TRANS-TEXAS WATER PROGRAM

SOUTHEAST AREA

Draft Screening Report

Environmental Analysis of Potential Transfer Routes

February 1998

Sabine River Authority of Texas
Lower Neches Valley Authority
San Jacinto River Authority
City of Houston
Brazos River Authority
Texas Water Development Board

This document is a product of the Trans-Texas Water Program: Southeast Area. The program's mission is to propose the best economically and environmentally beneficial methods to meet water needs in Texas for the long term. The program's four planning areas are the Southeast Area, which includes the Houston-Galveston metropolitan area, the South-Central Area (including Corpus Christi), the North-Central Area (including Austin) and the West-Central Area (including San Antonio).

The Southeast Area of the Trans-Texas Water Program draws perspectives from many organizations and citizens. The Policy Management Committee and its Southeast Area subcommittee guide the program; the Southeast Area Technical Advisory Committee serves as program advisor. Local sponsors are the Sabine River Authority of Texas, the Lower Neches Valley Authority, the San Jacinto River Authority, the City of Houston and the Brazos River Authority.

The Texas Water Development Board is the lead Texas agency for the Trans-Texas Water Program. The Board, along with the Texas Natural Resource Conservation Commission, the Texas Parks & Wildlife Department and the Texas General Land Office, set goals and policies for the program pertaining to water resources management and are members of the Policy Management Committee.

Brown & Root and Freese & Nichols are consulting engineers for the Trans-Texas Water Program: Southeast Area. Blackburn & Carter and Ekistics provided technical support. This document was prepared under the supervision of:

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Executive Summary

The goal of the Trans-Texas Water Program (TTWP) is to identify the most cost-effective and environmentally sensitive strategies for meeting the current and future water needs of Texas. Phase II of the TTWP for the Southeast area of Texas is an in-depth feasibility analysis of water resource management strategies recommended in Phase I of the TTWP. The interbasin transfer of water under three potential water demand scenarios is one management strategy in consideration by the program. The three scenarios include 1) the transfer of 600,000 acre-feet/year to areas west of the Southeast Study Area; 2) the transfer of 300,000 acre-feet/year to areas west of the Southeast Study Areas; and 3) no increase in the transfer of water out of the Southeast Study Area.

The environmental issues for water transfer between the five river basins in the TTWP Southeast Study Area are considered for 16 basin-to-basin transfer routes (or segments). The preferred alternative alignment for transfer of water between the Sabine, Neches, San Jacinto, Trinity, and Brazos rivers is determined in this report through analysis of environmental issues along each potential transfer segment.

Interbasin Transfer Routes

The interbasin transfer segments are numbered consistently with the Phase I TTWP report. Of the 16 segments analyzed in this report, three segments transfer water from the Sabine River to the Neches River (SN-1, SN-4a, and SN-4b). Three segments transfer water from the Neches River to the Trinity River (NT-1a, NT-3a, and NT-3b). Five segments run from the Trinity River to the San Jacinto River (TS-2a, TS-3a, TS-3b, TS-4a, and TS-4b). Four segments run from the San Jacinto River to the Brazos River (SB-1a, SB-1b, SB-1c, and SB-3). One segment (TB-1) runs directly from the Trinity River to the Brazos River without crossing the San Jacinto River.

Existing Environment for Segments

The existing environment along each of the 16 segments is described in terms of segment length, compatible land use, threatened and endangered species, river and stream crossings, wetlands, water quality, prime farmland soils, geology, public lands, and traffic. Sensitive natural communities, vegetational areas, fisheries, and cultural resources are discussed for the general vicinity surrounding the segments.

For portions of each segment requiring new construction, the area in consideration is a 200 foot right-of-way. For segments or portions of segments which run within an existing canal or drainageway, a smaller 100 foot right-of-way is considered. These right-of-ways are referred to as corridors in the remainder of the report. Generally the shorter segments have less environmental impact, as they disturb less area. However, portions of segments which run within existing channels may have less environmental impact due to a smaller amount of new land disturbance.

Static lift, or the total increase in elevation from the beginning to the end of a segment, is also included in the general description of each segment.

Preferred Alternatives

Based on in the examination of potential environmental impacts presented in this study, the three preferred segments which are recommended for further consideration by the TTWP include SN-4b, NT-3b, and TB-1.

1.0 Introduction

The Trans-Texas Water Program (TTWP) is a comprehensive water resources planning program created to evaluate a full range of water management strategies. The overall goal of the TTWP is to identify the most cost-effective and environmentally sensitive strategies for meeting the current and future water needs of some areas in Texas. The TTWP focuses on the Southeast, South-Central, North-Central, and West-Central Study Areas in Texas (Texas Water Development Board, (1995). This report focuses on the Southeast Study Area, which is shown in Figure 1.1.

Phase I of the TTWP was intended as an initial coarse screening of a broad range of water management strategies for each study area. Evaluations of each alternative were conducted in terms of technical feasibility, cost, legal and institutional issues, and other factors. The product of Phase I was a conceptual water management plan for each study area consisting of alternatives for further investigation in Phase II. A report summarizing the results of the Phase I investigation for the Southeast Study Area was published in March 1994. The report included recommendations regarding the water management strategies to be evaluated in Phase II. The recommendations for potential strategies to be evaluated are:

- implementation of aggressive water conservation programs in the Houston metropolitan area;
- wastewater reclamation and reuse, particularly by industries in the Houston area;
- systems operation of existing surface-water reservoirs to increase their effective yield;
- contractual water transfers;
- new surface-water supply projects (*i.e.*, a permanent saltwater barrier on the lower Neches River and the new Allens Creek Reservoir); and
- transfer of water from the Sabine River Basin to the Houston area.

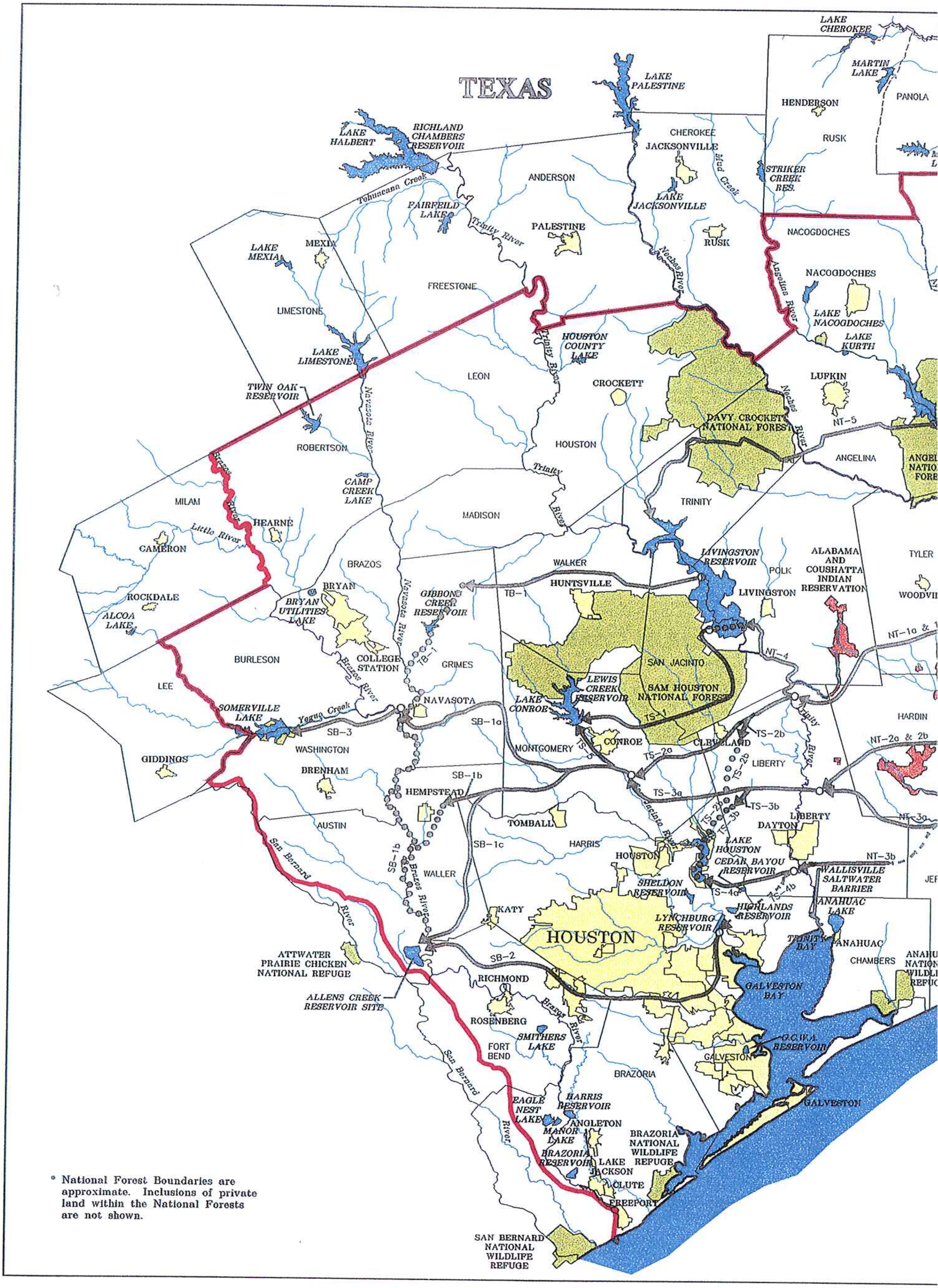
These strategies will be considered in the context of three water demand scenarios also described in the Phase I report. Scenario 1 represents the TWDB's proposed plan for new water supply development in the San Antonio area. Under this plan, transfer of additional water from the southeast would need to begin by 2010 and would increase to 600,000 acre-feet per year by 2050. Scenario 3 includes the TWDB's proposed plan, but also adds additional local projects and wastewater reuse to the proposed supply, resulting in a delay of the need for southeast water transfers until the year 2020. This plan also results in a reduction of the amount needed west of the Brazos in 2050 to 300,000 acre-feet per year. Scenario 3 assumes extensive development of local water resources west of the Brazos River basin and does not include any Southeast area water supplying the San Antonio area.

Figure 1.1 shows the potential routes for transfer of water from the Sabine River to the Houston area considered in Phase I. The Phase I report recommended that further analysis of 16 of these segments to be conducted in Phase II of the TTWP based on the preliminary screening process. The segments to be analyzed in Phase II consist of the following:

Segment SN-1	Toledo Bend Reservoir to Sam Rayburn Reservoir
Segment SN-4a	Sabine River Authority (SRA) Pump Station in Orange County to Lower Neches Valley Authority (LNVA) Neches First Lift Station in Jefferson County, via LNVA Canal
Segment SN-4b	Sabine River Authority (SRA) Pump Station in Orange County to Lower Neches Valley Authority (LNVA) Neches First Lift Station in Jefferson County, via new facilities.
Segment NT-1a	B.A. Steinhagen Lake to Transfer Station at the Trinity River near Romayor
Segment NT-3a	Neches First Lift Station to Transfer Station at the Trinity River near Moss Hill
Segment NT-3b	Neches First Lift Station to Transfer Station at the Trinity River South of Liberty
Segment TS-2a	Transfer Station at the Trinity River near Romayor to Transfer Station at the West Fork San Jacinto River below Conroe
Segment TS-3a	Transfer Station at the Trinity River near Moss Hill to Transfer Station at the West Fork San Jacinto River below Conroe
Segment TS-3b	Transfer Station at the Trinity River near Moss Hill to Luce Bayou/Lake Houston
Segment TS-4a	Transfer Station at the Trinity River South of Liberty to Lake Houston
Segment TS-4b	Transfer Station at the Trinity River South of Liberty to Lynchburg Reservoir
Segment SB-1a	Transfer Station at the West Fork San Jacinto River below Conroe to Transfer Station at the Brazos River near Navasota
Segment SB-1b	Transfer Station at the West Fork San Jacinto River below Conroe to a Tributary of the Brazos River near Hempstead
Segment SB-1c	Transfer Station at the West Fork San Jacinto River below Conroe to the Proposed Allens Creek Reservoir
Segment SB-3	Transfer Station at the Brazos River near Navasota to Lake Somerville
Segment TB-1	Lake Livingston to Gibbons Creek in the Brazos Basin

Phase II of the TTWP involves a more in-depth feasibility analysis of the alternatives that survived the initial screening in Phase I (TWDB, 1995).

The purpose of this report is to summarize the existing environment and possible environmental impacts of alternative interbasin transfer routes in the Southeast Area.



* National Forest Boundaries are approximate. Inclusions of private land within the National Forests are not shown.

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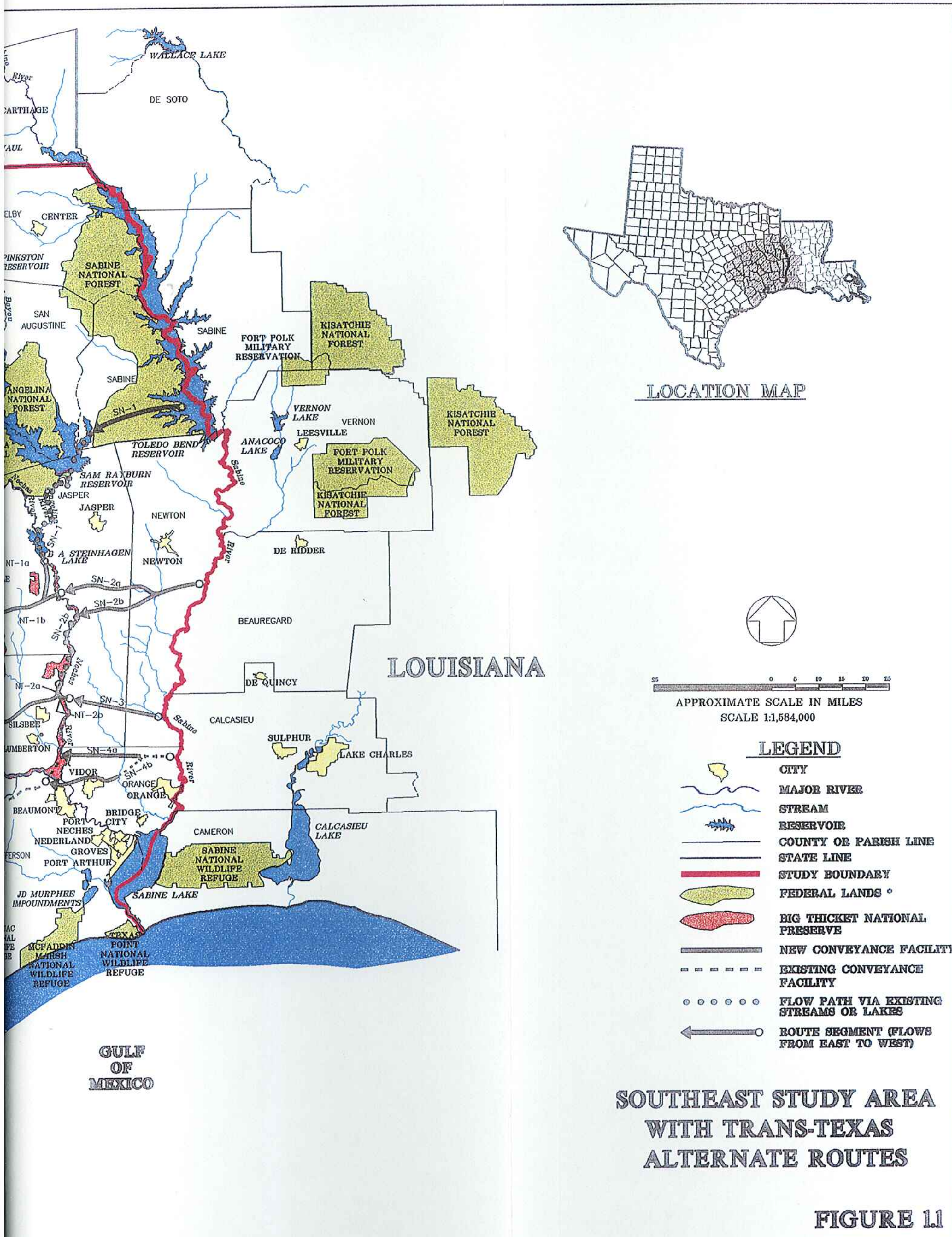


SOUTHEAST STUDY AREA WITH TRANS-TEXAS ALTERNATE ROUTES

FIGURE 1.1

2.0 Interbasin Transfer Routes

2.1 Route Selection

The feasibility of interbasin transfers is an important issue for the Trans-Texas Water Program. The Phase I investigation provided a preliminary study and screening of the available transfer route alternatives. This Phase II report includes a more detailed study of the interbasin transfer routes that were recommended in the Phase I report for further analysis (Figure 2.1).

2.2 Sabine River Basin to Neches River Basin

The Phase I study analyzed six separate transfer corridors between the Sabine and Neches rivers. After preliminary analysis, Segments SN-1, SN-4a, and SN-4b were chosen for further study (Figure 2.1).

Segment SN-1 begins at Toledo Bend Reservoir and traverses the watershed divide to Sam Rayburn Reservoir. From there, the natural flow path carries the water down the Angelina River to B.A. Steinhagen Lake on the Neches River. This segment makes use of existing reservoirs and stream channels and is the only segment which diverts water directly from Toledo Bend Reservoir. This segment has a high static lift.

Segment SN-4a uses the existing Sabine River Authority (SRA) canal for a short distance beginning at the SRA's pump station facilities in Orange County. The segment leaves the SRA canal approximately five miles west of the SRA's pump station facilities and runs due west to the Neches River at Lakeview. From this point the water will flow south in the Lakeview Canal through the Jack Gore Baygall unit of the Big Thicket National Preserve (BTNP) to the Lower Neches Valley Authority's (LNVA) Neches First Lift Pump Station. This segment requires a short distance of new conveyance facilities and utilizes existing facilities that are owned by the SRA and LNVA. Segment SN-4a has a very low static lift.

Segment SN-4b begins at the existing SRA pump station facilities in Orange County and uses the SRA Main Canal to Cow Bayou. From this point, the alignment proceeds to the west and ends at the LNVA's First Lift pump station at the Neches River in Jefferson County. This alignment completely avoids the BTNP and has a very low static lift.

2.3 Neches River Basin to Trinity River Basin

The Phase I study analyzed eight separate transfer corridors between the Neches and Trinity rivers. After preliminary analysis, Segments NT-1a, NT-3a, and NT-3b were chosen for further study (Figure 2.1).

Segment NT-1a begins at B.A. Steinhagen Lake and runs westward and southward, avoiding of the BTNP. The western terminus of the route is a transfer station just east of the Trinity River near Romayor. The topography is rough and would involve a substantial static lift. The entire length of Segment NT-1a would require the construction of new facilities.

Segment NT-3a begins at the LNVA's Neches First Lift Pump Station north of Beaumont, and runs approximately 11 miles within the LNVA's Neches Main Canal. The segment would then require a new canal to run to a transfer station on the east side of the Trinity River between Moss Hill and Hardin. Segment NT-3a has low static lift.

Segment NT-3b begins at the LNVA's Neches First Lift pump station. The route will use the existing LNVA Main Canal for the first 23 miles. A new canal will be constructed at the end of the 23 miles and will proceed west to a transfer station at the Trinity River south of Liberty in Liberty County. This segment has a low static lift.

2.4 Trinity River Basin to San Jacinto River Basin

The Phase I study analyzed eight possible segments between the Trinity and San Jacinto river basins. After preliminary analysis, Segments TS-2a, TS-3a, TS-3b, TS-4a, and TS-4b were chosen for further study (Figure 2.1).

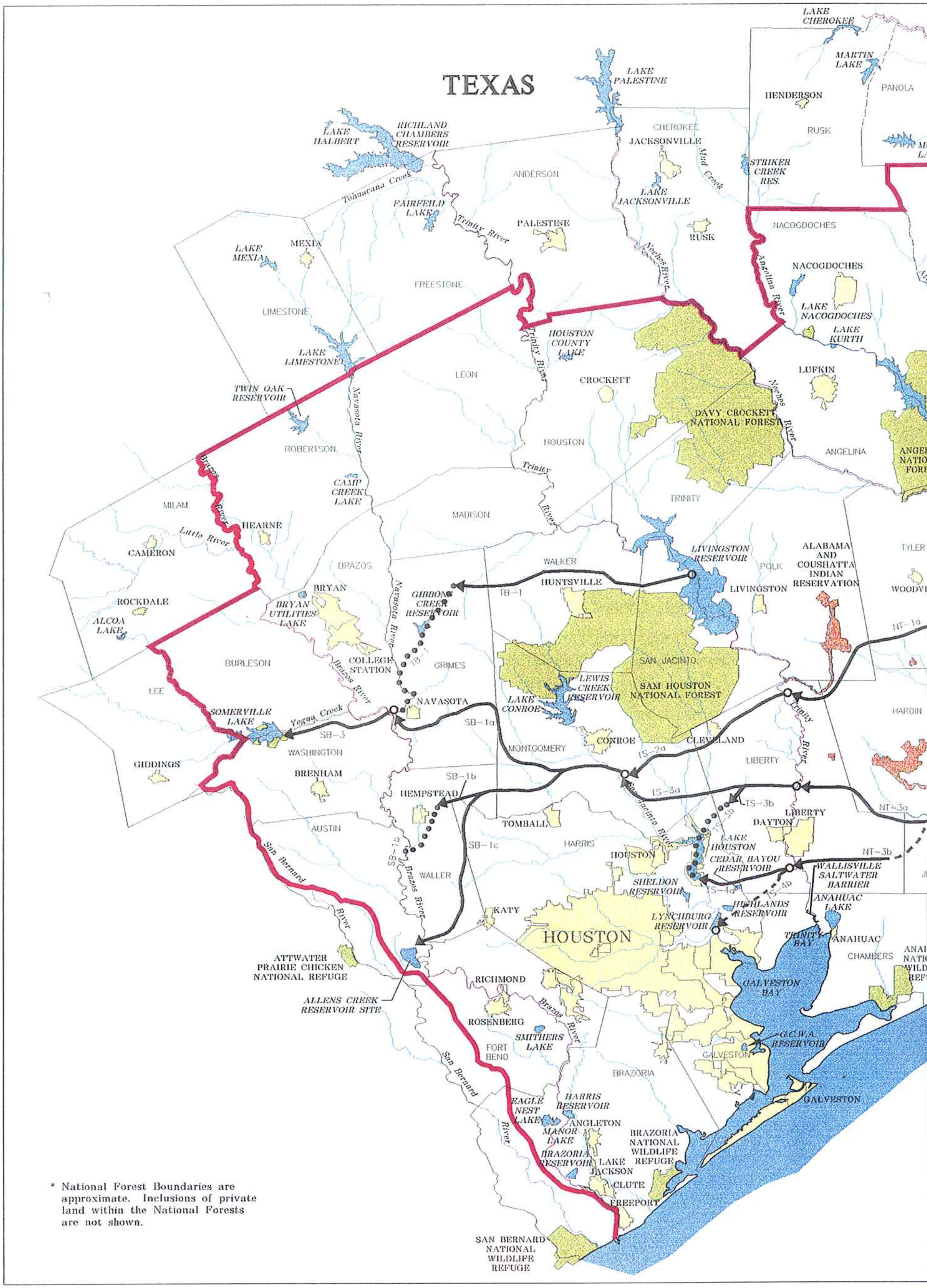
Segment TS-2a begins at a transfer station on the east side of the Trinity River near Romayor in Liberty County, passes south of Cleveland, and extends to a transfer station on the east side of the San Jacinto River southeast of Conroe in Montgomery County. This segment is one of only two segments (TS-3a) which can directly connect to the segment leading to Lake Somerville or the proposed Allens Creek Reservoir. This segment has a relatively high static lift.

Segment TS-3a begins at a transfer station on the east side of the Trinity River between Moss Hill and Hardin and travels almost due west to a transfer station on the east side of the Wet Fork San Jacinto River below Conroe. This segment requires substantial construction of new facilities and has relatively high static lift. This is the only segment besides Segment TS-2a that directly connects to the segment leading to Lake Somerville or the proposed Allens Creek Reservoir.

Segment TS-3b extends from a transfer station east of the Trinity River between Moss Hill and Hardin in Liberty County westward to Luce Bayou, which empties into Lake Houston in Harris County. This segment uses 22 miles of existing facilities and requires 11 miles of new facilities. This segment has low static lift.

Segment TS-4a begins at a transfer station on the east side of the Trinity River south of Liberty and travels west to Lake Houston. This segment uses part of the existing Dayton Canal *en route* and has low static lift.

Segment TS-4b begins at a transfer station east of the Trinity River and south of Liberty in Liberty County and travels west to the Lynchburg Reservoir in Harris County. The alignment will use the Coastal Water Authority Canal System for its entire length. This segment has low static lift.



* National Forest Boundaries are approximate. Inclusions of private land within the National Forests are not shown.

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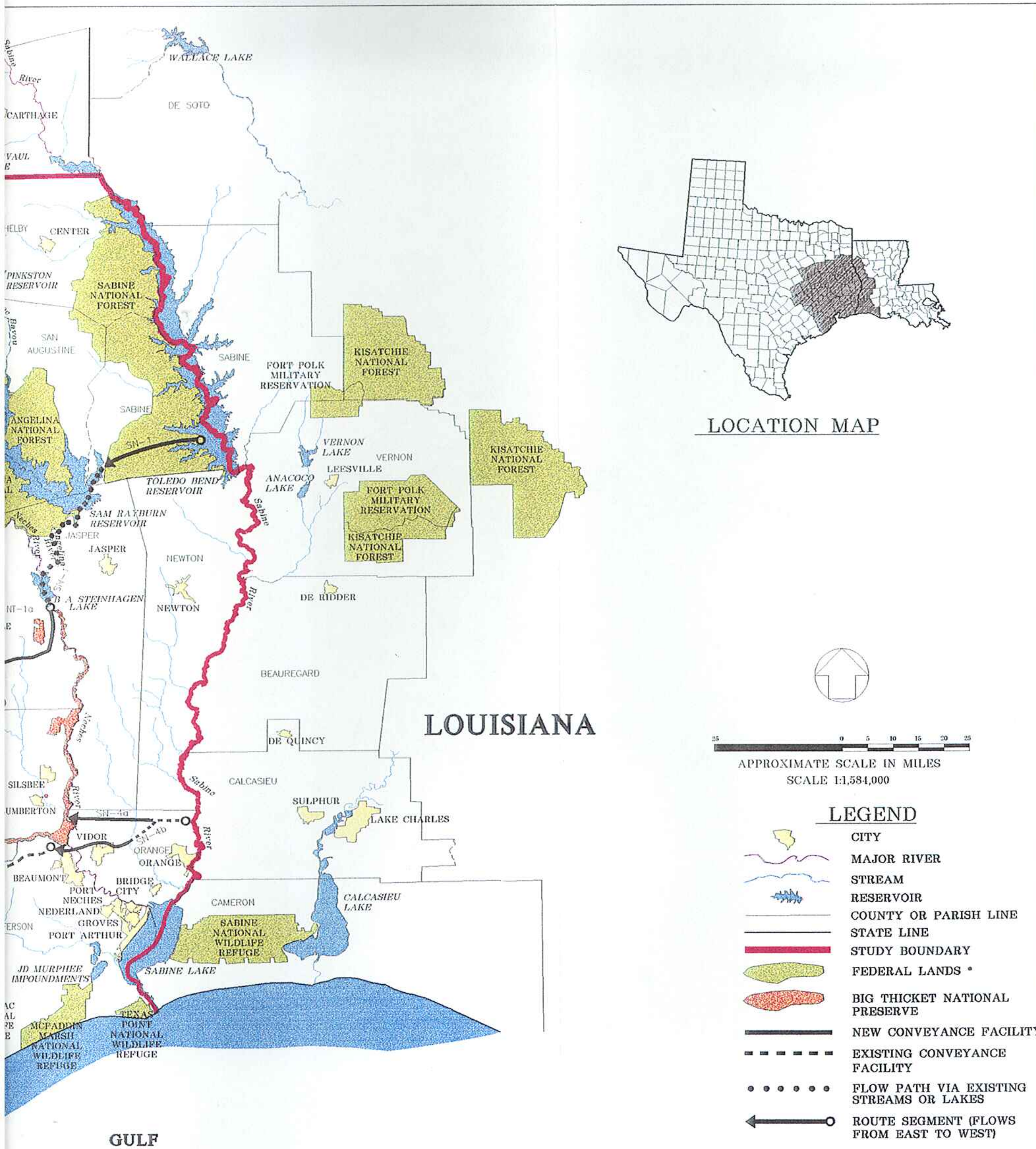

SOUTHEAST STUDY AREA ALTERNATE SEGMENTS

FIGURE 2.1

2.5 San Jacinto River Basin to Brazos River Basin

The Phase I study analyzed five segments between the San Jacinto and Brazos rivers. After preliminary analysis, Segments SB-1a, SB-1b, SB-1c, and SB-3 were chosen for further study (Figure 2.1).

Segment SB-1a begins at a transfer station on the east side of the West Fork San Jacinto River south of Conroe in Montgomery County. This segment travels westward to the Grimes County line, whereupon it turns north. After traveling approximately 10 miles northward, the alignment turns to the west again and heads due west toward Navasota in Grimes County. This segment ends at a transfer station on the east side of the Brazos River near Navasota. The static lift for this segment is very high.

Segment SB-1b begins at the same point as SB-1a in Montgomery County but branches southwest to a point where it crosses the watershed divide between the San Jacinto and Brazos rivers just east of Hempstead in Waller County. Once the water is in the Brazos River Basin, it would be released into a natural channel and, from there, would flow downstream to points where it would be picked up for transfer farther west. It is not known at the time of this report if transferred water will be blended with that of the Brazos River before being transferred westward. This segment has a very high static lift.

Segment SB-1c begins at the same point as SB-1a and SB-1b but heads in a southerly direction towards Wallis in Waller County in the Brazos River Basin. The terminus for this segment is the proposed Allens Creek Reservoir. This segment also has very high static lift.

Segment SB-3 is the only segment that transfers water to Lake Somerville. This segment begins at a transfer station on the east side of the Brazos River near Navasota and follows the valley of Yegua Creek to Lake Somerville. The static lift of this segment is high.

2.6 Trinity River Basin to Brazos River Basin

Only one segment, Segment TB-1, moves water directly from the Trinity River to the Brazos River. Segment TB-1 begins at the west side of Lake Livingston, near the U.S. Highway 190 bridge in San Jacinto County, and goes westward, running north of Huntsville, to discharge into the headwaters of Gibbons Creek in the Brazos River Basin. The water would then flow downstream, to be recovered for transfer to the West-Central Area. This segment bypasses the San Jacinto River Basin to transfer water directly from Lake Livingston into the Brazos River Basin. The topography along this segment is generally hilly and much of the alignment would not be suitable for canals. This segment has the highest static lift of any single segment in the study.

3.0 Existing Environment for Alternative Segments

This section discusses the various environmental conditions in the areas crossed by the 16 segments selected for further analysis in Phase II. Conditions related to land use, threatened and endangered species, hydrology, water quality, wetlands, soils and geology, public lands, and traffic descriptions are discussed in this section and summarized at the end of the section in Table 3.9.

3.1 Compatible Land Use

This section describes the types and area of land use along the 16 transfer route segments. Land use types were determined by comparing the proposed transfer routes to 1:24,000 and 1:20,000 scale aerial photos and 1:24,000 scale topographic maps of the affected areas. A 200-foot corridor was assumed for those portions of each segment which would involve a new channel. When possible, a 100-foot corridor (50 feet on each side) was assumed for those portions of each segment which would use an existing drainageway. Table 3.1 lists the segments, the total length for each, and the amount of each segment which would utilize existing drainageways, e.g., canals, streams, rivers. Table 3.2 provides the area of the three dominant land use types along the proposed transfer route segments. Table 3.2 presents the area within the segment corridor as well as the area within the corridor of the downstream flow path. Woodlands were characterized as natural areas covered by trees. On the aerial photos, woodland areas appeared as dark patches. Agriculture was composed of areas that were cleared for cultivation purposes, rangeland, or pastureland. The main indicators of agriculture on aerial photos were cleared land, plowed contours, and irrigation ditches within the fields. Common irrigation patterns in the project area were contours plowed to match the topography of the field. The few urban areas within the project area were characterized by streets, parking lots, and closely spaced residential and commercial areas. It appears that some of the urban areas could be avoided during the actual final placement of the proposed routes.

Some of the routes followed existing canals or streams. The impact to the existing land uses would be much less along the existing channels than along the areas where a new channel would cut across the landscape.

Segment SN-1

The majority of Segment SN-1 crosses through woodlands (454 acres). The aerial photos for Jasper County show that the woods are thick, mature forests with occasional clearings due to pipelines or roads. Much of the area in this segment which is considered agricultural land is cleared rangeland or pastureland and is not active cropland. In Jasper County, the downstream flow path of Segment SN-1 runs within the existing channel of the Angelina River. The total length of Segment SN-1 is approximately 19 miles.

Table 3.1
Comparative Lengths of New Channels,
Existing Channels, and Downstream Flow Paths for Each
Segment in the Southeast Area

Segment	Channel Length			
	New (Miles)	Existing (Miles)	Total (Miles)	Downstream Flow Path
SN-1	19	0	19	26
SN-4a	21	8	29	0
SN-4b	18	14	32	0
NT-1a	59	0	59	0
NT-3a	28	13	41	0
NT-3b	26	21	47	0
TS-2a	38	0	38	0
TS-3a	38	0	38	0
TS-3b	9	0	9	21
TS-4a	13	6	19	0
TS-4b	0	20	20	0
SB-1a	41	0	41	0
SB-1b	35	0	35	47
SB-1c	54	9	63	0
SB-3	25	0	25	0
TB-1	52	0	52	41

Table 3.2
Land Use along the Proposed Transfer Segments

Segment	Woodlands (acres)	Urban (acres)	Agricultural (acres)
SN-1	454	0	0
SN-4a	513	0	105
SN-4b	548	158	68
NT-1a	1,123	85	191
NT-3a	535	0	287
NT-3b	325	58	834
TS-2a	824	0	107
TS-3a	844	0	78
TS-3b	211	0	0
TS-4a	151	0	243
TS-4b	51	5	191
SB-1a	844	0	417
SB-1b	696	0	106
SB-1c	524	0	1,001
SB-3	150	0	445
TB-1	603	0	483

Segment SN-4a

Segment SN-4a crosses through 513 acres of woodlands and 105 acres of agricultural lands. The segment would run within the existing channel of the LNVA canal for approximately one-third the length that it crosses woodlands. The remaining two-thirds would require construction of a new channel through woodlands. The total length of the prospective alignment for Segment SN-4a is approximately 29 miles.

Segment SN-4b.

Segment SN-4b runs mainly through woodlands. Segment SN-4b crosses through more urban areas than any of the other prospective routes. The urban areas that the route crossed were Forest Heights and Vidor, Texas. Forest Heights is a small residential community that can be avoided by moving the final alignment. The route also runs through the outskirts of the town of Vidor. Approximately two-thirds of Segment SN-4b runs adjacent to Indian Bayou. The total length of the prospective alignment for Segment SN-4b is approximately 32 miles.

Segment NT-1a.

Segment NT-1a crosses through 1,123 acres of woodlands, 191 acres of agricultural lands, and 85 acres of urban land. The woodlands in this segment appear especially dense on the aerial photos in Tyler County, but begin to thin in Polk County. The segment crosses through urban areas in the towns of Spurger and Hillister, Texas. Both urban areas could be avoided by moving the final alignment. Much of the area in this segment which is considered agricultural land is cleared rangeland or pastureland and is not active cropland. The total length of the prospective alignment for Segment NT-1a is approximately 59 miles.

Segment NT-3a.

Segment NT-3a crosses through 535 acres of woodlands and 287 acres of agricultural lands. Most of the agricultural land is crossed while the segment runs within the existing channel of the LNVA canal, but all of the area within woodlands will require construction of a new channel. The total length of the prospective alignment for Segment NT-3a is approximately 41 miles.

Segment NT-3b.

Segment NT-3b crosses through 325 acres of woodlands and 834 acres of agricultural land. The segment also crosses through 58 acres of urban areas in the towns of Voth, China, and Nome, Texas. Segment NT-3b uses the existing Lower Neches Valley Authority (LNVA) Canal in these urban areas. The total length of the prospective alignment for Segment NT-3b is approximately 47 miles.

Segment TS-2a.

Segment TS-2a crosses through 824 acres of woodlands in addition to 107 acres of agricultural lands. Using the aerial photos, the woods are thick, mature forests with occasional clearings due to pipelines and roads. The forests appear to be similar in composition to nearby Sam Houston National Forest. Segment TS-2a does not run within any existing channel, so an entirely new channel would have to be constructed through the woodlands. No urban areas would be crossed by Segment TS-2a. The total length of the prospective alignment for Segment TS-2a is approximately 38 miles.

Segment TS-3a

Segment TS-3a crosses through 844 acres of woodlands and 78 acres of agricultural lands. All of the agricultural lands in the segment are accounted for in small patches cleared from the woodland in Liberty County. The total length of the prospective alignment for Segment TS-3a is approximately 38 miles.

Segment TS-3b.

The entire length of Segment TS-3b consists of woodlands. These woodlands are similar to those described for Segment TS-2a. No urban areas would be crossed by Segment TS-3b. The total length of the prospective alignment for Segment TS-3b is approximately nine miles. The downstream flow path includes approximately 21 miles of Luce Bayou, to Lake Houston.

Segment TS-4a

Segment TS-4a crosses through 243 acres of agricultural lands and 151 acres of woodlands. The wooded areas are interspersed along the route with concentrations near the beginning of the segment at the Trinity River and after the segment leaves the LNVA canal. The total length of the prospective alignment for Segment TS-4a is approximately 19 miles.

Segment TS-4b.

Segment TS-4b crosses through woodlands which are primarily interspersed among agricultural lands. The largest wooded area is near the beginning of the segment at the Trinity River. The entire route uses the existing LNVA Canal. For purposes of this study, it was assumed that the area of previous impact for the LNVA Canal was 100 feet wide. However, it is anticipated that the LNVA Canal may need widening, new parallel roads, or other ancillary facilities to accommodate the proposed project. Therefore, the area of impact for Segment TS-4b was limited to the outer 50-foot wide bands contained within a 200-foot right-of-way. Based on these measurements, Segment TS-4b would cross through 51 acres of woodlands, five acres of urban area, and 191 acres of agricultural lands. The total length of the prospective alignment for Segment TS-4b is approximately 20 miles.

Segment SB-1a.

Segment SB-1a crosses through both woodlands and agricultural lands. Woodlands account for approximately two-thirds the length of Segment SB-1a (844 acres), while agriculture accounts for the remaining one-third (417 acres). The woodlands vary from dense, mature woodlands to thin patches of younger trees. Segment SB-1a does not follow any existing channel, so an entirely new channel would have to be constructed through the woodlands. The total length of the prospective alignment for Segment SB-1a is approximately 41 miles.

Segment SB-1b.

Segment SB-1b crosses approximately 696 acres of woodlands and 106 acres of agricultural lands. The total length of the prospective alignment for Segment SB-1b is approximately 35 miles. The downstream flow path extends approximately 47 miles into the Clear Creek channel.

Segment SB-1c.

Segment SB-1c crosses approximately 524 acres of woodlands and 1,001 acres of agricultural lands. The first half of Segment SB-1c consists of the same alignment as the first half of Segment SB-1b. Segment SB-1c does not follow any existing channel, so an entirely new channel would have to be constructed. The total length of the prospective alignment for Segment SB-1c is approximately 63 miles.

Segment SB-3

Segment SB-3 crosses through 445 acres of agricultural lands and 150 acres of woodlands. The woodland areas are fairly evenly distributed among the mostly agricultural or rangeland areas in the segment. The total length of the prospective alignment for Segment SB-3 is approximately 25 miles.

Segment TB-1

Segment TB-1 crosses through 603 acres of woodlands and 483 acres of agricultural lands. Much of the area in this segment which is considered agricultural land is cleared rangeland or pastureland and is not active cropland. The total length of the prospective alignment for Segment TB-1 is approximately 52 miles. The downstream flow path of Segment TB-1 extends approximately 41 miles in the Gibbons Creek/ Gibbons Reservoir drainageway.

3.2 Biological Resources

This section discusses the biological resources associated with each of the 16 prospective transfer routes.

3.2.1 Natural Communities

The Texas Organization for Endangered Species (TOES) maintains a list of endangered and threatened species, and a watch list of natural communities within Texas (TOES, 1992). The Texas Biological and Conservation Data System (BCD) also maintains a database that records known locations of these species and natural communities. The natural communities possess characteristics which make them unique or rare and generally contain tighter restrictions on development or disturbances within them. The BCD database would need to be reviewed and a field investigation completed to determine known locations and proximity of these species to any proposed alignment.

Table 3.3 lists watch-listed natural communities which occur in the Trans-Texas Southeast Study Area. The American Beech-Southern Magnolia and American Beech-White Oak series occur on slopes and in ravines and creek bottoms. The two American beech series are listed as very rare in Texas, with only six to 20 occurrences in the state (Hayes, 1992).

The Bald Cypress-Water Tupelo Series are frequently flooded for long durations and possess hydric soils. This series is considered rare in Texas, with 21 to 100 occurrences (Hayes, 1992).

The Bluejack Oak-Pine Series occurs on deep, sandy soils of East Texas. This series is considered very rare in Texas, with only six to 20 occurrences (Hayes, 1992).

The Coastal Live Oak-Pecan Series is an evergreen-to-deciduous upland woodland of the upper Coastal Prairie. This series occurs mostly on clay soils near tributaries and bayous. This series is considered rare in Texas, with 21 to 100 occurrences (Hayes, 1992).

The Little Bluestem-Nuttall's Rayless Golden-Rod Series is restricted to flat, shallow soil areas with a fluctuating extractable water table. This series is considered rare in Texas, with 21 to 100 occurrences (Hayes, 1992).

The Longleaf Pine-Beakrush Series occurs primarily in poorly drained soils over the Montgomery Formation. The Longleaf Pine-Little Bluestem Series occurs in upland forests or savannahs over sandy or loamy soils with a low pH. These series are considered very rare in Texas, with six to 20 occurrences (Hayes, 1992).

Table 3.3
Natural Communities on the Texas Organization of Endangered Species Lists Located within the Trans-Texas Water Program Southeast Area

Community Type	Status[1]
American Beech-Southern Magnolia Series (*Fagus grandifolia-Magnolia grandiflora*)	G3, S2
American Beech-White Oak Series (*Fagus grandifolia-Quercus alba*)	G3, S2
Bald Cypress-Water Tupelo Series (*Taxodium distichum-Nyssa aquatica*)	G4, S3
Bluejack Oak-Pine Series (*Quercus incana-Pinus* spp.)	G4, S3
Coastal Live Oak-Pecan Series (*Quercus virginiana-Carya illinoensis*)	G3, S3
Little Bluestem-Nuttall's Rayless Golden-Rod Series (*Schizachyrium scoparium-Bigelowia nuttallii*)	G3, S3
Longleaf Pine-Beakrush Series (*Pinus palustris-Rhynchospora* spp.)	G3, S2
Longleaf Pine-Little Bluestem Series (*Pinus palustris-Schizachyrium scoparium*)	G3, S2
Sphagnum-Beakrush Series (*Sphagnum* spp.-*Rhynchospora* spp.)	G4, S2
Swamp Chestnut Oak-Willow Oak Series (*Quercus prinus-Quercus phellos*)	G3, S3
Water Oak-Coastal Live Oak Series (*Querus nigra-Quercus virginiana*)	G3, S3
Water Oak-Willow Oak Series (*Quercus nigra-Quercus phellos*)	G4, S3

Source: Hayes, 1992

[1] Status according to the Texas Biological and Conservation Data System. G3 - Very rare with 21 to 100 occurrences; G4 - Apparently secure globally; S2 - Imperiled in Texas, very rare with 6 to 20 occurrences in Texas; S3 - Rare in Texas with 21 to 100 occurrences (Hayes, 1992).

The Sphagnum-Beakrush Series occurs in seeps of East Texas and may contain a variety of acid-tolerant species. This series is considered very rare in Texas, with six to 20 occurrences (Hayes, 1992).

The Swamp Chestnut Oak-Willow Oak Series is a flatland community restricted to the Big Thicket. This series is considered rare in Texas, with 21 to 100 occurrences (Hayes, 1992).

The Water Oak-Coastal Live Oak Series occurs on floodplains and along bayous in the upper Coastal Prairie. The Water Oak-Willow Oak Series is the typical East Texas bottomland hardwood forest which intermixes with swamps and freshwater marshes. The Water Oak series are considered rare in Texas, with 21 to 100 occurrences of each community (Hayes, 1992).

Four vegetational areas are described for the study area. These are the Pineywoods, Gulf Prairies and marshes, Blackland Prairies, and the Post Oak Savannah Vegetational Areas.

The Pineywoods Vegetational Area is an area of high rainfall, with between 35 and 50 inches occurring throughout the year. The region is dominated by forest and ranching operations. However, small pockets of relatively pristine evergreen shrub bogs, open seepage slopes, and bald cypress-water tupelo swamps remain scattered throughout (Correll and Johnston, 1979).

The Gulf Prairies and Marshes Vegetational Area receives between 30 inches of rainfall in the western portions of the region to 50 inches in the eastern portions. The climax vegetation of the gulf prairie is either tallgrass prairie or post oak savannah; whereas, the marsh area has been used primarily for grazing and farming (Correll and Johnston, 1979).

The Blackland Prairies Vegetational Area receives from 30 inches of rainfall in the west to 40 inches in the east. This region can be classified as a true prairie with little bluestem (*Schizachyrium scoparium*) dominating the climax vegetation. In addition, the region contains a significant portion of woodlands.

The Post Oak Savannah Vegetational Area averages between 35 and 45 inches of rainfall annually. For the most part, the Post Oak Savannah Vegetational Area has been converted into improved pastures, with small farms and native pastures relatively common.

Segment SN-1.

Segment SN-1 extends from Toledo Bend Reservoir to Sam Rayburn Reservoir, down the Angelina River to B.A. Steinhagen Lake on the Neches River. This transfer route crosses the Sabine National Forest in the Pineywoods Vegetational Area.

Segment SN-4a.

Segment SN-4a extends from the Sabine River basin in Orange County to the Neches River basin at Lakeview. This transfer route crosses the Pineywoods Vegetational Area.

Segment SN-4b.

Segment SN-4b extends from the Sabine River basin in Orange County to the LNVA's First Lift pump station at the Neches River. This transfer route crosses the Pineywoods Vegetational Area.

Segment NT-1a.

Segment NT-1a extends from B.A. Steinhagen Lake on the Neches River to the Trinity River basin near Romayor. This transfer route crosses through the Pineywoods Vegetational Area.

Segment NT-3a.

Segment NT-3a extends from the LNVA First Lift north of Beaumont to the Trinity River basin between Moss Hill and Hardin. This transfer route crosses the Pineywoods and Gulf Prairies and Marshes vegetational areas.

Segment NT-3b.

Segment NT-3b extends from the LNVA's First Lift pump station to the Trinity River basin south of Liberty in Liberty County. This transfer route crosses through the Pineywoods and Gulf Prairies and Marshes vegetational areas of Texas.

Segment TS-2a.

Segment TS-2a extends from the Trinity River basin near Romayor to the San Jacinto River basin southeast of Conroe. This segment crosses the Pineywoods Vegetational Area.

Segment TS-3a.

Segment TS-3a extends from the Trinity River basin between Moss Hill and Hardin to the San Jacinto River basin south of Conroe. This transfer route crosses the Pineywoods Vegetational Area.

Segment TS-3b.

Segment TS-3b extends from the Trinity River basin westward to Luce Bayou, where water is then allowed to flow freely to Lake Houston. This transfer route passes along the boundary of the Pineywoods and Gulf Prairies and Marshes vegetational areas.

Segment TS-4a.

Segment TS-4a extends from the Trinity River basin south of Liberty westward to Lake Houston. This transfer route crosses the Pineywoods and Gulf Prairies and Marshes vegetational areas.

Segment TS-4b.

Segment TS-4b extends from the Trinity River basin and south of Liberty westward to Lynchburg Reservoir. This transfer route crosses the Gulf Prairies and Marshes Vegetational Area.

Segment SB-1a.

Segment SB-1a extends from the San Jacinto River basin westward to the Brazos River basin south of Navasota. This route crosses the Pineywoods and Blackland Prairies vegetational areas.

Segment SB-1b.

Segment SB-1b extends from the San Jacinto River basin westward to the Brazos River basin, where the water would be released into a natural stream channel and flow to the Brazos River. This transfer route crosses the Pineywoods and Post Oak Savannah vegetational areas.

Segment SB-1c.

Segment SB-1c begins in at the San Jacinto River basin and extends westward to its terminus at the proposed Allens Creek Reservoir near the Brazos River. This transfer route crosses the Pineywoods and Post Oak Savannah vegetational areas.

Segment SB-3.

Segment SB-3 extends from the San Jacinto River basin westward to Lake Somerville. This transfer route crosses the Post Oak Savannah Vegetational Area.

Segment TB-1.

Segment TB-1 extends from Lake Livingston westward to Gibbons Creek. This transfer route crosses through the Pineywoods, Post Oak Savannah, and Blackland Prairies vegetational areas.

3.2.2 Fisheries

The following discussion describes the fisheries characteristic of the major river basins located in the study area. Information pertaining to species distribution was taken from Conner & Suttkus (1986) who grouped the basins by their common drainage points into the Gulf of Mexico.

The Sabine and Neches River systems exhibit the greatest fish species richness in the study area. The southwestern range of ten species extends only as far as the Sabine and Neches River system. These include: *Ichthyomyzon castaneus, Esox niger, Hybognathus hayi, Notropis maculatus, Ictiobus cyprinellus, Ammocrypta clara, Etheostoma asprigene, E. fusiforme, E. histrio* and *E. whipplei.* Early studies by C. Hubbs (1957) cites several species as being confined to the extreme upper Sabine River system. Many of these have since been observed in appropriate habitats throughout both the Sabine and Neches Rivers. These include *Ichthyomyzon castaneus, Phenacobius mirabilis, Ictiobus cyprinellus,* and *Etheostoma histrio. Esox niger, Hybognathus hayi* and *Notropis maculatus* are still only known from isolated locations in the upper Sabine River tributaries.

The Trinity and San Jacinto River systems represent the eastern most drainage system in the study area to contain both upland and riverine habitats. Nine species reach their southwestern range limit in the Trinity and San Jacinto River system. These include *Ichthyomyzon gagei, Polyodon spathula, Notropis atherinoides, N. sabinae, N. umbratilis, Moxostoma poecilurum, Noturus nocturnus, Labidesthes sicculus and Amocrypta vivax.* Ten Trinity River system species which have not been observed in the San Jacinto system include *Campostoma anomalum, Notropis atherinoides, N. potteri, N. shumardi, N. stramineus, Phenacobius mirabilis,* *Pimephales promelas, Cycleptus elongatus, Fundullus zebrinus* and *Etheostoma spectabile.*

The Brazos River system is the largest basin in the study area and is one of the most distinctive with respect to fish species. Twelve species reach their southwestern range limits in the Brazos system. These include: *Esox americanus, Hybopsis streriana, Notropis atrocaudalis, Erimyzon oblongus, Cyprinodon rubrofluviatilis, Fundulus blairae, F. Olivaceus, Centrarchus macropterus, Elassoma zonatum, Lepomis marginaltus, Pomoxis nigromaculatus* and *Etheostoma parvipinne*. The Brazos River system also contains two endemic riverine shiners, *Notropis buccula* and *N. oxyrhynchus*.

3.2.3 Threatened and Endangered Species

The following discussion describes the federally listed and state-listed threatened and endangered species whose ranges overlap the Southeast Area of the Trans-Texas Water Program. Appendix B contains species descriptions for each of these species and a matrix depicting which species possibly occur within each segment according to the U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD) records.

The red-cockaded woodpecker (*Picoides borealis*) and bald eagle (*Haliaeetus leucocephalus*) are listed for all segments. The Arctic peregrine falcon (*Falco peregrinus tundrius*), white-faced ibis (*Plegadis chihi*), American swallow-tailed kite (*Elanoides forficatus*), wood stork (*Mycteria americana*), Texas horned lizard (*Phrynosoma cornutum*), and timber rattlesnake (*Crotalus horridus autricaudatus*) are listed as possibly occurring within segments between the Sabine and San Jacinto rivers, as well as Segments SB-1b, SB-1c, SB-3, and TB-1. The remaining species that possibly occur in the Southeast Area include the interior least tern (*Sterna antillarum*), Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*), brown pelican (*Pelecanus occidentalis*), whooping crane (*Grus americana*), piping plover (*Charadrius melodus*), Bachman's sparrow (*Aimophila aestivalis*), reddish egret (*Egretta rufescens*), white-tailed hawk (*Buteo albicaudatus*), mountain plover (*Charadrius montanus*), black bear (*Ursus americana*), Rafinesque's big-eared bat (*Plecotus rafinesquii*), Houston toad (*Bufo houstonensis*), western smooth green snake (*Liochlorophis vernalis*), alligator snapping turtle (*Macroclemys temmincki*), northern scarlet snake (*Cemophora coccinea copei*), paddlefish (*Polyodon spathula*), blue sucker (*Cycleptus elongatus*), creek chubsucker (*Erimyzon oblongus*), blackside darter (*Percina maculata*), prairie dawn (*Hymenoxys texana*), Texas trailing phlox (*Phlox nivalis ssp. texensis*), and Navasota ladies'-tresses (*Spiranthes parksii*).

3.3 Cultural Resources

No information is readily available regarding the presence of cultural resources within the proposed project area. The Texas Historical Commission will require a survey of the proposed alignment, and at that time adequate information should become available concerning cultural resources of the area.

3.4 Hydrology and Water Quality

3.4.1 Groundwater

All of the routes currently being examined in the project are within the recharge zone of the major aquifer called the Gulf Coast Aquifer. Heavy withdrawals of groundwater (groundwater mining) within the Gulf Coast Aquifer has caused a decline in aquifer pressure, which has the potential to cause saline water encroachment into the groundwater supply (Texas Water Development Board, 1990). Saltwater encroachment has been noted in Jefferson, Chambers, Montgomery, and Harris counties and is a potential problem in Orange, Hardin, Liberty, Fort Bend, Waller, and Grimes counties. Groundwater mining also has the potential to cause land surface subsidence in the Gulf Coast Aquifer. Subsidence is a problem in Orange, Jefferson, Harris and Galveston counties, parts of Chambers County, and a potential problem in Hardin County. Chambers County has the potential for activation of surface faults due to groundwater mining.

The Gulf Coast Aquifer also is known to have areas of high concentrations of iron and chloride. High chloride and iron may occur in Chambers and Jefferson counties. Water from some areas of the Gulf Coast Aquifer is corrosive and, therefore, objectionable for municipal, domestic, and manufacturing uses. Corrosive water may occur in Chambers, Orange, and Jefferson counties.

Routes SB-1a, SB-1b, SB-1c, SB-3, and TB-1 cross the minor aquifer called the Brazos River Alluvium Aquifer (Texas Water Development Board, 1992). The aquifer is located within Quaternary alluvium along the Brazos River. Water in the Brazos River Alluvium Aquifer is generally fresh; however, in many areas fluoride and nitrate concentrations exceed the United States (U.S.) Environmental Protection Agency's Interim Primary Drinking Water Standards.

3.4.2 Streams and Lakes

Rainfall patterns along central and eastern portions of Texas and the gulf coast area contribute heavily to the hydrology and physical structure of streams located in the study area. Variations in annual rainfall, geology and other factors across the study area result in variations of water quality, quantity and stream geomorphology of these streams.

Flow in smaller streams is flashy during periods of heavy rainfall and tapers to a more moderate flow which is sustained for some time by percolation of rainwater through shallow soils. Many streams are intermittent, either drying completely or retaining small pools during periods of light or no rainfall. These streams are often contained in channels characterized by alternating erosional and depositional areas. Intermittent streams flow in a general northwest to southeast direction and are major contributors of flow to the larger, perennial streams in the study area. Intermittent streams are not subject to water quality standards by TNRCC.

Perennial streams and rivers also flow in a northwest to southeast direction through the study area on their way to the tidally-influenced areas of the coastline. The north and west portions of the study area are characterized by faster moving streams with slightly higher gradients. The south and east portions of the study area are characterized by slower moving streams contained in meandering channels which cut through rich, deep soils. Rivers and larger perennial streams are classified water bodies and are subject to designated water quality standards by TNRCC.

Lakes in the study area are comprised of tributary and main stem reservoirs and exhibit a wide variety of hydrological regimes. Larger lakes are utilized for drinking water, irrigation, and recreation. These impoundments are generally classified water bodies and are subject to designated water quality standards by TNRCC. Smaller impoundments which occur on small, unclassified stream segments may not be subject to designated water quality standards.

Transfer segments will utilize existing stream channels, canals, lakes, and drainageways whenever possible in order to minimize construction and environmental impacts to surrounding areas. Conversely, construction of new transfer facilities may be preferable if the use of existing drainageways results in adverse water quality or environmental consequences. A detailed study of existing flow characteristics will be necessary to quantify hydrologic requirements and capacity of each proposed receiving stream or drainageway, as this report provides only a qualitative analysis.

Interbasin transfer segments designed to move water across basins are necessarily constructed perpendicular to the overall stream patterns of the study area. This results in a number of stream channels which may be crossed by each proposed segment. Discussion of stream crossings are included in the hydrology and water quality section of this report because the potential environmental consequences of construction or expansion of these facilities most directly affects hydrologic and water quality characteristics. Construction activities at these crossing sites can contribute suspended solids and other pollutants to the stream as well as disrupt or change the hydrologic characteristics of the channel. Stream crossing data were collected using USGS 7.5" quads which include the segment corridors within the study area. Table 3.4 contains the number of intermittent and perennial stream crossings and the number of major river crossings contained in the proposed path of each segment. Because the engineering and construction considerations are greater for major river crossings than for smaller stream crossings, they are presented separately in the table.

The most appropriate sites and methods of transferring water across stream and river channels will be chosen depending on site specific environmental and engineering constraints. A discussion of the number and types of stream crossings required by each segment is located in the segment-by-segment discussion below.

The quality of the state's water resources is protected and regulated by the Texas Natural Resource Conservation Commission (TNRCC). On even numbered years the TNRCC prepares The State of Texas Water Quality Inventory which is submitted to the United States Environmental Protection Agency (EPA) in accordance with Section 305(b) of the Clean Water Act. This report includes descriptions of surface water quality within each classified segment in each river and coastal basin in the state. For purposes of discussion in this section, TNRCC classified water quality segments will be referred to as river segments and TTWP interbasin transfer segments will be referred to as transfer segments.

Twelve river segments within the study area are either potential contributors or recipients of water transferred between basins via transfer segments. Table 3.5 contains a summary of the water quality concerns of river segments which contribute and receive water through transfer segments.

Table 3.4
Number of Stream and River Crossings for Each Segment

Segment	Number of River Crossings	Number of Perennial Stream Crossings	Number of Intermittent Stream Crossings
SN-1	0	4	25
SN-4a	1	2	17
SN-4b	1	3	7
NT-1a	0	6	45
NT-3a	0	3	13
NT-3b	0	4	30
TS-2a	1	7	20
TS-3a	1	11	10
TS-3b	0	5	1
TS-4a	0	2	4
TS-4b	0	1	0
SB-1a	0	5	80
SB-1b	0	5	52
SB-1c	0	6	58
SB-3	0	8	24
TB-1	0	10	69

All twelve river segments are designated by TNRCC as having a Contact Recreation use. Eight of these twelve are classified as supporting their Contact Recreation use. Fecal coliform contamination is the major cause of non-attainment in the remaining four river segments (Sabine 503, Neches 610, Trinity 802, and Brazos 1202).

Eleven of the twelve river segments are designated by TNRCC as Public Water Supply waters. All eleven of these river segments are classified as fully supporting their Public Water Supply use. All twelve of the river segments are also designated by TNRCC as having a High Aquatic Life use. Five of the twelve are supporting their High Aquatic Life use, while the remaining seven are classified as partially supporting. Major causes of non-attainment in

Table 3.5

Transfer Segments and Water Quality Concerns of Potentially Affected River Segments

Contributing River Segment	Transfer Segments and Receiving River Segment(s)	Classification of River Segment	Designated Uses of River Segment	Support of Designated Uses	Water Quality Concerns
Sabine 0504 Toledo Bend Reservoir	SN-1 to Neches 0610	Water Quality Limited (public water supply)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Supporting Supporting	metals in sediment & fish; nutrients; sulfate; restrictive consumption advisory Nov 1995
Sabine 0503 Below Toledo Bend Reservoir	SN-4a,b to Neches 0602	Water Quality Limited (wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Not Supporting Partially Supporting Supporting	sulfate; elevated fecal coliform, dissolved lead and cadmium in water
Neches 0610 Sam Rayburn Reservoir	flows directly to Neches 0609	Water Quality Limited (public water supply; wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Not Supporting Partially Supporting Supporting	dissolved oxygen; nutrients; ions; mercury in fish tissue; restricted-consumption advisory Nov 1995; metals in sediment
Neches 609 below Sam Rayburn Reservoir	flows directly to Neches 0603	Effluent Limited	Contact Recreation High Aquatic Life Public Water Supply	Supporting Supporting Supporting	dissolved oxygen
Neches 0603 B.A. Steinhagen Lake	NT-1a to Trinity 0802	Water Quality Limited (public water supply)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Supporting Supporting	mercury in fish tissue; nutrients
Neches 0602 below Steinhagen Lake	NT-3a to Trinity 0802; NT-3b to Trinity 0801	Water Quality Limited (wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Partially Supporting Supporting	fecal coliform; localized dissolved cadmium causing nonsupport of aq life use; consumption advisory (dioxin) 1990-1995

Contributing River Segment	Transfer Segments and Receiving River Segment(s)	Classification of River Segment	Designated Uses of River Segment	Support of Designated Uses	Water Quality Concerns
Trinity 0803 Lake Livingston	TB-1 to Gibbons Crk which flows to Brazos1209 which flows to Brazos 1202	Water Quality Limited (wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Partially Supporting Supporting	temperature; dissolved oxygen; ions; nutrients; chlorphyll-a; manganese in sediment, PCBs in fish tissue
Trinity 0802 below Lake Livingston	TS-2a,3a to San Jacinto 1004; TS-3b to San Jacinto 1002	Water Quality Limited (wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Not Supporting Partially Supporting Supporting	TDS; fecal coliform; nutrients; dissolved cadmium causing partial support of aq life use
Trinity 0801 Trinity River Tidal	TS-4a San Jacinto 1002 TS-4b Lynchburg Reservoir	Effluent Limited	Contact Recreation High Aquatic Life	Supporting Supporting	fecal coliform; nutrients
San Jacinto 1004 West Fork San Jacinto River	SB-1a,b Brazos 1202 SB-1C Allens Creek Reservoir	Water Quality Limited (advanced waste treatment required)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Supporting Supporting	fecal coliform; nutrients; chlorphyll-a;
San Jacinto 1002 Lake Houston	hydraulic terminus (does not flow to bay)	Water Quality Limited (public water supply; wq standards violations; advanced waste treatment required)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Partially Supporting Supporting	TDS; ions; pH; fecal coliform; DO; nutrients, diazinon; dissolved lead and cadmium in water

Contributing River Segment	Transfer Segments and Receiving River Segment(s)	Classification of River Segment	Designated Uses of River Segment	Support of Designated Uses	Water Quality Concerns
Brazos 1212 Somerville Lake	flows to Brazos 1211 which flows to Brazos 1202	Water Quality Limited (public water supply)	Contact Recreation High Aquatic Life Public Water Supply	Supporting Partially Supporting Supporting	TDS; chlorophyll-a
Brazos 1209 Navasota River below Lake Limestone	flows to Brazos 1202	Water Quality Limited (advanced waste treatment required)	Contact Recreation High Aquatic Life Public Water Supply	Partially Supporting Supporting Supporting	nutrients
Brazos 1202 below Navasota River	SB-3 Brazos 1212	Water Quality Limited (wq standards violation)	Contact Recreation High Aquatic Life Public Water Supply	Not Supporting Supporting Supporting	fecal coliform; nutrients; chlorphyll-a

From 1996 State of Texas Water Quality Inventory these river segments are suppressed dissolved oxygen concentrations and fish tissue contamination by metals and toxic substances.

Four of the river segments are fully supporting all of their designated uses. These include Sabine 504, Neches 0603, Trinity 801, and San Jacinto 1004. Even though these water bodies are supporting their designated uses, occasionally elevated concentrations of fecal coliform bacteria, chlorides, TDS, metals and nutrients continue to be a concern.

Water transferred westward to the Brazos River basin will be picked up for transfer before its entry into the Brazos River or will be stored in Somerville Lake or the proposed Allen's Creek Reservoir. Blending transferred water with that of the Brazos before use by the public is not a desired option because of the relatively high dissolved solids concentrations of the Brazos River. A discussion of the quality of water potentially carried or affected by each transfer segment is also located in the segment-by-segment discussion below.

Segment SN-1.

Segment SN-1 carries water from Toledo Bend Reservoir (Sabine River segment 504), crosses four perennial and 25 intermittent streams before ending at an eastern arm of Sam Rayburn Reservoir (Neches River segment 610). The flow path continues through the reservoir, into the Angelina River (Neches River segment 609), and then to B.A. Steinhagen Lake (Neches River segment 603). Toledo Bend Reservoir is fully supporting its designated uses of Contact Recreation, High Aquatic Life and Public Water Supply. Water quality concerns of the reservoir include metals, nutrients and sulfate. A restrictive fish consumption advisory was established in November 1995 due to elevated metals concentrations in fish tissue.

Water from Toledo Bend Reservoir will be transferred via a new canal to Sam Rayburn Reservoir. Water quality concerns at Sam Rayburn Reservoir include depressed dissolved oxygen, nutrients, and metals. A restrictive fish consumption advisory was also established for Sam Rayburn Reservoir in November 1995 due to elevated metals in fish tissue. Sam Rayburn Reservoir is supporting it's designated use as a Public Water Supply but is not supporting its uses as Contact Recreation or High Aquatic Life.

Although the constructed segment ends at Sam Rayburn Reservoir, the flow pathway continues through the reservoir, to the Angelina River and into B.A. Steinhagen Lake. The Angelina River (Neches River segment 609) is fully supporting its designated uses of Contact Recreation, High Aquatic Life and Public Water Supply. Although water quality is good, concerns include low dissolved oxygen concentrations in the upper portion of the segment. B.A. Steinhagen Lake (Neches River segment 603) is also fully supporting its designated uses of Contact Recreation, High Aquatic Life and Public Water Supply. Water quality concerns include metals in fish tissue and elevated nutrient concentrations.

Segment SN-4a

Segment SN-4a carries water from the Sabine River segment 503 via the existing SRA canal and crosses Cow Bayou before ending at the LNVA Lakeview Canal at the Neches River segment 602 near Lakeview. It is not known at the time of this report whether the transferred water will be blended with that of the Neches River segment 602 before entering the Lakeview Canal. Water is carried downstream through the Big Thicket Preserve by the Lakeview Canal, crossing Pine Island Bayou at the southern edge of the Preserve. The transfer segment ends at the LNVA Neches First Lift pump station south of Pine Island Bayou and west of the Neches River. Approximately two perennial and 17 intermittent streams are crossed by this segment.

Sabine River segment 503 is supporting its Public Water Supply designated use, but is not supporting its Contact Recreation use, and is only partially supporting its High Aquatic Life use. Water quality concerns in this river segment include elevated sulfate, fecal coliform and dissolved metals in water. Neches River segment 602 includes the portion of the Neches River located at the Lakeview crossing. This river segment is fully supporting its Contact Recreation and Public Water Supply designated uses but is only partially supporting its High Aquatic Life use. Water quality concerns in this river segment include elevated fecal coliform concentrations and localized dissolved metals. A consumption advisory was established for fish from 1990 to 1995 due to elevated dioxin concentrations in fish.

Segment SN-4b.

Segment SN-4b also carries water from the Sabine River segment 503 via the existing SRA canal and new facilities directly to the LNVA Neches First Lift pump station just west of the Neches River segment 602. Between the SRA canal and the pump station, the segment crosses Cow Bayou, two unnamed perennial streams, approximately seven intermittent streams, and the Neches River. Water quality concerns for the Sabine River segment 503 and Neches 602 were presented in the previous segment discussions.

Segment NT-1a.

Segment NT-1a begins at B.A. Steinhagen Lake (Neches River segment 603) and ends at a pump station just east of the Trinity River segment 802 near Romayor. Segment NT-1a utilizes new conveyance facilities and crosses six perennial and 45 intermittent streams. The water quality concerns of B.A. Steinhagen Lake are presented in the previous discussion of transfer segment SN-1. At the time of this report it is not known if the transferred water will be blended with that of the Trinity River segment 802 near the end of the transfer segment. Trinity River segment 802 is not supporting its Contact Recreation use, is only partially supporting its High Aquatic Life use, and is fully supporting its Public Water Supply use. Water quality concerns include elevated fecal coliform, dissolved solids, nutrients and dissolved metals concentrations.

Segment NT-3a.

Segment NT-3a begins at the LNVA First Lift pump station and utilizes both the existing LNVA Canal and a new canal.The segment crosses 4 perennial and thirteen intermittent streams before arriving at a transfer point located just east of the Trinity River segment 802.

The quality of water entering segment NT-3a may be affected by water quality of the Neches River segment 602 and potential connecting transfer segments. At the time of this report it is not known if the transferred water will be blended with that of the Trinity River segment 802 near the end of the transfer segment. Water quality concerns for Neches River segment 602 and Trinity River segment 802 are presented above.

Segment NT-3b.

Segment NT-3b also begins at the LNVA First Lift pump station and utilizes the LNVA Canal before diverging from NT-3a. Segment NT-3b continues in the LNVA canal until it enters a new canal which terminates at a transfer point south of Liberty and east of the Trinity River segment 801. The new canal crosses four perennial streams, approximately 30 intermittent streams, and numerous drainage ditches.

The quality of water carried by this transfer segment is potentially affected by the water quality of Neches River segment 602 and potential contributing transfer segments located upstream. A discussion of the water quality concerns of Neches River segment 602 is presented above. At the time of this report it is not known if the transferred water will be blended with that of the Trinity River segment 801 near the end of the transfer segment. Trinity River segment 801 is fully supporting its Contact Recreation and High Aquatic Life uses. This river segment is tidally influenced and is not designated as a public water supply. Water quality concerns of the river segment include elevated fecal coliform and nutrient concentrations.

Segment TS-2a.

Segment TS-2a begins at the transfer station just east of the Trinity River segment 802 near Romayor. The segment crosses the Trinity River via a new transfer facility and continues to a transfer point located on the east side of the West Fork San Jacinto River segment 1004 southeast of Conroe. The segment crosses seven perennial streams and approximately 20 intermittent streams.

It is unknown at the time of this report whether transferred water will be blended with that of the Trinity River segment 802, at the beginning of the transfer segment, or with that of the San Jacinto River segment 1004 near the end of the segment. Water quality concerns of Trinity River segment 802 are presented above. San Jacinto River segment 1004 is fully supporting its designated uses of Contact Recreation, High Aquatic Life and Public Water Supply. Water quality concerns of the river segment include elevated fecal coliform, nutrients, and chlorophyll-a.

Segment TS-3a.

Segment TS-3a begins at a transfer point located north of Liberty and east of the Trinity River segment 802. The transfer segment crosses eleven perennial and ten intermittent streams on its way to a transfer point located southeast of Conroe on the east side of the West Fork San Jacinto River segment 1004. Greens Bayou may be crossed between 1 and 5 times between the transfer station and the Trinity River. The transfer segment utilizes new conveyance facilities for its entire length. It is unknown at the time of this report whether transferred water will be blended with that of the Trinity River segment 802, near the beginning of the transfer segment, or with that of the San Jacinto River segment 1004 near the end of the transfer segment. Water quality concerns for these two river segments are presented above.

Segment TS-3b.

Segment TS-3b also begins at a transfer point located north of Liberty and east of the Trinity River segment 802. It follows the same pathway as TS-3a before it turn southward a short distance and ends at Luce Bayou. This transfer segment also crosses Greens Bayou up to five times, Gillen Bayou once, and one unnamed intermittent stream before reaching the diversion to Luce Bayou. Luce Bayou is an unclassified tributary of Lake Houston (San Jacinto River segment 1002). Lake Houston is fully supporting its Contact Recreation and Public Water Supply uses but is only partially supporting its High Aquatic Life use. Water quality concerns of Lake Houston include elevated concentrations of dissolved solids, fecal coliform bacteria, nutrients, pesticides and metals, as well as low dissolved oxygen concentrations.

Segment TS-4a.

Segment TS-4a begins with a new canal on the east side of the Trinity River segment 801 south of Liberty and runs within a portion of the Dayton Canal on its way to Lake Houston (San Jacinto River segment 1002). This transfer segment crosses two perennial and four intermittent streams. Water quality concerns of Trinity River segment 801 and Lake Houston are presented above.

Segment TS-4b.

Segment TS-4b begins at the same transfer station and new canal as TS-4a but turns southeast on the west side of Trinity River segment 801. This transfer segment follows the existing CWA canal until it reaches Lynchburg Reservoir. Lynchburg Reservoir is an unclassified water body located immediately adjacent to the San Jacinto River and Burnet Bay but is not hydrologically connected to these water bodies. Water quality concerns of Trinity River segment 801 are presented above.

Segments SB-1a, SB-1b, and SB-1c.

All three proposed segments for transferring water from the San Jacinto River basin to the Brazos River basin begin south of Conroe on the east side of the San Jacinto River segment 1004. These three transfer segments flow along the same route for approximately eight miles and utilize new conveyance facilities for their entire length. The segments cross three intermittent streams before Segment SB-1a splits to the north.

Segment SB-1a continues northwest, crossing 77 intermittent and five perennial streams on its way to a transfer station on the east side of the Brazos River segment 1202 near the confluence with the Navasota River (Brazos River segment 1209). It is unknown at the time of this report whether transferred water will be blended with that of the San Jacinto River segment 1004, near the beginning of the transfer segment, or with that of the Brazos River segments 1202 or 1209 near the end of the transfer segment. Water quality concerns of the San Jacinto River segment 1004 are presented above. The Navasota River (Brazos River 1209) is partially supporting its Contact Recreation use and fully supporting its High Aquatic Life and Public Water Supply uses. Water quality concerns of the Navasota River include elevated concentrations of fecal coliform bacteria, nutrients, and chlorophyll-a. The Brazos River segment 1202 is not supporting its Contact Recreation use and is fully supporting its High Aquatic Life and Public Water Supply uses. Water quality concerns of this segment of the Brazos River include elevated fecal coliform bacteria, nutrient, and chlorophyll-a concentrations.

From the split with Segment SB-1a, transfer segments SB-1b and SB-1c continue south and west, crossing approximately 27 intermittent and two perennial streams.

Segment SB-1b then splits from SB-1c and continues southwest, crossing fourteen intermittent and one perennial stream before entering the stream channel of Clear Creek. Clear Creek enters the Brazos River segment 1202 below its confluence with the Navasota River. It is unknown at the time of this report whether transferred water will be blended with that of the San Jacinto River segment 1004, near the beginning of the transfer segment, or with that of the Brazos River segment 1202 near the end of the transfer segment. Water quality concerns of each of these river segments are presented above.

Segment SB-1c continues southward from the split with SB-1b, crossing the Brazos River segment 1202, Mound Creek, Bessies Creek, and approximately 28 intermittent streams. Segment SB-1c ends at the proposed Allens Creek Reservoir. The proposed reservoir will release water to the Brazos River segment 1202.

Segment SB-3.

Segment SB-3 begins at a transfer point east of the Brazos River near the confluence with the Navasota River. The transfer segment crosses the Brazos River segment 1202, seven perennial and twenty-four intermittent streams on its way to Somerville Lake (Brazos River segment 1212). New conveyance facilities are utilized for the length of the segment. Although it does not cross Yegua Creek, segment SB-3 closely parallels the Yegua Creek channel from the confluence with the Brazos River to Somerville Lake. It is unknown at the time of this report whether transferred water will be blended with that of the Brazos River segment 1202, near the beginning of the transfer segment. Water quality concerns for this river segment are presented above. Somerville Lake is fully supporting its Contact Recreation and Public Water Supply uses but is only partially supporting its High Aquatic Life use. Water quality concerns for the lake include elevated dissolved solids and chlorophyll-a concentrations. Water from the lake returns to Brazos River segment 1202 by way of Yegua Creek.

Segment TB-1.

This segment bypasses the San Jacinto River basin and transfers water directly from Lake Livingston to the Brazos River basin. It begins on the west side of Lake Livingston traveling westward, crossing nine perennial and approximately 69 intermittent streams before terminating at the stream channel of Gibbons Creek in Grimes county. New conveyance facilities are utilized for the entire segment. Although the segment construction ends at Gibbons Creek, the flowpath continues through Gibbons Creek Reservoir to the confluence with the Navasota River (Brazos River segment 1209). The flow continues to a transfer point near the confluence with Brazos River segment 1202. It is unknown at the time of this report whether transferred water will be blended with that of the Brazos River segment 1202 before pickup at the next transfer station. Water quality concerns of these river segments are presented above.

3.4.3 Wetlands

This section discusses the estimated amount and type of wetlands that each segment will cross as well as the amount of wetland area potentially affected by uncontrolled additional flow in natural drainageways downstream of the segments. Wetlands are important resources in that they filter polluted waters, prevent or diminish the effects of floods, protect shorelines, recharge groundwater, and provide fish and wildlife habitat. Wetlands are protected from impacts by Section 404 of the Clean Water Act, Executive Order 11990 (Protection of Wetlands) and the No Net Loss concept developed by the National Wetlands Policy Forum (1988) and installed by former President George Bush in 1990. Section 404 is administered by the U.S. Army Corps of Engineers (Corps) and overseen by the U.S. Environmental Protection Agency (EPA). Jurisdictional wetlands are defined as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (33CFR328.3, 1984)." According to current regulations, construction in wetlands should follow a sequence of events which includes avoidance, where possible; minimization of impacts if avoidance is not possible; and, finally, mitigation.

Data about wetlands along each alignment was gathered from National Wetland Inventory (NWI) maps produced by the USFWS (Table 3.6). Wetlands were grouped into five wetland categories, including forested, emergent, open water, scrub shrub, and other. Wetlands delineated on NWI maps were categorized according to the USFWS definition of wetlands (Cowardin, et al., 1992). It is not sufficient to rely on these maps for an exact accounting of wetland acreage or type, but they are useful to provide a comparative index between alignments. These wetlands may or may not be considered jurisdictional according to Section 404 of the Clean Water Act.

An average right-of-way width of 200 feet was assumed for calculating the area potentially affected by each segment. A 100-foot right-of-way was assumed for those segment portions which utilized an existing drainageway or canal, and for the downstream flow path of Segments SN-1, TS-3b, TB-1, and SB-1b. If necessary, the final alignment may be moved to affect less wetland area.

Forested wetlands are characterized by woody vegetation that is approximately 20 feet tall or taller. These wetlands include broad-leaved deciduous trees, needle-leaved deciduous trees, broad-leaved evergreen trees, needle-leaved evergreen trees, and dead trees. Emergent wetlands are characterized by erect, rooted, herbaceous vegetation (excluding mosses and lichens). These wetlands can be persistent or nonpersistent (leaves fall at the end of the growing season). Open water areas are characterized by lack of vegetation in water less than 6.6 feet deep. Scrub shrub wetlands are dominated by woody vegetation less than 20 feet tall. Other wetlands along the segments include unconsolidated shore, unconsolidated bottom, and aquatic bed. Unconsolidated shore wetlands are characterized by (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; (2) less than 30 percent areal cover of vegetation other than pioneering plants; and (3) various exposed or flooded areas. Unconsolidated bottom wetlands have less than 25 percent cover of particles smaller than stones and less than 30 percent vegetative cover. Aquatic beds include areas dominated by vegetation at the water surface or below it for most of the growing season (Cowardin, et al., 1992).

Segment SN-1.

Segment SN-1 traverses an area that contains approximately five acres of wetlands according to the NWI maps. Approximately three acres of wetlands would also be crossed by additional flow downstream of Segment SN-1, in the Neches River basin. All of the wetlands affected by Segment SN-1 are forested.

Segment SN-4a.

Segment SN-4a traverses an area that contains approximately 82 acres of wetlands. The majority (72 acres) of these wetlands are forested.

Table 3.6
Estimated Wetland Acreage within Each Segment Corridor and Downstream Flow Paths

Segment	Forested (Acres)	Emergent (Acres)	Open Water (Acres)	Scrub Shrub (Acres)	Other (Acres)	Total Acres	Total Downstream Flow Path
SN-1	5	0	0	0	0	5	3
SN-4a	72	1	0	0	9	82	0
SN-4b	56	0	2	9	9[1]	79	0
NT-1a	44	6	0	6	1	57	0
NT-3a	63	37	0	0	3	103	0
NT-3b	18	30	5	7	0	60	0
TS-2a	29	16	3	2	7[2]	57	0
TS-3a	30	7	0	1	12	50	0
TS-3b	17	9	0	1	0	27	71
TS-4a	0	0	0	0	0	0	0
TS-4b	0	0	0	0	0	0	0
SB-1a	10	11	31	0	4[3]	56	0
SB-1b	8	9	8	0	0	25	58
SB-1c	10	27	23	0	4[3]	64	0
SB-3	12	0	4	0	0	16	0
TB-1	1	5	5	0	1	12	26

[1] Unconsolidated Bottom
[2] Unconsolidated Bottom (6) and Aquatic Bed (1)
[3] Unconsolidated Shore

Segment SN-4b.

Segment SN-4b traverses an area that contains approximately 79 acres of wetlands. The majority (59 acres) of these wetlands are forested, while the remainder are scrub shrub, open water, and unconsolidated bottom.

Segment NT-1a.

Segment NT-1a traverses an area that contains 57 acres of wetlands. Forty-four acres of this total are forested. Six acres are emergent. Six acres are scrub shrub and one fell in the "Other" category.

Segment NT-3a.

Segment NT-3a traverses an area that contain 103 acres of wetlands. Sixty-three acres of this total is forested while 37 acres are emergent and three fell in the "Other" category.

Segment NT-3b.

Segment NT-3b crosses through an area that contains approximately 60 acres of wetlands. Approximately 30 acres of this total are comprised of emergent wetlands. The remaining wetlands are composed of forested (18 acres), scrub shrub (seven acres), and open water (five acres).

Segment TS-2a.

Segment TS-2a traverses an area that contains approximately 57 acres of wetlands according to the NWI maps. Approximately 29 acres are forested wetlands and 16 acres are emergent wetlands. The remaining wetland acreage is composed of unconsolidated bottom (six acres), open water (three acres), scrub shrub (two acres), and aquatic bed (one acre).

Segment TS-3a.

Segment TS-3a traverses an area that contains approximately 50 acres of wetlands. Thirty acres of this total is forested wetlands, seven acres are emergent, one acre is short scrub, and 12 acres fell in the "Other" category.

Segment TS-3b.

Segment TS-3b crosses an area that contains approximately 27 acres of wetlands. Approximately 17 acres consist of forested wetlands. Nine acres are composed of emergent wetlands, while the remaining acreage is scrub shrub (one acre). Segment TS-3b will also affect approximately 71 acres of forested wetlands downstream of the segment, in the Luce Bayou/Lake Houston area.

Segments TS-4a and TS-4b.

According to the NWI map, Segments TS-4a and TS-4b would not cross any wetlands.

Segment SB-1a.

Based on the NWI maps, Segment SB-1a traverses an area that contains approximately 56 acres of wetlands. Approximately 31 acres are considered open water, while the remainder is divided between emergent (11 acres), forested (10 acres), and unconsolidated shore (four acres).

Segment SB-1b.

Segment SB-1b traverses an area that contains approximately 25 acres of wetlands, of which eight acres are considered open water. The remaining acreage is divided between forested wetlands (eight acres) and emergent (nine acres). Approximately 58 acres of wetlands would also be crossed by additional flow in the Clear Creek/Brazos River area downstream of Segment SB-1b. This area is divided between forested, emergent and open water wetlands.

Segment SB-1c.

Segment SB-1c traverses an area that contains approximately 64 acres of wetlands according to the NWI maps. Twenty-seven acres are composed of emergent wetlands, and 23 acres are composed of open water. The remaining wetlands are divided between forested wetlands (10 acres) and unconsolidated shore (four acres).

Segment SB-3.

Segment SB-3 crosses an area that contains approximately 16 acres of wetlands. Forested wetlands comprise 12 acres of this total. The remaining four are open water.

Segment TB-1.

Segment TB-1 traverses an area that contains approximately 12 acres of wetlands. This area is classified as forested (one acre), emergent (five acres), open water (five acres), and other (one acre). Approximately 26 wetland acres situated in the Gibbons Creek area, downstream of Segment TB-1 will also be crossed by the additional flow.

3.5 Soils and Geological Resources

3.5.1 Soils

The Farmland Protection Policy Act (FPPA) protects prime farmlands (7 U.S.C. 4201 et seq.). The formal definition of prime farmlands in the FPPA indicates that land not currently in crops can still be protected under the act if the land is used for timber or livestock. Much of the land along the segments is clearly being farmed, but other portions are undisturbed forest or livestock range.

For the purpose of this study, the area of prime farmland soils along a transfer route was determined by comparing the soil types along the route to the Natural Resources Conservation Service's (NRCS) list of prime farmland soil types in Texas (Soil Conservation Service; SCS,1982). An average width of 200 feet of right-of-way was used to calculate the areas along the transfer routes. Areas where data was not available are noted in the text. If necessary, the final alignment may be moved to affect less of the prime farmlands. Table 3.7 summarizes the acreage of prime farmland soil along the various segments.

Segment SN-1

Segment SN-1 is contained within Sabine County. The soil survey for Sabine County is not available, therefore prime farmland soil information from the county is not available.

Table 3.7
Acres of Prime Farmland Soils and Total Area within Each Segment Corridor

Segment	Prime Farmland Soils om Segment Corridor (acres)	Total Area in Segment Corridor (acres)
SN-1	Insufficient Data	755
SN-4a	Insufficient Data	674
SN-4b	Insufficient Data	776
NT-1a	Insufficient Data	1,399
NT-3a	160	819
NT-3b	377	984
TS-2a	553	1,065
TS-3a	504	908
TS-3b	88	123
TS-4a	220	394
TS-4b	216	279
SB-1a	138	1,272
SB-1b	201	600
SB-1c	885	1,598
SB-3	109	595
TB-1	32	1,148

Segment SN-4a and SN-4b.

Segment SN-4a crosses Newton, Orange, and Jefferson counties. The transfer route does not cross any prime farmland soils in Newton County (Neitsch, 1982). The soil survey for Orange County is available only as an unpublished draft, and the information from the county is preliminary and subject to corrections. The preliminary soil survey does not contain information on 9 of 16 soil types crossed by this segment. So the total length of prime farmland soils is unknown for Segment SN-4b in Orange County (SCS, 1995a). In Jefferson County, the segment crosses 60 acres of prime farmland soils (Crout, 1965a)

Segment NT-1a

Segment NT-1a crosses Tyler, Polk, Hardin, and Liberty counties. A total of 419 acres of the segment corridor crosses prime farmland out of 1,399 acres total area. However the soils surveys for Tyler and Hardin counties are not available, so information for 950 acres along the segment is only available at the association level.

Segment NT-3a

Segment NT-3a crosses Jefferson, Liberty, and Hardin counties. A total of 160 acres of the segment crosses prime farmland out of 819 acres total area in the segment corridor. In Jefferson County, the segment crosses no prime farmland soils (Crout, 1965a). In Liberty County, the segment crosses prime farmland in Ae, Aldine silt loam (AdA), LaA, Ba, Bm, Ka, SrB soils for a total of 160 acres (Griffith, 1996). The soils survey for Hardin County is not available, so information for 194 acres along the segment is unavailable.

Segment NT-3b.

Segment NT-3b crosses Jefferson and Liberty counties. A total of 377 acres of the segment corridor crosses prime farmland out of 984 acres total area. Segment NT-3b does not cross any prime farmland soils in Jefferson County (SCS, 1995b). In Liberty County, the route crosses prime farmland in soil types Bernard-Morey Complex (Bm); Beaumont clay (Ba); Anahuac-Aris complex (An); Vamont clay, 0 to 1 percent slopes (VaA); Aldine-Aris Complex (Ae); Lake Charles clay, 0 to 1 percent slopes (LaA); Vamont silty clay, depressional (Vd); Spurger-Waller Complex, 0 to 2 percent slopes (SwB); Mocarey-Yeaton Complex (My); and Kaman clay, occasionally flooded (Ka) for a total of 371 acres of prime farmland (Griffith, 1996).

Segment TS-2a.

Segment TS-2a crosses Liberty and Montgomery counties. A total of 553 acres of the segment crosses prime farmland out of 1,065 acres total area in the segment corridor. In Liberty County, the segment crosses prime farmland in soil types VaA; Segno fine sandy loam (Sa); SwB; Otanya fine sandy loam, 1 to 3 percent slopes (OyB); Sorter loam (Sb); Splendora fine sandy loam (Sp); Waller loam (Wa); Kirbyville fine sandy loam, 0 to 1 percent slopes (Kr); Waller-Kirbyville Complex, 0 to 1 percent slopes (Wk); and Spurger fine sandy loam, 0 to 2 percent slopes (SrB). (Griffith, 1996). In Montgomery County, the segment crosses prime farmland in Segno fine sandy loams (Se) and Sp. (McClintock, 1972).

Segment TS-3a

Segment TS-3a crosses Liberty and Montgomery counties. A total of 504 acres of the segment crosses prime farmland out of 908 acres total area in the segment corridor. In Liberty County, the segment crosses prime farmland in Swb, Oz, Ka, VaA, Wk, Waller loam (Wa), Sorter Loam (Sb), Sorter-Dallardsville Complex (Sd), Wk, Kr, Dallardsville loamy fine sand (DaB), and Wn soils for a total of 321 acres (Griffith, 1996). In Montgomery County, the segment crosses prime farmland in Sp, Sorter silt loam (So), and Se soils for a total of 183 acres (McClintock, 1972).

Segment TS-3b.

Segment TS-3b crosses Liberty and Harris counties. A total of 88 acres of the route crosses prime farmland out of 123 acres total area in the segment corridor. In Liberty County, the segment crosses prime farmland in SrB; Ka; SwB; VaA; Wk; and Owentown fine sandy loam, occasionally flooded (Oz). (Griffith, 1996). In Harris County, the segment does not cross any prime farmland soil types (Wheeler, 1976).

Segment TS-4a

Segment TS-4a crosses Liberty and Harris counties. A total of 220 acres of the segment crosses prime farmland out of 394 acres total area in the segment corridor. In Liberty County, the segment crosses prime farmland in Ae, Vd, Ba, Bm, LaA, Bernard clay loam (Be), and My soils. (Griffith, 1996). In Harris County, the segment crosses prime farmland in Addicks Loam (Ad), Bd, Lake Charles Clay (LcA), Be, Cd, VaA, and Ozan Loam (Oa) soils. (Wheeler, 1976).

Segment TS-4b.

Segment TS-4b crosses Liberty, Chambers, and Harris counties. A total of 216 acres of the route crosses prime farmland out of 279 acres total area in the segment corridor. In both Liberty and Chambers counties, the route crosses prime farmland in Ae; Ba; Bm; My; Va; and LaA soils (Griffith, 1996 and Crout, 1976). In Harris County, the route crosses prime farmland in Lake Charles clay, 0 to 1 percent slopes (LcA); Bernard clay loam (Bd); and Vamont clay, 1 to 4 percent slopes (VaB) (Wheeler, 1976).

Segment SB-1a.

Segment SB-1a crosses Montgomery and Grimes counties. A total of 138 acres of the segment crosses prime farmland out of 1,272 acres in the segment corridor. In Montgomery County, the segment crosses prime farmland in soil types Sp; Se; Houston black clay (Hs); and Burleson clay, 0 to 1 percent slopes (Bu) (McClintock, 1972). In Grimes County, the segment crosses prime farmland in Frelsburg clay, 1 to 5 percent slopes (FrC); Cuero clay loam, 1 to 5 percent slopes (CuC); Chazos loamy fine sand, 1 to 5 percent slopes (ChC); Rader fine sandy loam, 0 to 1 percent slopes (RaA); and Norwood silty clay loam, 0 to 1 percent slopes (NrA) (Greenwade, 1996).

Segment SB-1b.

Segment SB-1b crosses Montgomery, Harris, and Waller counties. A total of 201 acres of the segment crosses prime farmland out of the 600 acres contained in the segment corridor. In Montgomery County, the segment crosses prime farmland in Sp, Se, Bu, and Hockley fine sandy loam (Ho). (McClintock, 1972). In Waller County, the segment crosses prime farmland in Sp; Se; Hockley fine sandy loam, 1 to 3 percent slopes (HoA); Katy fine sandy loam, 1 to 3 percent slopes (KaB); Hockley fine sandy loam, 3 to 5 percent slopes (HoC); Hockley gravelly fine sandy loam, 1 to 5 percent slopes (HpC); Wockley fine sandy loam, 1 to 3 percent slopes (WoB); Aris fine sandy loam, 0 to 1 percent slopes (ArA); Wockley fine sandy loam, 0 to 1 percent slopes (WoA); and Chazos loamy fine sand, 5 to 8 percent slopes (ChD). (Greenwade, 1984). The segment also crosses prime farmland at the northern tip of Harris County (Wheeler, 1976) consisting of Kenny loam fine clay, (Ka), Hockley fine sandy loam (HoB) 1-4% slopes, and Wackley fine sandy loam (Wo).

Segment SB-1c.

Segment SB-1c crosses Montgomery, Harris, and Waller counties. A total of 885 acres of the segment corridor crosses prime farmland out of 1,598 acres total area. In Montgomery County, the segment crosses prime farmland in soil types Ho, Sp, Se, and Bu for a total of 114 acres (McClintock, 1972). In Harris County, the segment crosses prime farmland in soil types Hockley fine sandy loam, 1 to 3 percent slopes (HoB) and Wockley fine sandy loam (Wo) for a total of 64 acres (Wheeler, 1976). In Waller County, the segment crosses prime farmland in soil types Splendora fine sandy loam, 0 to 3 percent slopes (SpB); Se; WoA; HpC; HoC; HoB; ArA; Katy fine sandy loam, 0 to 1 percent slopes (KaA); Brazoria clay, 0 to 1 percent slopes (BrA); and NrA for a total of 707 acres (Greenwade, 1984).

Segment SB-3

Segment SB-3 crosses Washington County. A total of 109 acres of the segment corridor crosses prime farmland out of 595 acres total area. In Washington County, the segment crosses prime farmland in Frelsburg clay (32), Chazos loamy fine sand (21), Bleiblerville clay (7), Carbengle clay loam (19), Latium Clay (43), Bleiblerville clay (6), Clemville silt loam (24), Carbengle clay loam (18), Frelsburg clay (31), Trinity clay (68), Silawa loamy fine sand (61), Greenvine Clay (36) soils for a total of 109 acres (Chervenka, 1981).

Segment TB-1

Segment TB-1 crosses San Jacinto, Walker, and Grimes counties. A total of 32 acres of the segment corridor crosses prime farmland out of 1,148 acres total area. In San Jacinto County, the segment crosses prime farmland in SrB soils for a total of 23 acres (McKewen, 1988). In Walker County, the segment crosses prime farmland in Leson clay (33) soils for a total of

9 acres (McClintock, 1979). In Grimes County, the segment crosses prime farmland in Brazoria clay (BoB), Norwood Silt Loam (NoA), and Oklared very fine sandy loam (OkA) soils for a total of 320 acres (Greenwade, 1996).

3.5.2 Geology

The transfer routes southeast of Luce Bayou (SN-4a, Sn-4b, NT-3a, NT-3b, TS-3b, TS-4a, TS-4b) are mainly underlain by the Beaumont Formation (Fisher 1974, Fisher 1981, Flawn 1968a, Flawn 1968b). Routes northwest of Luce Bayou (SN-1, NT-1a, TS-2a, TS-3a, Sb-1a, Sb-1b, Sb-1c, Sb-3, TB-1) are underlain by the Montgomery, Bentley, and Willis formations, which are similar to the Beaumont Formation. All these formations were formed within the Quaternary Period. The Quaternary Period is the most recent of geologic periods, having occurred within the past three million years. All of the major formations in the area are cut by fluvial processes, resulting in erosional and depositional areas along the stream banks.

Segment SN-1

Segment SN-1 begins in the alluvium of Sabine Lake. The alluvium is composed mainly of sand, silt, clay, and organic material. The segment continues through the Yegua, Moody's Branch and Yazoo formations. The Moody's Branch Formation is a transition between the clay, quartz sand, and lignite of the Yegua Formation and the clay, sand, and glauconitic sand of the Yazoo Formation. All three formations were formed in the Eocene Epoch of the Tertiary Period. The segment briefly crosses the alluvium again before entering Sam Rayburn Reservoir (Flawn, 1967). After Sam Rayburn, the natural flow pathway continues on to B. A. Steinhagen Lake through the Deweyville Formation and quaternary alluvium formed from the Deweyville Formation.

Segment SN-4a

Segment SN-4a also begins in the alluvium of the Sabine River. The alluvium of the Sabine River is bounded on both sides by the narrow exposure of the Deweyville Formation. The Deweyville Formation is composed of sand, silt, clay, and gravel weathered from the Beaumont Formation and deposited in point bars, natural levees, stream channels, and shallow backswamp areas. Segment SN-4a crosses from the Deweyville Formation into the Beaumont Formation. The clay-rich Beaumont Formation comprises the majority of the surface geology in Orange County. Much of the Beaumont Formation is marshy with coastal flats and salt marshes due to the high clay content. Segment SN-4a ends in alluvium at the Neches River, which, like the Sabine River, is bounded by the Deweyville Formation.

Segment SN-4b.

Segment SN-4b splits from Segment SN-4b in the Beaumont Formation. The segment continues through the Beaumont Formation into the alluvium at the Neches River.

Segment NT-1a

Within Tyler, Polk and Hardin counties, Segment NT-1a crosses the Bentley and Willis formations. The segment briefly crosses the Beaumont and Deweyville formations before crossing the alluvium of the Trinity River.

Segment NT-3a

Segment NT-3a begins in the alluvium of the Neches River, and continues through the Beaumont Formation within Jefferson, Hardin, and Liberty counties. The formation in Jefferson County is marshy due to the high clay content. The formation is better drained in Liberty and Hardin counties, and is not as marshy. The segment briefly crosses the Deweyville Formation before it ends in the alluvium of the Trinity River.

Segment NT-3b.

Segment NT-3b begins in the alluvium of the Neches River, and continues through the Beaumont Formation within Jefferson County. The segment ends in the alluvium of the Trinity River.

Segment TS-2a.

Segment TS-2a begins in the alluvium of the Trinity River. Within Liberty County, the segment crosses the Bentley and Montgomery formations. The Bentley Formation is comprised of clay, silt, sand, and very minor siliceous gravel of granule and small pebble size. It is calcareous with occasional concretions of calcium carbonate, iron oxide, and iron-manganese oxides common in the zone of weathering. The topography of the Bentley Formation is fairly flat and featureless except for numerous rounded shallow depressions and pimple mounds. Rivers and streams are the major agents of erosion in the formation. Segment TS-2a runs mostly over the Bentley Formation but briefly crosses the Montgomery Formation on each side of the San Jacinto River. The Montgomery Formation has fewer iron oxide concretions and finer gravel than the Bentley Formation but otherwise is similar. The segment ends in the alluvium of the San Jacinto River.

Segment TS-3a

Segment TS-3a begins in the alluvium of the Trinity River. Within Liberty and Montgomery counties, the segment continues through the Beaumont Formation. The segment ends in the alluvium of Lake Houston (Flawn, 1968b).

Segment TS-3b.

Segment TS-3b begins in the alluvium of the Trinity River. Within Liberty and Montgomery counties, the segment runs within Luce Bayou to end in Lake Houston. Luce Bayou is entirely bounded by the Beaumont Formation but probably has alluvial deposits along the stream channel (Flawn, 1968b).

Segment TS-4a

Segment TS-4a begins in the alluvium of the Trinity River, where Segment NT-3b ends.

Within Liberty and Harris counties, the segment crosses through the Beaumont Formation and ends in the alluvium of the San Jacinto River.

Segment TS-4b.

Segment TS-4b begins in the alluvium of the Trinity River, where Segment NT-3b ends. Within Liberty, Chambers, and Harris counties, the segment crosses through the marshes of the Beaumont Formation. The segment ends in the alluvium of the San Jacinto River.

Segment SB-1a.

Segment SB-1a begins in the alluvium of the San Jacinto River and crosses the Willis Formation within Montgomery and Grimes counties. The Willis Formation is subdivided into two outcrop belts of different ages. The segment runs over the coastal outcrop of the Willis Formation, which is the older of the two outcrops. The coastal outcrop is composed of clay, silt, sand, and siliceous gravel of granule to pebble size and includes some petrified wood. The sand in the Willis Formation is coarser than the sand in the younger Beaumont Formation. The Willis Formation is highly weathered and has red oxidized subsurface soils called laterites. This segment ends in the alluvium of the Brazos River.

Segment SB-1b.

Segment SB-1b splits from Segment SB-1a in the coastal outcrop of the Willis Formation within Montgomery County. The segment remains within the coastal outcrop except where streams such as Threemile Creek, Spring Creek, and the Brazos River have eroded the formation into alluvium. In Waller County the segment runs within the Brazos River. The segment ends in the alluvium of the Brazos River near Allens Creek.

Segment SB-1c.

Segment SB-1c splits from SB-1b within the coastal outcrop of the Wallis Formation in Waller County. In Waller County, the segment crosses from the Wallis Formation to the Bentley Formation and then to the Montgomery Formation. The segment ends in the alluvium of the Brazos River near Allens Creek.

Segment SB-3

Segment SB-3 begins in the alluvium of the Brazos River, where Segment SB-1a ends. Segment SB-3 continues through the Oakville and Catahoula formations. The Oakville formation is a fossil containing sandstone which form cuesta of smoothly rounded hills. The segment ends in the alluvium at the base of Lake Somerville.

Segment TB-1

Segment TB-1 begins in the Beaumont Formation and the alluvium formed in the Beaumont at the Trinity River. It continues through the Fleming, Catahoula, and Whitsett formations. The Fleming Formation is composed of clay, silt, and sand, while the Catahoula Formation is composed primarily of mudstone and sand. The Whitsett Formation is composed of quartz sand and contains abundant fossilized wood. These three formations were formed in the Tertiary Period. Within Grimes County, the segment continues within the Catahoula and Manning formations. The Manning Formation is composed of quartz sand, clay and lignite and contains abundant fossilized wood. The segment then crosses a series of fault lines which occur in the Whitsett Formation before it enters the alluvium formed around Gibbons Creek, the Navasota River, and the Brazos River.

3.6 Public Lands

This section describes the public lands and recreation areas within a one-half mile corridor of the proposed transfer routes. Each of the segments has at least one public land or recreational area within the one-half mile corridor. Realignment of preferred segments to reduce potential impacts to public lands and recreation areas will be considered where possible.

Public lands such as State Parks, National Park Service facilities, National Forests and Grasslands, and National Wildlife refuges within the corridors surrounding the 16 alternate routes selected for study were identified from public land maps (Texas Department of Transportation, 1993) and USGS 7.5-minute topographic quadrangles. In addition, the Texas Outdoor Recreation Plan (TPWD, 1985) and the Texas Outdoor Recreation Database (TPWD, 1995c) identified other recreation areas near the routes.

Appendix E lists the public lands and recreation areas which occur within one-half mile of each of the segments.

Segment SN-1.

Segment SN-1 begins at Toledo Bend Reservoir and crosses the Sabine and Angelina National Forests. Recreational waterways used by this segment include the Angelina River and B.A. Steinhagen Lake.

Segment SN-4a.

Segment SN-4a begins in the alluvium of the Sabine River. This segment crosses the Sabine Island Wildlife Game Management Area and the Beaumont Unit of the Big Thicket National Preserve (BTNP) (while in the LNVA Canal).

Segment SN-4b.

Segment SN-4b is within one-half mile of the Sabine River, the Sabine Island Wildlife Game Management Area (WGMA), the Beaumont Unit of the BTNP, and the Neches River. The Sabine River is permanently floatable and considered a recreation area. The proposed route runs within Indian Bayou near the Sabine River. The WGMA is located on the Louisiana side of the Sabine River. The segment would not enter the WGMA, but changes to the flow of the Sabine River could have an impact on the area. The segment runs within one-half mile of the southern boundary of the Beaumont Unit of the BTNP where the segment crosses the Neches River. The BTNP is owned by the National Park Service. The segment, as proposed, does not cross the BTNP boundaries, but special attention should be given to the Neches River Corridor near Beaumont. The segment would require new channel construction through the area near the BTNP, but will not impact the BTNP.

Segment NT-1a

Segment NT-1a begins at B.A. Steinhagen Lake. In addition this segment crosses the Trinity River and passes within 800 feet of the Menard Creek Unit of the BTNP.

Segment NT-3a.

Segment NT-3a crosses Cotton Creek and Willow Creek which are used for recreational fishing and boating.

Segment NT-3b.

Segment NT-3b is located within one-half mile of the Beaumont Unit of the BTNP, the China City Park, and the Trinity River. Like Segment SN-4b, this segment, as proposed, does not cross the BTNP boundaries, but special attention should be given to the Neches River Corridor near Beaumont. The segment ends at the Trinity River, which is considered a recreation area because it is permanently floatable. Changes to the stream flow could impact recreation along this segment of the Trinity River.

Segments TS-2a and TS-3a.

Segments TS-2a and TS-3a would begin near the Trinity River and end near the West Fork San Jacinto River. Both rivers are permanently floatable and considered recreation areas. No other public lands occur within either segment's corridors.

Segment TS-3b.

Segment TS-3b ends near Lake Houston State Park (TPWD, 1995d). The park boundaries are Peach Creek to the southwest, the East Fork of the San Jacinto River to the southeast, and RM 1485 to the north. The flow path enters Lake Houston from the Luce Bayou Branch and does not cross the park boundary.

Segment TS-4a.

Segment TS-4a begins at the Trinity River, crosses Cedar Bayou, and ends at Lake Houston, all of which are used for fishing and boating.

Segment TS-4b.

Segment TS-4b is located within one-half mile of Mussel Shoals/Big Tupelo Breaks, the San Jacinto River, and the San Jacinto Battleground State Historical Complex (Texas Parks and Wildlife Department, 1994). The proposed route runs within the CWA near Mussel Shoals/Big Tupelo Breaks. The state historical complex contains the Battleship Texas State Park, the San Jacinto Memorial Monument, and the San Jacinto Museum of History. The segment, as presently aligned, does not cross any park boundaries. Both the Trinity and West Fork San Jacinto Rivers are considered recreation areas.

Segment SB-1a.

Segment SB-1a is located within one-half mile of the W.G. Jones State Park, the West Fork San Jacinto River and the Brazos River but does not enter the W.G. Jones State Park. The rivers are permanently floatable and considered recreation areas.

Segment SB-1b and SB-1c.

Segments SB-1b and SB-1c are located within one-half mile of the Stephen F. Austin State Historical Park near San Felipe, Texas; W.G. Jones State Park, Spring Creek; and the Brazos River. The Stephen F. Austin State Park is bordered on the east by the Brazos River. Neither of the routes enter the W.G. Jones State Park. Spring Creek and the Brazos River are permanently floatable and considered recreation areas.

Segment SB-3.

Segment SB-3 would begin near the Brazos River and end at Somerville Lake, which is a U.S. Army Corps of Engineers facility. This is an area of high recreational value. The Brazos River is also a recreation area.

Segment TB-1.

Segment TB-1 would begin at Lake Livingston. This segment would cross Harmon Creek and enter Gibbons Creek Reservoir. The water would then flow downstream into the Brazos River. Lake Livingston and Gibbons Creek Reservoir are areas of high recreational value. The Brazos River is also considered a recreation area.

3.7 Traffic

Improvements will be required at each point where a segment crosses an existing road, highway, or railroad. For the purpose of this study highway crossings are counted separately from smaller road crossings because construction of highway crossings generally will be more expensive and have greater impacts to traffic than smaller road crossings. Only new crossings are counted in Table 3.8 because it is assumed that no new construction will be required at existing crossings.

The source for this information is the preliminary alignments marked on 1:24,000 scale topographic maps. Any roads, highways, or railroads that have been built since the maps were produced have not been counted. Field confirmation will be required to get a more accurate count.

Segment SN-1.

Segment SN-1 would require 10 new road crossings and two new railroad crossings. No highways would require additional construction.

Segment SN-4a.

Segment SN-4a would require 11 new road crossings and one new railroad crossing. No additional construction for highways would be required.

Segment SN-4b.

While Segment SN-4b runs within Indian Bayou, it crosses U.S. Highway 87, FM 1130 twice, State Highway 62, and FM 1136. It also crosses two paved roads, the Sabine River, and the Northern Railroad rail line. Presumably all crossings over Indian Bayou are already bridged so they will not require new construction. The transfer route then crosses Doty-Ferry Road (FM 1135), the Kansas City Southern Railroad rail line, State Highway 12, four streets in Vidor, State Highway 105, and Bunns Bluff Road immediately east of the Neches River. Construction of new facilities for Segment SN-4b will require the installation of five new road crossings, three new highway crossings, and one railroad crossing.

Segment NT-1a.

Segment NT-1a would require 39 new road crossings and one new highway crossing. Three new railroad crossings would be required for this segment.

Segment NT-3a.

Segment NT-3a would require 11 new road crossings and one new railroad crossing. No new highway crossings would be required for this segment.

Segment NT-3b.

While Segment NT-3b runs within the LNVA canal, it crosses U.S. Interstate Highway 96 (IH-96), State Highway 105, and IH-90. It also crosses 10 small streets and the Atchison Topeka and Santa Fe Railroad rail lines. The rest of the transfer route does not run within any existing channel. The route crosses State Highways 61, 770, and 563, and 11 small roads. Segment NT-3b would require construction of 11 new road crossings and three highway crossings.

Segment TS-2a.

Segment TS-2a crosses State Highways 223, 105, 321, and 59, FM 1485, and FM 1314. It also crosses 18 small roads and the Gulf Colorado and Santa Fe Railroad rail line. Segment TS-2a does not run within any existing channels, so all 18 road crossings and six highway crossings would require improvement.

Segment TS-3a.

Segment TS-3a would require nine new road crossings and one highway crossing. No railroads would be crossed by this segment.

Segment TS-3b.

Segment TS-3b crosses FM 1011 and an unpaved road before it enters Luce Bayou. While it runs within Luce Bayou, the route crosses FM 1008, State Highway 321, and five streets. Segment TS-3b will require construction of one new road crossing, and one highway crossing. Other possible construction includes improving unbridged crossings at low water crossings of Luce Bayou.

Segment TS-4a.

Segment TS-4a would require six new road crossings and one highway crossing. One railroad crossing would be required with this segment.

Table 3.8
New Road Crossings along Each Segment

Segment	Number of New Road Crossings	Number of New Highway Crossings	Number of New Railroad Crossings
SN-1	10	0	2
SN-4a	11	0	1
SN-4b	5	3	1
NT-1a	39	1	3
NT-3a	11	0	1
NT-3b	11	3	0
TS-2a	18	6	1
TS-3a	9	1	0
TS-3b	1	1	0
TS-4a	6	1	1
TS-4b	0	0	0
SB-1a	39	9	6
SB-1b	28	3	3
SB-1c	39	7	3
SB-3	6	0	1
TB-1	28	4	2

Segment TS-4b.

Segment TS-4b runs within the CWA canal for its entire length. Segment TS-4b crosses FM 1409, State Highway 136, FM 1942, IH-10, State Highway 134, eight small roads, and the Southern Pacific Railroad rail line. There will be no new road, highway, or railroad crossings since the route runs within the CWA canal.

Segment SB-1a.

Segment SB-1a crosses IH-75 (State Highway 45), State Highway 149, State Highway 105, FM 1774, FM 2445, State Highway 6, Loop 508, and FM 1227. It also crosses 39 roads and six railroads, including the Missouri Pacific Railroad, the Atchison Topeka and Santa Fe Railroad, and the former Chicago Rock Island and Pacific Railroad rail lines. Segment SB-1a would require the construction of 39 road crossings, nine highway crossings, and six railroad crossings.

Segment SB-1b.

Segment SB-1b crosses IH-75 (State Highway 45), FM 1774, and IH-290. It also crosses 28 small streets and three railroads, including the Missouri Pacific Railroad, the former Chicago Rock Island and Pacific Railroad, and the Southern Pacific Railroad rail lines. While running within the Brazos River, Segment SB-1b crosses IH-90. Segment SB-1b would require construction of 28 road crossings, three highway crossings, and three railroad crossings.

Segment SB-1c.

Segment SB-1c crosses IH-75 (State Highway 45), FM 1774, IH-290, State Highway 529, IH-90, State Highways 10, and 359. It also crosses 39 small streets and three railroads, including the Missouri Pacific Railroad, the former Chicago Rock Island and Pacific Railroad, and the Texas and New Orleans Railroad rail lines. Segment SB-1c will require construction of 39 road crossings, seven highway crossings, and three railroad crossings.

Segment SB-3

Segment SB-3 does not cross any highways. Segment SB-3 would require construction of six road crossings and one railroad crossing.

Segment TB-1

Segment TB-1 crosses four highways. The segment would require construction of 28 road crossings and two railroad crossings.

3.8 Summary of Existing Environment

Table 3.9 contains a summary of the existing environmental conditions for each segment discussed in this report. Segments are grouped with respect to their basin locations and are presented in an east to west order. The relative impacts by each segment are discussed in Chapter 4.

Table 3.9
Summary of Environmental Conditions along Transfer Segments and Downstream Flow Pathways

	SN-1	SN-4a	SN-4b	NT-1a	NT-3a	NT-3b	TS-2a	TS-3a	TS-3b	TS-4a	TS-4b	SB-1a	SB-1b	SB-1c	SB-3	TB-1
Total Segment Length (miles)	19	29	32	59	41	47	38	38	9	19	20	41	35	63	25	52
New construction (miles)	19	21	18	59	28	26	38	38	9	13	0	41	35	54	25	52
Existing canals (miles)	0	8	14	0	13	21	0	0	0	6	20	0	0	9	0	0
Downstream Flowpath (miles)	26	0	0	0	0	0	0	0	21	0	0	47	0	0	0	41
Woodlands (acres)	454	513	548	1,123	535	325	824	844	211	151	51	844	696	524	150	603
Agricultural (acres)	0	105	68	191	287	834	107	78	0.0	243	191	417	106	1,001	445	483
Urban (acres)	0	0	158	85	0	58	0	0	0	0	5	0	0	0	0	0
Threatened and Endangered Species (number)	20	19	19	22	25	21	24	20	23	23	25	3	17[2]	18	11	19
Intermittent Stream Crossings (number)	25	17	7	45	13	30	20	10	1	4	0	80	52	58	24	69
Perennial Stream Crossings (number)	4	2	3	6	3	4	7	11	2	1	1	5	5	6	8	10
River Crossings (number)	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0
Wetlands in Segment Corridor (acres)	5	82	79	57	103	60	57	50	27	0	0	56	25	64	16	12
Wetlands in Downstream Flow Path (acres)	3	--	--	--	--	--	--	--	71	--	--	58	--	--	--	26
Prime Farmland (acres)	N/A	N/A	N/A	N/A	160	377	553	504	88	220	216	138	201	885	109	32
Public Land (number)	5	3	4	2	2	3	2	2	2	3	3	2	3	3	1	4
New Road Crossings (number)	10	11	5	39	11	11	18	9	1	6	0	39	28	39	6	28
New Highway Crossings (number)	0	0	3	1	0	3	6	1	1	1	0	9	3	7	0	4
New RR Crossing (number)	2	1	1	3	1	0	1	0	0	1	0	6	3	3	1	2
Static Lift	High	Very Low	Very Low	Very High	Low	Low	Medium	Medium	Low	Low	Low	Very High	Very High	Very High	High	Very High

N/A Complete Soils Data Not Available. -- parameter does not apply to segment

4.0 Environmental Impacts of Alternatives

This section discusses the potential environmental impacts of construction, operation and maintenance of the proposed segments which would be used to convey water across the Southeast Area of the Trans-Texas Water Program. The individual segments range from approximately 20 to 100 miles in length, using existing canals, stream channels and new canals. Two hundred foot right-of-ways for new facilities and 100 foot right-of-ways for existing canals and natural stream channels were used to calculate the potential area of impact for each segment and downstream flow path. In many cases, final alignment of a particular segment may decrease environmental impacts. Generally, shorter segments and those using existing canals have less environmental impacts, as they disturb less area. Those segments utilizing existing stream channels for conveyance may disturb less area but are at a higher risk of impacting aquatic communities and instream water uses. The existing environmental conditions potentially affected by each segment were discussed in Section 3.0.

4.1 Land Use Impacts

Of the three proposed Sabine-Neches River basin transfer options, segment SN-4b would impact the most woodland area and segment SN-1 would impact the least. The entire segment length of SN-1 would involve construction of new conveyance facilities, mostly through thick, mature forests contained in the Sabine National Forest. Woodland impacted by segment SN-4a includes an existing canal which passes through portions of the Big Thicket National Preserve. Approximately two-thirds of the remaining woodland affected by SN-4a would be in the area of new canal construction.

Segment SN-4a impacts more agricultural land than either SN-1 or SN-4b. The agricultural area impacted by segment SN-1 consists mostly of cleared rangeland or pastureland. Segment SN-4b would impact the least amount of agricultural land.

Urban areas would be impacted by SN-4b but not by the remaining Sabine-Neches River transfer segments. Segment SN-4b utilizes existing canals in the area nearest the city of Orange, but would require new construction of canals in the area of Vidor and Beaumont.

Three segments are proposed for the transfer of water from the Neches to the Trinity River basins. Of these, segment NT-1a impacts two to three times the number of woodland acres as the remaining two segments and would require new conveyance facilities for its entire length. Segment NT-3b impacts the least amount of woodland area and would utilize an existing canal for much of its length. The most agricultural area is impacted by segment NT-3b and the least by NT-1a.

Urban areas would be impacted by NT-1a and NT-3b. Although the area of impact to urban areas is greater for NT-1a, realignment of this segment may decrease or eliminate the use of urban right-of-way.

Five segments are proposed for the transfer of water from the Trinity to the San Jacinto River basins. The most woodland area would be impacted by segments TS-2a and TS-3a, the northernmost of the five segments. The least woodland area would be impacted by segment TS-4b which is contained entirely in an existing canal.

The greatest area of agricultural land potentially impacted by the Trinity-San Jacinto basin segments is located in the corridor of segment TS-4a. No agricultural land disturbance would occur in the corridor of segment TS-3b.

Segment TS-4b is the only one of the five segments potentially impacting urban areas. Segment TS-4b terminates at Lynchburg Reservoir near Burnet Bay and is contained entirely in an existing canal. If no improvement of this facility is required, then the potential impact to all land uses will be the least of all Trinity to San Jacinto basin segments.

Three segments are proposed for transferring water from the San Jacinto to the Brazos River basin. All three begin at the same location and diverge at different points in the San Jacinto River basin. The greatest amount of woodland would be impacted by segment SB-1c and the least by SB-3.

Segment SB-3 would transfer water from a location near the Brazos River at the confluence with the Navasota River, to Somerville Lake. Approximately three fourths of the segment corridor would impact agricultural land and one fourth would impact woodland areas.

Segment TB-1 would transfer water directly from the Trinity River basin to the Brazos River basin. The segment would impact a greater amount of woodland than agricultural area and would bypass all urban areas. The downstream flow path for TB-1 includes Gibbons Creek, Gibbons Creek Reservoir and the Navasota River. It is unknown at the time of this report if improvements will be required to any of these natural channels as a result of increased flow.

4.2 Biological Resources Impacts

4.2.1 Natural Communities

According to the Texas Biological and Conservation Data System (BCD), twelve watch-listed natural communities occur in the TTWP Southeast Study Area. A detailed field investigation will be required to determine which segments would impact these communities.

Four vegetational areas are described for the study area; Pineywoods, Gulf Prairies and Marshes, Blackland Prairies, and the Post Oak Savannah. Relative impacts to these vegetational areas is proportional to the total length of each transfer segment. Sabine-Neches transfer segments will impact the Pineywoods Vegetational Area. Segments transferring water from the Neches to the Trinity basin will impact the Pineywoods and Gulf Prairies and Marshes Vegetational Areas. Neches-San Jacinto transfer segments will affect the Pineywoods Vegetational Area to the north and the Gulf Prairies and Marshes Vegetational Area to the south. Segments TS-3b and TS-4a will impact both areas. Segments transferring water into and within the Brazos River basin will impact the Pineywoods, Post Oak Savannah and Blackland Prairies Vegetational Areas. The northernmost segments, TB-1 and SB-1a, cross into the southeastern edge of the Blackland Prairies area.

4.2.2 Fisheries

Interbasin water transfer has the potential to impact freshwater and coastal fisheries in several ways. Transfer of water between basins may results in changes in water chemistry, temperature, nutrients, organic particulates, and sediment, as well as changes in instream flows and inflows to bays and estuaries. Physical habitat conditions such as velocity, depth, and substrate or cover are directly related to stream flow and may affect fish production. Potential changes in water quality also could impact fisheries in the affected basins. Instream flows in the reach of the Sabine River below Deweyville and freshwater inflows to Sabine Lake will be reduced by additional diversion of water from the Sabine River to the Neches River or basins farther west; whereas, flows in portions of the Neches, Trinity, San Jacinto and Brazos Rivers will increase slightly. Detailed investigations will be necessary to quantify impacts of changes in stream flow on fisheries.

In addition, interbasin transfer of water could impact native fisheries resources by introducing exotic or nuisance species of plants and animals. Kaskey and Rasmussen (Undated) listed the following native species that could expand their range westward with the water transfers: chestnut lamprey (*Icthyomyzon casteneus*), smallmouth bass (*Ictiobus bubalus*), black buffalo (*Ictiobus niger*), chain pickerel (*Esox niger*), emerald shiner (*Notropis atherinoides*), and mud darter (*Etheostoma asprigene*). Two introduced species which could be harmful, the grass carp (*Ctenopharyngodon idella*) and the blue tilapia (*Tilapia aurea*), occur in the eastern basins and could be transferred to systems further west.

Kaskey and Rasmussen (Undated) also identified a number of means and types of other aquatic organisms that could spread via interbasin water transfer routes. Recipient basins could be affected by transfers of microbes, algae, mollusks, and fish. Algal blooms during the summer and fall could be spread between lake systems via that transfer route. Species such as giant duckweed (*Spirodela oligorhiza*), salvania (*Salvania spp.*), water hyacinth (*Eichornia crassipes*), egeria (*Egeria densa*), hydrilla (*Hydrilla verticullata*), alligatorweed (*Alternanthera philoxeroides*), and water fern (*Azolla sp.*) could be transferred to other water systems within the Southeast Area and west to other basins. These species could cause odor and taste problems in water supplies as well as detrimental economic and environmental impacts due to clogged waterways, limiting recreation, disruption of wildlife habitat, and providing microhabitats for various human disease vectors. Native mollusk populations could be affected by the spread of the introduced species.

4.2.3 Endangered and Threatened Species

The Texas Biological and Conservation Data System documents known locations of endangered and threatened species as listed by the Texas Organization for Endangered Species (TOES). The majority of the listed species would not be impacted by construction of a transfer facility. A few, such as the bald eagle and red-cockaded woodpecker, will nest in the region. When necessary, the alignment could be moved to avoid any nest sites. Mammalian, reptilian, amphibian, and vegetative species impacts due to construction of a transfer facility would depend on local habitat conditions. An assessment of habitat needs in addition to database record checks of the BCD would have to be conducted to more accurately determine impacts to any of these species.

4.3 Cultural Resources Impacts

No information is readily available regarding the presence of cultural resources within the proposed transfer segment corridors. The Texas Historical Commission will require a survey of the proposed alignment to obtain more information concerning cultural resources and possible impacts.

4.4 Hydrology and Water Quality Impacts

4.4.1 Groundwater

All of the proposed segments in the TTWP Southeast Study Area are within the recharge zone for the Gulf Coast Aquifer. Salt water encroachment due to groundwater pumping has been observed in portions of the region. Because the proposed interbasin transfer of water would maximize the use of surface water supplies, less demand may be made on groundwater supplies. Conversely, diversions of surface water to westward areas would decrease the amount of surface water available for groundwater recharge. No adverse impacts to groundwater supplies are expected as a result of construction, operation, or maintenance of the proposed segments.

4.4.2 Streams and Lakes

Disturbance of stream channels and riparian corridors by construction, operation, and maintenance of the proposed segments increases with the frequency and size of stream crossings. Construction of above-channel crossings has the potential to cause much more impact than below-channel crossings. Likewise, construction of conveyances across rivers and perennial streams has the potential to cause more impact than those over intermittent streams. In assessing the potential impacts of stream crossing construction, all are assumed to be above-ground conveyances with riparian crossings. The most appropriate sites and methods of transferring water across stream and river channels should be chosen depending on site specific environmental and engineering constraints.

Because the method of operation and water demands for the TTWP transfer segments is unknown at the time of this report, it is assumed that some blending of water will potentially occur at the beginning and end of each segment. According to TNRCC's 1996 Texas Water Quality Inventory, designated water quality uses are being supported by five of the river segments potentially affected by the water transfer segments. The most common causes of non-attainment are elevated fecal coliform bacteria and dissolved metals concentrations. Downstream impacts to water quality throughout the TTWP Southeast Study Area could result from the transfer of contaminants such as nutrients, fecal coliforms, metals and pesticides to south or westward river segments. Also, as water of different chemical composition is moved from the eastern basins to the western basins, water chemistry may change sufficiently to cause indirect water quality impacts, such as elevated concentrations of dissolved metals. An intensive investigation would be necessary to determine potential indirect or cumulative impacts to receiving water quality.

4.5 Wetlands

The U.S. Army Corps of Engineers (Corps) regulates activities in jurisdictional waters of the United States (U.S.). Jurisdictional waters include all waterways (i.e., streams, rivers, bayous, etc.), reservoirs, ponds constructed along jurisdictional waterways, and wetlands. A permit under Section 404 of the Clean Water Act (33 USC 1344) would be required for construction activities in non-navigable waters and wetlands. A permit under Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403) would be required for construction activities in navigable waters. Portions of the Big Cypress Bayou, Sabine, Neches, and Trinity rivers are considered navigable waters. Construction activities within the navigable portions of these rivers would require Corps notification for purposes of Section 10.

Impacts to wetlands and other jurisdictional waters of the U.S. would require mitigation. Forested wetlands typically require the greater amount of mitigation. These mitigation ratios can range from 1:1 up to 10:1 depending on the vegetation community and its value. The remaining wetlands also would require mitigation, and these ratios could range from 1:1 up to 5:1.

Additional mitigation acreage may be required to establish buffer zones around wetlands and for impacts at streams and rivers. These mitigation requirements would vary depending on the severity of impacts, but these ratios could range from 1:1 to 2:1.

Of the Sabine-Neches transfer segments, SN-1 impacts the fewest acres of wetlands, while SN-4a impacts the most. All or most of these wetland areas are forested. The downstream flow path of segment SN-1, however, includes natural systems such as Sam Rayburn Reservoir, the Angelina River and the Neches River. The first potential downstream transfer station which will move the additional flow from the Neches River is at B.A. Steinhagen Lake. If the lake transfer station is not included in the TTWP, the additional flow could potentially impact the Neches River as far downstream as the next transfer station, located north of Beaumont. The portion of the Neches below B.A. Steinhagen Lake flows through the Big Thicket National Preserve which encompasses numerous wetland areas.

Three segments are proposed for transferring water from the Neches to the Trinity River basin. Of these, segment NT-3a would impact the most wetland area. Although it is the longest of the three segments, NT-1a would impact the least number of wetland areas. The majority of wetlands impacted by all three segments are dominated by forest or emergent vegetation.

Of the five Trinity-San Jacinto transfer segments, TS-2a impacts the most wetland area. Although Segment TS-3b will require one of the shortest lengths of new construction, the downstream flow path utilizes the natural channel of Luce Bayou and Lake Houston. It is unknown at the time of this report if improvements will be required to the natural channel of Luce Bayou to accommodate the increased flow. If no improvements are required, then the potential impact to wetlands along the stream corridor will be minimal.

Of the three segments which transfer water from the San Jacinto River basin to the Brazos River basin, the Segment SB-1c corridor impacts the most wetland area, the majority of which is split between emergent vegetation and open water wetlands. The Segment SB-1a corridor impacts the second most, with a majority of the area classified as open water wetland. The Segment SB-1b corridor impacts the least wetland acreage of the three, split between open water, forested and emergent wetlands. Although the Segment SB-1b corridor impacts the least wetland area, the downstream flow path impacts approximately 58 acres of wetlands in the Clear Creek/ Brazos River area. This results in Segment SB-1b impacting the least total wetland acreage of the three segments. In spite of its relatively long extent, the corridor of Segment TB-1 would impact a very small amount of wetland area.

4.6 Soils and Geologic Resources Impacts

All of the transfer segments are located on the Beaumont and Willis Formations. No impacts are expected to any geologic resources within the region.

4.7 Public Lands Impacts

Potential impacts to public lands and recreation areas are determined for those areas within a one-half mile corridor of the proposed transfer routes. Each segment has at least one public land or recreational area within the one-half mile corridor. Realignment of segments to reduce potential impacts will be considered where possible.

The proposed segments could have two types of impacts to public lands and recreation areas including changing stream flows for existing channels or activities involving construction of a new channel.

The first type of impact would involve changes in stream flows of existing channels. The relationship between stream flow and recreation quality shows that quality increases with flow to a point but decreases with further increases in flow (Shelby, et al., 1992). In recognition of the economic importance of recreation areas, the impacts to recreation quality by changes in the stream flow should be minimized (TPWD, 1985). Stream flow in the reach of the Sabine River below Deweyville will be reduced by diversion of water from the Sabine River to the Neches River or basins farther west; whereas, flows in portions of the Neches, Trinity, San Jacinto and Brazos Rivers will increase slightly. The Sabine, Neches, Trinity, and San Jacinto rivers are recognized recreational areas which will experience localized changes in water level when water is transferred. Because water level changes on major rivers would be minimal, recreation activities in these areas are not expected to be significantly impacted.

The second type of impact would involve construction of a new channel for the proposed segment within an existing recreation area. Realignment of transfer segments may be necessary to reduce potential impacts to public lands and recreation areas.

Within the Sabine-Neches transfer area, construction activities and operation of transfer segments would impact the Toledo Bend Reservoir, the Sabine and Angelina National Forests, the Angelina and Neches Rivers, B.A. Steinhagen Lake, the Sabine River and the Sabine Island Wildlife Game Management Area. The entire length of SN-1 is located in the Sabine National Forest. As discussed earlier, the downstream flow path of SN-1 extends into the BTNP below B.A. Steinhagen Lake. Impacts to recreation activities due to increased water levels in this reach of the Neches river are not expected to be significant.

Construction and operation of segments SN-4a and SN-4b would impact the Sabine River, the Sabine Island Wildlife Game Management Area (WGMA) and the Neches River Corridor and Beaumont Units of the BTNP. The downstream flow path of Segment SN-4a, located in the BTNP (existing LNVA canal), would experience increased flow but it is not known at the time of this report whether improvements would be required to accommodate the increased water level. Segment SN-4b does not pass through the BTNP but both it and SN-4a would require new channel construction near the Beaumont Unit boundary. The Sabine Island WGMA is located on the Louisiana side of the Sabine River but could potentially be impacted by reduced flows to the area.

The three segments included in the Neches-Trinity River water transfer options are located within one-half mile of B.A. Steinhagen Lake, the Menard Creek, Big Sandy Creek Corridor and Beaumont Units of the BTNP, the China City Park, and the Trinity River. All three segments would potentially impact the BTNP. For segments NT-3a and NT-3b, only the common channel which follow the existing LNVA canal from the southern edge of the Beaumont Unit would potentially impact the BTNP. It is unknown at the time of this report if improvements will be made to the existing canal or transfer station to accommodate the additional flow. If no improvements are required, the segments potential impact to the BTNP as a public or recreational area will be minimal. Segment NT-1a would impact the Menard Creek and Big Sandy Creek Corridor Units of the BTNP near the Trinity River end of the segment. This portion of the segment is roughly parallel to Menard Creek and passes within a few hundred feet of the BTNP boundary. New facilities would also be required in the crossing of the Big Sandy Creek Corridor Unit of the BTNP. This segment would require construction of new conveyance facilities for its entire length.

In the Trinity-San Jacinto transfer area, public lands potentially impacted by the transfer segments include the Trinity and San Jacinto Rivers, Luce Bayou, Lake Houston State Park, Cedar Bayou, the Mussel Shoals/Big Tupelo Breaks, San Jacinto Battleground State Historical Complex. The Trinity and San Jacinto rivers would be impacted by potential construction activities in the vicinity of transfer stations at the beginning and end of the segments, as well as by slight water level changes downstream of transfer points. Water level changes in the major rivers are not expected to impact recreational use.

Luce Bayou will be directly impacted as a downstream conveyance for segment TS-3b. As discussed earlier, it is unknown at the time of this report if improvements will be made to the existing channel to accommodate the additional flow. If no improvements are required, the segments' potential impact to Luce Bayou as a recreational area may be minimal. Localized water quality impacts to the bayou and downstream Lake Houston may occur as a result of additional flow and erosional activity in the natural stream channel.

Although the San Jacinto Battleground State Historical Complex is located within one-half mile of the terminus of TS-4b at Lynchburg Reservoir, it is situated across Burnet Bay and is not expected to be impacted by any activities associated with the transfer segment.

The three segments included in the proposed transfer of water from the San Jacinto to the Brazos River basins are located within one-half mile of the San Jacinto and Brazos Rivers, the W.G. Jones State Park, the Stephen F. Austin State Historical Park, and Spring Creek. The Stephen F. Austin State Park is located adjacent to the Brazos River downstream of proposed segments SB-1b and SB-1c. Increases in water surface elevation of the river will impact the park and the golf course which is closest to the river. The downstream flow path of segment SB-1b includes the natural stream channel of Clear Creek. Localized water quality impacts to the stream and the Brazos River may occur as a result of additional flow and erosional activity in the natural stream channel. None of the three segments enters the W.G. Jones State Park and it is not anticipated to receive impacts from the any of the segments.

Segment SB-3 would impact the U.S. Army Corps of Engineers facility at Somerville Lake. Although construction and operation activities are expected to impact the facility, it is not anticipated that water level increases will impact the recreational use of the lake.

Segment TB-1, which would deliver water from Lake Livingston on the Trinity River directly to the Brazos River basin would potentially impact recreation activities on Lake Livingston. Lake levels are not expected to change significantly, but construction of new conveyance facilities in the vicinity of the lake will be necessary. The downstream flow path of TB-1 includes Gibbons Creek, Gibbons Creek Reservoir, the Navasota River and the Brazos River. It is not known at the time of this report if improvements to the Gibbons Creek channel will be required to accommodate the increased flow or if the increased flow will significantly raise the water level of Gibbons Creek Reservoir. Localized water quality impacts to the stream and downstream reservoir may occur as a result of additional flow and erosional activity in the natural stream channel. Increases in water level of the Navasota or Brazos Rivers is not expected to impact the recreational value of the rivers. Also, because these rivers will receive diversion water via natural channels, they will receive no direct impact from construction of conveyance facilities.

4.8 Traffic Impacts

All of the proposed segments cross numerous roadways, highways, and railroad tracks. No impacts are expected to occur as a result of increased flows at existing crossings. At crossings where new or improved conveyance facilities ares required, however, construction activities will impact the flow of traffic.

Of the three Sabine-Neches transfer segments, SN-1 and SN-4a require no new highway crossings and a moderate number of smaller road crossings (relative to other segments in the study area). Segment SN-4b would impact traffic at three highway crossings but fewer smaller road crossings than the other two segments. Segment SN-1 would impact traffic at two new railroad crossings while the other two would require only one each.

Of the three Neches-Trinity transfer segments, NT-1a would impact traffic at the most railroad crossings and the most small road crossings. Segment NT-3a requires no new highway crossings and NT-3b requires three. No new railroad crossings would be required by NT-3b.

Five segments are included in the Trinity-San Jacinto transfer options. Segment TS-2a will impact traffic at the most small road and highway crossings. Both TS-2a and TS-4a will impact traffic at only one railroad crossing. The remaining segments will not impact railroad traffic. Because segment TS-4b is contained in an existing canal, it will require no new crossings.

Three segments are included in the San Jacinto-Brazos transfer options. Segments SB-1a and SB-1c will impact traffic at the most small road, highway and railroad crossings of any segments in the TTWP Southeast Study Area. Segment SB-1b will impact traffic at fewer small road and highway crossings than the other two but ties with SB-1c with the number of new railroad crossings.

Segment SB-3 would require no new highway crossings and only one new railroad crossing. Segment TB-1, which delivers water directly to the Brazos from the Trinity River basin, would impact traffic at two new railroad crossings and four new highway crossings. It ties with SB-1b for impacts to traffic at small road crossings.

4.9 Summary of Impacts

Previous discussions have addressed the condition of and potential impacts to various environmental parameters by construction, operation and maintenance of interbasin transfer segments of the TTWP. Table 4.9 visually summarizes the relative environmental impacts of each segment and its downstream flow path. Individual segments are compared only to other segments in the same segment group, e.g. Sabine-Neches River basins (SN). This analysis will allow the reader to assess the feasibility of moving water between adjacent basins to meet water demands in a variety of geographic areas. The areas of concern discussed in this document are the Houston/northern Harris County area and the heavily urbanized areas west of the Brazos River basin, including the city of San Antonio. The Phase I report describes three water demand scenarios for meeting the needs of these areas.

Based on the environmental analyses included in this report, three segments are recommended as the preferred alternatives for transfer of water from the Sabine River to the Brazos River basins. Recommendations made in this report are based solely on the analysis of potential environmental impacts by each proposed segment.

To transfer water out of the Sabine River basin, Segment SN-4b is the environmentally preferred alternative. This segment utilizes the greatest extent of existing facilities of the Sabine-Neches group. This segment also bypasses the Big Thicket and impacts a moderate amount of other natural wetland areas.

For transfer of water from the Neches River basin to the Trinity River basin, Segment NT-3b is the environmentally preferred alternative. Segments NT-3a and NT-3b are very similar in nature and have the potential to impact similar environments. Segment NT-3a, however, has the potential to impact slightly more threatened and endangered species than NT-3b and the most wetland area of any NT segments. Segment NT-3a, however potentially impacts the most agricultural land, prime farmland soils, public lands and has the most new highway crossings of the NT segments.

To transfer water from the Trinity River basin to the Brazos River basin, segment TB-1 is the environmentally preferred segment. Segment TB-1 has much less potential environmental impact than any combination of TS/SB segments with respect to the parameters analyzed in this study. If it is necessary to move water from the Brazos River area to Lake Somerville for storage, the environmental impacts of Segment SB-3 would be minimal.

Although Segment TB-1 is the preferred alternative for delivering water directly to the Brazos from the Trinity, certain individual segments within the TS and SB groups would also have relatively low environmental impacts. For Trinity River to San Jacinto transfers, segments TS-3b, TS-4a and TS-4b are similar in their impact level. Segment TS-3b is the shortest of the group and therefore may result the least environmental impact. It would, however impact the downstream flow path, particularly in the headwaters of Luce Bayou. For San Jacinto River to Brazos River transfers, segments SB-1b provides the least environmental impact.

Using the environmental analyses presented in this document, Segments SN-4b, NT-3b, and TB-1 are recommended as the preferred alternatives for further consideration by the TTWP.

Table 4.1 Summary of Environmental Impacts of Transfer Segments

	Group SN			Group NT			Group TS					Group SB				Group TB*
Environmental	SN-1	SN-4a	SN-4b	NT-1a	NT-3a	NT	TS-2a	TS-3a	TS-3b	TS-4a	TS-4b	SB-1a	SB-1b	SB-1c	SB-3	TB-1
Total Length	○	⊙	●	●	○	⊙	●	●	○	⊙	⊙	⊙	⊙	●	○	○
New Construction	⊙	●	○	●	⊙	○	●	●	⊙	⊙	○	⊙	⊙	●	○	⊙
Existing Canals	●	⊙	○	●	⊙	○	●	●	⊙	⊙	○	●	●	○	●	●
Downstream Flow Path	●	○	○	○	○	○	○	○	●	○	○	●	○	○	○	●
Woodlands	○	⊙	●	●	⊙	○	⊙	●	⊙	⊙	○	●	⊙	●	⊙	⊙
Agricultural	○	●	⊙	○	⊙	●	⊙	⊙	○	●	⊙	⊙	○	●	⊙	⊙
Urban	○	○	●	●	○	⊙	○	○	○	○	●	○	○	○	○	○
Threatened & Endangered Species	●	○	○	⊙	●	○	⊙	○	⊙	⊙	●	○	⊙	●	⊙	⊙
Intermittent Streams	●	⊙	○	●	○	⊙	●	⊙	⊙	⊙	○	●	⊙	⊙	○	⊙
Perennial Stream	●	○	⊙	●	○	⊙	⊙	●	⊙	○	○	○	○	⊙	●	●
River Crossings	○	●	●	○	○	○	●	●	○	○	○	○	○	○	○	○
Wetlands in Segment	○	●	⊙	○	●	⊙	●	⊙	⊙	○	○	⊙	⊙	●	○	⊙
Wetlands in Downstream Flow Path	●	--	--	--	--	--	--	--	●	--	--	●	--	--	--	●
Prime Farmland Soils	N/A	N/A	N/A	N/A	○	●	●	⊙	○	⊙	⊙	⊙	⊙	●	⊙	○
New Road Crossings	⊙	●	○	●	○	○	●	⊙	⊙	⊙	○	●	⊙	●	○	⊙
New Highway Crossings	○	○	●	⊙	○	●	●	⊙	⊙	⊙	○	●	⊙	⊙	○	⊙
New Railroad Crossings	●	○	○	●	⊙	○	●	○	○	●	○	●	⊙	⊙	○	⊙
Public Lands	●	○	⊙	○	○	●	○	○	○	●	●	⊙	●	●	○	●
Other Parameters																
Static Lift	●	○	○	●	⊙	○	⊙	●	○	⊙	⊙	●	⊙	⊙	○	●

○ most desirable of group
⊙ moderately desirable of group
● least desirable of group

* Compared to Groups TS and SB
N/A data not available
-- parameter does not apply to segment

Appendix A
List of References

Arroyo, B. 1992. Threatened and endangered species of Texas. U.S. Fish and Wildlife Service. Austin, Texas.

Boschung, H.T., Jr., J.D. Williams, D.W. Gotshall, D.K. Caldwell, and M.C. Caldwell. 1983. The Audubon Society field guide to North American fishes, whales and dolphins. Alfred A. Knopf. New York.

Brown and Root, Inc. and Freese and Nichols, Inc. 1994. Trans-Texas Water Program Southeast Area Phase I Report. Houston and Fort Worth, Texas

Bureau of Reclamation. 1985. Bon Wier Project, Texas Basins Project. Amarillo, Texas.

Burnside, F.L. and D. A. James. 1993. The red-cockaded woodpecker in Arkansas: an endangered species. Arkansas Game and Fish Commission.

Chervenka, W.G. 1981. Soil Survey of Washington County, Texas. U.S. Department of Agriculture.

Clark, W.S., and B.K. Wheeler. 1987. Hawks. Houghton Mifflin Company. Boston, Massachusetts.

Correll, D.S., and M.C. Johnston. 1979. Manual of the vascular plants of Texas. The University of Texas at Dallas. Richardson, Texas.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1992. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service. Washington, DC.

Crout, J.D. 1965b. Soil Survey of Jefferson County, Texas. U.S. Department of Agriculture.

Crout, J.D. 1976. Soil Survey of Chambers County, Texas. Soil Conservation Service, U.S. Department of Agriculture.

Davis, W.B., and D.J. Schmidly. 1994. The Mammals of Texas. Texas Parks and Wildlife Department. Austin.

Fisher, W.L. 1974. Geologic Atlas of Texas, Seguin Sheet. Bureau of Economic Geology, University of Texas at Austin.

Fisher, W.L. 1981. Geologic Atlas of Texas, Austin Sheet. Bureau of Economic Geology, University of Texas at Austin.

Flawn, P.T. 1967. Geologic Atlas of Texas, Palestine Sheet. Bureau of Economic Geology, University of Texas at Austin.

Flawn, P.T. 1968a. Geologic Atlas of Texas, Beaumont Sheet. Bureau of Economic Geology, University of Texas at Austin.

Flawn, P.T. 1968b. Geologic Atlas of Texas, Houston Sheet. Bureau of Economic Geology, University of Texas at Austin.

Freese and Nichols, Inc. 1989. Preliminary Feasibility Study, Interbasin Water Transfer from the Sabine River to the San Jacinto River Authority Service Areas. Fort Worth, Texas.

Garrett, J.M., and D.G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Press, Inc. Austin.

Greenwade, J. M. 1996. Soil Survey of Grimes County, Texas. Natural Resources Conservation Service, U.S. Department of Agriculture.

Greenwade, J.M. 1984. Soil Survey of Austin and Waller Counties, Texas. Soil Conservation Service, U.S. Department of Agriculture.

Griffith, K.L. 1996. Soil Survey of Liberty County, Texas. U.S. Department of Agriculture.

Griffith, K.L. 1996. Soil Survey of Liberty County, Texas. Natural Resources Conservation Service, U.S. Department of Agriculture.

Hayes, T. 1992. Endangered, threatened, and watch list of natural communities of Texas. Texas Organization for Endangered Species. Austin.

Kaskey, J.B. and R.P. Rasmussen. Undated. Potential introduction of aquatic organisms via interbasin water transfers: Southeast, West-Central, and South-Central Texas.

Lewis, J.C. 1986. The whooping crane. Pages 659-676 in R.L. DiSilvestro, ed. Audubon Wildlife Report 1986. The National Audubon Society. New York.

McClintock, W.R. 1972. Soil Survey of Montgomery County, Texas. U.S. Department of Agriculture.

McClintock, W.R. 1972. Soil Survey of Montgomery County, Texas. Soil Conservation Service, U.S. Department of Agriculture.

McClintock, W.R. 1979. Soil Survey of Walker County, Texas. U.S. Department of Agriculture.

McKewen, H. 1988. Soil Survey of Polk and San Jacinto counties, Texas. U.S. Department of Agriculture.

Metcalf and Eddy, Inc. 1989. Houston water plan. Houston, Texas.

National Wetlands Policy Forum. 1988. Protecting America's wetlands: an action agenda. Conservation Foundation. Washington, D.C.

Neitsch, C.L. 1982. Soil Survey of Jasper and Newton counties, Texas. U.S. Department of Agriculture.

Neitsch, C.L. 1982. Soil Survey of Jasper and Newton Counties, Texas. Soil Conservation Service, U.S. Department of Agriculture.

Oberholser, H.C. 1974. The bird life of Texas. Volumes 1 and 2. University of Texas Press. Austin.

Pate Engineering, Inc. 1988. San Jacinto River Authority, Water Resources Development Plan. Tampa, Florida.

Pitman, V.M. 1992. Special report: Texas paddlefish recovery plan. Texas Parks and Wildlife Department. Austin.

Poole, J.M. and D.H. Riskind. 1991. Endangered, threatened, or protected native plants of Texas. Texas Parks and Wildlife Department. Austin.

Price, A.H. 1990. *Phrynosoma cornutum*. Reptilia: Squamata: Sauria: Iguanidae. Texas Parks and Wildlife Department. Austin, Texas.

Schmidly, D.J. 1983. Texas mammals east of the Balcones Fault Zone. Texas A&M University Press. College Station.

Scott, S.L., editor. 1987. Field guide to the birds of North American. National Geographic Society. Washington, DC.

Shelby, B., T.C. Brown and J.G. Taylor. 1992. Streamflow and recreation. General Technical Report RM-209. Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service. Fort Collins, Colorado.

Soil Conservation Service. 1974. General soil map Sabine and San Augustine counties, Texas. 4-R-34231. U.S. Department of Agriculture. Fort Worth, Texas.

Soil Conservation Service. 1982. Prime farmland soils by county in Texas. Volumes 1 and 2. U.S. Department of Agriculture. Fort Worth, Texas.

Soil Conservation Service. 1983. General soil map Tyler County, Texas. 4-R-38239. U.S. Department of Agriculture. Fort Worth, Texas.

Soil Conservation Service. 1991. General soil map Hardin County, Texas. NRCS-1005774. U.S. Department of Agriculture. Fort Worth, Texas.

Soil Conservation Service. 1995a. Draft Soil Survey of Orange County, Texas. Unpublished manuscript. U.S. Department of Agriculture. Washington, DC.

Soil Conservation Service. 1995b. Draft Soil Survey of Jefferson County, Texas. Unpublished manuscript. U.S. Department of Agriculture. Washington, DC.

Stolt, M.H. and J.C. Baker. 1995. Evaluation of National Wetland Inventory maps to inventory wetlands in the southern Blue Ridge of Virginia. Pages 346-353 in Wetlands. The Society of Wetland Scientists.

Tennant, A. 1985. A field guide to Texas snakes. Gulf Publishing Company. Houston, Texas.

Texas Department of Transportation. 1993. Texas official highway travel map. Austin.

Texas Natural Heritage Program. 1995. Rare plant information sheets. Texas Parks and Wildlife Department. Austin.

Texas Organization for Endangered Species. 1988. Endangered, threatened and watch list of vertebrates of Texas. Austin.

Texas Organization for Endangered Species. 1993. Endangered, threatened and watch lists of Texas plants. Austin.

Texas Parks and Wildlife Department. 1985. 1985 Texas Outdoor Recreation Plan. Comprehensive Planning Branch. Austin.

Texas Parks and Wildlife Department. 1990. Fanthorp Inn State Historical Park information sheet. PWD-OF-4507-114A. Austin.

Texas Parks and Wildlife Department. 1994. San Jacinto Battleground Historical Complex information sheet. PWD-BR-P4504-088. Austin.

Texas Parks and Wildlife Department. 1994. Stephen F. Austin State Historical Park information sheet. PWD-MP-P450-051A. Austin.

Texas Parks and Wildlife Department. 1995a. Texas threatened and endangered species. PWD LF R3000-017. Austin.

Texas Parks and Wildlife Department. 1995b. Black bear status. Job No. 68. Federal Aid Project No. W-125-R-6. Wildlife Research and Surveys, Nongame Resources. Austin.

Texas Parks and Wildlife Department. 1995c. Texas outdoor recreation inventory.

Statewide Planning and Research. Austin. Texas Parks and Wildlife Department. 1995d. Lake Houston State Park trail map. Austin.

Texas Natural Resource Conservation Commission. 1996. The state of Texas water quality inventory, 13th Ed., Texas Natural Resource Conservation Commission, Austin, Texas,

Texas Water Development Board. 1990. Evaluation of water resources of Orange and western Jefferson Counties, Texas. Report 320. Austin.

Texas Water Development Board. 1992. The State of Texas water quality inventory. 11th Edition. Austin.

Texas Water Development Board. 1995. Water For Texas: Trans-Texas Water Program. Austin, Texas.

Udvardy, M.D.F. 1977. The Audubon Society field guide to North American birds: western region. Alfred A. Knopf, Inc. New York.

United States Army Corps of Engineers. 1994. Environmental assessment and statement of findings, permit application 19611. Department of the Army, Galveston District. Galveston, Texas.

United States Fish and Wildlife Service. 1992. Houston toad (*Bufo houstonensis*). Unpublished information data sheet. Clear Lake Field Office, Department of the Interior. Houston, Texas.

United States Fish and Wildlife Service. 1994. County-by-county listings of threatened and endangered species and candidate species within Clear Lake (Texas) Field Office area of responsibility. Department of the Interior. Houston, Texas.

Wayne Smith and Associates, Inc. 1987. Feasibility Study, Interbasin Transfer, Sabine to San Jacinto. Houston, Texas.

Wetmore, A. 1964. Song and garden birds of North America. National Geographic Society. Washington, DC.

Wheeler, F.F. 1976. Soil Survey of Harris County, Texas. U.S. Department of Agriculture. Washington, DC.

Woodard, D.W., 1980. Selected vertebrate endangered species of the seacoast of the United states - Arctic peregrine falcon. FWS/OBS - 80/01.51. U.S. Fish and Wildlife Service. Washington, DC.

Appendix B
List of Threatened, Endangered, and Candidate Species Occurring in the Southeast Area

The following species are known to occur, either as residents or migrants, within the Southeast Area of the Trans-Texas Water Program. Table B.1 provides a listing of each segment analyzed in this report and indicates whether or not a threatened, endangered, or candidate species' range overlaps a particular segment corridor.

The interior least tern (*Sterna antillarum athalassos*) is a federally listed and state-listed endangered species. It is still fairly common along the eastern and Gulf coasts. However, populations are declining inland and along the west coast (Scott, 1987) due to habitat destruction and riverine alterations (TOES, 1988).

The Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*) is listed by the TPWD and USFWS as endangered. This species prefers coastal prairies with a mixture of agricultural lands. Prairie chickens use low growth areas during the breeding period in spring. Afterwards they need the regrowth from the herbaceous layer for concealment and nesting cover. The largest known wild population of the prairie chicken is located at the Attwater's Prairie Chicken National Wildlife Refuge near the town of Eagle Lake. Habitat destruction and flooding of nests have been the primary factors for this species' decline (Arroyo, 1992).

The red-cockaded woodpecker (*Picoides borealis*) is a federally listed and state-listed endangered species. This woodpecker species prefers mature to over-mature (75 to 126 years old) southern pines with heart rot for roosting and nesting. (Arroyo, 1992). Foraging can occur in a variety of habitat types based on food availability and proximity to cavity-tree sites. Reasons for the red-cockaded woodpecker's decline include timber harvesting practices, wildfire suppression agricultural practices, roadways, and urban expansion (Burnside and James, 1993).

The brown pelican (*Pelecanus occidentalis*) is a federally listed and state-listed endangered species that occurs primarily along the coast. Brown pelicans rarely travel far inland or seaward, preferring to live along the bays and estuaries. Historic use of pesticides, which resulted in lower reproductive rates, and disturbance human have been primary reasons for the brown pelican's decline (TOES, 1988).

TABLE B.1
Endangered and Threatened Species Potentially Occurring
Within the Trans-Texas Water Program's Southeast Area

	STATUS[1]		SEGMENT															
BIRDS:	USFW	TPWD	SN-1	SN-4a	SN-4b	NT-1a	NT-3a	NT-3b	TS-2a	TS-3a	TS-3b	TS-4a	TS-4b	SB-1a	SB-1b	SB-1c	SB-3	TB-1
Interior Least Tern	E	E		X	X		X	X	X				X			X		X
Attwater's Greater Prairie Chicken	E	E				X	X		X	X	X	X	X		X	X		
Red-Cockaded Woodpecker	E	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brown Pelican	E	E		X	X		X	X	X		X	X	X					
Whooping Crane	E	E													X	X	X	X
Arctic Peregrine Falcon	E(S/A)	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Bald Eagle	T	E	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Piping Plover	T	T					X	X					X					
Bachman's Sparrow	--	T	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
White-Faced Ibis	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Reddish Egret	--	T	X	X	X	X	X	X	X	X	X	X	X					
American Swallow-Tailed Kite	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Wood Stork	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
White-Tailed Hawk	--	T							X		X	X	X			X		
Mountain Plover	C	--													X			
MAMMALS:																		
Black Bear	T(S/A)	E	X	X	X	X	X	X	X	X	X	X	X					X
Refinesque's Big-Eared Bat	--	T	X	X	X	X	X	X	X	X	X	X	X					X

TABLE B.1
Endangered and Threatened Species Potentially Occurring Within the Trans-Texas Water Program's Southeast Area

	STATUS[1]		SEGMENT															
REPTILES/AMPHIBIAN:	USFW	TPWD	SN-1	SN-4a	SN-4b	NT-1a	NT-3a	NT-3b	TS-2a	TS-3a	TS-3b	TS-4a	TS-4b	SB-1a	SB-1b	SB-1c	SB-3	TB-1
Houston Toad	E	E				X	X		X	X	X	X	X		X	X		
Louisiana Pine Snake	--	E	X	X	X	X	X	X	X	X	X	X	X					X
Western Smooth Green Snake	--	E				X	X	X	X	X	X	X	X		X	X		
Texas Horned Lizard	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Alligator Snapping Turtle	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X		X
Northern Scarlet Snake	--	T	X	X	X	X	X	X	X	X	X	X	X					
Timber Rattlesnake	--	T	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
FISH:																		
Paddlefish	--	E	X	X	X	X	X	X	X	X	X	X	X					X
Blue Sucker	--	T	X	X	X	X	X	X							X	X	X	X
Creek Chubsucker	--	T	X			X	X		X	X	X	X	X		X	X		X
Blackside Darter	--	T	X															
VEGETATION:																		
Prairie Dawn	E	E							X		X	X	X					
Texas Trailing Phlox	E	E	X			X	X											
Navasota Ladies'-Tresses	E	E															X	X

[1] Status according to 50 Code of Federal Regulations 17.11 - 17.12 (1996) and the Texas Parks and Wildlife Department (1995a). E - Endangered, T - Threatened, E [or T] (S/A) - Similarity of Appearance to listed species.

The whooping crane (*Grus americana*) is listed as endangered by the USFWS and TPWD. The main population of this species breeds in Wood Buffalo National Park, Alberta, Canada, and winters at the Aransas National Wildlife Refuge on the Gulf coast of Texas (Scott, 1987). Major winter foods are found in estuarine habitats, although the whooping crane will feed on acorns, insects, and berries (Lewis, 1986).

The Arctic peregrine falcon (*Falco peregrinus tundrius*) is listed as threatened by the TPWD. The USFWS recently removed the Arctic peregrine falcon from its list of threatened species. However, all free-flying peregrine falcons in the lower 48 states are listed as endangered under the similarity of appearance provisions of the Endangered Species Act. Therefore, the Arctic peregrine falcon would be protected as endangered in Texas. This species prefers cliff ledges for nesting sites but also will use cutbanks, dikes, or low mounds. Nesting occurs only near a water source such as a river, lake, or marine body (Woodard, 1980).

The bald eagle (*Haliaeetus leucocephalus*) is listed as threatened by the USFWS and endangered by the TPWD. This species prefers to nest in trees or tall cliffs near seacoasts, rivers, or lakes. Fish constitute the main prey item, but the bald eagle is an opportunistic feeder and will consume various types of carrion. Pesticide contamination, human encroachment, and illegal taking are the primary causes for the bald eagle's decline (Scott, 1987).

The piping plover (*Charadrius melodus*) is listed by the USFWS and TPWD as a threatened species. Nesting occurs on sandy beaches of lakes; bare areas on dredge-created and natural alluvial islands in rivers; gravel pits along rivers; salt-encrusted bare areas of sand, gravel, or pebbly mud on alkaline lakes and ponds; fly-ash disposal ponds; dike roads adjacent to lakes; and gravel roads and parking lots. Winter habitat includes beaches, sandflats, mudflats, algal mats, and dunes (Arroyo, 1992). Habitat destruction is the primary reason for the decline of the piping plover (TOES, 1988).

The Bachman's sparrow (*Aimophila aestivalis*) is listed as threatened by the TPWD. This species prefers open areas of oak or pine woodlands with an undergrowth of scrub palmetto. Insects form the majority of this sparrow's diet, with the remainder of the diet comprised of seeds (Wetmore, 1964). This species is known to occur only within the eastern one-third of Texas.

The white-faced ibis (*Plegadis chihi)* is listed as threatened by the TPWD. This species prefers freshwater marshes, sloughs, and irrigated rice fields, as well as salt marsh habitats. At one time, this species bred further inland, but it is now confined to coastal rookeries (Oberholser, 1974).

The reddish egret (*Egretta rufescens*) is listed as threatened by the TPWD. This species occurs along the coast from Texas to Florida. The reddish egret is strongly tied to coastal salt bays and marshes and nests in *Yucca* spp. - pricklypear (*Opuntia* spp.) thickets on dry islands (Oberholser, 1974).

The American swallow-tailed kite (*Elanoides forficatus*) is listed as threatened by the TPWD. Individuals of this species are regularly observed along the Texas coast during migration and have been sporadically recorded throughout the southwestern United States. Swallow-tailed kites prefer to breed in areas near water, such as wetlands, rivers, and lakes. Habitats necessary for year-long needs generally consist of bottomland hardwood forests with adjacent semiprairie, freshwater marshes, and bald cypress swamps (Oberholser, 1974). Prey items include flying insects, frogs, lizards, snakes, and bird nestlings (Clark and Wheeler, 1987).

The wood stork (*Mycteria americana*) is listed as threatened by the TPWD. This species prefers to feed in wet areas such as swamps, ponds, wet meadows, and coastal shallows (Scott, 1987). Postbreeding dispersals have resulted in storks scattering as far as the United States-Canada border (Oberholser, 1974). Loss of habitat is the primary reason for the wood stork's decline (TOES, 1988).

The white-tailed hawk (*Buteo albicaudatus*) is listed by the TPWD as threatened. This hawk species is found in open coastal grasslands and semiarid inland brush country (Clark and Wheeler, 1987). Unlawful shooting and habitat destruction are the primary reasons for the decline of the white-tailed hawk (TOES, 1988).

The mountain plover (*Charadrius montanus*) is listed as a Candidate species by the USFWS. This species occurs in upland areas characterized as dry short-grass prairie or plains away from water. Prey items consist of insects, and feeding occurs within small flocks. Cultivation of the prairie belt is the prime factor in the mountain plover's decline (Udvardy, 1977).

The black bear (*Ursus americana*) is listed as endangered by the TPWD and threatened by the USFWS. The basis for the threatened listing by the USFWS is due to similarity of appearance with the Louisiana black bear. The black bear prefers bottomland hardwood and floodplain forests, with lesser preference for upland hardwood forest, mixed pine/hardwood forest, wetlands, and agricultural fields. Denning often occurs in larger bald cypress and tupelo-gum trees with visible cavities in or along rivers, lakes, streams, and other water bodies (USFWS, 1994). The black bear has been restricted by civilization to remote mountainous areas or to impenetrable thickets along water courses (Davis and Schmidly, 1994). The black bear is occasionally sighted in East Texas. These bears are considered wanderers from Louisiana although some native bears may exist in Texas (TPWD, 1995).

The Raffinesque's big-eared bat (*Plecotus rafinesquii*) is listed as threatened by the TPWD. This species prefers forested areas and will roost in hollow trees, crevices behind bark, and under dry leaves, as well as partially lit buildings and other man-made structures such as wells and cisterns. Winter aggregations of both sexes are common, but solitary individuals are frequently found. Little is known of its diet, but it probably prefers night-flying insects (Davis and Schmidly, 1994; and Schmidly, 1983). Habitat destruction in combination with the species' naturally low numbers are responsible for the big-eared bat's decline (TOES, 1988).

The Houston toad (*Bufo houstonensis*) is listed as endangered by the USFWS and TPWD. This species prefers rolling uplands with native grass meadows interspersed with pine and oak woodlands. Deep sandy soils or loamy sandy soils are evidently necessary for hibernation and aestivation. The Houston toad also requires standing bodies of water which last a minimum of 30 days for breeding. These water bodies include ephemeral rain pools, flooded fields, blocked drainages, and permanent ponds which contain shallow water (USFWS, 1992).

The Louisiana pine snake (*Pituophis melanoleucus ruthveni*) is listed as endangered by the TPWD. This species occurs only in hardwood-conifer communities of East Texas and Louisiana. Historically fairly common, this species is rare within Texas according to recent estimates (Tennant, 1985). Logging, cultivation, and urbanization are the prime reasons for the pine snake's decline (TOES, 1988).

The western smooth green snake (*Liochlorophis vernalis*) is listed as endangered by the TPWD. The green snake prefers mesic prairie communities covered with native short grasses. These mesic communities are not as abundant as before, which may contribute to the decline of this species. Prey items include insects, spiders, and snails (Tennant, 1985).

The Texas horned lizard (*Phrynosoma cornutum*) is listed as threatened by the TPWD. This species occurs throughout a broad range, including Texas, Oklahoma, parts of adjoining states, and Mexico. This species has been virtually eliminated from its former range in Southeast Texas. Several factors, such as pesticide use on fire ants, habitat alteration, commercial exploitation, and heavy agricultural use, are thought to be responsible for the Texas horned lizard's decline (Price, 1990).

The alligator snapping turtle (*Macroclemys temmincki*) is listed as threatened by the TPWD. This species occurs throughout the eastern part of Texas in rivers, lakes, and large streams with muddy bottoms. It leaves the water only to lay eggs (Garrett and Barker, 1987).

The northern scarlet snake (*Cemophora coccinea copei*) is listed as threatened by the TPWD. This species occurs in a variety of habitats, including woodlands, open areas, swamps, stream banks, and agricultural fields. The preferred prey item for this species appears to be reptile eggs (Tennant, 1985). Habitat destruction is the primary reason for the northern scarlet snake's decline (TOES, 1988).

The timber rattlesnake (*Crotalus horridus autricaudatus*) is listed as threatened statewide by the TPWD. This species is an uncommon but widely distributed species across the eastern third of Texas. Although primarily associated with dense, low-growth vegetation in forest clearings and along riparian corridors, the timber rattlesnake also is found in overgrown thickets around farmsteads and urban areas (Tennant, 1984). Reservoir impoundments, draining, and habitat destruction are the primary reasons for the timber rattlesnake's decline (TOES, 1988).

The paddlefish (*Polyodon spathula*) is listed as an endangered species by the TPWD. A planktivore, the paddlefish is one of the largest freshwater fish and is native only to North America. Its range historically extended from the Great Lakes throughout the large streams of the Mississippi Valley and adjacent Gulf slope drainages as well as through the easternmost portions of Texas. The fish were documented in the Neches and Angelina rivers as early as 1897 and were abundant in the natural oxbow lakes and ponds throughout the floodplain of the Neches River from 1920 to 1940. However, populations have subsequently declined, and in 1977 the fish was placed on the Texas State Endangered Species List. Its decline has been attributed to commercial and recreational harvest as well as decreased habitat availability and water quality resulting from dam construction, channelization, logging, pollution, urbanization, and industrialization (Boschung, et al., 1983).

In 1989, the TPWD initiated the Paddlefish Recovery Plan in an effort to restore populations within their native Texas range. The Neches River was selected as the initial recovery area, with target recovery areas including the Neches River basin and two major tributaries, Pine Island Bayou and Village Creek; B.A. Steinhagen Reservoir; the Angelina River basin beginning at the headwaters of Steinhagen Reservoir; and Sam Rayburn Reservoir. The TPWD has begun a stocking program in these areas in 1989, and it will continue over the next three years (Pitman, 1992).

Table B.2 depicts the numbers of paddlefish stocked to date in the rivers within the TTWP Southeast Study Area. Stocking was begun in 1989 and involved initially only the Neches River. In 1990 both the Neches and Trinity rivers were stocked with a total of 137,504 paddlefish. The Sabine and Angelina rivers were added to the stocking program in 1991. Big Cypress Bayou and Sulphur River were added to the stocking program in 1992, and a total 221,422 paddlefish were stocked. Each of these waterways was stocked from 1992 to 1995. As of August 28, 1996, 70,206 paddlefish have been stocked in the Neches, Angelina, Sabine, and Trinity rivers (TPWD, unpublished data).

Life history information for the fish gathered from historic records and from hatcheries in other states indicated that during summer, the paddlefish use bayous, oxbow lakes, backwaters, and reservoirs with abundant zooplankton for feeding. In the winter, the fish inhabit deeper (greater than three meters) still-water areas which provide refuge from river currents. When water temperatures rise from 50 to 63 degrees in the spring, sexually mature paddlefish migrate to spawning areas in deep pools at the mouths of tributaries. Spawning migrations of over 240 miles have been documented. In addition to changes in temperature and photoperiod, the actual spawning run is triggered by a sudden, 10- to 20-foot rise in water elevation. Spawning occurs in well-oxygenated water over clean gravel substrate (U.S. Army Corps of Engineers, 1994).

The blue sucker (*Cycleptus elongatus*) is listed as threatened by the TPWD. This species prefers deep river channels with a firm substrate and good flow. The numbers of blue suckers has declined since the beginning of the century due to siltation, pollution, and dams (Boschung, et al., 1983).

The creek chubsucker (*Erimyzon oblongus*) is listed as threatened by the TPWD. This species occurs in creeks and small rivers with soft bottoms, slow current, and vegetation. The creek chubsucker appears to be intolerant of silty streams (Boschung, et al., 1983).

The blackside darter (*Percina maculata*) is listed as threatened by the TPWD. This species prefers clear water of riffles and pools in large creeks and rivers over sand, gravel, or rocks. The darter is often found around vegetation and debris. Young feed on small crustaceans while adults feed on aquatic insects (Boschung et al., 1983). Impoundments and siltation are the main reasons for this species decline (TOES, 1988).

Table B.2

Paddlefish Stocking Rates
within the Trans-Texas Southeast Study Area

	Stocking Rate for Each Waterway						
Year	Neches River	Trinity River	Angelina River	Sabine River	Big Cypress Bayou	Sulphur River	Total
1989	31,986	--	--	--	--	--	31,986
1990	74,247	63,257	--	--	--	--	137,504
1991	24,420	50,381	28,974	34,179	--	--	137,954
1992	10,827	20,371	43,584	106,278	28,371	11,991	221,422
1993	4,815	28,003	43,777	42,403	10,986	12,086	142,070
1994	5,000	26,691	35,028	41,070	5,130	5,728	118,647
1995	4,701	26,826	71,529	54,798	4,710	4,975	167,539
1996[1]	4,945	24,022	24,825	16,414	--	--	70,206
	160,941	239,551	247,717	295,142	49,197	34,780	1,027,328

Source: Unpublished data from TPWD dated August 27, 1996.

[1] Data records through August 28, 1996.

The prairie dawn (*Hymenoxys texana*) is listed as endangered by the USFWS and TPWD. This species occurs in poorly drained depressions or at the base of mima mounds in open grassland in mostly barren areas (Poole and Riskind, 1991).

The Texas trailing phlox (*Phlox nivalis ssp. texensis*) is listed as endangered by the USFWS and TPWD. This species prefers open, longleaf pine savannahs, fire-maintained pinelands, and the edges of young pine plantations on deep, sandy soil (Poole and Riskind, 1987).

The Navasota ladies'-tresses (*Spiranthes parksii*) is listed as endangered by the USFWS and TPWD. This species prefers open wooded margins of slightly eroded, intermittent, minor tributaries of the Brazos and Navasota rivers. This orchid is typically found growing with post oak, blackjack oak, yaupon, American beautyberry, and little bluestem (Poole and Riskind, 1987).

Appendix C
List of Prime Farmland Soils Within the Southeast Area

Table C.1
List of Prime Farmland Soils within Southeast Area

Abbreviation	Soil Description
Ad	Addicks Loam
AdA	Aldine Silt Loam, 0 to 2 percent slopes
Ae	Aldine-Aris complex
An	Anahuac-Aris Complex
Ar	Aris Silt Loam
ArA	Aris Fine Sandy Loam, 0 to 1 percent slopes
Ba	Beaumont Clay
Bd	Bernard Clay Loam
Be	Bernard Clay Loam
BeB	Besner-Mollville Complex, gently undulating
BeC	Bernaldo Fine Sandy Loam, 3 to 8 percent slopes
Bm	Bernard-Morey Complex
BoB	Brazoria Clay, 1 to 3 percent slopes
BrA	Brazoria Clay, 0 to 1 percent slopes
Bu	Burleson Clay, 0 to 1 percent slopes
Cd	Clodine Loam
ChC	Chazos Loamy Fine Sands, 1 to 5 percent slopes
ChD	Chazos Loamy Fine Sands, 5 to 8 percent slopes
CuC	Cuero Clay Loam, 1 to 5 percent slopes
DaA	Dallardsville Loamy Very Fine Sand, 0 to 2 percent slopes
DaB	Dallardsville Loamy Very Fine Sand, 1 to 3 percent slopes
FrC	Frelsburg Clay, 1 to 5 percent slopes
Ho	Hockley Fine Sandy Loam
HoA	Hockley Fine Sandy Loam, 1 to 3 percent slopes
HoB	Hockley Fine Sandy Loam, 1 to 4 percent slopes
HoC	Hockley Fine Sandy Loam, 3 to 5 percent slopes
HpC	Hockley Gravelly Fine Sandy Loam, 1 to 5 percent slopes
Hs	Houston Black Clay
Ka	Kaman Clay, occasionally flooded
KaA	Katy Fine Sandy Loam, 0 to 1 percent slopes
KaB	Katy Fine Sandy Loam, 1 to 3 percent slopes
Kr	Kirbyville Fine Sandy Loam (Liberty)
Kr	Kirbyville Fine Sandy Loam, 0 to 1 percent slopes
KuA	Kirbyville Fine Sandy Loam, 0 to 2 percent slopes
LaA (LcA)	Lake Charles Clay, 0 to 1 percent slopes
My	Mocarey-Yeaton Complex
NoA	Norwood Silt Loam, 0 to 1 percent slopes

Abbreviation	Soil Description
NrA	Norwood Silty Clay Loam, 0 to 1 percent slopes
Oc	Ochlockonee Soils, occasionally flooded
OkA	Oklared Very Fine Sandy Loam, 0 to 1 percent slopes
On	Ozan-Urban Land Complex
OtA	Otanya Fine Sandy Loam, 0 to 3 percent slopes
Oyb	Otanya Fine Sandy Loam, 1 to 3 percent slopes
Oz	Owentown Fine Sandy Loam, Occasionally Flooded
PfB	Pinetucky Fine Sandy Loam, 1 to 5 percent slopes
RaA	Rader Fine Sandy Loam, 0 to 1 percent slopes
Sa	Segno Fine Sandy Loam (Liberty)
Sd	Sorter-Dallardsville Comples
Se	Segno Fine Sandy Loam (Montgomery)
SMB	Spurger-Mollville Association, gently undulating
So	Sorter Silt Loam
Sp	Splendora Fine Sandy Loam
SpB	Splendora Fine Sandy Loam, 0 to 3 percent slopes
SrB	Spurger Fine Sandy Loam, 0 to 2 percent slopes
SwB	Spurger-Waller Complex, 0 to 2 percent slopes
Um	Urbo-Mantachie, frequently flooded
VaA	Vamont Clay, 0 to 1 percent slopes
Vab	Vamont Clay, 1 to 4 percent slopes
Vd	Vamont Silty Clay, Depressional
Wa	Waller Loam
WaA	Waller Silt Loam, 0 to 1 percent slopes
Wd	Waller-Dallardsville Comples
Wk	Waller-Kirbyville Complex, 0 to 1 percent slopes
Wn	Waller-Splendora Complex
Wo	Wockley Fine Sandy Loam
WoA	Wockley Fine Sandy Loam, 0 to 1 percent slopes
WoB	Wockley Fine Sandy Loam, 1 to 3 percent slopes
6	Bleiblerville Clay, 1 to 3 percent slopes (Washington)
7	Bleiblerville Clay, 3 to 5 percent slopes (Washington)
18	Carbengle Clay Loam, 1 to 3 percent slopes (Washington)
19	Carbengle Clay Loam, 3 to 5 percent slopes (Washington)
21	Chazos Loamy Fine Sand, 1 to 5 percent slopes
24	Clemville Silt Loam, 1 to 3 percent slopes (Washington)
31	Frelsburg Clay, 1 to 3 percent slopes (Washington)
32	Frelsburg Clay, 3 to 5 percent slopes (Washington)
33	Leson Clay, 0 to 3 percent slopes (Walker)
36	Greenvine Clay, 3 to 5 percent slopes (Washington)
43	Latium Clay, 3 to 5 percent slopes (Washington)
61	Silawa Loamy Fine Sand, 1 to 5 percent slopes
68	Trinity Clay, occasionally flooded (Washington)

Appendix D
Recreation Areas Near Proposed Segment Transfer Routes

Table D.1
Recreation Areas near Proposed Segment Transfer Routes

Route	Recreation Areas
SN-1	Toledo Bend Reservoir Sabine National Forest Angelina National Forest Angelina River B.A. Steinhagen Lake
SN-4a	Sabine Island Wildlife Game Management Area Big Thicket National Preserve
SN-4b	Sabine River Sabine Island Wildlife Game Management Area Big Thicket National Preserve Neches River
NT-1a	B.A. Steinhagen Lake Trinity River
NT-3a	Cotton Creek Willow Creek
NT-3b	Big Thicket National Preserve China City Park Trinity River
TS-2a	San Jacinto River
TS-3a	Greens Bayou San Jacinto River
TS-3b	Lake Houston State Park San Jacinto River
TS-4a	Trinity River Cedar Bayou Lake Houston
TS-4b	Mussel Shoals/Big Tupelo Breaks San Jacinto River San Jacinto Battleground State Historical Complex
SB-1a	W.G. Jones State Park Brazos River
SB-1b	W.G. Jones State Park Spring Creek Brazos River
SB-1c	W.G. Jones State Park Spring Creek Brazos River
SB-3	Somerville Lake
TB-1	Lake Livingston Harmon Creek Gibbons Creek Reservoir Brazos River