipeline (from Choke Canyon to Lake Corpus Christi) be used for Beeville and if so, what impact would it have? Could this pipeline be tied into the Simmons diversion?*
		Response: Yes. The pipeline could potentially provide raw water to Beeville and this option has been added to the Phase II write-up. Again, yes. Combined use with the Simmons diversion is a possibility in which case the portion of the pipeline from Simmons to Choke Canyon would be able to flow either direction. This possibility is noted in the Phase II report.
10-8	N-5 (3-67)	*Comment: Need to add Three Rivers diversion in addition to 2,000 acft/month requirement.*

		Response: So noted. As modeled, water is released from Choke Canyon to satisfy senior water rights (including Three Rivers Diversion) located on the reach between Choke Canyon and Lake Corpus Christi. This discussion has been added to the Phase II write up.
10-9	N-6 (3-70)	*Comment: Previous studies indicated a pretty significant quality improvement with significantly less chlorides and solids. (with installation of Choke Canyon to Lake Corpus Christi pipeline)*
		Response: So noted, although the "previous study" was not located.
10-10	L-1 (3-81)	*Comment: Did the desalination option include the costs of a pipeline system to collect the source waters?*
		Response: Yes, please refer to Section 3.7 containing information on desalination gathered in Phase II studies.
10-11	L-2 (3-97)	*Comment: They didn't reference the 1985 USGS study which studied this issue. Why not?*
		Response: The Phase I report failed to reference the 1986 USGS report, although the report was included in the references that were studied during preparation of this section. The 1986 report is titled "Simulated Effects of Projected Pumping on the Availability of Freshwater in the Evangeline Aquifer in an Area Southwest of Corpus Christi, Texas" by George E. Groschen, from the USGS, Water Resources Investigations Report 85-4182, Austin, Texas, 1985, prepared in cooperation with Coastal Bend Council of Governments.

TEXAS WATER DEVELOPMENT BOARD

INTEROFFICE MEMORANDUM

TO : Dennis Crowley **DATE:** 9/14/93

THRU : Tony Bagwell, Tommy Knowles, Mike Personett

FROM : Stephen Densmore

SUBJECT: Review of Trans-Texas Water Program Corpus Christi Service Area Phase I

I have reviewed the Phase I report and offer the following comments or questions that need to be addressed in the report.

On the following pages:

2-6 Say something other than drought. The projections are based on a period of below normal rainfall that might be similar to a drought period but to say these are drought projection would be incorrect.

2-11 Rewrite to say that any effects of NAFTA on water needs for the area have not been estimated or included in the projections.

2-13 Sentence on irrigation change needs to only say change due to increase conservation effects only.

2-20 This section appears to be a restatement of section 2-3, why have it?

2-24 Why not put section that discusses groundwater before the the demands upon CC/LCC section? It is that way in the supply projection sections of the report, thus to keep the report consistent the report should be the same in the demand sections.

2-26 Statement on water quality is to strong. Only in certain areas is quality a problem and while it could be a problem in the future for additional supply, the report only deals in general terms.

2-31 Part of operating rule is city policy and not part of any agreement with Parks. Parks agreement is for instream flows below Choke. The write-up needs to state this as a city policy and not suggest this is a Parks requirement.

2-31 Does 97,000 represent total flow to bay or flow at gage. Or does it include return flows and other diversion. If demands increase and supplies are available, would this need as charge to the CC\LCC system change? Thus more water could be developed by the CC\LCC system.

2-36 Table 2.7-1 Check irrigation. Are 1990 figures reported diversions and projected figures for 2000 and on estimates of on-farm use? If so, then the table should note this.

3-14 Was any attempt made to evaluate other operating rules? Could additional supplies be developed with different rules?

3-17 In the discussion on the differences between policies and annual inflows the statement was made that "Changes of this magnitude are expected to have salinity impacts at the margin of detectablity .....", was any analysis conducted to check this or is these statements just gut feel?

3-20 What are the cost if no work was done to determine if any relocations or lowing of intakes were needed? Statement in write-up needs to explain what the cost estimate means or how it was computed.

3-27 Each time HDR change their model they renamed it. It is still the same model but with different diversion points. No need for this.

3-35 Were all the provisions of Trans-Tex environmental rules considered? Was the 40% and 30% capacity thresholds run? Need more info on what was done using Trans-Tex rules.

3-39 Question should be frequency of events with flows > 97000. The relationship to total flows may not be important.

3-40 There are upper and lower viability limits. The project could reduce the number of upper limit problems and the release rules could lower the number on lower limit problems or not change them from just the cc/cc system. Again this appears to be just gut feeling statements.

3-44 Cost assumed mitigation for all conservation storage. Only 400 acres of wet lands, and would assume no more than 14000 acres or 1/2 land cost. Thus total cost would be 20 Million less.

3-147 No information on this project. Need to either delete or provide all information.

3-170 TWDB studies indicate that with a supply of 30,000 acre-feet per year, the effects on salinity would be no worst than with Texana.

General comments:

The report needs to have some type of matrix of the various options, so that comparison can be made between the options.

It appears that the options to consider for further study would be:

1. Change of operating policy,
2. Wastewater reuse,
3. R&M Reservoir,
4. Texana,
5. Diversion from Garwood.

It appears that surface water needs by 2050 would be about 100,000 acre-feet. No project alone will supply that amount. Report does not address this or provide any configurations of alternatives.

The study needs more work on Goliad. It report left a lot of questions un-answered on this project. The study also did not give any indication of cost for Trans-Tex water from East Texas or if it could be used to meet the area needs or if some type of system on a larger scale could be developed to meet the needs on more than just the Corpus area.

Reviewer: Texas Water Development Board, (Steve Densmore), 9/14/93.		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
11-1	Section 2.0 Water Demand Projections (pg 2-6)	*Comment: Say something other than drought. The projections are based on a period of below normal rainfall that might be similar to a drought period but to say these are drought projections would be incorrect.*
		Response: In the Phase II report, Section 2.3 this language has been revised.
11-2	Section 2.0 Water Demand Projections (pg 2-11)	*Comment: Rewrite to say that any effects of NAFTA on water needs for the area have not been estimated or included in the projections.*
		Response: In the Phase II report, Section 2.3, Industrial Water Demand, the language has been revised as suggested.
11-3	Section 2.0 Water Demand Projections (pg 2-13)	*Comment: Sentence on irrigation change needs to only say change due to increase conservation effects only.*
		Response: In the Phase II report, Section 2.3, Irrigation Water Demand, the language has been revised, as suggested.
11-4	Section 2.0 Water Demand Projections (pg 2-20)	*Comment: This section appears to be a restatement of Section 2-3, why have it?*
		Response: Table 2.3-8 is a summary by type of use, whereas all other water demand projections are presented as a table for each type of use for each county of the study area.
11-5	Section 2.0 Water Demand Projections (pg 2-24)	*Comment: Why not put section that discusses groundwater before the demands upon CC/LCC section? It is that way in the supply projection sections of the report, thus to keep the report consistent the report should be the same in the demand sections.*
		Response: In the Phase II report the sections have been relocated, as suggested.
11-6	Section 2.0 (pg 2-26)	*Comment: Statement on water quality is too strong. Only in certain areas is quality a problem and while it cold be a problem in the future for additional supply, the report only deals in general terms.*
		Response: The statement has been revised to respond to the comment (see Section 2.5.1. of the Phase II report).
11-7 (KP)	Section 2.0 (pg 2-31)	*Comment: Part of operating rule is city policy and not part of any agreement with Parks. Parks agreement is for instream flows below Choke. The write-up needs to state this as a city policy and not suggest this is a Parks requirement.*
		Response: In Phase II, report text has been revised in accordance with comment.
11-8	Section 2.0 (pg 2-31)	*Comment: Does 97,000 represent total flow to bay or flow at gage. Or does it include return flows and other diversion. If demands increase and supplies are available, would this need as charge to the CC/LCC system change? Thus more water could be developed by the CC/LCC system.*

		Response: The volume of water supplied to Nueces Bay under the TNRCC interim order was 97,000 acft/yr. This water is supplied to the bay through: (1) return flows from the cities of Corpus Christi and Portland, and CP&L; (2) spills and releases from the CC/LCC System as measured at Calallen Reservoir; and (3) by intentional diversion of freshwater and/or effluent into the Rincon Delta. This volume has changed under the new TNRCC agreed order. Under the new order, 138,000 acft/yr are to be delivered to the Nueces Bay and/or Delta when the CC/LCC System storage is greater than or equal to 70 percent, and 97,000 acft/yr is delivered when reservoir system storage is between 70 and 40 percent. These volumes of water are supplied as described previously. As more supplies from outside the CC/LCC System become available, return flows to the Nueces Bay & Estuary System increase as a whole. However, in our analysis we did not assume that the volume of effluent going to the Nueces Bay directly would change since current volumes assumed in the modeling are the maximum capacities of the plants that discharge into the bay. This conservative assumption was made because of uncertainties over which of the city's wastewater treatment plants will be upgraded to handle the increased flow. The City of Corpus Christi is currently engaged in a wastewater system masterplan study that should define where future effluent will be discharged.
11-9	Section 2.0 (pg 2-36)	*Comment: Table 2.7-1 check irrigation. Are 1990 figures reported diversions and projected figures for 2000 and on estimates of on-farm use? If so, then the table should note this.*
		Response: The data presented in Table 2.7-1 of the Phase I report were a listing of water rights permits of the Lower Colorado River Basin, and as the reviewer has stated, are not a determination of water supply in the Colorado River Basin. In the revisions, footnotes and definitions will be included, as needed.
11-10	Section N-1 (pg 3-14)	*Comment: Was any attempt made to evaluate other operating rules? Could additional supplies be developed with different rules?*
		Response: In the Phase II report, several alternative operating rules were evaluated.
11-11	Section N-1 (pg 3-17)	*Comment: In the discussion on the differences between policies and annual inflows the statement was made that "Changes of this magnitude are expected to have salinity impacts at the margin of detectability...", was any analysis conducted to check this or are these statements just gut feel?*
		Response: During the Phase I analysis, the impact of changes in bay and estuary inflow on salinity in upper Nueces Bay was not presented. However, the Phase II report has included salinity changes due to water supply alternatives for the alternatives which significantly change the estuary inflow volumes.
11-12	Section N-1 (pg 3-20)	*Comment: What are the cost if no work was done to determine if any relocations or lowing of intakes were needed? Statement in write-up needs to explain what the cost estimate means or how it was computed.*
		Response: Data specific to each intake was obtained and cost estimates made based on site specific information. The results of this work have been added to the Phase II report sections.
11-13	Section N-2 (pg 3-27)	*Comment: Each time HDR change their model they renamed it. It is still the same model but with different diversion points. No need for this.*
		Response: This has been changed in the Phase II report.
11-14	Section N-3 (pg 3-35)	*Comment: Were all the provisions of Trans-Tex environmental rules considered? Was the 40% and 80% capacity thresholds run? Need more info on what was done using Trans-Tex rules.*
		Response: In the Phase II report, all the provisions of the Trans-Texas environmental rules were considered and a range of target levels calculated.

11-15	Section N-3 (pg 3-39)	*Comment: Question should be frequency of events with flows > 97000. The relationship to total flows may not be important.*
		Response: From an ecological point of view detailed information such as monthly inflow and salinity statistics, and changes in low and high flow frequencies would be more informative than annual averages. However, inflows are being analyzed in greater detail as studies progress. Also, final permits stipulate releases based on detailed analyses. An in-depth analysis of the effects R&M reservoir on the bays and estuary would be required prior to any permit application.
11-16	Section N-3 (pg 3-40)	*Comment: There are upper and lower viability limits. The project could reduce the number of upper limit problems and the release rules could lower the number on lower limit problems or not change them from just the CC/LCC system. Again this appears to be just gut feeling statements.*
		Response: The statements referred to in the comment were based on data presented in figures 3.2-2 and 3.2-3 which were generated using a bay and estuary model The statements referred to concern the effects of reservoir operation on freshwater inflows to the bay, not "viability limits." Reservoir operation generally involves capturing water during periods of high flow. During periods of low flow release requirements and credited wastewater return flows stipulated by permits tend to increase freshwater inflow. The modeling study indicated that as a result of R&M operation inflows during times of high flow would decrease while inflows during times of low flow would increase. Thus, one effect of reservoir operation would be to decrease variability in freshwater inflow.
11-17	Section N-3 (pg-3-44)	*Comment: Cost assumed mitigation for all conservation storage. Only 400 acres of wet lands, and would assume no more than 14000 acres or 1/2 land cost. Thus total cost would be 20 Million less.*
		Response: Environmental mitigation requirements will not be known until the permitting phase, therefore, for comparison of alternatives, especially cost comparisons, consistent criteria was used. For instance, for reservoir alternatives, it was assumed that mitigation would include purchase and set-aside for wildlife management, an area equivalent to the inundated area. The environmental mitigation requirements were applied uniformly for each type of project regardless of estimated loss of habitat types, such as wetlands, or bottomland hardwoods.
11-18	Section GS-1 (pg 3-147)	*Comment: No information on this project. Need to either delete or provide all information.*
		Response: Section 3.12 of the Phase II report contains updated information on the McFaddin Reservoir alternative, including the engineering/costing and implementation sections.
11-19	Section LN-2 (pg 3-170)	*Comment: TWDB studies indicate that with a supply of 30,000 acre-feet per year, the effects on salinity would be no worst than with Texana.*
		Response: Permit amendment CA-2095B (issued in late 1994) provides for bay and estuary needs from the firm yields of Stage 1 (Lake Texana) and Stage 2. Bay and estuary needs from Stage 2 are estimated to be about 18,000 acft/yr, leaving about 30,000 acft/yr for other purposes.
11-20		*Comment: The report needs to have some type of matrix of the various options, so that comparison can be made between the options. It appears that the options to consider for further study would be:* *1. Change of operating policy,* *2. Wastewater reuse,* *3. R&M Reservoir,* *4. Texana,* *5. Diversion from Garwood.* *It appears that surface water needs by 2050 would be about 100,000 acre-feet. No project alone will supply that amount. Report does not address this or provide any configurations of alternatives.*

		Response: An integrated water supply plan to meet the long term water demands of the study area has been developed and is presented in Section 4.0 of the Phase II report.
11-21	Section G-1	*Comment: The study needs more work on Goliad. The report left a lot of questions un-answered on this project. The study also did not give any indication of cost for Trans-Tex water from East Texas or if it could be used to meet the area needs or if some type of system on a larger scale could be developed to meet the needs on more than just the Corpus area.*
		Response: Section 3.11, Goliad Reservoir, has been updated in the Phase II report. The cost of importing water from East Texas to the Corpus Christi area has not been specifically studied. However, the cost of importing new water supplies from both the Colorado River and the Brazos River are studied in Sections 3.16 (Garwood), 3.20 (Colorado River), and 3.21 (Brazos River). The cost of importing water from the Brazos River has been found to be significantly higher than sources closer to the study area.

TEXAS WATER DEVELOPMENT BOARD

INTEROFFICE MEMORANDUM

TO : Dennis Crowley DATE: August 30, 1993

THRU : Tony Bagwell TB

FROM : F. G. Bloodworth FGB

SUBJECT: Review of Corpus Christi Service Area - Trans Texas Water Program

Pursuant to your August 6, 1993, memorandum, population and water use information presented in the subject report has been reviewed. TWDB population projections are shown in Table 1 and the projections of municipal and industrial water demands are shown in Table 2 for the Choke Canyon/Lake Corpus Christi Reservoir System Service Area. The methodology utilized in distributing TWDB projections appears reasonable, as do the resulting projections.

Reviewer:	(Letter No. 12) 08/20/94 memo from F.G. Bloodworth, TWDB.
Comment:	*Noted. No response necessary.*

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

September 20, 1993

Mr. Emmett Gloyna
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

Dear Mr. Gloyna:

I have recently received the agenda for the TransTexas Water Program meetings to be held September 22, 1993, in Austin. On the agenda for the South Central Texas Policy Management Committee (PMC) meeting is PMC review and action on the draft Phase I Report.

It was my understanding that the TAC members would be provided sufficient opportunity to review and comment on the full draft Phase I Report and that these comments would be addressed in the Final Phase I Report. This would allow all necessary and relevant information to be before the PMC so that it could make an informed decision with respect to options on hich the Phase II Report should focus.

ack Nelson (Lavaca-Navidad River Authority) and Dr. Herb Grubb (HDR) inform me that not :l TAC members were provided a copy of the full draft Report. They also informed me that there is no plan to incorporate or otherwise address TAC member comments in the Phase I Report before it is submitted to the PMC for review and action. They stated that the draft Phase I Report, for all intents and purposes, is the final Report and no changes will be made. Instead, any comments that they receive will be addressed in the Phase II Report.

The importance of following a process which allows full opportunity of TAC members to review, comment, and provide guidance on the development and finalization of the Phase I Report cannot be stressed enough. Without such a process, the credibility and validity of the Report, as well as the TransTexas Water Program itself, is put in doubt.

Therefore, it is expected that copies of the full draft Report, not just an executive summary, be provided to all TAC members and that these copies should be provided without the TAC members having to request them first. TAC members should also be provided sufficient time to review and comment on the draft Phase I Report. It is also expected that these comments be addressed in the Phase I Report before it is finalized. Only when this has been done should the Phase I Report be submitted to the PMC for its review and action.

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The success of the TransTexas Water Program is contingent upon the fulfillment of the program sponsors' commitment that the process be open and responsive, and that the work product be objective and unpredetermined. I look forward to working with you to ensure that this commitment is carried out as the program is developed and completed.

Sincerely,

Mark Jordan

Mark Jordan, Director
Water Policy Division
Texas Natural Resource
Conservation Commission

cc: South Central Texas Policy Management Committee
South Central Texas Technical Advisory Committee

Trans-Texas -- Corpus Christi Draft Phase 1 Report:

General comments on the water supply planning approach in the report:

1. Water demands are presented, followed by 16 possible water supply alternatives, with each alternative consistently discussed in terms of a range of issues. This approach is congruent with the water supply planning approach.

2. However, the report claims that the municipal water demand estimates include a 15% reduction in per capita use due to water conservation (*the validity and accuracy of this claim is discussed below*). I assume this 15% reduction in per capita water is due to "automatic" conservation primarily because of improved plumbing fixture efficiences, as is implied in the report. **Consideration of additional ("advanced") water conservation strategies, except reuse, are <u>not</u> presented and would be expected to accompany any water rights application which required a conservation plan.**

Additional ("advanced") water conservation strategies would include:

* Reducing outdoor irrigation demand in the commercial and residential sectors.

* Commercial retrofit (replace ice-making machines, etc.).

* Conservation in other sectors (e.g., agriculture) or in other river basins and procurement of the conserved water.

The "yield" from each strategy would be estimated, as is done w/the other alternatives, and the cost, environmental and related issues also discussed.

3. What about the use of drought plans (temporarily suspending non-essential uses) as a water management alternative?

4. A summary table of each supply alternative vs. the cost, environmental impacts and other issues should be included.

5. *The initial per capita water use appears too high for several reasons:*

(a) P. 2-7 of the report indicates that the per capita use for the "driest" historical year for a 10-year period was used as a base and then reduced 15%.

What was the probability of the drought which was used in the baseline data?

In that historical numbers do not reflect reduced demands due to the new plumbing fixtures standards, this is unreasonable. Instead, an engineering design approach should be used to help estimate the per capita use.

Also, it may be more cost-effective to implement drought measures as an alternative to supply development for these "dry" years.

(b) The Corpus Christi (inside city limits) 1988-1990 average is 163 gpcd (pumped), and the per capita use for 1989 (a "dry" year) was 167 gpcd.

(c) The South Central regional average is 182 gpcd for 1988-1990, 190 gpcd for 1989, and 192 gpcd for 1984 (both "dry" years).

6. How does the dollar cost/acre-feet of water for meeting the obvious municipal irrigation demand (contained within the estimated 186,054 acre-feet) compare to the costs of a xeriscape program in dollar cost/acre-foot of water save)?

7. The water supply plan (and related drought contingency plan) should include a <u>minimum municipal demand</u> which must be supplied on a firm basis in order to protect public health and safety (i.e., provide adequate water supplies and wastewater services for hygiene, sanitation and fire-fighting purposes).

TNRCC staff estimate this demand for the service area to be <u>112,457</u> acre-feet per year (based on 130 gpcd pumped). However, please note that we are currently considering revising this number <u>downwards</u> in order account for the recent new plumbing fixtures standards.

8. Regarding <u>industrial demands</u>, this is supposed to increase from 43,611 acre-feet to 100,231 acre-feet by the year 2050. Why? Isn't this area's future growth industries expected to be tourism, which is not necessarily water-intensive?

Reviewer: Texas Natural Resource Conservation Commission, Water Policy Division, 9/20/93		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
13-1	Section 2.0 Accelerated Conservation	*Comment: The report claims that the municipal water demand estimates include a 15% reduction in per capita use due to water conservation . . . I assume this 15% reduction in per capita water is due to "automatic" conservation primarily because of improved plumbing fixture efficiencies, as is implied in the report. Consideration of additional ("advanced") water conservation strategies, except reuse, are not presented and would be expected to accompany any water rights application which required a conservation plan.* *Additional ("advanced") water conservation strategies would include:* ** Reducing outdoor irrigation demand in the commercial and residential sectors.* ** Commercial retrofit (replace ice-making machines, etc.).* ** Conservation in other sectors (e.g. agriculture) or in other river basins and procurement of the conserved water.* *The yield from each strategy would be estimated, as is done with the other alternatives, and the cost, environmental, and related issues also discussed.*
		Response: Although the 15% mentioned in the report is in error, the comment is correct (see response to comment number 1-2). Accelerated conservation is evaluated and included in the Phase II report as Section 3.17.
13-2	Section 2.0 Water Demand	*Comment: What about the use of drought plans (temporarily suspending non-essential uses) as a water management alternative?*
		Response: This is a possibility for water system operations. Since the study objectives are to evaluate water supply options to meet projected demands per dry year conditions, it was not included as an option for evaluation in this study.
13-3	Executive Summary	*Comment: A summary table of each supply alternative vs. the cost, environmental impacts and other issues should be included.*
		Response: The Executive Summary in the Phase II report contains a summary table providing the yield potentially available from each water supply alternative, the estimated unit cost, and significant environmental and permitting concerns.
13-4	Section 2.0 Water Demand Projections	*Comment: The initial per capita water use appears too high for several reasons:* *(a) P. 2-7 of the report indicates that the per capita use for the "driest" historical year for a 10-year period was used as a base and then reduced 15%.* *What was the probability of the drought which was used in the baseline data?* *In that historical numbers do not reflect reduced demands due to the new plumbing fixtures standards, this is unreasonable.* *Instead, an engineering design approach should be used to help estimate the per capita use.* *Also, it may be more cost-effective to implement drought measures as an alternative to supply development for these "dry" years.* *(b) The Corpus Christi (inside city limits) 1988-1990 average is 163 gpcd (pumped), and the per capita use for 1989 (a "dry" year) was 167 gpcd.* *(c) The South Central regional average is 182 gpcd for 1988-1990, 190 gpcd for 1989, and 192 gpcd for 1984 (both "dry" years).*
		Response: The comments pertain to the TWDB water demand projections methods, which were not a part of the study.
13-5	Section 2.0 Water Demand Projections	*Comment: How does the dollar cost/acre-feet of water for meeting the obvious municipal irrigation demand (contained within the estimated 186,054 acre-feet) compare to the costs of a xeriscape program in dollar cost/acre-foot of water saved)?*

		Response: Estimates for the cost of accelerated municipal water conservation and potential quantities of water associated therewith are shown in the Phase II report in Section 3.17 and in the Executive Summary are compared to costs of other alternatives.
13-6	Section 2.0 Water Demand Projections	*Comment: The water supply plan (and related drought contingency plan) should include a minimum municipal demand which must be supplied on a firm basis in order to protect public health and safety (i.e. provide adequate water supplies and wastewater services for hygiene, sanitation, and fire-fighting purposes).* *TNRCC staff estimate this demand for the service area to be 112,457 acre-feet per year (based on 130 gpcd) pumped. However, please note that we are currently considering revising this number downwards in order to account for the recent new pluming fixtures standards.*
		Response: The comment is noted. However, the statement that the TNRCC staff estimate of minimum municipal demand is 112,457 acft/yr does not specify the time period over which this quantity applies. Therefore, we shall assume that the per capita value of 130 gpcd further adjusted as mentioned would apply to the population projection for a particular date.
13-7	Section 2.0 Water Demand Projections	*Comment: Regarding industrial demands, this is supposed to increase from 43,611 acre-feet to 100,231 acre-feet by the year 2050. Why? Isn't this area's future growth industries expected to be tourism, which is not necessarily water-intensive?*
		Response: The area's industry is projected to grow and thereby increase its demand for water from 43,611 acft in 1990 to 100,231 acft in 2050. Tourism is also projected to grow, but its water use is included in the municipal category.

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

September 20, 1993

Mr. Jack C. Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

Re: TransTexas Water Program - Phase I Draft Interim Report, Review and Comment.

Dear ~~Mr. Nelson:~~ Jack

I want to take this opportunity to express my appreciation for your efforts in coordinating the Trans-Texas Water Program studies for the Corpus Christi service area and your timely responses to our information requests. The value and success of this program hinges on the cooperative efforts of all participants and it is through these efforts that the future quality of life in Southeast and South Central Texas will come to depend.

During the August 12 and 13, 1993, Technical Advisory Committee (TAC) meetings, participants were asked to comment on the Phase I - Interim Report Summary. The consensus appeared to be that without the full report, it would be difficult for the TAC to provide substantive comment and informed recommendations regarding the potential water supply alternatives investigated by the consultants. The draft full report arrived in my office on August 25, and has been reviewed by appropriate agency staff.

In general, the draft document meets the objective of identifying most potential alternative water supply options for the southern portion of the South Central Texas area. Three possible options which were not included, but should be investigated are the dredging of Lake Corpus Christi to recover lost storage capacity due to sedimentation, aquifer storage and recovery, and wastewater reuse for nonconsumptive use . While dredging has been considered cost prohibitive in the past, the single greatest problem has centered around the disposal of the dredge material. I believe there are opportunities now available to utilize such material for land reclamation, such as wetlands restoration which would turn a liability into an asset.

Texas Water Code Section 16.1331. entitled "Reservation and Appropriation for Bays and Estuaries and Instream Uses" provides for a reservation of water (5 percent of the firm annual yield) from reservoirs and associated works constructed with state financial participation within 200 river miles from the coast. It is unclear from the text of the report if this reservation was included in the analysis for all appropriate options.

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As a follow-up to our meeting on Friday, September 17, 1993, I am providing a list of major topics discussed for further edification. The comments are more of a general nature and request clarification and/or elaboration of statements presented in the draft document and during our meeting.

Comments:

* Pg 1-4. Reference is made to the completion of Choke Canyon in 1978. In fact, construction was not finished until 1982 and if you go by the City of Corpus Christi's definition of "completion", Choke Canyon was not completed until it was filled, in 1987.

* Pg 2-2. Table 2.1-1. This table shows growth rates for the Corpus Christi 12-County Area, but no similar table is included for the 10-county area targeted for having surplus water. The report should include a similar analysis for all areas identified as possible water sources. In its calculation of surplus water in the Lower Colorado Basin, are the projected demands in the upper basin considered?

* Pg 2-7. Municipal Water Demand. Clarification should be included concerning the definition of "commercial use" and how it differs from industrial use.

* Pg 2-17. Total Water Demand. Authors have included livestock use as part of their calculations for total demand. Yet, in the previous paragraph they state that "Livestock drinking" "...is not usually included explicitly in water supply plans." Why have they chosen to do so in this case?

* Pg 2-23. Why were M&I demands for Robstown excluded from Table 2.4-1?

* Pg 2-31. The description of the 1992 TWC agreed order includes a provision for "intentional diversions". Define.

* Pg 2-33. Table 2.6-1 includes yield projections for the LCC/CC reservoir system. Does the simulation use the Phase II operating conditions plan throughout the model run or does it shift into phase IV when the demand surpasses 150,000 acft/yr (i.e. in year 2000)?

* Pg 3-1. Three options which should have been looked at during the Phase I study include the dredging of Lake Corpus Christi, aquifer storage and recovery, and wastewater reuse.

* Pg 3-8. The first full paragraph on this page suggests changes in streamflow or freshwater inflow with all alternatives, yet the explanation provides little if any insight into these changes. This paragraph should be expanded.

* Pg 3-14. The statement is made: "Under the Phase IV operating policy, recreational use of Lake Corpus Christi would be minimally affected." Explain.

* Pg 3-18. In the first full paragraph the statement is made "... reduced releases from Choke Canyon Reservoir..." Yet on the previous page the author suggests "Increased water level fluctuations..." Explain.

* Pg 3-30. Should be Speckled Racer (not Specked).

* Pg 3-35. Table 3.3-1 appears to use Phase IV operating rules for determining yield. Why weren't Phase II rules utilized at least for 1990 projections?

* Pg 3-39. In the first full paragraph, the statement is made: "...all return flows delivered to Nueces Bay." Explain.

* Pg 3-47. The author suggests that the Nueces County Water Control and Improvement District No. 3 will only experience a 5 percent increase in municipal and industrial demands between 1990 and 2050. Yet they project a 95 percent increase in use in the City's service area. Explain.

* Pg 3-67. Will this option as well as others require TPWD sand, gravel and marl permits?

* Pg 3-97. The first full paragraph references a one year water supply for the CC/LCC reservoir system. What is the volume and percentage of system storage?

* Pg 3-122. The last paragraph on this page describes the use of treated wastewater for irrigating lawns during drought conditions. How will this program affect return flows for Bay and Estuary purposes? Is any consideration given to expanding the reuse program for other irrigation purposes (i.e. parks and golf courses)?

* Pg 3-150. Specific yield figures for the McFaddin Dam and reservoir option were not provided in the draft report. Will they be provided in the revision?

* Pg 3-160. The Lake Texana pipeline to Corpus Christi (LN-1) option indicates a 5 percent reduction in median annual flows in the Lavaca River. Explain.

I have attached a copy of comments concerning conservation and demand projections provided to me by Ms. Kariann Sokulsky of the Water Policy Division. Most of the topics were

presented during the September 17 meeting and provided for your information in developing responses.

We appreciate the opportunity for providing comment and if you should have any questions or require additional information, please do not hesitate to call me at (512) 463-8208.

Sincerely,

Bruce

Bruce A. Moulton
Water Policy Division
Texas Natural Resource
Conservation Commission

BAM/ag

Attachment

Trans-Texas -- Corpus Christi Draft Phase 1 Report:

General comments on the water supply planning approach in the report:

1. Water demands are presented, followed by 16 possible water supply alternatives, with each alternative consistently discussed in terms of a range of issues. This approach is congruent with the water supply planning approach.

2. However, the report claims that the municipal water demand estimates include a 15% reduction in per capita use due to water conservation (*the validity and accuracy of this claim is discussed below*). I assume this 15% reduction in per capita water is due to "automatic" conservation primarily because of improved plumbing fixture efficiences, as is implied in the report. **Consideration of additional ("advanced") water conservation strategies, except reuse, are not presented and would be expected to accompany any water rights application which required a conservation plan.**

   Additional ("advanced") water conservation strategies would include:

   * Reducing outdoor irrigation demand in the commercial and residential sectors.

   * Commercial retrofit (replace ice-making machines, etc.).

   * Conservation in other sectors (e.g., agriculture) or in other river basins and procurement of the conserved water.

   The "yield" from each strategy would be estimated, as is done w/the other alternatives, and the cost, environmental and related issues also discussed.

3. What about the use of drought plans (temporarily suspending non-essential uses) as a water management alternative?

4. A summary table of each supply alternative vs. the cost, environmental impacts and other issues should be included.

Trans-Texas -- Corpus Christi Draft Phase 1 Report:

Comments on the Water Demand Estimates and Water Conservation:

1. *Summary of Total Water Demands, Municipal Demands, and Per Capita Use in Report:*

TABLE 1:

Year	Population Served	Estimated Total Water Use (acre-feet)	Estimated Municipal Use (acre-feet)	Municipal GPCD
1990	379,293	245,590	115,473	272
2050	772,291	403,646	186,054	215

The draft report states that a 15% reduction in per capita water use is included in the year 2050 municipal water demand.

2. The **conservation goal** is unreasonable and therefore would not meet Commission standards in Title 30 TAC §288.

   The goal is unreasonable because it is arbitrary: To be rational, and therefore reasonable, the following steps should have been performed: (1) identification of a problem, (2) system audit and engineering analysis to quantify the technical potential for water conservation from specific water conservation strategies, and (3) determination of water conservation goals based upon the system audit and engineering analysis. Additionally, as is done with the other water supply strategies, a cost analysis of the water conservation strategies should be included to help determine a reasonable goal.

3. In setting the per capita use goal, the percentage reduction (if there is one) should also be translated into a reduction in gallons per day per person and the sources of this water savings should be identified (e.g., indoor use, unaccounted-for uses, outdoor irrigation use, etc.).

4. The goal is supposed to be a 15% reduction in per capita use, but the figures above actually result in a 21% reduction in per capita water use.

5. Municipal conservation goals can also be set for unaccounted-for uses and **peak-to-average day ratios** in order to decrease long-run demands. Why have these not been considered?

(continued)

5. *The initial per capita water use appears too high for several reasons:*

(a) P. 2-7 of the report indicates that the per capita use for the "driest" historical year for a 10-year period was used as a base and then reduced 15%.

What was the probability of the drought which was used in the baseline data?

In that historical numbers do not reflect reduced demands due to the new plumbing fixtures standards, this is unreasonable. Instead, an engineering design approach should be used to help estimate the per capita use.

Also, it may be more cost-effective to implement drought measures as an alternative to supply development for these "dry" years.

(b) The Corpus Christi (inside city limits) 1988-1990 average is 163 gpcd (pumped), and the per capita use for 1989 (a "dry" year) was 167 gpcd.

(c) The South Central regional average is 182 gpcd for 1988-1990, 190 gpcd for 1989, and 192 gpcd for 1984 (both "dry" years).

6. How does the dollar cost/acre-feet of water for meeting the obvious municipal irrigation demand (contained within the estimated 186,054 acre-feet) compare to the costs of a xeriscape program in dollar cost/acre-foot of water save)?

7. The water supply plan (and related drought contingency plan) should include a <u>minimum municipal demand</u> which must be supplied on a firm basis in order to protect public health and safety (i.e., provide adequate water supplies and wastewater services for hygiene, sanitation and fire-fighting purposes).

TNRCC staff estimate this demand for the service area to be <u>**112,457**</u> acre-feet per year (based on 130 gpcd pumped). However, please note that we are currently considering revising this number <u>downwards</u> in order to account for the recent new plumbing fixtures standards.

8. Regarding <u>**industrial**</u> <u>**demands**</u>, this is supposed to increase from 43,611 acre-feet to 100,231 acre-feet by the year 2050. Why? Isn't this area's future growth industries expected to be tourism, which is not necessarily water-intensive?

Reviewer: 09/20/93 Letter from Bruce A. Moulton, Water Policy Division, TNRCC		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
14-1	Section 3.17 & 3.19	*Comment: In general, the draft document meets the objective of identifying most potential alternative water supply options for the southern portion of the South Central Texas area. Three possible options which were not included, but should be investigated are the dredging of Lake Corpus Christi to recover lost storage capacity due to sedimentation, aquifer storage and recovery, and wastewater reuse for nonconsumptive use. While dredging has been considered cost prohibitive in the past, the single greatest problem has centered around the disposal of the dredge material. I believe there are opportunities now available to utilize such material for land reclamation, such as wetlands restoration which would turn a liability into an asset.*
		Response: Subsequent to Phase I, scope items were added for study of dredging Lake Corpus, ground water storage and recovery, and further study of wastewater reuse. The results of this work are contained in Phase II report, Sections 3.19, 3.18, and 3.10, respectively.
14-2		*Comment: Texas Water Code Section 16.1331. entitled "Reservation and Appropriation for Bays and Estuaries and Instream Uses" provides for a reservation of water (5 percent of the firm annual yield) from reservoirs and associated works constructed with state financial participation within 200 river miles from the coast. It is unclear from the text of the report if this reservation was included in the analysis for all appropriate options.*
		Response: The issue mentioned in the comment was discussed with representatives of the Texas Parks and Wildlife Department and the decision for the Phase I study was to use the Trans-Texas Environmental Criteria which has an impact greater than the 5% of the firm yield. The decision was based upon the fact that the former would amount to at least 5% of the firm yield. However, when permit applications are made for reservoir projects located within 200 river miles of the coast, that are financed in whole or in part with state financial participation, it will be necessary to show that the Environmental Criteria applied would satisfy the requirement that 5% of the firm yield (or more) has been reserved for bays and estuaries and instream uses.
14-3	Section 1.0	*Comment: Page 1-4. Reference is made to the completion of Choke Canyon in 1978. In fact, construction was not finished until 1982 and if you go by the City of Corpus Christi's definition of "completion", Choke Canyon was not completed until it was filled in 1987.*
		Response: Comment noted and text is revised.
14-4	Section 2.0	*Comment: Page 2-2. Table 2.1-1. This table shows growth rates for the Corpus Christi 12-County Area, but no similar table is included for the 10-county area targeted for having surplus water. The report should include a similar analysis for all areas identified as possible water sources. In its calculation of surplus water in the Lower Colorado Basin, are the projected demands in the upper basin considered?*
		Response: Projections for the 10-county water supply area were shown in Table 2.7-1 of the Phase I report, and although the projected population growth rate was not shown in the table, it is 0.81 percent per year. The projections for the supply area pertain only to the Lower Colorado Basin, including only Colorado, Wharton, and Matagorda counties. However, as was explained in the response to comment number 5-1, further analyses have been made of the water supply of the Lower Colorado River.
14-5	Section 2.0	*Comment: Page 2-7. Municipal Water Demand. Clarification should be included concerning the definition of "commercial use" and how it differs from industrial use.*

		Response: The separate descriptions of municipal and industrial water use, as presented in the Phase II report, Section 2.3 should indicate to the reader the differences between commercial and industrial water use.
14-6	Section 2.0	*Comment: Page 2-17. Total Water Demand. Authors have included livestock use as part of their calculations for total demand. Yet, in the previous paragraph they state that "Livestock drinking" "...is not usually included explicitly in water supply plans." Why have they chosen to do so in this case?*
		Response: For the purpose of giving an indication of the quantities of water needed for livestock drinking water in each area, and for completeness of the demands for water within an area, livestock water demands have been included. Incidentally, livestock water demands have been included in Texas Water Plans of the past. Thus, the projections of the Trans-Texas studies are consistent with Texas Water Plans.
14-7	Section 2.0	*Comment: Page 2-23. Why were M&I demands for Robstown excluded from Table 2.4-1?*
		Response: The projections of municipal water demand for Robstown were included in Table 2.3-1, and for industrial water demand were included in Table 2.3-2 as a part of the Nueces County totals. These projections were also included in the Nueces County total of Table 2.4-1. In Table 2.4-2, the Robstown projections were shown separately, since Robstown is not supplied from the CC/LCC system. Robstown is supplied from the Nueces County Water Control and Improvement District No. Three, which has a right to divert water from the Calallen Reservoir pool. These rights include 3,500 acft/yr for municipal use and 5,106 acft/yr for irrigation use, all of which are senior to Corpus Christi's rights. The District holds rights to an additional 746 acft/yr for municipal use and 2,194 acft/yr for irrigation use (see Section 3.4, Tables 3.4-1 and 3.4-2). Since the permits for municipal use are greater than the projected Robstown demands for municipal water (2,456 acft/yr) in 2050, the Robstown demands were shown separately in Table 2.4-3. Likewise, the supplies from the Nueces County WCID No. 3 are not included in the yields of the CC/LCC system, as shown in Table 2.5-2. This has been more fully explained in the Phase II report (see Table 2.4-3). The potential purchase of the Robstown unutilized water right is addressed in the Phase II report.
14-8	Section 2.0	*Comment: Page 2-31. The description of the 1992 TWC agreed order includes a provision for "intentional diversions". Define.*
		Response: The words "intentional diversions" are taken from paragraph 1.b of the TNRCC Interim Order. Later, in paragraph 1.b, the following sentence appears; "Any inflows, including measured wastewater effluent and rainfall runoff meeting lawful discharge standards which are intentionally diverted to the upper Nueces Bay or its associated Rincon Bayou region, shall be credited toward the total inflow amount delivered to Nueces Bay and/or Rincon Bayou." Thus, it appears that "intentional diversions" refers to any wastewater effluent that might be piped to the Nueces Delta.
14-9	Section 2.0	*Comment: Page 2-33. Table 2.6-1 includes yield projections for the LCC/CC reservoir system. Does the simulation use the Phase II operating conditions plan throughout the model run or does it shift into phase IV when the demand surpasses 150,000 acft/yr (i.e., in year 2000)?*
		Response: The simulation uses the Phase II operating conditions throughout the model run.
14-10	Section 3.0	*Comment: Page 3-1. Three options which should have been looked at during the Phase I study include the dredging of Lake Corpus Christi, aquifer storage and recovery, and wastewater reuse.*

		Response: Subsequent to Phase I, scope items were added for study of dredging Lake Corpus Christi, ground water storage and recovery, and further study of municipal wastewater reuse. The results of this work are contained in Phase II report sections 3.19, 3.18, and 3.10, respectively.
14-11	Section 3.0	*Comment: Page 3-8. The first full paragraph on this page suggests changes in streamflow or freshwater inflow with all alternatives, yet the explanation provides little if any insight into these changes. This paragraph should be expanded.*
		Response: Comment noted and the paragraph has been revised. Also, report sections discussing individual water supply alternatives affecting instream flow or bay and estuary inflows contain more detailed information regarding potential streamflow changes.
14-12	Section N-1	*Comment: Page 3-14. The statement is made: "Under the Phase IV operating policy, recreational use of Lake Corpus Christi would be minimally affected." Explain.*
		Response: Under the Phase IV operating policy, the median lake level at Lake Corpus Christi would be lowered by 2 feet.
14-13	Section N-1	*Comment: Page 3-18. In the first full paragraph the statement is made "...reduced releases from Choke Canyon Reservoir..." Yet on the previous page the author suggests "Increased water level fluctuations..." Explain.*
		Response: Since less water would be released from Choke Canyon Reservoir to meet water supply needs, additional releases would be needed from Lake Corpus Christi to meet water supply needs at Calallen. Therefore, Lake Corpus Christi would experience greater water level fluctuations.
14-14	Section N-1	*Comment: Page 3-30. Should be Speckled Racer (not Specked).*
		Response: So noted.
14-15	Section N-3	*Comment: Page 3-35. Table 3.3-1 appears to use Phase IV operating rules for determining yield. Why weren't Phase II rules utilized at least for 1990 projections?*
		Response: As stated on page 3-14 of the Phase I draft report: "The change to the Phase IV operating policy was determined to be the least expensive alternative source of water and was therefore used as the baseline operating policy for the CC/LCC System in the evaluation of the remaining alternatives involving the CC/LCC System throughout the remaining sections of this study."
14-16	Section N-3	*Comment: Page 3-39. In the first full paragraph, the statement is made: "...all return flows delivered to Nueces Bay." Explain.*
		Response: This statement means that all return flows currently delivered to Nueces Bay (City of Portland, Allison WWTP, and CP&L) are delivered to the bay in the "Without R&M" scenario.
14-17	Section N-4	*Comment: Page 3-47. The author suggests that the Nueces County Water Control and Improvement District No. 3 will only experience a 5 percent increase in municipal and industrial demands between 1990 and 2050. Yet they project a 95 percent increase in use in the City's service area. Explain.*
		Response: The TWDB 1992 water demand projections used in the Phase I report show only a 5 percent increase for the Robstown area served from the Nueces County WCID No. 3 system and a 95% increase for the CC/LCC System service area. The 1995 TWDB consensus water plan projections are somewhat higher at 2,859 acft/yr in 2050, which is a 17% increase, the supplies available from the Nueces County WCID No. 3 are still adequate to meet the new demand projections (see response to comment No. 14-7).

<table>
<tr><td rowspan="2">14-18</td><td rowspan="2">Section N-5</td><td>Comment: Page 3-67. Will this option as well as others require TPWD sand, gravel and marl permits?</td></tr>
<tr><td>Response: Yes. In all likelihood, water supply alternatives involving stream crossings will require Texas Parks and Wildlife Department sand, gravel, and marl permits for excavation of the pipe trench.</td></tr>
<tr><td rowspan="2">14-19</td><td rowspan="2">Section L-2</td><td>Comment: Page 3-97. The first full paragraph references a one year water supply for the CC/LCC reservoir system. What is the volume and percentage of system storage?</td></tr>
<tr><td>Response: The Corpus Christi Drought Contingency Plan is implemented in response to various conditions of water demand and CC/LCC System storage. Condition I (Water Shortage Possibility) is implemented when the combined water supply in the reservoirs is estimated to be one year demand without rationing, conservation, or stormwater inflow. This amount of system storage changes depending on water demand.</td></tr>
<tr><td rowspan="2">14-20</td><td rowspan="2">Section L-4</td><td>Comment: Page 3-122. The last paragraph on this page describes the use of treated wastewater for irrigating lawns during drought conditions. How will this program affect return flows for Bay and Estuary purposes? Is any consideration given to expanding the reuse program for other irrigation purposes (i.e., parks and golf courses)?</td></tr>
<tr><td>Response: The City uses approximately 800 acft/yr of treated wastewater for golf course and baseball park irrigation. The use of wastewater for irrigation and other non-potable purposes reduces return flows to the bay and under TNRCC bay and estuary release orders would have to be offset with additional releases from the CC/LCC System.</td></tr>
<tr><td rowspan="2">14-21</td><td rowspan="2">Section GS-1</td><td>Comment: Page 3-150. Specific yield figures for the McFaddin Dam and reservoir option were not provided in the draft report. Will they be provided in the revision?</td></tr>
<tr><td>Response: Yes. Please see Section 3.12 of the Phase II report.</td></tr>
<tr><td rowspan="2">14-22</td><td rowspan="2">Section LN-1</td><td>Comment: Page 3-160. The Lake Texana pipeline to Corpus Christi (LN-1) option indicates a 5 percent reduction in median annual flows in the Lavaca River. Explain.</td></tr>
<tr><td>Response: The percentage for reduction of the Lavaca River is computed for a point downstream of the confluence with the Navidad River. The alternative would not impact the Lavaca River upstream of this confluence. The reduction is due to the fact that, currently, only part of the authorized diversion from Lake Texana are being diverted and therefore the undiverted portion contributes to the median annual flow. This contribution would cease when the full authorized diversion is made as would occur in Alternative LN-1.</td></tr>
<tr><td>14-23</td><td></td><td>Comment: Summary of Total Water Demands, Municipal Demands, and Per Capita Use in Report:

Table 1:
<table>
<tr><th>Year</th><th>Population Served</th><th>Estimated Total Water Use (acre-feet)</th><th>Estimated Municipal Use (acre-feet)</th><th>Municipal GPCD</th></tr>
<tr><td>1990</td><td>379,293</td><td>245,590</td><td>115,473</td><td>272</td></tr>
<tr><td>2050</td><td>772,291</td><td>403,646</td><td>186,054</td><td>215</td></tr>
</table>
The draft report states that a 15% reduction in per capita water is included in the year 2050 municipal water demand.</td></tr>
</table>

		Response: The draft report stated that the effects of water conservation upon per capita water use were estimated by the TWDB to be 15 percent by 2020 (see Phase I report, Section 2.3. The author of this section of the report was not aware that the TWDB had estimated that further reductions in per capita water use were included in the projections after 2020 to ultimately reach 20.9 percent by 2050. Although the explanation in the text was in error, it did not affect the projected quantities used in the report.
14-24	Section 2.0	*Comment: The conservation goal is unreasonable and therefore would not meet Commission standards in Title 30 TAC §288.* *The goal is unreasonable because it is arbitrary: To be rational, and therefore reasonable, the following steps should have been performed: (1) identification of a problem, (2) system audit and engineering analysis to quantify the technical potential for water conservation from specific water conservation strategies, and (3) determination of water conservation goals based upon the system audit and engineering analysis. Additionally, as is done with the other water supply strategies, a cost analysis of the water conservation strategies should be included to help determine a reasonable goal.*
		Response: The comment is noted. However, the Phase I study scope of work did not provide for the approach outlined above. Instead, the scope specified that the TWDB high case, with conservation projections would be used in the Phase I study.
14-25	Section 2.0	*Comment: In setting the per capita use goal, the percentage reduction (if there is one) should also be translated into a reduction in gallons per day per person and the sources of this water savings should be identified (e.g., indoor use, unaccounted-for uses, outdoor irrigation use, etc.).*
		Response: See response to Comment No. 14-24 above.
14-26	Section 2.0	*Comment: The goal is supposed to be a 15% reduction in per capita use, but the figures above actually result in a 21% reduction in per capita water use.*
		Response: See response to Comment No. 14-24 above.
14-27	Section 2.0	*Comment: Municipal conservation goals can also be set for unaccounted-for uses and peak-to-average day ratios in order to decrease long-run demands. Why have these not been considered?*
		Response: See response to Comment No. 14-24 above.

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

September 20, 1993

Mr. Emmett Gloyna
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

Dear Mr. Gloyna:

I have recently received the agenda for the TransTexas Water Program meetings to be held September 22, 1993, in Austin. On the agenda for the South Central Texas Policy Management Committee (PMC) meeting is PMC review and action on the draft Phase I Report.

It was my understanding that the TAC members would be provided sufficient opportunity to review and comment on the full draft Phase I Report and that these comments would be addressed in the Final Phase I Report. This would allow all necessary and relevant information to be before the PMC so that it could make an informed decision with respect to options on which the Phase II Report should focus.

Jack Nelson (Lavaca-Navidad River Authority) and Dr. Herb Grubb (HDR) inform me that not all TAC members were provided a copy of the full draft Report. They also informed me that there is no plan to incorporate or otherwise address TAC member comments in the Phase I Report before it is submitted to the PMC for review and action. They stated that the draft Phase I Report, for all intents and purposes, is the final Report and no changes will be made. Instead, any comments that they receive will be addressed in the Phase II Report.

The importance of following a process which allows full opportunity of TAC members to review, comment, and provide guidance on the development and finalization of the Phase I Report cannot be stressed enough. Without such a process, the credibility and validity of the Report, as well as the TransTexas Water Program itself, is put in doubt.

Therefore, it is expected that copies of the full draft Report, not just an executive summary, be provided to all TAC members and that these copies should be provided without the TAC members having to request them first. TAC members should also be provided sufficient time to review and comment on the draft Phase I Report. It is also expected that these comments be addressed in the Phase I Report before it is finalized. Only when this has been done should the Phase I Report be submitted to the PMC for its review and action.

P.O. Box 13087 • Austin, Texas 78711-3087 • 512/908-1000

The success of the TransTexas Water Program is contingent upon the fulfillment of the program sponsors' commitment that the process be open and responsive, and that the work product be objective and unpredetermined. I look forward to working with you to ensure that this commitment is carried out as the program is developed and completed.

Sincerely,

Mark Jordan

Mark Jordan, Director
Water Policy Division
Texas Natural Resource
Conservation Commission

cc: South Central Texas Policy Management Committee
South Central Texas Technical Advisory Committee

Trans-Texas -- Corpus Christi Draft Phase 1 Report:

General comments on the water supply planning approach in the report:

1. Water demands are presented, followed by 16 possible water supply alternatives, with each alternative consistently discussed in terms of a range of issues. This approach is congruent with the water supply planning approach.

2. However, the report claims that the municipal water demand estimates include a 15% reduction in per capita use due to water conservation (*the validity and accuracy of this claim is discussed below*). I assume this 15% reduction in per capita water is due to "automatic" conservation primarily because of improved plumbing fixture efficiences, as is implied in the report. **Consideration of additional ("advanced") water conservation strategies, except reuse, are <u>not</u> presented and would be expected to accompany any water rights application which required a conservation plan.**

   Additional ("advanced") water conservation strategies would include:

   * Reducing outdoor irrigation demand in the commercial and residential sectors.
   * Commercial retrofit (replace ice-making machines, etc.).
   * Conservation in other sectors (e.g., agriculture) or in other river basins and procurement of the conserved water.

   The "yield" from each strategy would be estimated, as is done w/ the other alternatives, and the cost, environmental and related issues also discussed.

3. What about the use of drought plans (temporarily suspending non-essential uses) as a water management alternative?

4. A summary table of each supply alternative vs. the cost, environmental impacts and other issues should be included.

Trans-Texas -- Corpus Christi Draft Phase 1 Report:

Comments on the Water Demand Estimates and Water Conservation:

1. *Summary of Total Water Demands, Municipal Demands, and Per Capita Use in Report:*

TABLE 1:

Year	Population Served	Estimated Total Water Use (acre-feet)	Estimated Municipal Use (acre-feet)	Municipal GPCD
1990	379,293	245,590	115,473	272
2050	772,291	403,646	186,054	215

The draft report states that a 15% reduction in per capita water use is included in the year 2050 municipal water demand.

2. The conservation goal is unreasonable and therefore would not meet Commission standards in Title 30 TAC §288.

The goal is unreasonable because it is arbitrary: To be rational, and therefore reasonable, the following steps should have been performed: (1) identification of a problem, (2) system audit and engineering analysis to quantify the technical potential for water conservation from specific water conservation strategies, and (3) determination of water conservation goals based upon the system audit and engineering analysis. Additionally, as is done with the other water supply strategies, a cost analysis of the water conservation strategies should be included to help determine a reasonable goal.

3. In setting the per capita use goal, the percentage reduction (if there is one) should also be translated into a reduction in gallons per day per person and the sources of this water savings should be identified (e.g., indoor use, unaccounted-for uses, outdoor irrigation use, etc.).

4. The goal is supposed to be a 15% reduction in per capita use, but the figures above actually result in a 21% reduction in per capita water use.

5. Municipal conservation goals can also be set for unaccounted-for uses and peak-to-average day ratios in order to decrease long-run demands. Why have these not been considered?

5. *The initial per capita water use appears too high for several reasons:*

(a) P. 2-7 of the report indicates that the per capita use for the "driest" historical year for a 10-year period was used as a base and then reduced 15%.

What was the probability of the drought which was used in the baseline data?

In that historical numbers do not reflect reduced demands due to the new plumbing fixtures standards, this is unreasonable. Instead, an engineering design approach should be used to help estimate the per capita use.

Also, it may be more cost-effective to implement drought measures as an alternative to supply development for these "dry" years.

(b) The Corpus Christi (inside city limits) 1988-1990 average is 163 gpcd (pumped), and the per capita use for 1989 (a "dry" year) was 167 gpcd.

(c) The South Central regional average is 182 gpcd for 1988-1990, 190 gpcd for 1989, and 192 gpcd for 1984 (both "dry" years).

6. How does the dollar cost/acre-feet of water for meeting the obvious municipal irrigation demand (contained within the estimated 186,054 acre-feet) compare to the costs of a xeriscape program in dollar cost/acre-foot of water save)?

7. The water supply plan (and related drought contingency plan) should include a minimum municipal demand which must be supplied on a firm basis in order to protect public health and safety (i.e., provide adequate water supplies and wastewater services for hygiene, sanitation and fire-fighting purposes).

TNRCC staff estimate this demand for the service area to be 112,457 acre-feet per year (based on 130 gpcd pumped). However, please note that we are currently considering revising this number downwards in order account for the recent new plumbing fixtures standards.

8. Regarding industrial demands, this is supposed to increase from 43,611 acre-feet to 100,231 acre-feet by the year 2050. Why? Isn't this area's future growth industries expected to be tourism, which is not necessarily water-intensive?

LAVACA-NAVIDAD RIVER AUTHORITY

Post Office Box 429
Edna, Texas 77957-0429

Telephone 512-782-5229
Fax 512-782-5310

September 21, 1993

Mr. Mark Jordan, Director
Water Policy Division
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, Texas 78711-3087

REFERENCE: Phase I Interim Report

Dear Mark:

We certainly appreciate your letter and comments of September 20, 1993 (FAX) concerning the Trans-Texas Program and more specifically the South-Central PMC meeting agenda for September 22.

We certainly agree with your comment that the TAC members should be provided sufficient opportunity to review and comment on the full draft of the Phase I Interim Report. However, there seems to be a misunderstanding concerning the purpose or definition of the interim report, which addresses the work completed in Phase I.

All TAC members were given an opportunity by an August 16 letter to obtain, by return mail, a full interim report if they so desired. It appears that at least 41 copies have been issued to date. It certainly did not seem prudent for a rather meager study budget to bear the cost of printing and mailing a 329 page report for someone who may not want it.

Also, the scope of work for the South-Central Trans-Texas Program, as approved by the PMC, described the preparation of the Phase I Interim Report exactly as has been accomplished. As you were correctly informed by Dr. Grubb and Mr. Nelson, all the comments received on the interim report will be addressed in a continuing study, Phase II. Upon approval by the PMC, Phase II will revisit the more viable alternatives in detail, will possibly investigate new alternatives, and will certainly address the concerns and comments from the TAC.

In summary, we could not agree more with your statement, "The success of the Trans-Texas Water Program is contingent upon the fulfillment of the program sponsors' commitment that the process be open and responsive, and that the work product be objective and unpredetermined."

Sincerely,

Emmett Gloyna
General Manager

CC with incoming letter:

Mr. James Dodson
Regional Water Coordinator
City of Corpus Christi

Dr. Herbert Grubb
HDR Engineering, Inc.

Mr. Jack Nelson
Director of Water Resources
Lavaca-Navidad River Authority

Dr. Tommy Knowles
Texas Water Development Board

Reviewer:	(Letter No. 15) 09/21/93 letter from Mark Jordan, Director, Water Policy Division, TNRCC from Lavaca-Navidad River Authority
Comment:	*Noted. No response necessary.*

September 28, 1993

Mr. Emmett Gloyna
General Manager
Lavaca-Navidad River Authority
Box 429
Edna, Texas 77957

Dear Mr. Gloyna:

Listed below are several additional comments on the Trans-Texas Draft Phase 1 Report for the Corpus Christi Area.

- Page 2-12, Table 2.3-3; The correct Steam Electric Power Water Demand Projection for Atascosa County in 1990 is 6,036 Acre-Feet in lieu of 3,622 giving a new regional total of 8,480 Acre-Feet.

- Page 2-7; The report states that "the per capita water use statistic was lowered by five percent per decade from 1990 through 2020 until a 15 percent water conservation effect had been factored into the projection method". In fact, water conservation was factored into the projections at a rate of 2.5% for 1990, 7.5% by year 2000, 12.5% by year 2010 and 15% by year 2020 through 2040.

If you have any questions, please call me at (512) 463-8043.

Sincerely,

for Tommy Knowles

cc: Dr. Herb Grubb, HDR

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Telefax (512) 475-2053 • 1-800- RELAY TX (for the hearing impaired)

Reviewer:	09/28/93 letter from Tommy Knowles, Texas Water Development Board	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
16-1	Section 2.0	*Comment: Page 2-12, Table 2.3-3; The correct Steam Electric Power Water Demand Projection for Atascosa County in 1990 is 6,036 Acre-Feet in lieu of 3,622 giving a new regional total of 8,480 Acre-Feet.*
		Response: Noted, and corrected in Phase II report.
16-2	Section 2.0	*Comment: Page 2-7; The report states that "the per capita water use statistics was lowered by five percent per decade from 1990 through 2020 until a 15 percent water conservation effect had been factored into the projection method". In fact, water conservation was factored into the projections at a rate of 2.5% for 1990, 7.5% by year 2000, 12.5% by year 2010 and 15% by year 2020 through 2040.*
		Response: Noted: However, this appears to omit an additional 5.9% by 2050 (see Comment No. 14-23 above).

TEXAS WATER DEVELOPMENT BOARD

October 6, 1993

Mr. Emmett Gloyna
General Manager
Lavaca-Navidad River Authority
Box 429
Edna, Texas 77957

Dear Mr. Gloyna:

Enclosed for your review are commemts from the Board's Environmental Section of the Water Resources Planning Division on the draft Phase 1 Interim Report for the Corpus Christi area.

If you have any comments or questions, please me at (512) 463-7976 or Tommy Knowles at (512) 463-8043.

Sincerely,

Dennis J. Crowley, P.E.
Regional Planning\Projects

cc: **Dr. Herb Grubb, P.E., w/attachment**
HDR

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Telefax (512) 475-2053 • 1-800- RELAY TX (for the hearing impaired)

TEXAS WATER DEVELOPMENT BOARD

September 21, 1993

TO: *Tommy Knowles, Deputy Exec. Admin. for Planning*

THRU: *Mike Personett, Dir., Local & Regional Assistance Div.*
Dennis Crowley, Head, Regional Projects Unit
Tony Bagwell, Dir., Water Resources Planning Div. TB
Butch Bloodworth, Chief, Water Uses & Projections Sec.
Gary Powell, Chief, Environmental Section 09/21/93

FROM: *Ray Mathews, Jr., Fisheries Biologist/Ecologist, Env. Sec.* 9/21/93

SUBJECT: *Trans-Texas Draft Phase I Report for the Corpus Christi Area*

In accordance with your request, I have read the Draft Phase I Report for the Trans-Texas Water Program, Corpus Christi Service Area. The water demand of the Corpus Christi Service Area was projected in the Board's 1990 Texas Water Plan to need some new source of water supply for the metropolitan area. The Trans-Texas water program has since been identified as a potential method of meeting that need through transmission of surplus waters from river systems east of Corpus Christi. I have reviewed the draft report with a focus on the potential for providing this transmission of water in an environmentally responsible manner.

The report is based entirely on available environmental information, and as we have determined from our previous water related analyses, there is a significant deficit of information on the aquatic ecosystems of Texas. In application of available information, HDR (the reporting contractor) admits that the degree to which project activities could be accurately defined varied among alternatives. Although they attempted to apply an equal level of effort in evaluating each alternative, those that were obviously not viable in terms of producing significant amounts of new, firm water supply were examined somewhat less closely. They state that a primary concern of new water resources development is the potential impacts to the amount and timing of stream flows that would be impounded or diverted for water supply, and reductions in freshwater input to the brackish wetlands and shallow, muddy bays that comprise Texas estuaries. An interagency (i.e., TWDB, TPWD, and TNRCC) set of guidelines were developed for incorporating minimum stream flow requirements into the analysis of Trans-Texas alternatives. I am pleased that the needs of the fluvial ecosystems were recognized and have been allocated water to maintain their function.

P.O. Box 13231 • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone (512) 463-7847 • Telefax (512) 475-2053 • 1-800- RELAY TX (for the hearing impaired)

The report does appropriately account for differences in the types of impacts that the proposed Trans-Texas Water Program would generate versus building a new reservoir, which inevitably would cause significant unavoidable impacts. The problem with a new reservoir in Texas is that the physical requirements limit site availability and the few remaining sites are almost always in low wetland areas of a river basin that often contain unique natural resources, such as endangered species, bottomland hardwoods, or highly restricted hydrophytic plant communities. Water transmission lines on the other hand affect smaller areas, provide more flexibility in location, and therefore, can avoid sensitive habitats.

Several rare and endangered species are considered in the report, including the Jaguarundi and Coati in the brushland and lower perennial riverine wetlands of the Nueces River area transmission line corridor. Construction impacts appear to be more potentially detrimental than operational impacts. Reservoirs, as an alternative, completely and irreversibly remove terrestrial habitat that would be potentially used by these species. The alternative involving diversion of water from the pool behind the salt water barrier at the confluence of the Guadalupe and San Antonio Rivers may impose impacts to the Attwaters Greater Prairie Chicken. This species is particularly vulnerable and is projected to become extinct by 1998, unless some increases in this species occur (Steve LaBuda, USFWS, Refuge Manager, Attwaters Prairie Chicken NWR). I recommend that we provide considerable care in any project that may affect this sensitive species.

While it is appropriate that existing information be used for the preliminary assessment of this project, the general lack of comprehensive environmental information for the project area requires detailed ecological assessments, corridor mapping of vegetation communities and sensitive wildlife habitats, and consideration of safeguards to protect against contamination of water supplies. If raw water supplies are introduced from distant locations, then there is some potential for introduction of exotic species, pathogens, and incompatible water qualities. These considerations need to be carefully assessed in Phase II of the project by qualified scientists and engineers, in my opinion. Three different diversion scenarios were considered in the report: 1) diversion from the Nueces River at Three Rivers to Choke Canyon Reservoir, 2) diversion from Lake Texana to a water treatment plant in Corpus Christi, and 3) diversion from the Colorado River in Wharton County to an outfall area at Sandy Creek (Navidad River Basin) that would flow into Lake Texana for further transport to Corpus Christi.

Any potential interbasin transfer of organisms would be minimized by pipeline transport of Lake Texana water directly into the water treatment plant in Corpus Christi. The potential for adverse effects from transfer of aquatic species from one river basin to another may not be great here because the proximity of these rivers, and their biological similarity as part of the Gulf Coast Prairies and Marshes Biological Region, are widely *recognized. Natural exchanges of water and organisms between adjacent river systems probably already occurs as a consequence of flooding, and migrating waterfowl and fishes. Diversion of Nueces River water to Choke Canyon is over a relatively short distance, 6.5 miles, and does not constitute a major concern. However, diversions from the Guadalupe and San Antonio Rivers to Corpus Christi by pipeline would extend more than 50 miles, and in the case of Lake Texana, the pipeline to Corpus Christi would extend approximately 90 miles.*

I hope these review comments are helpful and can be incorporated into subsequent final reports in a constructive manner. If you should need further information on any of these issues, let me know.

Reviewer:	09/21/93 memo from Ray Mathews, Jr., Fisheries Biologist/Ecologist, Environmental Section, Texas Water Development Board	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
18-1	Section GS-1	*Comment: Several rare and endangered species are considered in the report, including the Jaguarundi and Coati in the brushland and lower perennial riverine wetlands of the Nueces River area transmission line corridor. Construction impacts appear to be more potentially detrimental than operational impacts. Reservoirs, as an alternative, completely and irreversibly remove terrestrial habitat that would be potentially used by these species. The alternative involving diversion of water from the pool behind the salt water barrier at the confluence of the Guadalupe and San Antonio Rivers may impose impacts to the Attwaters Greater Prairie Chicken. This species is particularly vulnerable and is projected to be come extinct by 1998, unless some increases in this species occur (Steve LaBuda, USFWS, Refuge Manager, Attwaters Prairie Chicken NWR). I recommend that we provide considerable care in any project that may affect this sensitive species.*
		Response: As a class of water supply alternatives new reservoirs can be expected to produce considerable impact, especially in terms of construction and terrestrial habitat loss. Special care has been given to the identification of potential impacts to sensitive species and habitats, and to habitats of greater importance to wildlife. Project studies have included coordination with officials of concerned agencies including Steve Labuda, Refuge Manager, Attwater's Prairie Chicken NWR.
18-2		*Comment: While it is appropriate that existing information be used for the preliminary assessment of this project, the general lack of comprehensive environmental information for the project area requires detailed ecological assessments, corridor mapping of vegetation communities and sensitive wildlife habitats, and consideration of safeguards to protect against contamination of water supplies. If raw water supplies are introduced from distant locations, then there is some potential for introduction of exotic species, pathogens, and incompatible water qualities. These considerations need to be carefully assessed in Phase II of the project by qualified scientists and engineers, in my opinion. Three different diversion scenarios were considered in the report: 1) diversion from the Nueces River at Three Rivers to Choke Canyon Reservoir, 2) diversion from Lake Texana to a water treatment plant in Corpus Christi, and 3) diversion from the Colorado River in Wharton County to an outfall area at Sandy Creek (Navidad River Basin) that would flow into Lake Texana for further transport to Corpus Christi.*
		Response: The level of environmental studies is commensurate with the level of engineering studies. The data provided by the environmental studies contributes information used to determine which alternatives merit further consideration. Detailed investigations can be expected to focus on those alternatives which continue on into the later stages of the study process (see comment nos. 4-4 through 4-9). Additionally the environmental data will be used in future planning and design phases to minimize impacts and avoid impacts. However, alternative GS-1 is not being proposed as part of the integrated plan.

18-3		*Comment: Any potential interbasin transfer of organisms would be minimized by pipeline transport of Lake Texana water directly into the water treatment plant in Corpus Christi. The potential for adverse effects from transfer of aquatic species from one river basin to another may not be great here because the proximity of these rivers, and their biological similarity as part of the Gulf Coast Prairies and Marshes Biological Region, are widely recognized. Natural exchanges of water and organisms between adjacent river systems probably already occurs as a consequence of flooding, and migrating waterfowl and fishes. Diversion of Nueces River water to Choke Canyon is over a relatively short distance, 6.5 miles, and does not constitute a major concern. However, diversion from the Guadalupe and San Antonio River to Corpus Christi by pipeline would extend more than 50 miles, and in the case of Lake Texana, the pipeline to Corpus Christi would extend approximately 90 miles.*
		Response: The interbasin transfer of organisms is an issue the sponsors of Trans-Texas have decided to study in greater detail. To this end the sponsors of have contracted with the Corps of Engineers to investigate the interbasin transfer issue.

October 29, 1993

Policy Management Committee
South Central Area
Trans Texas Water Program

Dear Sirs:

The Friends for Conservation of the San Antonio River Basin wishes it to be stated for the record that we are opposed to the building of the proposed Goliad Reservoir on the San Antonio River.

Thank you,

Denise Prescott,
secretary-treasurer
for
Friends for Conservation
of the
San Antonio River Basin

Reviewer:	(Letter No. 19) 10/28/93 letter from Friends of the River
Comment:	*Noted. No response necessary.*

20

RECEIVED FEB 17 1995

TEXAS
PARKS AND WILDLIFE DEPARTMENT
4200 Smith School Road • Austin, Texas 78744 • 512-389-4800

P.O. Box 688
Port O'Connor, TX 77982
Tel 512/983-4425
FAX 512/983-4404

8 February 95

Re: Phase II Status Update - Trans-Texas Water Program

Albert W. Green, Chief
Aquatic Studies Branch
Resource Protection Division
Texas Parks & Wildlife Department
4200 Smith School Road
Austin, TX 78744

Dear Al:

As the TPWD representative on the South-Central Technical Advisory Committee (TAC) for the Trans-Texas Water Program, I attended the January 31, 1995 TAC meeting in Edna. The meeting was called to conduct a briefing on the status of Phase II. Presentations were given summarizing the status of several of the identified alternatives. Information was also presented on environmental issues and public outreach efforts. Because some of the participants in these meetings, such as myself, are not involved in every aspect of alternative development, it is necessary to present a complete and consistent explanation of all information as we go through this process.

I raised several questions at the TAC meeting which are included here along with one comment (item no. 2) not discussed. I have forwarded copies of this information to the individuals you suggested. If you have any questions or need clarification please call.

1. There is an apparent contradiction in population and water use projections for the Colorado-Lavaca-Guadalupe (C-L-G) area. Table 2.7-1 of the Phase II Status Update indicates the population of the C-L-G region will increase by 59% from 1990 to 2050. Table 2.7-2 of the same document indicates the water use in this same region will <u>decrease</u> by 12% over the same time frame. A similar scenario was indicated in the Phase I Interim

Report document using different boundaries for the water supply area (see number 2 below). At the TAC meeting and in the Phase I document this reduction in water use was attributed to more efficient irrigation, primarily in rice farming. If this is the case then a description of the anticipated irrigation techniques should be presented. Also, any existing documentation of the effectiveness of these techniques should be presented to support the anticipation of water savings.

The assumption that the C-L-G region will generate surplus water in the future is crucial to several of the proposed alternatives. For this reason a detailed treatment of the reasons for the assumption is absolutely necessary. This material should be included in the next Phase II document.

2. The C-L-G water supply area boundaries given in the Phase II Status Update document are not the same as those in the Phase I Interim Report document. The Phase I document identified a 10 county water supply area (Table 2.7-1, Phase I Interim Report, p. 2-36). The Phase II document does not present the water supply area by county. Instead, the region is divided into 1 river basin and 2 "coastal basins" (Tables 2.7-1 and 2.7-2, Phase II p. 2-35). The continuity of the 2 phases is disrupted making comparison and evaluation of the listed alternatives more difficult. The reason necessitating this change along with supporting documentation should be included in the Phase II document.

3. The Brazos River alternative (B-3) may yield more water than indicated. The Phase II Status Update document indicated a potential yield from the Brazos River alternative (B-3) of 29,000 acre-feet per year (Table 6). Discussions at the meeting revealed that there may be more water available through this alternative. I feel this alternative should be given very serious consideration. The Brazos River does not support a major estuary as does the Guadalupe, Lavaca and, recently, the Colorado Rivers. Therefore, a decrease in Brazos River flow will not likely impact estuarine life to the extent that diversion of Colorado, Lavaca or Guadalupe River water would.

4. The Public Information/Public Involvement aspect of Phase II needs to include increased public contact and information dissemination in the water supply area. Much of the Phase II Status Summary text on this topic details efforts to involve the public in the Corpus Christi area. It is indicated that the media (written and video) have been contacted on a continuing basis. No media from the water supply area were specifically identified in the document. It was indicated at the meeting that all water supply area county judges received mailings and local newspapers were contacted. Unfortunately the Port Lavaca Wave and the Victoria Advocate chose not to run announcements of this meeting. The public contacts in the water supply area to this point have not been adequate.

The public outreach efforts detailed in the summary may, in time, reach the water supply area public. However, the summary listed no specific plans to contact the public in the water supply area. If significant contacts are not made soon, and the program explained, alternatives will be selected with limited public comment from this region. Considering the magnitude of this program I feel that public hearings should be held in Port Lavaca, Victoria and Palacios.

Sincerely,

Norman W. Boyd
Conservation Scientist
Coastal Fisheries Division
Port O'Connor

xc: Lynn Benefield
Gene McCarty
C. Lance Robinson
Jerry Mambretti
Larry McKinney
Jack Nelson
Tommy Knowles
Bruce Moulton

Reviewer:	02/08/95 letter from Norman W. Boyd, Conservation Scientist, Coastal Fisheries Division, Texas Parks and Wildlife Department	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
20-1	Section 2.0	*Comment: There is an apparent contradiction in population and water use projections for the Colorado-Lavaca-Guadalupe (C-L-G) area. Table 2.7-1 of the Phase II Status Update indicates the population of the C-L-G region will increase by 59% from 1990 to 2050. Table 2.7-2 of the same document indicates the water use in this same region will decrease by 12% over the same time frame. A similar scenario was indicated in the Phase I Interim Report document using different boundaries for the water supply area (see number 2 below). At the TAC meeting and in the phase I document this reduction in water use was attributed to more efficient irrigation, primarily in rice farming. If this is the case then a description of the anticipated irrigation techniques should be presented. Also, any existing documentation of the effectiveness of these techniques should be presented to support the anticipation of water savings.* *The assumption that the C-L-G region will generate surplus water in the future is crucial to several of the proposed alternatives. For this reason a detailed treatment of the reasons for the assumption is absolutely necessary. This material should be included in the next Phase II document.*
		Response: See response to Comments Nos. 1-1, and 14-24 above. The water demand projection methods and assumptions were decided by the TWDB and are not a part of the work of the Trans-Texas studies.
20-2	Section 2.0	*Comment: The C-L-G water supply area boundaries given in the Phase II Status Update document are not the same as those in the Phase I Interim Report document. The Phase I document identified a 10 county water supply area (Table 2.7-1, Phase I Interim Report, p. 2-36). The Phase II document does not present the water supply area by county. Instead, the region is divided into 1 river basin and 2 "coastal basins" (Tables 2.7-1 and 2.7-2, Phase II p. 2-35). The continuity of the 2 phases is disrupted making comparison and evaluation of the listed alternatives more difficult. The reason necessitating this change along with supporting documentation should be included in the Phase II document.*
		Response: The approach in the Phase II study was modified in response to comments pertaining to the Phase I report. In the Phase II report, Section 2.7 pertains only to the Lavaca and adjacent coastal basins water supply area, which is the source of water for option number LN-1 (Phase II, Section 3.13). For the Garwood option (option C-1, Phase II, Section 3.16) further analyses are included.
20-3	B-3	*Comment: The Brazos River alternative (B-3) may yield more water than indicated. The Phase II Status Update document indicated a potential yield from the Brazos River alternative (B-3) of 29,000 acre-feet per year (Table 6). Discussions at the meeting revealed that there may be more water available through this alternative. I feel this alternative should be given very serious consideration. The Brazos River does not support a major estuary as does the Guadalupe, Lavaca, and, recently, the Colorado Rivers. Therefore, a decrease in Brazos River flow will not likely impact estuarine life to the extent that diversion of Colorado, Lavaca or Guadalupe River water would.*

		Response: The Southeast Trans-Texas Phase I study found that up to 85,000 acft/yr is potentially available from the Allens Creek Reservoir (with the Trans-Texas Environmental Criteria applied). However, a water purchase quantity for this alternative was chosen which resulted in about the same net yield increase as purchase of Garwood water rights (i.e., 29,000 acft/yr), or the construction of Stage II of Lake Texana. It was assumed that the remainder of the Allens Creek Reservoir firm yield would be purchased by other entities. This alternative is being given equal consideration to other alternatives, including permitting issues, environmental impact, cost, and water supply potential.
20-4	Public Involvement	*Comment: The Public Information/Public Involvement aspect of Phase II needs to include increased public contact and information dissemination in the water supply area. Much of the Phase II Status Summary text on this topic details efforts to involve the public in the Corpus Christi area. It is indicated that the media (written and video) have been contacted on a continuing basis. No media from the water supply area were specifically identified in the document. It was indicated at the meeting that all water supply area county judges received mailings and local newspapers were contacted. Unfortunately the Port Lavaca Wave and the Victoria Advocate chose not to run announcements of this meeting. The public contacts in the water supply area to this point have not been adequate.* *The public outreach efforts detailed in the summary may, in time, reach the water supply area public. However, the summary listed no specific plans to contact the public in the water supply area. If significant contacts are not made soon, and the program explains, alternatives will be selected with limited public comment from this region. Considering the magnitude of this program I feel that public hearings should be held in Port Lavaca, Victoria, and Palacios.*
		Response: The January 31, 1995 meeting was announced by the Lavaca-Navidad River Authority via the following news release of January 23, 1995. "The Lavaca-Navidad River Authority has announced upcoming meetings for the Technical Advisory Committee of the Trans-Texas Water Program, South-Central Area. The meetings will be in <u>Edna on Tuesday, January 31</u> at 1:30 p.m. at the Texana Room, Victoria Bank & Trust Building, 700 North Wells; and in <u>Corpus Christi on Wednesday, February 1</u>, at 1:30 p.m. at the City Council Meeting Room, City Hall, 1201 Leopard Street. A status update of the Phase II Finding which includes various water supply alternatives for the City of Corpus Christi will be discussed. The study consultant, HDR Engineers, will present to the Committee a summary of the finding for the various alternatives, including a pipeline from Lake Texana to Corpus Christi. The public is also invited to attend either or both meetings." The news release was sent to the <u>Victoria Advocate</u>, the <u>Port Lavaca Wave</u>, and the <u>Jackson County Herald/Tribune</u>.

MEMORANDUM

February 8, 1995

TO: Jack Nelson

FROM: Ron Marek

SUBJECT: Comments Regarding Trans-Texas Phase II Status Update Technical Advisory Committee Meeting on February 1, 1995

Mr. Nelson,

I would like to take this opportunity to comment on two items regarding the Phase II draft.

My first concern is the expected annual cost for power, and the method used to calculate cost/acft for Lake Texanna water via the pipeline. Per Table 3.13-7 on page 44 of the TTWP Draft, annual power cost is $3,047,000 per year. However, using a formula from Cameron's Hydraulic Data handbook, I have found the annual cost for power to be approximately $5 million dollars per year. This is based on a kilowatt-hour rate of $0.065 assuming 95% pump operation during the year. The cost of water per acft increases by approximately $50 dollars or $405/acft.

The second concern I have is the method in which the cost for water in prior years is calculated. I have been given conflicting data in terms of the method in which payments made to LNRC prior to the actual pumping of Lake Texanna is calculated. It would appear that the cost of water from Lake Texanna prior to receiving water via the pipeline would have an infinite cost. Please have someone address this issue and be kind enough to explain their approach.

Specifically , I would like to refer you to Table 3.13-1, Estimated Cost to Acquire Water in Lake Texanna, in Section 3.13, page 3. The table starts with the Fiscal Year 1995 and ends with the year of 2004. Cost per acft in the year of 1995 is shown to cost $28.03/acft and ends with the year of 2004 with a cost of $72.27 per acft. How did HDR arrive at these figures, and why did they decide to stop at the year of 2004?

I am really concerned with the fact that 80% of the study regarding the Lake Texanna Pipeline report, Section 3.13, deals specifically with the environmental impact and only a small portion to the engineering and costing. Since insufficient data is presented, the task of determining relative cost of the pipeline to other options is near impossible.

I look forward to your reply regarding my concerns and if I can help in lending a hand in resolving the needs for a dependable water supply, please don't hesitate to contact me.

Regards,

Ron Marek
4514 Acushnet
Corpus Christi, Texas 78413
Phone: 512-851-2121
FAX: 512-851-0410

Reviewer:	02/08/95 memo from Ron Marek	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
21-1	LN-1	*Comment: My first concern is the expected annual cost for power, and the method used to calculate cost/acft for Lake Texana water via the pipeline. Per Table 3.13-7 on page 44 of the TTWP Draft, annual power cost is $3,047,000 per year. However, using a formula from Cameron's Hydraulic Data handbook, I have found the annual cost for power to be approximately $5 million dollars per year. This is based on a kilowatt-hour rate of $0.065 assuming 95% pump operation during the year. The cost of water per acft increases by approximately $50 dollars or $405/acft.*
		Response: We have checked our calculations, and verified that the annual power cost for current electric rates would be about $3,047,000 per year. Pumping costs for operation of the pipeline were determined for: Hazen-Williams Roughness Coefficient: 130 Pumping Unit Efficiency: 70% Pump Station Energy Friction Losses: 5% No. of Pump Stations: 3 Downtime for Maintenance: 5% Pumping Rate: 60.7 cfs Total Pumping Head (incl. static head and friction losses at three pump stations): 1,025 ft. The status update for Section 3.13 incorrectly states that power costs were estimated for a kilowatt-hour rate of $0.065. For Phase II, power costs were estimated using the demand charge - fuel cost method which includes cost components for the utility capacity charge (based on installed pumping horsepower), energy cost and fuel cost. Energy rates for the utilities that would serve the three pump stations currently are: Demand charge: $9.00 to $13.13 per kW Energy and Fuel Costs: $0.028 to $0.0411 per kW-hr Total electricity consumed per year to pump 41,840 acft/yr would be about 62,817,000 kW-hrs. This results in a net unit power cost of about: $3,047,000 ÷ 62,817,000 kW-hrs = $0.0485/kW-hr
21-2	LN-1	*Comment: The second concern I have is the method in which the cost for water in prior years is calculated. I have been given conflicting data in terms of the method in which payments made to LNRA prior to the actual pumping of Lake Texana is calculated. It would appear that the cost of water from Lake Texana prior to receiving water via the pipeline would have an infinite cost. Please have someone address this issue and be kind enough to explain their approach.* *Specifically, I would like to refer you to Table 3.13-1, Estimated Cost to Acquire Water in Lake Texana, in Section 3.13, page 3. The table starts with the Fiscal Year 1995 and ends with the year of 2004. Cost per acft in the year of 1995 is shown to cost $28.03/acft and ends with the year of 2004 with a cost of $72.27 per acft. How did HDR arrive at these figures, and why did they decide to stop at the year of 2004?*

		Response: The costs to the City of Corpus Christi for acquiring water in Lake Texana are based on the costs of service and have been calculated in accordance with the Water Delivery and Conveyance Contract Between Lavaca-Navidad River Authority and City of Corpus Christi, December 14, 1993. In general terms, the payments by the City of Corpus Christi to LNRA are the sum of several items, including: (a) a pro-rata portion (based on the portion of the Lake Texana permitted diversion purchased, i.e. pro-rata proportion is 41,840/74,400) of the principal, interest, and other payments (if any), due on the Texana Bonds (TWDB bonds) and the Federal Contract payments, and any purchase by LNRA of the interest of the federal government or the TWDB in the Palmetto Bend Reclamation Project; (b) principal, interest, and other payments (if any), due on the bonds issued to finance the Texana Pipeline; (c) a pro-rata portion of the Lake Texana operating and maintenance expenses (based on the portion of the Lake Texana permitted diversion purchased, i.e. 41,840/74,400); and, (d) LNRA operating and maintenance expenses associated with the Texana Pipeline. Payments are to begin August 1, 1995, and continue through December, 2035, unless the contract is renewed and extended beyond 2035. LNRA has prepared a summary of expected costs of service to acquire water in Lake Texana and the summary is reported in Table 3.13-1. For the remainder of 1995, no debt service is owed on the TWDB bonds and no O&M expenses are applied to the payment schedule. From 1996 to 1999, the cost of service payments include debt service on the TWDB bonds as well as the Federal Contract payment, however, LNRA has reduced the O&M expenses below the amounts allowed by the water purchase contract (reduced by 80%, 60%, 40%, and 20% respectively for the next 4 years). From 1995 to 2004, debt service payments to the TWDB and federal government increase as reflected in the water costs reported in Table 3.13-1. From 2004 until 2035 when the debts are retired, the debt service payments are constant and the costs of service to acquire water in the lake will increase slightly, as needed, to cover O&M costs.
21-3	LN-1	*Comment: I am really concerned with the fact that 80% of the study regarding the Lake Texana Pipeline report, Section 3.13, deals specifically with the environmental impact and only a small portion of the engineering and costing. Since insufficient data is presented, the task of determining relative cost of the pipeline to other options is near impossible.*
		Response: The amount of environmental assessment presented is appropriate to the size of this potential water supply project and much of the information developed will possibly be used (and needed) in permitting processes if this project moves forward. However, with respect to reporting of the engineering and costing performed to this point, it was decided that a reconnaissance-level overview would be the most helpful to the majority of the readers and a detailed discussion of the work actually performed (which would be quite lengthy) was not done. For comparison of relative costs of projects, a consistent methodology was applied to each of the projects resulting in unit costs ($ per acft/yr) of raw water delivered to the O.N. Stevens WTP. As with any cost estimating effort, individual cost components may be affected by market factors, but the application of a consistent method, as used in this study, assures that the comparison of costs (and the resulting ranking of projects from lowest to highest cost) remains valid.

COASTAL BEND ENVIRONMENTAL COALITION
P.O.BOX 3512 Corpus Christi, 78404

February 10, 1995

Mr. Jack Nelson
Lavaca-Navidad River Authority
Edna, Tx 77957

Dear Mr. Nelson:

There are several comments on the Phase II study for the South Central portion of the TransTexas Water Plan which we wish to make. They mostly are concerned with two factors. The first is the total lack of publicity for the so called public hearings. There was no notice to the public that the hearing was to be held on February 1 and no notice that copies of the study, if any, were available for the public to see. There were less than ten members of the general public present at the February 1 meeting and they responded to a notice in the weekly newspaper, the Flour Bluff Sun, which got its information from the Sierra Club.

The second major concern is the apparent bias which has predetermined that the transfer of water from across Texas is the most desirable thing since apple pie. Other states have tried this method of encouraging growth and have found that a few years down the road major problems have been created. California, Florida, and Arizona are just cases in point. The results have been extreme environmental damage and massive expenditures to correct this damage. Just consider the Kissimmee project in Florida. Or the problems with excessive salt in California.

Specifically, we want to comment on two reports given at the February 1 meeting which illustrate the bias point. One is the study on desalting water. No consideration has been given to small scale mobile plants which could supply individual industrial units. The only concern has been to prove that desalting is too expensive to supply the 100,000 acre feet the Development Board says Corpus Christi might need in the year 2050. The reason given is that industry does not want to be responsible for these plants. But since they are the ones who think they need additional water to grow, we feel they should be the ones to pay. At the very least, a thorough study of this option should be undertaken and not just glossed over.

CORPUS CHRISTI RECYCLING - LEAGUE OF WOMEN VOTERS - MAIN GROUP, SINTON
COASTAL BEND SIERRA CLUB - COASTAL BEND AUDUBON SOCIETY - OPUS
AUDUBON OUTDOOR CLUB - EARTH SAVE

The second area where we have much disagreement is over the possible removal of sediment behind the Wesley Seale dam. Again the study seems to us to be biased in the extreme. The Corps of Engineers dredge for much less than $2 per cubic yard. Why then does it cost $8 for the same amount of material at the dam site? Also no consideration was given to several smaller scale removals of such sediment as exists along the shores of the lake when the lake is low. Currently, Lake Corpus Christi is about 58% full and much sediment along the shores could be removed by bulldozers. This material is dry and could be sold as top soil. Next to the dam itself, a bypass system could be installed which would release the current amount of sediment downstream with a possible 10% additional quantity. This would over the years gradually remove sedimentation from the picture. This would also not be excessively costly and would serve to help in the erosion problem of our beaches due in part to lack of sediment coming down the rivers.

The report included some information on the amount of sediment in the lake using the determination of this amount by the USGS in 1987. In this table it was stated that the 1987 measurements were modified. How? There have been no additional actual determinations made to our knowledge. So it is a computer manipulation. We also disagree with the so-called firm yield of 168,000 acre feet and so does the USGS and the Washington office of the Bureau of Reclamation. Again the computer has come into play and one can get any results depending on the figures fed into the machine. The public has not been informed about the source of these figures and their reliability.

We also understand that the Lavaca-Navidad River Authority needs to begin the payback of their balloon note on their dam. But we disagree that the citizens of Corpus Christi should be paying this note off without a vote to that effect. This amounts to $400,000 million over a 25 year period and that is a lot of money. The utility rate is already extremely high and the present contract calls for utility revenues to pay the cost of the water. There wil l be no incentive to industry to locate in Corpus Christi with extreme utility bills unless the citizens further subsidize them.

In addition, we are opposed to a few people "playing GOD" in deciding that they know better where the water should be used in Texas. We do not know yet what an additional 100,000 acre feet will do to the semiarid bay system in this area. No studies have been done on this effect, nor on the long term loss to the eastern part of the state. Episodic floods are a natural phenomena which the Sabine and Galveston bays just might need. Can one really say you know better?

We strongly suggest that the technical committee look carefully at a number of smaller ways that the City of Corpus Christi could make of a deficit of 100,000 acre feet of water, if in fact such a large amount is needed. This must start with better management of the two reservoirs the city currently owns. Mention was made of an aquifer near Sinton. A combination of these smaller facilities would yield the water and could be brought on line as needed much less expensively for the citizens of Corpus Christi.

As you know, the City Council has committed to an election this April on the wishes of the citizens on water from Lake Texana. The outcome is at best uncertain.

If the current schedule is maintained with a final report in the summer, a lot of work remains to be done. Only the least of which is presentation of the situation concerning the 1995 version of the Texas Water Plan to the public. Only if they can read for themselves and attend public meetings can they be informed. We trust that next time, the public is notified.

Sincerely,

Bette Lovely, Secretary

Enclosure

cc: TWDB
Senator Truan

EDITORIALS

A10/Tuesday, February 7, 1995

Corpus Christi Caller-Times

LETTERS TO THE EDITOR

Not so high

The letter to the editor featured in the *Caller-Times* on Jan. 25 caught my attention because it was wrong on two counts: 1) the writer's belief that siltation has lowered the water level in Lake Corpus Christi; and 2) his lack of knowledge that a fairly recent siltation study of the lake has been made.

Within a standing body of water, addition of solids (silt, in this case) will displace water volume and cause the surface of the water to rise, following a simple principle of hydrostatics. To illustrate, fill a can two-thirds of water and begin pouring in sand. As accumulation of sand progresses, the water will begin to overflow the can.

In 1987, the U.S. Geological Survey, in contract with the city, did a siltation study of Lake Corpus Christi. The thickness of the silt layer that has accumulated on the bottom was determined by use of a state-of-the-art high-resolution seismic reflection profiling system that produced an analog of the mud (silt) layer deposited since the lake was initially impounded in 1938 (nearly 57 years ago). Using the thickness of the mud layer as indicator, it was found that approximately 10 percent of the water volume in the reservoir had been displaced by silt inflow. This is an accumulation rate of about 0.2 percent per year, not a high rate by any stretch of the imagination.

Henry L. Berryhill

Reviewer:	02/10/95 letter from Bette Lovely, Secretary, Coastal Bend Environmental Coalition	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
22-1	Public Involvement	*Comment: There are several comments on the Phase II study for the South Central portion of the Trans Texas Water Plan which we wish to make. They mostly are concerned with two factors. The first is the total lack of publicity for the so called public hearings. There was no notice to the public that the hearing was to be held on February 1 and no notice that copies of the study, if any, were available for the public to see. There were less than ten members of the general public present at the February 1 meeting and they responded to a notice in the weekly newspaper, the Flour Bluff Sun, which got its information from the Sierra Club.*
		Response: In the Edna area, local newspapers: the Victoria Advocate, the Jackson County Herald/Tribute, and the Port Lavaca Wave, were advised of the January 31, 1995 meeting. All three verbally stated the LNRA news release would be reported. However, only the Jackson County Herald/Tribune chose to write an article. In the Corpus Christi area, all local television and newspapers were contacted through the mail one week before and by phone and fax the day before the February 1, 1995 meeting. Five TV stations were represented at the meeting, as well as the Flour Bluff Sun. The Caller-Times elected to do a follow-up story.
22-2	L-1	*Comment: The major concern is the apparent bias which has predetermined that the transfer of water from across Texas is the most desirable thing since apple pie. Other states have tried this method of encouraging growth and have found that a few years down the road major problems have been created. California, Florida, and Arizona are just cases in point. The results have been extreme environmental damage and massive expenditures to correct this damage. Just consider the Kissimmee project in Florida. Or the problems with excessive salt in California.* *Specifically, we want to comment on two reports given at the February 1 meeting which illustrate the bias point. One is the study on desalting water. No consideration has been given to small scale mobile plants which could supply individual industrial units. The only concern has been to prove that desalting is too expensive to supply the 100,000 acre feet the Development Board says Corpus Christi might need in the year 2050. The reason given is that industry does not want to be responsible for these plants. But since they are the ones who think they need additional water to grow, we feel they should be the ones to pay. At the very least, a thorough study of this option should be undertaken and not just glossed over.*
		Response: In the desalt committee work, information was presented for seawater desalting plants that range in size from 16 acft/yr to 100,000 acft/yr. Costs for the 16 acft/yr and the 456 acft/yr size plants were $6,000/acft and $4,000 acft, respectively. The quality of the product water from these plants would be adequate for municipal uses, but may not be suitable for some industrial purposes; i.e., at the present it is necessary for industry to use small demineralization units to demineralize the treated water they now obtain from Corpus Christi. Small scale mobile plants would be required to use membrane processes, which for desalting seawater are more costly per acft than the costs quoted above.

22-3	N-7	*Comment: The second area where we have much disagreement is over the possible removal of sediment behind the Wesley Seale dam. Again the study seems to us to be biased in the extreme. The Corps of Engineers dredge for much less than $2 per cubic yard. Why then does it cost $8 for the same amount of material at the dame site? Also no consideration was given to several smaller scale removals of such sediment as exists along the shores of the lake when the lake is low. Currently, Lake Corpus Christi is about 58% full and much sediment along the shores could be removed by bulldozers. This material is dry and could be sold as top soil. Next to the dam itself, a bypass system could be installed which would release the current amount of sediment downstream with a possible 10% additional quantity. This would over the years gradually remove sedimentation from the picture. This would also not be excessively costly and would serve to help in the erosion problem of our beaches due in part to lack of sediment coming down the rivers.*
		Response: Additional detailed cost data for inland dredging programs has been added in the Phase II report; please refer to Section 3.19. Regarding small scale removal of sediment along the shores of Lake Corpus Christi, previous dredging studies for other reservoirs were reviewed. Due to the fact that a relatively small amount of sedimentation has occurred near the shoreline of the lake, the unit cost of restored yield using dry land techniques would actually be higher than a hydraulic dredging program. Additionally, under present reservoir operating policy, such a program would restore only a small amount of yield. Regarding the concept to release accumulated silt either through, or over, the dam, a discussion has been added to Section 3.19.
22-4	N-1	*Comment: The report included some information on the amount of sediment in the lake using the determination of this amount by the USGS in 1987. In this table it was stated that the 1987 measurements were modified. How? There have been no additional actual determinations made to our knowledge. So it is a computer manipulation. We also disagree with the so-called firm yield of 168,000 acre feet and so does the USGS and the Washington office of the Bureau of Reclamation. Again the computer has come into play and one can get any results depending on the figures fed into the machine. The public has not been informed about the source of these figures and their reliability.*
		Response: The 1987 sedimentation report prepared by the USGS had an error in the capacity figures for Lake Corpus Christi. However, the 1987 report included a fairly detailed topographic map showing the lake bottom contours of Lake Corpus Christi as measured during the sedimentation survey. Using standard methods of determining surface areas from maps (which did not include the use of a computer), HDR recomputed the elevation-area-capacity data for Lake Corpus Christi using the map developed by the USGS.
22-5	LN-1	*Comment: We also understand that the Lavaca-Navidad River Authority needs to begin the payback of their balloon note on their dam. But we disagree that the citizens of Corpus Christi should be paying this note off without a vote to that effect. This amounts to $400,000 million over a 25 year period and that is a lot of money. The utility rate is already extremely high and the present contract calls for utility revenues to pay the cost of the water. There will be no incentive to industry to locate in Corpus Christi with extreme utility bills unless the citizens further subsidize them.*
		Response: There appears to be an error in the quotation of the total repayment; i.e., is it possible that the comment should have been $400 million instead of $400,000 million? However, regardless of the project repayment requirements, the cost of water from Lake Texana is the lowest per acft for options other than two local options capable of producing small quantities (6,300 acft/yr to 22,900 acft/yr) of water; i.e., the cost of Lake Texana water delivered to the O.N. Stevens Water Treatment Plant ranges between $304 per acft and $355 per acft, depending upon whether or not the pipeline is shared with the transfer of water of other options (see Summary of Potential Water Supply Alternatives in the Executive Summary of the Phase II report).

22-6		*Comment: In addition, we are opposed to a few people "playing GOD" in deciding that they know better where the water should be used in Texas. We do not know yet what an additional 100,000 acre feet will do to the semiarid bay system in this area. No studies have been done on this effect, nor on the long term loss to the eastern part of the state. Episodic floods are a natural phenomena which the Sabine and Galveston bays just might need. Can one really say you know better?*
		Response: Supplying Corpus Christi with an additional 100,000 acre-feet/year of water would increase freshwater inflows to Nueces Estuary about 47,000 acre-feet/year, not 100,000 acre-feet/year. In 1990, total municipal and industrial water demand upon the Choke Canyon/Corpus Christi system was 132,086 acre-feet. Based on this amount, an estimated 47 percent of this volume (62,000 acre-feet) would be expected to be returned to the estuary as wastewater while 53 percent (70,000 acre-feet) would be lost to the Nueces River and Estuary system. To completely compensate for the loss of 70,000 acre-feet would require supplying Corpus Christi 149,000 acre-feet of water per year from sources other than the Nueces River or its reservoirs. Minimum freshwater releases to Nueces Estuary are regulated in accordance with Certificate of Adjudication No. 21-3214. Corpus Christi's demand for water is expected to exceed supplies available from the Choke Canyon/Corpus Christi system. One could choose to ignore the projections and hope for the best. However, using available information to plan for the future hardly can be construed to be "playing God."
22-7		*Comment: We strongly suggest that the technical committee look carefully at a number of smaller ways that the City of Corpus Christi could make of a deficit of 100,000 acre feet of water, if in fact such a large amount is needed. This must start with better management of the two reservoirs the City currently owns. Mention was made of an aquifer near Sinton. A combination of these similar facilities would yield the water and could be brought on line as needed much less expensively for the citizens of Corpus Christi.*
		Response: The Integrated Water Supply Plans present two action plans made up of component water supply alternatives. The plans are inherently flexible with respect to scheduling because no single option will meet the projected needs. Consequently, if the water demand projections are low (as has historically occurred), the plans can be implemented more quickly. If the projections prove to be high, then the city may choose to delay implementation of subsequent projects. Please refer to Section 3.1 (Modification of Operating Policies N-1) for a presentation of the substantial amount of work that has been performed on benefits available from reservoir management alternatives. Use of the Gulf Coast Aquifer near Sinton is a possibility and a good bit of information is presented (Local Groundwater, L-2). However, historically in the Corpus Christi area, long term use of groundwater has led to degradation of the water quality and has resulted in local groundwater being utilized as a drought back-up supply.

Organization for the Preservation of an Unblemished Shoreline

OPUS

721 Crestview Drive
Corpus Christi, TX. 78412

February 15, 1995

Mr. Jack Nelson, Executive Director
Lavaca Navidad River Authority
Edna, TX 77957

Dear Mr. Nelson:

I am writing on behalf of our organization concerning the February 1, 1995 Technical Advisory Committee Meeting, South-Central Study Area, Trans-Texas Water Program in Corpus Christi.

OPUS is an environmental organization active since 1964 in the Coastal Bend area. We are concerned about the low turnout of citizens not connected with the Program. Only five members of the general public, including this writer, attended. I read a meeting notice/story in the Coastal Ben Sun weekly newspaper. Other Board members at our February meeting reported not having known about it.

In view of the public information/public involvement thrust of this Program, we thought that you would want to know of our concern. Future water needs and proposed remedies are subjects of continuing interest here, as reflected in newspaper stories, letters to the Editor, City Council meetings, etc. Perhaps some way of tuning in to this interest might be found.

Sincerely yours,

Frank Hankins

Frank Hankins, Secretary

cc:Craig Pederson, Ex. Dir. TWDB

Sen. Carlos Truan

Reviewer:	(Letter No. 23) 02/15/95 letter from Frank Harkins, Secretary, Organization for the Preservation of an Unblemished Shoreline
Comment:	*Noted. No response necessary.*

February 17 - 1995

Mr Jack Nelson
Lavaca Navidad River Authority
Edna Texas

Dear Mr Nelson

A letter dated February 10 from the Coastal Bend Environmental Coalition on a letterhead listing the League of Women Voters as one of their sponsoring organizations.

Please be advised the Corpus Christi League of women voters is not a part of that Coalition -

I am a director on the local league board, so I can assure you we had not been advised that this letter was being sent.

I have enjoyed attending the Lavaca - Navidad meeting in the past, and look forward to the next meeting in June -

Eunice S Owen

RECEIVED
FEB 20 1995

E. S. Owen
410 Dolphin Pl.
Corpus Christi, Tex. 78411

Reviewer:	(Letter No. 24) 02/17/95 letter from Eunice Owen
Comment:	*Noted. No response necessary.*

SAN ANTONIO RIVER AUTHORITY

1.11-3.6 GC

February 21, 1995

Mr. Jack Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77959

RE: TRANS-TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA
SOUTH CENTRAL PHASE II - STATUS UPDATE
DATED: JANUARY, 1995

Dear Mr. Nelson:

The San Antonio River Authority has reviewed the South-Central Phase II - Status Update and offer the following comments:

1. The firm yield for the Goliad Reservoir was reported to be 85,400 ac-ft/year in the South-Central Phase II - Status Update. The West-Central Study reported the firm yield of Goliad Reservoir to be 115,400 ac-ft/year. The difference is due to return flows from the City of San Antonio being included in the analysis for the Goliad Reservoir in the West-Central Study Area, whereas, the South-Central Phase II - Status Update did not include any return flows in the analysis.

2. A portion of the return flow from the City of San Antonio is presently being reused and the amount of reuse will likely increase. However, there will always be a portion of the City of San Antonio return flow released to provide for downstream flow in the river which will reach the Goliad Reservoir site. We feel it is acceptable to be conservative and not include return flow, which the South-Central Study participants have no control over, in the analysis of Goliad Reservoir for the South-Central Study Area.

If you have any questions concerning these comments, please contact us.

Sincerely,

STEVEN J. RAABE.
Chief, Engineering Division

SJR:rmc

P:\RMC\WPDATA\TRANSTEX\LTRS

FEB 24 1995

100 East Guenther Street • P.O. Box 830027 • San Antonio, Texas 78283-0027 • (210) 227-1373 • FAX (210) 227-4323

Reviewer:	(Letter No. 25) 02/21/95 letter from Steven J. Raabe, Chief, Engineering Division, San Antonio River Authority
Comment:	*Noted. No response necessary.*

John Hall, Chairman
Pam Reed, Commissioner
Peggy Garten, Commissioner
Dan Pearson, Executive Director

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

Protecting Texas by Reducing and Preventing Pollution

Mr. Jack C. Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

March 13, 1995

Re: Trans-Texas Water Program - Corpus Christi Service Area Phase II Status Update, January 1995

Dear Jack:

I appreciate the opportunity to review the above-referenced draft document. Since the document is lacking discussion for several of the water supply alternatives and Sections 4.0, 5.0, 6.0, and 7.0, it is difficult to provide substantive comments without knowing the full range of alternatives and possible recommendations for an integrated water management strategy. The questions/comments which I have provided will, therefore, be limited to the technical aspects of the alternatives presented in this document.

Section 2.0 of the document contains discussion of water demands for the 12-county study area, which includes 1990 ground water use. The revised draft of this document should include an explanation of the source of ground water data and its reliability.

Table 2.7-4 presents the projected 2050 water supply for the Lavaca, Colorado-Lavaca, and Lavaca-Guadalupe Basins and includes an estimate of imported water from the Garwood Irrigation Company, "...with estimated use in Colorado County in Lavaca River Basin of 90 percent." Further explanation of this figure is needed to identify how much Garwood water is presently being used within the Lavaca Basin and accounted for through the firm yield analysis of Lake Texana. Is there a significant portion of runoff entering Lake Texana through West Mustang Creek that has its origin in the Colorado Basin?

In the discussion covering the purchase of existing water rights (Section 3.4), three alternatives were discussed relative to rights held by Robstown WCID #3, relative to the restoration of yield to Lake Corpus Christi/Choke Canyon. Would it be feasible for the City of Corpus Christi to contract with the District to provide water directly to the City's customers in areas adjacent to the District's service area?

Section 3.10.3 states that the effect of the Interim Order on the yield of the reservoir systems is estimated to be 30,000 acre feet per year, " ... if the system is operated at its maximum yield potential under the Phase IV operation policy (Section 2.5.2)." There is no discussion of the Phase IV operation policy in the referenced section.

Discussion in Section 3.13, page 32, suggests flow reductions in the Lavaca River as a result of diversion from Lake Texana to the City of Corpus Christi. A brief explanation how this occurs would provide clarity to this assertion.

The discussion presented in Section 3.17, Accelerated Municipal Water Conservation lacks detail and emphasis which, I believe, should be elevated in importance because of the semi-arid nature of the Coastal Bend area and the potential savings. Study sponsors are suggesting water shortages as early as the year 2003, therefore, it may not be too early to aggressively pursue conservation strategies to extend existing water supplies.

As you are aware, the City of Corpus Christi is on the verge of petitioning the Commission to modify the interim operating plan currently in place for the Lake Corpus Christi/Choke Canyon reservoir system. The proposed plan will increase the yield of the reservoir systems, which should be reflected in the future draft of the Phase II report.

Again, thank you for the opportunity to provide comment and if you have any questions, please do not hesitate to contact me at (512) 239-4809.

Sincerely,

Bruce

Bruce A. Moulton

cc: Mark Jordan, Director, Water Policy and Regulations Division

Reviewer:	03/01/95 letter from Bruce A. Moulton, Texas Natural Resource Conservation Commission	
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
26-1	Section 2.0	*Comment: Section 2.0 of the document contains discussion of water demands for the 12-county study area, which includes 1990 ground water use. The revised draft of this document should include an explanation of the source of ground water data and its reliability.*
		Response: The source of groundwater data is the Texas Water Development Board, which is referenced in the Phase II study report. The information is taken from studies that have been conducted in the past by TWDB, in cooperation with the U.S. Geological Survey, and is the most reliable data available.
26-2	Table 2.7-4	*Comment: Table 2.7-4 presents the projected 2050 water supply for the Lavaca, Colorado-Lavaca, and Lavaca-Guadalupe Basins and includes an estimate of imported water from the Garwood Irrigation Company, "...with estimated use in Colorado County in Lavaca River Basin of 90 percent." Further explanation of this figure is needed to identify how much Garwood water is presently being used within the Lavaca Basin and accounted for through the firm yield analysis of Lake Texana. Is there a significant portion of runoff entering Lake Texana through West Mustang Creek that has its origin in the Colorado Basin?*
		Response: No studies were found which address this question, and since it was not a part of the scope of this study, it is not possible to give a definitive response to it at this time.
26-3	Section 3.4	*Comment: In the discussion covering the purchase of existing water rights (Section 3.4), three alternatives were discussed relative to rights held by Robstown WCID #3, relative to the restoration of yield to Lake Corpus Christi/Choke Canyon. Would it be feasible for the City of Corpus Christi to contract with the District to provide water directly to the City's customers in areas adjacent to the District's service area?*
		Response: Although it may be feasible for the City and District to reach an agreement for the District to provide service to some of the City's customers, the economics of the expansion of a small water treatment plant and distribution system are generally less favorable than the experience of a larger water treatment plant and distribution system.
26-4	Section 3.10.3	*Comment: Section 3.10.3 states that the effect of the Interim Order on the yield of the reservoir systems is estimated to be 30,000 acre feet per year, "...if the system is operated at its maximum yield potential under the Phase IV operation policy (Section 2.5.2)." There is no discussion of the Phase IV operation policy in the referenced section.*
		Response: So noted. The Phase II report includes a discussion of the Phase IV operating policy in Section 3.1.
26-5	Section 3.13, pg. 32	*Comment: Discussion in Section 3.13, page 32, suggests flow reductions in the Lavaca River as a result of diversion from Lake Texana to the City of Corpus Christi. A brief explanation how this occurs would provide clarity to this assertion.*
		Response: The referenced section describes expected flow reduction when the permitted firm yield is diverted compared to the no-diversion condition. Once the project firm yield is being diverted, there will be no flow reductions other than as permitted in CA 16-2095B, which is in accordance with the Agreement Concerning Bay and Estuary Releases between LNRA, TPWD, and TWDB.

26-6	Section 3.17	*Comment: The discussion presented in Section 3.17, Accelerated Municipal Water Conservation lacks detail and emphasis which, I believe, should be elevated in importance because of the semi-arid nature of the Coastal Bend area and the potential savings. Study sponsors are suggesting water shortages as early as the year 2003, therefore, it may not be too early to aggressively pursue conservation strategies to extend existing water supplies.*
		Response: This analysis is appended in the Phase II report and accelerated conservation is included in the recommended plan.
26-7	Section 3.1	*Comment: As you are aware, the City of Corpus Christi is on the verge of petitioning the Commission to modify the interim operating plan currently in place for the Lake Corpus Christi/Choke Canyon reservoir system. The proposed plan will increase the yield of the reservoir systems, which should be reflected in the future draft of the Phase II report.*
		Response: So noted. The modified operating policy was agreed to by TNRCC and was issued as an Agreed Order in April, 1995. The effects of the new operating policy were implemented in the work for Phase II and Section 3.1 contains a description of the new policy.

RECEIVED ... 1995.

Community Technical Support Group

October 11, 1995

Herb Grubb
HDR Engineering, Inc.
2211 South IH 35, Suite 300
Austin, Texas 78741

Ref: Comments on Volume 2 - Technical Report

Dr. Grubb:

Please include the Community Technical Support Group's (CTSG) final report addressing the economics of Lake Texana versus the construction of a site specific conceptualized desalination plant.

Please contact me at 289-6090 or John Williamson at 242-8356 should you have any question regarding this request.

Regards,

Ron Marek
Chairman

cc: Jack Nelson
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957

John Williamson

4833 Saratoga, Suite 202 Corpus Christi, Texas 78413 FAX: 512-994-1119

30 October 1995

HDR ENGINEERING, INC.
Austin, TX
fax (512) 442-5069

ATTN: Herb Grubb

Dear Sir:

RE: Trans-Texas Water Program--Phase II Report

I have reviewed the section of your report dedicated to the study on desalination of seawater, primarily the parts concerned with distillation and dual-purpose plants. I have the following comments:

PAGE 3-158:
Your report states that the product water is extremely aggressive and corrosive, yet it is no different than the condensate handled continuously by power plants and industrial facilities. For distribution in a municipal water system and human consumption, remineralization is simple and relatively inexpensive. Also, the water could be mixed with existing city water to the benefit of both.

PAGE 3-159:
Your report makes mention of the largest MED in the world being an 11.0 mgd in Russia, as though Corpus Christi would need larger unit size. However, massive units adversely effect the ability to "turndown" the MED plants for reduced demand.

On the same page your report quotes MED product water costs for plants operated by the Virgin Islands Water and Power Authority without mention of whether these plants are part of a dual purpose plant or mention that the Virgin Islands has to import fuel.

Further on the same page your report mentions that MED has very little commercial acceptance: Why then does IDE Technologies, alone, have 250 MED plants operating worldwide?

PAGE 3-168:
Your report compare in Table 3.7-4 the total energy consumption of various desalination technologies without considering that Reverse Osmosis and Vapor Recompression consume electrical kilowatts, a high level energy source, while MEDs use very low pressure steam, a low level energy source with little remaining ability to produce power.

On the same page, your report states that there is no "waste heat" in a modern power plant and that extracting steam to produce water adversely effects the plant. This is true; however, the extent of adverse effects on a combined cycle gas turbine facility is mitigated by the fact that most of the power comes from the gas turbine(s).

PAGE 3-169:
Your report indicates in the last paragraph of this page that fuel costs will have a substantial impact on the cost of MED product water; however, the citizens of Corpus Christi are faced with power bills that vary with the cost of fuel due to the variable fuel charge hinged to the price of fuel. For a dual purpose plant, therefore, the impact of fuel costs on water costs is largely mitigated.

PAGE 3-170:
Your report indicates there are siting problems to be considered; however, there are existing power plant sites such as Barney M. Davis and Nueces Bay or areas next to them that may be utilized. Also, there is idle space on the Channel where Encycle is located.

Secondly, the concentrate outfalls need be located only a slight distance offshore of the Gulf side of Padre and Mustang Islands.

PAGE 3-171:
Your report discusses part-time operation of desalination in a negative manner without considering that a dual-purpose plant using MEDs will increase power output and efficiency as the MEDs are "turned down", lowering the cost of produced power. You also do not mention that if the full capacity of the pipeline is not **required**, the cost of the pipeline water goes up because the unit cost of our existing water supply has to be added to the cost of the pipeline water.

PAGE 3-172/3:
In this section, your report suggests that some segments of the MED plant need to be built for the ultimate capacity. However, your report does not consider that the population growth may not meet expectations. In fact, there have been suggestions that the growth projected in your report is high.

Also, it may be advantageous to have more than one location for dual purpose plants, depending on where the water and power needs grow. The methods of handling and installing piping change considerably with pipe size. It also may be advantageous to install concentrate disposal piping on a modular basis to disperse the concentrate at scattered locations.

PAGE 3-174:
Your report refers to the high economic value of Padre and Mustang Islands. A lot of this value may evaporate with the next hurricane that makes landfall in this area.

PAGES 3-185/6/7:

It would appear that the chief obstacle to the San Diego Water Authority plant involved was San Diego Gas & Electric waffling about. Your report on this alternative presents no definitive information regarding the price SDGE planned to charge for steam, the pressure and temperature at which they would supply the steam, nor the credit they would give for returned condensate. Also, the cost of given for the MED plant at $10 per gpd capacity is very high considering that IDE Technologies quotes turnkey at about $4.5 to $5.0 per gpd.

PAGES 3-187/8/9 & 190:

Your report provides no flow diagram, electrical revenue projections, fuel costs, nor cash flow projections for the Baja California plant. If it uses some of its power for RO, then the full power output is not available for sale to cut water costs. In fact, your report shows absolutely no impact of electrical revenues on water costs leaving one to conjecture that the entire plant cost is borne by the water revenues, vastly inflating the cost of the water.

As for the projected cost of the power plant, $735 per kilowatt seems high in view of some of the turnkey costs indicated in trade journals such as TurboMachinery International in recent months. Westinghouse supplied information that indicates the cost would be $400 to $450 turnkey. When I worked for Dow Chemical, Dow built a combined cycle plant in the late 1970s for $132 per KW when quotations from large E&C firms were running $350 to $400 per KW for areas outside California ($700 per KW in California).

The MED costs of $6.0 per gpd are 20 to 30% high from information I have seen; and, the RO prices are high compared to modern prices with today's membrane technology.

In conclusion, I find your report lacking in detail, ingenuity, and site specificity concerning dual-purpose desalination facilities, particularly gas turbine combined cycle / multi-effect distillation plants. Your report does not give specifics of land costs, power costs, fuel costs, etc. at the location of the plants used as examples, much less factor those to arrive at local cost projections. While I realize your organization loves to emphasize the expertise of Bechtel, your report leaves me unimpressed due to the lack of specific information.

Based on the lack of detail concerning the plants presented as examples in your report and the failure to convert these to site specific conditions, I, and a number of people I know, remain unconvinced that a proper evaluation of the desalination option was conducted.

Sincerely,

Byron Wooldridge, P.E.
6705 Deerwood
Corpus Christi, TX 78413

Reviewer:		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
27	Section 3.7	*Comment: Request to include Community Technical Support Group (CTSG) report addressing the economied of Lake Texana versus the construction of a site specific conceptualized desalination plant.*
		Response: See analyses which follow.
28	Section 3.7	*Comment: See letter from Byron Wooldridge, which preceeds this page.*
		Response: Analyses of the CTSG report address issues raised by Mr. Wolldridge. The analyses are included in the following pages.

REPORT

OF THE

COMMUNITY TECHNICAL SUPPORT GROUP

ON THE

FEASIBILITY

OF

REVERSE OSMOSIS SEA WATER DESALINATION

AS AN

ALTERNATE FUTURE SOURCE

OF

FRESH WATER

FOR THE LOCAL

TWELVE-COUNTY SERVICE REGION

Ron Marek - chairman
Byron Wooldridge, P.E. - co-chairman, treasurer
Rudy Bendixen, co-chairman public relations
John Williamson, P.E. - secretary
Bill Brock, P.E.
George Clower
John Hartley
E. Richard Smith
Jim Tarleton, P.E.

COMMUNITY TECHNICAL SUPPORT GROUP REPORT ON DESALINATION

TABLE OF CONTENTS

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1.0 EXECUTIVE SUMMARY

Comparison of net present value (NPV), or debit, calculations of pumped Lake Texana water and sea water desalination is the only acceptable method of evaluating these two alternative sources of fresh water. This is true because only NPV calculations take into account the time value of money, which is necessary since the two options require different annual cash flows over different time periods.

The Community Technical Support Group has estimated the costs associated with an investment strategy for reverse-osmosis sea water desalination plants located in the local area, calculated annual cash flows for that strategy, and compared 1995 NPVs of that strategy to the figures provided by the City's consultant on pumped Lake Texana water. Sea water desalination proves to have a much lower cost for water than the Lake Texana option. If one invested $77.4 million today, one would be able to provide our estimated fresh water shortfall needs, up to the published capacity of Lake Texana, via the pipeline. For $47.1 million today, one would be able to provide the same amount of water via sea water desalination, employing the proven reverse osmosis technology.

As an aid to better understand the sensitivity of the overall economics to our estimated costs, consider that we could double both the estimated capital costs and the estimated annual O&M costs[1] of sea water desalination and desalinated sea water would still have only a 4% higher NPV than pumped Lake Texana water, $80.4 million versus $77.4 million! Certainly this is evidence enough that sea water desalination is indeed an economically feasible alternative. Certainly this is evidence enough that pumped Lake Texana water is not the overwhelming superior alternative it has been claimed.

Additionally, sea water desalination is more reliable than pumped Lake Texana water since desalination is independent of droughts, independent of other water rights holders, independent of modifications made by the TNRCC to reservoir pass-through requirements, and independent of the future needs of other communities with limited access to fresh water.

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[1] Excluding electrical power.

Sea water desalination is also more flexible in meeting our actual supplemental fresh water demands than is pumped Lake Texana water. We must keep in mind that we are predicting our supplemental water needs for more than fifty years in advance - more than half a century! Any option that allows us to continually adjust our investments to our actual water shortfall is much more attractive than an option that requires us to commit immediately to our estimated needs that far in the future. Any option that would allow us to postpone investment during periods of high rainfall - which we would certainly expect to occur at least occasionally during the next fifty-plus years - is much more attractive than an option that inherently lacks such adjustment capability.

2.0 INTRODUCTION

In an effort to continue the evaluation of alternate sources of fresh water for the local region, several members of the general public, who have volunteered their time and energy as members of the Citizens Advisory Committee on Desalination, have joined together to form the Community Technical Support Group (CTSG). Since the group's inception in the Spring of 1995, its membership has grown and now includes members not originally involved with the Citizens Advisory Committee.

CTSG is made up of technical individuals fully capable of addressing all of the pertinent issues involved in the evaluation of alternative water supplies. The group's background includes formal education and practical experience in the estimation, economic evaluation, engineering, design, construction, commissioning, and operation of industrial processes ranging from petroleum and chemical plant units to water treatment facilities. Appendix C provides the credentials of the full membership of CTSG to date.

CTSG has defined several opportunities for improvement in the most recent evaluation of local sea water desalination performed by Naismith Engineering, Inc. (Naismith), as reported to members of the Citizens Advisory Committee on Desalination. CTSG has taken into account all of the issues presented by both Naismith and the citizen membership of that committee in our desalination feasibility study. This report provides an evaluation of a conceptual reverse-osmosis sea water desalination process.

We, the members of the CTSG, commend the Mayor and City Council members for their lead in the effort to secure a reliable source of fresh water for the local region. Their efforts have helped the citizens of the area understand the problem. Once the citizens of the area have had a chance to review all of the options available, including their costs and risks, we feel strongly that the community will begin to work together to see that the most cost-effective alternate supply is chosen and implemented.

3.0 SCOPE

This report documents CTSG's evaluation of the economic, water availability, local impact, and institutional issues of reverse-osmosis desalination of sea water in the Corpus Christi area. This evaluation does not include the assessment of current desalination technologies in general. That assessment has been completed by others interested in this discussion, and many engineering handbooks provide an adequate primer on the various technologies currently available.

Since pumped Lake Texana water has been identified as an attractive future source of fresh water for our region, a comparison of reverse-osmosis desalination to Lake Texana was used as the basis for our investigations. And since only general cost calculations have been made for pumped Lake Texana water, we have used only general estimates and cost calculations of desalination for our comparison.

4.0 BACKGROUND

Figure 1 plots the estimated fresh water shortfall that our local region will experience over the next several decades.[2] It is evidence enough of the need to establish an alternate source of fresh water. It is also evidence that our reliance on future alternative fresh water supplies will grow at a

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[2] Trans-Texas Water Program Phase II - Status Summary Report (Draft). Although other studies forecast a more gradual increase in demand, CTSG has based our investigation on this forecast in order to compare desalination evenly with the pumped Lake Texana water option. The data taken from the Trans-Texas Water Program Phase II - Status Summary Report (Draft) has been modified to include the approximately 11,713 ac-ft/yr combined pass-through and treated waste water diversion plan approved by the Texas Natural Resource Conservation Commission earlier in the year.

relatively slow pace.. And, finally, it is evidence that we have ample time - well over a decade - to consider all aspects of all options before we have to make a decision on which alternative to pursue.

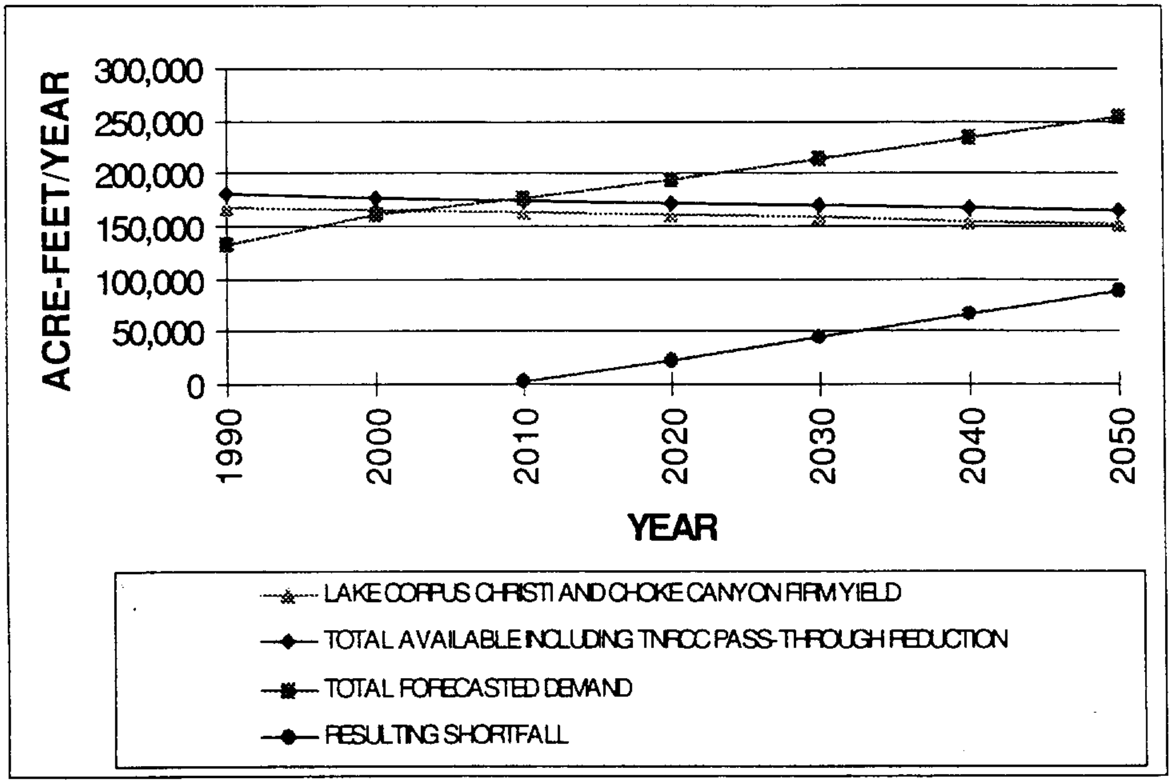

Figure 1
Local Reservoir Yield, Total Available, Forecasted Demand, Shortfall

5.0 ECONOMIC

For several months desalination has been reported to cost 4 to 5 times as much as pumped Lake Texana water ($1400/ac-ft compared to $303-$393/ac-ft).[3] However, this comparison is not only overly simplified, but more important, inaccurate. Since the two alternatives have different cash flows over different time periods, there is really only one accurate method of comparing their

---

[3] "Desalination Costly Despite New, Less Expensive Process", December 18, 1994, Corpus Christi Caller-Times, quoting preliminary studies by Naismith Engineering, Inc. of Corpus Christi.

relative costs - calculating their net present values, or NPVs. NPV is the amount of money required today to fully fund an investment venture.[4] NPVs of alternative investment options allow a direct comparison of the investments. And NPV comparisons of alternate fresh water sources are necessary since there is no way to calculate the cost of any one acre-foot of water - either Lake Texana water or desalinated water. It is obvious that the first acre-foot of water pumped from Lake Texana would be much more costly than $355; after all, more than $100,000,000 would have to have been spent building the pipeline required for it to have been pumped. It makes as much sense to claim that Lake Texana water costs $100,000,000/ac-ft as it does to claim $355/ac-ft.[5]

Making payments on Lake Texana water, beginning this year and continuing for year after year until we build a pipeline to pump the water, is much more costly than investing in desalination since we will not have to make any payments for desalination until we actually need water. Paying for a pipeline capable of pumping much more water than we will eventually need, literally for

[4] As an example to help understand the concept of the time value of money, consider that making a one-time $100,000 payment today for a home is much more costly than paying $10,000 per year for the next ten years, simply because the former investment requires a full $100,000 immediately, while the latter has a lesser "net present value" based on the potential interest earned by investing the difference. Investing only $72,469 today at 8% annual percentage rate will fund ten annual payments of $10,000. The difference between the two investment strategies is equal to $27,631 in today's dollars - a 27.6% difference! Another way to view this is by the hypothetical sale of a home. If you agreed to sell your home for $100,000, would you accept ten annual payments of $10,000 instead of an immediate $100,000 payment? Of course not. Ten annual payments of $10,000 has less value than $100,000 right now. At 8% annual percentage rate, those ten payments have a net present value of only $72,469.

[5] Since our investment strategy is to minimize service cost rather than generate any return, we are actually dealing with "costs", not "values". The term "net present value" is used throughout this report because the economic community understands its definition and how it can be used for cost calculations as well as value calculations. There is simply no convention for using the term "net present cost" or the abbreviation "NPC". One needs to realize that the lower the net present value, when it is used to describe the cost of providing a service, such as fresh water, the better the investment is. According to Stermole and Stermole, NPV calculation is the preferred method of investment analysis at this time. "A large majority of individuals, companies and government organizations that use formal evaluation techniques use rate of return analysis as their primary decision making criterion with net present value the second most used technique." Again, since rate of return analysis has no application in investments intended to minimize service costs, NPV analysis is the most widely accepted method for this type of investment evaluation.

decades, is much more costly than investing in desalination because desalination lends itself to phasing its necessary investments to much more closely meet the water needs. The actual annual costs are, of course, important in the overall calculation, but it is the net present value calculation of all of the annual costs which provides the one number representing the total cost of either investment alternative.

And since we are dealing with such long time periods, the time value of money has a tremendous impact on the investment decision - an impact so great that to not consider it would result in gross errors in the economic calculations.

The reverse osmosis sea water desalination strategy, which CTSG has developed for its estimating needs, includes a phased approach in its investment to better meet our future freshwater requirements. CTSG has estimated the costs associated with the design, construction, and operation of 4,180-ac-ft/yr modules.

Naismith, in their role as facilitator of the Citizens Advisory Committee on Desalination, has prepared a spreadsheet outlining the annual cash flows associated with the pumped Lake Texana water option.[6] CTSG has completed a conceptualization of a sea water desalination strategy, calculated its annual cash flow requirements, and compared these two alternatives, expanding the

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[6] Naismith Engineering, Inc., Trans-Texas Water Program, Trans-Texas Desalination Citizens Advisory Committee "Questions and Comments Desalt Committee Meeting - February 2, 1995". Annual cash flows and 1995 NPV figures from this Naismith spreadsheet have been included in CTSG's spreadsheet used for the desalination comparison calculations. Appendix B is a printout of that spreadsheet. Naismith originally produced NPV calculations using a discrete discounting method with single discrete cash flows occurring at the end of each period. (This explains why the 1995 NPV of the 1995 cash flow is less than the cash flow itself.) Since either fresh water option would require monthly payments of O&M costs and most probably of debt service payments, rather than discrete annual payments, a more accurate NPV calculation method would be continuous discounting. Including the continuous discounting factor in each period's present value calculation would convert the end-of-period discrete discounted NPV to a continuously discounted NPV. Continuous discounting would yield a higher (approximately 4% for an 8% discounting rate) NPV for each option. Note that the 1995 NPV would still be less than the 1995 cash flow since continuously discounting that year's cash flow over the entire year produces a lower 1995 NPV than if the entire 1995 cash flow occurred at the beginning of the year). CTSG has also used discrete discounting in our analysis, but only to be consistent with Naismith's earlier work. The small error (4% at an 8% discounting rate) is inconsequential compared to accuracies of the overall investment estimates.

Naismith spreadsheet to include the annual cash flows and 1995 NPV calculations of our conceptualized desalination plant.

It is important to note here that a reverse-osmosis desalination process was chosen for our comparison purposes not because it appears to be the best process for our needs, but rather only because reverse osmosis is a more readily understood and therefore a more readily estimated alternative. The Citizens Advisory Committee on Desalination and CTSG have also reviewed a Gas Turbine - Combined Cycle co-generation (electrical power and desalinated sea water) process which shows tremendous potential.[7]

The most cost-effective module capacity is difficult to define since an accurate knowledge of our fresh water needs is required. CTSG has therefore chosen a module capacity of 4,180 ac-ft/yr, equal to one-tenth the reported availability of pumped Lake Texana water.

Figure 2 shows the annual cash flow comparisons of pumped Lake Texana water and CTSG's conceptualized reverse-osmosis desalination plant.

Figure 3 shows the 1995 net present value comparison of pumped Lake Texana water and CTSG's conceptualized reverse-osmosis desalination plant.[8] Since this work was first completed, the Texas Natural Resource Conservation Commission (TNRCC) has amended the mandated pass-through of our local reservoirs, in effect increasing the overall firm yield, thereby postponing by several years the date we will first need to augment our local fresh water supplies. Figures 2 and 3 provide the comparisons of annual cash flows and 1995 NPVs for pumped Lake Texana water and CTSG's conceptualized desalination plant based on the resulting postponement in schedule.

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[7] CTSG plans to fully evaluate this alternative over the next several weeks and fully intends to have a written report available at the end of that investigation.

[8] As the debt service for the pumped Lake Texana water option has been previously calculated at 8% APR over a 25-year repayment period, CTSG used the same basis for calculating the annual cash flows of the desalination option. CTSG also used 8% APR as its NPV discounting rate.

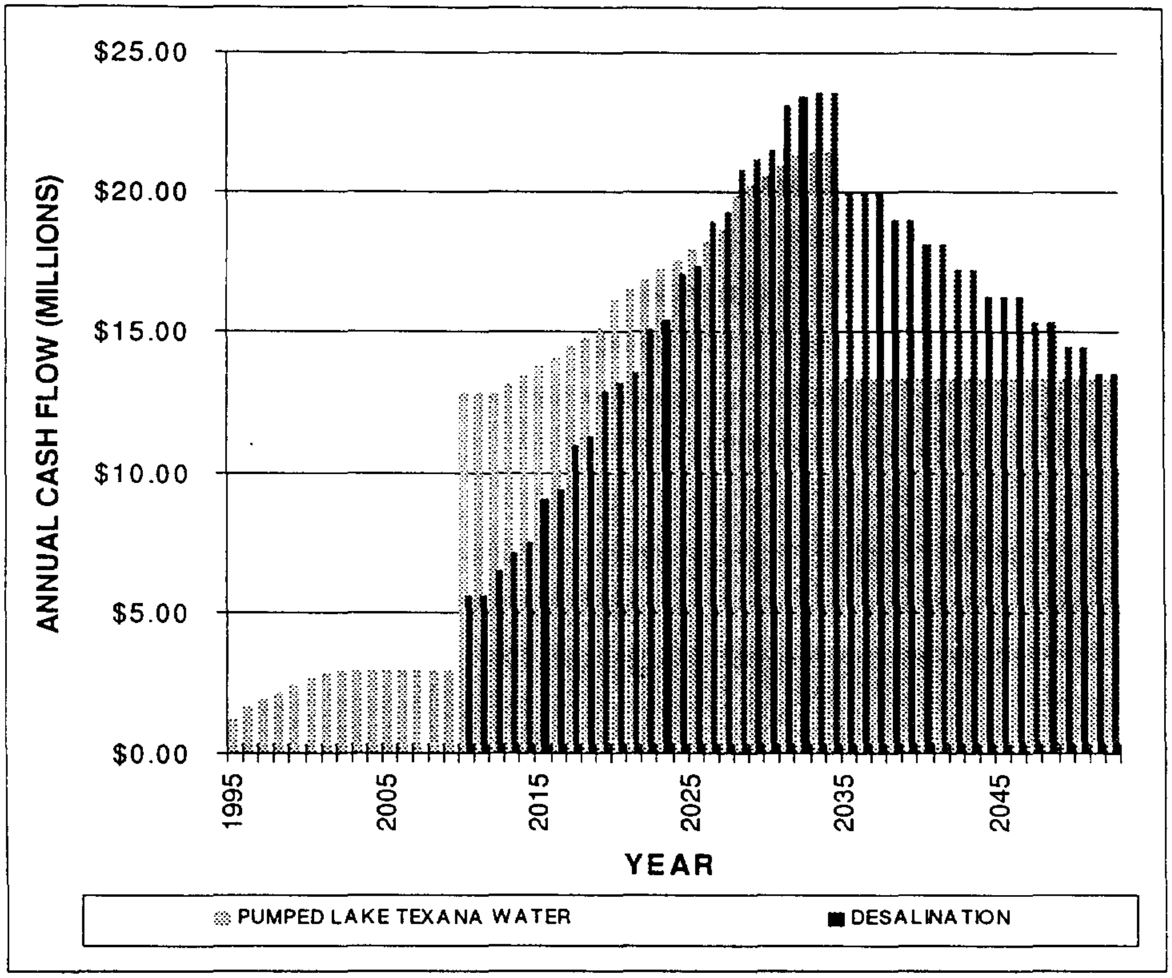

Figure 2
Pumped Lake Texana Water and Desalination Annual Cash Flows

CTSG's selection of a 4,180-ac-ft/yr module appears to be an adequate basis since it allows a few years between commissioning of modules. It also allows comparison to one of the desalination plant capacities originally evaluated by Stone & Webster in 1984.[9]

[9] "Report on the Feasibility of Desalination and Waste Water Reuse for the City of Corpus Christi, Texas", November, 1984, Stone & Webster Engineering Corporation and DSS Engineers, Inc. Factored for 4,180-ac-ft/yr modules, with a feedwater and brine disposal capacity of 41,840 ac-ft/yr, and using an 8% financing rate, 25-year repayment schedule and $0.04/kwhr electric power cost, the Stone & Webster estimated total capital costs and total operating costs agree well with CTSG's estimates. CTSG has estimated a 7% higher total capital cost, including a larger power recovery turbine, which results in a 12% lower estimated total annual operating cost. The Stone & Webster report did not contain any NPV calculations or summaries; however, if it had, they would also closely match the results calculated by CTSG.

Alternative methods of evaluating the costs associated with desalination include the review of case studies of other municipalities. This is the strategy used predominantly by Naismith during the Citizens Advisory Committee on Desalination evaluation. Unfortunately, such case studies pose very real, and possibly insurmountable, difficulties. Again, there is only one accurate method of comparing alternative investment strategies where different cash flows over different time periods are concerned. It would be necessary to calculate net present values for each of the alternative case studies of interest in order to fairly compare them with any other alternative - a most daunting task.

Additionally, site specific criteria must be equated. For example, energy costs which may have favored various aspects of a particular desalination strategy for a community in southern California during a drought period of the mid-1980's, will have nothing to do with our local, current needs.

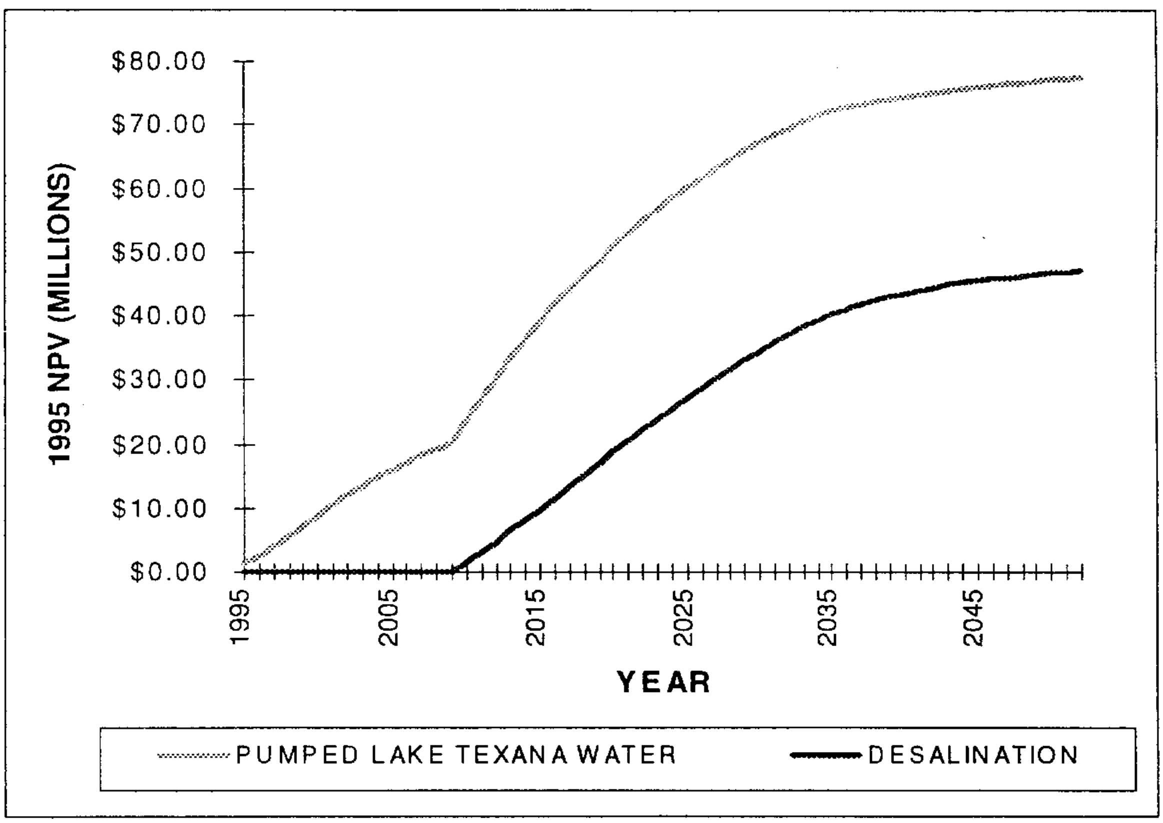

Figure 3
Pumped Lake Texana and Desalination 1995 Net Present Values

Appendix A provides the estimation methodology, including summaries, of CTSG's conceptualized desalination plant.

6.0 WATER AVAILABILITY

With desalination, there is no limit to the amount of fresh water available. Desalination capacity is unaffected by drought. It is unaffected by modifications made by the TNRCC to reservoir pass-through requirements. It is unaffected by other water rights holders. It is unaffected by future needs of other communities with limited access to fresh water. It is arguably the single most reliable source of fresh water for our community.

Pumped Lake Texana water capacity is affected by drought. It can be affected by modifications made by the TNRCC to reservoir pass-through requirements. It is affected by other water rights holders. It can be affected by future needs of other communities with limited access to fresh water. It is arguably one of the least reliable sources of fresh water for our community.

Pumped Lake Texana water is obviously not as reliable as desalinated water.

7.0 LOCAL IMPACT

Consideration must be given to the benefit of creating a new desalination industry in the local area. Other than the cost of electrical power required to operate the facility, literally millions of dollars would be spent annually on other operating and maintenance costs. Such expenditures will generate an increase in support jobs within the area, significantly increasing the local economy. Building and operating a pipeline and making water payments outside the local area offer little for the local economy.

Additionally, such a new local industry could well create whole new local collegiate curricula, creating a powerful atmosphere for Corpus Christi to become a world leader in the applied techniques of desalination.

8.0 INSTITUTIONAL

As is the case with either a pipeline from Lake Texana or sea water feed piping and brine discharge piping, construction and operating permits from the various local, state, and federal agencies will be required. CTSG does not anticipate any significant differences in permitting costs between the two alternatives. CTSG expects that permitting a desalination plant might be more expedient since all concern is focused in one area - brine concentration in sea water. A pipeline from Lake Texana to Corpus Christi will offer many more areas of concern.

Typical natural salt concentration in local sea water runs 35,000 milligram/liter TDS. Concentration to 70,000 milligrams/liter TDS would be typical for a reverse osmosis brine disposal stream. Figure 4 compares the TDS levels of sea water feed and brine disposal. Figure 5 compares the same concentrations, expressed as percent concentration. It is perhaps easier to visualize how little concentration occurs in a reverse-osmosis desalination plant when comparing percent concentrations.

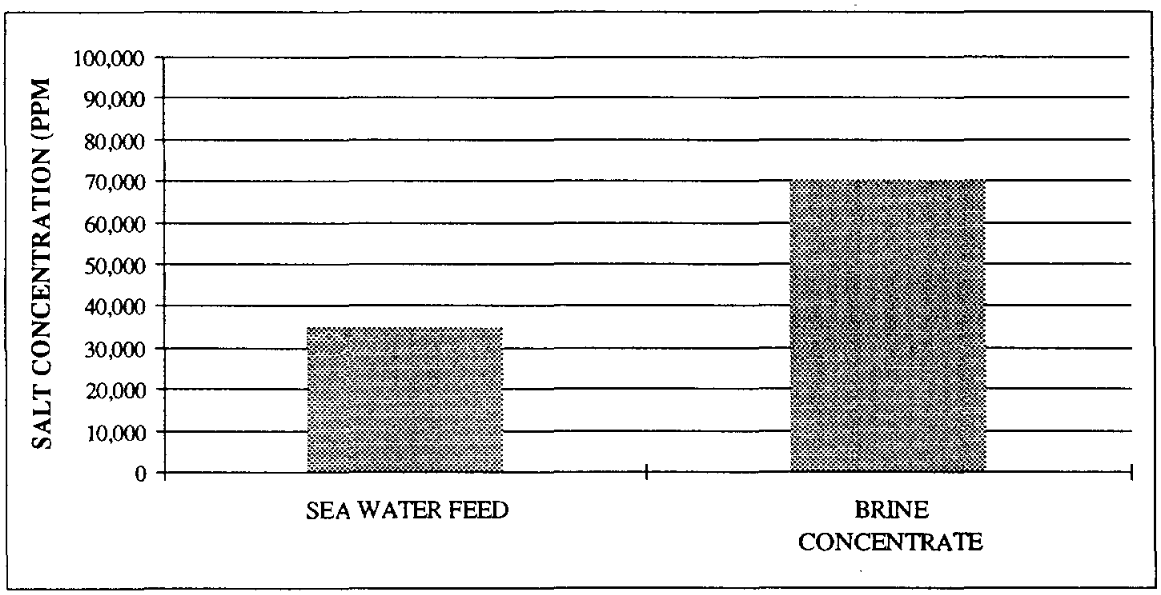

Figure 4
Salt Concentration of Sea Water and Brine Concentrate Expressed in PPM (milligram per liter)

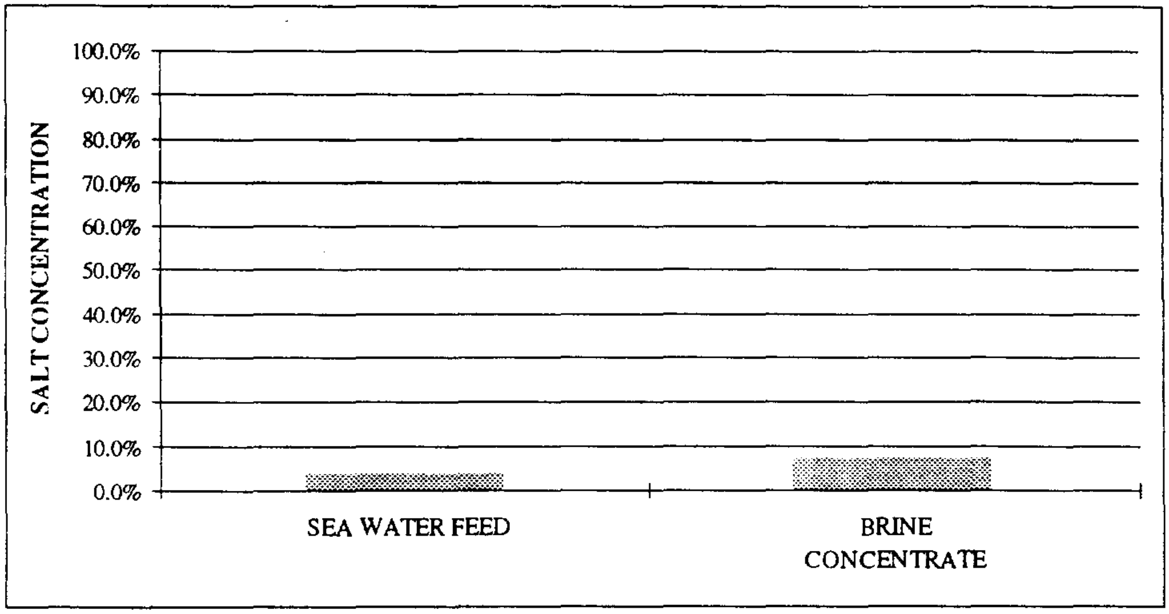

Figure 5
Salt Concentration of Sea Water and Brine Concentrate Expressed as Percent Concentration

9.0 CONCLUSION

Net present value or cost comparison is the only fair method of evaluating alternative sources of fresh water for the local region. Based on our evaluation of a reverse-osmosis sea water desalination plant, we find that desalination is a more economically attractive alternative than pumped Lake Texana water. We recommend that further evaluations - performed by experienced and qualified entities - of other sea water desalination processes and strategies be made. Only by such comprehensive evaluations can we expect to define the most cost-effective long-term source of fresh water. These evaluations must include the costs of all related expenses as well. For example, conventional water treating costs - both O&M and capital costs associated with plant expansions - must be included in the cost estimates of the pumped Lake Texana water option since such additional expenses will not be required with sea water desalination.

10.0 BIBLIOGRAPHY

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Appendix A

Conceptualized Reverse-Osmosis Sea Water Desalination Plant Estimating Strategy

The conceptualized desalination plant site was chosen to be either Padre Island or Mustang Island. Siting the desalination plant on either Padre Island or Mustang Island offers the advantage of shorter sea water feed piping and brine disposal piping. CTSG has estimated that fifteen acres will suffice for the site. This acreage resulted from the layout of ten identical desalination modules, each rated for 4,180 ac-ft/yr capacity. Figure A1 depicts the layout of a typical module.

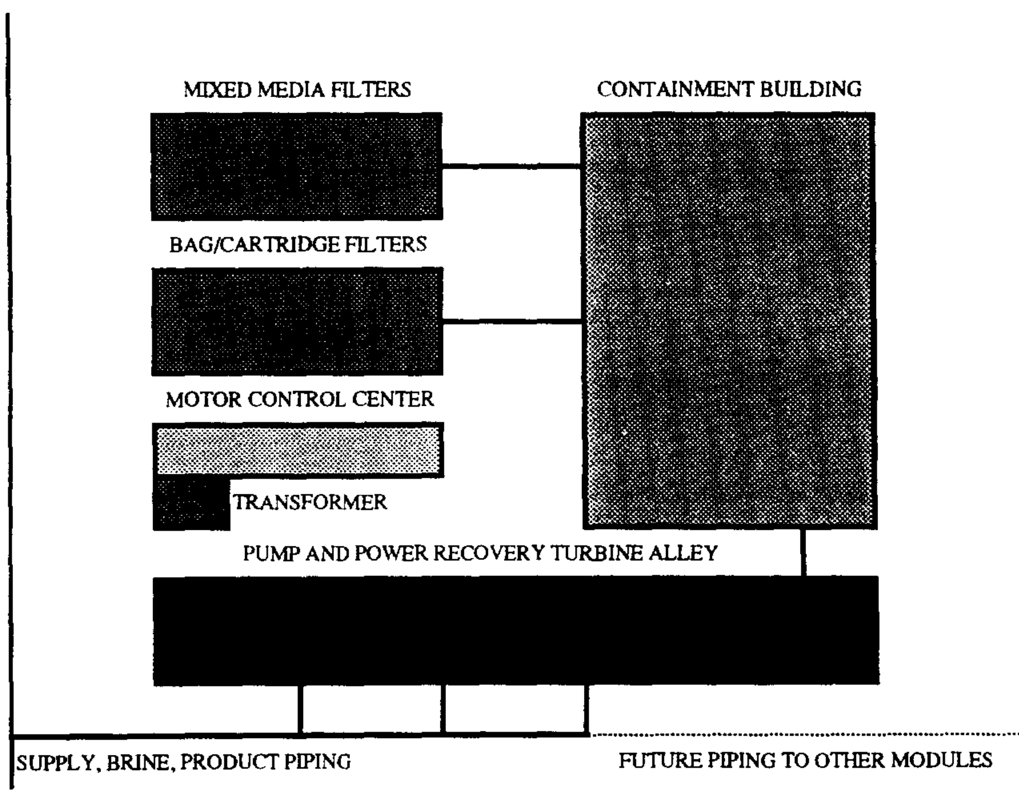

Figure A1
4,180 Acre-Feet/Year Desalination Module

Each module consists of a containment building, approximately forty feet by seventy-five feet, housing 200 pressure vessels containing the 1,200 reverse osmosis membranes. The cost for the containment building was originally estimated at $60/sq ft due to the severe environment of the site, but after further investigation the estimated cost was increased to $500,000. This higher estimate allows for more area to house a water quality laboratory, a maintenance area, a storeroom, an office, and other miscellaneous space. The higher estimate also provides for additional equipment dedicated to the maintenance of such a large number of membranes.

Mixed media filters and bag or cartridge filters are mounted on concrete pads adjacent to the containment building, along with the motor control center and power transformers. Along the end of each module site is the pump and power recovery turbine alley.

The overall site is laid out with expansion in mind. Modules, as needed, will be added on-line, causing virtually no upset to existing operations.

Whenever available, CTSG relied on manufacturers' and suppliers' budgetary estimates for equipment. Other estimated costs were obtained by comparison to similar equipment with which CTSG membership has had previous experience. For factored estimates, CTSG has tried to maintain consistency with factors presented to the Citizens Advisory Committee on Desalination by Naismith Engineering, Inc.

Appendix A

Table A1
Conceptualized Reverse-Osmosis Sea Water Desalination Plant
First Module, Including Overall Site, Sea Water Feed, and Brine Disposal

ITEM	DESCRIPTION	COSTS ($)	TOTAL ($)
LAND	15 acres on Padre Island/Mustang Island		1,000,000
EQUIPMENT	200 eight inch diameter pressure vessels and 1,200 membranes	3,600,000	
	2) 210 HP, 5100 gpm booster pumps	120,000	
	1) 3700 HP, 5100 gpm transfer pump	400,000	
	2) mixed media filters	200,000	
	2) bag/cartridge filters	200,000	
	1) 930 HP power recovery turbine	400,000	
	1) containment building	500,000	
	electrical and controls	600,000	
			6,020,000
PIPING	including sea water feed, brine discharge, internal piping, and desalinated water transfer (factored @ 30% of equipment costs, times 10 for all modules)		18,060,000
CONSTRUCTION	including civil/structural (factored @ 40% of equipment and piping costs)		9,632,800
ENGINEERING	factored @ 10% of equipment, piping, and construction costs		3,371,200
PERMITTING, LEGAL, AND ADMINISTRATIVE			350,000
TOTAL CAPITAL COSTS			**38,433,200**
DEBT SERVICE	@ 8% for 25 years		3,600,375
O&M	(factored at 2% of total capital costs per year)		768,664
INSURANCE	(factored at 1% of total capital costs per year)		384,332
POWER	calculated at actual design power at $0.04/kwhr		784,195
TOTAL ANNUAL OPERATING COSTS			**5,537,566**

Appendix A

Table A2
Conceptualized Reverse-Osmosis Sea Water Desalination Plant
All Other Modules

ITEM	DESCRIPTION	COSTS ($)	TOTAL ($)
LAND	15 acres on Padre Island/Mustang Island		0
EQUIPMENT	200 eight inch diameter pressure vessels and 1,200 membranes	3,600,000	
	2) 210 HP, 5100 gpm booster pumps	120,000	
	1) 3700 HP, 5100 gpm transfer pump	400,000	
	2) mixed media filters	200,000	
	2) bag/cartridge filters	200,000	
	1) 930 HP power recovery turbine	400,000	
	1) containment building	500,000	
	electrical and controls	600,000	
			6,020,000
PIPING	(factored @ 10% of equipment costs)		602,000
CONSTRUCTION	including civil/structural (factored @ 40% of equipment and piping costs)		2,648,800
ENGINEERING	factored @ 5% of equipment, piping, and construction costs		463,540
PERMITTING, LEGAL, AND ADMINISTRATIVE			50,000
TOTAL CAPITAL COSTS			**9,784,340**
DEBT SERVICE	@ 8% for 25 years		911,901
O&M	(factored at 2% of total capital costs per year)		194,687
INSURANCE	(factored at 1% of total capital costs per year)		97,343
POWER	calculated at actual design power at $0.04/kwhr		784,195
TOTAL ANNUAL OPERATING COSTS			**1,988,126**

APPENDIX B

ANNUAL CASH FLOW AND 1995 NET PRESENT VALUE COMPARISONS OF PUMPED LAKE TEXANA WATER AND A CONCEPTUALIZED DESALINATION PLANT LOCATED IN THE CORPUS CHRISTI AREA

DATE		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
YEAR		1	2	3	4	5	6	7	8	9	10	11	12
PUMPED LAKE TEXANA WATER													
WATER USED (AC-FT)		0	0	0	0	0	0	0	0	0	0	0	0
UNIFORM DEBT SERVICE ($)		0	0	0	0	0	0	0	0	0	0	0	0
O&M EXCL POWER - FIXED ($)		0	0	0	0	0	0	0	0	0	0	0	0
O&M POWER - FIXED ($)		0	0	0	0	0	0	0	0	0	0	0	0
WATER RIGHTS PAYMENT ($)		1,172,775	1,621,718	1,863,135	2,112,920	2,371,073	2,638,849	2,760,185	2,882,358	2,882,358	2,882,358	2,882,358	2,882,358
WATER TREATMENT - @ $/ACFT ($)	$150	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ($)		1,172,775	1,621,718	1,863,135	2,112,920	2,371,073	2,638,849	2,760,185	2,882,358	2,882,358	2,882,358	2,882,358	2,882,358
1995 NPV - @ % ($)	8.0%	1,085,903	2,476,265	3,955,281	5,508,340	7,122,053	8,784,975	10,395,517	11,952,765	13,394,662	14,729,751	15,965,945	17,110,569
DESALINATION													
WATER USED (AC-FT)		0	0	0	0	0	0	0	0	0	0	0	0
MODULES		0	0	0	0	0	0	0	0	0	0	0	0
UNIFORM DEBT SERVICE ($)		0	0	0	0	0	0	0	0	0	0	0	0
O&M EXCL POWER - FIXED ($)		0	0	0	0	0	0	0	0	0	0	0	0
O&M POWER - @ $/ACFT ($)	$188	0	0	0	0	0	0	0	0	0	0	0	0
WATER RIGHTS PAYMENT ($)		0	0	0	0	0	0	0	0	0	0	0	0
WATER TREATMENT ($)		0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ($)		0	0	0	0	0	0	0	0	0	0	0	0
1995 NPV - @ % ($)	8.0%	0	0	0	0	0	0	0	0	0	0	0	0

ANNUAL CASH FLOW AND 1995 NET PRESENT VALUE COMPARISONS OF PUMPED LAKE TEXANA WATER AND A CONCEPTUALIZED DESALINATION PLANT LOCATED IN THE CORPUS CHRISTI AREA

DATE	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
YEAR	13	14	15	16	17	18	19	20	21	22	23	24
PUMPED LAKE TEXANA WATER												
WATER USED (AC-FT)	0	0	0	4,184	4,184	4,184	6,034	7,884	9,734	11,584	13,434	15,284
UNIFORM DEBT SERVICE ($)	0	0	0	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000
O&M EXCL POWER - FIXED ($)	0	0	0	730,032	730,032	730,032	738,507	746,981	755,458	763,931	772,405	780,880
O&M POWER - FIXED ($)	0	0	0	283,468	283,468	283,468	317,963	352,458	386,953	421,448	455,943	490,438
WATER RIGHTS PAYMENT ($)	2,882,358	2,882,358	2,882,358	3,004,949	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777
WATER TREATMENT - @ $/ACFT ($)	0	0	0	627,600	627,600	627,600	905,100	1,182,600	1,460,100	1,737,600	2,015,100	2,292,600
TOTAL ($)	2,882,358	2,882,358	2,882,358	12,788,233	12,807,061	12,807,061	13,129,381	13,451,700	13,774,022	14,096,340	14,418,659	14,740,979
1995 NPV - @ % ($)	18,170,406	19,151,737	20,060,376	23,793,140	27,254,491	30,459,445	33,501,681	36,387,719	39,124,008	41,716,896	44,172,614	46,497,256
DESALINATION												
WATER USED (AC-FT)	0	0	0	4,184	4,184	4,184	6,034	7,884	9,734	11,584	13,434	15,284
MODULES	0	0	0	1	1	1	2	2	3	3	4	4
UNIFORM DEBT SERVICE ($)	0	0	0	3,600,375	3,600,375	4,512,276	4,512,276	4,512,276	5,424,177	5,424,177	6,336,078	6,336,078
O&M EXCL POWER - FIXED ($)	0	0	0	1,152,996	1,152,996	1,152,996	1,445,026	1,445,026	1,737,056	1,737,056	2,029,086	2,029,086
O&M POWER - @ $/ACFT ($)	0	0	0	786,592	786,592	786,592	1,134,392	1,482,192	1,829,992	2,177,792	2,525,592	2,873,392
WATER RIGHTS PAYMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
WATER TREATMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ($)	0	0	0	5,544,148	5,544,148	6,456,049	7,097,730	7,447,380	9,000,962	9,350,612	10,904,194	11,253,844
1995 NPV - @ % ($)	0	0	0	1,618,284	3,116,695	4,732,315	6,376,945	7,974,767	9,762,860	11,482,816	13,339,967	15,114,690

APPENDIX B

ANNUAL CASH FLOW AND 1995 NET PRESENT VALUE COMPARISONS OF PUMPED LAKE TEXANA WATER AND A CONCEPTUALIZED DESALINATION PLANT LOCATED IN THE CORPUS CHRISTI AREA

DATE	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
YEAR	25	26	27	28	29	30	31	32	33	34	35	36
PUMPED LAKE TEXANA WATER												
WATER USED (AC-FT)	17,134	18,984	20,834	22,684	24,534	26,384	28,234	30,084	31,934	33,784	35,634	37,484
UNIFORM DEBT SERVICE ($)	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000	8,138,000
O&M EXCL POWER - FIXED ($)	789,355	797,829	806,304	814,779	823,253	831,728	840,203	848,677	857,152	865,627	874,101	882,576
O&M POWER - FIXED ($)	524,934	1,306,531	1,370,245	1,433,959	1,497,673	1,561,387	1,625,101	1,688,815	1,752,529	2,670,606	2,757,083	2,843,560
WATER RIGHTS PAYMENT ($)	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777
WATER TREATMENT - @ $/ACFT ($)	2,570,100	2,847,600	3,125,100	3,402,600	3,680,100	3,957,600	4,235,100	4,512,600	4,790,100	5,067,600	5,345,100	5,622,600
TOTAL ($)	15,063,300	16,132,721	16,484,260	16,835,799	17,187,337	17,538,876	17,890,415	18,241,953	18,593,492	19,799,394	20,173,695	20,547,997
1995 NPV - @ % ($)	48,696,768	50,877,940	52,941,552	54,893,052	56,737,727	58,480,693	60,126,899	61,681,114	63,147,935	64,594,187	65,958,626	67,245,436
DESALINATION												
WATER USED (AC-FT)	17,134	18,984	20,834	22,684	24,534	26,384	28,234	30,084	31,934	33,784	35,634	37,484
MODULES	5	5	5	6	6	7	7	8	8	9	9	9
UNIFORM DEBT SERVICE ($)	7,247,979	7,247,979	7,247,979	8,159,880	8,159,880	9,071,781	9,071,781	9,983,682	9,983,682	10,895,583	10,895,583	10,895,583
O&M EXCL POWER - FIXED ($)	2,321,116	2,321,116	2,321,116	2,613,146	2,613,146	2,905,176	2,905,176	3,197,206	3,197,206	3,489,236	3,489,236	3,489,236
O&M POWER - @ $/ACFT ($)	3,221,192	3,568,992	3,916,792	4,264,592	4,612,392	4,960,192	5,307,992	5,655,792	6,003,592	6,351,392	6,699,192	7,046,992
WATER RIGHTS PAYMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
WATER TREATMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ($)	12,807,426	13,157,076	13,506,726	15,060,308	15,409,958	16,963,540	17,313,190	18,866,772	19,216,422	20,770,004	21,119,654	21,469,304
1995 NPV - @ % ($)	16,984,804	18,763,664	20,454,528	22,200,224	23,854,137	25,539,928	27,133,020	28,740,469	30,256,432	31,773,584	33,202,002	34,546,508

APPENDIX B

ANNUAL CASH FLOW AND 1995 NET PRESENT VALUE COMPARISONS OF PUMPED LAKE TEXANA WATER AND A CONCEPTUALIZED DESALINATION PLANT LOCATED IN THE CORPUS CHRISTI AREA

DATE	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
YEAR	37	38	39	40	41	42	43	44	45	46	47	48
PUMPED LAKE TEXANA WATER												
WATER USED (AC-FT)	39,334	41,184	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840
UNIFORM DEBT SERVICE ($)	8,138,000	8,138,000	8,138,000	8,138,000	0	0	0	0	0	0	0	0
O&M EXCL POWER - FIXED ($)	891,051	899,525	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000
O&M POWER - FIXED ($)	2,930,038	3,016,399	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742
WATER RIGHTS PAYMENT ($)	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777
WATER TREATMENT - @ $/ACFT ($)	5,900,100	6,177,600	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000
TOTAL ($)	20,922,300	21,296,485	21,434,359	21,434,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359
1995 NPV - @ % ($)	68,458,630	69,602,049	70,667,624	71,654,267	72,220,975	72,745,704	73,231,564	73,681,434	74,097,981	74,483,672	74,840,794	75,171,462
DESALINATION												
WATER USED (AC-FT)	39,334	41,184	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840
MODULES	10	10	10	10	10	10	10	10	10	10	10	10
UNIFORM DEBT SERVICE ($)	11,807,484	11,807,484	11,807,484	11,807,484	8,207,109	8,207,109	8,207,109	7,295,208	7,295,208	6,383,307	6,383,307	5,471,406
O&M EXCL POWER - FIXED ($)	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266
O&M POWER - @ $/ACFT ($)	7,394,792	7,742,592	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920
WATER RIGHTS PAYMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
WATER TREATMENT ($)	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL ($)	23,022,886	23,372,536	23,496,520	23,496,520	19,896,145	19,896,145	19,896,145	18,984,244	18,984,244	18,072,343	18,072,343	17,160,442
1995 NPV - @ % ($)	35,881,506	37,136,389	38,304,481	39,386,048	40,234,046	41,019,230	41,746,252	42,388,567	42,983,303	43,507,533	43,992,931	44,419,695

ANNUAL CASH FLOW AND 1995 NET PRESENT VALUE COMPARISONS OF PUMPED LAKE TEXANA WATER AND A CONCEPTUALIZED DESALINATION PLANT LOCATED IN THE CORPUS CHRISTI AREA

DATE	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
YEAR	49	50	51	52	53	54	55	56	57	58
PUMPED LAKE TEXANA WATER										
WATER USED (AC-FT)	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840
UNIFORM DEBT SERVICE ($)	0	0	0	0	0	0	0	0	0	0
O&M EXCL POWER - FIXED ($)	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000	908,000
O&M POWER - FIXED ($)	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742	3,046,742
WATER RIGHTS PAYMENT ($)	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777	3,023,777
WATER TREATMENT - @ $/ACFT ($)	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000	6,276,000
TOTAL ($)	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359	13,296,359
1995 NPV - @ % ($)	75,477,636	75,761,131	76,023,626	76,266,677	76,491,725	76,700,102	76,893,043	77,071,693	77,237,110	77,390,273
DESALINATION										
WATER USED (AC-FT)	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840	41,840
MODULES	10	10	10	10	10	10	10	10	10	10
UNIFORM DEBT SERVICE ($)	5,471,406	4,559,505	4,559,505	4,559,505	3,647,604	3,647,604	2,735,703	2,735,703	1,823,802	1,823,802
O&M EXCL POWER - FIXED ($)	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266	3,781,266
O&M POWER - @ $/ACFT ($)	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920	7,865,920
WATER RIGHTS PAYMENT ($)	0	0	0	0	0	0	0	0	0	0
WATER TREATMENT ($)	0	0	0	0	0	0	0	0	0	0
TOTAL ($)	17,160,442	16,248,541	16,248,541	16,248,541	15,336,640	15,336,640	14,424,739	14,424,739	13,512,838	13,512,838
1995 NPV - @ % ($)	44,814,847	45,161,286	45,482,063	45,779,078	46,038,658	46,279,010	46,488,326	46,682,136	46,850,246	47,005,903

Appendix C

Community Technical Support Group
Membership Credentials

Rudy Bendixen, co-chairman, public relations
Bachelor of Science in Chemical Engineering, Texas A&I University, Kingsville, 1964
self-employed, commercial printing
20 years experience in refinery process engineering

Bill Brock, P.E.
Professional Engineer - Texas
Bachelor of Science in General Engineering, Texas A&I University, Kingsville, 1960
recently retired
34 years experience in facilities management

George E. Clower
American Institute of Architects, National Council of Architectural Registration Board, Certified Construction Specifier
Architect & Certified Construction Specifier
Bachelor of Arts and Bachelor of Science in Architecture, Rice University, 1959
Senior Project Architect
36 years experience in commercial and industrial design

John Hartley
Instrument Society of America
Honorary Bachelor of Science in Mechanical Engineering, Marietta College, 1981
Senior Projects Supervisor
35 years experience in mechanical, instrumentation, and civil design

Ron E. Marek, chairman
Instrument Society of America, Mechanical/Plumbing Board, City of Corpus Christi
Del Mar College
Technical Sales Representative
28 years experience in industrial process operations and sales, including 2 years operation of sea water desalination plants

E. R. Smith
Principal and CEO of an industrial service organization
35 years experience in project and corporate management

James Tarleton, P.E.
American Institute of Mining Engineers, Society of Petroleum Engineers
Professional Engineer - Texas
Master of Science in Reservoir Engineering, Mississippi State University, 1975
Plant Engineer
20 years experience in petroleum production and *in situ* uranium mining

Appendix C

Community Technical Support Group
Membership Credentials
continued

John Albert Williamson, P.E., secretary
Instrument Society of America
Professional Engineer - Texas
Bachelor of Science in Electrical Engineering, University of Texas at El Paso, 1977
Senior Process Control Engineer
18 years experience in industrial instrumentation and process control design, including industrial waste water, sour water, and boiler feedwater treatment design and commissioning

M. Byron Wooldridge, P.E., co-chairman, treasurer
American Society of Mechanical Engineers
Professional Engineer - Texas
Bachelor of Science in Mechanical Engineering, University of Southwestern Louisiana, 1971
Maintenance Superintendent
24 years experience in chemical and petroleum industry, including 6 years production responsibilities in gas turbine, combined cycle co-generation facilities

NAISMITH ENGINEERING, INC.
ENGINEERING • ENVIRONMENTAL • SURVEYING
Est. 1949

August 3, 1995

Mr. James Dodson
Regional Water Director
City of Corpus Christi
P. O. Box 9277
Corpus Christi, Texas 78469-9277

Re: **CTSG Seawater Desalination Comparison**

Dear Mr. Dodson:

Per your request, Naismith Engineering, Inc. with the assistance of HDR Engineering, Inc., has reviewed the above referenced Report. As you are aware, considerable additional time, effort and expense could be spent in addressing each and every statement to which the document alludes, but we feel the inaccuracies of the Report speak for themselves. We focused our review only on technical desalination areas. Our summary identifies important points that were either not considered or were treated inaccurately.

In addition to the attached detailed comparison, we have listed below a few of the key reasons why the CTSG Net Present Value (NPV) analysis is not appropriate for comparison of future water resources, such as the Texana Pipeline.

- Capital and O&M costs are inaccurate and unsubstantiated;
- CTSG's permitting, legal and administrative costs have no justifiable basis and are perceived to be extremely low;
- No replacement costs of desalt equipment is accounted for in the NPV calculations through the year 2052;
- A desalt facility located on Padre or Mustang Island is extremely vulnerable to effects from a hurricane or tropical storm. Cost estimates utilized by CTSG do not account for this extreme environment;
- Reference to the Stone & Webster Report is inaccurate;
- NPV calculations do not account for adequate support facilities (i.e., labor, utilities, electrical power, water storage and distribution);
- The CTSG approach of phased desalination modules is completely inflexible to respond to rapid or unpredictable drought protection, unless the ultimate 41,800 ac-ft of capacity was constructed initially. If this were the case, their NPV calculations would increase astronomically; and,

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- Sound financial and technical decisions must be based on proven technologies and proven operational data. The CTSG Report does not provide this assurance.

The **bottom line** is the CTSG Report's Net Present Value (NPV) analysis comparison is predicated on a 41,840 ac-ft/yr seawater desalination plant, producing municipal potable water at a cost of $563.00 per ac-ft, which is much too low. The basis for this cost is, CTSG's capital and operating data, which are not consistent with current seawater desalination accepted cost information, and therefore have no validity. Inputting such data into a NPV analysis results in extremely inaccurate and meaningless information.

Please advise us if we can be of further assistance.

Sincerely,

NAISMITH ENGINEERING, INC.

Richard A. Poremba

Richard A. Poremba, P.E., M.B.A.
Environmental Manager

RAP/ddk

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CTSG SEAWATER DESALINATION COMPARISON
AUGUST 3, 1995

- CTSG quotes "for several months desalination has been reported to cost four to five times as much as pumped Lake Texana water ($1,400.00/ac-ft compared to $303.00-$393.00/ac-ft). (Data taken from an article entitled 'Desalination Costly Despite New, Less Expensive Process,' which appeared in the December 18, 1994, Corpus Christi Caller-Times, quoting preliminary studies by Naismith Engineering, Inc. of Corpus Christi). However, this comparison is not only overly simplified, but more important, inaccurate. Since the two alternatives have different cash flows over different time periods, there is only one accurate method of comparing their relative costs - calculating their Net Present Values, or NPVs."

  Any NPV comparison must be based on representative and accepted costs for desalination. The CTSG's cost figures do not meet these criterion. The referenced December 18, 1994 article followed the Trans-Texas Seawater Desalination Workshop held on December 17, 1994. This supposedly inaccurate figure of $1,400.00/ac-ft was supported by the two international authorities at this "Ask the Experts" Workshop, Mr. Ian Watson and Dr. John Arnold. Mr. Ian Watson, President of the American Desalting Association who also serves on the Board of Directors of the International Desalination Association, has more than 30 years of professional experience with the design and construction of desalination reverse osmosis, electrodialysis and membrane filtration plants. He presently is Director of Membrane Processes for Boyle Engineering Corporation, Santa Rosa, California. Mr. Watson, in his slide presentation, summarized that seawater desalting costs would range from $1,300.00-$2,600/ac-ft (see Attachment 1). Dr. John Arnold, Marketing Manager of Ionics, Inc., desalination plant suppliers and consultants based in San Diego, California, has over 33 years of desalination experience and worked directly on the Santa Barbara desalination plant. Dr. Arnold, in his slide presentation, summarized that desalination costs would be in the general range of $1,400.00, **under normal conditions** (see Attachment 2).

  In addition, the "draft" Trans-Texas Phase II, desalt section concluded a 5,000 ac-ft/yr or 10,000 ac-ft/yr desalt plant could produce potable water in Corpus Christi, **under favorable conditions**, in the range of $1,635-$2,000 at a mainland location.

- CTSG's report attacks the validity of evaluating general costs associated with desalination through the review of similar desalination feasibility studies of other municipalities by stating that "case studies pose very real, and possibly insurmountable difficulties."

  Sound financial and technical decisions must be based on proven technologies and proven operational data. The desalination segment of the Phase II Study reviewed current seawater desalination feasibility studies, as well as operating and previously operated seawater desalting plants. Overall, this information included ten (10) feasibility studies, four (4) operating plants and three (3) previously operated plants. This information was supplemented by data from the American Desalting Association, National Water Supply Improvements Association, California Coastal Commission, and other sources referenced in the report. As mentioned previously, the "Ask the Experts" Desalination Workshop in December, 1994, further substantiated the report's conclusions.

It is important to recognize that the total installed municipal, seawater desalting capacity in the entire United States is only approximately 20,000 ac-ft/yr. As a result, there is very little reliable capital and operating cost information available. Most of this installed capacity is in California where the drought of the late 1980s and early 1990s provided the impetus for the construction of three municipal seawater desalting plants. The most notable of these is the 7,500 ac-ft/yr RO plant constructed for the City of Santa Barbara. The other two municipal plants are located on Santa Catalina Island (135 ac-ft/yr) and in the City of Morro Bay (645 ac-ft/yr). Presently, none of these plants are operating. A number of other California communities looked to the Pacific Ocean as a potential, inexhaustible, drought-proof water supply because existing surface water supplies were already overdrawn. Numerous feasibility studies and preliminary design studies were completed, from Marin County, north of San Francisco, to San Diego and even into Baja, California, Mexico. These studies investigated the technical, economic, environmental, and institutional feasibility of seawater desalination plants from as small as 1,000 ac-ft/yr to as large as 100,000 ac-ft/yr. **These feasibility studies, supplemented with data from operating seawater desalting facilities in California and the Virgin Islands, represent current information on seawater desalination.**

Based on all of the information obtained, the cost to desalinate seawater was found to range from $1,635.00 to $6,000.00 per ac-ft. The potential for new "experimental" plants or new treatment technologies have been repeatedly considered in California. However, the "bottom line" remains, if reliable and acceptable desalting options were available at less than $1,200.00 per ac-ft/yr, a number of desalination projects would have been built along the California coast, not as pilots, but as large operating seawater plants.

- CTSG's capital and operating cost data for a phased construction seawater desalting facility to ultimately supply 41,840 ac-ft/yr of potable municipal water at $563.00 per ac-ft is grossly inaccurate, and unsupported by currently accepted desalting cost information. This type of unproven data used in their NPV analysis results in a poor and dangerous misrepresentation of desalination facts. According to the report's Appendix "A", the first module will produce water at a total annual cost of approximately $1,325.00 per ac-ft while each of nine (9) successive 4,180 ac-ft modules will produce water at a total annual cost of approximately $476.00 per ac-ft. This results in an ultimate capacity unit cost of $563.00 per ac-ft.

  Tables A-1 and A-2 of Appendix "A" represent the capital and operating costs of their first and nine (9) subsequent 4,180 ac-ft modules. The summary for each module provides for $3,600,000.00 for 1,200 pressure vessels and membranes at $3,000.00. The $3,000.00 may be sufficient for vessels without membranes. However, with probably six (6) membranes per vessel at approximately $800.00/membrane, each vessel's membranes would cost approximately $4,800.00 or a total cost of approximately $9,360,000.00 for vessels and membranes, not $3,600,000.00. They expect the high pressure pump for each 4,180 ac-ft module will only cost $400,000.00. We believe they will find that these pumping units are more like $1,000,000.00 each. These capital equipment cost adjustments would increase their costs for each module from $6,020,000.00 to approximately $12,160,000.00. The report's piping costs are based on "<u>thirty percent</u>

(30%) of equipment costs times ten (10) for all modules." There is no engineering basis for determining piping cost requirements for a desalination facility from equipment costs. However, under this unjustifiable parameter, CTSG piping costs would have to "double" based on projected higher equipment costs.

CTSG's permitting, legal and administrative costs have no justifiable basis and are perceived to be extremely low. Permitting would have to address the ultimate capacity in addition to the initial capacity. Otherwise, phased permitting could result in the possibility of not being able to permit the facility's ultimate capacity at their specific site. Apparently, CTSG believes this permitting effort will be relatively simple. The report indicates that brine concentration seawater would be the only real concern for permitting. This is a good example of the oversimplification that CTSG has used in their whole analysis. Permitting will be required for a multitude of other issues. There is significant experience and history throughout the State of Texas in permitting reservoir and pipeline construction. However, there is little or no experience in permitting large scale municipal desalting facilities, and CTSG has no operational or permit history on which to base their figure. There is adequate discussion of permitting issues and requirements in the desalting section of Trans-Texas Phase II "draft" report.

Current operating costs for RO seawater desalting plants are $750.00 - $1,000.00 per ac-ft/yr, depending on many factors including power consumption and power rates. CTSG's operating cost data for their ultimate capacity 41,840 ac-ft/yr plant is approximately $278.00 ac-ft. According to their calculations, their first 4,180 ac-ft/yr module will produce water at $463.00/ac-ft operating costs, while each of the other nine (9) modules will produce water at approximately $257.00 ac-ft operating costs. **These figures are quite honestly ridiculous**. Not only that, since labor would be the only significant variable to decrease in adding additional modules, we do not understand why CTSG reduced their operating costs from $463.00 to $257.00/ac-ft with increasing modules.

In regard to power, their power consumption is 4,690 KWH/ac-ft. This is extremely optimistic. Santa Barbara's operational power consumption was approximately 6,600 KWH/ac-ft. CTSG's unit power cost of $.04/KWH is lower than the $.0485/KWH for a Lake Texana pipeline in Phase II. Pipeline rates reflected specific rate structures of power companies supplying power to the proposed routing. This included a demand charge/fuel cost method providing for the utility capacity (based upon installed horsepower), energy costs and fuel costs.

In total, CTSG's capital and operating data have no validity and are not consistent with current seawater desalination accepted cost information. Inputting their data in a NPV analysis is meaningless.

- CTSG's NPV calculations make no allowance for changing energy costs. Energy costs constitute a major portion of desalination costs and must be addressed in any credible NPV comparison. As mentioned earlier, even though CTSG's power costs are extremely low, they represent approximately 40% and 73% of their first module and succeeding modules O & M costs, respectively. Over the past two decades, fuel prices have fluctuated from lows in the $13.00 per barrel range to highs in the $40.00 range, with the current price being between $17.00-$18.00 per barrel. It is generally agreed that as fossil fuel reserves are reduced, energy prices will increase relative to other prices in the economy. Even without inflation or "outbursts" in the Middle East, long-term energy prices are expected to increase. For example, if the energy costs of a desalination process is 30% of the process' total cost, then a 20% increase in energy costs would result in a 6% increase in the cost of the process. Similarly, if energy costs are 60% of the total costs, the same 20% increase in energy costs would result in a 12% increase in the total cost of the process.

- The CTSG report references the 1984, Stone and Webster "Report on the Feasibility of Desalination and Wastewater Reuse for the City of Corpus Christi" and makes various **unsubstantiated claims** including that "<u>the Stone and Webster report did not contain any NPV calculations or summaries; however, if it had, they would also closely match the results calculated by CTSG.</u>" The Stone & Webster report presented two cases for seawater desalination, one for a surface intake (open sea intake) and one if Ranney Collectors or "beach wells" were used. Their total unit costs for desalted water costs per thousand gallons for a 5 mgd seawater Reverse Osmosis plant with energy recovery in mid-1985 dollars was $6.18 per thousand gallons and $5.31 per thousand gallons, respectively. This equates to approximately $2,014/ac-ft and $1,730.00/ac-ft. These "night and day" differences would hardly closely match any NPV calculation as referenced in the CTSG report.

- The CTSG report, Appendix "A" and NPV calculations in Appendix "B", do not appear to include expected significant capital investment to provide support facilities for labor; utilities, especially electrical power; and storage and distribution costs to convey desalted water into the existing City of Corpus Christi water system. It is important for CTSG to realize that the City of Corpus Christi water distribution system is presently designed and constructed to account for hydraulic consideration from the O. N. Stevens Water Treatment Plant, located in Calallen, to all delivery points, north, south, east, and west. Introduction of this new island water supply will impact the City's existing distribution system and will need to be incorporated into their design and their NPV calculations.

- The CTSG report anticipates that only a 15-acre area would suffice for ultimate development of the facility. Other desalting facilities located around the world have required considerable more space for similar sized facilities. Fifteen acres provides little in the way of support facilities, water storage, buffer zones, power equipment, support vehicles, chemical storage, staff, maintenance operations, etc. Fifteen acres might be adequate for a temporary facility, but not a permanent facility. The use of $500,000.00 for the containment building is not realistic. Water plants must meet state and federal drinking standards, which also require laboratories, testing equipment, office space, etc. We doubt seriously that $500,000.00 would support even the minimal requirements for a water plant and still provide necessary standards for windstorm and flooding as well as corrosivity.

- The CTSG report indicates that through the year 2010, the desalination option has no costs. We assume they believe that they can design and permit a desalt facility within the same year that they are going to construct it. Permitting and design will have to be completed well ahead of construction. Costs will be incurred long before the units are actually brought on-line.

- It also is important to note that the CTSG report assumes that all Lake Texana water will have a treatment cost of approximately $150/ac-ft. The City does have the option of supplying Lake Texana water direct to its raw water customers. This would avoid treatment cost to the extent of its supply and demand.

- History has testified that properly designed pipelines and pumping facilities will last in excess of 50 years. However, the typical lifespan of a seawater RO module is questionable. We would expect an amortization of **no more than 20 years** with supplemental capital requirements depending on construction and equipment specifications. The "Ask the Experts" Desalination Workshop further supported this. CTSG uses a 25-year amortization.

  CTSG's NPV analysis does not provide for any capital equipment replacement cost through the year 2052. We cannot agree that CTSG modules operational in 2010, 2013, 2015, 2017, 2019, 2022, 2024, 2026, 2028 or 2031 will be operating in 2052 with no additional capital requirements for replacement or technology improvements. These associated costs will have to be incurred at future date prices. Deferring this type of capital outlays may keep rates low in the near term, but will inevitably have a greater impact on rates to future water users in a major way.

- The CTSG approach of phased desalination modules is completely inflexible to respond to rapid or unpredictable drought protection unless the ultimate 41,800 ac-ft of capacity was constructed initially. If this were the case, their NPV calculation would increase "astronomically". On the other hand, a Lake Texana pipeline can provide rapid and unpredictable "drought protection".

- CTSG's suggested site for the desalination plant is either Padre Island or Mustang Island. These sites will be exposed to the full force of hurricanes. A desalt facility constructed on the islands could be completely inoperative in a matter of a few hours under hurricane conditions. Structures would have to be designed and constructed to withstand hurricane force winds and storm surges. The costs included by CTSG do not appear to be adequate to provide such structures.

- The CTSG report states "it makes as much sense to claim that pumped Lake Texana water cost $86,000,000.00/ac-ft as it does to claim $355.00/ac-ft." This statement is without any substantiation. Public utilities develop financing based on use throughout a finance period as well as useful life. Otherwise, we would calculate water coming from a new water storage reservoir at its total capital cost, divided by quantity used, on the first day of reservoir use. Whether water, solid waste, sanitary sewer, or public facilities, they all are evaluated on the same basis. Municipalities have always operated under the pretense of "pay now" for facilities to be fully utilized over future periods. **The LCC/CC system would not be here today under similar CTSG guidelines/statements.**

Additionally, other brief comments include...

- If permits cannot be obtained for sites on the barrier island, then CTSG's representative costs for transmission lines to bring seawater to the site and transmission lines to return brine concentrate to the ocean would have to be substantially increased.

- A Texana pipeline would be financed and constructed based on an interest rate at the time of pipeline construction. This interest rate would not change. The uncertainty in interest financing for phased desalting modules is not addressed in CTSG's NPV calculations.

- Initial mention is made in the CTSG report that several of the Desalination Citizens Advisory Committee have joined together to form the group. There were approximately 70 members on the Citizens Advisory Committee - are the other members involved?

- Since CTSG's capital and operating costs are "substantially" different from those documented in the Trans-Texas Phase II desalination section and their evaluation did not include assessment of current desalination technologies, what is the source of their general estimates and cost calculations?

- The CTSG report states that annual cash flows and 1995 NPV figures from the Naismith spreadsheet have been included in CTSG's spreadsheet used for desalination comparison calculations. This is incorrect. The figures for the Lake Texana pipeline have been adjusted to reflect pumped Lake Texana water starting in 2010 vs. our referenced February 1, 1995 figures showing pumpage in 2003. The completed Phase II report will show expected pumpage to start in 2007. In addition, the yearly total ($) in the CTSG report in Appendix "B" for both Texana and desalt doesn't appear to even add up to the correct annual cost prior to calculating NPV. Much more importantly, the desalination figures are "radically" different.

- All CTSG's assumptions are based on reverse osmosis desalt modules. Technology could very well provide other improvements to desalting technologies over this 50+ year planning horizon.

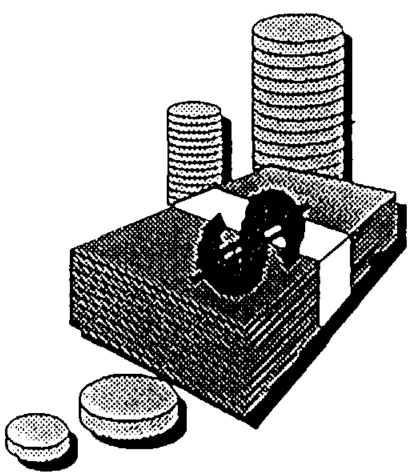
- CTSG's operational costs were estimated at 2% of total capital costs per year. Although this is incorrect, it also is important to note that operating a desalting facility requires a great deal more technical expertise. Desalt processing is different than current local water treatment technologies.

Seawater Desalting - Summary

- Two process types
  - RO
  - Thermal
- Least costly in US
  - RO most cases
  - Thermal some cases
- Costs
  - Site specific
  - $1,300 - $2,600/AF

Total Water Costs

(in $ per acre-foot)



Amortized Capital	**$ 500**
O & M Costs	**$ 900**
Total	**$1400**

To **James Dodson**
City of Corpus Christi

From **Kenneth L. Choffel, P.E.**

Date **September 9, 1995**

HDR

Memorandum

Subject **Present Worth Comparison of Texana Pipeline and Desalination of Seawater**

At your request we have prepared an updated present worth comparison of the Lake Texana water supply project and desalination of seawater. The methods used were similar to the present worth analysis prepared by HDR Engineering and Naismith Engineering and submitted to the Trans-Texas Desalination Citizens Advisory Committee on March 7, 1995. However, this comparison was made using the same project phasing scenario presented in the "Report of the Community Technical Support Group on the Feasibility of Desalination as an Alternative Future Source of Freshwater for the Local Twelve-County Service Region (Draft 2)" dated June 22, 1995 (CTSG Report). Estimated costs and the timeline of projected water shortages were taken from the Phase 2 Trans-Texas report just issued. For both alternatives, water delivery of 4,184 acft/yr begins in 2007 and increases as needed to meet projected shortages. Full utilization of 41,840 acft/yr occurs in year 2028 and remains at 41,840 acft/yr through year 2050.

The study period for the analysis was 1995 to 2050. For the Texana Pipeline, water payments start in 1995 and continue throughout the period of analysis, adhering to the payment schedule provided in the Phase I Trans-Texas Report. Raw water costs for the Desalt Alternative are assumed to be zero. For either alternative, the project would be operational in 2007 and debt service and operational costs were assumed to start in 2007. Annual debt service was calculated at an interest rate of eight percent and a financing period of 25 years. After 2032, debt service for the Texana Pipeline ends and annual costs are comprised of O&M costs and the cost of water. The present worth of each alternative, or the amount of money required in 1995 to fully fund the project for the planning period, was calculated at an interest rate of eight percent.

Phasing Scenario - Desalt Alternative

The CTSG Report defined a phased implementation of desalt treatment capacity of ten equally sized modules. Each module would be sized to treat 4,184 acft/yr and would be installed as needed to meet growing water demands in the Corpus Christi service area. Upon installation of the tenth module, the total desalt treatment capacity would be 41,840 acft/yr, which is the amount of water Corpus Christi has contracted to divert from Lake Texana. The first module installation, to be operational in 2007, would include installation of several key facilities sized to service the full capacity of the plant. These include items that could not be economically phased with each plant expansion. The full-size facilities include: a 66-inch diameter seawater intake pipeline, platform-mounted intake pump station, 48-inch brine discharge pipeline, ground storage tank (clearwell), high service pump station, 48-inch transmission pipeline to the municipal distribution system, and treatment plant site and fencing. One simplifying assumption used in the analysis is that the desalt equipment is assumed to have a life of 50 years and no replacement equipment was included in our analysis. If in fact replacement equipment is needed, then the costs presented here are on the low side.

Phasing Scenario - Texana Pipeline

Consistent with the analysis presented in March, 1995, the Texana Pipeline alternative would include construction of a 48-inch pipeline and pump stations with a delivery capacity in 2007 of 41,840 acft/yr. For estimating operation and maintenance costs, the water delivered in each year of the analysis was what is needed to meet the Corpus Christi service area demands in excess of the current supply capacity. Therefore, the quantity of water delivered from either alternative is the same. The present worth analysis includes treatment O&M costs for the Texana water of $150 per acft/yr, consistent with the previous analysis.

Estimated Costs - Desalt Alternative

As part of the Trans-Texas Water Program[1], Naismith Engineers, Inc, assessed the viability of desalination as a municipal water source. They found that the total installed desalt treatment capacity in the United States is about 20,000 acft/yr. Most of this capacity is in California, where the drought of the late 1980's and early 1990's provided the impetus for the construction of three municipal seawater desalting plants. In all, seventeen desalt plants (or potential plants) in the United States were studied and the results of that work are summarized in the attached Table 3.7-5 (taken from the Phase II Trans-Texas report). The costs experienced by other municipalities or water districts for desalt plants (either operating or in feasibility estimates) are plotted on the following graphs.

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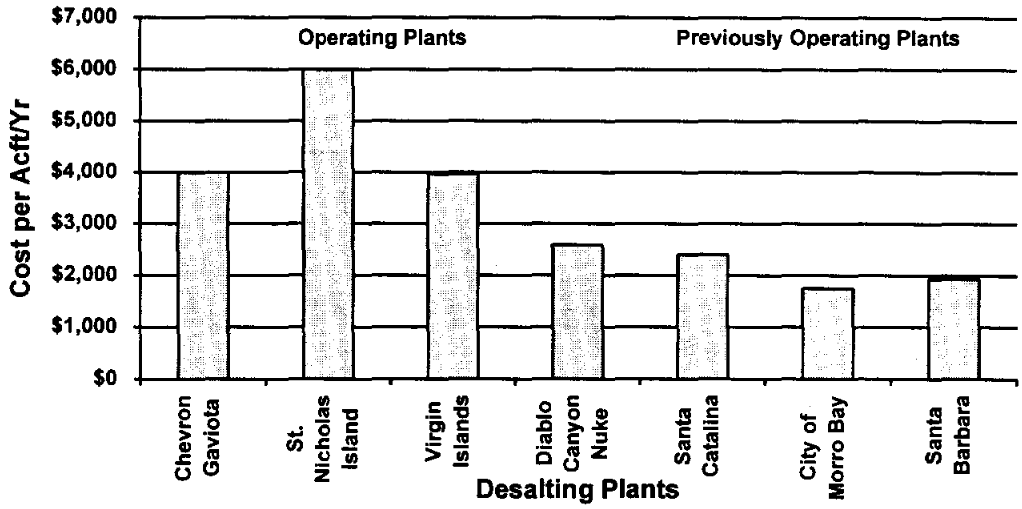
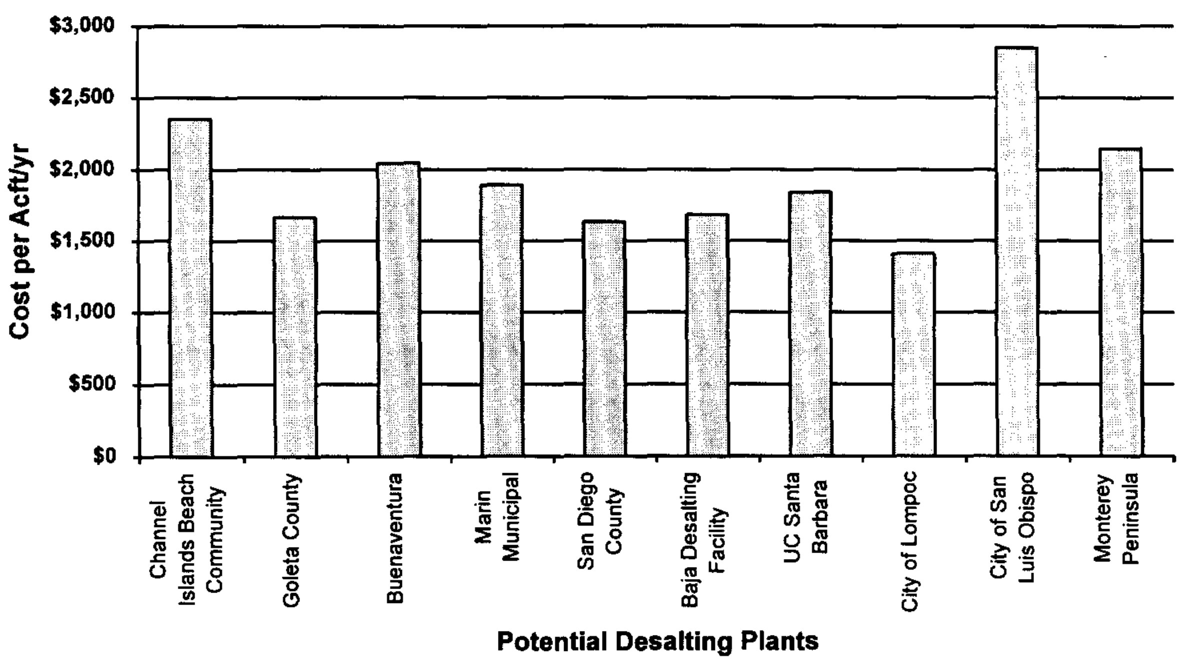
[1] HDR Engineering, Inc., "Trans-Texas Water Program, Corpus Christi Service Area, Phase II Report", Section 3.7 - Desalination of Seawater, September, 1995.

DESALTING COSTS - EXISTING PLANTS



COST OF POTENTIAL DESALTING PLANTS



Based on all of the information obtained, visits to facilities, and discussions with desalination plant operators, the cost to desalt seawater was found to range from about $1,635 to $6,000 per acft/yr. The costs vary based on a number of factors, including: raw water intake system; brine discharge system; water source quality; product water quality goal; desalination process; pre-treatment and post-treatment requirements; recovery rate; transmission, storage, and distribution system; and, regulatory issues. After considering all of the foregoing factors and considering currently accepted desalt processes, it appears a desalt plant at Corpus Christi sized to produce 5,000 to 10,000 acft/yr of potable water from seawater could be built and operated for a cost ranging from $1,635 to $2,000 per acft/yr. A desalt module of 4,184 acft/yr would probably cost at the upper end of the range (or higher). However, for comparison purposes, the low end of the range (i.e., $1,635 per acft/yr) was used. However, the initial project phase will cost more than $1,635 per acft/yr to pay for the cost of constructing the seawater intake, brine disposal pipeline, and treated water pumping/transmission facilities for the full plant capacity of 41,840 acft/yr.

Using cost guidelines for similar facilities, a reconnaissance-level cost estimate of the key facilities for full plant capacity was made in order to estimate the unit cost of the first treatment module. On the basis of this analysis, the unit cost of the first module will be $3,310 per acre foot or higher. The remaining nine modules are assumed to cost $1,635 per acft/yr, including debt service and O&M costs. Consistent with the analysis performed in March, 1995, this combined unit cost can be divided as 35% ($572 per acft/yr) for debt service on capital costs and 65% ($1,063 per acft/yr) for O&M costs. As before, 46% of the O&M costs are assumed to be for purchase of electrical power.

Cost Comparisons

Table 1 contains a summary of total annual costs and 1995 present worth of the Texana Pipeline and Desalt alternatives. Calculations showing detailed costs by year are provided in the attached spreadsheet tables.

Figure 1 is a bar chart showing the total annual cost by year for both the Texana Pipeline and Desalt Alternatives. Figure 2 is a bar chart of the 1995 present worth of each alternative for each year of the study period.

As seen in Table 1, the present worth of the Desalt Alternative is 1.9 times greater than the present worth of the Texana Pipeline project.

Table 1
Comparison of Costs for Texana Pipeline and Desalination of Seawater Alternatives - Increasing Water Delivery Schedule with Phased Construction of Desalination

	Texana Pipeline	Desalination	Desalt Divided by Texana Pipeline (factor)
Total Annual Costs - year 2028	$21,300,000	$75,400,000	3.5
Total Annual Costs - year 2050	$11,255,000	$46,400,000	4.1
Present Worth (1995 thru 2050)	$87,900,000	$168,400,000	1.9

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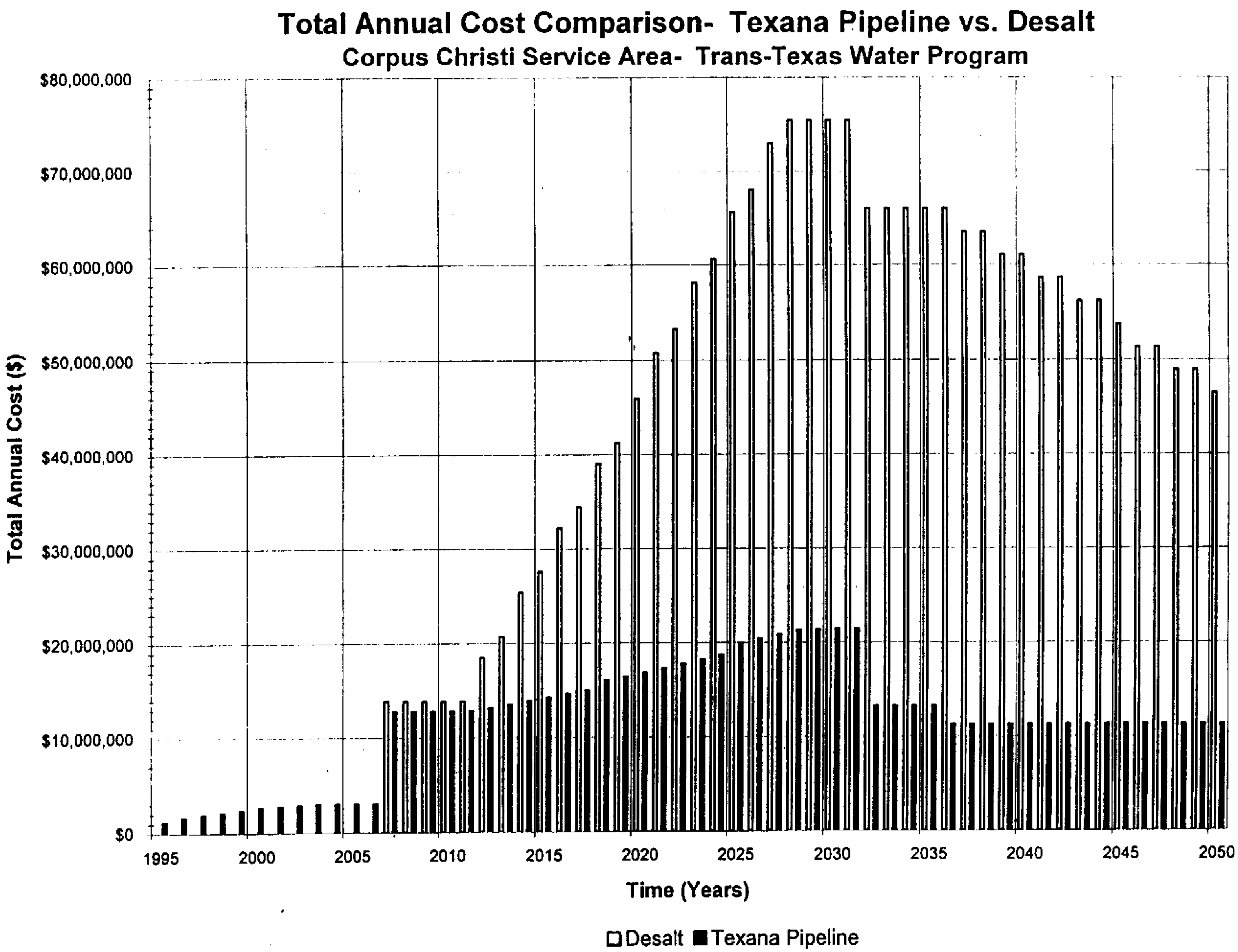
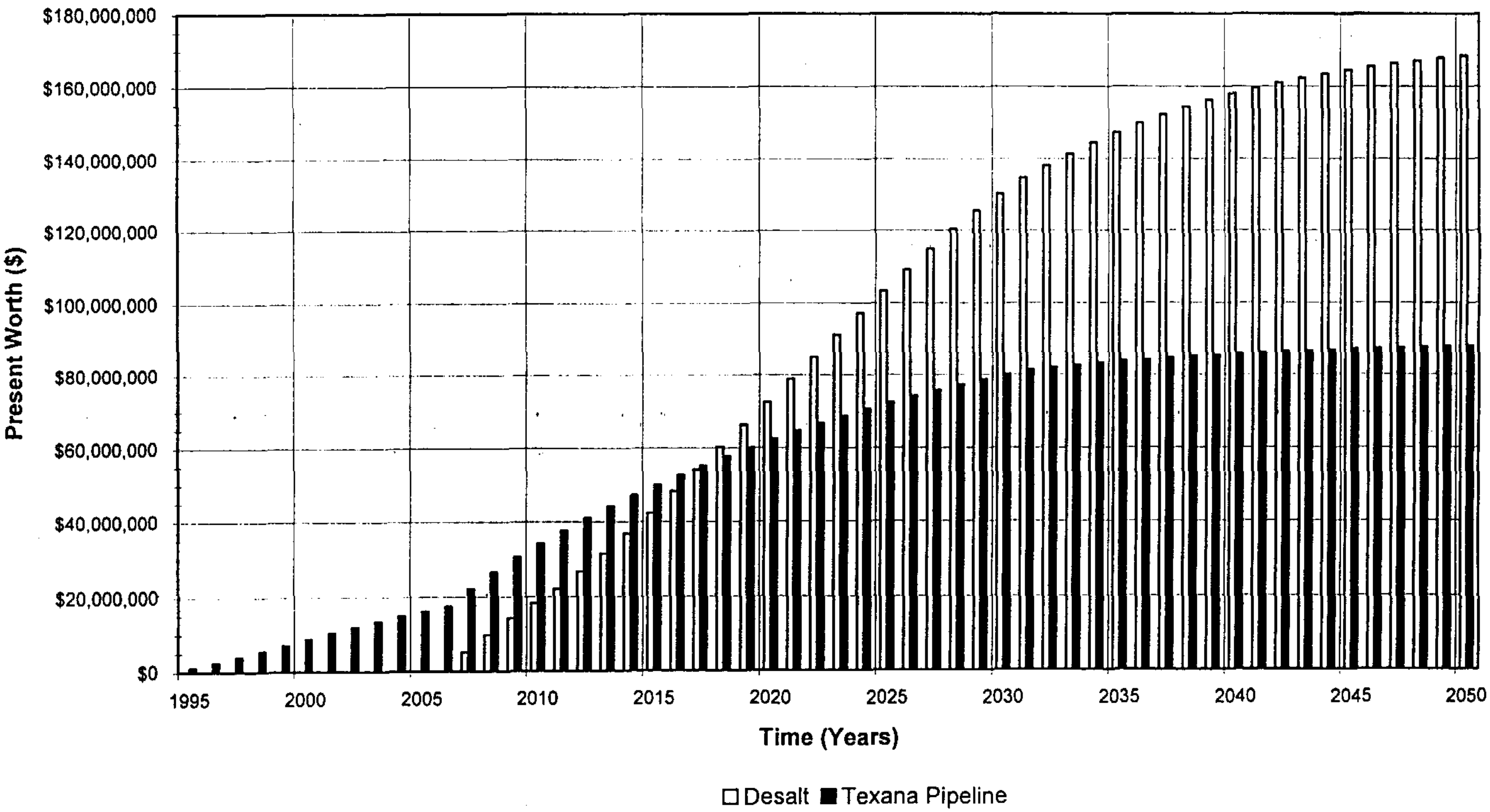


Operation of either alternative begins in 2007.
Costs are 1995 dollars.

Figure 1
9/14/95

Present Worth Comparison- Texana Pipeline vs. Desalt
Corpus Christi Service Area- Trans-Texas Water Program



Operation of either alternative begins in 2007.
Present worths are in 1995 dollars.

Figure 2
9/14/95

TRANS-TEXAS WATER PROGRAM

SOUTH CENTRAL STUDY AREA

PHASE 2

DESALT

INPUT-		
UNIT COST FIRST MODULE-	**$3,310**	/ACFT
UNIT COST, ALL OTHER MODULES-	**$1,635**	/ACFT
AVERAGE UNIT COST, ALL MODULE!	**$1,803**	/ACFT

UNIT COST BREAKDOWN-		
CAPITAL COSTS-	**35.7**	%
O&M EXC POWER-	**34.7**	%
O&M POWER-	**29.6**	%
TOTAL-	**100.0**	%

TIME (YR)	TIME (YR)	ANNUAL Q (AC-FT)	DESALT MODULES (# OPER)	DEBT SERVICE ($/YR)	O&M EXC POWER ($/YR)	O&M POWER ($/YR)	COST OF WATER ($/YR)	TOT ANN COST ($/YR)	PRESENT WORTH ($, 1995)
1995	1	0	0	$0	$0	$0	$0	$0	$0
1996	2	0	0	$0	$0	$0	$0	$0	$0
1997	3	0	0	$0	$0	$0	$0	$0	$0
1998	4	0	0	$0	$0	$0	$0	$0	$0
1999	5	0	0	$0	$0	$0	$0	$0	$0
2000	6	0	0	$0	$0	$0	$0	$0	$0
2001	7	0	0	$0	$0	$0	$0	$0	$0
2002	8	0	0	$0	$0	$0	$0	$0	$0
2003	9	0	0	$0	$0	$0	$0	$0	$0
2004	10	0	0	$0	$0	$0	$0	$0	$0
2005	11	0	0	$0	$0	$0	$0	$0	$0
2006	12	0	0	$0	$0	$0	$0	$0	$0
2007	13	4,184	1	$9,450,380	$2,373,771	$2,024,889	$0	$13,849,040	$5,092,263
2008	14	4,184	1	$9,450,380	$2,373,771	$2,024,889	$0	$13,849,040	$9,807,322
2009	15	4,184	1	$9,450,380	$2,373,771	$2,024,889	$0	$13,849,040	$14,173,117
2010	16	4,184	1	$9,450,380	$2,373,771	$2,024,889	$0	$13,849,040	$18,215,520
2011	17	4,184	1	$9,450,380	$2,373,771	$2,024,889	$0	$13,849,040	$21,958,485
2012	18	6,275	2	$11,892,560	$3,559,901	$3,036,688	$0	$18,489,148	$26,585,376
2013	19	8,365	2	$11,892,560	$4,746,030	$4,048,487	$0	$20,687,077	$31,378,822
2014	20	10,456	3	$14,334,740	$5,932,159	$5,060,286	$0	$25,327,185	$36,812,724
2015	21	12,547	3	$14,334,740	$7,118,289	$6,072,085	$0	$27,525,113	$42,280,746
2016	22	14,637	4	$16,776,920	$8,304,418	$7,083,884	$0	$32,165,221	$48,197,233
2017	23	16,728	4	$16,776,920	$9,490,547	$8,095,683	$0	$34,363,150	$54,049,802
2018	24	18,819	5	$19,219,099	$10,676,676	$9,107,482	$0	$39,003,258	$60,200,590
2019	25	20,909	5	$19,219,099	$11,862,806	$10,119,281	$0	$41,201,186	$66,216,701
2020	26	23,000	6	$21,661,279	$13,048,935	$11,131,080	$0	$45,841,294	$72,414,525
2021	27	25,355	7	$24,103,459	$14,385,032	$12,270,806	$0	$50,759,297	$78,768,920
2022	28	27,710	7	$24,103,459	$15,721,130	$13,410,532	$0	$53,235,121	$84,939,601
2023	29	30,065	8	$26,545,639	$17,057,227	$14,550,257	$0	$58,153,124	$91,181,031
2024	30	32,420	8	$26,545,639	$18,393,325	$15,689,983	$0	$60,628,947	$97,206,174
2025	31	34,775	9	$28,987,819	$19,729,422	$16,829,709	$0	$65,546,950	$103,237,546
2026	32	37,130	9	$28,987,819	$21,065,520	$17,969,435	$0	$68,022,774	$109,033,089
2027	33	39,485	10	$31,429,999	$22,401,617	$19,109,161	$0	$72,940,777	$114,787,309
2028	34	41,840	10	$31,429,999	$23,737,715	$20,248,886	$0	$75,416,600	$120,296,138

2029	35	41,840	10	$31,429,999	$23,737,715	$20,248,886	$0	$75,416,600	$125,396,905
2030	36	41,840	10	$31,429,999	$23,737,715	$20,248,886	$0	$75,416,600	$130,119,838
2031	37	41,840	10	$31,429,999	$23,737,715	$20,248,886	$0	$75,416,600	$134,492,923
2032	38	41,840	10	$21,979,619	$23,737,715	$20,248,886	$0	$65,966,220	$138,034,681
2033	39	41,840	10	$21,979,619	$23,737,715	$20,248,886	$0	$65,966,220	$141,314,087
2034	40	41,840	10	$21,979,619	$23,737,715	$20,248,886	$0	$65,966,220	$144,350,574
2035	41	41,840	10	$21,979,619	$23,737,715	$20,248,886	$0	$65,966,220	$147,162,135
2036	42	41,840	10	$21,979,619	$23,737,715	$20,248,886	$0	$65,966,220	$149,765,433
2037	43	41,840	10	$19,537,439	$23,737,715	$20,248,886	$0	$63,524,040	$152,086,655
2038	44	41,840	10	$19,537,439	$23,737,715	$20,248,886	$0	$63,524,040	$154,235,934
2039	45	41,840	10	$17,095,259	$23,737,715	$20,248,886	$0	$61,081,860	$156,149,500
2040	46	41,840	10	$17,095,259	$23,737,715	$20,248,886	$0	$61,081,860	$157,921,319
2041	47	41,840	10	$14,653,079	$23,737,715	$20,248,886	$0	$58,639,680	$159,496,299
2042	48	41,840	10	$14,653,079	$23,737,715	$20,248,886	$0	$58,639,680	$160,954,614
2043	49	41,840	10	$12,210,899	$23,737,715	$20,248,886	$0	$56,197,501	$162,248,670
2044	50	41,840	10	$12,210,899	$23,737,715	$20,248,886	$0	$56,197,501	$163,446,870
2045	51	41,840	10	$9,768,720	$23,737,715	$20,248,886	$0	$53,755,321	$164,508,101
2046	52	41,840	10	$7,326,540	$23,737,715	$20,248,886	$0	$51,313,141	$165,446,080
2047	53	41,840	10	$7,326,540	$23,737,715	$20,248,886	$0	$51,313,141	$166,314,580
2048	54	41,840	10	$4,884,360	$23,737,715	$20,248,886	$0	$48,870,961	$167,080,473
2049	55	41,840	10	$4,884,360	$23,737,715	$20,248,886	$0	$48,870,961	$167,789,633
2050	56	41,840	10	$2,442,180	$23,737,715	$20,248,886	$0	$46,428,781	$168,413,450
							TOTAL	$2,194,070,791	

TRANS-TEXAS WATER PROGRAM
SOUTH CENTRAL STUDY AREA
PHASE 2

TEXANA PIPELINE

FLOW CAPACITY DATA:			PUMP DATA:			
Q =	41840	AF/YR	ONE:	18785 AF/YR	27	CFS
DIA =	48	INCHES	TWO:	33396 AF/YR	49	CFS
V =	4.8	FPS	THREE:	41840 AF/YR	61	CFS
Q =	60.7	CFS	DOWNTIME:	5.0%	ANNUAL	

ECONOMIC DATA:		
INTEREST RATE:	8.0%	ANNUAL
O&M EXC POWER:	$908,000	@ FULL CAPACITY OPERATION
PUMP STATION:	28.0%	OF TOTAL O&M EXCLUDING POWER

TIME (YR)	TIME (YR)	ANN Q (AC-FT)	PUMPS (#)	Q (CFS)	PUMP TIME (DY/YR)	PUMP TIME (% YR)	DEBT SERVICE ($/YR)	O&M EXC POWER ($/YR)	O&M POWER ($/YR)	COST OF WATER ($/YR)	WATER TREATMENT ($YR)	TOT ANN COST ($/YR)	PRESENT WORTH ($)
1995	1	0	0	0	0	0	$0	$0	$0	$1,172,775	$0	$1,172,775	$1,085,903
1996	2	0	0	0	0	0	$0	$0	$0	$1,621,718	$0	$1,621,718	$2,476,265
1997	3	0	0	0	0	0	$0	$0	$0	$1,863,135	$0	$1,863,135	$3,955,282
1998	4	0	0	0	0	0	$0	$0	$0	$2,112,920	$0	$2,112,920	$5,508,341
1999	5	0	0	0	0	0	$0	$0	$0	$2,371,073	$0	$2,371,073	$7,122,053
2000	6	0	0	0	0	0	$0	$0	$0	$2,638,849	$0	$2,638,849	$8,784,976
2001	7	0	0	0	0	0	$0	$0	$0	$2,760,185	$0	$2,760,185	$10,395,517
2002	8	0	0	0	0	0	$0	$0	$0	$2,882,358	$0	$2,882,358	$11,952,765
2003	9	0	0	0	0	0	$0	$0	$0	$3,004,949	$0	$3,004,949	$13,455,988
2004	10	0	0	0	0	0	$0	$0	$0	$3,023,777	$0	$3,023,777	$14,856,582
2005	11	0	0	0	0	0	$0	$0	$0	$3,023,777	$0	$3,023,777	$16,153,428
2006	12	0	0	0	0	0	$0	$0	$0	$3,023,777	$0	$3,023,777	$17,354,211
2007	13	4184	1	27.3	77.2	21	$8,138,000	$730,032	$283,468	$3,023,777	$627,600	$12,802,877	$22,061,802
2008	14	4184	1	27.3	77.2	21	$8,138,000	$730,032	$283,468	$3,023,777	$627,600	$12,802,877	$26,420,683
2009	15	4184	1	27.3	77.2	21	$8,138,000	$730,032	$283,468	$3,023,777	$627,600	$12,802,877	$30,456,684
2010	16	4184	1	27.3	77.2	21	$8,138,000	$739,399	$283,468	$3,023,777	$627,600	$12,812,244	$34,196,455
2011	17	4184	1	27.3	77.2	21	$8,138,000	$748,765	$283,468	$3,023,777	$627,600	$12,821,610	$37,661,739
2012	18	6275	1	27.3	115.8	32	$8,138,000	$758,132	$322,451	$3,023,777	$941,200	$13,183,560	$40,960,912
2013	19	8365	1	27.3	154.4	42	$8,138,000	$767,499	$361,433	$3,023,777	$1,254,800	$13,545,509	$44,099,569
2014	20	10456	1	27.3	193.0	53	$8,138,000	$776,866	$400,416	$3,023,777	$1,568,400	$13,907,459	$47,083,390
2015	21	12547	1	27.3	231.6	63	$8,138,000	$786,232	$439,399	$3,023,777	$1,882,000	$14,269,408	$49,918,090
2016	22	14637	1	27.3	270.2	74	$8,138,000	$795,599	$478,381	$3,023,777	$2,195,600	$14,631,357	$52,609,389
2017	23	16728	1	27.3	308.8	85	$8,138,000	$804,966	$517,364	$3,023,777	$2,509,200	$14,993,307	$55,162,978
2018	24	18819	2	48.6	195.4	54	$8,138,000	$814,333	$1,300,848	$3,023,777	$2,822,800	$16,099,757	$57,701,899
2019	25	20909	2	48.6	217.1	59	$8,138,000	$823,699	$1,372,845	$3,023,777	$3,136,400	$16,494,721	$60,110,424
2020	26	23000	2	48.6	238.8	65	$8,138,000	$833,066	$1,444,842	$3,023,777	$3,450,000	$16,889,685	$62,393,939
2021	27	25355	2	48.6	263.3	72	$8,138,000	$842,433	$1,543,168	$3,023,777	$3,803,250	$17,350,628	$64,566,009
2022	28	27710	2	48.6	287.7	79	$8,138,000	$851,800	$1,641,495	$3,023,777	$4,156,500	$17,811,571	$66,630,615
2023	29	30065	2	48.6	312.2	86	$8,138,000	$861,166	$1,739,821	$3,023,777	$4,509,750	$18,272,514	$68,591,758
2024	30	32420	2	48.6	336.6	92	$8,138,000	$870,533	$1,838,147	$3,023,777	$4,863,000	$18,733,457	$70,453,439
2025	31	34775	3	60.7	288.9	79	$8,138,000	$879,900	$2,716,816	$3,023,777	$5,216,250	$19,974,743	$72,291,436
2026	32	37130	3	60.7	308.4	84	$8,138,000	$889,267	$2,782,801	$3,023,777	$5,569,500	$20,403,345	$74,029,802
2027	33	39485	3	60.7	328.0	90	$8,138,000	$898,633	$2,848,786	$3,023,777	$5,922,750	$20,831,947	$75,673,212
2028	34	41840	3	60.7	347.5	95	$8,138,000	$908,000	$2,914,772	$3,023,777	$6,276,000	$21,260,548	$77,226,195

2029	35	41840	3	60.7	347.5	95	$8,138,000	$908,000	$2,980,757	$3,023,777	$6,276,000	$21,326,534	$78,668,605
2030	36	41840	3	60.7	347.5	95	$8,138,000	$908,000	$3,046,742	$3,023,777	$6,276,000	$21,392,519	$80,008,303
2031	37	41840	3	60.7	347.5	95	$8,138,000	$908,000	$3,046,742	$3,023,777	$6,276,000	$21,392,519	$81,248,763
2032	38	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$3,023,777	$6,276,000	$13,254,519	$81,960,405
2033	39	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$3,023,777	$6,276,000	$13,254,519	$82,619,332
2034	40	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$3,023,777	$6,276,000	$13,254,519	$83,229,450
2035	41	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$3,023,777	$6,276,000	$13,254,519	$83,794,374
2036	42	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$84,238,542
2037	43	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$84,649,808
2038	44	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$85,030,610
2039	45	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$85,383,205
2040	46	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$85,709,681
2041	47	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$86,011,974
2042	48	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$86,291,875
2043	49	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$86,551,042
2044	50	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$86,791,012
2045	51	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,013,207
2046	52	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,218,942
2047	53	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,409,438
2048	54	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,585,823
2049	55	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,749,143
2050	56	41840	3	60.7	347.5	95	$0	$908,000	$3,046,742	$1,024,234	$6,276,000	$11,254,976	$87,900,364
											TOTAL	$668,149,577	

DAVIS FORD

PRESENTATION TO CORPUS CHRISTI CITY COUNCIL

September 26, 1995

REVIEW OF MATERIALS

- Engineering Reports
- Trans-Texas Planning Documents
- CTSG Report
- Lake Texana Water Quality Data
- Newspaper Articles & Correspondence

PERSONAL CONTACTS

- CTSG - Ron Marek, Chairman
- Naismith Engineering - Dick Poremba
- HDR Engineering
- LNRA - Emmett Gloyna
- Formosa Engineering Personnel
  (R.O. & Desalination)
- Juan Garza - City of Corpus Christi
- James Dodson - City of Corpus Christi
- Site Visit to Stevens Water Treatment
  Plant

Water Contract - LNRA & City of Corpus Christi (42 yrs) with Option to Renew (50 yrs)

Sec. 401 ≈ 42,000 AF/yr

(City has option to purchase Garwood Water ≈ 32,000 AF/yr net)

Sec. 403

Cost $\frac{42,000}{74,000}$ (LNRA O&M + Debt Service)

Debt Service, $76,000,000, 42 yrs, 3.5% (Federal Contract)

Debt Service, $3,400,000, 20 yrs, 6% (Lake Texana Bonds)

≈ $48/AF (1996)
to ≈ $67/AF (2004 to 2035)

ADVANTAGES TO CITY

(Lake Texana)

- **Long-term Contract with Defined Payments - Favorable Rate**
- **Excellent Water Quality**
- **Present Payments are a Prudent Investment:**

  (1) **Purchasing a Future Water Right Currently in Demand**

  (2) **Reduce Principal**

  (3) **Flexibility in Future Water Assignment**

- **City has Invested in an Appreciating Asset**

REVERSE OSMOSIS (R.O.)

- Proven Technology
- Technology Will Continue to Improve With Time
- Currently Most Attractive Desalination Option
- Energy Intensive

LAKE TEXANA - STEVENS WATER PLANT PIPELINE

- Design & Construction -
  Non-complex

- Permitting -
  Needs to be Defined

- Good Long-term Asset

R.O. TECHNICAL ISSUES

- Intake & Reject Structure Costs
- Permitting Requirements for R.O. Reject
- Pre- and Post- Treatment Requirements
- Pipeline (Barrier Island - Stevens Plant) Permitting Requirements
- Phasing Economies
- Hurricane Susceptibility
- Module and Membrane Life

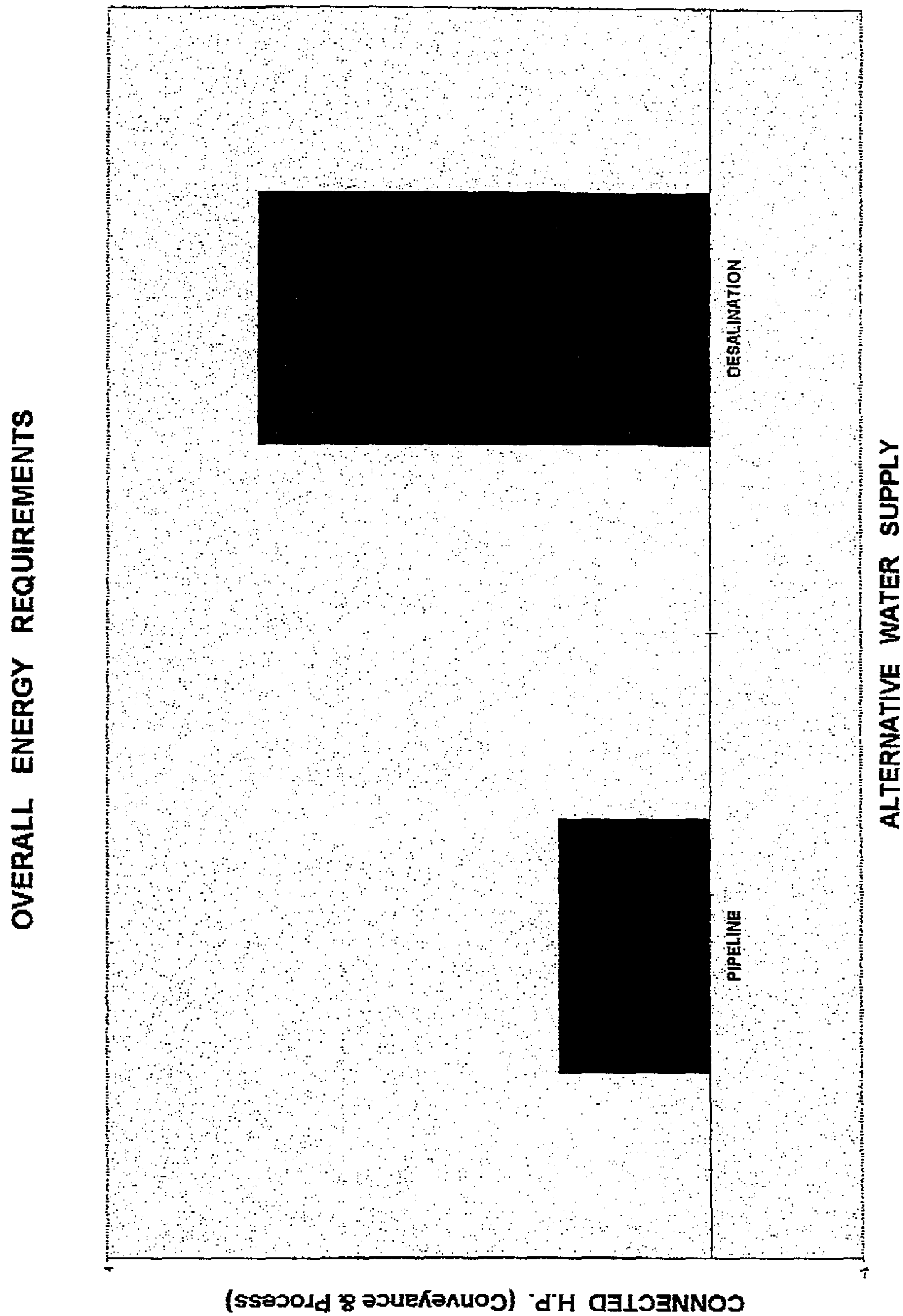
SUMMARY

1. LNRA - City of Corpus Christi contract is an excellent asset

2. Pipeline Construction is a good investment but commence at a date consistent with sound technical, permitting, water demand, and economic principles.

3. R.O. is proven technology and should continue to be considered as a candidate supplement.

4. R.O. should be periodically reviewed in terms of technical and economic applicability throughout the life of the LNRA-City contract. A more intense review and update is suggested within the next five year period.


OVERALL ENERGY REQUIREMENTS
DESALINATION
PIPELINE
ALTERNATIVE WATER SUPPLY
CONNECTED H.P. (Conveyance & Process)

ECONOMICS OF DESALTING

presented by

John Potts, P.E.

Hutcheon Engineers
A division of Kimley-Horn and Associates, Inc.

American Desalting Association Technical Workshop, October, 1995

Comparison of Construction Costs Associated with Desalting Brackish Water and Sea Water

	Conventional	Brackish Water	Sea Water
Treatment Equipment	$0.20 to $1.50	$0.80 to $1.50	$3.50 to $5.00
Raw Water Supply	$0.40 to $1.00	$0.60 to $1.20	$0.80 to $1.40
Concentrate Disposal	0	$0.15 to $3.00	$0.15 to $3.00
TOTAL	$0.60 to $2.50	$1.55 to $5.70	$4.45 to $9.40

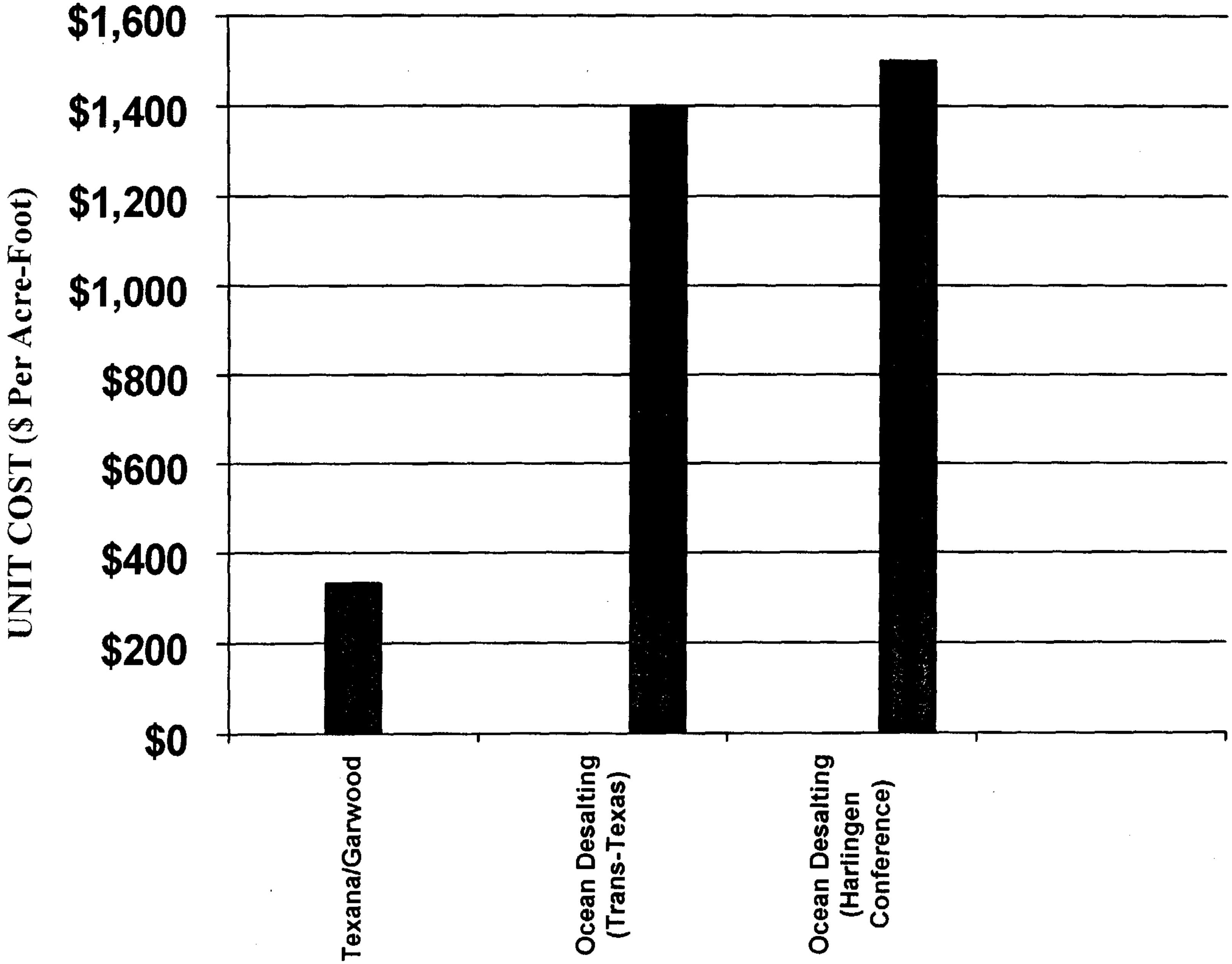
- Cost Is Expressed as Dollars per Gallon of Treatment Capacity
- Treatment Capacity Is Generally Expressed as Gallons Per Day (GPD)
- Costs Are for Plants with Treatment Capacity of 2,000,000 to 10,000,000 GPD
- Each Case Is Site Specific and Costs Can Vary Beyond These Ranges

Comparison of Operating Costs Associated with Desalting Brackish Water and Sea Water

	Conventional	Brackish Water	Sea Water
Energy and Chemicals	$0.25 to $0.50	$0.30 to $0.90	$2.50 to $4.00
Labor	$0.50 to $1.00	$0.50 to $1.25	$0.50 to $1.25
Replacement Parts	$0.10 to $0.20	$0.10 to $0.30	$0.40 to $0.60
TOTAL	$0.85 to $1.70	$0.90 to $2.45	$3.40 to $5.85

- Cost Is Expressed in Dollars per 1,000 Gallons of Sellable Water
- Costs Are for Plants with Treatment Capacity of 1,500,000 to 10,000,000 GPD
- Each Case Is Site-Specific and Costs Can Vary Beyond These Ranges

COMPARISON OF OCEAN DESALTING COSTS WITH TEXANA / GARWOOD COSTS



SAN PATRICIO MUNICIPAL WATER DISTRICT
P. O. DRAWER S
INGLESIDE, TEXAS 78362

October 11, 1995

Mayor Mary Rhodes
City of Corpus Christi
P. O. Box 9277
Corpus Christi, Texas 78466

Dear Mayor Rhodes:

The Board of Directors of the District, at its regular meeting on Tuesday, October 10, 1995, adopted the enclosed resolution. President Gene Dressen asked that I convey a copy to all of the sponsors of the Trans-Texas Water Program, Corpus Christi Study Area, and also express his thanks for your efforts.

Very truly yours,

SAN PATRICIO MUNICIPAL WATER DISTRICT

Jim Naismith, P.E.
Manager/District Engineer

alp-8872.004

PHONE 512-643-6521
FAX 512-643-9093

RESOLUTION OF THE BOARD OF DIRECTION

SAN PATRICIO MUNICIPAL WATER DISTRICT

October 10, 1995

WHEREAS: the San Patricio Municipal Water District serves the fresh water needs of the cities of Odem, Taft, Gregory, Portland, Ingleside, Ingleside on the Bay, Aransas Pass, Rockport, Fulton and Port Aransas, rural water supply corporations, and all major industry in San Patricio County including Reynolds Metals Company, E. I. duPont de Nemours, Occidental Chemical Corporation, and Naval Station Ingleside, and;

WHEREAS: all of the cities served by the District were originally founded based on the local ground water resource and cisterns and later changed to surface water when the well water and "roof water" proved to be inadequate in both quantity and quality, and;

WHEREAS: location of major industry in San Patricio County would not have been possible without an adequate and dependable fresh water resource, and:

WHEREAS: the District believes that growth of cities and industries in San Patricio County has been and will continue to be an important economic asset to the Coastal Bend region and will continue to support improvement in the quality of life for all regional residents, and;

WHEREAS: the District purchases all of its fresh water from the City of Corpus Christi under long-term contract and is dependent on the City of Corpus Christi for a continuing supply, and;

WHEREAS: District customers have been and continue to be active and effective in water conservation and reuse, with per capita and per ton of product fresh water requirements well below State and National averages;

NOW THEREFORE BE IT RESOLVED: that the San Patricio Municipal Water District commends the City of Corpus Christi, the Port of Corpus Christi Authority, the Corpus Christi Board of Trade, the Texas Water Development Board and the Lavaca-Navidad River Authority for their sponsorship of the Trans-Texas Water Program, Corpus Christi Study Area, and;

BE IT FURTHER RESOLVED: that the District wishes to continue as an active supporter of and participant in the Implementation Plan for Integrated Water Supply for the Corpus Christi Study Area.

\wpdata\resoluti

Reviewer:		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
29	Trans-Texas Program	*Comment: Resolution of the Board Directors, San Patricio Municipal Water District.*
		Response: None needed.

RECEIVED 30

1995

Coleman Rowland
711 Mariner
Austin, TX 78734-4342

October 29, 1995

Jack C. Nelson
Director of Water Resources
Lavaca-Navidad River Authority
P.O. Box 429
Edna, TX 77957-0429

Dear Jack:

I received the Phase II report from the South-Central Study Area, and I have no comments to make about it as a member of the TAC. I do have a question about the funds spent, however. Could you give me a figure on the amount of the grants and loans by source for the first two phases of the project, and a breakdown using a few broad categories on how those funds were spent?

Thanks for your help.

Sincerely,

Cole Rowland

Phone & fax 512/261-5922

Reviewer:		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
30	Phase II Report Water Supply	*Comment: No comments to make, however requested information about the grants and loans for Phase I and II of the project.*
		Response: Texas Water Development Board (TWDB) made a loan to the Corpus Christi Study Sponsor for $350,000 and Corpus Christi contributed $125,000 for the Phase I Study. The Phase II Study was funded by a loan from the TWDB of $864,800 to Corpus Christi.

City of Austin

Founded by Congress, Republic of Texas, 1839
Municipal Building, Eighth at Colorado, P.O. Box 1088, Austin, Texas 78767 Telephone 512 499-200(

October 30, 1995

Mr. Emmett Gloyna, P.E., General Manager
Lavaca-Navidad River Authority
P.O. Box 429
Edna, Texas 77957-0429

RE: Phase II Draft Report for Corpus Christi

Dear Mr. Gloyna,

We have received the Corpus Christi Study Area Phase II Draft Report dated September, 1995 and appreciate the opportunity to offer comments on the study.

At this time, our concern is the recommended schedule for pursuing the diversion of Garwood Water Rights to Corpus Christi. The report recommends that Phase III be initiated in 1996 for this water right transfer. It is our recommendation that Phase III for this option, which includes the permitting of an interbasin transfer of this water right from the Colorado River basin to the Corpus Christi area, be delayed at least until we have been able to complete the Austin Study Area Phase II report, which should be completed in early 1997. This should have minimal impact on the overall plan for Corpus Christi since the report indicates this water is not going to be needed until at least 2029. This would also allow time to mediate any impacts this transfer might have on the City of Austin or others dependent on the Colorado River basin water.

If you have any questions regarding these comments please do not hesitate to call.

Sincerely,

Randy J. Goss, P.E., Director
Water and Wastewater Utility

Reviewer:		
Comment No. (Responder)	Alternate No. (Ph I Report page no.)	Comment/Response
31	Section 4.3	*Comment: At this time, our concern is the recommended schedule for pursuing the diversion of Garwood Water Rights to Corpus Christi. It is our recommendation that Phase III for this option be delayed at least until we have been able to complete the Austin Study Area Phase II report, which is scheduled for completion in early 1997.*
		Response: Concern has been noted and Corpus Christi representatives are informed of the City of Austin's concern. Section 3.16 of the report, which addresses the purchase of Garwood water rights, shows that under all purchase scenarios investigated, water availability to the City of Austin is essentially unchanged from existing conditions.

APPENDIX K

Interbasin Transfer Policies of Brazos River Authority and Lower Colorado River Authority

EVALUATION PROCEDURES FOR INTERBASIN TRANSFER REQUESTS

BRAZOS RIVER AUTHORITY
BRIEFING PAPER
ON
INTERBASIN TRANSFER ISSUES

Purpose: The primary purpose of these procedures is to insure that any transfer of Authority water supplies or use of Authority facilities for such purpose is not detrimental to the interests of the Brazos Basin. Adequate water supplies must be maintained for the citizens of the Brazos Basin. These procedures are a flexible guide for the Authority staff to conduct deliberate evaluations of any request or consideration for an interbasin transfer on a case-by-case basis. Any final action will be require approval of the Authority's Board of Directors.

Requests: Interbasin transfer requests can take several forms: a direct request for water supply under a long-term contract, a request for construction by the Authority of reservoirs or facilities for the generation of and/or conveyance of water supplies, a request for use of facilities for conveyance, or any combination of these examples. The request must come from either a potential customer or as the result of alternative evaluations conducted through the Trans-Texas Water Program.

Procedures: In order to determine if a request would have a detrimental effect on the interests of the Brazos Basin, the effects on the following items will be considered. The extent to which each of the following items is pertinent to a request will be determined on a case-by-case basis.

- Contractual commitments by the Authority, including impacts on the ability to deliver supplies through the basinwide system;
- Future needs of Authority customers, including consideration of future needs that are not under long-term contract;
- Impacts on conveyance facilities, either existing or planned, to serve entities in the Brazos Basin in the near-term and long-term future (for example, the expansion of the Williamson Country Raw Water Line);
- Future needs of users other than Authority customers located in the Brazos Basin;
- Cost of existing supplies versus cost of future supplies;
- Potential problems with development and permitting of future "replacement" water supply facilities;
- Compliance with TWC guidelines and applicable State laws; and
- Water quality and environmental impacts.

Data and Information: Any entity requesting consideration of an interbasin transfer shall provide the Authority with specific details on the amounts required, including a detailed schedule of water demands and evidence of water conservation measures that will be employed prior to any transfer. Additional economic or environmental data may be requested as needed.

LCRA BOARD POLICY

502 - INTERBASIN TRANSFERS

April 23, 1992

502.10 PURPOSE

The purpose of this policy is to avoid, if possible and consistent with the law, any future transfer of water from the lower Colorado River basin to other river basins which are detrimental to the interest of LCRA's ten-county statutory district.

LCRA recognizes that in the past, through its actions, investments have been made in the reliance that water will be available from the lower Colorado River for use either in the district or within the basin. LCRA will honor those past written commitments.

502.20 POLICY

LCRA, while recognizing the jurisdiction of the Texas Water Commission, will oppose future interbasin transfers of water outside the lower Colorado River basin unless the transfer is within LCRA's ten-county statutory district or it is demonstrated to the satisfaction of the Board that (1) the transfer will have no detrimental effect on the public welfare or commercial interests of LCRA's ten-county statutory district and (2) the receiving basin is prudently using and conserving existing water resources and aggressively planning and developing needed additional local water supplies.

The determination of detrimental effect will be based on the estimated direct and indirect impacts, both present and future, of the proposed interbasin transfer on all of the following considerations:

1. Existing water rights and obligations;

2. Contractual commitments by LCRA;

3. Water supplies for environmental purposes and economic activities, including instream flows, inflows to the bays and estuaries, municipal, industrial, irrigation, and lake and river recreation and tourism; and

4. Water quality and aquatic ecosystems in the Highland Lakes and lower Colorado River basin and associated bays and estuaries.

Anyone requesting LCRA's acquiescence in a proposed interbasin transfer must provide LCRA with comprehensive evaluations of the environmental, economic and institutional impacts from the proposed transfer.

In the event of coordinated statewide interbasin water transfers, LCRA may participate to address regional water resources problems if such transfers: (1) comply with the criterion of no detrimental effect indicated in this policy and (2) provide positive economic or environmental benefits to LCRA's ten-county statutory district.

As the steward of the lower Colorado River, LCRA will, in the event of interbasin transfers, seek to be the negotiating and contracting party. In any interbasin transfer, water supplies from the lower Colorado River will be provided only through temporary water sale contracts. LCRA opposes any sale of water rights for use outside of the LCRA's ten-county statutory district.

502.30 AUTHORITY

LCRA Act, §§ 2(a) and (q).

EFFECTIVE: July 7, 1986. Amended March 19, 1987 (republished), and April 23, 1992.

APPENDIX L

Amendment to Certificate of Adjudication No. 16-2095B

THE STATE OF TEXAS
COUNTY OF TRAVIS

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

I hereby certify that this is a true and correct copy of a Texas Natural Resource Conservation Commission document, the original of which is filed in the permanent records of the Commission.
Given under my hand and the seal of office on
DEC 1 9 1994

Gloria A. Vasquez, Chief Clerk
Texas Natural Resource
Conservation Commission

AMENDMENT TO CERTIFICATE OF ADJUDICATION NO. 16-2095

CERTIFICATE OF ADJUDICATION: 16-2095B

OWNERS:
Texas Water Development Board
c/o Executive Administrator
P.O. Box 13231
Austin, Texas 78711

Lavaca Navidad River Authority
c/o General Manager
Box 429
Edna, Texas 77957

COUNTY: Jackson

PRIORITY DATES:
May 24, 1982, and October 6, 1993

WATERCOURSES: Lavaca River and Navidad River

BASIN: Lavaca Basin

WHEREAS, Lavaca-Navidad River Authority (LNRA) and Texas Water Development Board (TWDB) have filed Application 16-2095B and requested amendments of Certificate of Adjudication No. 16-2095, as amended, to appropriate the entire firm yield of the Stage 1 and Stage 2 reservoirs authorized by this certificate of adjudication, and to quantify existing requirements that water be released or passed through to satisfy freshwater inflow needs of the downstream bay and estuary system;

WHEREAS, the Commission finds that it has jurisdiction to hear both Application 16-2095B and the previous application to amend Certificate of Adjudication No. 16-2095 which is the application subject to Cause No. 361,294 remanded from the District Court of Travis County, Texas;

WHEREAS, all parties to the contested case hearing have settled and resolved all matters in dispute and recommend that the application be granted as reflected by this amendment;

WHEREAS, the Commission finds that the entire remaining firm yield of Lake Texana (Stage 1) is 79,000 acre-feet per year;

WHEREAS, the Commission finds that releases for the bay and estuary system specified by this amendment could impact the firm yield of Lake Texana (Stage 1) by reducing it by up to 4,500 acre-feet per year, from 79,000 acre-feet per year to 74,500 acre-feet per year;

WHEREAS, the Commission finds that the entire remaining firm yield of Stage 2 is 48,122 acre-feet per year;

WHEREAS, the District Court of Travis County has remanded LNRA and TWDB's May 24, 1982 application to the Commission for consideration of whether changed circumstances may now exist that demonstrate the need for the additional appropriation requested by such application;

WHEREAS, issuance of this amendment to Certificate of Adjudication No. 16-2095 effectively resolves all matters of dispute in Cause Nos. 361,294 and 374,305, Lavaca-Navidad River Authority v. Texas Department of Water Resources, and the applicants waive and abandon all contested matters in those proceedings, subject to the issuance and legal effectiveness of this amendment;

NOW, THEREFORE, this amendment to Certificate of Adjudication No. 16-2095 is issued to Texas Water Development Board and Lavaca-Navidad River Authority subject to the following terms and conditions:

1. USE

A. Owners are authorized to use from the impoundment of Lake Texana (impoundment Stage 1) an additional 4,000 af/yr, as follows:

(1) Owner LNRA is authorized to use 406 af/yr for municipal purposes and 1301 af/yr for industrial purposes;

(2) Owner TWDB is authorized to use 546 af/yr for municipal purposes and 1747 af/yr for industrial purposes.

B. 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 af/yr, for a total or 48,122 af/yr, of which up to 7,150 af/yr shall be for municipal purposes, up to 22,850 af/yr shall be for industrial purposes, and at least 18,122 af/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. PRIORITY

A. The time priority for the additional 4,000 af/yr appropriation for Lake Texana is May 24, 1982.

B. The time priority for the additional 18,122 af/yr appropriation for Stage 2 is October 6, 1993.

3. WATER CONSERVATION

A. Within 120 days of issuance of the amended certificate, LNRA shall submit a written response to the following staff recommendations regarding the technical review of LNRA's water conservation plan:

1. The conservation plan needs to be revised to address all of the minimum requirements of 30 TAC Ch. 288, specifically:

a) The water conservation plan should be adopted by the LNRA Board and integrated into LNRA operations and management.

b) A requirement must be added in wholesale contracts so that each successive wholesaler implements water conservation measures in accordance with 30 TAC Ch. 288. For long term contracts already signed, compliance with this provision should be sought voluntarily or this provision should be added at the first available opportunity.

2. Conservation goals and strategies need to be evaluated as to effectiveness for the water users. Goals need to be set based upon an engineering analysis and the technical potential to achieve those goals.

B. Within 180 days of issuance of the amended certificate, LNRA shall revise and implement the "Water Conservation Plan" dated May, 1991. Any subsequent plan used by LNRA shall provide for the utilization of those practices, techniques, and technologies that reduce or maintain the consumption of water, prevent or reduce the loss or waste of water, maintain or improve the efficiency in the use of water, increase the recycling and reuse of water or prevent the pollution of water, so that a water supply is made available for future use or alternative uses. Such plan shall include a requirement in every wholesale water supply contract entered into, on or after the effective date of this amendment, including any contract extension or renewal, that each successive wholesale customer develop and implement water conservation measures. If the customer intends to resell the water, then the contract for the resale of the water must have water conservation requirements so that each successive wholesale customer in the resale of the water will be required to implement water conservation measures.

4. BAY AND ESTUARY RELEASE SCHEDULE

A. The first full paragraph on page 4 of Certificate of Adjudication 16-2095 is amended to provide, with respect to Lake Texana (Stage 1), as follows: This certificate of adjudication is issued subject to all superior and senior water rights in the Lavaca River and to the release of water from Stage 1 for the maintenance of Lavaca-Matagorda Bay and Estuary System as follows:

1. When 78.18% or more of the reservoirs's capacity contains stored inflows, all inflows into the reservoir up to the historical monthly median flow during the months of January (84.5 cfs), February (142.4 cfs), March (86.8 cfs), July (126.5 cfs), November (68.3 cfs), and December (79.3 cfs), and all inflows up to the historical monthly average flow of the months of April (806.8 cfs), May (1,169.3 cfs), June (1,191.4 cfs), August (265.7 cfs), September (1,027.3 cfs), and October (708.3 cfs) shall be passed through the reservoir and shall not be subject to diversion for other uses.

2. When less than 78.18% of the reservoir's capacity contains stored inflows, all inflows up to the annual median daily flow for the drought period January 1954 through December 1956 (5 cfs) shall be passed through the reservoir and shall not be subject to diversion for other uses.

As used in this provision, the term "inflows" refers to naturally occurring in-basin inflows. It does not include water supplies imported from out of the basin, unless those supplies are imported by a junior permittee upstream of Lake Texana for the purpose of replacing naturally occurring in-basin inflows in order to avoid impairment of water rights granted pursuant to Certificate of Adjudication 16-2095, as amended, including required freshwater inflows.

Lavaca-Navidad River Authority, Texas Water Development Board, and Texas Parks and Wildlife Department shall cooperate in developing operating procedures to implement the release schedule and provide such procedures to the TNRCC for review and approval as part of the Water Management Plan. Such procedures shall in part assist in the determination of when priority calls on water can be made by the certificate holder on a daily, monthly, or other appropriate schedule. Additional gages needed to measure inflows and outflows in connection with the release schedule shall be installed within one year following LNRA's issue of "Texana Bonds" to finance acquisition of TWDB's interest. LNRA shall notify the TNRCC in writing of the issuance of such bonds not later than thirty (30) days from date of issuance.

B. The Stage 2 appropriation for municipal and industrial uses remains subject to the release of water for maintenance of the Lavaca-Matagorda Bay and Estuary System as follows:

> Prior to commencement of construction of Stage 2, or any diversion of water appropriated under the Stage 2 portion of this Certificate of Adjudication, upon the joint recommendation of Lavaca-Navidad River Authority, Texas Water Development Board, and Texas Parks and Wildlife Department, LNRA and/or TWDB shall submit an application to TNRCC to establish a schedule for the release of fresh water inflows from Stage 2 for the maintenance of the Lavaca-Matagorda Bay and Estuary System. In establishing the Stage 2 release schedule, TNRCC may consider, upon the motion of any party, modification of the Stage 1 release schedule set forth herein; provided, however, the applicant(s) shall retain the right to withdraw its application without prejudice at any time prior to the final decision by the Commission and shall pay reasonable costs incurred by protesting parties. In the event that the application to set the release schedule for Stage 2 is withdrawn, the Stage 1 release schedule shall remain unchanged from the release schedule specified in Section 4.A of this certificate of adjudication.

5. SPECIAL CONDITION:

Within 36 months of issuance of this amendment, LNRA shall submit to the TNRCC, following appropriate public involvement, a water management plan pursuant to Texas Water Code section 11.173(b). Such plan shall address:

a) the potential of water conservation and reuse to enhance existing water supplies and the potential impact of such practices on the timing of construction of Stage 2;

b) a drought management plan in accordance with 30 TAC section 288.2(a)(1)(H);

c) an assessment of environmental water needs (i.e., instream needs, water quality, aquatic and wildlife habitat, and beneficial inflows to affected bays and estuaries) and potential responses to address such needs, particularly as related to Stage 2. Such assessment shall be done in coordination with the Clean Rivers Program (Texas Water Code section 26.0135) and studies performed pursuant to Texas Water Code section 16.058; and,

d) the management of water supply, including planning and timing of construction of Stage 2. This may include the incorporation of integrated resource planning principles where water supply and demand management options are identified, analyzed, and compared so that the most cost-effective and environmentally sensitive strategies are pursued.

This Amendment is issued subject to all terms, conditions and provisions contained in Certificate of Adjudication No. 16-2095, as amended, except as herein amended.

This amendment is issued subject to all superior and senior water rights in the Lavaca River Basin.

Owners agree to be bound by the terms, conditions, and provisions contained herein and such agreement is a condition precedent to the granting of this amendment.

All other matters requested in the application which are not specifically granted by this amendment are denied.

This amendment is issued subject to the Rules of the Texas Natural Resource Conservation Commission and the right of continual supervision of State water resources exercised by the Commission.

Issue Date: **DEC 16 1994**

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

John Hall, Chairman

ATTEST:

Gloria A. Vasquez, Chief Clerk

APPENDIX M

Vegetation Observed - Lake Texana Pipeline

Table M-1. Vegetation Observed - Lake Texana Pipeline (LN-1)

Common Name	Scientific Name
<u>SITE 0</u>	
Giant ragweed	*Ambrosia trifida*
Bushy bluestem	*Andropogon glomeratus*
Roosevelt weed	*Baccharis neglecta*
Coastal water hyssop	*Bacopa rotundifolia*
King Ranch bluestem	*Bothriochloa ischaemum*
Silver bluestem	*Bothriochloa laguroides* ssp. *torreyana*
Sandbur	*Cenchrus incertus*
Horsetail	*Conyza canadensis*
One seed croton	*Croton monangthogynus*
Bermudagrass	*Cynodon dactylon*
Poorland flatsedge	*Cyperus compressus*
Fragrant flatsedge	*Cyperus odoratus*
Gordo bluestem	*Dichanthium aristatum*
Pony foot	*Dichondra carolinensis*
Spikerush	*Eleocharis austrotexana*
Snow-on-the-prairie	*Euphorbia bicolor*
Common sunflower	*Helianthus annuus*
Umbrella water pennywort	*Hydrocotle umbellata*
Bigleaf sumpweed	*Iva frutescens*
Climbing hempweed	*Mikania scandens*
Dallis grass	*Paspalum dilatatum*
Vasey grass	*Paspalum urvillei*
Passion flower	*Passiflora incarnnata*
Marsh-fleabane	*Pluchea* sp.
Least snoutbean	*Rhynchosia minima*
Grassy arrowhead	*Sagittaria graminea*
Knotroot bristlegrass	*Setaria genculata*
Southwest bristlegrass	*Setaria scheelei*
Goldenrod	*Solidago* sp.
Johnson grass	*Sorghum halepense*

Common Name	Scientific Name
Germander	*Teucrium cubense*
Narrow-leaved cattail	*Typha spp.*
Brazilian vervain	*Verbena brasiliensis*
Marsh millet	*Zizanopsis milliaceae*

SITE 1

Boxelder	*Acer negundo*
Western ragweed	*Ambrosia cumanensis*
Giant ragweed	*Ambrosia trifida*
Annual broomweed	*Amphiachyris dracunculoides*
Annual aster	*Aster subulatus*
Prostrate lawn flower	*Calyptocarpus vialis*
Bitternut hickory	*Carya cordiformus*
Sugar hackberry	*Celtis laevigata*
Inland sea oats	*Chasmanthium latifolia*
Dayflower	*Commelina* s
Bermudagrass	*Cynodon dactylon*
Gordo bluestem	*Dichanthium aristatum*
Dicliptera	*Dicliptera brachiata*
Anacua	*Ehretia anacua*
Snow on the prairie	*Euphorbia bicolor*
Green ash	*Fraxinus pennsylvanica*
Sneeze weed	*Helenium amarum*
Yaupon	*Ilex vomitoria*
Seacoast sumpweed	*Iva annua*
Pepperwort	*Marsilea vestita*
Basketgrass	*Oplisemnus hirtellus*
Virginia creeper	*Parthenocissus quinquefolia*
Bahia grass	*Paspalum notatum*
Thin paspalum	*Paspalum setaceum*
Passion flower	*Passiglans incarnata*
mistletoe	*Phoradendron tomentosum*
Bitter orange	*Poncirus trifoliata*
Poison ivy	*Rhus toxidendron*

Common Name	Scientific Name
Dewberry	*Rubus sp.*
Wild petunia	*Ruellia nudiflora*
Palmetto	*Sabal minor*
Soapberry	*Sapindus saponaria var. drummondii*
Knotroot bristlegrass	*Setaria geniculata*
Arrow-leaf sida	*Sida rhombifolia*
Prickly sida	*Sida spinosa*
Green brier	*Smilax bona-nox*
Johnson grass	*Sorghum halepense*
Spanish moss	*Tillandsia usneoides*
Cedar elm	*Ulmus crassifolia*
Frostweed	*Verbensins virginica*
Texas Ironweed	*Vernonia texana*
Violet	*Violet sp.*

SITE 2

Huisache	*Acacia smallii*
Boxelder	*Acer negundo*
Fineleaf gerardia	*Agalinis strictifolia*
Western ragweed	*Ambrosia cumanensis*
Peppervine	*Ampelopsis arborea*
Milkweed	*Asclepias sp.*
Annual Aster	*Aster subulatus*
Nuttall wild indigo	*Baptisia nuttalliana*
Rattan vine	*Berchemia scandens*
Hairy grama	*Bouteloua hirsuta*
Texas grama	*Bouteloua rigidiseta*
American beautyberry	*Callicarpa americana*
Trumpet Creeper	*Canpsis radicans*
Bitternut hickory	*Carya cordiformus*
Sugar hackberry	*Celtis laevigata*
Grassbur	*Cenchrus incertus*
Green hawthorn	*Crataegus viridis*
Wooly croton	*Croton capitatus var. lindheimeri*

Common Name	Scientific Name
One-seed croton	*Croton monanthogynus*
Bermudagrass	*Cynodon dactylon*
Flatsedge	*Cyperus ochraceus*
Spikerush	*Eleocharis austrotexana*
Plains lovegrass	*Eragrostis intermedia*
Coral bem	*Erythrina herbacea*
Euthamia	*Euthamia gymnosperoides*
Green ash	*Fraxinus pennsylvanica*
Neally globe amaranth	*Gomphrena nealleyi*
Sneeze weed	*Helenium amarum*
Deciduous holly	*Ilex decidua*
Yaupon	*Ilex vomitoria*
Seacoast sumpweed	*Iva annua*
Pepperwort	*Marsilea vestita*
Texas prickly pear	*Optuntia lindhemeri*
Gaping panicum	*Panicum hians*
False ragweed	*Parthenium hysterophorus*
Bahia grass	*Paspalum notatum*
Harryseed paspalum	*Paspalum pubiflorum*
Passion flower	*Passiflora incarnata*
Mistletoe	*Phoradendron tomentosum*
Sawtooth frog-fruit	*Phyla incisa*
Honey mesquite	*Prosopis glandulosa*
Water oak	*Quercus nigra*
Sand post oak	*Quercus stellata var. margaretta*
Live oak	*Quercus virginiana*
Carolina buckthorn	*Rhamnus caroliniana*
Rose	*Rosa bractata*
Wild petunia	*Ruellia nudiflora*
Dwarf palmetto	*Sabal minor*
Black Willow	*Salix nigra*
Tropical sage	*Salvia coccinea*
Soapberry	*Sapindus saponaria var. drummondii*
Wild senna	*Senna marilandica*
Rattlebush	*Sesbania drummondii*
Coffee bean	*Sesbania macrocarpa*

Common Name	Scientific Name
Knotroot bristlegrass	*Setaria geniculata*
Smutgrass	*Sporobolus indicus*
Coral berry	*Symphoricarpos orbiculatus*
Germander	*Teucrium cubense*
Spanish moss	*Tillandsia usneoides*
Cedar elm	*Ulmus crassifolia*
Brazilian vervain	*Verbena brasiliensis*
Slender vervain	*Verbena officinale ssp. hali*
Coarse verbena	*Verbena xutha*
Frostweed	*Verbesina virginica*
Cocklebur	*Xanthium strumarium*
Prickly Ash	*Zanthoxylum clava-herculis*

<u>SITE 3</u>

Huisache	*Acacia smallii*
Strict-leaf Gerardia	*Agalinis strictifolia*
Annual broomweed	*Amphiachyris dracunculoides*
King Ranch bluestem	*Bothriochloa ischaemum var. songarica*
Sugar hackberry	*Celtis laevigatus*
Sandbur	*Cenchrus incertus*
One seed croton	*Croton monanthogynus*
Gordo bluestem	*Dichanthium aristatum*
Pink eupatorium	*Eupatorium incarnatum*
Snow-on-the-prairie	*Euphorbia bicolor*
Toothed spurge	*Euphorbia dentata*
Yaupon	*Ilex vomitoria*
Retama	*Parkinsonia aculeata*
Mistletoe	*Phoradendron tomentosum*
Live oak	*Quercus virginiana*
Little bluestem	*Schizachyrium scoparium*
Knotroot bristlegrass	*Setaria geniculata*
Greenbrier	*Smilax bona-nox*
Cedar elm	*Ulmus crassifolia*
Frostweed	*Verbesina virginica*
Lime prickly ash	*Zanthoxylum fagara*

Common Name	Scientific Name
SITE 4	
Huisache	*Acacia smallii*
Poppy	*Argemone sp.*
Annual Aster	*Aster subulatus*
Prostrate lawnflower	*Calyptocarpus vialis*
Trumpet creeper	*Canpsis radicans*
Chillipiquin	*Capsicum annuum*
Sugar hackberry	*Celtis laevigata*
Marine vine	*Cissus incisa*
Redberried moonseed	*Cocculus canolinus*
Woolly croton	*Croton captatus*
One seed croton	*Croton monanthogynus*
Jointed flatsedge	*Cyperus articulatus*
Pony foot	*Dichondra carolinensis*
Dicliptera	*Dicliptera bractiata*
Leafy elephantfoot	*Elephantopus carolinianus*
Coral bean	*Erythrina herbacea*
Deciduous holly	*Ilex decidua*
Seacoast sumpweed	*Iva annua*
Three-lobe false mallow	*Malvastrum coromandelianum*
Drummond waxmallow	*Malvaviscus arboreus var. drummondii*
Largefoot pepperwort	*Marsilia macropodia*
Herbaceous mimosa	*Mimosa strigillosa*
Basketgrass	*Oplismenus hirtellus*
Rose palafoxia	*Palafoxia rosea*
Dallis grass	*Paspalum dilatatum*
Bahia grass	*Paspalum notatum*
Water elm	*Planera aquatica*
Live oak	*Quercus virginiana*
Palmetto	*Sabal minor*
Arrow-leaf sida	*Sida rhombifolia*
Greenbrier	*Smilax bona-nox*
Poison ivy	*Toxidendron radicans*
Cedar elm	*Ulmus crassifolia*
Course vervain	*Verbena xutha*

Common name	Scientific Name
Frostweed	*Verbesina virginica*
Grape	*Vitis sp.*
Cocklebur	*Xanthium Strumarium*

SITE 5

Huisache	*Acacia smallii*
Boxelder	*Acer negundo*
Peppervine	*Ampelopsis arborea*
Milkweed	*Asclepias sp.*
Coma	*Bumelia lonuginosa*
Prostrate lawnflower	*Calyptocarpus vialis*
Trumpet creeper	*Campsis radicans*
Chillipiquin	*Capsicum annuum*
Flatsedge	*Cyperus ochraceus*
Cherokee sedge	*Carex cherokeensis*
Bitternut hickory	*Carya cordiformis*
Sugar hackberry	*Celtis laevigata*
Broad leaf wood oats	*Chasmanthium latifolium*
Carolina moon seed	*Cocculus carolinus*
Flowering dogwood	*Cornus florida*
Downy hawthorn	*Crataegus mollis*
Bermudagrass	*Cynodon dactylon*
Grass ponyfoot	*Dichondra carolinensis*
Dicliptera	*Dicliptera brachiata*
Texas persimmon	*Diospyros texana*
Anacua	*Ehretia anacua*
Leafy elephant foot	*Elaphantopus carolinianus*
Virginia wildrye	*Elymus virginicus*
Coral bean	*Erythrina herbacea*
Green ash	*Fraxinus pennsylvanica*
Deciduous holly	*Ilex decidua*
Yaupon	*Ilex vomitoria*
Seacoast sumpweed	*Iva annua*
Drummond waxmallow	*Malvaviscus arboreus var. drummondii*
Pepperwort	*Marsilea* sp.

Common Name	Scientific Name
Basketgrass	*Oplismenus hirtellus*
Savannah panicum	*Panicum gymnocarpon*
Gaping panicum	*Panicum hians*
Resurrection fern	*Polypodium polypodioides*
Skunk bush	*Ptelea trifoliata*
Overcup oak	*Quercus lyrata*
Live oak	*Quercus virginiana*
Bloodberry	*Rivina humilis*
Dwarf palmetto	*Sabal minor*
Soapberry	*Sapindus saponaria var. drummondii*
Greenbrier	*Smilax bona-nox*
Smutgrass	*Sporobolus indicus*
Coral berry	*Symphoricarpos orbiculatus*
Spanish moss	*Tillandria usneoides*
Small ball moss	*Tillandsia recurvata*
Poison ivy	*Toxicodendron radicans*
Winged elm	*Ulmus alata*
American elm	*Ulmus americana*
Cedar elm	*Ulmus crassifolia*
Mexican buckeye	*Ungnadia speciosa*
Frostweed	*Verbesina virginica*
Mustang grape	*Vitis mustangensis*

SITE 6

Giant ragweed	*Ambrosia trifida*
Baccharis	*Baccharis sp.*
Common balloonvine	*Cardiospermum halicacabum*
Gordo bluestem	*Dichanthium aristatum*
Common sunflower	*Helianthus annuus*
Sharp pod morning glory	*Ipomoea trichocarpus*
Seacoast sumpweed	*Iva annum*
Switchgrass	*Panicum virgatum*
Black willow	*Salix nigra*
Rattlebush	*Sesbania drummondii*

Common Name	Scientific Name
Common goldenrod	*Solidago canadensis*
Johnson grass	*Sorgum halepense*
Poison ivy	*Toxidendron radicons*

SITE 7

Giant ragweed	*Ambrosia trifida*
Baccharis	*Baccharis sp.*
Sugar hackberry	*Celtis laevigata*
Late-flowering boneset	*Eupatorium serotinum*
Virginia wildrye	*Elymus virginicus*
Green ash	*Fraxinus pennsylvanica*
Common sunflower	*Helianthus annuus*
Seacoast sumpweed	*Iva annua*
Chinaberry	*Melia azedarach*
Red mulberry	*Monus rubra*
Live oak	*Quercus virginiana*
Chinese tallow tree	*Sapium sebiferum*
Little bluestem	*Schizachyrium scoparium*
Greenbrier	*Smilax bona-nox*
Goldenrod	*Solidago* sp.
Mustang grape	*Vitis mustangensis*

SITE 8

Huisache	*Acacia smallii*
Prairie agalinis	*Agalinis heterophylla*
Giant ragweed	*Ambrosia trifida*
Annual broomweed	*Amphiachyris dracunculoides*
Bushy bluestem	*Andropogon glomeratus*
Red lovegrass	*Aragrostis secudiflora spp.*
Red threeawn	*Aristida purpurea var longiseta*
Heath aster	*Aster ericoides*
Devil weed	*Aster spinosa*

Common Name	Scientific Name
Annual Aster	*Aster subulatus*
Baccharis	*Baccharis sp.*
King Ranch bluestem	*Bothriochloa ischaemum*
Silver bluestem	*Bothriochloa laguroides var. torreyana*
Sideoats grama	*Bouteloua curtipendula*
Coma	*Bumelia lonuginosa*
American beauty berry	*Callicarpa americana*
Chillipiquin	*Capsicum annuum*
Partridge pea	*Cassia fasciculata*
Sugar hackberry	*Celtis laevigata*
Spiny hackberry	*Celtis pallida*
Partridge Pea	*Chamaecrista fasciculata*
Short spike windmill grass	*Chloris subdolichostachya*
Woolly croton	*Croton capitatus*
One-seed croton	*Croton monanthogynus*
Bermudagrass	*Cynodon dactylon*
Globe flatsedge	*Cyperus echinatus*
Green flatsedge	*Cyperus virens*
Bundleflower	*Desmanthus brevipes*
Fall witchgrass	*Digitania cognata*
Poor-joe	*Diodia teres*
Mexican persimmon	*Diospyros texana*
Devils pincushion	*Echinocactus texensis*
Red lovegrass	*Eragrostis secundiflora var oxylepsis*
Coral bean	*Erythrina herbacea*
Christmas bush	*Eupatorium odoratum*
Snow on the prairie	*Euphorbia bicolor*
Late flowering boneset	*Eupotorium serotinum*
Narrow-leaf forestiera	*Forestiera angustifolia*
Golden beach aster	*Haplopappus phyllocephalus*
Lance-leaf gaillardia	*Gaillardia aestivalis*
Bundleflower	*Gutierrezia triflora*
Yaupon	*Ilex vomitoria*
Seacoast sumpweed	*Iva annua*
Pinweed	*Lechea san-sabeana*
Carolina wolfberry	*Lycium carolinianum var. quadrifidum*

Common Name	Scientific Name
Drummond wax-mallow	*Manaviscus arboreus var. drummondii*
Herbaceous mimosa	*Mimosa strigillosa*
Shoregrass	*Monanthochloe littoralis*
Pencil cactus	*Opuntia leptocaulis*
Texas prickly pear	*Opuntia lindheimeri*
Palafoxia	*Palafoxia rosea*
Gaping panicum	*Panicum hians*
Single spike paspalum	*Paspalum monostachyum*
Brownseed paspalum	*Paspalum plicatulum*
Hairseed paspalum	*Paspalum pubiflorum*
Paspalum	*Paspalum sp.*
Bushy knotweed	*Polygonum ramosissimum*
Shaggy portulaca	*Portulaca pilosa*
Honey mesquiet	*Propsis glandulosa*
Welder macaeranthera	*Psilactis heterocarpa*
Sand post oak	*Quercus minima*
Live oak	*Quercus virginiana*
Mexican hat	*Ratibida columnifera*
Macarthey rose	*Rosa bracteata*
Dewberry	*Rubus sp.*
Violet ruellia	*Ruellia nudiflora*
Little bluestem	*Schizachyrium scoparium*
Karnes sensitive brier	*Schrankia latidens*
Bag-pod	*Sesbania vesicaria*
Knotroot bristlegrass	*Setaria sp.*
Common goldenrod	*Solidago canadensis*
Yellow indian grass	*Sorghastrum nutams*
Gulfcoast cordgrass	*Spartina spartinae*
Poison ivy	*Toxidendron radicans*
Brazilian vervain	*Verbena brasiliensis*
Slender Vervain	*Verbena officin*
Mustang grape	*Vitis mustangensis*
Prickly ash	*Zanthoxylum clava-herculis*
Lime prickly ash	*Zanthoxylum fagara*

Common Name	Scientific Name

SITE 9

Western ragweed	*Ambrosia cumanensis*
Toothcup	*Ammannia coccinea*
Roosevelt weed	*Baccharis neglecta*
Saltwort	*Batis maritima*
Bushy sea-ox-eye	*Borrichia frutescens*
Common balloonvine	*Cardiospermum halicacabum*
Marine Vine	*Cissus incisa*
Jointed flatsedge	*Cyperus articulatus*
Saltgrass	*Distichlis spicata*
Burhead	*Echinodorus cordifolius*
Spike rush	*Eleochania sp.*
Seacoast sumpweed	*Iva annua*
Sea lavender	*Limnium carolinianum*
Shoregrass	*Monanthochloe littoralis*
Purple pluchea	*Pluchea odorata*
Dwarf glasswort	*Salicornia virginia*
Seaside goldenrod	*Solidago sempervirens*
Marsh hay cordgrass	*Spartina patens*
Gulfcoast cordgrass	*Spartina spartinae*
Annual seepweed	*Suaeda linearis*
Cattail	*Typha spp.*

SITE 10

Baccharis	*Baccharis sp.*
Green ash	*Fraxinus pennsylvatica*
Honey mesquiet	*Prosopis glandulosa*
Spartina	*Spartina spp.*
Cattail	*Typha spp.*
Cedar elm	*Ulmuis crassifolia*

Common Name	Scientific Name
<u>SITE 11</u>	
Boxelder	*Acer negundo*
Carelessweed	*Amaranthus palmeri*
Giant ragweed	*Ambrosia trifida*
Pepper vine	*Ampelopsis arborea*
Big bluestem	*Andropogon gerardii*
Bushy bluestem	*Andropogon glomeratus*
Hierba de zizotes	*Asclepias oenotheroides*
King Ranch bluestem	*Bothriochloa ischaemum var. songarica*
Silver bluestem	*Bothriochloa laguroides var Torreyana*
Trumpet creeper	*Campsis radicans*
Chillipiquin	*Capsicum annuum*
Pecan	*Carya illinioensis*
Sugar hackberry	*Celtis laevigata*
Spiny hachberry	*Celtis pallida*
Netleaf hackberry	*Celtis reticulata*
Common buttonbush	*Cephalanthus occidentalis*
Fringed chloris	*Chloris ciliata*
Multiflowered false rhodesgrass	*Chloris pluriflora*
Tumble windmill grass	*Chloris verticillata*
Bluewood	*Condalia hookeri*
Jointed flatsedge	*Cyperus articulatus*
Durban crowfoot grass	*Dactyloctenium aegyptium*
Southern crabgrass	*Digitaria ciliaris*
Fall witchgrass	*Digitaria cognata*
Coastal saltgrass	*Distichlis spicata*
Anaqua	*Ehretia anacua*
Red lovegrass	*Eragrostis secundiflora var oxylepsis*
Coral Bean	*Erythrina herbacea*
Eustachys	*Eustachys petraea*
Swamp privit	*Forestieria acuminata*
Green ash	*Fraxinus pennsylvanica*
Common honey locust	*Gleditsia triacanthos*
Nealley glove amaranth	*Gomphrena nealleyi*
Golden beach aster	*Haplopappus phyllocephalus*
Salt heliotrope	*Heliotropium curassavicum*

Common Name	Scientific Name
Gold aster	*Heterotheca subaxillaris var. latifolia*
Alamo vine	*Merremia dissecta*
Climbing hempweed	*Mikonia scandens*
Spotted beebalm	*Monarda punctata*
Texas prickly pear	*Opuntia lindheimeri*
Dillens oxalis	*Oxalis dillenii*
Tagua passionflower	*Passiflora foetida*
Water elm	*Plonera aquatica*
Purple pluchea	*Pluchea odorata*
Bushy knotweed	*Polygonum ramosissimum*
Cottonwood	*Populus deltoides*
Wingpod purslane	*Portulaca umbraticola*
Live oak	*Quercus virginiana*
Least snoutbean	*Rhynchosia minima*
American snoutbean	*Rhynchosia americana*
Bloodberry	*Rivina humilis*
Violet ruellia	*Ruellia nudiflora*
Dwarf palmetto	*Sabal minor*
Longlobe arrowhead	*Sagittaria longiloba*
Black willow	*Salix nigra*
Chinese tallow tree	*Sapium sebiferum*
Border bonebract	*Sclerocarpus uniserialis*
Short-fruited sergania-vine	*Serjania brachycarpa*
Knotroot bristlegrass	*Setaria geniculata*
Southwestern bristlegrass	*Setaria scheelei*
Hairy tubetongue	*Siphonoglossa pilosella*
Silverleaf nightshade	*Solanum eleagnifolium*
Texas nightshade	*Solanum triquetrum*
Gulfcoast cordgrass	*Spartina spartinae*
Annual seepweed	*Suaeda linearis*
Bald cypress	*Taxodium distichum*
Ball moss	*Tillondsia usneoides*
American elm	*Ulmus americana*
Brazilian vervain	*Verbena brasiliensis*
Capitana	*Verbesina microptera*
Mustang grape	*Vitis mustangensis*
Prickly ash	*Zanthoxylum clava-herculis*
Lime prickly ash	*Zanthoxylum fagara*

Common Name	Scientific Name

<u>SITE 12</u>

Annual broomweed	*Amphiachris dracunculoides*
Sugar hackberry	*Celtis laevigata*
Honey mesquiet	*Prosopsis glandulosa*
Live oak	*Quercus virginiana*
Black willow	*Salix nigra*

SITE 13

Western ragweed	*Ambrosia cumonensis*
Bushy bluestem	*Andropogon glomeratus*
Annual aster	*Aster subulatus*
Woolly Croton	*Croton capitatus*
One seed croton	*Croton monanthogynus*
Bermudagrass	*Cynodon dactylon*
Gordo bluestem	*Dichanthium aristatum*
Snow on the prairie	*Euphorbia bicolor*
Bitterweed	*Helenium amarum*
Seacoast sumpweed	*Iva annua*
Herbaceous mimosa	*Mimosa strigillosa*
Rose palafoxia	*Palafoxia rosa*
Dallisgrass	*Paspalum dilatatum*
False ragweed	*Panthenium hysterophorus*
Knotroot bristlegrass	*Setaria geniculata*
Bracted sida	*Sida ciliaris*

<u>SITE 14</u>

Huisache	*Acacia smallii*
Boxelder	*Acer negundo*
Giant ragweed	*Ambrosia trifida*
Peppervine	*Ampelopsis arborea*

Common Name	Scientific Name
Sugar hackberry	*Celtis laevigata*
Red berried moon seed	*Cocculus carolinus*
Dicliptera	*Dicliptera brachiata*
Green ash	*Fraxinus pennsylvanica*
Black willow	*Salix nigra*
American elm	*Ulmus americana*
Cedar elm	*Ulmus crassifolia*
Violet	*Violet sp.*
Mustang grape	*Vitis mustangensis*

SITE 15

Western ragweed	*Ambrosia cumonensis*
Peppervine	*Ampelopsis arborea*
Bushy bluestem	*Andropogon glomeratus*
Red threeawn	*Aristida longespica var. geniculata*
Heath Aster	*Aster ericoides*
Devil weed	*Aster spinosa*
King Ranch bluestem	*Bothriochloa ischaemum*
Coma	*Bumelia lanuginosa*
Pecan	*Carya Illinioensis*
Sugar hackberry	*Celtis laevigata*
Spiny hackberry	*Celtis pallida*
Sandbur	*Cenchrus incertus*
Partridge pea	*Chamaecrista fasciculata*
Trumpet creeper	*Conpsis radicans*
Horsetail	*Conyza canadensis*
One seed croton	*Croton monanthogynus*
Texas croton	*Croton texensis*
Common bermudagrass	*Cynodon dactylon*
Ponyfoot	*Dichondra carolinensis*
Texas persimmon	*Diospyros texana*
Mourning lovegrass	*Eragrostis lugens*
Snow-on-the-prairie	*Euphorbia bicolor*
Texas broomweed	*Gutierrezia texana*

Common Name	Scientific Name
Common sunflower	*Helianthus annuus*
Golden aster	*Heterotheca latifolia*
Seacoast sumpweed	*Iva annua*
Drummond wax mallow	*Malvaviscus arboreus var. drummondii*
Texas prickly pear	*Opuntia lindheimeri*
False ragweed	*Parthenium hysterophorus*
Dallis grass	*Paspalum disatatum*
Brownseed paspalum	*Paspalum plicatulum*
Passion flower	*Passiflora incarnata*
Sawtooth frog fruit	*Phyla incisa*
Honey mesquiet	*Prosopis gandulosa*
Live oak	*Quercus virginiana*
American snoutbean	*Rhynchosia americana*
Dewberry	*Rubus sp.*
Brown-eyed susan	*Rudbeckia hirta*
Little bluestem	*Schizachyrium scoparium*
Knotroot bristlegrass	*Setaria geniculata*
Germander	*Teucrium cubense*
Poison ivy	*Toxicodendron radicans*
Slender vervain	*Verbena officinale var. halei*
Coarse vervain	*Verbena xutha*
Mustang grape	*Vitis mustangensis*
Cocklebur	*Xanthium strumarium*
Prickly Ash	*Zanthoxylum clava-herculis*

SITE 16

Boxelder	*Acer negundo*
Coma	*Bumelia lanuginosa*
Trumpet creeper	*Campsis radicans*
Sugar hackberry	*Celtis laevigaeta*
Pony foot	*Dichondra carolinensis*
Dicliptera	*Diclipter bractata*
Virginia wildrye	*Elymus virginicus*
Green ash	*Fraxinus pennsylvanica*

Common Name	Scientific Name
Seacoast sumpweed	*Iva annua*
Violet ruellia	*Ruellia nudiflora*
Drummond wax-mallow	*Malvaviscus arboreous var. drummondii*
Green brier	*Smilax bona-nox*
Cedar elm	*Ulmus crassifolia*

SITE 17

Giant ragweed	*Ambrosia trifida*
Coma	*Bumelia lonuginosa*
Spiny aster	*Aster spinosa*
Ponyfoot	*Dichondra carolinensis*
Swamp privet	*Forestiera acuminata*
Green ash	*Fraxinus pennsylvania*
Mistletoe	*Phoradendron tomentosum*
Violet ruellia	*Ruellia nudiflora*
Cedar elm	*Ulmus crassifolia*

SITE 18

Tall aster	*Aster praeltus*
Texas persimmon	*Diospyros texana*
Green ash	*Fraxinus pennsylvanica*
Umbrella-grass	*Fuirena simplex*
Lance-leaf gaillardia	*Gaillardia aestivalis*
Heliotrope	*Heliotropium indicum*
Matelia	*Matelia* sp.
Red mulberry	*Morus rubra*
Star-rush	*Rhynchospora colorata*
Violet ruellia	*Ruellia Nudiflora*
Common goldenrod	*Solidago canadensis*
Poison ivy	*Toxicodendron radicans*
Violet	*Violet sp.*

Common Name	Scientific Name

SITE 19a

Drummond wax mallow	*Alveviscus aroreus var drummondii*
Giant ragweed	*Ambrosis trifida*
Peppervine	*Ampelopsis arborea*
Sugar hackberry	*Celtis laevigata*
Partridge pea	*Chaemaecrista fasciculata*
Texas bullnettle	*Cnidoscolus texanus*
Trumpet creeper	*Compsis radicans*
Horsetail	*Conyza canadensis*
One-seed croton	*Croton monanthogynus*
Yaupon	*Ilex vomitoria*
Sharp pod morning glory	*Ipomea trichacarpa*
Climbing hempweed	*Mikania scondens*
Dewberry	*Rubus sp.*
Black willow	*Salix nigra*
Soapberry	*Sapindus saponaria var. drummondii*
Little bluestem	*Schizachyrium scoperum*
Johnson grass	*Sorghum halopense*
Poison ivy	*Toxicodendron radicans*
Cattail	*Typha sp.*
Mustang grape	*Vitis mustangensis*
Prickly ash	*Zanthoxylum clava-herculis*

SITE 19b

Boxelder	*Acer negundo*
Pepper vine	*Ampelopsis arborea*
Pecan	*Carya illinioensis*
Anacua	*Ehretia anacua*
Passion flower vine	*Passiflora incarnata*
Black willow	*Salix nigra*
Poison ivy	*Toxicodendron radicans*
American Elm	*Ulmus americana*
Mustang grape	*Vitis mustangensis*

Common Name	Scientific Name
SITE 20	
Western ragweed	*Ambrosia cumanensis*
Annual broomweed	*Amphiachyris dracunculoides*
Bushy bluestem	*Andropogon glomeratus*
Smooth wild mercury	*Argythamnia humilis*
Milkweed	*Asclepias sp.*
Heath aster	*Aster ericoides*
Tall aster	*Aster praetlus*
Devil weed	*Aster spinosa*
Annual aster	*Aster subulatus*
Silver bluestem	*Bothriochloa laguroides var. torreyana*
Tall grama	*Bouteloua curtipendula var. curtipendula*
Common balloonvine	*Cardiospermum halicacabum*
One-seed croton	*Croton monanthogynus*
Bermudagrass	*Cynodon dactydon*
Jointed flatsedge	*Cyperus articulatus*
Flatsedge	*Cyperus ochraceus*
Purple lovegrass	*Eragrostis spectablilis*
Snow on the prairie	*Euphorbia bicolor*
Euthamia	*Euthamia gymnospermoides*
Common sunflower	*Helianthus annuus*
Seacoast sumpweed	*Iva annua*
Clasping false pimpernel	*Lindernia dubia var. anagallidea*
Wright false-mallow	*Malvastrum aurantiacum*
Herbaceous mimosa	*Mimosa strigillosa*
Welder machaeranthera	*Psilactis heterocarpa*
Crow poison	*Nothoscordum bivalve*
Drummond oxalis	*Oxalis drummondii*
Torpedo grass	*Panicum reptans*
Florida paspalum	*Paspalum floridanum*
Sawtooth frog fruit	*Phyla incisa*
Purple pluchea	*Pluchea odorata*
Honey mesquite	*Prosopsis glandulosa*
Welder machaeranthera	*Psilactis heterocarpa*
Mexican hat	*Ratibida columnifera*

Common Name	Scientific Name
Dewberry	*Rubra sp.*
Little bluestem	*Schizachyrium scoparium*
Knotroot bristlegrass	*Setaria geniculata*
Goldenrod	*Solidago sp.*
Yellow Indian grass	*Sorghastrum nutans*
Heart-leaf nettle	*Urtica chamaedryoides*
Coarse vervain	*Verbena xutha*
Cocklebur	*Xanthium strumarium*

SITE 21

Annual broomweed	*Amphiachris dracunculoides*
Annual aster	*Aster subulatus*
King Ranch bluestem	*Bothriochloa ischaemum*
Buffalo grass	*Buchloe dactyloides*
Slimspike windmill grass	*Chloris andropogonoides*
Stink grass	*Eragrostis cilianensis*
Netted globe-cherry	*Margaranthus solanaceus*
False ragweed	*Parthenium hysterophorus*
Welder machaeranthera	*Psilactis heterocarpa*
Purpletop	*Tridens flavus*

SITE 22

Huisache	*Acacia smallii*
Devil weed	*Aster spinosa*
Annual aster	*Aster subulatus*
Buffalo grass	*Buchloe dactyloides*
Jones rainlily	*Cooperia jonesii*
One-seed croton	*Croton monanthogynus*
Bermudagrass	*Cynodon dactylon*
Showy primrose	*Denothera speciosa*
Pony Foot	*Dichondra sp.*

Common Name	Scientific Name
Eryngo	*Eryngium hookeri*
Euthamia	*Euthamia gymnospermoides*
Silky evolvulus	*Evolvulus sericus*
Neally globe Amaranth	*Gomphrena nealleyi*
Seacoast sumpweed	*Iva annua*
Crow poison	*Nothoscordium bivalve*
Drummond oxalis	*Oxalis drummondii*
Filly panicum	*Panicum hallii* var. filipes
Fall panicum	*Panicum dichotomiflorum*
Gaping panicum	*Panicum hians*
False ragweed	*Parthenium hysterophorus*
Paspalidium	*Paspalidium geminatum*
Bahia grass	*Paspalum notatum*
Honey mesquite	*Prosopsis glandulosa*
Welder machaeranthera	*Psilactis heterocarpa*
Dock	*Rumex sp.*
Knotroot bristlegrass	*Setaria geniculata*
Little bluestem	*Schizachyrium scopanium*
White tridins	*Tridens albescens*
Heart-leaf nettle	*Urtica chamaedryoides*
Cocklebur	*Xanthium strumarium*

SITE 23

Huisache	*Acacia smallii*
Western ragweed	*Ambrosia cumanensis*
Kearney threeawn	*Aristida longespica var. geniculata*
Red threeawn	*Aristida purpurea var. longesita*
Purple threeawn	*Aristida purpurea var. purpurea*
Annual aster	*Aster sufulatus*
Baccharis	*Baccharis sp.*
Smallhead boltonia	*Boltonia diffusa*
Silver bluestem	*Bothriochloa laguroides ssp. torreyana*
Buffalo grass	*Buchloe dactyloides*
Yellow fugosia	*Cienfuegosia drummondii*

Common Name	Scientific Name
Jones rain lily	*Cooperia jonesii*
Showy primrose	*Denothera speciosa*
Spikerush	*Eleocharis austrotexana*
Stink grass	*Eragrostis cilianensis*
Euthamia	*Euthamia gymnospermoides*
Neally globe amaranth	*Gomphrena nealleyi*
Little-head gumweed	*Grindelia microceophala*
Plains gumweed	*Grindelia oolepsis*
Seacoast sumpweed	*Helenium amarum*
Common curry mesquite	*Hilaria belangeri*
Pepperwort	*Marsilea vestita*
Herbaceous mimosa	*Mimosa strigillosa*
Yellow puff	*Neptunia lutea*
Crow poison	*Nothoscordium bivalve*
Grassland prickly pear	*Opuntia macrorhiza*
Gaping panicum	*Panicum hians*
Honey mesquite	*Prosopsis glandulosa*
Welder machaeranthera	*Psilactis heterocarpa*
Knotroot bristlegrass	*Setaria geniculata*
Rattlebush	*Sesbania drummondii*
Bracted sida	*Sida ciliaris*
Slender vervain	*Verbena haleii*

SITE 24

Huisache	*Acacia smallii*
Western ragweed	*Ambrosia cumanensis*
Bushy bluestem	*Andropogon glomeratus*
Annual broomweed	*Amphoachris dracunculoides*
Heath aster	*Aster ericoides*
Devil weed	*Aster spinosa*
Annual Aster	*Aster subulatus*
Eastern baccharis	*Baccharis halimifolia*
King Ranch bluestem	*Bothriochloa ischaemum var. songarica*

Common Name	Scientific Name
Silver bluestem	*Bothriochloa laguroides var. Torreyana*
Jointed flatsedge	*Cyperus articulatus*
Seacoast sumpweed	*Iva annua*
Red sprangletop	*Leptochloa filiformis*
Pepperwort	*Marsilea vestita*
Fall panicum	*Panicum dichotomiflorum*
Torpedo grass	*Panicum reptans*
Switch grass	*Panicum virgatum*
Honey mesquite	*Prosopsis glandulosa*
Welder machaeranthera	*Psilactis heterocarpa*
Violoet ruellia	*Ruellia nudiflora*
Little bluestem	*Schizachyrium scoparum*
Knotroot bristlegrass	*Setaria geniculata*
Yellow Indian grass	*Sorghastrum nutans*
Dropseed	*Sporobolus asper*
Silveus grass	*Trichoneura elegans*

SITE 25

Huisache	*Acacia smallii*
Strict-leaf gerardia	*Agalinis strictifolia*
Western ragweed	*Ambrosia cumanensis*
Annual broomweed	*Amphiachris dracunculoides*
Annual aster	*Aster subulatus*
Small-head boltonia	*Boltonia diffussa*
One-seed croton	*Croton monanthogynus*
Woolly croton	*Croton capitatus*
Bermudagrass	*Cynodon dactylon*
Flatsedge	*Cyperus ochraceus*
Pony foot	*Dichondra carolinensis*
Spikerus	*Eleocharis austrotexana*
Euthamia	*Ethamia gymnospermoides*
Snow on the prairie	*Euphorbia bicolor*
Seacoast sumpweed	*Iva annua*
Machaeranthera	*Machaerantera heterocarpa*
Herbaceous mimosa	*Mimosa strigillosa*

Common Name	Scientific Name
False ragweed	*Parthenium hysterophorus*
Sawtooth frog fruit	*Phyla incisa*
Honey mesquiet	*Prosopsis glndulosa*
Indianola beak-rush	*Rhynchospora indianolensis*
Prairie buttonweed	*Richardia triocca*
Wild petunia	*Ruellia nudiflora*
Rattlebush	*Sesbonia drummondii*
Crinkleawn	*Trachypogon secundus*
Slender vervain	*Verbena officianale*

SITE 26

Annual broomweed	*Amphiachyris dracunculoides*
Bushy bluestem	*Andropogon glomeratus*
Annual aster	*Aster subulatus*
Yellow fugosia	*Cienfuegosia drummondii*
Horsetail	*Conyza canadensis*
Yankee weed	*Eupatorium compositifolium*
Sneezeweed	*Helenium amarum*
Yaupon	*Ilex vomitoria*
Herbaceous mimosa	*Mimosa strigillosa*
Dewberry	*Rubra sp.*
Chinese tallow tree	*Sapium sebiferum*
Little bluestem	*Schizachyrum scoparium*
Golden crown beard	*Verbesena encelioides*

SITE 27

Annual broomweed	*Amphiachris dracunculoides*
Annual aster	*Aster subulatus*
Wormseed	*Chenopodium ambrosioides*
Late flowering boneset	*Eupatorium serotinum*

Common Name	Scientific Name
Herbaceous mimosa	*Mimosa strigillosa*
Chinese tallow tree	*Sapium sebiferum*
Prickly Sida	*Sida spinosa*
Prickly sida	*Sida spinosa*

SITE 28

Huisache	*Acacia smallii*
Giant ragweed	*Ambrosia trifida*
Baccharis	*Baccaris sp.*
Sugar hackberry	*Celtis laevigata*
Christmas bush	*Eupatorum odoratum*
Snow on the prairie	*Euphorbia bicolor*
Green ash	*Fraxinus pennsylvanica*
Golden aster	*Heterotheca latifolia*
Matelea	*Matelea sp.*
Chinaberry	*Melia azedarach*
Climbing hempweed	*Mikovia scondina*
Live oak	*Quercus virginiana*
Macarthey rose	*Rosa bracteata*
Black willow	*Salix nigra*
Chinese tallow tree	*Sapium sebiferum*
Poison ivy	*Toxicodendron radicans*
Mustang grape	*Vitis mustangensis*

SITE 29

Huisache	*Acacia smallii*
Sugar hackberry	*Celtis laevigata*
Wolly croton	*Croton capitatus*
Common sunflower	*Helianthas anuua*
sharppod morning glory	*Ipomea tricholarpa*
Seacoast sumpweed	*Iva annua*
False ragweed	*Parthenium hysterophorus*

Common Name	Scientific Name
Honey mesquite	*Prosopsis glandulosa*
Live oak	*Quercus virginiona*
Johnson grass	*Sorghum halepense*

SITE 30

Huisache	*Acacia smallii*
Sugar hackberry	*Celtis laevigata*
Devil weed	*Leucasyris spinosa*
Gaping panicum	*Panicum hians*
Black willow	*Salix nigra*
Chinese tallow tree	*Sapium sebiferum*
Mustang grape	*Vitis mustangensis*

SITE 31

Huisache	*Acacia smallii*
Baccharis	*Baccharis sp.*
Sugar hackberry	*Celtis laevigata*
Sneezeweed	*Helenium amarum*
Seacoast sumpweed	*Iva annua*
Red mulberry	*Monus rubra*
Welder machaeranthera	*Psilactis heterocarpa*
Live oak	*Quercus virginiana*
Rattlebush	*Sesbania drummondii*
Ball moss	*Tillondsia recurvata*
Mustang grape	*Vitis mustangensis*

SITE 32

Sugar hackberry	*Celtis laevigata*
Silver leaf sunflower	*Helionthus argophyllus*

Common Name	Scientific Name
Common reed	*Phragmites australis*
Honey mesquite	*Prosopsis glandulosa*
Mustang grape	*Vitis mustangensis*

SITE 33

Huisache	*Acacia smallii*
Honey mesquiet	*Prosopsis glandulosa*
Live oak	*Quercus virginiana*

SITE 34

Huisache	*Acacia smallii*
Live oak	*Quercus virginiana*
Rattlebush	*Sesbania drummondii*

SITE 35

Huisache	*Acacia smallii*
Prairie agilinis	*Agalinis heterophylla*
Tumbleweed amaranth	*Amaranthus albus*
King Ranch Bluestem	*Bothriochloa ischaemum*
Coma	*Bumelia lanuginosa*
Sugar hackberry	*Celtis laevigata*
Bermudagrass	*Cynodon dactylon*
Late flowering Boneset	*Eupatorium serotinim*
Seacoast sumpweed	*Iva annua*
Switchgrass	*Panicum virgatum*
Retama	*Parkinsonia aculeata*
Welder machaeranthera	*Psilactis heterocarpa*
Black willow	*Salix nigra*
Rattlebush	*Sesbania drummondii*

Common Name	Scientific Name
Salt cedar	*Tamarix sp.*
Slender vervain	*Verbena officinale*
Golden crownbeard	*Verbensina encelioides*
Mustang grape	*Vitis mustangensis*
Cocklebur	*Xanthium strumarium*

SITE 36

Huisache	*Acacia smallii*
Round copperleaf	*Acalypha radians*
Giant ragweed	*Ambrosia trifida*
Texa maderia-vine	*Anredera vesicaria*
Curly threeawn	*Aristida desmantha*
Annual aster	*Aster subulatus*
Prairie baccharis	*Baccharis texana*
Silver bluestem	*Bothriocloa laguroides ssp. torreyana*
Texas signal grass	*Brachiaria texana*
Chillipiquin	*Capsicum annum*
Sugar hackberry	*Celtis laevigata*
Spiny hackberry	*Celtis pallida*
Partridge Pea	*Chamaecrista fasciculata*
Fringed chloris	*Chloris ciliata*
Hooded windmill grass	*Chloris cucullata*
Texas virginsbower	*Clematis drummondii*
Texas bullnettle	*Cnidoscolus texanus*
Texas colubrina	*Colubrina texensis*
Dayflower	*Commeliana sp.*
Bluewood	*Condalia hookeri*
Woolly croton	*Croton capitatus*
Bermudagrass	*Cynodon dactylon*
Texas persimmon	*Diospyros texana*
Pink eupatorium	*Eupatorium incarnatum*
Christmas bush	*Eupatorium odoratum*
Narrow-leaf thryallis	*Galphimia angustifolia*
Common sunflower	*Helianthus annuus*

Common Name	Scientific Name
Golden aster	*Heterotheca latifolia*
Whorled nod-violet	*Hybanthus verticillatus*
Sharppod morning glory	*Ipomea trichocarpa*
Common lantana	*Lantana horrida*
Welder machaeranthera	*Psilactis heterocarpa*
Red mulberry	*Monus rubra*
Pencil cactus	*Opuntia leptocaulis*
Texas Prickly Pear	*Opuntia lindheimeri*
Switchgrass	*Panicum virgatum*
Retama	*Parkinsonia aculeata*
Honey mesquiet	*Prosopsis glandulosa*
Least snoutbean	*Rhynchosia minima*
Bloodberry	*Rivina humilis*
Karnes sensitive brier	*Schrankia latidens*
Border bonebract	*Sclerocarpus uniserialis*
Short-fruited serjania vine	*Serjania brachycarpa*
Knotroot bristlegrass	*Setaria geniculata*
Southwestern bristlegrass	*Setaria scheelei*
Common goldenrod	*Solidago canadensis*
Johnson grass	*Sorghum halepense*
Mexican wissadula	*Wissadula amplissima*
Lime prickley ash	*Zanthoxylum fagara*

SITE 37a

Berlandier abutilon	*Abutilon berlandieri*
Round copperleaf	*Acalypha radians*
Western ragweed	*Ambrosia commensis*
Texas madrai-vine	*Andredera vesicaria*
Bushy bluestem	*Andropogon glomeratus*
Hierba de zizotes	*Asclepias oenotheroides*
Baccharis	*Baccharis* sp.
Sandbur	*Cenchrus incertus*
Partridge pea	*Chamaecrista fasciculata*
Thick-leaf goosefoot	*Chenopodium pratericola*

Common Name	Scientific Name
Wormseed	*Chenopodium ambrosioides*
Tumble windmill grass	*Chloris verticillata*
Texas bullnettle	*Cnidoscolus texanus*
Dayflower	*Commelina* sp.
Roughleaf dogwood	*Cornus drummondii*
One-seed croton	*Croton monanthogynus*
Texas croton	*Croton texensis*
Woolly croton	*Croton capitatus*
Bermudagrass	*Cynodon dactylon*
One-flower flat-sedge	*Cyperus retroflexus*
Durban crowfoot grass	*Dactyloctemium aegyptium*
Southern crabgrass	*Digitaria ciliaris*
Red love-grass	*Eragrostis secundiflora* var. *oxylepsis*
Toothed spurge	*Euphorbia dentata*
Eustachys	*Eustachys petraea*
Snakecotton	*Frolechia floridana*
Cucumber leaf sunflower	*Helionthus debilis*
Gold-aster	*Heterotheca subaxillaris var. latifolia*
Indigo	*Indigofera suffruticosa*
Sharp pod morning glory	*Ipomoea trichocarpa*
Common lantana	*Lantana horrida*
Angle-pod melochia	*Melocia pyramidata*
Alama vine	*Merremis dissecta*
Spotted beebalm	*Monarda punctata*
Drummond oxalis	*Oxalis drummondii*
Rose palafoxia	*Palafoxia rosea*
Switch grass	*Panicum virgatum*
Retama	*Parkinsona aculeata*
Round-seed paspalum	*Paspalum laevae*
Thin paspalum	*Paspalum setaceum*
Honey mesquite	*Prosopsis glandulosa*
Wand blackroot	*Pterocaulon virgatum*
Umbrella grass	*Rhynchospora colorata*
Least snoutbean	*Rhyncosia minima*
Little bluestem	*Schizachyrium scoparium*

Common Name	Scientific Name
Bristlegrass	*Setaria leucopila*
Plains bristlegrass	*Setaria macrostachya*
Hairy tubetongue	*Siphonoglossa pilosella*
Southern shield fern	*Thelypteris kunthii*
Silveus-grass	*Trichoneura elegans*
Golden Crown beard	*Verbesena encoloides*

SITE 37b

Western ragweed	*Ambrosia cumanensis*
Texas bull nettle	*Cnidoscolus texana*
Dayflower	*Commelina* sp.
Woolly croton	*Croton capitatus*
Bermudagrass	*Cynadon dactylon*
Poon Joe	*Diodia teres*
Pink eupatorium	*Eupatorium incarnatum*
Snakecotton	*Frolechia floridana*
Cucumber leaf sunflower	*Helianthus debilis*
Indigo	*Indigo suffruticosa*
Sharp pod morning glory	*Ipomea trichocarpa*
Pink scale gayfeather	*Liatris elegans*
Texas prickly pear	*Opuntia lindheimeri*
Switch grass	*Panicum virgatum*
Retama	*Parkinsonia aculeata*
Longtom	*Paspalum lividum*
Honey mesquite	*Prosopsis glandulosa*
Golden crown beard	*Verbena encelioides*
Slender vervain	*Verbena halei*
Mexican wissadula	*Wissadula amplissima*
Buckly yucca	*Yucca constricta*

SITE 37c

Common Name	Scientific Name
Western ragweed	*Ambrosia cumanensis*
Annual aster	*Aster subulatus*
Silver beard-grass	*Bothriochloa laguroides* spp. *torreyana*
Prostrate lawnflower	*Calyptocarpus vialis*
Chillipiquin	*Capsicum annuum*
Spiny hackberry	*Celtis pallida*
Texas virgins bower	*Clematis drummondii*
Bermudagrass	*Cynodaon dactlyon*
Bermudagrass	*Cynodon dactylon*
Fall witchgrass	*Digitaria cognatum*
Christmas bush	*Eupatorium odoratum*
Pink eupatorium	*Eupatorium incarnatum*
Cucumber leaf sunflower	*Heliosthus debilis*
Seacoast sumpweed	*Iva annua*
Herbaceous mimosa	*Mimosa strigillosa*
Rose palafoxia	*Palafoxia rosea*
Gaping panicum	*Panicum hians*
Guinea-grass	*Panicum maximum*
Retama	*Parkensonia aculeata*
False ragweed	*Parthenium hysterophorus*
Paspalum	*Paspalum laeve*
Thin paspalum	*Paspulum setaceum*
Honey mesquite	*Prosopsis glandulosa*
Border bonebract	*Sclerocarpus usniserialis*
Coffee bean	*Sesbania macrocarpa*
Knotroot bristlegrass	*Setaria geniculata*
Golden crown beard	*Verbesina encelioides*
Cocklebur	*Xanthium strumanium*

<u>SITE 37d</u>

Golden crownbeard	*Berbesina encelioides*
Grassbur	*Cenchrus incertus*
Goldmane coreopsis	*Coreopsis basalis*
Slender goldenweed	*Croptilon divaricatum*

Common Name	Scientific Name
Snakecotton	*Frolechia floridana*
Indigo	*Indigofera suggruticosa*
Pinkscale gayfeather	*Liatris elegans*
Palafoxia	*Palofoxia rosea*
Wingpod purslane	*Portulaca umbraticoloa*
Honey mesquite	*Prosopsis glandulosa*
Border bonebract	*Sclerocarpus uniserialis*
Knotroot bristlegrass	*Setaria geniculata*
Silverleaf nightshade	*Solanum eleagnifolium*
Texas nightshade	*Solanum triquetrum*
Capitana	*Verbesina microptera*
Buckley yucca	*Yucca constricta*
Lime prickley ash	*Zanthoxylum fagara*

SITE 37e

Huisache	*Acacia smallii*
Western ragweed	*Ambrosia cumanensis*
Kearney threeawn	*Aristida longespica var. geniculata*
Annual aster	*Aster subulatus*
King Ranch bluestem	*Bothriochloa ischaemum var. songarica*
Texas signal grass	*Brachiaria texana*
Coma	*Bumelia lanuginosa*
Prostrate lawnflower	*Calyptocarpus vialis*
Chillipiquin	*Capsicum annuum*
Sugar hackberry	*Celtis laevigata*
Spiny hackberry	*Celtis pallida*
Netleaf hackberry	*Celtis reticulata*
Sandbur	*Cenchrus incertus*
Slimspike windmill grass	*Chloris andropogonoides*
Hooded windmill grass	*Chloris cucullata*
Marine vine	*Cissus incisa*
Texas virgins bower	*Clematis drummondii*
Texas bull nettle	*Cnidoscolus texana*
Carolina snailseed	*Cocculus carolinus*

Common Name	Scientific Name
Texas colubrina	*Colubrina texensis*
Dayflower	*Commelina* sp.
Bluewood	*Condalia hookeri*
Goldmane coreopsis	*Coreopsis basalis*
Slender goldenweed	*Croptilon divaricatum*
Woolly croton	*Croton capitatus*
Bermuda grass	*Cynodon dactylon*
Poor joe	*Diodia teres*
Texas persimmon	*Diospyros texana*
Anacua	*Ehretia anacua*
Stink grass	*Eragrostis cilianensis*
Plains lovegrass	*Eragrostis intermedia*
Red lovegrass	*Eragrostis secundiflora var. oxylepsis*
Purple lovegrass	*Eragrostis spectabilis*
Heart-sepal wild buchwheat	*Eriogonum multiflorum*
Pink eupatorium	*Eupatorium incarnatum*
Christmas bush	*Eupatorium odoratum*
Narrow-leaf forestiera	*Forestiera angustifolia*
Snakecotton	*Frolechia floridana*
Neally glob amaranth	*Gomphrena nealleyi*
Common sunflower	*Helianthus annuus*
Cucumberleaf sunflower	*Helianthus debilis*
Gold aster	*Heterotheca subaxillaris var. latifolia*
Sharp pod morning glory	*Ipomoea trichorcarpa*
Seacoast sumpweed	*Iva annua*
West indian lantana	*Lantana camara*
Common lantana	*Lantana horrida*
Pinkscale gayfeather	*Liatris elegans*
Alamo vine	*Merremia dissecta*
Herbaceous mimosa	*Mimosa strigillosa*
Red mulberry	*Morus rubra*
Showy primrose	*Oenothera speciosa*
Texas prickly pear	*Opuntia lindheimeri*
Drummond oxalis	*Oxalis drummondii*
Rose palafoxia	*Palafoxia rosea*
Gaping panicum	*Panicum hians*
Switch grass	*Panicum virgatum*

Common Name	Scientific Name
Retama	*Parkinsonia aculeata*
False ragweed	*Parthenium hysterophorus*
Longtom	*Paspalum lividum*
Tagua passion flower	*Passiflora foetida*
Saw-tooth frog-fruit	*Phyla incisa*
Bitter orange	*Poncirus trifoliata*
Wingpod purslane	*Portulaca umbraticola*
Honey mesquite	*Prosopsis glandulosa*
American snoutbean	*Rhynchosia americana*
Bloodberry	*Rivina humilis*
Tropical sage	*Salvia coccinea*
Short-fruited serjania-vine	*Serjania brachycarpa*
Coffee bean	*Sesbania macrocarpa*
Knotroot bristlegrass	*Setaria geniculata*
Texas nightshade	*Solanum triquetrum*
Texas grass	*Vaseyochloa multinervosa*
Slender vervain	*Verbena officinale spp. halei*
Golden crown-beard	*Verbesina enceloides*
Capitana	*Verbesina microptera*
Wissadula	*Wissadula amplissima*
Cocklebur	*Xanthium strumarium*
Buckly yucca	*Yucca constricta*
Spanish dagger	*Yucca treculeana*
Lime prickly ash	*Zanthoxylum fagara*
Lotebush	*Zizyphus obtusifolia*
Coma	*Bumelia longuginosa*

SITE 38a

Huisache	*Acacia smalli*
Palmer amaranth	*Amaranthus palmeri*
Western ragweed	*Ambrosia cumanensis*
King Ranch bluestem	*Bothriochloa ischaemum* var. songarica
Silver bluestem	*Bothriochloe laguroides* var. torreyana

Common Name	Scientific Name
Buffalo grass	*Buchloe dactyloides*
Buffalo grass	*Buchloe dactyloides*
Spiny hackberry	*Celtis pallida*
Sugar hackberry	*Celtis laevigata*
Sandbur	*Cenchrus inceru*
Fringed chloris	*Chloris ciliata*
Jones rainlily	*Cooperia jonesi*
One-seed croton	*Croton monanthogynus*
Woolly croton	*Croton capitatus*
Bermuda grass	*Cycodon dactylon*
Bermuda grass	*Cynodon dactylon*
Southern crabgrass	*Digitaria ciliaris*
Anacua	*Ehretia anacua*
Red lovegrass	*Eragrostis secundiflora*
Prairie cupgrass	*Ericochloa contracta*
Isocoma	*Isocoma drummondii*
Mexican sprangletop	*Leptochloa uninervia*
Pencil cactus	*Opuntia leptocaulis*
Texas prickly pear	*Opuntia lindheimeri*
Dillens oxalis	*Oxalis dillenii*
Drummond oxalis	*Oxalis drummondii*
Rose palafoxia	*Palafoxia rosea*
Retama	*Parkinsonia aculeata*
False ragweed	*Parthenium hysterophorus*
Mesquite	*Prosopsis glandulosa*
Knotroot bristlegrass	*Setaria geniculata*
Southwestern bristlegrass	*Setaria scheelei*
Ball moss	*Tillandsia recurvata.*
Brazilian vervain	*Verbena brasiliensis*
Golden crownbeard	*Verbesina enceloides*

Common Name	Scientific Name
SITE 38b	
Huisache	*Acacia smallii*
Bushy bluestem	*Andropogon glomeratus*
Annual aster	*Aster subulatus*
Bushy sea-ox-eye	*Borrichea frutescens*
Multiflowered false rhodesgrass	*Chloris pluriflora*
Jointed flatsedge	*Cyperus articulata*
Nutgrass	*Cyperus rotundus*
Coastal saltgrass	*Distichlis spicata*
Haplopappus	*Haplopappus phyllocephalus*
Salt helitrope	*Heliotropium curassavicum*
Pepperwort	*Marsilea vestita*
Gaping panicum	*Panicum hians*
Retama	*Parkinsonia aculeata*
Purple pluchea	*Pluchea odorata*
Bushy knotweed	*Polygonum ramosissimum*
Wingpod purslane	*Portulaca umbraticola*
Mesquite	*Prosopsis glandulosa*
Violet ruellia	*Ruellia nudiflora*
Longlobe arrowhead	*Sagittaria longiloba*
Black willow	*Salix nigra*
Saltmarsh bulrush	*Scirpus robustus*
Coffee bean	*Sesbania macrocarpa*
Gulfcoast cordgrass	*Spartina spartinae*
Annual seepweed	*Suadeda liniaris*
Salt cedar	*Tamarix* sp.
Cattail	*Typha* sp.

Common Name	Scientific Name
SITE 38c	
Huisache	*Acacia smallii*
Bermuda grass	*Cynodon dactylon*
Gulf cordgrass	*Spartina spartinae*
Cattail	*Typha* sp.
Golden crownbeard	*Verbesina enceloides*
SITE 39	
Huisache	*Acacia smallii*
Spiny aster	*Aster spinosa*
Sugar hackberry	*Celtis laevigata*
Green ash	*Fracinus pennsylvanica*
Carolina wolfberry	*Lycium carolinianum var quadrifidum*
Retama	*Parkinsonia aculeata*
Gulfcoast cordgrass	*Spartina spartinae*

APPENDIX N

Summaries of Water Rights for Adjacent Coastal River Basins

Table N-1
Nueces - Rio Grande River Basin
Water Rights of Record, Authorized Amounts and Reported Use

CONSUMPTIVE RIGHTS								
Type of Use	Authorized Amount AF/YR	Number of Rights	Average Reported Use		Maximum Reported Use		Minimum Reported Use	
			AF/YR	%	AF/YR	%	AF/YR	%
Municipal	7725	4	2286	30	5623	73	144	2
Irrigation	54,164	57	4021	7	11,425	21	653	1
Other	0	6	0	0	0	0	0	0
Industrial Consumptive	24,448	9	4720	19	8080	33	0	0
Total Consumptive	86,337	85	11,627	13	18,536	21	5547	6
NON-CONSUMPTIVE RIGHTS								
Type of Use	Authorized Amount AF/YR	Number of Rights	Average Reported Use		Maximum Reported Use		Minimum Reported Use	
			AF/YR	%	AF/YR	%	AF/YR	%
Recreation Non-consumptive	10,427	9	408	4	7104	68	0	0
Total Non-consumptive	1,517,717	18	849,470	56	1,065,772	70	245,904	16

Table N-2
Summary of Surface Water Rights
San Antonio-Nueces Coastal Basin

Permit Number	Applicant or Appropriator	County	Stream Name	Use	Authorized Diversion (Acft/Yr)	Acres Irrig.	Storage Capacity (Acft)	Priority Date	Remarks
004237 004547*	E I DuPont de Nemours	San Patricio	La Quinta Chnl	Industrial	4000	0	--	03/12/85	
-- 004497*	U S Aransas Nat'l Wildlife Refuge	Aransas	Burgentine	Recreation	7685	--	700	12/31/39	Also 2 natural lakes
-- 004499*	C W Marshall	Refugio	Mission	Recreation	95	--	56	04/20/81	
-- 004498*	Mary P. Dougherty Etal	Bee	Peoples Hollow	Recreation	--	--	240	09/08/53	
004235 004521*	North Shore Associates, Inc.	San Patricio	Unnamed	Irrigation	557	185	261	11/27/84	Trib Corpus Christi Bay
-- 004501*	Refugio Co. WCID #2	Refugio	Aransas	Recreation	--	--	150	07/06/70	
-- 004500*	H A & J S Hudson	Bee	Poesta	Irrigation	60	93	4	01/24/70	Effluent from Beeville & Air Station
-- 004502*	Reynolds Metals Co.	Aransas	Unnamed	Irrigation	15	137	360	07/06/70	Trib of Swan Lake
005100 005100*	J T Stellman	Aransas	Port Bay	Industrial	6	--	11	10/02/86	Fish Farming
005024A 005024A*	Reynolds Metal Company	Aransas	Port Bay	Industrial	12000	--	--	10/16/85	Amended 9/4/86
004115 004415*	H J Ewald Jr.	Aransas	Unnamed	Industrial	10	--	--	11/28/83	Trib Intracoastal Waterway
-- 004503*	Texas A&M University	Nueces	Intercoastal	Industrial	1	--	--	07/31/72	Shrimp Culture-53 Ponds

* Denotes State Master Number.

APPENDIX O

1995 Agreed Order to Certificate of Adjudication No. 21-3214

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

DOCKET NO. 95-0616-WR

IN RE: AGREED ORDER ESTABLISHING OPERATIONAL PROCEDURES PERTAINING TO SPECIAL CONDITION 5.B., CERTIFICATE OF ADJUDICATION NO. 21-3214, HELD BY THE CITY OF CORPUS CHRISTI, NUECES RIVER AUTHORITY, AND THE CITY OF THREE RIVERS	§ § § § § § § § §	BEFORE THE TEXAS NATURAL RESOURCE CONSERVATION COMMISSION

AN AGREED ORDER amending the operational procedures and continuing an Advisory Council pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214

On April 26, 1995, came to be considered before the Texas Natural Resource Conservation Commission ("Commission") the Motion by the City of Corpus Christi for the adoption of an Agreed Order establishing operating procedures pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214, held by the City of Corpus Christi, the Nueces River Authority, and the City of Three Rivers" (the two cities and river authority shall be referred to herein as "Certificate Holders").

After hearing and considering the proposed operational procedures and the presentations of the parties, the Commission finds that it has authority to establish operational procedures under Special Condition 5.B. of Certificate of Adjudication No. 21-3214, and that operational procedures previously established should be amended. The Commission finds that, because of the need to continue to monitor the ecological environment and health of related living marine resources of the estuaries to assess the effectiveness of freshwater inflows provided by requirements contained in this Agreed Order relating to releases and spills from Choke Canyon Reservoir and Lake Corpus Christi (collectively referred to as the Reservoir System), as well as return flows, and to evaluate potential impacts which may occur to the reservoirs as well as to the availability of water to meet the needs of the Certificate Holders and their customers which may result from those operational procedures, the existing advisory council should be maintained to consider such additional information and related issues and to formulate recommendations for the Commission's review.

The Commission additionally finds that based on the preliminary application of the Texas Water Development Board's Mathematical Programming Optimization Model, (GRG-2), 138,000 acre-feet of fresh water is necessary to achieve maximum harvest in the Nueces Estuary and, therefore, when water is impounded in the Lake Corpus Christi-Choke Canyon Reservoir System to the extent greater than 70 percent of the system's storage capacity, the delivery of 138,000 acre-feet of water to Nueces Bay and/or the Nueces Delta, by a combination of releases and spills, together with diversions and return flows noted below, should be accomplished; and that during periods when the reservoir system contains less than 70 percent storage capacity, reductions in releases and spills, along with diversions and return flows, are appropriate in that a satisfactory level of marine harvest will be sustained and the ecological health of the receiving estuaries will be maintained.

The Commission further finds that return flows, other than to Nueces Bay and/or the Nueces Delta, that are delivered to Corpus Christi Bay and other receiving estuaries are currently in the assumed amount of 54,000 acre-feet per annum (per calendar year), and that they shall be credited at this amount until such time as it is shown that actual return flows to Corpus Christi Bay and other receiving estuaries exceed 54,000 acre-feet per annum.

The Commission finds that by contractual relationships, the City of Corpus Christi is the managing entity for operating the Reservoir System.

When the Commission uses the word "release" in this Order, release means spills, inflow passage, intentional releases, and return flows; provided, however, under this Order no release from storage is required to meet conditions of this Order.

By consenting to the issuance of this Agreed Order, no party admits or denies any claim, nor waives with respect to any subsequent proceeding any interpretation or argument which may be contrary to the provisions of this Agreed Order.

NOW, THEREFORE, BE IT ORDERED BY THE TEXAS NATURAL RESOURCE CONSERVATION COMMISSION THAT:

1. a. The City of Corpus Christi, as operator of the Choke Canyon/Lake Corpus Christi reservoirs (the "Reservoir System"), shall provide not less than 151,000

acre-feet of water per annum (per calendar year) for the estuaries by a combination of releases and spills from the Reservoir System at Lake Corpus Christi Dam and return flows to Nueces and Corpus Christi Bays and other receiving estuaries (including such credits as may be appropriate for diversion of river flows and/or return flows to the Nueces Delta and/or Nueces Bay), as computed and to the extent provided for herein.

b. When water impounded in the Reservoir System is greater than or equal to 70 percent of storage capacity, a target amount of 138,000 acre-feet is to be delivered to Nueces Bay and/or the Nueces Delta by a combination of releases and spills from the Reservoir System as well as diversions and return flows. In accordance with the monthly schedule and except as provided otherwise in this Agreed Order, target inflows to Nueces Bay and/or the Nueces Delta shall be in the acre-foot amounts as follow:

January	2,500	July	6,500
February	2,500	August	6,500
March	3,500	September	28,500
April	3,500	October	20,000
May	25,500	November	9,000
June	25,500	December	4,500

It is expressly provided, however, that releases from Reservoir System storage shall not be required to satisfy the above targeted inflow amounts, as calculated in Subparagraph d.

c. When water impounded in the Reservoir System is less than 70 percent but greater than or equal to 40 percent of storage capacity, a targeted amount of 97,000 acre-feet is to be delivered to Nueces Bay and/or the Nueces Delta by a combination of releases and spills from the Reservoir System as well as diversions and return flows. In accordance with the monthly schedule and except as provided otherwise in this Agreed Order, target inflows to Nueces Bay and/or the Nueces Delta shall be in the acre-foot amounts as follows:

January	2,500	July	4,500
February	2,500	August	5,000
March	3,500	September	11,500
April	3,500	October	9,000
May	23,500	November	4,000
June	23,000	December	4,500

It is expressly provided, however, that releases from Reservoir System storage shall not be required to satisfy the above targeted inflow amounts as calculated in Subparagraph d.

d. The amounts of water required in subparagraphs 1.b. and 1.c. will consist of return flows, and intentional diversions, as well as spills and releases from the Reservoir System as defined in this subparagraph. For purposes of compliance with monthly targeted amounts prescribed above, the spills and releases described in this paragraph shall be measured at the U. S. Geological Survey stream monitoring station on the Nueces River at Calallen, Texas (USGS Station No. 08211500). Any inflows, including measured wastewater effluent and rainfall runoff meeting lawful discharge standards which are intentionally diverted to the upper Nueces Bay or its associated Nueces Delta region, shall be credited toward the total inflow amount delivered to Nueces Bay and/or the Nueces Delta.

Inflow passage from the Reservoir System for the purpose of compliance with the monthly targeted amounts prescribed in subparagraphs 1.b. and 1.c. shall in no case exceed the estimated inflow to Lake Corpus Christi as if there were no impoundment of inflows at Choke Canyon Reservoir. The estimated inflow to Lake Corpus Christi as if there were no impoundment of inflows at Choke Canyon Reservoir shall be computed as the sum of the flows measured at the U.S. Geological Survey (USGS) streamflow gaging stations on the Nueces River near Three Rivers, Texas (USGS No. 08210000), Frio River at Tilden, Texas (USGS No. 08206600), and San Miguel Creek near Tilden, Texas (USGS No. 08206700) less computed releases and spills from Choke Canyon Reservoir.

e. The passage of inflow necessary to meet the monthly targeted allocations may be distributed over the calendar month in a manner to be determined by the City. Relief from the above requirements shall be available under subparagraphs (1) or (2) below and Section 2(b) and 3(c) at the option of the City of Corpus Christi. However, passage of inflow may only be reduced under one of those subparagraphs below, for any given month.

(1) Inflows to Nueces Bay and/or the Nueces Delta in excess of the required monthly targeted amount may be credited for up to fifty (50) percent of the targeted requirement for the following month, based on the

amount received.

(2) When the mean salinity in Upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52") for a 10-day period, ending at any time during the calendar month for which the reduction of the passage of inflow is sought, is below the SUB[1], pass through of inflow from the reservoir system for that same calendar month may be reduced as follows:

(a) For any month other than May, June, September and October, if 5 ppt below the SUB for the month, a reduction of 25% of the current month's targeted Nueces Bay inflow;

(b) If 10 ppt below the SUB for the month, a reduction of 50% of the current month's targeted Nueces Bay inflow except that credit under this provision is limited to 25% during the months of May, June, September and October;

(c) If 15 ppt below the SUB for that month, a reduction of 75% of the current month's targeted Nueces Bay inflow.

f. The City of Corpus Christi shall submit monthly reports to the Commission containing daily inflow amounts provided to the Nueces Estuary in accordance with this Agreed Order through releases, spills, return flows and other freshwater inflows.

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[1] "SUB" means "salinity upper bounds" as set forth more specifically in Section 3.b.

2. a. Certificate holders are to provide in any future contracts or any amendments, modifications or changes to existing contracts the condition that all wholesale customers and any subsequent wholesale customers shall develop and have in effect a water conservation and drought management plan consistent with Commission rule. The City of Corpus Christi shall solicit from its customers and report to the Commission annually the result of conservation under the City's plan, the customers' plans, and the feasibility of implementing conservation plans and programs for all users of water from the reservoir system. This report shall be submitted with the Certificate Holder's annual water use report as provided by 31 T.A.C. §295.202.

b. The Certificate Holders may obtain relief from targeted Nueces Bay inflows during times of prolonged drought in accordance with subparagraphs b(l) -b(3).

(1) In any month when water impounded in the Reservoir System is less than 40 percent but equal to or greater than 30 percent of storage capacity, the City of Corpus Christi may reduce targeted inflows to Nueces Bay to 1,200 acre-feet per month[2], when the City has implemented and required its customers to implement Condition II - Drought Watch as described in the City of Corpus Christi's "Water Conservation and Drought Contingency Plan" ("Plan").

(2) In any month when water impounded in the Reservoir System is less than 30 percent of the storage capacity, the City of Corpus Christi may suspend the passage of inflow from the Reservoir System for targeted inflow purposes to

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[2] 1,200 acre-feet per month represents the quantity of water that is the median inflow into Lake Corpus Christi during the drought of record.

Nueces Bay, when the City has implemented and required its customers to implement Condition III - Drought Warning as described in the Plan. However, return flows directed into Nueces Bay and/or the Nueces Delta shall continue to be made.

(3) Certificate Holders' rights to obtain whole or partial suspension of the passage of inflow through the reservoir, is contingent upon the City implementing and requiring its customers to implement water conservation measures and levels of drought management, and diminished reservoir system levels, as set forth in subparagraphs b(l) and b(2). However, the decision whether to avail itself of relief from inflow passage, through the initiation of drought management levels, is solely that of the Certificate Holders. The initiation of drought management levels set forth in subparagraph b(l) shall not be a prerequisite to the Certificate Holders' rights to avail themselves of complete suspension of inflow passage as provided for in subparagraph b(2) . However, suspension of inflow passage pursuant to subparagraph b(2) shall not be available unless Condition III is implemented during the month water impounded in the Reservoir System drops below 30 percent.

c. For purposes of this Agreed Order, Reservoir System storage capacity shall be determined by the figures contained in the "Regional Water Supply Planning Study - Phase I Nueces River Basin (December 1990)" by HDR and based on 1990 sedimentation conditions. According to the Study, the storage capacity for Choke Canyon Reservoir is 689,314 acre-feet (220.5 feet mean sea level) and the storage capacity for Lake Corpus Christi is 237,473 acre-feet (94 feet mean sea level) making total Reservoir System storage capacity equal to 926,787 acre-feet.

d. Percentage of the Reservoir System capacity shall be determined on a daily basis and shall govern, in part, the inflow to be passed through the reservoir during the remaining days of the month.

e. Within the first ten days of each month, the City of Corpus Christi shall submit to the Commission a monthly report containing the daily capacity of the Reservoir System in percentages and mean sea levels as recorded for the previous month as well as reservoir surface areas and estimated inflows to Lake Corpus Christi assuming no impoundment of inflows at Choke Canyon Reservoir. The report shall indicate which gages or measuring devices were used to determine Reservoir System capacity and estimate inflows to Lake Corpus Christi.

3. a. The City of Corpus Christi, with the assistance and/or participation of federal, state and local entities, shall maintain a monitoring program to assess the effect of this operating plan on Nueces Bay. The cornerstone of this program is the development of a salinity monitoring program. The program shall include at least two monitoring stations, one in upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52") and one in mid Nueces Bay (Lat. 27°51'25", Long. 97°25'28") with the capability of providing continuous salinity and/or conductivity data, temperature, pH, and dissolved oxygen levels. Additional stations may be established at the recommendation of the Advisory Council (continued by

paragraph 4 of this Agreed Order) to assess inflow effects throughout the estuarine system, but the City shall not be obligated to establish such additional stations except to the extent authorized by its City Council.

b. The City of Corpus Christi or its designated representatives shall monitor salinity levels in Upper and Mid-Nueces Bay. The lower (SLB) and upper (SUB) salinity bounds (in parts per thousand-ppt) developed for application of the Texas Estuarine Mathematical Programming Model and considered appropriate for use herein, are as follows:

	SLB	SUB		SLB	SUB
January	5	30	July	2	25
February	5	30	August	2	25
March	5	30	September	5	20
April	5	30	October	5	30
May	1	20	November	5	30
June	1	20	December	5	30

c. When the average salinity for the third week (the third week includes the seven days from the 15th through 21st) of any month is at or below the subsequent month's established SLB for upper Nueces Bay (Lat. 27°51'02", Long. 97°28'52"), no releases from the Reservoir System to satisfy targeted Nueces Bay inflow amounts shall be required for that subsequent month.

d. All data collected as a result of the monitoring program required by paragraph 3 of this Agreed Order shall be submitted monthly to the Commission within the first ten days of the immediately following month. The Nueces Estuary Advisory Council shall study the feasibility of developing a method of granting credits for inflows which exceed the required amounts to replace the credits that are set out in subparagraph 1.e.(1) and make recommendations to the Commission for possible implementation. That method shall have as its goal the maintenance of the proper ecological environment and health of related living marine resources and the provision of maximum reasonable credits towards monthly inflow requirements.

4. a. To assist the Commission in monitoring implementation of this Order and making recommendations to the Commission relating to any changes to this Agreed Order and the establishment of future operating procedures, the Nueces Estuary Advisory Council shall be continued. Its members shall include, but are not limited to a qualified representative chosen by each of the following entities or groups: the Executive Director of the Texas Natural Resource Conservation Commission, whose representative shall serve as chair; the Texas Water Development Board; the Texas Parks and Wildlife Department; the Texas Department of Health; the General Land Office; the holders of Certificate of Adjudication No. 21-3214 (the Cities of Corpus Christi and Three Rivers and the Nueces River Authority); the University of Texas Marine Science Institute; Texas A&M University - Corpus Christi; Save Lake Corpus Christi; Corpus Christi Bay Area Business Alliance; the City of Mathis; a commercial bay fishing group; a

conservation group (e.g. the Sierra Club or the Coastal Bend Bays Foundation); wholesale water suppliers who are customers of the Certificate Holders (e.g., the South Texas Water Authority and the San Patricio Municipal Water District); the Port of Corpus Christi Authority; and a representative of industry. The representatives should have experience and knowledge relating to current or future water use and management or environmental and economic needs of the Coastal Bend area.

b. No modification shall be made to this Order without the unanimous consent of the Certificate Holders, except to the extent provided by law.

c. Matters to be studied by the Nueces Estuary Advisory Council and upon which the Executive Director shall certify recommendations to the Commission shall include, but are not limited to:

(1) the effectiveness of the inflow requirements contained in this Agreed Order on Nueces Estuary and any recommended changes;

(2) the effect of the releases from the Reservoir System upon the aquatic and wildlife habitat and other beneficial and recreational uses of Choke Canyon Reservoir and Lake Corpus Christi;

(3) the development and implementation of a short and long-term regional water management plan for the Coastal Bend Area;

(4) the salinity level to be applied in Paragraphs 1.e. and 3.c., at which targeted inflows in the subsequent month may be suspended;

(5) the feasibility of discharges at locations where the increased biological productivity justifies an inflow credit computed by multiplying the amount of discharge by a number greater than one; and development of a methodology for granting credits for inflows which exceed the required amount to replace the credits that are set out in subparagraph 1.e. That methodology shall have as its goal the maintenance of the proper ecological environment and health of related living marine resources and the provision of maximum reasonable credits towards monthly inflow requirements; and,

(6) any other matter pertinent to the conditions contained in this Agreed Order.

5. This Agreed Order shall remain in effect until amended or superseded by the Commission.

Issued date: APR 28 1995

TEXAS NATURAL RESOURCE
CONSERVATION COMMISSION

John Hall

John Hall, Chairman

ATTEST:

Laurie Schmaster
for Gloria A. Vasquez, Chief Clerk

corpus\order95.002

APPENDIX P

Clarifications and Explanations

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The purpose of this appendix is to clarify and explain selected phrases and statements of Volumes I and II. Each such phrase or statement is referenced as to location and is followed with explanatory and clarifying commentary.

- Volume I, Page 22: In Table 5-5, the term "uncertainty" is used as a potential permitting issue for option L-1 (Desalination of Seawater). This term is used because there is very little history of such permits having been issued in Texas, consequently there is little procedure or experience from which to draw; i.e., a precedent has not been established whereby brine disposal permits have been issued for the discharge of desalination plant concentrates in ocean environments.
- Volume I, Page 22: In Table 5-5, the terms "uncertain water rights issues" are listed as permitting issues for option GS-1 (Diversion from Guadalupe/San Antonio Rivers). In this case, the term is used since the water needs of the Guadalupe/San Antonio Basins have not been taken into account in this specific analysis; i.e.; it is not known whether or not there is sufficient surplus water in the Guadalupe/San Antonio Basins to allow a permit to be issued to an out-of-basin water user, such as Corpus Christi and its regional customers.
- Volume I, Page 22: In Table 5-5, the word "uncertain" is used with respect to obtaining necessary environmental permits for dredge disposal for Option N-7 (Dredging Lake Corpus Christi). Since this is not now a standard and widely use practice in lake management, for which there is an established permitting procedure, it is not clear that a suitable site can be located and permits obtained for the disposal of sediments that would have to be dredged from Lake Corpus Christi.
- Volume II, Page 3-7: A comprehensive environmental data base is referenced. More specifically, in Appendix C, Table 22, the environmental effects of each of the 22 water supply alternatives are compared. In volume II, pages 4-3 and 4-4, the acreages

affected by each alternative are shown numerically and graphically. The options having the lowest affected acreages ranked highest in the recommended regional water supply plans.

Volume II, Page 3-45: The detail of the environmental analyses varied among the water supply options that were studied. The differences in analyses performed on the options depended upon the strategies determined for supplying Corpus Christi's future water needs. In the Environmental Overview, Section 3.0.2, there is a summary comparison of the alternatives and a categorization of the alternative water supply strategies: water budget alternatives, desalination, interbasin transfers, new reservoir construction, groundwater and underground pipeline installation. Environmental criteria which are important to consider under some alternatives are not relevant to other alternatives. Fluctuations in lake levels were considered in Section 3.1, Modify Existing Reservoir Operating Policy (N-1), because this alternative dealt with increasing water supply by changing reservoir operating policy. Changes in lake levels of Choke Canyon were also discussed under Section 3.18, Groundwater Recharge and Recovery (Carrizo/Wilcox Aquifer) (L-7). Alternative L-7 involved using Choke Canyon Reservoir to supply water to the aquifer during wet periods and for storing water from the aquifer during dry periods. Like Alternative N-1, Alternative L-7 involved changes to the historical function of an existing reservoir.

- Volume II, Page 3-46: The statement is made that, "Water level fluctuations in both reservoirs (Choke Canyon and Lake Corpus Christi) might be expected to adversely affect nesting success in Centrarchid game fish only if severe (>1 meter/month), prolonged fluctuations occur during the spawning period (March--September)." The statement does not mean that only Centrarchid game fish would be affected. Other fish that nest in shallows, like Centrarchids, can be expected to be affected by rapid changes in lake levels during the nesting season. It is important to note that the Texas Parks and Wildlife Department is conducting surveys of fish populations of Lakes Corpus Christi and Choke Canyon. Some results are presented below.

Lake Corpus Christi, a 21,900 acre reservoir was built in 1958 to provide water for Corpus Christi and the Coastal Bend area of Texas. Lake Corpus Christi has a mean depth of 13.6 feet and a maximum depth of 39.8 feet. The reservoir fluctuates annually 1 to 5 feet with greater fluctuations during periods of drought (Reed and Jons, 1994a).[1] Choke Canyon is a 26,000 acre reservoir built in 1982 to provide water for Corpus Christi and other cities of a 10-county area of South Texas. During the Texas Parks and wildlife Department's survey conducted in the summer of 1993, lake levels in Choke Canyon dropped 4 feet (Reed and Jons, 1994b).[2] Although surface levels of Choke Canyon fluctuate, Texas Parks and Wildlife Department monitors and manages a sport fishery at the lake, and bass and catfish are abundant (Cox, 1994).[3] Lake level changes compared between the alternative operational policies described in the report are within the range of historical fluctuations for these lakes (Reed and Jons, 1994a,b). Because Lake Corpus Christi and Choke Canyon are shallow with large surface areas, and located in a semiarid region, drought tends to be the most significant factor potentially impacting the ecology of the lakes. Although changing between the alternative operating policies considered in the report would result in changes in lake levels, these would not be expected to produce changes in the frequency or magnitude of fluctuations greater than those occurring in the past.

- Volume II, Environmental Sections: References are made to lists of protected and endangered species. These lists are in Appendix C, Tables 1 through 20.
- Volume II, Page 3-159: Costs are presented for small scale Multiple-effect distillation (MED) desalination plants located in the Virgin Islands. This reference to MED was included as a part of the information about available desalination methods, and to let the reader know that this method of desalination has not been used in the United States. It is important to note, that where this method has been used in the Virgin Islands, that the plants are small and the cost per 1,000 gallons is quite high.

[1] Reed, M. and G. Jons. 1994a. Statewide Freshwater Fisheries Monitoring and Management Program. Survey Report for Lake Corpus Christi, 1993.

[2] Reed, M. and G. Jons. 1994b. Statewide Freshwater Fisheries Monitoring and Management Program. Survey Report for Choke Canyon Reservoir, 1993.

[3] Cox, J. 1994. Best State Park Fishing Holes. Texas Parks and Wildlife, Vol 52, No 7.

However, the experience with this method has not been in the size ranges that would necessairily be applicable to Corpus Christi.

- Volume II, Page 3-160: The statement is made that, "A single pass/stage seawater RO plant will produce water with a TDS of 300-500 mg/L, most of which is sodium and chloride;" and that, "The product water will be corrosive, but this may be acceptable, if a source of blending water is available." The reason the product water is expected to be corrosive is that pretreatment will probably result in a lowering of the pH to around 4, which is a level that would be corrosive. However, such water would be blended with Corpus Christi's present supply, or otherwise buffered, and thereby made usable. The statement was made in order to recognize that demineralized seawater via the Reverse Osmosis method would be expected to have corrosive properties that would require special attention and additional costs to be made usable.
- Volume II, Page 3-206: The discussion of a seawater desalination plant location includes a statement that "due to the high economic value and environmental sensitivity of both Padre and Mustang Islands, the most acceptable plant location would be a mainland site, rather than an island site." Consideration could be given for utilizing the Barney Davis Power Plant intake structure or cooling water storage ponds for feedwater, with Central Power and Light Company's (CP&L) concurrence. However, siting considerations for a seawater desalination plant would be similar to those of any comparably sized industrial facility. This would include land cost, environmental mitigation for any endangered species, unique biological communities, wetlands and cultural resources, site access, and compatibility with adjacent property uses, and other coastal zone issues. Although Barney Davis's discharge water and the discharge water from a seawater desalination process are classified as industrial wastes, Barney Davis' is primarily classified, as such, due to thermal impacts which are mitigated through retention in a holding pond prior to discharge into adjacent waters. The discharge from a desalination plant is much higher in TDS and would have significantly more environmental impacts. Due to the expected environmental

and regulatory constraints on bays or estuary discharges, the desalination facilities considered feasible for Corpus Christi would necessitate the waste concentrate being discharged several miles offshore in the Gulf of Mexico. Therefore, for these reasons, plus the major environmental, regulatory, and market issues involving electric power plant operations, it does not appear to be feasible to suggest that the intakes and discharges for a seawater desalination plant for the South Central Trans-Texas region be located at or near the Barney Davis Power Plant.

- Volume II, Page 3-281: The potential effects of sediment transport reductions to the Guadalupe Estuary by construction of Goliad Reservoir were not listed among the potential environmental effects of this alternative. However, this is a factor which should be thoroughly studied if this option is given further consideration, since data on sediment transport in the San Antonio and Guadalupe Rivers are limited.[4,5] For example, it is generally believed that reservoirs trap at least 80 percent of the sediment carried into them by the supplying tributaries. However, in a recent study of sedimentation trapping rates in Lake Texana performed by the Bureau of Reclamation it was estimated that only about 20 percent of the sediment is trapped.[6] A large portion of the total sediment load passes through Lake Texana during flood flows. When adequate baseline data concerning sediment transport in the San Antonio and Guadalupe Rivers is collected and correlated with sediment deposition in the Guadalupe-San Antonio Estuary, it may then be possible to develop statistical models of sediment transport and deposition. Once adequate models are developed, it may become possible to test hypotheses concerning sedimentation changes caused by potential reservoirs like Goliad.
- Volume II, Pages 3-317 through 3-342: The scope of the analysis was directed toward permitting issues and protected species. However, in order to accommodate the regulatory agencies' focus on habitat protection and analyze potential affects on

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[4] Holly, E.R., 1992. Sediment Transport in The Lower Guadalupe and San Antonio Rivers. Texas Water Resources Institute. Texas A&M University.

[5] White, W. A., and T. R. Calnan, 1989. Sedimentation in Fluvial-Deltaic Wetlands and Estuarine Areas, Texas Gulf Coast. Texas Parks and Wildlife Department, Resource Protection Division.

[6] Ibid.

species using a more comprehensive habitat/ecosystem approach, a thorough description of vegetational communities and habitats represented in project activity areas was provided. The plant species and communities listed by the Texas Organization for Endangered Species (TOES) were considered, and important TOES plant species were given special attention in the field surveys.[7] TOES plant species within the project area are listed in the text on page 3-329. Additionally, Welder machaeranthera and plains gumweed were the only TOES species observed during the field surveys. These plants are described in the text. From the perspective of individual animals, most vertebrates are highly mobile most of the time and can avoid localized construction impacts. However, consideration has been given in the report to critical nesting seasons as, for example, Attwater's prairie chicken. Habitat destruction and the effectiveness of mitigation programs will determine impacts to all unprotected species.

[7] Texas Organization For Endangered Species (TOES), a volunteer organization, provides a watch list of species whose survival and range are endangered. TOES watch lists are updated at five-year intervals while Texas Parks and Wildlife Department and U.S. Fish and Wildlife Service reflect the current conservation concerns of permit agencies. In March 1995, TOES Animal Committee updated the vertebrate list to reflect U.S. Fish and Wildlife candidate species and the rarity ranks assigned by the Texas Natural Heritage Program. Future TOES watch lists will be updated in the newsletter, *News and Notes*, and organizational activities will focus on conservation and technical assistance to regulatory agencies. In keeping with a focus on the importance of protecting habitat, TOES supports a habitat/ecosystem approach to protecting species.