East Texas Region

Special Study No. 1:

Inter-Regional Coordination on the Toledo Bend Project

Prepared for:

East Texas Regional Water Planning Group

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FINAL REPORT

March 2009

East Texas Region – Special Study No. 1
Inter-Regional Coordination on the Toledo Bend Project

March 25, 2009

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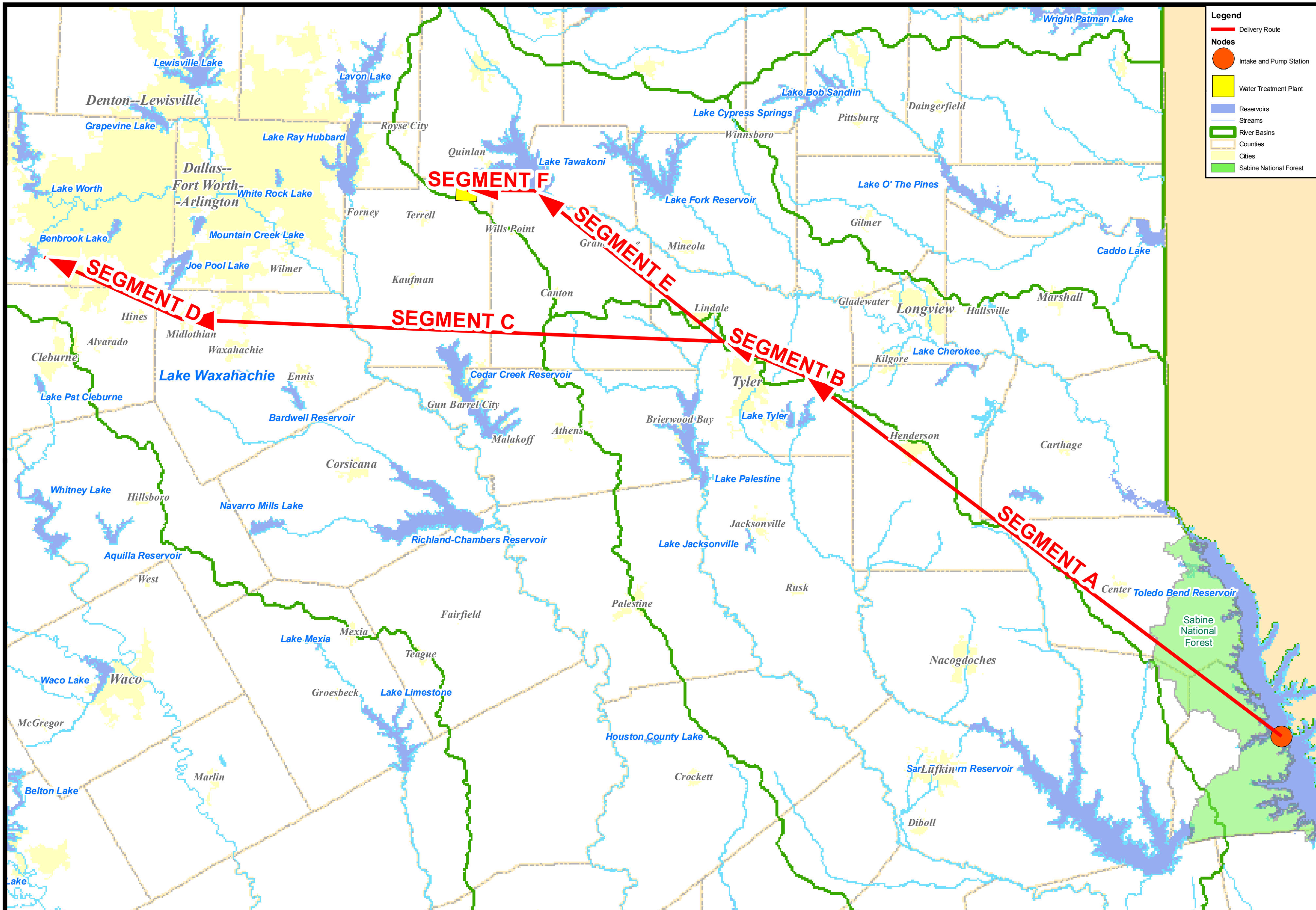
EXECUTIVE SUMMARY

The 2007 State Water Plan recommends moving water from Toledo Bend Reservoir in East Texas to water providers in North Texas to satisfy projected increased water demands in the Metroplex. The project consists of transporting up to 500,000 to 700,000 acre-feet per year of water from Toledo Bend Reservoir to other lakes in Texas. The Toledo Bend Project is a recommended water management strategy for the North Texas Municipal Water District, Tarrant Regional Water District and the Sabine River Authority, and it is an alternative water management strategy for Dallas Water Utilities and the Upper Trinity Regional Water District. Since this study was recommended in the 2007 State Water Plan, there have been on-going developments regarding future water supplies for the participants of this project. This study was conducted to better understand the impacts of these developments on the proposed Toledo Bend Project, and update the strategy descriptions. The major tasks included: 1) coordination with the major participants and confirmation of supply amounts and delivery locations, 2) review and update schematic transmission routes, 3) identify potential impacts to receiving reservoirs, 4) review naturalized flows to Sabine Lake and compare these flows to the Texas Parks and Wildlife Department's recommended freshwater inflows, and 5) update capital costs and develop life cycle costs for the refined project.

Pipeline Routing and Preliminary Cost Analysis

The consultants from Region C and the East Texas Region met individually with each of the four major participants to better define the quantities of supply, preferred delivery locations, and timing of the Toledo Bend project. Other discussion topics included the potential pipeline route corridor, other on-going studies and the feasibility of shared facilities. Based on these discussions, the demands for the project were confirmed and the pipeline routing was updated as shown on Figure ES-1. Two of the main differences between the 2007 project and the updated Toledo Bend project are that the updated route does not utilize other infrastructure to move the water to the final destinations and the implementation of the project is delayed from 2050 to 2060. The strategy in the 2007 State Water Plan assumed that some



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Region C Water Plan
East Texas Regional Water Plan

Proposed Corridor for Water Delivery from Toledo Bend

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FIGURE

infrastructure would be oversized to accommodate future water from Toledo Bend. Due to the timing of the Toledo Bend Project (expected to be developed by 2060), it was considered no longer feasible to construct infrastructure that may not be used for 50 years. As the participants continue to plan and develop projects for future water supplies, these assumptions may change and there may other opportunities for efficiency of design and/or operation. The pipeline route presented in this report is for planning purposes only, and during final design the route will be adjusted to maximize efficiency and minimize impacts.

The cost analyses include the development of capital costs, average annual costs, life cycle costs over 100 years, and a cost sensitivity analysis to electric rates. The costs were developed for each participant based on the percentage of use of the infrastructure. For the 700,000 acre-feet per year scenario, the total net present cost is $19.8 billion, with an average life cycle unit cost of $410 per acre-foot of water (adjusted to 2007 dollars). For the 500,000 acre-feet per year scenario, the total net present cost is $15.9 billion or an average unit cost over the 100-year life of $463 per acre-foot (adjusted to 2007 dollars). The life cycle analyses showed that operating costs account for over 70 percent of the total cost over 100 years. Energy cost, which comprises most of the operating costs, is a major factor in the cost feasibility of this project.

Potential Impacts on Receiving Reservoirs

Potential environmental impacts of moving water from one reservoir with unique physiochemical and biological characteristics to another water body include altered biodiversity (fish, macroinvertebrates, and aquatic plants) and water quality. Most of the fish species presently found in Toledo Bend Reservoir are found in other reservoirs throughout the state. In addition, the design of the intake would probably preclude entrainment of live fishes.

Plants native to Toledo Bend Reservoir that are not found in the receiving reservoirs pose very little threat to altering biodiversity because of the specific physio-chemical characteristics they require and general lack of invasive character. Plants that could be of some concern include Giant salvinia, hydrilla, Eurasian water-milfoil, and water hyacinth as these are nonindigenous plant species of concern in Toledo Bend Reservoir now. Mitigation to prevent the movement of aquatic species will primarily be a function of the intake structure's location in Toledo Bend Reservoir and its design.

Water quality in Toledo Bend appears to be generally similar to the receiving reservoirs for those parameters for which there is a water quality standard (i.e., pH, dissolved solids, etc.). Ambient concentrations of dissolved solids are well within the water quality standards for these parameters in the receiving reservoirs.

Feasibility of Recommended Freshwater Inflows to Sabine Lake Estuary

For this study, historical and naturalized freshwater inflows were reviewed to identify how flow conditions may have been altered by human influences and provide a reference for inflows to the Sabine Lake Estuary. Then, recommended target inflows proposed by the Texas Parks and Wildlife Department (TPWD) were compared to historical and naturalized inflows to demonstrate the probability of achieving the recommended inflows under each scenario. Finally, drought-of-record conditions were reviewed to highlight the severity of the flow deficits under each scenario with drought inflow. Some of the key observations resulting from this evaluation are as follows:

- Neither historical nor naturalized inflows would achieve the recommended target inflows to Sabine Lake on a consistent basis. During most months, there is a significant rate of failure in meeting recommended target inflows.
- Under drought conditions, the probability of not meeting the target inflows is even more dramatic. In a three-year drought-of-record, target inflows would be met in only five of the 36 months under naturalized conditions. The cumulative target inflows would be short by approximately 11.3 million ac-ft of freshwater inflow under a naturalized flow scenario and approximately 13.6 million ac-ft for historical inflows.
- The methodology utilized by TPWD to develop the target inflows has been challenged and is subject to refinement, which could change the target inflow quantities. The documented concerns about the methodology used to derive the recommended target inflows supports the need to address the significant uncertainty about the recommended target inflows and the means by which such flows should be applied.

Sabine Lake's substantial existing freshwater inflows are far greater than other bays and estuaries on the Texas Coast. However, the TPWD's recommended target inflows to the estuary far exceed historical and naturalized conditions. This is especially true during times of drought. The cumulative deficit of target inflows over a three-year drought is the equivalent of between four and five volumes of stored water in Sam Rayburn Reservoir, or between 2.5 and three volumes of stored water in Toledo Bend Reservoir. This fact does not alter the need to adequately address freshwater inflow needs. It does, however, indicate that it is essential to ensure that the question of adequate inflow is answered using sound science, and that the relationship of freshwater inflows to various water management strategies is clearly understood. The following recommendations would aid in providing an improved understanding of these issues:

- Additional investigations should be performed to improve the methodology in order to establish the target inflows based on sound science. Work being performed to establish freshwater inflow targets for other Texas estuaries should be monitored. Improvements developed for these other areas should be considered for inclusion in the methodology used for Sabine Lake and its freshwater requirements. Of particular interest is the previously cited work by Ward which suggested that improved estimates of the target inflows could be achieved by extending the biological databases used in verification of inflow targets. Other, more appropriate biota could be used and more catch data would improve the methodology for determining necessary inflows.
- Additional study of Sabine Lake should also include a more deliberate assessment of the impact of the Sabine-Neches Waterway on salinity in the estuary.
- Additional modeling should be performed to determine how various drought-of-record periods might affect salinities. Additional modeling for drought-of-record periods of two years through seven years is recommended. This would help to establish what the critical drought-of-record for the estuary might be.

There is no question that freshwater inflows to Sabine Lake are important to the estuary's health. Without sufficient inflows to the estuary, the effect of saltwater intrusion via the Sabine-Neches Waterway, tides, and storm surges from the Gulf of Mexico could create an increasingly saline environment, substantially altering the estuary's aquatic flora and fauna. Likewise, the character of the marshes adjacent to Sabine Lake could be significantly altered. The question is, however, how much freshwater inflow is necessary to maintain a "sound ecological environment" in the estuary? Furthermore, the term "sound ecological environment" must be defined. In accordance with requirements of the water planning process for the State of Texas, the East Texas Regional Water Planning Region will continue to consider the needs of bays and estuaries as part of the evaluations of water management strategies and impacts to the region.

1.0 Introduction

SCOPE OF WORK

Coordinate with participants
- Demands
- Delivery locations
- Transmission routes

Impacts to State waters
- Receiving reservoirs
- Flows to Sabine Lake

Cost Analyses
- Capital costs
- Life cycle costs
- Energy cost sensitivity

The 2007 State Water Plan recommends moving water from Toledo Bend Reservoir in East Texas to water providers in North Texas to satisfy projected increased water demands in the Metroplex. The Toledo Bend Pipeline Project consists of transporting up to 500,000 acre-feet per year of water from Toledo Bend Reservoir to other lakes in Texas, with the potential to increase this amount to 700,000 acre-feet per year. This project is a recommended water management strategy for the North Texas Municipal Water District (NTMWD) and Tarrant Regional Water District (TRWD) and it is an alternative water management strategy for Dallas Water Utilities (DWU) and the Upper Trinity Regional Water District (UTRWD). The strategy also proposes delivering water to Lake Fork or Lake Tawakoni to supply customers of the Sabine River Authority (SRA) in Region D.

Since the development of this strategy for the 2007 Plan, there have been on-going developments of water supplies by the Region C providers and the East Texas Region. This study was conducted to better understand these changes and the impacts to the proposed Toledo Bend Pipeline Project. The major tasks included: 1) coordination with the major participants and confirmation of supply amounts and delivery locations, 2) review and update schematic transmission routes, 3) identify potential impacts to receiving reservoirs, 4) review the naturalized flows to Sabine Lake, and 5) update capital costs and develop life cycle costs for the refined project.

1.1 Authorization and Objectives

This study was authorized by the East Texas Regional Water Planning Group and is funded through a Research and Planning Grant sponsored by the Texas Water Development Board.

The Toledo Bend Study addresses several concerns raised during the last round of regional water planning, including inter-regional coordination, the timing of the project, the associated costs to move the water, and the potential impacts to environmental flows. As previously discussed, there are also on-going developments in water supply planning of the major participants. Considering these factors, the objectives of this study are to refine and update water supply plans of the participants regarding the Toledo Bend Pipeline Project, provide inter-regional coordination, and review the potential impacts of this water transfer on State waters.

1.2 Inter-Regional Coordination and Study Review

A major component of this study effort is inter-regional coordination. The Toledo Bend Pipeline Project crosses three regions: East Texas Region (source water), Region D and Region C. As the primary recipient of the water from this project, representatives of Region C were included in the development of the study and provided input to the project design. The Sabine River Authority, which supplies water to both the East Texas Region and Region D, was also involved with the routing study and the impacts of the study. A copy of the draft study report was provided to Regions C and D on December 1, 2009. Copies of the transmittal letters are included in Appendix D. The draft study report was submitted to the Texas Water Development Board (TWDB) in the end of December.

The East Texas Region received comments on the draft study from Region C and the TWDB. Copies of these comments are included in Appendix D. No comments were received from Region D. The East Texas Region consultants have addressed the comments in this final study report. The responses to the comments are included in Appendix D.

2.0 Strategy Update

2.1 Demand Coordination

UPDATED TOLEDO BEND PIPELINE PROJECT

Demand – 700,000 af/y
- 500,000 af/y (w/o DWU)

Timing of Development – 2060

Delivery Locations:
- TRWD – Near Lake Benbrook
- NTMWD – Terrell WTP
- DWU – Near Joe Pool Lake/Lake Tawakoni
- SRA – Longview/ Lake Tawakoni

Route Corridor
- 305 miles (total for all participants)

The consultants from Region C and the East Texas Region met individually with each of the four major participants: North Texas Municipal Water District, Tarrant Regional Water District, Sabine River Authority and Dallas Water Utilities. At these meetings, the quantities of supply, preferred delivery locations, and timing of the Toledo Bend Pipeline Project were discussed. Other discussion topics included the potential pipeline route corridor, other on-going studies and the feasibility of shared facilities. Based on these discussions, the demands for the project were confirmed and the pipeline routing was updated.

Expected Supply

The Toledo Bend Pipeline Project has the potential to provide up to 700,000 acre-feet per year to water providers in Region C and D. The maximum demand is distributed among all water suppliers as follows:

North Texas Municipal Water District	200,000 acre-feet per year
Tarrant Regional Water District	200,000 acre-feet per year
Dallas Water Utilities	200,000 acre-feet per year
Sabine River Authority	100,000 acre-feet per year
Total	**700,000 acre-feet per year**

Dallas Water Utilities may decide to not participate in the project if their future water needs are satisfied with other recommended water management strategies. If DWU does not participate, the supply from the Toledo Bend Pipeline Project would be reduced to 500,000 acre-feet per year.

Timing of Project

The three major participants in Region C confirmed the expected timing of the Toledo Bend Pipeline Project is 2060 or later. Each of these participants is seeking other water supplies that would be developed prior to the Toledo Bend Pipeline Project. If any of these projects was not to be completed or no longer preferred, the timing of the Toledo Bend Pipeline Project may be sooner. For planning purposes, the development of the Toledo Bend Pipeline Project is assumed to occur in 2060. This is a decade later than currently shown in the 2007 State Water Plan.

2.2 Route Study

Based on the meetings with the major participants, water from the Toledo Bend Pipeline Project should be delivered to the areas with growth or to future water treatment plants. Since the development of the project will be in the distant future the final delivery points may change. At this time, the preferred delivery points for each participant are:

- TRWD: Near Lake Benbrook. Most of the water from Toledo Bend will likely go directly to one or more water treatment plants near the areas of growth. Some water may be placed in terminal storage near the Fort Worth service area.
- DWU: One delivery point near Joe Pool Lake (near the location of a proposed water treatment plant in southwest Dallas) and another delivery point to Lake Tawakoni. These two delivery points provide flexibility of moving water to different areas of need. For purposes of this study, it was assumed that 30 percent of Dallas' share of water will be transported to Lake Tawakoni.
- NTMWD: Near the proposed Terrell WTP (currently under design) near Lake Tawakoni.
- SRA: One delivery point to the Longview/Marshall area and another delivery point to Lake Tawakoni.

Toledo Bend Reservoir is about 240 miles from Lake Benbrook and 170 miles from Lake Tawakoni. The facilities of the Toledo Bend Pipeline Project include large diameter pipelines, several booster and pump stations, and balancing reservoirs. The schematic of the proposed delivery system is shown in Figure 2.1. The layout was selected considering the preferred delivery points for each participant, the potential of increasing operational flexibility of the transmission systems, and the goal of minimizing cost.

Several locations were considered for the intake structure and the SRA provided data on lake depth and shoreline access. The 2006 plans assumed that the Toledo Bend intake would be located near the upper end of the reservoir to minimize the transmission distance. However, after the drought of 2006 there were concerns that an upper location may not provide the reliability during drought. The intake structure for the updated project was moved to a more downstream location, in the central part of the lake. The final location will be determined during a more detailed feasibility study. This location is proposed for planning purposes.

To increase the operational flexibility, the route corridor proposed by this study runs near Cedar Creek Reservoir and Lake Palestine. Cedar Creek is currently a source for TRWD and Lake Palestine is a future source for DWU. Discharging water from Toledo Bend in any of these reservoirs would add operational flexibility because water from Toledo Bend could be delivered to the Metroplex through more than one route. However, such discharges result in additional head loss and increase power cost. To minimize energy cost, the participants prefer to transfer the water from Toledo Bend from pump station to pump station without any discharge to intermediate lakes when possible. Discharges in Cedar Creek or Lake Palestine would only occur occasionally when needed. If water is placed in these intermediate lakes, transmission of Toledo Bend water from these lakes would likely use the infrastructure that is in place at these lakes. This study did not include additional infrastructure to move water back to the Toledo Bend pipeline. Due to the pipeline's large diameter and associated unit cost, the selected route tried to minimize costs while maintaining operational flexibility.

Potential Conflicts and/or Environmental Concerns

The Toledo Bend Pipeline Project will move water across the eastern part of Texas to the Dallas-Fort Worth area. The pipeline route has not been finalized and during design the route can be adjusted to minimize stream crossings and environmentally sensitive areas. Based on available data, the pipeline corridor will cross approximately 24 miles through the Sabine National Forest that is adjacent to the Toledo Bend Reservoir. (Note that the Sabine National Forest is not contiguous and actual crossing through the forest will be less.) The pipeline route can be adjusted to minimize disturbance of the forest if needed. The corridor does not cross other significant Federal or State lands. As the pipeline corridor nears development around the Dallas-Fort Worth area, the potential for structural and facilities conflicts is greater. The corridor crosses near the Fort Worth Spinks Airport in Tarrant County. As development continues in urban and suburban areas, the potential for conflicts through these areas will increase.

The proposed pipeline corridor crosses nine counties. There is a total of six listed Federal endangered or threatened species:

- Louisiana black bear (Panola, Rusk, Sabine, Smith)
- Whooping crane (Ellis, Johnson, Tarrant)
- Red-cockaded woodpecker (Sabine, Shelby)
- Black-capped vireo (Johnson)
- Golden-cheeked warbler (Johnson)
- Least tern (Tarrant)

It is anticipated that the construction of the pipeline will have minimal impacts to the habitats of these species. Care will be taken during design and construction to minimize any impacts and restore disturbed areas.

2.3 Cost

One of the major tasks of this study is to develop costs for the updated Toledo Bend Project. The cost analyses include the development of capital costs, average annual costs, life cycle costs over 100 years, and a cost sensitivity analysis to electric rates. The costs were developed for each participant based on the percentage of use of the infrastructure. The detailed assumptions for the cost estimates are outlined in Appendix A. A brief overview of the assumptions and findings is presented in the following subsections.

2.3.1 Capital Cost

Capital costs were developed following the Texas Water Development Board's guidance for the special studies. These costs are based on second quarter 2007 dollars. For comparison purposes, capital costs were also developed using the same unit costs as used in the 2006 regional water plans (adjusted 2002 unit prices).

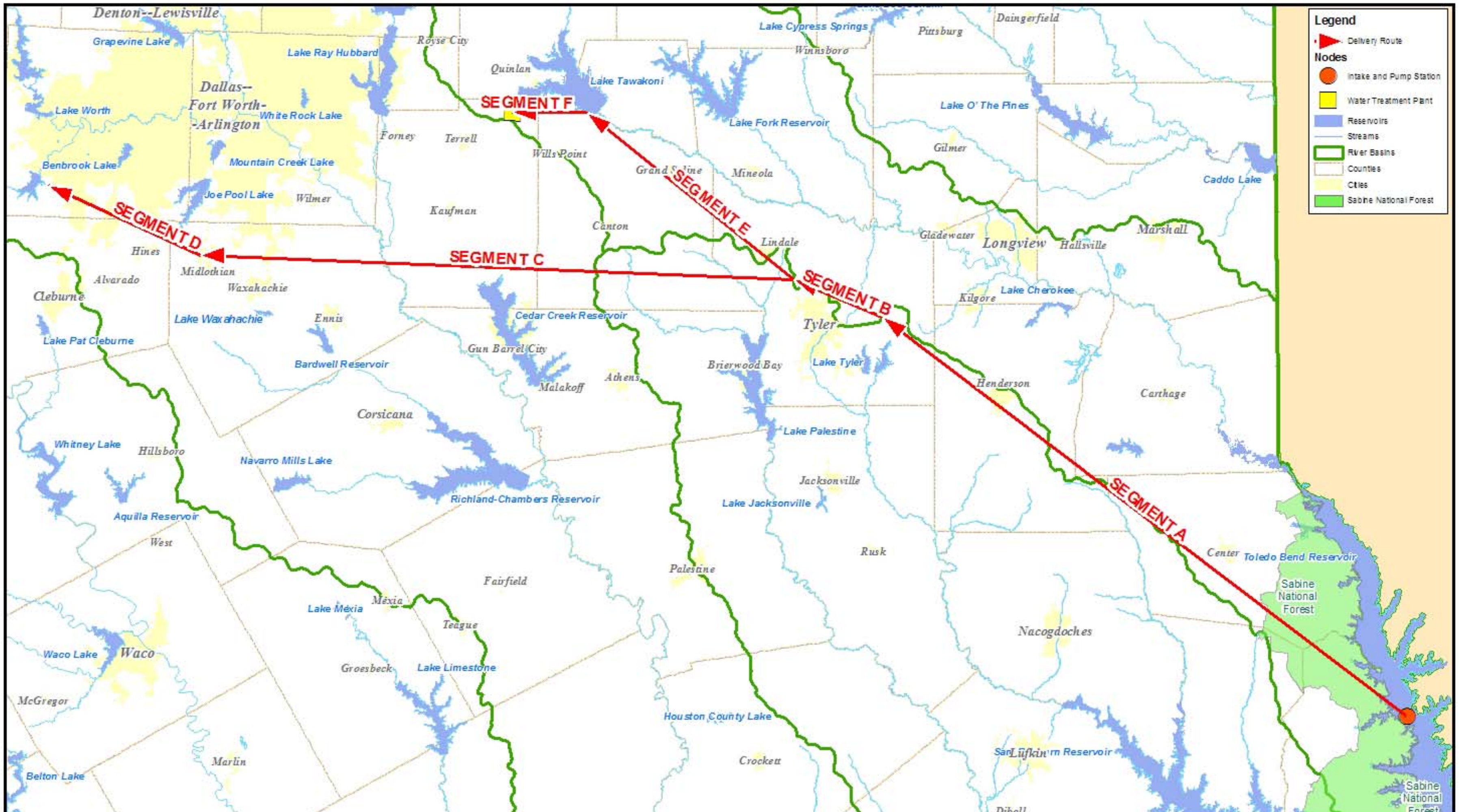
CAPITAL COSTS

Assumptions:
- June 2007 dollars
- Engineering/contingencies
  - 30% for pipelines
  - 35% for pump stations
- ROW land costs range:
  - $10,000/ acre (rural)
  - $60,000/ acre (urban)
- Permitting/mitigation – 1%

Project Costs
- 700,000 af/y $4.6 billion
- 500,000 af/y $3.4 billion

Capital cost estimates are based on standard unit costs for installed pipe, pump stations and other facilities developed from experience with similar projects throughout Texas. All unit costs include the contractor's mobilization, overhead and profit. The costs for engineering, contingencies, financial and legal services, right-of-ways, permitting and environmental studies are estimated separately from the unit costs. Unit cost tables for pipelines and pump stations are included in Appendix A.

The initial capital cost of the project is $4.6 billion (2007 dollars) for a total supply of 700,000 acre-feet per year and $3.4 billion for a supply of 500,000 acre-feet per year. For purposes of estimating the cost of the project, the proposed route was divided in the six segments shown in Figure 2.1. Table 2.1 shows the cost of each section of the pipeline with participation of DWU. Table 2.2 includes the cost of the project assuming no participation from DWU. Appendix B is a detailed breakdown of the cost of each component



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	Proposed Corridor for Water Delivery from Toledo Bend		FIGURE

Table 2.1
Summary Cost of the Toledo Bend Pipeline Project With DWU Participation

		Share by Participant (acre-feet per year)						
Segment	Maximum delivery (acre-feet per year)	DWU	NTMWD	SRA	TRWD	Size[1]	Length (miles)	Cost[2] ($ Million)
A	700,000	200,000	200,000	100,000	200,000	2 x 120 in.	107	2,410
B	650,000	200,000	200,000	50,000	200,000	2 x 114 in.	16	286
C	350,000	150,000	0	0	200,000	1 x 120 in.	95	1,156
D	200,000	0	0	0	200,000	1 x 90 in.	33	297
E	300,000	50,000	200,000	50,000	0	1 x 114 in.	42	385
F	200,000	0	200,000	0	0	1 x 96 in.	12	95
Total							**305**	**4,628**

1. Pipelines were sized for 1.25 peaking capacity
2. Costs are second quarter 2007 dollars.

Table 2.2
Summary Cost of the Toledo Bend Pipeline Project **Without** DWU Participation

		Share by Participant (acre-feet per year)						
Segment	Maximum delivery (acre-feet per year)	DWU	NTMWD	SRA	TRWD	Size[1]	Length (miles)	Cost[2] ($ Million)
A	500,000	0	200,000	100,000	200,000	2 x 102 in.	107	1,780
B	450,000	0	200,000	50,000	200,000	2 x 96 in.	16	209
C	200,000	0	0	0	200,000	1 x 90 in.	95	703
D	200,000	0	0	0	200,000	1 x 90 in.	33	299
E	250,000	0	200,000	50,000	0	1 x 102 in.	42	319
F	200,000	0	200,000	0	0	1 x 96 in.	12	95
Total							**305**	**3,404**

1. Pipelines were sized for 1.25 peaking capacity
2. Costs are second quarter 2007 dollars.

Comparison to 2006 Regional Plan

As part of this study, the capital costs for the updated Toledo Bend route was compared to the project costs developed for the 2006 regional water plans[1]. Unit costs used for the 2006 Region C water plan strategies, which are based on adjusted 2002 dollars, were applied to the new assumptions and route. Overall the new route added length to the pipeline due to the change in location of the intake on Toledo Bend Reservoir and final delivery points assumed for the participants. Also the assumptions for utilization of existing infrastructure have changed due to the timing of the Toledo Bend Pipeline Project and other future projects. This results in higher capital costs for all users. The capital costs for the updated routes for the 700,000 acre-feet per year project are 40 percent higher than the costs estimated for the 2006 plans. For the 500,000 acre-feet per year project, the total cost increases are approximately 25 percent.

CHANGES FROM 2006 PLAN

2006 Plan Assumptions:

- Intake at upper end of reservoir
- SRA delivery to Lake Fork
- DWU delivery to east Dallas via Tawakoni
- NTMWD delivery to Lavon via Chapman
- TRWD delivery through 3rd pipeline from Richland-Chambers/ Cedar Creek
- 2002 dollars for costs

Updated Assumptions:

- Intake is located further downstream
- SRA delivery to Tawakoni
- Additional DWU delivery to south Dallas near Joe Pool Lake
- NTMWD delivery to Tawakoni WTP
- TRWD delivery through new dedicated pipeline from Toledo Bend
- 2007 dollars for costs

The smallest impact seen was for NTMWD. The 2006 water management strategy assumed that NTMWD would move Toledo Bend water to Lake Chapman and then parallel NTMWD's existing water line from Chapman to Lake Lavon. The new route takes the water directly to a water treatment plant on the eastern side of the NTMWD's service area. For NTMWD, the overall route is approximately similar distances and their share of capital costs is comparable to costs reported in the 2006 plans.

For TRWD, the 2006 water management strategy assumed that TRWD's third pipeline from Richland Chambers and Cedar Creek would be oversized to move water from Toledo Bend. This resulted in some cost savings of the pipeline. The updated route assumes that new infrastructure will be dedicated to moving only Toledo Bend water. This is because of the timing of the projects. TRWD is proceeding with the design and construction of the third pipeline. Toledo Bend water is expected to be developed in approximately 50 years. TRWD

[1] Freese and Nichols. Inc. et al., 2006 Region C Water Plan, January 2006.

could not justify oversizing the third pipeline considering the timing of the project and the age of the existing transmission system at the time that Toledo Bend would be developed.

The costs for SRA and DWU increased mainly due to additional pipeline needed with the new intake location and the changes in delivery locations. The assumptions for DWU in the 2006 plan had all of the Toledo Bend water delivered to the east side of the city. With the updated route DWU has increased the flexibility in the delivery points and increased some pipe length. Water for SRA is now delivered to Lake Tawakoni rather than Lake Fork. This is because of the locations of demands.

Comparisons of the capital costs by user for the two project alternatives (700,000 ac-ft/yr and 500,000 ac-ft/yr) are shown in Figures 2.2 and 2.3.

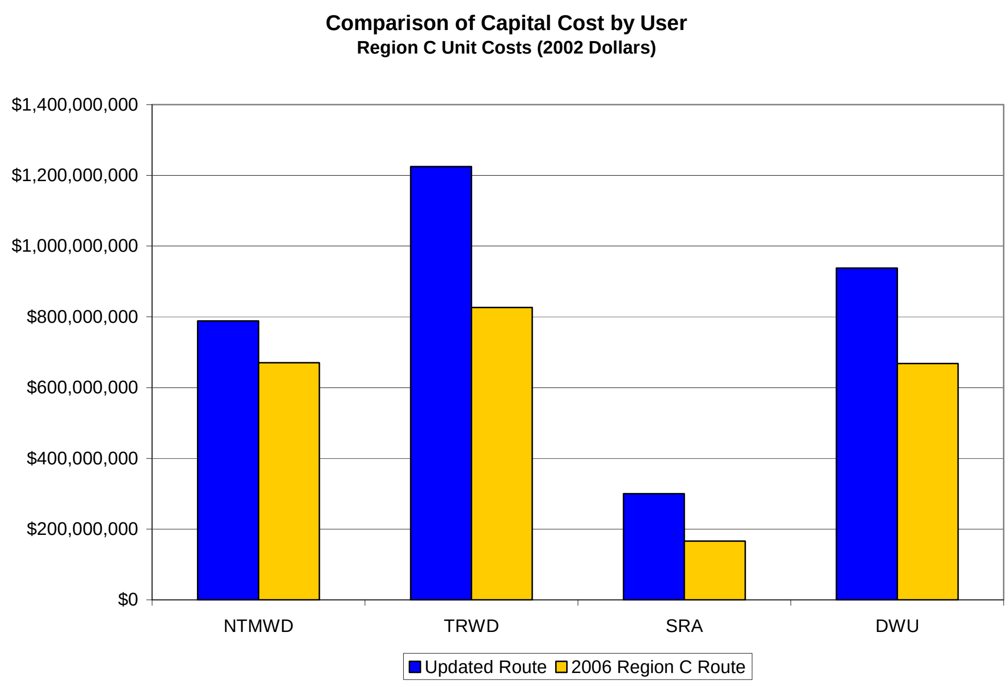

Figure 2.2 Comparisons to 2006 Region C Toledo Bend 700,000 ac-ft/yr Strategy

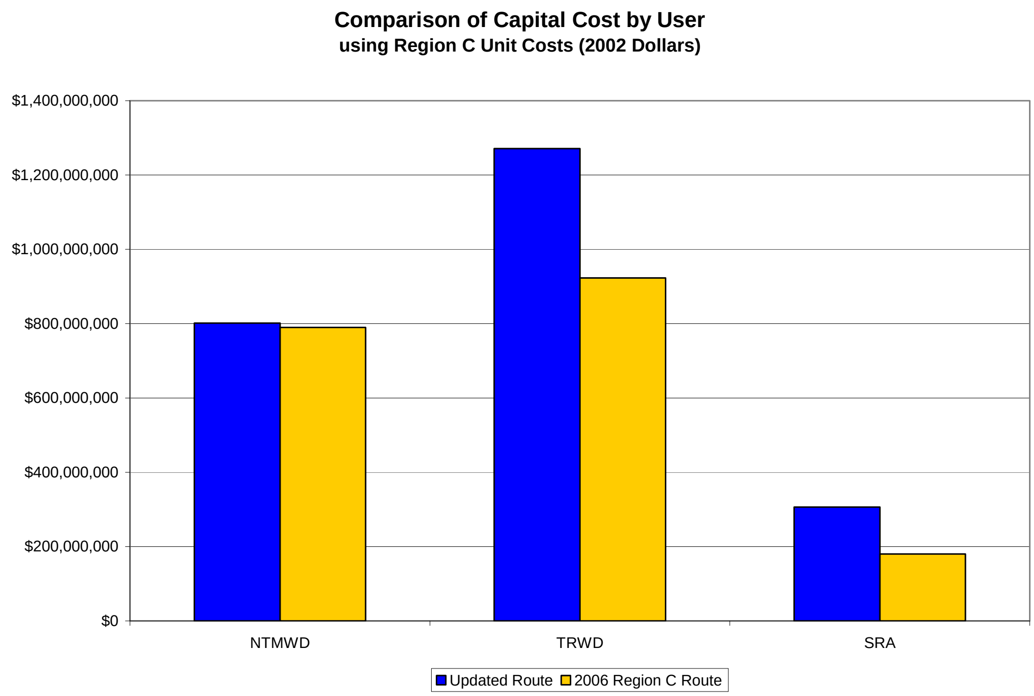

Figure 2.3 Comparisons to 2006 Region C Toledo Bend 500,000 ac-ft/yr Strategy

Annual Cost

Annual costs represent the costs incurred by the water supplier on an annual basis, and it includes the amortized debt, operation and maintenance of the facilities, electricity, and water purchase costs. For this study, water purchase costs are not included in the total annual cost. It was assumed that the purchase price will be negotiated between the buyer and seller at the time of purchase. The annual costs are shown with the cost estimates in Appendix B.

ANNUAL COSTS

Assumptions:

- Debt amortized over 30 years
    - 6% interest
- Electricity - $0.09/ kWh
- Operation and Maintenance
    - 1% for pipelines
    - 2.5% for pump stations
- Raw water purchase costs are not included

Costs per Ac-ft during Debt Service

- 700,000 af/y $794
- 500,000 af/y $857

Costs per Ac-ft after Debt Service

- 700.000 af/v $314

For the larger 700,000 acre-feet per year project, the total annual cost during amortization is $556 million, which produces a unit cost $794 per acre-foot of water. After amortization, the annual cost is $220 million (operation, maintenance and electricity only), which produces a unit cost of $314 per acre-foot of raw water. The cost share for each participant is shown in Table 2.3.

If DWU does not participate and the supply is 500,000 acre-feet per year, the capital cost is $3.4 billion. The total annual cost for this scenario is $428 million and the initial unit cost of water is $857 per acre-foot. After amortization, the annual cost is $181 million, which results in a unit cost of $362 per acre-foot of raw water. The cost share for each participant for these assumptions is shown in Table 2.4.

Table 2.3
Share of Capital Cost and Annual Cost for Each Participant With DWU Participation

	DWU	NTMWD	SRA	TRWD	TOTAL
Supply (acre-feet per year)	*200,000*	*200,000*	*100,000*	*200,000*	*700,000*
Capital Cost ($Million)	$ 1,336	$ 1,128	$ 430	$ 1,734	$ 4,628
Debt Service ($ Million)	$ 97	$ 82	$ 31	$ 126	$ 336
Annual O&M ($ Million)	$ 63	$ 54	$ 22	$ 81	$ 220
During Amortization					
Annual Cost ($ Million)	$ 160	$ 136	$ 53	$ 207	$ 556
Unit Cost ($ / acre-foot)	$ 801	$ 679	$ 530	$ 1,035	$ 794
After Amortization					
Annual Cost ($ Million)	$ 63	$ 54	$ 22	$ 81	$ 220
Unit Cost ($ / acre-foot)	$ 315	$ 269	$ 217	$ 405	$ 314

Capital costs are based on 2007 dollars.

Table 2.4
Share of Capital Cost and Annual Cost for Each Participant **Without** DWU Participation

	NTMWD	SRA	TRWD	TOTAL
Supply (acre-feet per year)	*200,000*	*100,000*	*200,000*	*500,000*
Capital Cost ($Million)	$ 1,154	$ 443	$ 1,807	$ 3,404
Debt Service ($ Million)	$ 84	$ 32	$ 131	$ 247
Annual O&M ($ Million)	$ 61	$ 25	$ 95	$ 181
During Amortization				
Annual Cost ($ Million)	$ 145	$ 57	$ 226	$ 428
Unit Cost ($ / acre-foot)	$ 725	$ 571	$ 1,131	$ 857
After Amortization				
Annual Cost ($ Million)	$ 61	$ 25	$ 95	$ 181
Unit Cost ($ / acre-foot)	$ 306	$ 249	$ 474	$ 362

Capital costs are based on 2007 dollars.

2.3.2 Life Cycle Cost Analysis

A life cycle cost analysis was conducted to estimate the total cost of the project after 100 years. The total cost includes capital costs of the initial project, operation and maintenance, and replacement of pumps. It was assumed that only the pumps would be replaced over the time period. The life expectancy of pipelines and underground balancing reservoirs is assumed to be 100 years.

LIFE CYCLE COSTS

Assumptions:
- Debt service is constant for 30 years
  - 6% interest
- Inflation rate – 3.5%
- Discount rate – 4.5 %
- Electricity Sensitivity
  - $0.09/ kWh (base rate)
  - $0.14/ kWh
  - $0.18/ kWh
- Life expectancy
  - 100 years - pipelines
  - 50 years – pump stations

Net Present Cost after 100 years
- 700,000 af/y $19.8 billion
- 500.000 af/v $15.9 billion

For the life cycle costs an annual inflation rate of 3.5 percent and a discount rate of 4.5 percent were assumed. The inflation rate accounts for future increases in costs, while the discount rate is used to convert future costs back to today's dollars. Future expenditures for debt service are held constant at the annual amortized value, and then are discounted to today's dollars. The base analysis assumed electricity rates at $0.09 per kilowatt-hour. A sensitivity analysis on the cost of electricity is discussed in a later subsection.

Analysis with Participation of Dallas Water Utilities

Over the 100-year life cycle, the total net present cost is $19.8 billion (2007 dollars). Figure 2.4 shows the distribution of this total cost. Operation of the transmission system represents 70 percent of the total cost. The initial capital expenditure is 28 percent and the replacement cost of the pump stations is 2 percent of the total life time costs.

The unit cost immediately following completion of the project is $794 per acre-foot. This unit cost decreases after debt is paid. Assuming that 700,000 acre-feet per year are supplied during the 100-year life cycle, the average unit cost of the project is $410 per acre-foot of water. Figures 2.5 and 2.6 show the change of annual cost and unit cost respectively over the life of the project.

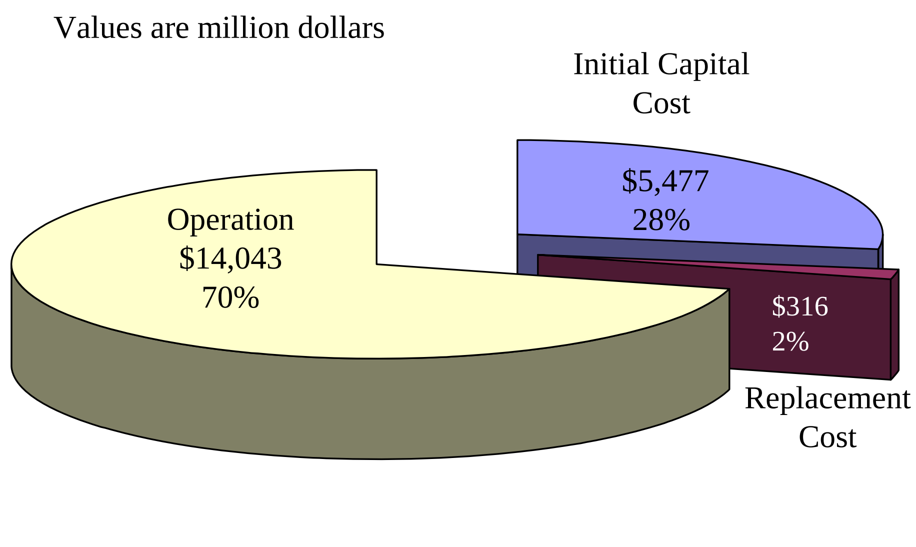

Figure 2.4 Distribution of Net Present Cost Over 100 Years With DWU Participation

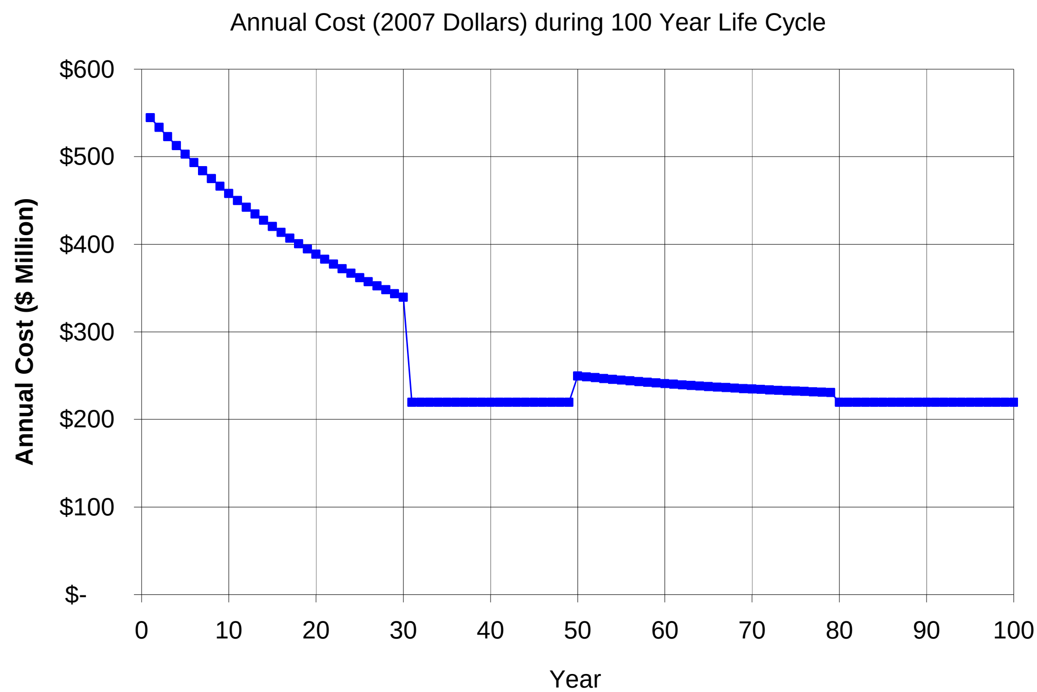

Figure 2.5 Annual Cost (Adjusted to 2007 Dollars) During the 100-Year Life Cycle With DWU Participation

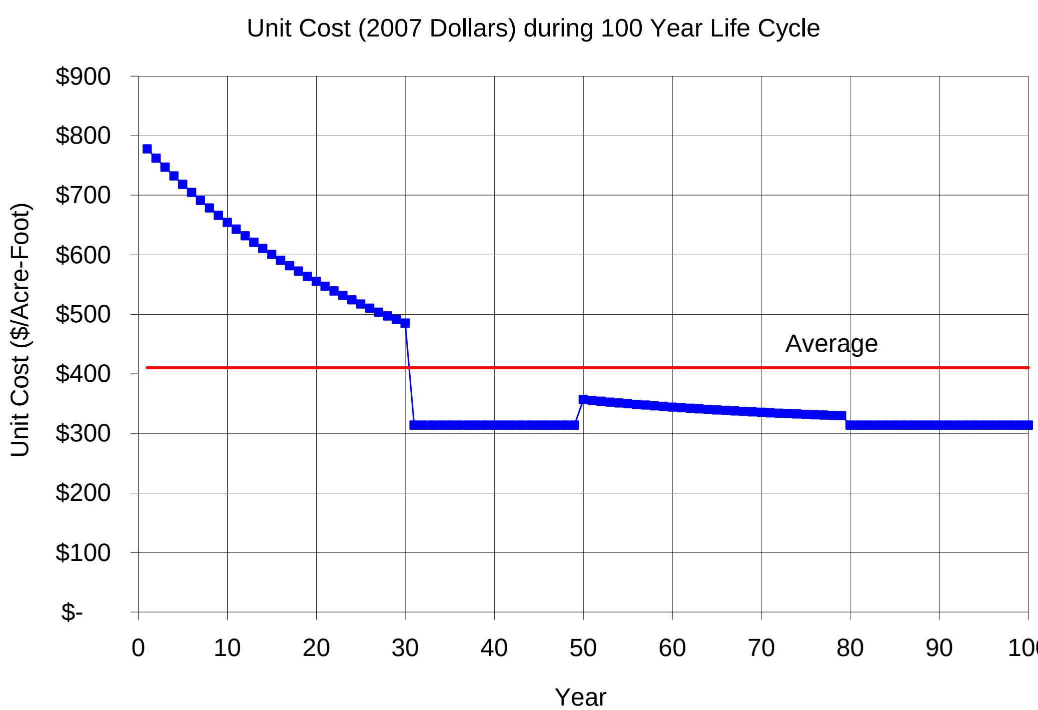

Figure 2.6 Unit Cost (Adjusted to 2007 Dollars) During the 100-Year Life Cycle With DWU Participation

Analysis <u>Without</u> Participation of Dallas Water Utilities

Over the 100-year life cycle, the total net present cost is $15.9 billion (2007 dollars) or $3.9 billion less than the cost with DWU participation. Figure 2.7 shows the distribution of this total cost. The unit cost after completion of the project is $857 per acre-foot or $63 per acre-foot higher than the cost with DWU participation. The average unit cost over the 100-year life cycle is $463 per acre-foot. Figures 2.8 and 2.9 show the change of annual cost and unit cost respectively over the life of the project.

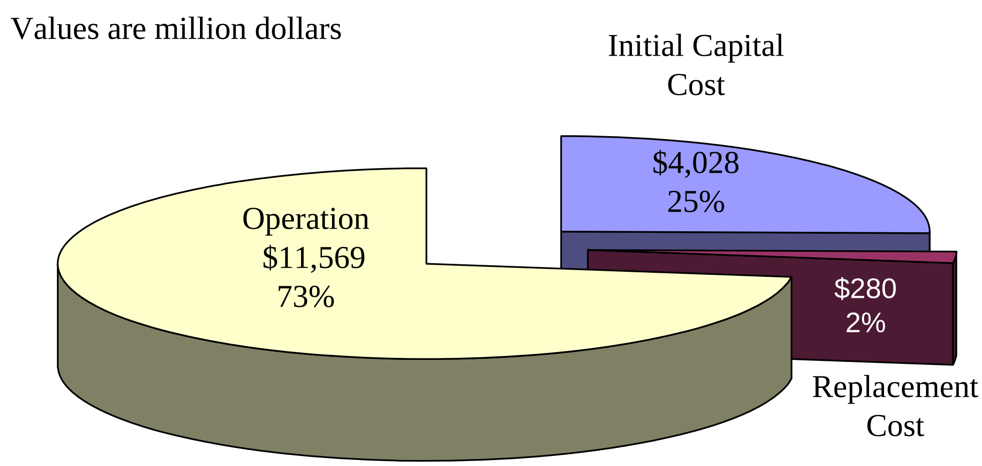

Figure 2.7 Distribution of Total Cost Over 100 Years Without DWU Participation

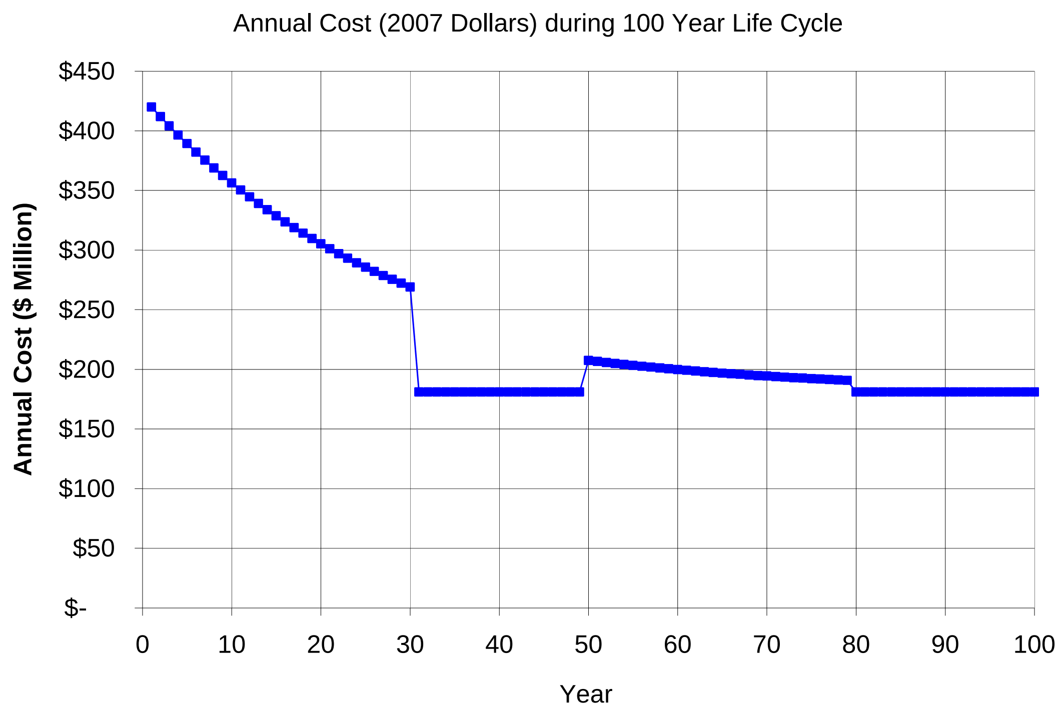

Figure 2.8 Annual Cost (Adjusted to 2007 Dollars) During the 100-Year Life Cycle Without DWU Participation

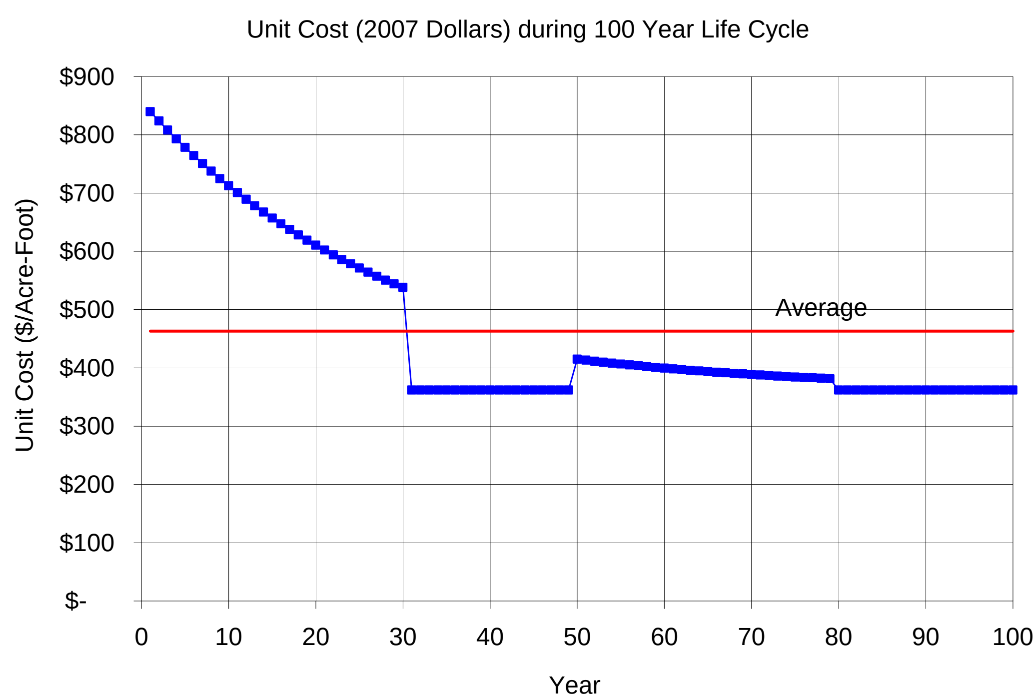

Figure 2.9 Unit Cost (Adjusted to 2007 Dollars) During the 100-Year Life Cycle Without DWU Participation

2.3.3 Sensitivity to Increase in Electricity Rates

Electricity used for pumping is a significant component of the annual cost of this project. Assuming a rate of 9 cents per Kilowatt-hour, the electricity cost represents 81% of the total annual cost of operations and maintenance. Higher rates of electricity may substantially increase the cost of the project. Electricity rates change frequently and the future rate of electricity cost in very uncertain at this time.

A sensitivity analysis was completed to evaluate the impact on possible higher electric rate in the cost of the project. The total annual cost and total cost over the 100-year life cycle were calculated assuming a rate of 1.5 and 2.0 times the current rate. (The assumed current rate is 9 cent per Kilowatt-hour. The rates at 1.5 and 2.0 times are 13.5 cents and 18 cents per Kilowatt-hour respectively.)

This analysis showed that the annual operation and maintenance cost (with Dallas participation) increases by 45 percent if the electricity rate is 1.5 times higher than the current rate. The annual operation cost would increase by 81 percent if the electricity rates double. Figure 2.10 is a comparison of the annual cost for different electricity rates.

Figure 2.11 compares the average unit cost over the 100-year life cycle. If the electricity rate is doubled, the average unit cost would increase from $410 to $664 per acre-foot assuming a supply of 700,000 acre-feet per year. Without participation of Dallas, the average unit cost would increase from $463 to $762 per acre-foot.

Figures 2.12 and 2.13 show the unit cost of water by user during amortization of the capital debt and following amortization under different electric rate assumptions.

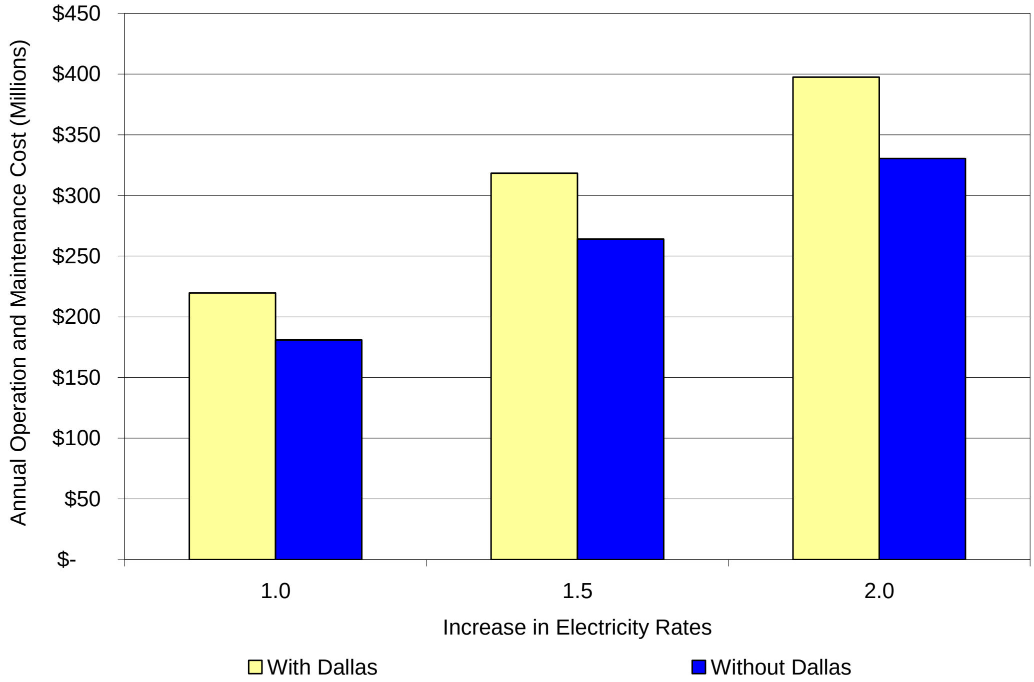

Figure 2.10 Comparison of Annual Cost for Different Electric Rates

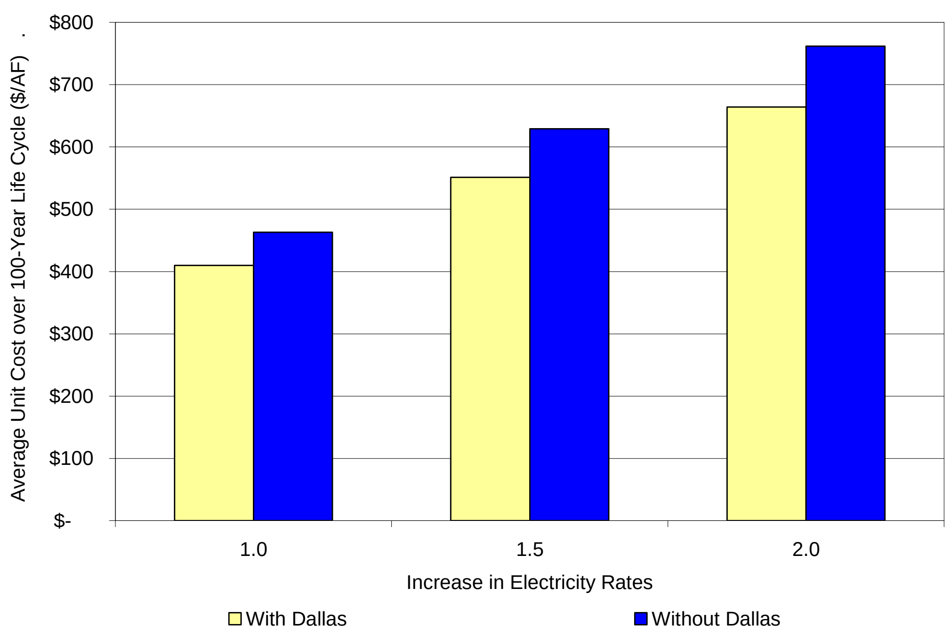

Figure 2.11 Comparison of Average Unit Cost Over 100 Years for Different Electric Rates

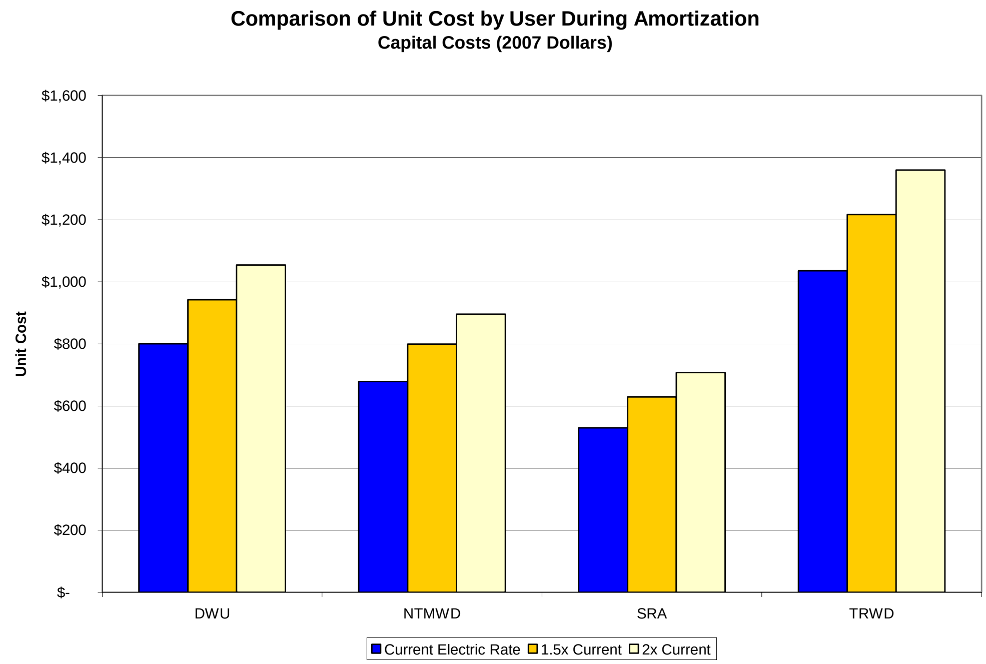

Figure 2.12 Impacts of Electric Rates on Unit Cost by User During Amortization

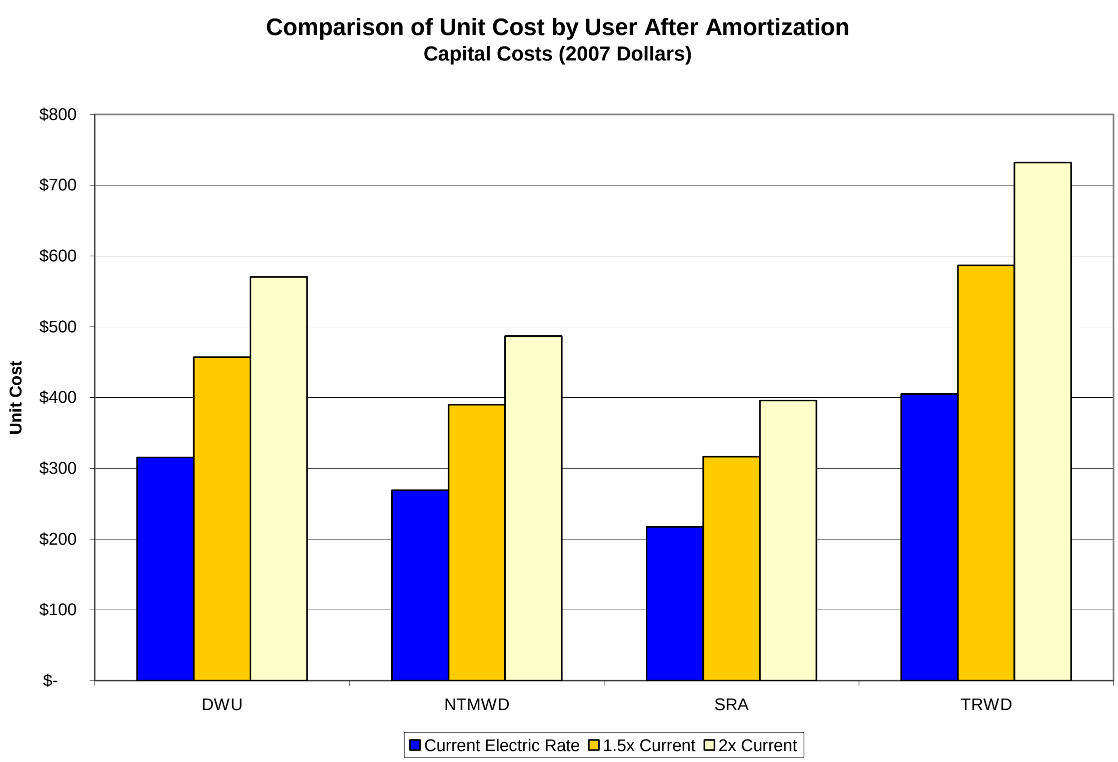

Figure 2.13 Impacts of Electric Rates on Unit Cost by User After Amortization

2.4 Potential Users in East Texas Region

The scope of work included identification of possible entities that may benefit from the Toledo Bend strategy. The method of identification included the use of CCN maps to locate water providers in the general vicinity of the proposed pipe line corridor. The list of potential beneficiaries were separated into users identified with shortages during the planning cycle of the 2006 water plan and users with no shortages. The list of entities in each of the categories is shown in Table 2.5 and 2.6.

Table 2.5 – Potential Beneficiaries with Water Shortages in the 2006 Water Plan

County	Entity	Maximum Shortage (ac-ft.)	First Year of Shortage
Henderson	County – Other	1,000	2010
	Aqua – Texas		
	Edom WSC		
	Leagueville WSC.		
	Monarch Utilities LLP		
	Moore's Station WSC		
	Three Community WSC		
	Union Hill WSC		
Nacogdoches	County-Other	291	2060
	Arlam-Concord WSC		
	Appleby Water Supply Corporation	458	2050
Sabine	County-Other	60	2010
	Frontier Park Marina		
	Mid Lake Kamp Grounds		
	Pendleton Utility Corporation		
San Augustine	County-Other	13	2050
	San Augustine Rural WSC		
	Bland Lake WSC		
	New Water Supply Corporation		
Shelby	County-Other	304	2020
	Buena Vista WSC		
	East Lamar WSC		
	Five Way Water Supply Corp.		
	Flat Fork Water Supply Corp.		
	Huber Water Supply Corp.		
	McClelland WSC		
	Sand Hills WSC		
	Shelbyville WSC		
	Choice Water Supply Corp.		
	Tennessee WSC		
	Timpson Rural WSC		
	Gary WSC		
	City of Center	568	2010

Table 2.5- (Continued)

County	Entity	Maximum Shortage (ac-ft.)	First Year of Shortage
Smith County	Community Water Company	227	2010
	Dean WSC	328	2020
	Jackson WSC	68	2050
	City of Lindale	59	2040
	Lindale Rural WSC	73	2060
	RPM WSC	6	2050

Table 2.6 – Potential Beneficiaries with No Water Shortage in 2006 Water Plan

County	Entity	County	Entity
Henderson	City of Brownsboro	Sabine	G-M Water Supply Corp.
	City of Chandler		City of Hemphill
	City of Murchison	San Augustine	City of San Augustine
Nacogdoches	City of Garrison	Shelby	City of Tenaha
Panola	County-Other		City of Timpson
	Clayton Water Supply Corp.	Smith County	County-Other
	Fairplay WSC		Ben Wheeler WSC
	Murvaul WSC		Carroll WSC
	South Murvaul WSC		Crystal System, Texas Inc.
Rusk	County-Other		Lake Shore Utility Company, Inc.
	Church Hill WSC		Southern Utilities Company
	Crims Chapel WSC.		Alpha Casco
	Gaston WSC		Texas Water Systems, Inc.
	Good Springs WSC		Wright WSC
	Jacobs Water Supply Corp.		City of Arp
	Kennedy Road WSC		City of Troup
	Laneville Water Supply Corp.		City of Tyler
	Leveretts Chapel WSC.		Walnut Groves WSC
	Minden-Brachfield WSC		City of Whitehouse
	Oakland WSC		
	Pine Hill-Chapman WSC.		
	Pleasant Hill WSC		
	Price Water Supply Corp.		
	South Rusk County WSC		
	West Gregg WSC		
	Cross Roads SUD		
	Ebenezer WSC		
	City of Henderson		
	City of Kilgore		
	Mount Enterprise WSC		
	City of New London		
	New Prospect WSC		
	City of Overton		

The amount of water needed and the time frame for implementation to meet shortages in the East Texas area do not appear to be in sufficient quantities or to occur in synchronization of the plan to be feasible. The use of this strategy should continue to be visited as the actual location of the pipeline and trends in demands are better defined as the time for implementation is closer.

3.0 Impacts on Receiving Reservoirs

IMPACTS ON RECEIVING RESERVOIRS

Aquatic Biota Impacts
- Fish
- Plants

Water Quality Impacts
- pH
- TDS
- Chloride
- Sulfate
- Hardness
- Alkalinity

Potential environmental impacts of moving water from one reservoir with unique physiochemical and biological characteristics to another water body have been identified and addressed in this chapter. The transfer of water from Toledo Bend to reservoirs located in north-central Texas may be viable to help meet future water demands in water planning Regions C and D. Potential risks associated with such a transfer include altered biodiversity and water quality. The following were used to assess potential environmental impacts of the proposed transfer:

1. Collecting and assessing existing information on aquatic plants, fishes, and macroinvertebrates that may affect biodiversity and the spread of introduced (nonindigenous) species.
2. Collecting and assessing existing water quality information for Toledo Bend Reservoir and receiving reservoirs.
3. Identifying the need for additional data collection.
4. Identifying potential mitigation factors.

Reservoirs identified as possible receivers of Toledo Bend Reservoir water include Lake Benbrook (Tarrant Regional Water District; TRWD), Cedar Creek Reservoir (TRWD), Joe Pool Lake (Dallas Water Utility; DWU) in Region C, Lake Tawakoni (Sabine River Authority; SRA) in Region D, and Lake Palestine (DWU) in Region I. Cedar Creek Reservoir and Lake Palestine are considered optional at this time and will only be used as necessary.

3.1 Potential Biological Impacts of Interbasin Transfer

This section will focus on the potential impacts of transporting plants, fishes, and macroinvertebrates and discuss potential mitigation factors associated with the transfer of water between reservoirs. The transfer of water can result in altered biodiversity from transporting plants and animals that are either native or nonindigenous in the source reservoir to other water bodies where they may not be native or even present. Native plants and animal species are those that evolved in a specific area or region or those that were transported there because of some type of geologic change (e.g., depressed sea levels or terrestrial uplift) or other means during prehistoric times. Nonindigenous aquatic species are a member(s) (i.e. individual, group, or population) of a species that enters a body of water or aquatic ecosystem outside of its historic or native range. Transport of nonindigenous aquatic species is primarily a result of anthropogenic activities.

3.1.1 Aquatic Plants

Native aquatic plants are not homogenously distributed throughout Texas and vary among and within drainage basins. Transport of species native to Toledo Bend Reservoir is not much of a concern, in part, because of the likelihood of their occurrence in the adjacent drainages wherein the receiving reservoirs are located. Also, plants native to Toledo Bend Reservoir that are not found in the receiving reservoirs pose very little threat to altering biodiversity because of the specific physio-chemical characteristics they require and general lack of invasive character. Subtle changes in water chemistry and water temperature and competition with plants already present in receiving reservoirs would substantially reduce the likelihood of transported plants establishing sustainable populations.

Numerous aquatic plant species have been introduced throughout Texas, however. These introduced (nonindigenous) species often effectively compete with native vegetation for nutrients and space. Nonindigenous species are most often introductions from the aquarium and ornamental plant trade and are often distributed between drainages via recreational boats (i.e., ballasts and live wells). Some nonindigenous plants are considered invasive species because of the rapid rate at which they replace native vegetation or disperse throughout a water body. Invasive species can be a nuisance to boat traffic and recreation. In addition, invasive species can adversely impact water quality (e.g., depressed dissolved oxygen) and reduce quality of aquatic habitat in the reservoir.

The United States Geological Survey (USGS) reports occurrences of numerous non-indigenous plant species in Toledo Bend Reservoir (Table 3.1)[2]. Many of the species reported by the USGS have also been observed by the Texas Parks and Wildlife Department (TPWD)The USGS listing is based on limited data (i.e., observations of plants in the reservoir). Some of those listed by the USGS may only represent one-time occurrences and may not be sustainable populations. Most of the species listed are native to the subtropical regions of Central America, South America, and Southeast Asia. Most of the non-indigenous plant species listed also have a wide range throughout the southeastern United States of America in coastal drainages where the climate is warm enough to maintain adequate water temperature.

Table 3.1

Non-indigenous Aquatic Plants in Toledo Bend Reservoir

Common Name	Species
Alligatorweed	*Alternanthera philoxeroides*
Brazilian waterweed	*Egeria densa*
Dotted duckweed	*Landoltia punctata*
Duck lettuce	*Ottelia alismoides*
Eurasian water-milfoil	*Myriophyllum spicatum*
Giant Salvinia	*Salvinia molesta*
Hydrilla	*Hydrilla verticillata*
Parrot feather	*Myriophyllum aquaticum*
Water hyacinth	*Eichhornia crassipes*
Water lettuce	*Pistia stratiotes*
Water spangles	*Salvinia minima*

[2]Nonindigenous Aquatic Species Program (http://nas.er.usgs.gov)

The TPWD reports Giant salvinia, hydrilla, Eurasian water-milfoil, and water hyacinth as non-indigenous plant species of concern in Toledo Bend Reservoir[3]. Thus, the TPWD may only be concerned with species with established, viable populations. Exactly how and when these species were brought into the state are not entirely known; however, once they established viable populations, they were probably inadvertently spread by boats and trailers moving between reservoirs, and possibly the aquarium and pond industries.

Giant salvinia was discovered in Toledo Bend Reservoir in 1998. It has since been reported in other reservoirs in east Texas, but great effort has been made to restrict further colonization within Toledo Bend Reservoir (e.g., including herbicides and biological controls) and to restrict the species transport to other reservoirs. Hydrilla was reported in Toledo Bend Reservoir in 1975. This species has now been introduced into many reservoirs in the eastern half of Texas. Water hyacinth was first observed in Texas before 1950, and the first documentation of Eurasian water-milfoil in the USA was in 1942 on the east coast; it has since radiated westward. Methods for controlling water hyacinth and Eurasian water-milfoil are similar to those used for giant salvinia.

Giant salvinia, hydrilla, and Eurasian water-milfoil of particular concern to TPWD because of their ability to reproduce asexually (vegetatively; from leaf or stem fragments). These species can spread rapidly in areas of high boat traffic because of fragmentation by boat propellers and subsequent regrowth by the fragments. Likewise, plant fragments could become entrained in the water intake and via the pipeline to the new reservoir. Fragments could then become established in a new water body.

Water hyacinth can reproduce both asexually (budding) and sexually (seeds). Seeding plants pose a threat if seeds are cast near the intake structure. Seeds have high probability surviving transport. The specific life history characteristics of seeding plants typically result in their ability to over-winter, thus increasing the probability of propagation following transport.

[3]Texas Parks and Wildlife Department. 2007. Nuisance Aquatic Vegetation Control in 2005. Management Data Series No. 246.

3.1.2 Fishes and Macroinvertebrates

The fishes and macroinvertebrates of Texas are not evenly distributed throughout their native range. Many species are distributed among drainage basins across the state, while others are restricted to only one or a few rivers. Specific habitat requirements and life history traits (e.g., mode of reproduction) further restrict some species to individual stream segments. Numerous fish species that occur in the Sabine River basin require moving water (i.e., *Etheostoma sp*.) or other physio-chemical parameters that are not provided by lake type conditions. Because of this, only a subset of the Sabine River fish assemblage succeeds in Toledo Bend Reservoir. Most of the fish species presently found in Toledo Bend Reservoir, including nonindigenous species, are found in other reservoirs throughout the state. Intentional stocking of recreational fishes, unintentional stocking that coincides with stocking of recreational fishes, and bait-bucket releases of forage type fishes (e.g., *Cyprinella sp*. and *Lepomis sp*.) have resulted in partial homogenization of fish assemblages[4].

Because reservoir fishes are typically nest spawners that utilize the substrate, their eggs would not likely be broadcast over a properly designed intake structure. Fishes are not considered to be of concern for this project. Macroinvertebrates are also not considered to be a concern if the intake structure is designed appropriately.

3.2 Water Quality

In order to understand how water transferred from Toledo Bend Reservoir will impact the quality and characteristics of water in a receiving reservoir, the following information is needed:

1. The anticipated relative proportions of transferred water to water that is otherwise in the receiving reservoir (this will require an understanding of the hydrology of the watershed for the receiving reservoirs)
2. The current water quality in both Toledo Bend Reservoir and the receiving reservoirs

[4] F. J. Rahel. 2002. Homogenization of freshwater faunas. Annual Review of Ecology and Systematics, 33:291-315.

3. Water quality standards for any constituent of concern in the receiving reservoirs for which there are standards

With this information, the anticipated degree of the impact can be modeled. At this point in project planning, it is not possible to know how much water will actually be transferred to the various reservoirs. In fact, it is possible that most of the water will actually be taken directly to terminal reservoirs or water treatment plants to be located near the pipeline's termination points. Release of water into reservoirs may, therefore, be limited and intermittent. As planning develops for this water management strategy, consideration will need to be given to establishing how much water each reservoir will be likely to receive.

It is possible, however, to review ambient water quality for a limited number of parameters, enabling some general observations on potential water quality impacts. For this study, the following parameters have been selected for review:

- pH
- Total Dissolved Solids (TDS)
- Chloride (Cl)
- Sulfate (SO_4)
- Hardness
- Alkalinity

The parameters pH, TDS, Cl, and SO_4 have been selected because both water quality standards and ambient water quality are known in Toledo Bend Reservoir and the proposed receiving reservoirs. Hardness and Alkalinity do not have water quality standards associated with them. However, these, along with other parameters such as pH and TDS are important parameters for treatment of surface water, and the ambient concentrations of these parameters can be found in TCEQ databases. Table 3.2 summarizes current water quality and water quality standards for the above-listed parameters, for Toledo Bend Reservoir and the proposed receiving reservoirs.

Ambient concentrations (i.e., the concentrations currently found in the reservoirs) of the parameters of interest are determined using data collected by the TCEQ, or by contractors for the TCEQ, and entered into the Surface Water Quality Monitoring (SWQM) database. The SWQM database is maintained by the TCEQ. Ambient conditions are usually calculated using several years of data. In this manner, ambient water quality may be determined over multiple seasons, and over a variety of hydrological and meteorological conditions.

Water quality standards for classified water bodies are generally contained in Title 30 Texas Administrative Code (30 TAC) Chapter 307. The receiving reservoirs have specific water quality standards provided in Appendix A – Site-Specific Uses and Criteria for Classified Segments of 30 TAC Chapter 307. In addition, 30 TAC Chapter 307 Table 1 (Criteria in Water for Specific Toxic Materials – Aquatic Life Protection) and Table 3 (Criteria in Water for Specific Toxic Materials – Human Health Protection) contain water quality standards for a wide range of toxic pollutants. To consider the toxic pollutants in the appendices of 30 TAC Chapter 307, additional water quality data for all reservoirs participating in the project would be needed.

Table 3.2

Summary of Water Quality for Selected Parameters for Toledo Bend Reservoir and Proposed Receiving Reservoirs

Reservoir	pH		TDS		Cl		SO_4		Hardness		Alkalinity	
	Ambient	Standard	Ambient	Standard	Ambient	Standard	Ambient	Standard	Ambient	Standard	Ambient	Standard
Toledo Bend Reservoir	6.5	6.0-8.5	126	240	19	70	15.4	50	36	NA	26	NA
Benbrook Lake	7.6	6.5-9.0	215	300	23.9	75	27	75	94	NA	112	NA
Cedar Creek Reservoir	7.2	6.0-8.5	114	200	12.7	50	25.4	100	76	NA	226	NA
Joe Pool Lake	7.5	6.5-9.0	358	500	21	100	110	250	168	NA	104	NA
Lake Palestine	6.6	6.0-8.5	112	200	24	50	27	50	43	NA	32	NA
Lake Tawakoni	7.3	6.0-9.0	148	200	6	50	12	50	68	NA	70	NA

[Values for pH are in standard units; all other values are in milligrams per liter (mg/L)]

Notes:
1) Ambient values are generally medians of available data from TCEQ
2) NA = not applicable

Water quality standards are applied to wastewater discharges through the National Pollutant Discharge Elimination System (NPDES) program. The transfer of water from one reservoir to another is not considered to be a discharge subject to the NPDES program. Nonetheless, water quality standards can be considered to be appropriate benchmarks for consideration of water quality impacts for inter-basin transfers. Furthermore, since an inter-basin transfer permit would be required for the project, it is logical to assume that such a permit would expect water quality standards in the receiving water reservoirs to be maintained.

As seen in Table 3.2, the water quality in Toledo Bend appears to be generally similar to the receiving reservoirs for those parameters for which there is a water quality standard (i.e., pH, TDS, Cl, and SO_4). Toledo Bend Reservoir pH is slightly lower than ambient levels in the other reservoirs. However, it is within the allowable ranges established in 30 TAC Chapter 307. For TDS, Cl, and SO_4, the situation is similar. The ambient concentrations of these parameters in Toledo Bend Reservoir water is sufficiently near those of the receiving reservoirs to indicate that impacts will be minimal. Certainly, the ambient concentrations of TDS, Cl, and SO_4 are well within the water quality standards for these parameters in the receiving reservoirs.

Hardness in Toledo Bend Reservoir water is less than in any of the receiving reservoirs (e.g., 21 percent of hardness in Joe Pool Reservoir and 84 percent of hardness in Lake Palestine). Alkalinity in Toledo Bend Reservoir water is also less than that of the receiving reservoirs (e.g., 11 percent of alkalinity in Cedar Creek Reservoir and 81 percent of alkalinity in Lake Palestine). While these parameters are not specifically health issues, they do have water treatment implications. Changes in hardness and alkalinity of raw water can require modifications in treatment chemical usage, or other operational changes at a water treatment plant. Blending waters with significant differences in hardness or alkalinity can sometimes create treatment challenges, as well.

3.3 Additional Data and Mitigation Factors

Additional data collection for water quality and aquatic species is not needed at this time. However, when the specific location of the intake structure planned for Toledo

Bend Reservoir is established, target sampling to determine presence of nonindigenous plant species and up-to-date water quality parameters will be necessary. Parameters to evaluate should include those indicated above. Others could include chlorophyll "a" and total organic carbon.

Mitigation will primarily be a function of the intake structure's location in Toledo Bend Reservoir and its design. The above referenced design parameters describe an intake structure with a through-screen velocity less than 0.5 feet per second to limit the possibility of impingement and entrainment of fishes. And, to prevent the transport of sediment and plants, the intake structure should be placed in the water column in an area of sufficient depth to allow mid-column placement.

4.0 Bay and Estuary Inflows

SABINE LAKE INFLOWS

Sources of Inflow
- Sabine River Basin
- Neches River Basin
- Taylor Bayou watershed
- Black Bayou watershed
- Coastal Areas
- Direct precipitation

Inflow Scenarios Reviewed
- TPWD Target Inflows
- Naturalized inflows
- Historical inflows

The success of the Toledo Bend Pipeline Project is dependent on many factors. Competing interests for available water will come from many types or designations of use, including, potentially, requirements for freshwater inflows to the Sabine Lake Estuary (Sabine Lake) below Toledo Bend Reservoir. Sabine Lake is an estuary system located on the boundary between Texas and Louisiana below Toledo Bend Reservoir. As such, this estuary system and its inflows are shared by both States.

For this study freshwater inflow scenarios Sabine Lake were compared in several ways to understand the relationships that exist between them. Historical and naturalized freshwater inflows were reviewed to identify how flow conditions may have been altered by human influences and provide a reference for inflows to Sabine Lake. Recommended target inflows proposed by TPWD were then compared to historical inflows and naturalized inflows to demonstrate the probability of achieving the recommended inflows under each scenario. Finally, the two freshwater flow scenarios were reviewed during drought-of-record conditions to determine the likelihood of meeting the recommended target flows under each scenario with drought inflow.

It is important to note that although target freshwater inflows have been recommended, they have not yet been approved. Likewise, decisions have not been made regarding how target freshwater inflows will be applied in the watershed. In addition, the Senate Bill 3 environmental flows process that is underway at this time for the Sabine and Neches watersheds and the Sabine Lake estuary will probably have a significant impact on any recommendations for freshwater inflows. That process, however, will not be completed for some time. Therefore, this section presents a historical perspective of inflows to the Sabine Lake Estuary and how these flows compare to the proposed target inflows.

4.1 Description of the Sabine Lake Estuary

Sabine Lake is located on the Texas-Louisiana border in southeast Texas, approximately seven miles from the Gulf of Mexico. With a surface area for the main body of the lake of 55,000 to 60,000 acres[5], it is one of the smallest estuaries on the Texas Coast. The lake supports an extensive coastal wetland (i.e., salt marsh) system around much of the perimeter. The average depth of the lake is less than seven feet[6]. Its small volume, coupled with large freshwater inflows from the Sabine and Neches Rivers, result in a turnover rate of around 50 times per year. This is a substantially higher turnover rate than any other bay and estuary system on the Texas Coast. A map of Sabine Lake and vicinity is provided in Figure 4.1.

Sabine Lake is hydraulically connected to the Gulf of Mexico via Sabine Pass, a seven-mile long tidal inlet between the Gulf and the southern end of the lake. Historically, Sabine Pass was a narrow, shallow waterway. However, in the latter part of the 19th century, a ship channel was dredged in the pass and lake to enable deep-water navigation to inland ports. Over ensuing years, the ship channel has been expanded in length, depth, and width, and extended up into the Neches and Sabine Rivers.

Today, the Sabine-Neches Waterway extends from the Gulf of Mexico to Port Arthur on the western shore of Sabine Lake; to Beaumont upstream on the Neches River; and Orange, upstream on the Sabine River. The waterway is some 400 feet wide and 40 feet deep[7]. The United States Army Corps of Engineers (USACE) is currently considering whether to further expand the channel to accommodate larger ship traffic. The expansion could deepen the channel to 48 feet and widen it to as much as 700 feet.

One feature of the Sabine-Neches Waterway is that it was constructed adjacent to the western shore of Sabine Lake, largely separated from the main body of the lake by Pleasure Island, a manmade island built from the dredge spoil from the waterway construction. This island extends most of the length of Sabine Lake. This feature allows the intrusion of salt water into Sabine Lake from the Gulf of Mexico at both the southern end of the estuary near Sabine Pass and the northern end near the confluence of the Neches and Sabine Rivers.

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[5] Communication with Sabine River Authority of Texas
[6] www.gulfbase.org
[7] Handbook of Texas Online

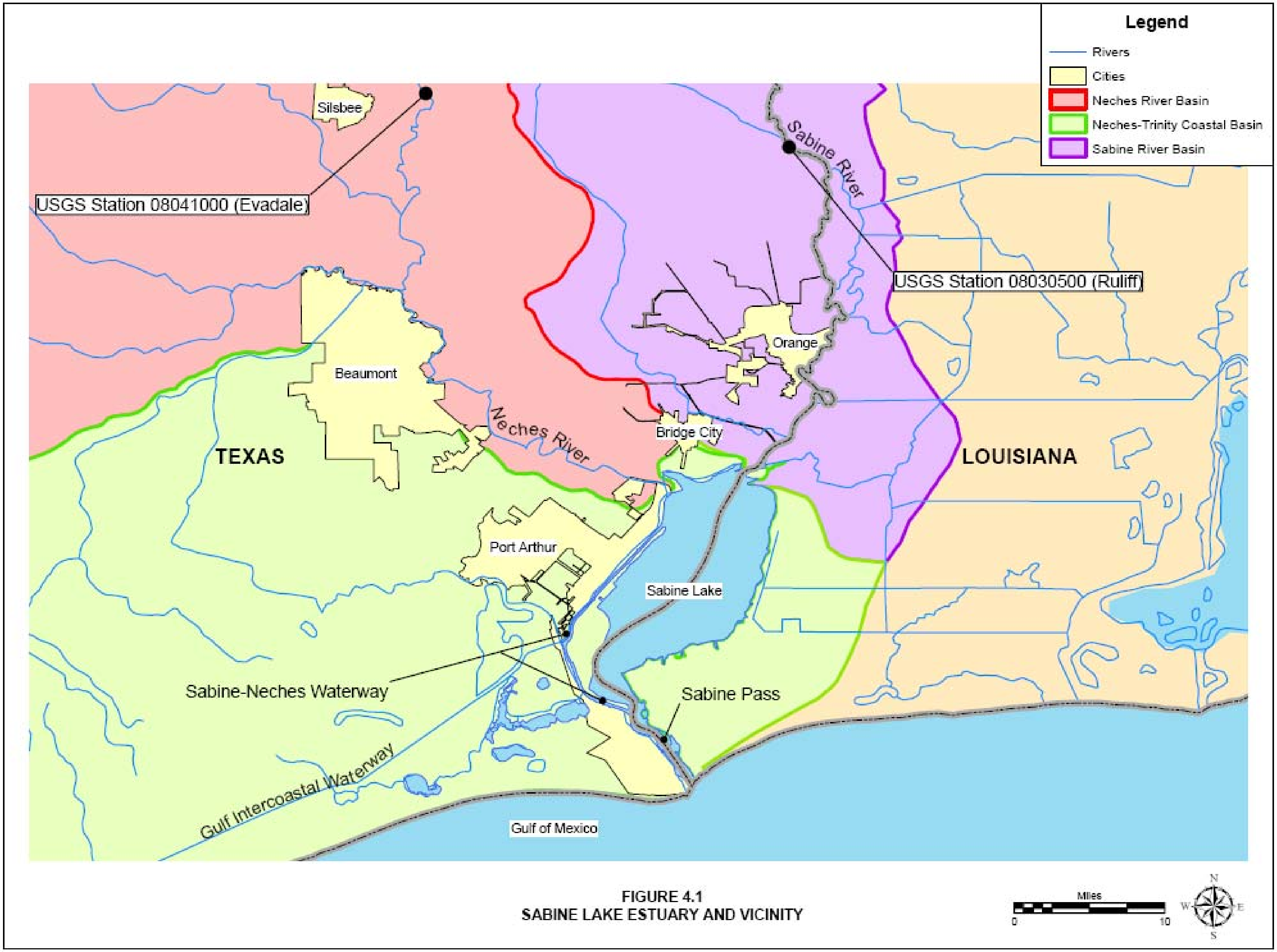


FIGURE 4.1
SABINE LAKE ESTUARY AND VICINITY

Water movement in Sabine Lake is driven by freshwater inflows, tides, wind, and salinity gradients, all of which stimulate currents in the estuary. Tidal influence is a relatively small component of water movement into and out of the lake, compared to other influences. However, wind can be a significant factor, owing to the lake's large surface area and relatively shallow depth. Wind causes significant turbulent mixing in the lake, as well as significant changes in water surface elevation (much more than tides) in the lake and in Sabine Pass, stimulating flow of more or less salt water into the lake, depending on wind direction.

Salinity gradients are pressure gradients in the water column caused by variations in the salinity. The denser salt water tends to sink in the water column, displacing freshwater and moving upstream into freshwater areas. This is sometimes referred to as a "salt wedge." Salinity gradients are not usually significant in shallow systems, but their intensity increases as the depth of water increases. The Sabine-Neches Waterway, with its 40-foot depth, increases the effect of salinity intrusion into Sabine Lake and further upstream into rivers and streams feeding the lake. There have been instances on the Sabine and Neches Rivers when the density current extended upstream to the extent that the salt wedge threatened freshwater diversions for irrigation or other purposes. The Lower Neches Valley Authority (LNVA) has constructed a salt water barrier on the Neches River to mitigate the impacts of salt water intrusion.

Salinity intrusion also adversely affects the marshes that surround Sabine Lake. These marshes are an important component of the estuary. However, due to extensive channelization into and through the marshes to support petroleum exploration over the years, salt water flow has increased into these sensitive areas.

4.2 Freshwater Inflow Scenarios for Sabine Lake

The importance of freshwater inflows is acknowledged in the Texas Water Code 16.058(a), in which the TPWD and Texas Water Development Board (TWDB) are directed to "establish and maintain on a

INFLOW SCENARIOS

TPWD Recommended Inflow
- 9.6 million ac-ft/yr

Naturalized Inflow (1969 – 1996)
- Median – 14.5 million ac-ft/yr

Historical Inflow (1969 – 1996)
- Median – 14.1 million ac-ft/yr

3-Year Drought Average (1963 – 1965)
- Naturalized – 5.8 million ac-ft/yr
- Historical – 5.1 million ac-ft/yr

continuous basis a bay and estuary data collection and evaluation program and conduct studies and analyses to determine bay conditions necessary to support a sound ecological environment." The question is what quantity of freshwater inflow is necessary to support a sound ecological environment in Sabine Lake? To answer that question, one must also define the term "sound ecological environment." Given the complicated nature of Sabine Lake, coupled with substantial alterations to estuary ecology resulting from the Sabine-Neches Waterway, this is not an easy question to answer. The answer is even further complicated if the Sabine-Neches Waterway is expanded as proposed by the USACE.

The TPWD published a report in 2005 that described its assessment and recommendations for freshwater inflows. These recommended freshwater inflows included in that report are described in Section 4.2.1. These recommended inflows will be compared to historical, naturalized, and drought-of-record freshwater inflow scenarios. These scenarios are described in Sections 4.2.2, 4.2.3, and 4.2.4, respectively.

4.2.1 Recommended Target Freshwater Inflows

The TPWD issued a report entitled Freshwater Inflow Recommendation for the Sabine Lake Estuary of Texas and Louisiana, (March 2005) to address requirements of the Texas Water Code to determine conditions necessary to support estuary health. The study upon which the report is based described the State's modeling of freshwater inflow needs. A mathematical model developed by the TWDB, the Texas Estuarine Mathematical Programming or Optimization Model (TxEMP), was used. This model incorporates salinity, sediment, nutrient, and fisheries productivity constraints, along with salinity-inflow, and catch-inflow equations to determine the above defined inflow targets. The target inflows developed by TxEMP were then used as inputs in a second model "TxBLEND," which is a high-resolution hydrodynamic and conservative mass transport model. TxBLEND was used to predict bay salinity regimes.

TPWD then compared the model results for TxEMP and TxBLEND with actual physical and biological data for salinity and catch for Sabine Lake. Using the model results, recommendations for monthly freshwater inflows to the estuary necessary to maintain certain levels of health and productivity were established. These recommended inflows included the following:

- MinQ – the minimum freshwater inflows that satisfy all model constraints.
- MaxQ – the maximum freshwater inflows that satisfy all model constraints.
- MaxC – the freshwater inflows that maximize fishery productivity, while remaining within the range of MinQ and MaxQ inflows.

TPWD verified the model results for TxEMP and TxBLEND with actual physical and biological data for salinity and catch for Sabine Lake. Monthly values of MinQ, MaxQ, and MaxC were developed and verified. These recommended monthly inflows are depicted in Figure 4.2. TPWD also summed the 12 monthly values to develop the following annual target freshwater inflows:

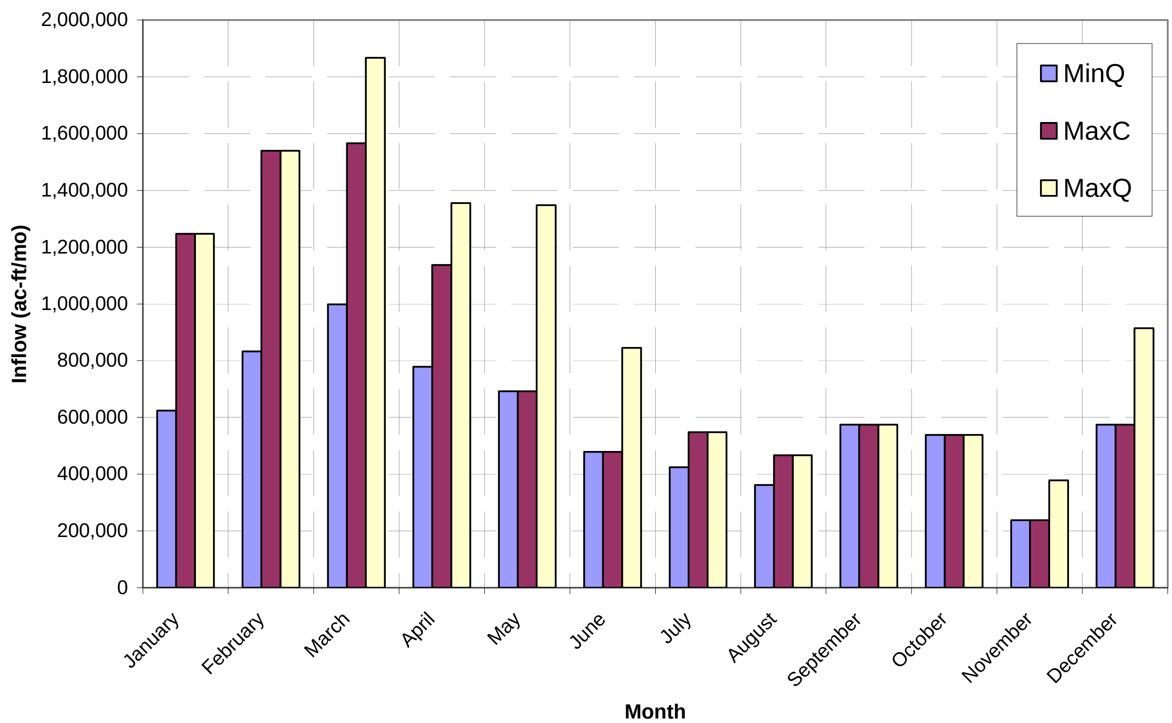
MinQ:	7,114,000 acre-feet (ac-ft)
MaxQ:	11,619,300 ac-ft
MaxC:	9,596,600 ac-ft

TPWD found that the MaxC inflow would be the most appropriate target for the estuary, stating that the MaxC "will create biologically suitable salinity and nutrient regimes in the Sabine Lake system." Their recommendation was based on the following:

- MaxC was better at maintaining salinities below the upper salinity boundary in Sabine Lake than MinQ.
- MaxC appeared to improve the abundance of some of the aquatic species used in the study better than MinQ.
- MaxC inflows were predicted to achieve more advantageous salinity conditions for the wetlands that surround Sabine Lake.
- MaxC closely approximated the inflow needed to provide for sufficient nutrient loadings to Sabine Lake.

A detailed discussion of these findings is not within the scope of this report. However, the findings have been challenged in a report entitled Determination of Target Freshwater Inflows for the Sabine Lake Estuary: Review and Critique (Ward; April 2006). For purposes of this evaluation of inflow scenarios, the discussion will focus on the MaxC recommended target inflow.

Figure 4.2
Monthly Distribution of Recommended Target Inflows for Sabine Lake



4.2.2 Historical Freshwater Inflows

Historical freshwater inflow to Sabine Lake originates in five different sources:

- Sabine River and its tributaries (9,797 sq. miles of drainage area)
- Neches River and its tributaries (10,025 sq. miles of drainage area)
- Taylor Bayou and its tributaries (617 sq. miles of drainage area. This stream is part of the Neches-Trinity Coastal Basin.)
- Adjacent coastal drainage areas not included in the contributing areas listed above in Texas and Louisiana (230 sq. miles of drainage area)
- Direct precipitation less evaporation (92 sq. miles of surface area)

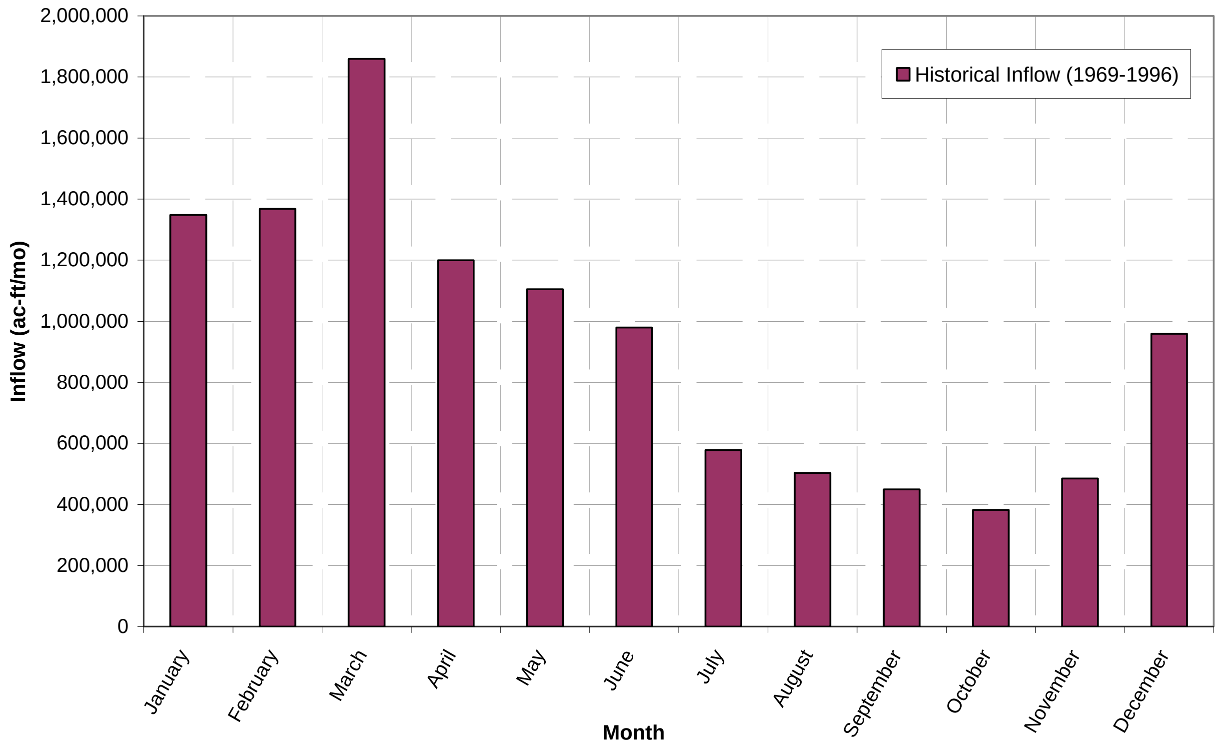
Historical gauging records available from the USGS were used to estimate inflows from the Sabine and Neches river basins. For areas with no historical gauge records, inflows were estimated based on rainfall-runoff estimates for the contributing drainage areas. For these areas, adjustments were made for historical diversions and return flows as appropriate. Available records ranged from 1925 to the present, with some historical data covering only a portion of this record. The monthly historical flows are presented in Appendix C.

A period of record for historical flows of 1969 through 1996 was used to determine annual and monthly median historical inflows. This period was selected because it represents flow after the construction and impoundment of Toledo Bend Reservoir on the Sabine River and the Sam Rayburn Reservoir on the Angelina River, a major tributary to the Neches River. Sam Rayburn Reservoir was impounded in 1965 and Toledo Bend in 1967. The initial filling of Toledo Bend was completed in late 1968.

Annual median historical freshwater inflows to Sabine Lake have been approximately 14.1 million acre-feet. The predominant sources of these freshwater inflows are the Sabine and Neches Rivers. Figure 4.3 depicts the total monthly median inflows to Sabine Lake for this scenario. Inflow varies significantly from month to month, being higher during the January through May period, and relatively low from July through October.

Historical freshwater inflows were also reviewed for a longer period (i.e., 1940 through 1996). It was determined that the annual median inflows during the longer period of record were approximately 13.5 million ac-ft, slightly lower than for the more recent period. Since the reservoirs were constructed inflows to the bay have tended to be higher during the months of July through October (traditional low-flow months). This phenomenon is probably due to the release of more water during the hotter summer months for irrigation use, power generation purposes, and to mitigate salt water intrusion during months that generally have lower levels of freshwater inflow.

Figure 4.3
Monthly Median Historical Freshwater Inflows (1969-1996)



4.2.3 Naturalized Freshwater Inflows

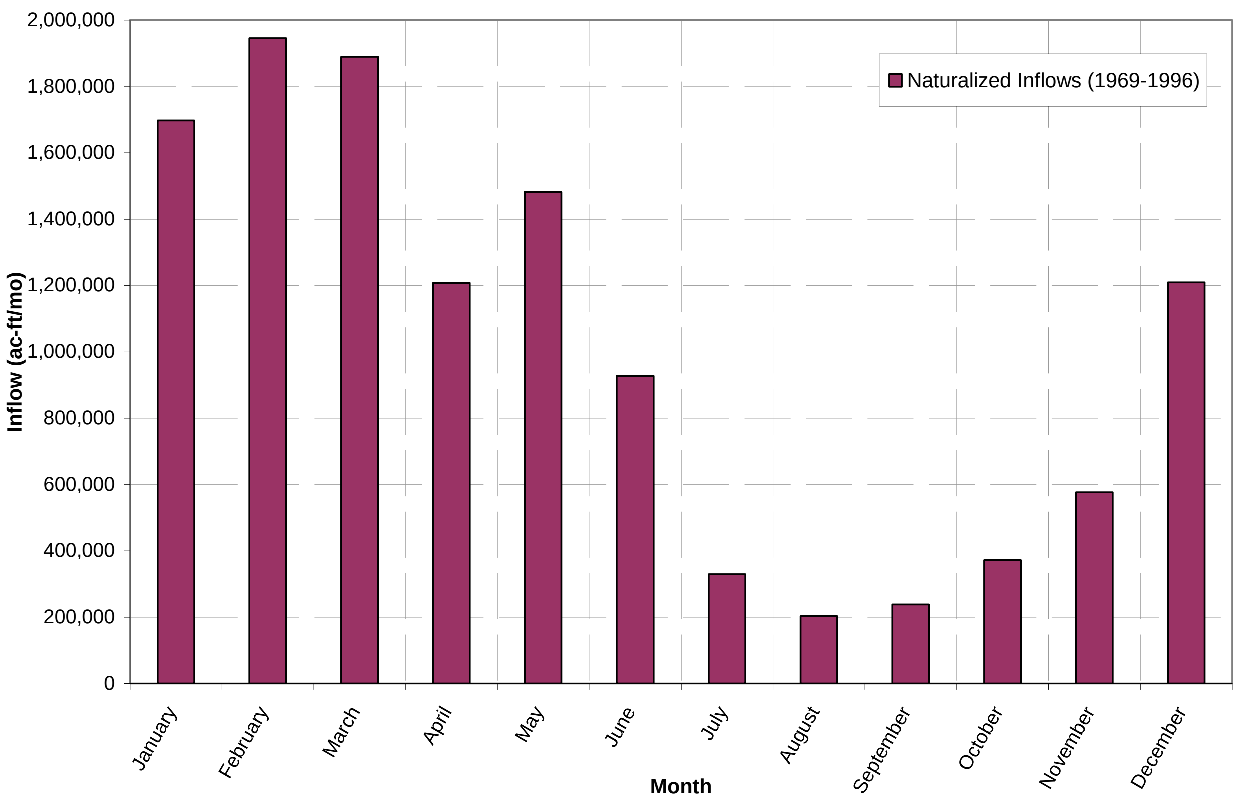
Naturalized freshwater inflows for a watershed represent an estimate of the flow of fresh water that would enter the system in the absence of anthropogenic effects on the system. These effects include water diversions for irrigation or other uses, impoundments within the watershed, and return flows produced by human activity. Naturalized inflows were developed for monthly time steps for the purposes of comparing these flows to other scenarios of inflow (e.g., historical inflows) and to recommended target inflows.

As previously discussed, inflows to the Sabine Lake originate from five sources. The naturalized inflows associated with Texas river basins were obtained from the TCEQ Water Availability Models (WAM) for the Sabine River, Neches River and the Neches-Trinity

Coastal Basin. Inflows from other contributing areas were determined from rainfall-runoff estimates. A summary of the monthly naturalized inflows is included in Appendix C.

Over the historical period from 1969 to 1996, the annual median naturalized inflow was estimated to be approximately 14.5 million ac-ft, approximately 400,000 ac-ft per year higher than historical values. Figure 4.4 depicts the monthly median total inflows for the naturalized inflows scenario. As with historical inflows, the naturalized freshwater inflows vary significantly from month to month.

Figure 4.4
Monthly Median Naturalized Freshwater Inflows (1969-1996)



4.2.4 Freshwater Inflows during Droughts-of-Record

In determining the drought-of-record for Sabine Lake, it was necessary to establish a target length for the drought-of-record. The target length might typically be set as the length of time required for critical conditions of salinity or other measure of ecological health to be reached under drought conditions. Determining critical conditions, and the time required to reach critical conditions, is beyond the scope of this evaluation. However, a target drought-of-record of three years (DR3) has been selected for purposes of this evaluation. A three-year drought would be considered severe in terms of its effect on flow in the Neches and Sabine Rivers, and would probably be significant in its impact on the estuary. For this evaluation, droughts for both historical and naturalized inflows were developed.

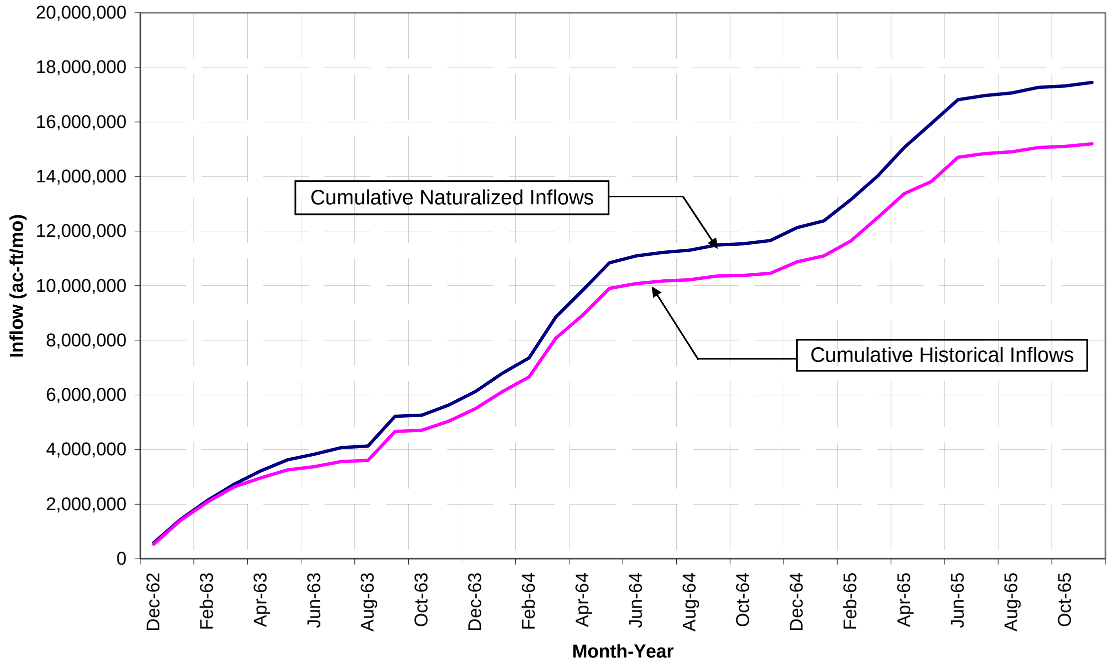
To develop the DR3, the moving total inflow for every 36-month (i.e., three-year) period for the full period of record was evaluated. Both the historical and naturalized flow scenarios for a period of record from January 1940 through December 1996 were evaluated in this manner. The 36-month period having the minimum total inflow represents the DR3 for each flow scenario. The evaluation indicated that the same three-year period could be used for both naturalized and historical inflow scenarios: December 1962 through November 1965. It should be noted that Sam Rayburn Reservoir was impounded in 1965, and the initial filling of the reservoir occurred during the latter part of the historical drought of record. The average annual inflow during the historical drought-of-record is approximately 5.1 million ac-ft. For naturalized conditions, the average annual drought-of-record inflow is approximately 5.8 million ac-ft. Figure 4.5 depicts the cumulative monthly inflows during the historical DR3 and naturalized DR3.

4.3 Comparisons of Freshwater Inflow Scenarios

To better understand the freshwater inflows to Sabine Lake and the feasibility of the proposed Target Inflows, the following comparisons were made:

1. Historical and naturalized freshwater inflow scenarios from 1969 to 1996.
2. Above scenarios of freshwater inflows with recommended target freshwater inflows proposed by the TPWD.
3. Freshwater inflows during the 3-year drought-of-record for the Sabine Lake Estuary with recommended target freshwater inflows proposed by the TPWD.

Figure 4.5
Cumulative Historical and Naturalized Freshwater Inflows for the Three-year Drought-of-Record

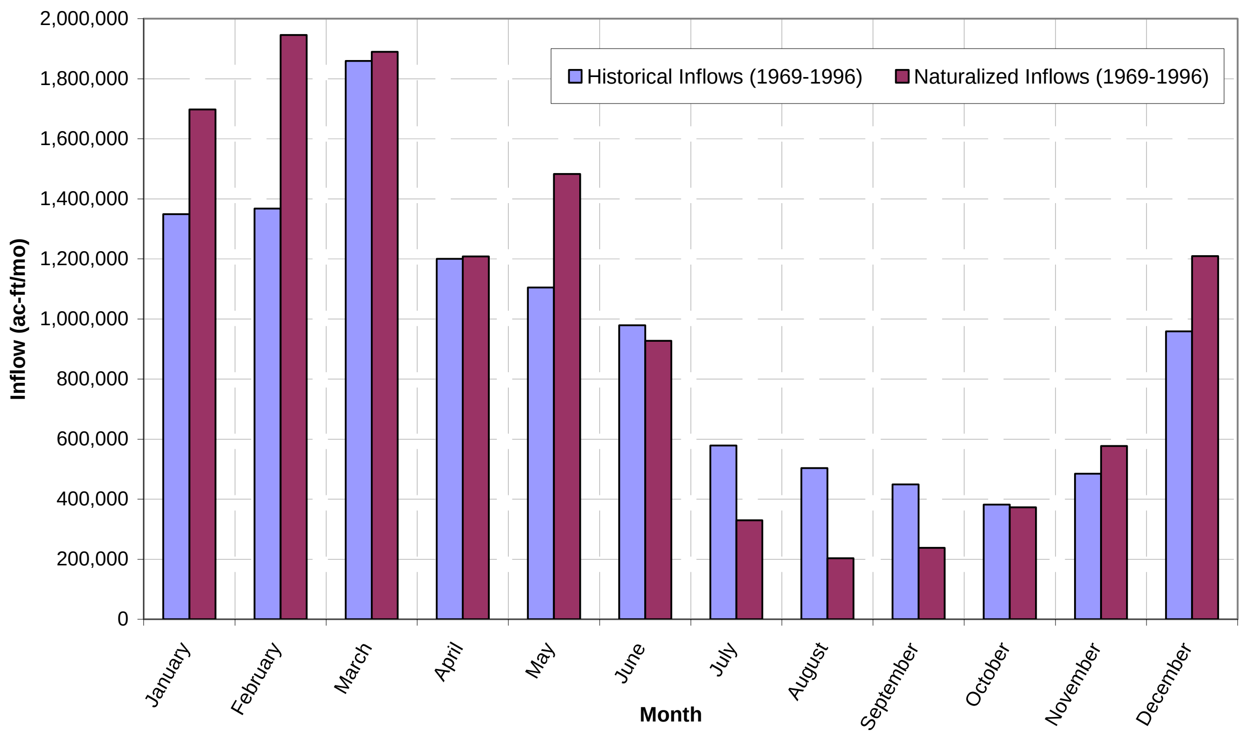


4.3.1 Historical Inflows Compared to Naturalized Inflows

The comparison of historical and naturalized inflows was made first on the basis of annual inflows and then on the basis of monthly inflow distributions. Annual median inflows for historical and naturalized scenarios show that historical inflows are slightly less than naturalized inflows (i.e., 14.1 million ac-ft to 14.5 ac-ft, or approximately 2.8 percent less).

The comparison of monthly median inflows shows a significant variation from month to month in the difference between the two inflow scenarios. Figure 4.6 depicts the two scenarios on a monthly basis. As may be seen, naturalized inflows between December and May (inclusive) are higher than historical inflows. However, during the warmer months, when inflows would be expected to be at their lowest, historical inflows actually exceed naturalized inflows. This phenomenon is probably due to the release of stored water from both Toledo Bend and Sam Rayburn Reservoirs during warm weather months to generate hydro-electric power and to mitigate salt water intrusion.

Figure 4.6
Comparison of Monthly Median Historical and Naturalized Freshwater Inflows (1969-1996)



4.3.2 Historical Inflows Compared to Recommended Target Inflows

An effective comparison of historical freshwater inflows to those recommended by the TPWD (i.e., MaxC) may be made using frequency distributions for each month of historical inflow. These distributions can be used to describe the probability that the historical inflow will be less than a prescribed monthly level of flow. The same approach may also be taken for annual volumes of freshwater inflows. A frequency distribution for annual inflows was prepared and compared to the annual MaxC. The probability that the annual MaxC will not be met or exceeded and the recurrence interval for MaxC are established in this way.

Table 4.1 summarizes the probability that MaxC will not be met or exceeded in each month using historical flows. The table also presents the recurrence interval for not meeting or exceeding MaxC. Based on this analysis the most likely month for achieving the recommended MaxC target inflows is November, when there is only 12 percent chance that MaxC will not be met or exceeded. The recurrent interval for not meeting MaxC in November is approximately 8.4 years. In other words, it could be expected that MaxC would not be met or exceeded in one year out of eight in November.

In three out of 12 months (February, September, and October), the probability that MaxC inflows will not be achieved exceeds 50 percent. In fact, in October, MaxC would be expected to not be met or exceeded in two out of three years (68 percent probability). On an annual basis, inflows would fail to meet or exceed MaxC in one out of three years (30 percent probability).

Table 4.1

Probability That MaxC Will Not Be Met Under
Historical Freshwater Inflows

Month	MaxC (ac-ft)	Probability that MaxC Will Not Be Met	Recurrence Interval for not Meeting MaxC (years)
January	1,246,400	48%	2.1
February	1,539,200	58%	1.7
March	1,565,780	39%	2.6
April	1,136,640	44%	2.3
May	691,900	23%	4.4
June	478,700	22%	4.6
July	547,300	48%	2.1
August	466,500	42%	2.4
September	574,600	62%	1.6
October	537,900	68%	1.5
November	237,550	12%	8.4
December	574,130	34%	2.9
Annual	**9,596,600**	**30%**	**3.3**

4.3.3 Naturalized Inflows Compared to Recommended Target Inflows

The approach to comparing monthly and annual naturalized inflows to recommended target inflows was the same as with historical inflows. That is, a frequency distribution of naturalized inflows was developed for each month, and the probability that MaxC would not be met or exceeded established for each month. Likewise, the frequency distribution for annual naturalized inflows was developed and compared to the annual MaxC. Table 4.2 summarizes the results.

Table 4.2

Probability That MaxC Will Not Be Met Under
Naturalized Freshwater Inflows (1969 – 1996)

Month	MaxC (ac-ft)	Probability that MaxC Will Not Be Met	Recurrence Interval for not meeting MaxC (years)
January	1,246,400	38%	2.7
February	1,539,200	40%	2.5
March	1,565,780	35%	2.8
April	1,136,640	43%	2.3
May	691,900	20%	5.0
June	478,700	38%	2.8
July	547,300	60%	1.7
August	466,500	81%	1.2
September	574,600	78%	1.3
October	537,900	69%	1.5
November	237,550	12%	8.3
December	574,130	15%	6.8
Annual	**9,596,600**	**26%**	**3.8**

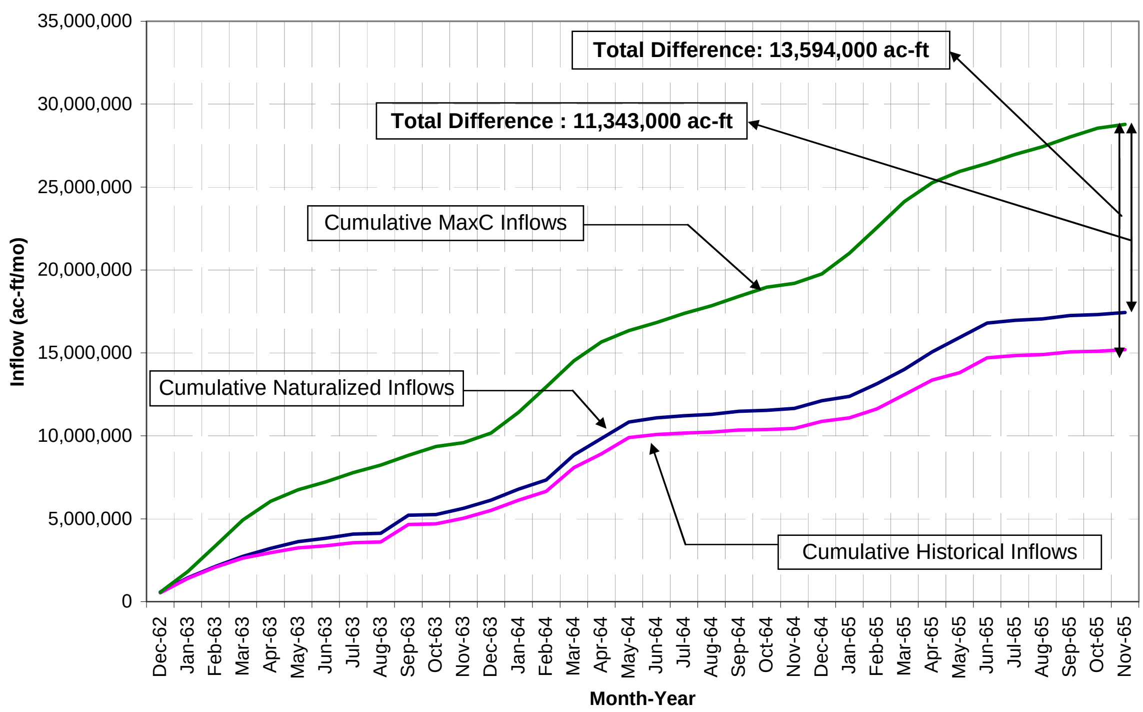
November and December are the only months under naturalized flow conditions, for which there is a relatively low probability that MaxC will not be met or exceeded (12 and 15 percent, respectively). During low-flow periods, the probability of not achieving MaxC rises to over 80 percent (August), or four out of five years. On an annual basis, MaxC would not be met or exceeded in approximately one out of four years.

4.3.4 Droughts-of-Record Inflows Compared to Recommended Target Inflows

Freshwater inflows during droughts-of-record were compared to target inflows on the basis of cumulative inflows over the period of drought. A cumulative review was necessary because the droughts-of-record extend over a multi-year period; and, by nature, result in a cumulative effect.

Figure 4.7 compares cumulative historical and naturalized inflows to cumulative target inflows for the three-year period associated with the historical drought-of-record. The figure depicts the theoretical gaps (or difference) between historical or naturalized inflows and MaxC. As seen in Figure 4.7, the difference generally grows as the drought lengthens. For historical inflows, the difference for the three-year drought is over 13 million ac-ft of freshwater inflows. This is an average difference of approximately 4.5 million ac-ft per year. For naturalized inflows, the difference is over 11 million ac-ft, or approximately 3.8 million ac-ft per year.

Figure 4.7
Cumulative Historical and Naturalized Freshwater Inflows Compared to Cumulative MaxC Inflows for the Three-year Drought-of-Record



4.4 Summary of Findings

The comparisons made and evaluated for this project yield the following observations relating to the various inflow scenarios:

- Annual median historical inflows are approximately 97 percent of annual naturalized median inflows, but during the traditionally low-flow months of August through October, historical flows are significantly higher than naturalized flows.
- The higher inflows during what would otherwise be expected to be low-flow periods are made possible primarily by the storage of water behind the Sam Rayburn Reservoir and Toledo Bend Reservoir dams during the fall and winter months.
- The lower historical inflows during the naturally occurring high-inflow months (January through May) are partly associated with the retention of flood waters in reservoirs. In the case of Sam Rayburn Reservoir, which is a flood control reservoir, the reservoir is accomplishing its task of flood control while supporting more beneficial inflows when they are needed during summer months. Although Toledo Bend Reservoir was not developed for flood control purposes, it too, is retaining flood waters and providing important additional fresh water to Sabine Lake during the low-flow months.
- Neither historical nor naturalized inflows would achieve the recommended target inflows to Sabine Lake on a consistent basis. Whether historical or naturalized inflow scenarios are used, during most months, there is a significant rate of failure in meeting recommended target inflows. In some months, it could be expected that recommended target inflows would be met less than once in five years.
- The comparisons of the recommended target inflows to drought inflows are even more dramatic. In a three-year drought-of-record, cumulative target inflows would be short by approximately 11.3 million ac-ft of freshwater inflow under a naturalized flow scenario. For historical inflows, the cumulative target inflow difference would be approximately 13.6 million ac-ft. In other words, these differences amount to between four and five volumes of stored water in Sam Rayburn Reservoir, or between 2.5 and three volumes of stored water in Toledo Bend Reservoir.
- The methodology utilized by TPWD to develop the target inflows has been challenged and is subject to refinement, which could change the target inflow quantities. The documented concerns about the methodology used to derive the recommended target inflows supports the need to address the significant uncertainty about the recommended target inflows and the means by which such flows should be applied.

4.4.1 Recommendations

Fortunately, Sabine Lake's substantial existing freshwater inflows are far greater than other bays and estuaries on the Texas Coast. This fact does not alter the need to adequately address freshwater inflow needs, but it does mean that there is time available to ensure that the question is answered using sound science, and that the relationship of freshwater inflows to various water management strategies is clearly understood. The following recommendations would aid in providing an improved understanding of these issues:

- Additional investigations should be performed to improve the methodology in order to establish the target inflows based on sound science. Monitor the inflow work being performed for other Texas estuaries and support incorporating improvements developed for these other areas into the methodology used for Sabine Lake and its freshwater requirements. Of particular interest is the previously cited work by Ward which suggested that improved estimates of the target inflows could be achieved by extending the biological databases used in verification of inflow targets. Other, more appropriate biota could be used and more catch data would improve the methodology for determining necessary inflows.
- Additional study of Sabine Lake should also include a more deliberate assessment of the impact of the Sabine-Neches Waterway on salinity in the estuary, and of how habitat restoration for the marshes around the estuary could improve the ecological health of the entire system.
- Additional modeling should be performed to determine how various drought-of-record periods might affect salinities. Additional modeling for drought-of-record periods of two years through seven years is recommended. This would help to establish what the critical drought-of-record for the estuary might be.

In accordance with requirements of the water planning process for the State of Texas, the East Texas Regional Water Planning Region will continue to consider the needs of bays and estuaries as part of the evaluations of water management strategies and impacts to the region.

5.0 Conclusions

The Toledo Bend Pipeline Project is a viable project to provide needed water supplies to the North Texas area. At this time the major participants are pursuing other water supply projects in the near-term with the intent of developing the Toledo Bend Pipeline Project by 2060. The cost feasibility of this project is somewhat contingent on the pipeline route (total length of pipeline), increasing capital costs, and uncertain energy costs. The cost analyses conducted for this study are based on a preliminary assessment of a pipeline corridor and delivery points. Over the next 50 years, these assumptions may change and more detailed analyses will be needed when this project moves to development. As each participant continues to development water supply projects, the options for transmitting Toledo Bend water to the areas of growth could increase. The East Texas Region should continue to monitor the demand for water from sources in its region and coordinate with adjoining regions to best utilize its resources.

6.0 References

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APPENDIX A

ASSUMPTIONS FOR COST ESTIMATES

ASSUMPTIONS FOR CAPITAL COSTS:

Conveyance Systems

Standard pipeline costs used for these cost estimates are shown in Table 1. Pump station costs are based on required horsepower capacity and are listed in Table 2. The power capacity is to be determined from the hydraulic analyses conducted from a planning level hydraulic grade line evaluation (or detailed analysis if available). Pipelines and pump stations are to be sized for peak pumping capacity.

- Pump efficiency is assumed to be 75 percent.
- Peaking factor of 2 times the average demand for strategies when the water is pumped directly to a water treatment plant. (or historical peaking factor, if available)
- Peaking factor of 1.2 to 1.5 is to be used if there are additional water sources and/or the water is transported to a terminal storage facility.
- Ground storage is to be provided at each booster pump station along the transmission line.
- Ground storage tanks should provide sufficient storage for 2.5 to 4 hours of pumping at peak capacity. Costs for ground storage are shown in Table 3. Covered storage tanks are used for all strategies transporting treated water.

Other Costs

- Engineering, contingency, construction management, financial and legal costs are to be estimated at 30 percent of construction cost for pipelines and 35 percent of construction costs for pump stations, treatment facilities and reservoir projects. (TWDB Exhibit B)
- Permitting and mitigation for transmission and treatment projects are to be estimated at 1 percent of the total construction costs.
- Right-of-way costs for transmission lines are estimated per acre of ROW using the unit costs in Table 4. If a small pipeline follows existing right-of-ways (such as highways), no additional right-of-way cost is assumed. Large pipelines will require ROW costs regardless of routing.

Interest during construction is the total of interest accrued at the end of the construction period using a 6 percent annual interest rate on total borrowed funds, less a 4 percent rate of return on investment of unspent funds. This is calculated assuming that the total estimated project cost (excluding interest during construction) would be drawn down at a constant rate per month during the construction period. Factors were determined for different lengths of time for project construction. These factors were used in cost estimating and are presented in Table 5.

ASSUMPTIONS FOR ANNUAL COSTS:

Annual costs are to be estimated using the following assumptions:

- Debt service for all transmission and treatment facilities is to be annualized over 30 years, but not longer than the life of the project. Debt service for reservoirs is to be annualized over 30 years. [Note: uniform amortization periods should be used when evaluating similar projects for an entity.]
- Annual interest rate for debt service is 6 percent.
- Operation and Maintenance costs are to be calculated based on the construction cost of the capital improvement. Engineering, permitting, etc. should not be included as a basis for this calculation. However, a 20% allowance for construction contingencies should be included for all O&M calculations. Per the "General Guidelines for Regional Water Plan Development (2007-2012)", O&M should be calculated at:
    - 1 percent of the construction costs for pipelines
    - 1.5 percent for dams
    - 2.5 percent of the construction costs for pump stations, storage tanks, meters and SCADA systems
    - Assume O&M costs for treatment facilities are included in the treatment cost
- Pumping costs are to be estimated using an electricity rate of $0.09 per Kilowatt Hour. If local data is available, this can be used.

Table 1

Pipeline Costs (does not include ROW)

Diameter	**Base Installed Cost**	**Rural Cost with Appurtenances**	**Urban Cost with Appurtenances**	**Assumed ROW Width**	**Assumed Temporary Easement Width**
(Inches)	($/Foot)	($/Foot)	($/Foot)	(Feet)	(Feet)
6	22	24	36	15	50
8	29	32	48	15	50
10	36	40	60	20	60
12	44	48	72	20	60
14	51	56	84	20	60
16	58	64	96	20	60
18	65	72	108	20	60
20	76	84	126	20	60
24	98	108	162	20	60
30	123	135	200	20	60
36	155	171	257	20	60
42	182	200	300	30	70
48	227	250	348	30	70
54	268	295	405	30	70
60	309	340	460	30	70
66	373	410	550	30	70
72	436	480	648	30	70
78	500	550	743	40	80
84	573	630	850	40	80
90	655	720	972	40	80
96	727	800	1,080	40	80
102	809	890	1,200	40	80
108	909	1,000	1,350	40	80
114	1,000	1,100	1,485	50	100
120	1,127	1,240	1,675	50	100
132	1,364	1,500	2,025	50	100
144	1,609	1,770	2,390	50	100

Notes: a. Costs are based on PVC class 150 pipe for the smaller long, rural pipelines.
b Appurtenances assumed to be 10% of installed pipe costs.
c For urban pipelines, costs were increased by 35% for cost with appurtenances. For pipes 42"and smaller, additional costs were added.
d Adjust costs for obstacles (rock, forested areas) and easy conditions (soft soil in flat country).

Table 2
Pump Station Costs for Transmission Systems

Horsepower	Booster PS Costs	Lake PS with Intake Costs
5	$480,000	
10	$500,000	
20	$525,000	
25	$550,000	
50	$600,000	
100	$690,000	
200	$1,040,000	$1,380,000
300	$1,340,000	$1,780,000
400	$1,670,000	$2,220,000
500	$1,890,000	$2,510,000
600	$2,000,000	$2,660,000
700	$2,110,000	$2,810,000
800	$2,340,000	$3,110,000
900	$2,450,000	$3,260,000
1,000	$2,670,000	$3,551,000
2,000	$3,890,000	$5,174,000
3,000	$4,670,000	$6,211,000
4,000	$5,670,000	$7,541,000
5,000	$6,500,000	$8,645,000
6,000	$7,500,000	$9,975,000
7,000	$8,300,000	$11,039,000
8,000	$9,200,000	$12,236,000
9,000	$10,200,000	$13,566,000
10,000	$11,400,000	$15,162,000
20,000	$19,000,000	$25,270,000
30,000	$25,000,000	$33,250,000
40,000	$31,000,000	$41,230,000
50,000	$36,000,000	$47,880,000
60,000	$41,000,000	$54,530,000
70,000	$46,000,000	$61,180,000

Note:
1. Lake PS with intake costs include intake and pump station.
2. Adjust pump station costs upward if the pump station is designed to move large quantities of water at a low head (i.e. low horsepower). See Rusty Gibson for appropriate factor.
3. Assumed multiple pump setup for all pump stations.

Table 3
Ground Storage Tanks

Size	With Roof	Without Roof
0.05	$116,000	$99,000
0.1	$170,000	$145,000
0.5	$407,000	$310,000
1.0	$590,000	$436,000
1.5	$740,000	$550,000
2.0	$890,000	$664,000
2.5	$1,010,000	$764,000
3.0	$1,130,000	$863,000
3.5	$1,260,000	$952,000
4.0	$1,400,000	$1,040,000
5.0	$1,600,000	$1,212,000
6.0	$1,930,000	$1,400,000
7.0	$2,275,000	$1,619,000
8.0	$2,625,000	$1,925,000
10.0	$3,485,000	$2,560,000
14.0	$5,205,000	$3,800,000

Note: Costs assume steel tanks smaller than 1 MG, concrete tanks 1 MG and larger.

Table 4
Pipeline Easement Costs

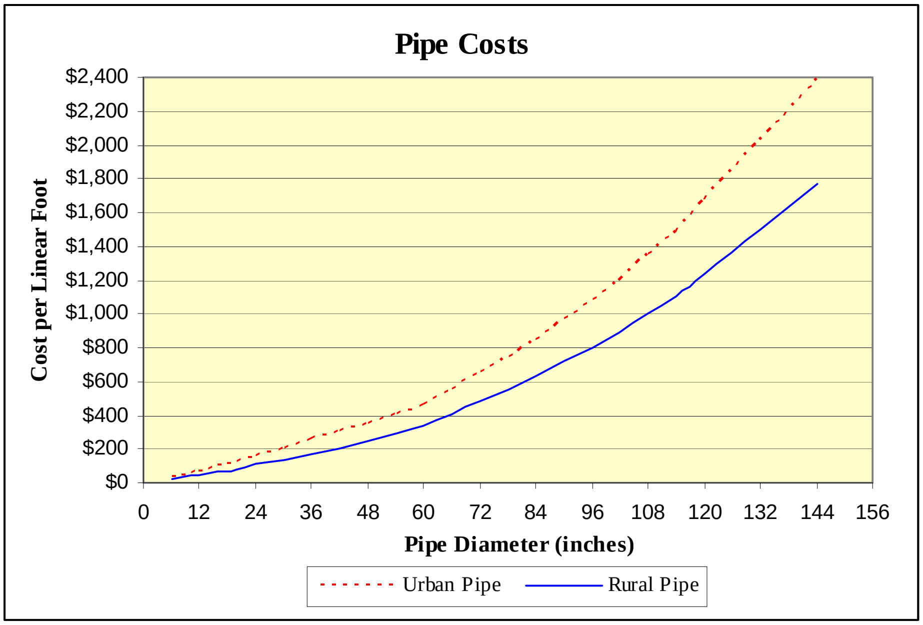
Description of Land	Cost per Acre
Rural County	$ 10,000
Suburban County	$ 25,000
Urban County	$ 60,000
Highly Urbanized Area	Evaluate on a case-by-case basis

Note: Suburban County is defined as a county immediately bordering the Dallas/Fort Worth Metroplex.

Table 5
Factors for Interest During Construction

Construction Period	Factor
6 months	0.02167
12 months	0.04167
18 months	0.06167
24 months	0.08167
36 month construction	0.12167
48 month construction	0.16167

Figure 1


Pipe Costs
Cost per Linear Foot
$2,400
$2,200
$2,000
$1,800
$1,600
$1,400
$1,200
$1,000
$800
$600
$400
$200
$0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
Pipe Diameter (inches)
Urban Pipe
Rural Pipe

APPENDIX B

OPINION OF PROBABLE CONSTRUCTION COST

OPINION OF PROBABLE CONSTRUCTION COST

For

TOLEDO BEND PIPELINE PROJECT WITH DWU

(700,000 Acre-Feet per Year)

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT A

AVERAGE FLOW: 700,000 ACRE-FEET PER YEAR   MAX FLOW: 780 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Lake Intake		1	LS	$ 20,790,000	$ 20,790,000
2	Pump Station 1	41,000 HP	2	LS	$ 31,500,000	$ 63,000,000
3	Pump Station 2	37,000 HP	2	LS	$ 29,200,000	$ 58,400,000
4	Pump Station 3	41,000 HP	2	LS	$ 31,500,000	$ 63,000,000
SUBTOTAL, PUMP COMPONENTS						**$ 205,190,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 205,190,000**	**$ 71,817,000**
TOTAL PUMP STATIONS						**$ 277,007,000**
PIPELINES RAW WATER						
5	Pipeline Rural	120 in	1,129,920	LF	$ 1,240	$ 1,401,101,000
6	Pipeline Urban	120 in	-	LF	$ 1,675	$ -
7	ROW Rural		1,297	ACRES	$ 10,000	$ 12,970,000
8	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 1,414,071,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 1,401,101,000**	**$ 420,330,000**
TOTAL PIPELINES						**$ 1,834,401,000**
STORAGE						
11	Storage Tank	98 MG	2	EA	$ 7,711,000	$ 15,422,000
SUBTOTAL, STORAGE TANKS						**$ 15,422,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 15,422,000**	**$ 5,398,000**
TOTAL STORAGE						**$ 20,820,000**
SUBTOTAL CAPITAL COST						**$ 2,132,228,000**
PERMITTING AND MITIGATION			**1%**		$ 1,634,683,000	**$ 16,346,830**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 2,148,574,830	**$ 261,417,100**
TOTAL CAPITAL COST						**$ 2,409,991,930**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		1,309,216,680	KW-H	$ 0.09	$ 117,830,000
	O&M Pipeline		1.00%		$ 1,681,321,200	$ 16,813,000
	O&M Tanks and Pump Station		2.50%		$ 220,612,000	$ 5,515,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 175,083,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 315,241,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 140,158,000**

SHARE OF CAPITAL AND UNIT COST

SHARE OF CAPITAL COST						
	DWU	200,000	Ac-Ft/Year	28.6%		$ 688,569,123
	NTMWD	200,000	Ac-Ft/Year	28.6%		$ 688,569,123
	SRA	100,000	Ac-Ft/Year	14.3%		$ 344,284,561
	TRWD	200,000	Ac-Ft/Year	28.6%		$ 688,569,123
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	200,000	Ac-Ft/Year	28.6%		$ 90,068,857
	NTMWD	200,000	Ac-Ft/Year	28.6%		$ 90,068,857
	SRA	100,000	Ac-Ft/Year	14.3%		$ 45,034,429
	TRWD	200,000	Ac-Ft/Year	28.6%		$ 90,068,857
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	200,000	Ac-Ft/Year	28.6%		$ 40,045,143
	NTMWD	200,000	Ac-Ft/Year	28.6%		$ 40,045,143
	SRA	100,000	Ac-Ft/Year	14.3%		$ 20,022,571
	TRWD	200,000	Ac-Ft/Year	28.6%		$ 40,045,143

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT B

AVERAGE FLOW: 650,000 ACRE-FEET PER YEAR MAX FLOW: 725 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PIPELINES RAW WATER						
1	Pipeline Rural	114 in	168,425	LF	$ 1,100	$ 185,267,000
2	Pipeline Urban	114 in	-	LF	$ 1,485	$ -
3	ROW Rural		193	ACRES	$ 10,000	$ 1,933,000
4	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 187,200,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 185,267,000**	**$ 55,580,000**
TOTAL PIPELINES						**$ 242,780,000**
STORAGE						
5	Storage Tank	91 MG	1	EA	$ 7,408,000	$ 7,408,000
SUBTOTAL, STORAGE TANKS						**$ 7,408,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 7,408,000**	**$ 2,593,000**
TOTAL STORAGE						**$ 10,001,000**
SUBTOTAL CAPITAL COST						**$ 252,781,000**
PERMITTING AND MITIGATION			**1%**		$ 194,608,000	**$ 1,946,080**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 254,727,080	**$ 30,992,644**
TOTAL CAPITAL COST						**$ 285,719,724**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	O&M Pipeline		1.00%		$ 222,320,400	$ 2,223,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 20,757,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 23,165,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 2,408,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	DWU	200,000	Ac-Ft/Year	30.8%		$ 87,913,761
	NTMWD	200,000	Ac-Ft/Year	30.8%		$ 87,913,761
	SRA	50,000	Ac-Ft/Year	7.7%		$ 21,978,440
	TRWD	200,000	Ac-Ft/Year	30.8%		$ 87,913,761
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	200,000	Ac-Ft/Year	30.8%		$ 7,127,692
	NTMWD	200,000	Ac-Ft/Year	30.8%		$ 7,127,692
	SRA	50,000	Ac-Ft/Year	7.7%		$ 1,781,923
	TRWD	200,000	Ac-Ft/Year	30.8%		$ 7,127,692
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	200,000	Ac-Ft/Year	30.8%		$ 740,923
	NTMWD	200,000	Ac-Ft/Year	30.8%		$ 740,923
	SRA	50,000	Ac-Ft/Year	7.7%		$ 185,231
	TRWD	200,000	Ac-Ft/Year	30.8%		$ 740,923

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT C

AVERAGE FLOW: 350,000 ACRE-FEET PER YEAR   MAX FLOW: 390 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Lake Intake					
2	Pump Station 1	15,000 HP	1	LS	$ 15,200,000	$ 15,200,000
3	Pump Station 2	22,000 HP	1	LS	$ 20,200,000	$ 20,200,000
4	Pump Station 3	40,000 HP	1	LS	$ 31,000,000	$ 31,000,000
SUBTOTAL, PUMP COMPONENTS						**$ 66,400,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 66,400,000**	**$ 23,240,000**
TOTAL PUMP STATIONS						**$ 89,640,000**
PIPELINES RAW WATER						
5	Pipeline Rural	120 in	344,095	LF	$ 1,240	$ 426,678,000
6	Pipeline Urban	120 in	158,400	LF	$ 1,675	$ 265,320,000
7	ROW Rural		395	ACRES	$ 10,000	$ 3,950,000
8	ROW Urban		182	ACRES	$ 60,000	$ 10,909,000
SUBTOTAL, PIPELINES						**$ 706,857,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 691,998,000**	**$ 207,599,000**
TOTAL PIPELINES						**$ 914,456,000**
STORAGE						
9	Storage Tank	49 MG	3	EA	$ 4,504,000	$ 13,512,000
SUBTOTAL, STORAGE TANKS						**$ 13,512,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 13,512,000**	**$ 4,729,000**
TOTAL STORAGE						**$ 18,241,000**
SUBTOTAL CAPITAL COST						**$ 1,022,337,000**
PERMITTING AND MITIGATION			**1%**		$ 786,769,000	**$ 7,867,690**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 1,030,204,690	**$ 125,345,005**
TOTAL CAPITAL COST						**$ 1,155,549,695**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		423,570,102	KW-H	$ 0.09	$ 38,121,000
	O&M Pipeline		1.00%		$ 830,397,600	$ 8,304,000
	O&M Tanks and Pump Station		2.50%		$ 79,912,000	$ 1,998,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 83,949,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 132,372,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 48,423,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	DWU	150,000	Ac-Ft/Year	42.9%		$ 495,235,583
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	57.1%		$ 660,314,111
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	150,000	Ac-Ft/Year	42.9%		$ 56,730,857
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	57.1%		$ 75,641,143
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	150,000	Ac-Ft/Year	42.9%		$ 20,752,714
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	57.1%		$ 27,670,286

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT D

AVERAGE FLOW: 200,000 ACRE-FEET PER YEAR MAX FLOW: 223 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Pump Station 1	20,000 HP	1	LS	$ 19,000,000	$ 19,000,000
SUBTOTAL, PUMP COMPONENTS						**$ 19,000,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 19,000,000**	**$ 6,650,000**
TOTAL PUMP STATIONS						**$ 25,650,000**
PIPELINES RAW WATER						
2	Pipeline Rural	90 in	-	LF	$ 720	$ -
3	Pipeline Urban	90 in	172,995	LF	$ 972	$ 168,151,000
4	ROW Rural		-	ACRES	$ 10,000	$ -
5	ROW Urban		159	ACRES	$ 60,000	$ 9,531,000
SUBTOTAL, PIPELINES						**$ 177,682,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 168,151,000**	**$ 50,445,000**
TOTAL PIPELINES						**$ 228,127,000**
STORAGE						
6	Storage Tank	28 MG	2	EA	$ 3,447,000	$ 6,894,000
SUBTOTAL, STORAGE TANKS						**$ 6,894,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 6,894,000**	**$ 2,413,000**
TOTAL STORAGE						**$ 9,307,000**
SUBTOTAL CAPITAL COST						**$ 263,084,000**
PERMITTING AND MITIGATION			**1%**		$ 203,576,000	**$ 2,035,760**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 265,119,760	**$ 32,257,121**
TOTAL CAPITAL COST						**$ 297,376,881**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		110,018,208	KW-H	$ 0.09	$ 9,902,000
	O&M Pipeline		1.00%		$ 201,781,200	$ 2,018,000
	O&M Tanks and Pump Station		2.50%		$ 25,894,000	$ 647,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 21,604,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 34,171,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION						**$ 12,567,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 297,376,881
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 34,171,000
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 12,567,000

FREESE • NICHOLS

OPINION OF PROBABLE CONSTRUCTION COST

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT E

AVERAGE FLOW: 300,000 ACRE-FEET PER YEAR

MAX FLOW: 335 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		July 11, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Pump Station 1	12,000 HP	1	LS	$ 12,920,000	$ 12,920,000
SUBTOTAL, PUMP COMPONENTS						**$ 12,920,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 12,920,000**	**$ 4,522,000**
TOTAL PUMP STATIONS						**$ 17,442,000**
PIPELINES RAW WATER						
2	Pipeline Rural	114 in	224,077	LF	$ 1,100	$ 246,484,000
3	Pipeline Urban	114 in	-	LF	$ 1,485	$ -
4	ROW Rural		257	ACRES	$ 10,000	$ 2,572,000
5	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 249,056,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 246,484,000**	**$ 73,945,000**
TOTAL PIPELINES						**$ 323,001,000**
SUBTOTAL CAPITAL COST						**$ 340,443,000**
PERMITTING AND MITIGATION			**1%**		$ 261,976,000	**$ 2,619,760**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 343,062,760	**$ 41,740,446**
TOTAL CAPITAL COST						**$ 384,803,206**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		66,010,925	KW-H	$ 0.09	$ 5,941,000
	O&M Pipeline		1.00%		$ 295,780,800	$ 2,958,000
	O&M Tanks and Pump Station		2.50%		$ 12,920,000	$ 323,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 27,956,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 37,178,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 9,222,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	DWU	50,000	Ac-Ft/Year	16.7%		$ 64,133,868
	NTMWD	200,000	Ac-Ft/Year	66.7%		$ 256,535,471
	SRA	50,000	Ac-Ft/Year	16.7%		$ 64,133,868
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	50,000	Ac-Ft/Year	16.7%		$ 6,196,333
	NTMWD	200,000	Ac-Ft/Year	66.7%		$ 24,785,333
	SRA	50,000	Ac-Ft/Year	16.7%		$ 6,196,333
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	50,000	Ac-Ft/Year	16.7%		$ 1,537,000
	NTMWD	200,000	Ac-Ft/Year	66.7%		$ 6,148,000
	SRA	50,000	Ac-Ft/Year	16.7%		$ 1,537,000
	TRWD	0	Ac-Ft/Year	0.0%		$ -

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT F

AVERAGE FLOW: 200,000 ACRE-FEET PER YEAR MAX FLOW: 223 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		July 11, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Pump Station 1	12,000 HP	1	LS	$ 12,920,000	$ 12,920,000
SUBTOTAL, PUMP COMPONENTS						**$ 12,920,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 12,920,000**	**$ 4,522,000**
TOTAL PUMP STATIONS						**$ 17,442,000**
PIPELINES RAW WATER						
2	Pipeline Rural	96 in	63,231	LF	$ 800	$ 50,585,000
3	Pipeline Urban	96 in	-	LF	$ 1,080	$ -
4	ROW Rural		58	ACRES	$ 10,000	$ 581,000
5	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 51,166,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 50,585,000**	**$ 15,176,000**
TOTAL PIPELINES						**$ 66,342,000**
SUBTOTAL CAPITAL COST						**$ 83,784,000**
PERMITTING AND MITIGATION			**1%**		$ 64,086,000	**$ 640,860**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 84,424,860	**$ 10,271,973**
TOTAL CAPITAL COST						**$ 94,696,833**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		66,010,925	KW-H	$ 0.09	$ 5,941,000
	O&M Pipeline		1.00%		$ 60,702,000	$ 607,000
	O&M Tanks and Pump Station		2.50%		$ 12,920,000	$ 323,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 6,880,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 13,751,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 6,871,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 94,696,833
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST DURING AMORTIZATION						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 13,751,000
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	DWU	0	Ac-Ft/Year	0.0%		$ -
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 6,871,000
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -

OPINION OF PROBABLE CONSTRUCTION COST

For

TOLEDO BEND PIPELINE PROJECT WITHOUT DWU

(500,000 Acre-Feet per Year)

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT A

AVERAGE FLOW: 500,000 ACRE-FEET PER YEAR MAX FLOW: 558 MGD

ACCOUNT NO.		ESTIMATOR	CHECKED BY		DATE	
NTD07286		AAS			May 20, 2008	
Item	**Description**		**Quantity**	**Unit**	**Unit Price**	**Total**
PUMP STATIONS						
1	Lake Intake		1	LS	$ 18,480,000	$ 18,480,000
2	Pump Station 1	35,000 HP	2	LS	$ 28,000,000	$ 56,000,000
3	Pump Station 2	30,000 HP	2	LS	$ 25,000,000	$ 50,000,000
4	Pump Station 3	32,500 HP	2	LS	$ 26,500,000	$ 53,000,000
SUBTOTAL, PUMP COMPONENTS						**$ 177,480,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 177,480,000**	**$ 62,118,000**
TOTAL PUMP STATIONS						**$ 239,598,000**
PIPELINES RAW WATER						
5	Pipeline Rural	102 in	1,129,920	LF	$ 890	$ 1,005,629,000
6	Pipeline Urban	102 in	-	LF	$ 1,200	$ -
7	ROW Rural		1,038	ACRES	$ 10,000	$ 10,376,000
8	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 1,016,005,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 1,005,629,000**	**$ 301,689,000**
TOTAL PIPELINES						**$ 1,317,694,000**
STORAGE						
11	Storage Tank	70 MG	2	EA	$ 6,477,000	$ 12,954,000
SUBTOTAL, STORAGE TANKS						**$ 12,954,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 12,954,000**	**$ 4,534,000**
TOTAL STORAGE						**$ 17,488,000**
SUBTOTAL CAPITAL COST						**$ 1,574,780,000**
PERMITTING AND MITIGATION			**1%**		$ 1,206,439,000	**$ 12,064,390**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 1,586,844,390	**$ 193,071,357**
TOTAL CAPITAL COST						**$ 1,779,915,747**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		1,072,677,532	KW-H	$ 0.09	$ 96,541,000
	O&M Pipeline		1.00%		$ 1,206,754,800	$ 12,068,000
	O&M Tanks and Pump Station		2.50%		$ 190,434,000	$ 4,761,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 129,309,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 242,679,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION						**$ 113,370,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	200,000	Ac-Ft/Year	40.0%		$ 711,966,299
	SRA	100,000	Ac-Ft/Year	20.0%		$ 355,983,149
	TRWD	200,000	Ac-Ft/Year	40.0%		$ 711,966,299
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	40.0%		$ 97,071,600
	SRA	100,000	Ac-Ft/Year	20.0%		$ 48,535,800
	TRWD	200,000	Ac-Ft/Year	40.0%		$ 97,071,600
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	40.0%		$ 45,348,000
	SRA	100,000	Ac-Ft/Year	20.0%		$ 22,674,000
	TRWD	200,000	Ac-Ft/Year	40.0%		$ 45,348,000

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT B

AVERAGE FLOW: 450,000 ACRE-FEET PER YEAR MAX FLOW: 500 MGD

ACCOUNT NO.		ESTIMATOR	CHECKED BY		DATE	
NTD07286		AAS			May 20, 2008	
Item	**Description**		**Quantity**	**Unit**	**Unit Price**	**Total**
PIPELINES RAW WATER						
1	Pipeline Rural	96 in	168,425	LF	$ 800	$ 134,740,000
2	Pipeline Urban	96 in	-	LF	$ 1,080	$ -
3	ROW Rural		155	ACRES	$ 10,000	$ 1,547,000
4	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 136,287,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 134,740,000**	**$ 40,422,000**
TOTAL PIPELINES						**$ 176,709,000**
STORAGE						
5	Storage Tank	63 MG	1	EA	$ 6,158,000	$ 6,158,000
SUBTOTAL, STORAGE TANKS						**$ 6,158,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 6,158,000**	**$ 2,155,000**
TOTAL STORAGE						**$ 8,313,000**
SUBTOTAL CAPITAL COST						**$ 185,022,000**
PERMITTING AND MITIGATION			**1%**		$ 142,445,000	**$ 1,424,450**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 186,446,450	**$ 22,684,940**
TOTAL CAPITAL COST						**$ 209,131,390**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	O&M Pipeline		1.00%		$ 161,688,000	$ 1,617,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 15,193,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 16,964,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 1,771,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	200,000	Ac-Ft/Year	44.4%		$ 92,947,284
	SRA	50,000	Ac-Ft/Year	11.1%		$ 23,236,821
	TRWD	200,000	Ac-Ft/Year	44.4%		$ 92,947,284
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	44.4%		$ 7,539,556
	SRA	50,000	Ac-Ft/Year	11.1%		$ 1,884,889
	TRWD	200,000	Ac-Ft/Year	44.4%		$ 7,539,556
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	44.4%		$ 787,111
	SRA	50,000	Ac-Ft/Year	11.1%		$ 196,778
	TRWD	200,000	Ac-Ft/Year	44.4%		$ 787,111

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT C

AVERAGE FLOW: 200,000 ACRE-FEET PER YEAR   MAX FLOW: 223 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Lake Intake		0	LS	$ 4,514,400	$ -
2	Pump Station 1	13,000 HP	1	LS	$ 13,680,000	$ 13,680,000
3	Pump Station 2	19,000 HP	1	LS	$ 18,240,000	$ 18,240,000
4	Pump Station 3	26,000 HP	1	LS	$ 22,600,000	$ 22,600,000
SUBTOTAL, PUMP COMPONENTS						**$ 54,520,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 54,520,000**	**$ 19,082,000**
TOTAL PUMP STATIONS						**$ 73,602,000**
PIPELINES RAW WATER						
5	Pipeline Rural	90 in	344,095	LF	$ 720	$ 247,749,000
6	Pipeline Urban	90 in	158,400	LF	$ 972	$ 153,965,000
7	ROW Rural		316	ACRES	$ 10,000	$ 3,160,000
8	ROW Urban		145	ACRES	$ 60,000	$ 8,727,000
SUBTOTAL, PIPELINES						**$ 413,601,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 401,714,000**	**$ 120,514,000**
TOTAL PIPELINES						**$ 534,115,000**
STORAGE						
9	Storage Tank	28 MG	3	EA	$ 3,447,000	$ 10,341,000
SUBTOTAL, STORAGE TANKS						**$ 10,341,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 10,341,000**	**$ 3,619,000**
TOTAL STORAGE						**$ 13,960,000**
SUBTOTAL CAPITAL COST						**$ 621,677,000**
PERMITTING AND MITIGATION			**1%**		$ 478,462,000	**$ 4,784,620**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 626,461,620	**$ 76,221,585**
TOTAL CAPITAL COST						**$ 702,683,205**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		319,052,804	KW-H	$ 0.09	$ 28,715,000
	O&M Pipeline		1.00%		$ 482,056,800	$ 4,821,000
	O&M Tanks and Pump Station		2.50%		$ 64,861,000	$ 1,622,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 51,049,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 86,207,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION						**$ 35,158,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 702,683,205
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 86,207,000
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 35,158,000

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT D

AVERAGE FLOW: 200,000 ACRE-FEET PER YEAR   MAX FLOW: 223 MGD

ACCOUNT NO.	ESTIMATOR	CHECKED BY	DATE
NTD07286	AAS		May 20, 2008

Item	Description		Quantity	Unit	Unit Price	Total
PUMP STATIONS						
1	Pump Station 1	22,000 HP	1	LS	$ 20,200,000	$ 20,200,000
SUBTOTAL, PUMP COMPONENTS						**$ 20,200,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 20,200,000**	**$ 7,070,000**
TOTAL PUMP STATIONS						**$ 27,270,000**
PIPELINES RAW WATER						
2	Pipeline Rural	90 in	-	LF	$ 720	$ -
3	Pipeline Urban	90 in	172,995	LF	$ 972	$ 168,151,000
4	ROW Rural		-	ACRES	$ 10,000	$ -
5	ROW Urban		159	ACRES	$ 60,000	$ 9,531,000
SUBTOTAL, PIPELINES						**$ 177,682,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 168,151,000**	**$ 50,445,000**
TOTAL PIPELINES						**$ 228,127,000**
STORAGE						
6	Storage Tank	28 MG	2	EA	$ 3,447,000	$ 6,894,000
SUBTOTAL, STORAGE TANKS						**$ 6,894,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 6,894,000**	**$ 2,413,000**
TOTAL STORAGE						**$ 9,307,000**
SUBTOTAL CAPITAL COST						**$ 264,704,000**
PERMITTING AND MITIGATION			**1%**		$ 204,776,000	**$ 2,047,760**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 266,751,760	**$ 32,455,687**
TOTAL CAPITAL COST						**$ 299,207,447**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		121,020,029	KW-H	$ 0.09	$ 10,892,000
	O&M Pipeline		1.00%		$ 201,781,200	$ 2,018,000
	O&M Tanks and Pump Station		2.50%		$ 27,094,000	$ 677,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 21,737,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 35,324,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 13,587,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 299,207,447
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 35,324,000
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	0	Ac-Ft/Year	0.0%		$ -
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	200,000	Ac-Ft/Year	100.0%		$ 13,587,000

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT E

AVERAGE FLOW: 250,000 ACRE-FEET PER YEAR   MAX FLOW: 280 MGD

ACCOUNT NO.		ESTIMATOR	CHECKED BY		DATE	
NTD07286		AAS			July 11, 2008	
Item	**Description**		**Quantity**	**Unit**	**Unit Price**	**Total**
PUMP STATIONS						
1	Pump Station 1	15,000 HP	1	LS	$ 15,200,000	$ 15,200,000
SUBTOTAL, PUMP COMPONENTS						**$ 15,200,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 15,200,000**	**$ 5,320,000**
TOTAL PUMP STATIONS						**$ 20,520,000**
PIPELINES RAW WATER						
2	Pipeline Rural	102 in	224,077	LF	$ 890	$ 199,428,000
3	Pipeline Urban	102 in	-	LF	$ 1,200	$ -
4	ROW Rural		206	ACRES	$ 10,000	$ 2,058,000
5	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 201,486,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 199,428,000**	**$ 59,828,000**
TOTAL PIPELINES						**$ 261,314,000**
SUBTOTAL CAPITAL COST						**$ 281,834,000**
PERMITTING AND MITIGATION			**1%**		$ 216,686,000	**$ 2,166,860**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 284,000,860	**$ 34,554,385**
TOTAL CAPITAL COST						**$ 318,555,245**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		82,513,656	KW-H	$ 0.09	$ 7,426,000
	O&M Pipeline		1.00%		$ 239,313,600	$ 2,393,000
	O&M Tanks and Pump Station		2.50%		$ 15,200,000	$ 380,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 23,143,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 33,342,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 10,199,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	200,000	Ac-Ft/Year	80.0%		$ 254,844,196
	SRA	50,000	Ac-Ft/Year	20.0%		$ 63,711,049
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	80.0%		$ 26,673,600
	SRA	50,000	Ac-Ft/Year	20.0%		$ 6,668,400
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	80.0%		$ 8,159,200
	SRA	50,000	Ac-Ft/Year	20.0%		$ 2,039,800
	TRWD	0	Ac-Ft/Year	0.0%		$ -

OPINION OF PROBABLE CONSTRUCTION COST

FREESE • NICHOLS

TOLEDO BEND WATER SUPPLY STUDY
SEGMENT F

AVERAGE FLOW: 200,000 ACRE-FEET PER YEAR   MAX FLOW: 223 MGD

ACCOUNT NO.		ESTIMATOR	CHECKED BY		DATE	
NTD07286		AAS			July 11, 2008	
Item	**Description**		**Quantity**	**Unit**	**Unit Price**	**Total**
PUMP STATIONS						
1	Pump Station 1	12,000 HP	1	LS	$ 12,920,000	$ 12,920,000
SUBTOTAL, PUMP COMPONENTS						**$ 12,920,000**
ENGINEERING AND CONTINGENCY			**35%**		**$ 12,920,000**	**$ 4,522,000**
TOTAL PUMP STATIONS						**$ 17,442,000**
PIPELINES RAW WATER						
2	Pipeline Rural	96 in	63,231	LF	$ 800	$ 50,585,000
3	Pipeline Urban	96 in	-	LF	$ 1,080	$ -
4	ROW Rural		58	ACRES	$ 10,000	$ 581,000
5	ROW Urban		-	ACRES	$ 60,000	$ -
SUBTOTAL, PIPELINES						**$ 51,166,000**
ENGINEERING AND CONTINGENCY			**30%**		**$ 50,585,000**	**$ 15,176,000**
TOTAL PIPELINES						**$ 66,342,000**
SUBTOTAL CAPITAL COST						**$ 83,784,000**
PERMITTING AND MITIGATION			**1%**		$ 64,086,000	**$ 640,860**
INTEREST DURING CONSTRUCTION			**0.12167**		$ 84,424,860	**$ 10,271,973**
TOTAL CAPITAL COST						**$ 94,696,833**

ANNUAL COST

ITEM	DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	TOTAL
	Electricty		66,010,925	KW-H	$ 0.09	$ 5,941,000
	O&M Pipeline		1.00%		$ 60,702,000	$ 607,000
	O&M Tanks and Pump Station		2.50%		$ 12,920,000	$ 323,000
	Debt Service (Capital Cost at 6%, 30 Years)					$ 6,880,000
TOTAL ANNUAL COST (DURING AMORTIZATION)						**$ 13,751,000**
TOTAL ANNUAL COST (AFTER AMORTIZATION)						**$ 6,871,000**

SHARE OF CAPITAL AND ANNUAL COST

SHARE OF CAPITAL COST						
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 94,696,833
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST DURING AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 13,751,000
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -
SHARE OF ANNUAL COST AFTER AMORTIZATION						
	NTMWD	200,000	Ac-Ft/Year	100.0%		$ 6,871,000
	SRA	0	Ac-Ft/Year	0.0%		$ -
	TRWD	0	Ac-Ft/Year	0.0%		$ -

APPENDIX C

HISTORICAL AND NATURALIZED INFLOWS TO SABINE LAKE ESTUARY

Historical Flows - Sabine Lake Estuary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1940	1,150,144	2,034,507	575,544	997,800	1,003,590	1,092,557	750,153	1,291,482	276,629	117,392	1,728,684	7,290,044	18,308,526
1941	3,792,978	1,753,653	2,907,497	1,379,025	2,598,025	2,657,938	1,937,678	359,126	583,621	743,725	2,892,121	1,449,262	23,054,649
1942	1,316,768	1,123,808	1,780,026	2,537,666	2,194,441	1,595,427	755,510	790,639	771,586	219,070	253,491	437,693	13,776,124
1943	1,262,245	575,222	645,302	648,179	477,302	557,276	1,259,845	246,481	231,406	116,164	264,969	419,779	6,704,169
1944	1,816,619	1,839,904	2,446,741	2,198,537	6,856,033	2,712,513	216,846	195,474	355,795	122,440	388,297	1,654,187	20,803,386
1945	4,206,897	2,937,775	2,595,560	6,170,144	1,620,704	637,943	1,197,516	894,823	237,298	1,056,378	641,398	1,518,681	23,715,117
1946	3,657,818	4,709,792	3,460,169	2,129,267	2,371,971	3,669,936	1,390,288	382,238	442,465	417,784	2,597,482	2,512,196	27,741,406
1947	4,416,555	1,653,477	2,781,649	1,743,502	1,458,428	1,034,373	253,064	169,574	87,679	83,061	375,120	1,284,779	15,341,262
1948	1,356,821	2,461,943	2,003,314	1,491,620	825,425	552,755	149,085	48,904	54,106	35,435	448,138	298,792	9,726,338
1949	1,370,486	2,188,988	2,601,937	2,528,883	1,173,496	617,173	445,632	339,914	249,368	2,046,321	763,696	2,117,569	16,443,463
1950	3,737,340	3,878,971	3,314,960	1,062,200	2,667,687	5,118,647	664,041	321,047	272,606	181,429	200,853	227,227	21,647,008
1951	831,164	686,396	917,125	1,125,468	471,604	201,703	216,703	30,254	456,857	92,933	112,186	393,668	5,536,063
1952	327,196	1,393,317	1,182,563	2,162,081	2,065,526	802,006	452,116	105,550	21,278	5,040	198,728	483,244	9,198,645
1953	725,456	1,343,674	2,342,149	1,093,218	8,287,276	2,068,938	517,244	504,156	200,894	111,905	163,915	621,154	17,979,981
1954	753,754	511,190	344,231	652,934	1,592,687	320,572	151,668	39,706	16,866	108,380	217,984	182,352	4,892,326
1955	541,764	1,555,670	628,565	2,022,933	723,546	407,241	194,744	866,061	262,909	113,752	107,919	267,389	7,692,492
1956	392,057	1,299,091	663,544	586,050	719,433	141,040	33,899	40,212	10,267	67,295	104,000	631,086	4,687,973
1957	132,367	338,660	1,300,364	1,581,876	4,676,266	2,260,430	879,677	180,544	457,933	768,477	2,763,664	2,588,219	17,928,476
1958	2,544,345	1,827,532	1,297,809	1,018,510	2,409,455	659,886	384,187	235,130	1,599,877	1,305,342	324,907	365,088	13,972,068
1959	428,708	2,042,928	998,347	1,889,580	1,401,686	569,559	837,172	531,477	175,504	333,792	365,239	1,084,286	10,658,277
1960	1,849,592	1,932,170	2,036,388	564,487	413,127	337,569	376,513	230,392	99,304	455,433	902,587	2,635,730	11,833,291
1961	5,363,495	2,866,905	2,668,548	1,975,708	464,111	767,893	1,407,957	333,414	1,354,266	233,174	798,552	2,240,901	20,474,924
1962	1,622,427	1,230,739	1,045,650	615,627	1,535,817	614,866	204,538	185,980	165,978	137,747	249,779	539,475	8,148,621
1963	885,907	674,559	577,400	333,734	295,751	148,111	206,903	40,373	1,072,925	50,581	346,518	474,419	5,107,181
1964	619,359	531,384	1,437,256	847,680	986,490	180,300	106,394	52,468	136,280	28,933	74,135	422,676	5,423,355
1965	211,887	545,286	860,307	884,479	441,541	896,682	144,712	57,957	154,964	45,661	90,041	558,826	4,892,343
1966	767,328	2,749,143	562,260	509,114	3,225,536	731,489	216,731	286,918	181,359	327,184	381,203	288,509	10,226,774
1967	353,629	342,533	276,366	828,369	355,972	200,857	97,689	47,935	43,593	51,069	23,255	218,081	2,839,348
1968	653,336	267,739	460,045	1,542,106	1,367,745	2,302,177	953,212	421,583	618,661	362,300	426,809	1,772,820	11,148,533
1969	1,192,353	1,387,327	2,922,466	3,511,095	3,542,702	1,431,401	427,980	312,200	249,818	123,985	150,053	463,671	15,715,050
1970	367,230	362,364	966,876	1,146,532	979,863	199,824	132,815	201,885	385,180	1,394,719	367,810	219,799	6,724,897
1971	359,833	336,266	451,246	113,647	178,386	177,018	115,537	214,821	101,259	109,962	106,969	1,729,818	3,994,762
1972	1,863,879	960,578	683,117	418,655	969,673	307,100	356,080	438,013	515,000	246,245	473,140	936,945	8,168,425
1973	1,951,297	2,083,737	2,455,354	3,736,783	2,961,547	2,443,390	1,761,745	871,862	1,533,630	1,511,026	1,520,102	2,426,981	25,257,454
1974	4,529,516	3,010,254	1,920,361	1,222,484	986,602	575,640	522,295	590,240	656,509	334,776	1,241,861	2,357,529	17,948,067
1975	2,981,157	2,540,064	2,356,386	1,712,973	2,770,164	2,208,872	1,242,631	1,334,315	673,908	585,979	439,238	459,215	19,304,903
1976	429,899	368,066	1,059,359	766,494	1,262,776	1,392,137	1,065,364	890,500	630,955	368,072	329,777	974,817	9,538,217
1977	1,110,901	919,075	1,316,165	1,524,164	933,094	603,804	390,501	509,106	433,413	193,831	538,001	614,132	9,086,187
1978	1,142,147	1,161,936	516,144	195,867	195,380	543,605	327,916	339,828	265,549	41,256	397,006	555,237	5,681,872
1979	2,157,853	2,564,723	3,119,101	4,435,771	2,406,511	2,286,545	1,699,092	989,766	1,452,837	491,084	572,548	1,152,336	23,328,166

Historical Flows - Sabine Lake Estuary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1980	1,555,189	1,979,883	1,784,429	2,396,853	2,684,391	816,343	373,902	320,003	807,520	637,163	263,366	308,132	13,927,172
1981	292,322	303,770	312,312	183,358	237,912	1,718,793	974,245	525,527	292,655	457,306	283,514	385,494	5,967,208
1982	349,764	815,076	486,545	1,218,067	1,612,918	500,961	406,470	418,958	231,684	265,121	526,577	2,896,492	9,728,632
1983	2,573,184	2,865,481	2,389,514	1,202,501	2,243,101	1,680,946	972,976	988,654	704,336	245,431	348,819	1,666,247	17,881,190
1984	1,232,169	1,969,497	2,407,606	778,400	778,733	446,905	444,825	370,241	305,964	887,456	841,378	914,388	11,377,562
1985	829,194	1,583,389	2,336,030	1,053,018	687,294	492,895	448,582	359,110	329,878	662,288	943,807	1,547,027	11,272,513
1986	1,010,471	1,347,355	573,817	368,815	946,622	2,858,290	1,337,040	461,980	417,295	631,089	1,872,150	2,491,557	14,316,481
1987	2,342,197	1,298,180	2,613,756	1,070,665	612,635	1,496,859	890,300	489,434	392,691	249,618	633,743	1,566,196	13,656,274
1988	1,849,828	1,029,813	1,797,758	1,064,713	313,923	422,198	353,655	323,731	404,548	255,333	223,527	437,057	8,476,085
1989	1,059,688	1,299,293	1,284,314	1,573,131	3,169,563	3,484,710	5,197,843	888,314	464,935	385,917	299,959	358,043	19,465,709
1990	1,462,866	1,939,465	1,798,271	2,300,282	2,253,711	2,001,229	716,074	532,098	381,803	306,529	345,730	428,794	14,466,851
1991	3,076,967	2,644,690	2,513,793	2,894,420	3,644,012	2,256,178	1,027,890	731,014	884,275	697,845	781,477	1,607,412	22,759,974
1992	2,737,361	3,010,282	3,990,472	2,193,770	815,547	890,722	593,288	598,912	422,435	299,798	590,879	1,304,333	17,447,799
1993	2,109,509	1,397,294	2,402,061	2,757,438	1,662,812	1,245,604	1,581,987	486,483	584,766	331,801	664,561	641,617	15,865,932
1994	750,633	1,280,817	2,176,434	892,602	1,217,123	892,337	459,456	617,653	633,372	3,261,615	1,430,333	1,769,045	15,381,419
1995	3,603,338	2,655,423	3,096,629	3,132,187	2,489,128	1,072,805	806,912	699,861	494,844	444,100	491,702	996,867	19,983,798
1996	654,682	322,151	280,402	287,590	123,622	276,209	204,904	268,476	782,089	392,319	224,375	498,456	4,315,274
Median	**1,232,169**	**1,393,317**	**1,780,026**	**1,202,501**	**1,262,776**	**802,006**	**452,116**	**359,126**	**385,180**	**299,798**	**381,203**	**641,617**	**13,656,274**
Median ('69 - '96)	**1,347,518**	**1,367,341**	**1,859,316**	**1,210,284**	**1,101,862**	**982,571**	**557,791**	**499,270**	**449,174**	**376,994**	**482,421**	**955,881**	**14,121,826**

Naturalized Flows - Sabine Lake Estuary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1940	1,146,916	2,031,264	576,131	1,010,121	1,023,434	1,116,779	775,009	1,306,339	282,383	118,238	2,203,313	6,808,252	18,398,180
1941	3,789,191	1,750,348	2,906,072	1,386,572	2,610,879	2,673,520	1,954,487	369,078	586,840	743,383	2,888,778	1,445,565	23,104,711
1942	1,313,896	1,121,215	1,779,859	2,561,841	2,194,135	1,614,170	775,341	802,553	775,915	219,714	251,472	435,182	13,845,293
1943	1,259,722	573,064	646,577	661,138	497,911	582,039	1,285,305	262,247	237,865	139,743	241,367	417,537	6,804,516
1944	1,813,327	1,836,492	2,447,953	2,213,068	6,876,044	2,739,594	245,786	213,321	363,016	124,203	387,201	1,650,461	20,910,468
1945	4,203,793	2,934,889	2,597,407	6,184,261	1,645,117	667,961	1,280,220	861,764	245,299	1,058,407	639,668	1,515,999	23,834,787
1946	3,654,302	4,706,671	3,461,134	2,143,342	2,394,588	3,697,129	1,418,415	399,847	449,662	419,535	2,633,817	2,470,467	27,848,909
1947	4,412,265	1,650,714	2,783,803	1,762,036	1,520,846	1,036,580	289,357	192,193	97,235	85,772	373,451	1,282,057	15,486,308
1948	1,353,089	2,458,649	2,005,515	1,510,862	856,236	589,746	187,051	72,220	63,648	37,763	445,809	295,670	9,876,258
1949	1,367,885	2,188,654	2,606,730	2,548,978	1,203,371	651,735	480,689	361,441	258,866	2,049,671	762,430	2,115,773	16,596,223
1950	3,738,099	3,882,313	3,319,385	1,083,527	2,704,680	5,157,167	703,006	345,865	283,847	184,944	200,090	225,973	21,828,897
1951	829,672	702,456	942,156	1,148,687	548,543	227,045	230,192	62,533	479,008	96,150	120,847	395,143	5,782,433
1952	324,489	1,391,246	1,268,053	2,178,821	2,079,999	852,157	479,020	91,422	30,361	9,711	206,828	490,344	9,402,451
1953	721,806	1,347,536	2,365,193	1,177,812	8,364,039	2,061,779	572,101	493,370	191,493	111,696	181,268	682,255	18,270,348
1954	745,728	519,346	360,015	682,227	1,628,635	347,367	149,017	54,517	27,379	124,335	291,991	200,922	5,131,477
1955	539,702	1,544,346	646,270	2,042,064	765,904	436,927	228,709	867,389	265,279	109,095	91,476	282,718	7,819,880
1956	425,243	1,322,096	668,056	611,260	779,266	140,998	40,803	43,094	15,145	66,797	112,247	648,475	4,873,479
1957	150,091	386,389	1,299,137	1,753,231	4,607,154	2,240,356	915,095	217,015	472,392	881,499	2,802,699	2,424,387	18,149,445
1958	2,551,190	1,821,806	1,301,769	1,060,030	2,446,307	711,068	405,560	243,876	1,715,964	1,237,000	309,787	374,998	14,179,355
1959	432,895	2,042,402	1,014,205	1,904,724	1,435,933	623,987	869,888	545,786	167,344	365,445	342,721	1,094,938	10,840,270
1960	1,869,450	1,942,266	2,029,216	605,384	430,064	419,370	404,355	279,449	139,633	438,221	895,006	2,796,896	12,249,311
1961	5,427,464	2,887,791	2,762,890	2,031,002	522,881	903,743	1,374,519	356,855	1,374,944	232,206	837,115	2,323,790	21,035,199
1962	1,663,623	1,271,403	1,057,930	770,829	1,566,648	672,649	275,937	223,497	292,727	161,875	303,065	583,436	8,843,619
1963	857,106	690,665	602,598	485,657	406,019	201,044	246,436	54,695	1,094,001	36,980	369,678	500,682	5,545,560
1964	663,779	558,487	1,503,375	976,821	1,009,214	245,406	132,045	85,185	185,235	45,639	119,854	472,534	5,997,574
1965	252,289	767,482	869,427	1,051,097	870,388	874,863	153,853	90,931	207,381	51,129	131,525	750,341	6,070,707
1966	897,452	3,200,536	664,377	1,210,928	3,454,200	830,805	183,273	330,414	214,663	294,136	369,710	257,427	11,907,920
1967	382,799	453,386	356,918	1,138,692	726,296	623,768	165,745	50,560	64,638	142,866	150,550	376,989	4,633,209
1968	1,463,447	602,905	1,233,172	3,763,690	2,065,735	2,270,274	969,156	276,276	775,374	250,890	496,323	1,755,164	15,922,407
1969	997,996	1,844,679	3,399,355	3,462,298	3,694,126	929,214	313,657	58,365	47,699	88,498	277,349	643,716	15,756,952
1970	590,592	683,870	1,422,217	1,170,327	1,087,785	280,791	33,053	128,839	260,024	1,483,611	488,730	246,937	7,876,775
1971	291,933	429,338	552,127	235,827	361,497	139,650	94,025	262,895	89,631	282,871	224,868	2,043,045	5,007,708
1972	2,129,426	1,016,987	1,128,826	530,518	971,789	209,845	305,888	111,412	196,717	309,051	903,425	1,479,416	9,293,301
1973	2,418,926	2,195,556	2,892,467	3,941,629	2,562,066	2,893,947	1,324,503	630,037	1,364,276	2,034,310	1,685,136	2,855,743	26,798,598
1974	5,025,517	2,581,805	1,413,925	1,436,257	922,355	636,329	168,149	197,245	654,914	642,105	2,069,559	2,584,607	18,332,766
1975	2,714,718	3,003,656	1,926,970	1,813,303	3,109,462	2,175,344	938,284	797,138	233,816	551,317	538,698	581,531	18,384,239
1976	807,189	564,067	1,455,519	998,469	1,804,456	1,348,094	1,088,522	137,098	207,475	363,139	282,664	1,281,269	10,337,961
1977	1,221,935	1,398,619	1,883,470	1,771,433	825,432	417,420	151,586	296,593	94,981	112,116	558,974	753,187	9,485,747
1978	1,707,031	1,544,674	816,459	489,925	346,137	439,864	70,507	197,837	518,409	6,747	436,729	828,062	7,402,381

Naturalized Flows - Sabine Lake Estuary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1979	3,268,913	2,980,535	3,178,436	4,796,712	2,243,215	2,199,084	1,406,737	574,080	1,306,014	583,694	815,798	1,238,684	24,591,902
1980	2,058,699	2,191,866	2,019,059	2,628,459	2,955,186	445,598	84,393	66,001	576,124	479,569	103,854	284,670	13,893,478
1981	227,702	474,423	526,045	271,302	609,678	2,613,195	919,937	84,036	399,407	586,600	415,998	349,870	7,478,191
1982	442,543	886,807	776,624	2,138,817	1,768,286	494,807	285,130	85,073	31,796	107,626	747,445	4,098,386	11,863,339
1983	2,096,888	3,720,786	2,099,587	1,095,469	3,032,261	1,192,967	674,305	816,843	614,375	102,172	355,675	1,939,541	17,740,868
1984	1,358,095	2,517,364	2,382,195	1,014,925	943,181	235,456	109,107	208,236	120,760	1,287,790	1,016,291	1,179,797	12,373,197
1985	1,035,737	2,360,814	2,470,986	1,071,685	904,708	320,216	139,520	87,271	80,393	788,396	1,637,419	2,273,675	13,170,820
1986	493,969	1,471,346	682,074	715,858	1,433,529	3,289,543	786,385	108,014	252,953	381,900	2,545,661	2,863,824	15,025,055
1987	1,687,711	2,154,129	2,302,604	803,884	578,580	1,693,870	642,821	212,499	269,694	29,917	1,076,513	2,259,810	13,712,033
1988	2,081,963	1,113,112	1,895,847	1,177,782	196,129	239,847	257,768	129,623	160,450	73,948	214,405	599,672	8,140,545
1989	1,680,628	1,794,427	1,776,083	2,032,822	3,725,862	3,628,619	4,788,850	416,344	115,325	215,892	164,184	209,530	20,548,567
1990	2,512,053	2,320,757	1,651,964	2,438,239	2,689,241	1,794,751	260,200	107,494	203,034	236,525	609,109	671,239	15,494,606
1991	4,506,065	2,747,262	1,769,035	3,833,262	3,667,054	1,598,423	813,407	689,328	585,978	462,081	829,367	2,306,890	23,808,152
1992	3,319,787	4,213,173	3,702,455	1,238,992	871,674	1,037,796	346,098	240,323	242,236	130,570	594,378	2,065,995	18,003,477
1993	2,793,067	1,255,295	3,182,473	2,459,819	1,535,485	2,002,280	970,952	176,735	111,838	481,426	661,027	726,575	16,356,972
1994	1,077,887	2,317,128	2,282,395	1,049,470	1,531,568	812,828	419,302	468,378	252,423	4,229,133	952,111	2,598,163	17,990,786
1995	4,482,318	2,046,741	3,288,135	3,205,147	2,021,906	925,492	520,159	329,431	79,521	226,590	337,831	1,133,232	18,596,504
1996	684,860	304,460	228,064	422,409	220,616	287,124	158,957	301,928	917,333	518,331	528,503	1,018,443	5,591,029
Median	**1,358,095**	**1,750,348**	**1,769,035**	**1,210,928**	**1,520,846**	**830,805**	**404,355**	**223,497**	**245,299**	**232,206**	**436,729**	**1,018,443**	**13,845,293**
Median ('69 - '96)	**1,697,371**	**1,945,710**	**1,889,659**	**1,208,387**	**1,482,548**	**927,353**	**329,877**	**203,037**	**238,026**	**372,520**	**576,676**	**1,209,241**	**14,459,266**

APPENDIX D

INTER-REGIONAL COORDINATION
AND
RESPONSE TO COMMENTS

EAST TEXAS
Regional Water Planning Group
Region I WPG

December 1, 2008

Mr. Jim Parks
Chairman, Region C
505 E. Brown Street
Wylie, TX 75098

Re: Inter-Regional Coordination on the Toledo Bend Project

Dear Mr. Parks:

The East Texas Regional Water Planning Group (ETRWPG), Region I, has recently completed the draft study of the update to the Toledo Bend Project as part of the Special Studies conducted during this round of regional water planning. This project is a recommended water management strategy for wholesale water providers in Region C and the Sabine River Authority. The scope of work for the study included:

1. Coordinate with the project participants to update the project assumptions, delivery routes and demands,
2. Review potential impacts to State waters, and
3. Update the cost analyses, including developing life cycle costs.

I have enclosed a copy of the draft study report for your information and consideration. The ETRWPG approved this draft report on November 5, 2008 for submittal to the Texas Water Development Board (TWDB). We welcome comments that you may have on the draft report. Please send us your comments by January 15, 2009. We will address your comments in the final document that will be submitted to the TWDB by April 30, 2009.

If you have any questions regarding this study, please contact me at 936-633-7543 or by email at kholcomb@anra.org.

Sincerely,

Kelley Holcomb
Chairman, East Texas Region

Cc: Temple McKinnon, TWDB

Lila Fuller, Administrative Contact
P. O. Box 635030, Nacogdoches, TX 75963-5030
Phone: 936-559-2504 Fax: 936-559-2912

EAST TEXAS
Regional Water Planning Group
Region I WPG

December 1, 2008

Jim Thompson
Chairman, North East Texas Region
P.O. Box 1107
Atlanta, Texas 75551

Re: Inter-Regional Coordination on the Toledo Bend Project

Dear Mr. Thompson:

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Sincerely,

Kelley Holcomb
Chairman, East Texas Region

Cc: Temple McKinnon, TWDB

Lila Fuller, Administrative Contact
P. O. Box 635030, Nacogdoches, TX 75963-5030
Phone: 936-559-2504 Fax: 936-559-2912

ATTACHMENT 1

TWDB Contract No. 0704830694

Region I, Region-Specific Studies 1 – 5:

<u>TWDB Comments on Draft Final Region-Specific Study Reports</u>:

1. **Inter-Regional Coordination on the Toledo Bend Project**
2. **Regional Solutions for Small Water Suppliers**
3. **Study of Municipal Water Uses to Improve Water Conservation Strategies and Projections**
4. **Lake Murvaul Study**
5. **LNG and Refinery Expansions Jefferson County**

Region-Specific Study Number 1: Inter-Regional Coordination on the Toledo Bend Project

1. The contract scope of work states "coordination with Regions C and D on water supply and locations". Please document coordination with Region D in the report.

Response: The coordination efforts are discussed in Section 1.2 of the report and copies of the transmittal letters are included in Appendix D.

2. Page ES-1: This strategy is expected to come online by 2050 in the State Water Plan. Please clarify if the 2060 online date is a recommended revision based upon results of the current study.

Response: The 2060 on line date is the preferred timing at the time of the study. This will be confirmed during the update of the 2011 regional water plans.

3. Page ES-1: The Toledo Bend strategy is also an alternative for the Upper Trinity Regional Water District. Please revise the final report to indicate this.

Response: The report was revised to recognize that the Toledo Bend Pipeline strategy is also an alternative for the Upper Trinity Regional Water District.

4. Task 1b: It is not clear in the report whether other entities in Region I beyond SRA would benefit from Toledo Bend water in this project or if that was determined to not be feasible. Please indicate where this is located in the report or include the analysis and determination in the final report.

Response: A discussion of potential entities in Region I that may benefit from this project is included in Section 2.4 of the report.

5. Task 1c: Please document coordination efforts for supplying raw water to smaller entities. Coordination efforts in the report appear limited to large wholesale providers.

Response: Since the timing of this project is more than 50 years from today, the coordination efforts with smaller entities were limited to a desktop analysis.

6. Task 5: Due to the inter-regional nature of this study, please ensure coordination during the Round 3 Phase 2 regional water plan development to include consistent cost estimates and strategy elements in the appropriate regional plans.

Response: Region I consultants will coordinate with Regions C and D regarding project development and costs. However, Region I does not have any control over what information is included in the other regional water plans.

7. Region C Study 2: Please take into consideration comments developed by Region C consultants on this inter-regional study of the Toledo Bend Project.

Response: The comments were considered and responses to Region C's comments are included in Appendix D.

Comments for Consideration:

8. Please consider clarifying the environmental flows process established by Senate Bill 3 and how its determination of flow regimes might be different from the inflow numbers from Texas Parks and Wildlife Department analyzed in the report.

Response: Since the environmental flow process established by SB3 is currently being fleshed out by the Texas Environmental Flow Science Advisory Committee and the Basin and Bay Expert Science Teams, it is difficult to clarify how the process may differ from the values recommended by TPWD. This was noted in the report.

DRAFT MEMORANDUM TO FILE

DRAFT
THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF THOMAS C. GOOCH, P.E., TEXAS NO. 50668 ON DECEMBER 29, 2008. IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING OR PERMIT PURPOSES.

From: Tom Gooch, Freese and Nichols, Inc.

Date: December 29, 2008

Project: NTD-07286, Region C
File: NTD07286\T\Study 2 – Toledo Bend Study\Comments.doc

Subject: Comments on December 2008 Draft Report *East Texas Region Special Study No. 1: Inter-Regional Coordination on the Toledo Bend Project*

We have reviewed the December 2008 Draft Report *East Texas Region Special Study No. 1: Inter-Regional Coordination on the Toledo Bend Project*, prepared by Schaumburg and Polk, Inc., Freese and Nichols, Inc., and Alan Plummer Associates, Inc. for the East Texas Regional Planning Group. The draft report provides a useful update of the cost of the proposed project and basic information on possible water quality concerns and environmental flow issues. Based on our review, we offer the following comments on the draft report:

More Substantive Comments

1. In Section 2, it would be useful to summarize the changes from the 2006 plan, perhaps in a text box. Changes include the pump station location on Toledo Bend reservoir, the delivery points for NTMWD and Dallas, and TRWD's decision to use a separate pipeline for Toledo Bend flows. All of these changes have an impact on the project cost.

Response: The changes are summarized in a text box on page 2-8.

2. The Right of Way cost should be expressed on a per linear foot basis. The cost per acre for rural areas appears high when rural acreages sell at much lower costs ($2,000 to $3,000 per acre).

Response: The cost is appropriate for right of way purchases, which are typically not representative of large acreage prices. Future cost estimates will be coordinated with Region C and expressed on a per linear foot basis.

3. It is not clear from the report what the peak delivery rates are in each pipeline segment and what peaking factors are used. The peak flow for each segment should be added to Tables 2.1 and 2.2.

Response: A note referencing the peaking factors used was added to Tables 2.1 and 2.2.

4. On page 2-7, the report should indicate that the 2006 regional water plans used Second Quarter 2002 unit prices in the cost estimates, as required by the Texas Water Development Board.

Response: The report states that Region C used adjusted 2002 dollars. This is correct. Appendix U of the Region C plan states that the second quarter 2002 dollars were adjusted to account for significant increases in material costs. No changes made.

5. The life cycle cost was conducted assuming that the discount and inflation rate are the same (3.5 percent per year). This is an unusual approach. It is usually assumed that the discount rate (which reflects the time value of money) is 2 percent per year to 4 percent per year higher than inflation. The result of assuming that discount rate and inflation are the same is to make the purchase of (say) a certain amount of electricity 100 years from now as important as the purchase of the same amount of electricity today. (The price is inflated by 3.5 percent per year and then reduced by the same 3.5 percent per year to get present value.) We recommend that the life cycle cost consider the effect of a larger discount rate, at least 5 percent per year.

Response: The discount rate was changed to 4.5%. A lower rate was selected due to the public nature of the project and project sponsors.

6. The discussion of life cycle costs and the tables and figures should make it clear whether the costs and unit costs discussed are discounted present worth costs, estimated future costs with inflation, or costs at 2007 prices.

Response: Clarifications were made.

7. On page 3-5, the text discusses the regulations controlling power plant intakes (Title 40 CFR 122, Section 316(b)). Water supply intakes are not governed by Section 316(b) regulations, and the intakes do not usually meet these standards. The reference should be removed.

Response: The reference was removed.

8. In Section 3, it might be useful to compare chlorophyll “a” and total organic carbon (TOC) levels in the various reservoirs.

Response: A sentence was added to Section 3.3 referencing these parameters for potential future consideration.

9. On page 4-9, the text should point out that the median historical flows from 1940 through 1996 are very near the 1969-1996 values, considering natural variations in flow. The text could be read to imply that the reservoirs caused an increase in flows by releasing more water in the summer. It would be clearer to say “Since the reservoirs were constructed, inflows to the bay have tended to be higher from July through October (traditional low-flow months). This is probably due to the release of stored water from the reservoirs during the hotter summer months for power generation and to mitigate salt water intrusion.”

Response: There is a comparison to the 1969-1996 values. No changes made. The wording in the third sentence of the last paragraph was changed as requested.

10. Figure 4.6 should follow Figure 4.4 at the end of Section 4.2.3 and be renumbered as Figure 4.5. Text should be added to discuss the figure: "Figure 4.5 shows the monthly median historical inflows to the bay and the naturalized inflows that would have occurred without human activity. The figure shows that human activity has reduced flows in January, February, May, and December, probably primarily due to the storage of flows in reservoirs. On the other hand, human activity has increased flows in July, August, and September, probably primarily due to the release of stored water for hydropower generation. Overall, human activity has reduced annual median flows slightly (by about 2.7 percent, from 14.9 million acre-feet per year to 14.5 million acre-feet per year), probably primarily by the use of water for municipal, industrial, and irrigation purposes and evaporation from reservoirs." Section 4.3.1 would be removed.

Response: Figure 4.6 was moved to page 4-14 to follow its first reference. No other changes made.

11. I would suggest adding a bullet to Section 4.4 discussing the application of TPWD's inflow targets. "The available data shows that the target inflows recommended for Sabine Lake by TPWD cannot be met under drought conditions, even if all existing uses of water are abandoned and the reservoirs in the watershed are dedicated solely to environmental flows. It is unclear how the suggested TPWD targets would be applied under drought conditions."

Response: Comment noted. No changes made.

12. In addition to our comments, the Upper Trinity Regional Water District (UTRWD) submitted comments to the Region C Water Planning Group on December 8, 2008. The UTRWD comments are attached to this memorandum for your consideration.

Response: The Toledo Bend Pipeline Project was noted as an alternative strategy for Upper Trinity Regional Water District in the discussions in the Executive Summary and Section 1.0.

Minor Editorial Comments:

- Page 4-10, add ", 400,000 acre-feet per year higher than historical values" at the end of the first sentence of the last paragraph.

Response: Text was added.

- It would be helpful to include the design peak flow capacity for each segment on the cost tables in Appendix B.

Response: Text was added.