APPENDIX O: ALTERNATIVES DISMISSED FROM DETAILED CONSIDERATION

References cited can be found in Chapter 6 of the EIS

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TABLES:

FIGURES:

In Chapter 2 of the Revised Draft Environmental Impact Statement (Revised DEIS) for the proposed Lower Bois d'Arc Creek Reservoir (LBCR) project, the following alternatives were dismissed from detailed consideration in Chapters 3 and 4 for the reasons indicated below.

1.0 ALTERNATIVES THAT DO NOT REQUIRE A SECTION 404 PERMIT

Three alternatives – new groundwater supplies, desalination, and water conservation – would not have required North Texas Municipal Water District (NTMWD) to apply for a Section 404 permit because they do not entail placing fill into waters of the United States under U.S. Army Corps of Engineers (USACE) jurisdiction.

1.1 NEW GROUNDWATER SUPPLIES

Groundwater comprises 30 percent of the Earth's fresh water. On a global scale, it is far more abundant than the planet's liquid surface fresh water, and in the United States groundwater comprised 41 percent of all non-thermoelectric (non-thermal power plant related) water withdrawals in 2010 (USGS, 2016b). However, new groundwater supplies are limited and inadequate to meet NTMWD's needs.

Figure 1 shows the major groundwater aquifers in Texas. Under Senate Bill (SB) 2, passed in 2001, Texas began a groundwater Joint Planning effort. Previous groundwater regulation was strictly limited to the jurisdiction of the individual Groundwater Conservation Districts (GCDs). However, the Texas Water Development Board's (TWDB's) Joint Planning effort created 16 Groundwater Management Areas (GMAs) in Texas based on hydrogeologic and aquifer boundaries. GMAs are intended to provide management guidance over common aquifers. The GMAs are comprised of the GCDs that fall within the boundary of the GMA (Freese and Nichols, 2015h). GMA 8 covers all of Region C except for Jack County, Henderson County, and a small portion of Navarro County (Region C Water Planning Group, 2010).

The GMAs are responsible for developing Desired Future Conditions (DFCs) for aquifers within their respective areas. DFCs are defined in the Texas Administrative Code as the desired, quantified condition of groundwater resources (such as water levels, water quality, spring flows, or volumes) for a specified aquifer within a management area at a specified time or times in the future. TWDB then quantifies Managed Available Groundwater (MAG) based on the DFCs provided by the GMAs. The MAG is the amount of groundwater that models predict may be produced under a permit to meet the DFC established by the GMA for that particular aquifer.

In Texas water planning, groundwater use cannot exceed MAG values. The GMAs have adopted the MAG values and they are included in the 2016 regional water planning process. For the 2011 regional water plans, only a few GMAs had adopted MAG values prior to the development of the plans. Consequently, water that may have been shown as available in the 2011 regional water plans may not be available at present (Freese and Nichols, 2015h).

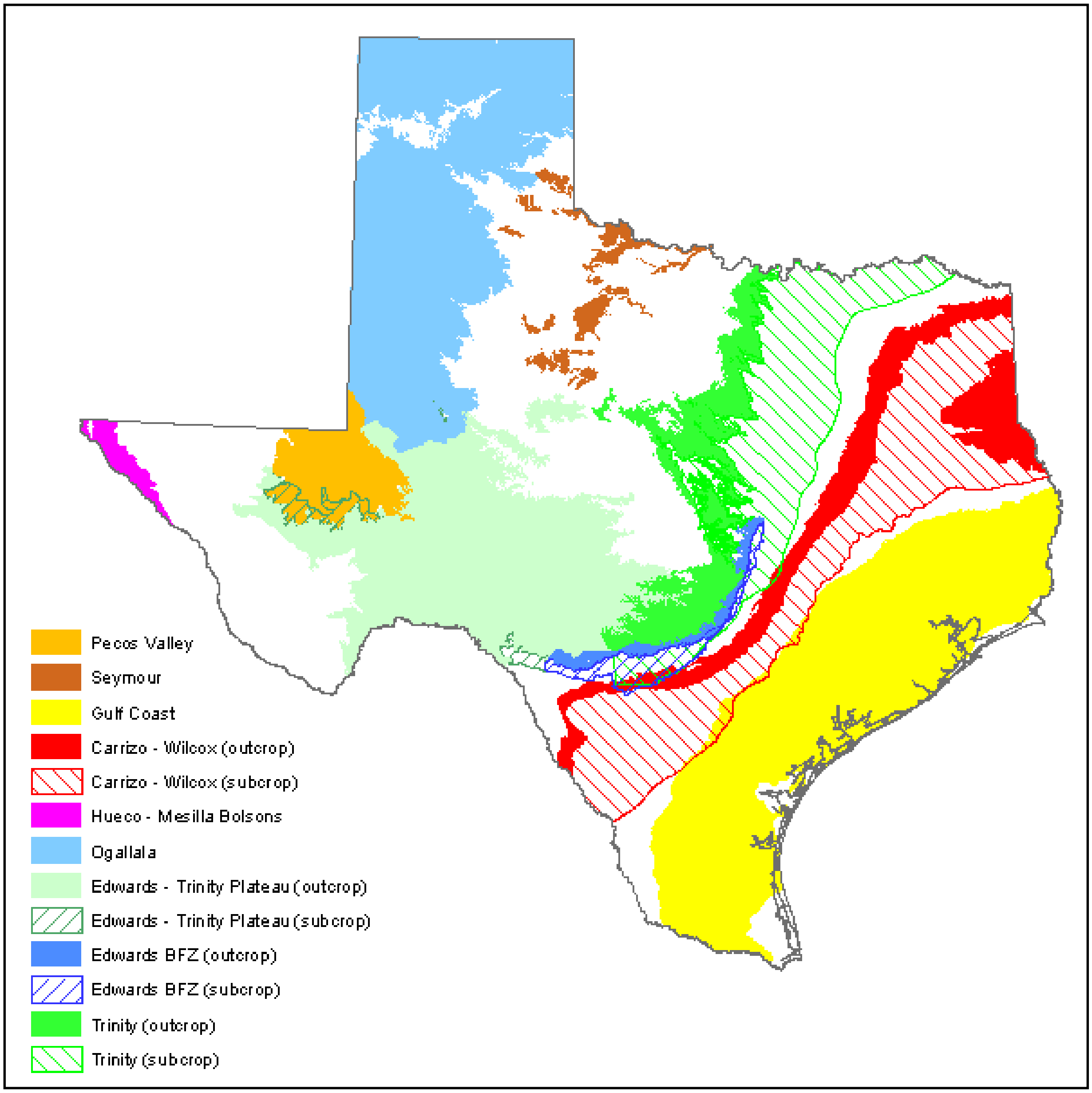

Figure 1. Major Aquifers of Texas

Source: TWDB, no date-b

The *2011 Region C Water Plan* identified two potential groundwater sources for NTMWD: 1) Roberts County groundwater from the Ogallala Aquifer; and 2) Brazos County groundwater from the Carrizo-Wilcox Aquifer. At present, neither of these projects is listed as a recommended or alternative strategy in the *2016 Region C Water Plan* and, therefore, neither is considered viable (Region C Water Planning Group, 2015).

1.1.1 Roberts County Ogallala Aquifer Groundwater Alternative

Roberts County is located in the panhandle of Texas. Prior to 2011, Mesa Water, Inc. controlled rights to groundwater in Roberts County with options for additional supply and had permits from the local groundwater conservation district to export groundwater. Mesa Water had been interested in selling groundwater from the Ogallala Aquifer in Roberts County to water suppliers in North Texas; however, Mesa Water sold these rights to the Canadian River Municipal Water Authority on June 23, 2011. With the completion of this sale, this water supply alternative is no longer available to NTMWD.

1.1.2 Brazos County Carrizo-Wilcox Aquifer Groundwater Alternative

The Carrizo-Wilcox Aquifer covers a large area of east, central, and south Texas, including Brazos County (Figure 1). Brazos County is about 150 miles from the NTMWD service area. Because of this distance – over which a pipeline would have to be built and operated, including pumping costs – this alternative is a relatively expensive source of supply for the NTMWD. Moreover, the Bureau of Economic Geology (BEG) has identified a potential conflict for the Carrizo-Wilcox Aquifer in Brazos County in 2020 because the sum of the county's currently available supplies and water management strategies exceeds the MAG in that year (BEG, 2011). MAG values are smaller than previous estimates of availability and the water supply potentially available for export from the Carrizo-Wilcox Aquifer in Brazos County is thus reduced. Overall, due to high cost considerations, uncertain availability, and competition for this water source, the Carrizo-Wilcox groundwater alternative is not considered a viable alternative to the Proposed Action.

1.1.3 Freestone and Anderson Counties Carrizo-Wilcox Aquifer Groundwater (Region I)

The *2016 Region C Water Plan* states that development and export of water supplies from Freestone, Anderson, and surrounding counties has been under study, and that Dallas Metroplex wholesale water suppliers have been approached as possible customers (Region C Water Planning Group, 2015). The 2016 plan shows Carrizo-Wilcox groundwater from Freestone and Anderson counties as an alternative strategy for NTMWD. The quantity potentially available to NTMWD is listed as 42,000 acre-feet per year (AFY), at a capital cost of $230 million, and cost per thousand gallons of $1.86 with debt service and $0.42 after debt service. The Region C Water Planning Group (2015) rates the reliability as high, environmental factors as medium, agricultural and rural impacts as medium, other natural resources impacts as medium to high, third party impacts as medium, and key water quality parameters as low. However, this alternative would require cooperation with local GCDs and there are potentially competing uses for the water. In any case, 42,000 AFY is only about 40 percent of the stated purpose and need of 105,804 AFY by 2025.

More recent analysis casts doubt on whether even 42,000 AFY would be available from this alternative. The amount of water that could be permitted from both the Carrizo-Wilcox and Queen City aquifers under the current MAG value is about 21,000 AFY, only half of the proposed total quantity for this strategy. With the current MAG values, it is unclear whether this well field could be permitted without changes to the DFCs (Freese and Nichols, 2016a).

Developing water from Anderson County in particular is a strategy sponsored by the Forestar Group, Inc. (Forestar). Forestar has groundwater holdings in a number of east Texas counties, including Anderson County, south of Lake Palestine. Forestar's groundwater holdings in Anderson County are depicted in Figure 2. They lie in the eastern portion of the county within the Neches River Basin (Freese and Nichols, 2016a).

The concept behind this alternate strategy would be to develop a well field in eastern Anderson County and pump the groundwater to NTMWD's existing pump station near Lake Tawakoni. NTMWD has an interim contract with the Sabine River Authority (SRA) for 40,000 AFY of water from Lakes Tawakoni and Fork (Sabine Basin supplies), but this contract expires in 2025. Some of NTMWD's supply from the Sabine Basin is currently treated at a local water treatment plant (WTP) near Lake Tawakoni and delivered to the city of Terrell. The rest of the Sabine Basin supply is transported to Lake Lavon for subsequent diversion and treatment. The proposed groundwater source in Anderson County would provide up to 42,000 AFY of water to NTMWD, potentially replacing the interim supplies from the SRA due to expire in 2025 (Freese and Nichols, 2016a).

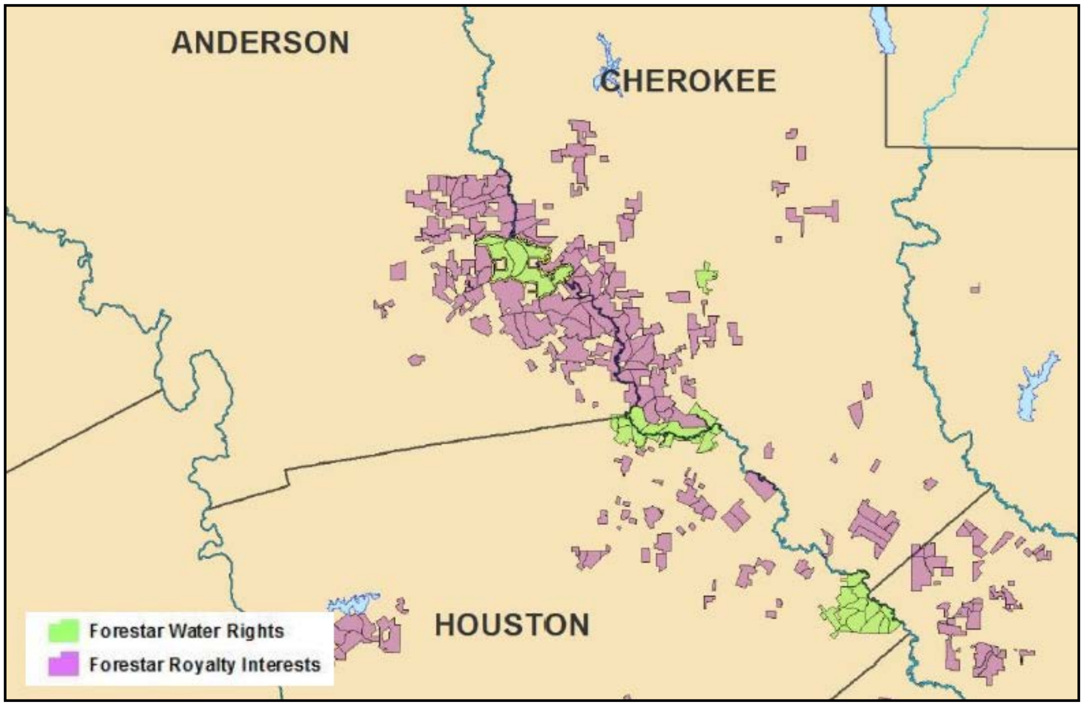

Figure 2. Forestar Group, Inc. Holdings in Anderson and Neighboring Counties

Under this strategy, new facilities would be needed from the well field to NTMWD's existing 84-inch East Fork Wetlands Project pipeline. The groundwater would then be transmitted to Lake Lavon using the existing 84-inch pipeline. Additional infrastructure for this project would include a new well field, pumping station, raw water pipeline from the well field to the Lake Tawakoni WTP, and a new pumping station and 60-inch pipeline from the water plant to the existing 84-inch East Fork Wetlands Project pipeline.

Anderson County is located in the Neches and Trinity Valley GCD, which would be responsible for permitting the well field, including setting the permitted amount that could be withdrawn. Current Neches and Trinity Valley GCD rules do not allow for such a permit. Thus, these rules would need to be modified before any development could occur. Moreover, the Neches and Trinity Valley GCD would need to agree to changes to the DFCs. Furthermore, issuance of a permit would probably require notification of all existing permittees within the GCD, and with the proposed quantity of 42,000 AFY (which is 2-3 times the total current use within the county), it may be protested by existing permit holders. This may result in a contested case hearing, which could substantially delay permit issuance or even result in denial of the permit (Freese and Nichols, 2016a).

In conclusion, groundwater from Anderson County does not meet the quantity criterion of the purpose and need and may not meet the timeframe criterion either. Thus, this alternative is not considered a reasonable alternative.

1.1.4 Other Groundwater Supplies in Region C

Two major aquifers and four minor aquifers supply groundwater in Region C. The two major aquifers are the Trinity and the aforementioned Carrizo-Wilcox. The four minor aquifers are the Woodbine, Queen City, Nacatoch, and locally undifferentiated formations referred to collectively as the "other aquifer." The Nacotoch and Queen City aquifers are known to have limited supplies and water quality issues, and therefore are not utilized extensively. Figure 3 shows Region C counties overlaid atop local aquifers that may serve as groundwater sources.

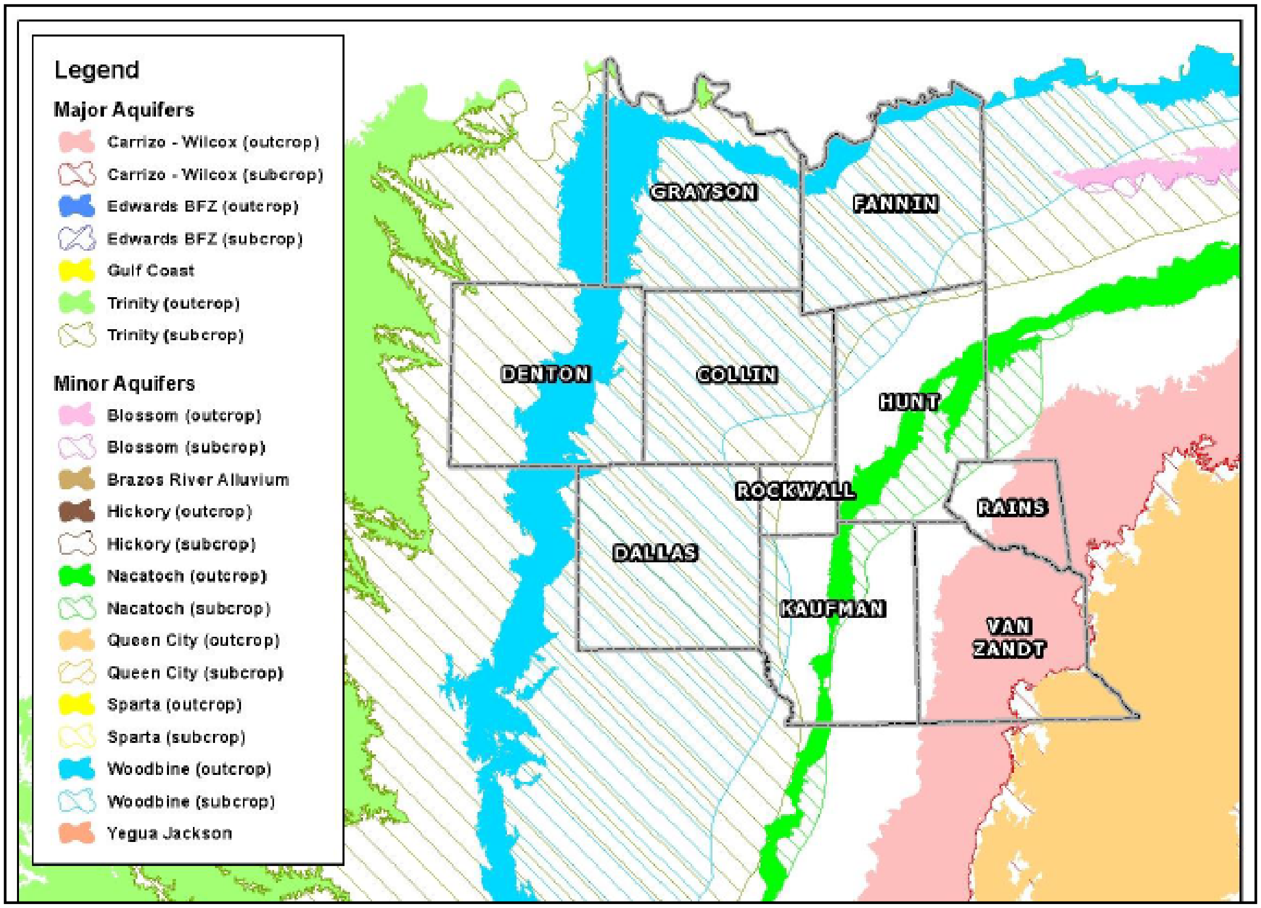

Figure 3. Aquifers and Potential Groundwater Sources Underlying Region C Counties

In all of Region C, an estimated 146,152 AFY of groundwater is hypothetically available in perpetuity, which is more than the estimated firm yield of 120,665 AFY for the LBCR. However, many providers and users already compete for this water, and little additional water supply is actually available from Region C aquifers. In addition, the Texas Commission on Environmental Quality (TCEQ) has designated a ten-county area within Region C as a priority groundwater management area (PGMA) due to excessive declines in groundwater in the region. The Region C Water Planning Group (2010) does not list Region C aquifers among the group of "Potentially Feasible Water Management Strategies for Wholesale Water Providers" in Table O.1 of Appendix O of the *2011 Region C Water Plan.* The situation has not changed in the *2016 Region C Water Plan.*

Overall, there is little groundwater available to NTMWD for future development in Region C and the surrounding region. Table 1 in Freese and Nichols (2015h) summarizes local groundwater availability and indicates that only about 30,000 AFY in total from a number of aquifers might be available in the surrounding counties, some of which are outside of Region C. This estimate might be optimistic, as it does not take into account more recent potential reductions in MAG values as a result of the Joint Planning effort of the GMAs.

In conclusion, groundwater supplies in general, including aggregate supplies from a number of potential sources from major and minor aquifers over a widespread geographic area, do not represent a reasonable alternative for NTMWD. The quantities potentially available are insufficient to meet the purpose and need of the proposed project, these quantities may be subject to reduction to conform with MAG values, and there is growing competition among users for these constrained groundwater supplies.

1.2 DESALINATION

1.2.1 Desalination of Lake Texoma Water

As described in Appendix N of the Revised DEIS, Lake Texoma is a 2.5 million AF reservoir that straddles the Texas–Oklahoma border on the Red River. This large lake was built and is owned and operated by the USACE. It serves four important functions: flood control, hydropower, water supply, and recreation. The water in Lake Texoma is shared by the states of Texas and Oklahoma (Water Data for Texas, 2016).

Water in the upper reaches of the Red River, as well as from Lake Texoma itself, has naturally-occurring high concentrations of dissolved salts. Thus, if this water is to be used for municipal and drinking water purposes, it requires either advanced treatment (desalination) or blending with freshwater sources.

At present, all of the Lake Texoma water allocated to Texas has been permitted for water supply by TCEQ and NTMWD is the single largest water right holder in the reservoir. NTMWD has two water rights for supplies from Lake Texoma. Permit/Application 02-5003 authorizes diversion of 84,000 AFY and Permit/Application 02-5003A authorizes diversion of 113,000 AFY. Until relatively recently, this water was blended directly in Lake Lavon. However, with the 2009 discovery of the zebra mussel in Lake Texoma, and the subsequent effort to prevent this costly invasive bivalve from spreading to the Trinity River basin, water from the lake is now blended at NTMWD's main water treatment plant in Wylie with other existing supplies from Lake Lavon, Jim Chapman Lake and wastewater reuse from the Wilson Creek wastewater treatment plant (WWTP) and East Fork Raw Water Supply Project.

Blending at the WTP constrains the use of the water diverted under Permit/Application 02-5003 to about 77,000 AFY, which is the same amount that is authorized under the bed and banks permit[1] to convey the water through Lake Lavon (Freese and Nichols, 2015i).While Permit/Application 02-5003A authorizes diversion and use of Lake Texoma water, it does not permit NTMWD to place the Lake Texoma water directly into another lake. Because the NTMWD does not have other freshwater supplies sufficient to blend the 113,000 AFY, this water is currently not being used (Freese and Nichols, 2016b).

To utilize the entire permitted amount of water from Lake Texoma, one option would be for NTMWD to desalinate a portion of this supply and blend it back in with raw Texoma water. This alternative would require an advanced treatment (desalination) facility, disposal facilities, and a blending facility. It would also be necessary to obtain permits for brine disposal. In an analysis conducted in the fall of 2015, Freese and Nichols (2015i) assumed that the new advanced water treatment facility would be located in Sherman, TX and that treated water would be delivered to the NTMWD system in McKinney (Figure 4).

[1] A "bed and banks" permit must be obtained from the TCEQ for the conveyance of water – less carriage losses from evaporation, transpiration, and seepage – in a watercourse rather than a pipeline, for subsequent diversion and eventual use.

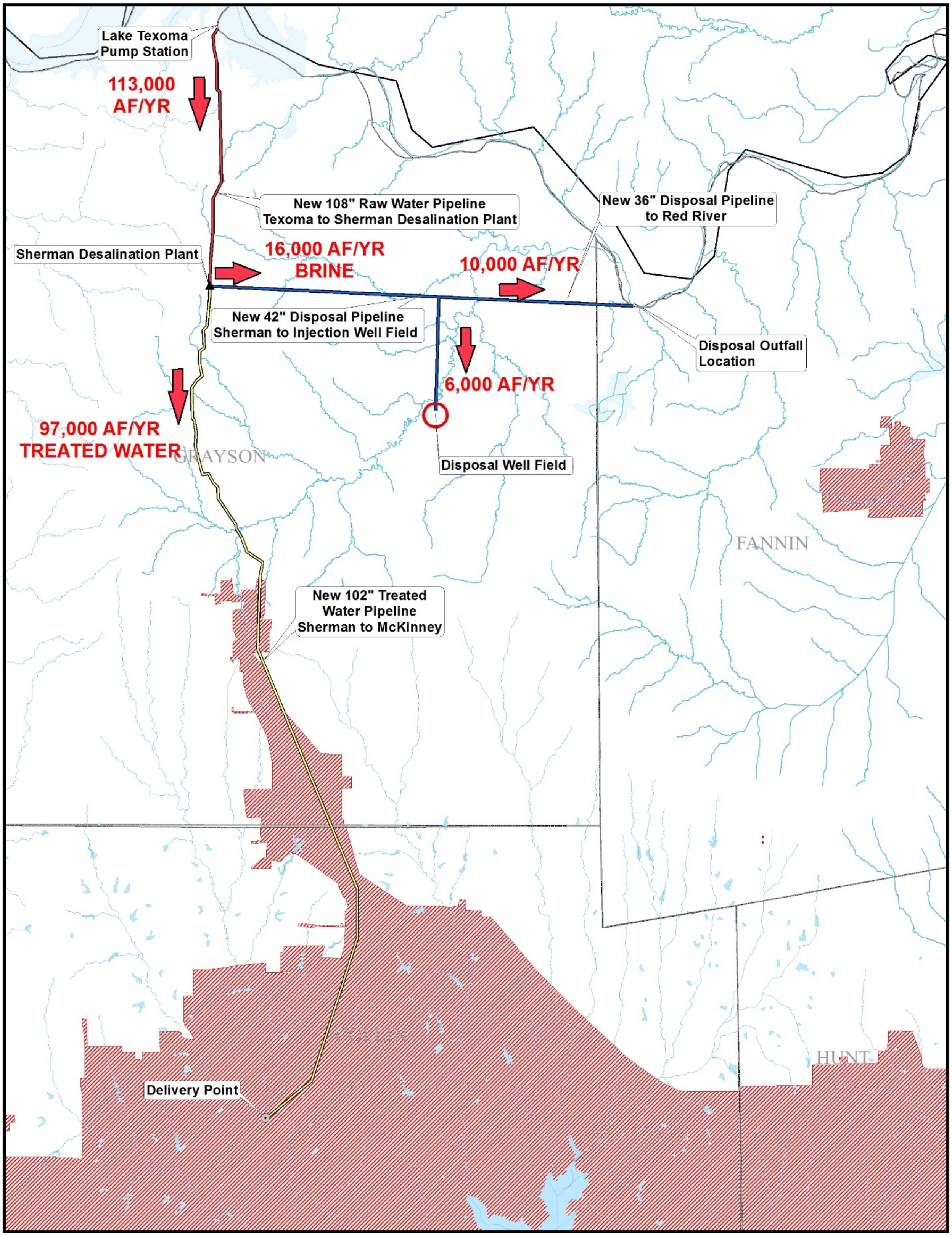

Figure 4. Possible New Infrastructure and Facilities for Lake Texoma Desalination

Source: Freese and Nichols, 2016b

Lake Texoma's brackish water would be desalinated using reverse osmosis water treatment or another similar treatment method. Reverse osmosis is an expensive and energy-intensive process that can result in losses of up to one-third of the raw supply. This process requires disposal of large quantities of highly saline water. Disposal options for the highly saline water include deep injection wells, discharge to a stream or the ocean, or evaporation ponds. Each of these disposal options would require additional environmental studies of potential impacts.

Desalination is also a more expensive strategy than blending, and there are considerable uncertainties in the operation and long-term costs of a large-scale desalination facility. The estimated costs for desalination of water from Lake Texoma are based on current cost information for large desalination facilities. According to the *2016 Region C Water Plan*, the cost of desalination is more than four times the cost for water from LBCR: $7.20 per thousand gallons for desalination versus $1.55 per thousand gallons for LBCR. However, these costs should be regarded as more uncertain than other cost estimates developed for the potential alternatives for the following reasons:

- There is not an established track record in the development of large water desalination facilities;
- Most large desalination facilities built to date are located on or near the coast rather than inland; and
- If a 100-million gallon per day (mgd) or larger plant were to be developed for Lake Texoma water, it would be the largest inland desalination facility in the world. To date, large-scale inland desalination facilities (greater than 50 mgd) have not been permitted or constructed anywhere in Texas. The Fort Bliss/El Paso Water Utilities desalination facility, which is the largest inland desalination plant in Texas, produces 27.5 mgd.

The method, cost and regulatory requirements of brine disposal for such a facility are uncertain. Brine disposal has the potential to significantly increase the estimated cost for desalination. Deep well injection would probably require multiple sites to accommodate the quantity of discharge required, and large-volume discharges of brine to surface water would be quite difficult to permit. Building a pipeline for disposal in the ocean would be prohibitively expensive due to its length and would still entail environmental impacts. Detailed studies to better quantify the cost estimates and feasibility would be required if a large-scale desalination strategy is pursued.

In 2015 and 2016, in an effort to quantify water yields and costs (Option 1 in Table 1 below), potential future supplies from desalination of Lake Texoma water were estimated based on the total permitted amount of 113,000 AFY of raw water, including treatment losses associated with reverse osmosis, and a blend ratio of the treated supply to raw water (Freese and Nichols, 2016b). The following assumptions were made:

- Depending on the quality of the incoming water, between 15 to 25 percent of the water could be lost in the reverse osmosis treatment process itself. For this analysis, loss from the treatment process was assumed to be 20 percent; and
- Post-reverse osmosis process desalinated water would have a very low salt content, so that the blend ratio could be higher than what NTMWD currently employs to blend with existing brackish water sources. In this analysis, the blend ratio was assumed to be two parts treated water to one part raw water, a ratio based on previous studies conducted for NTMWD.

Using these assumptions, the supply from the Lake Texoma desalination alternative was estimated at 97,000 AFY. Reverse osmosis would be performed initially on 80,000 AFY of Texoma water, supplying 64,000 AFY of low-dissolved-salt-content treated water. This treated, low-salinity water would then be blended back with the remaining 33,000 AFY of raw brackish water from Texoma to yield 97,000 AFY for the NTMWD treatment and distribution system. The reverse osmosis treatment process would generate approximately 16,000 AFY of brine waste requiring disposal (Freese and Nichols, 2025i; Freese and Nichols, 2016b).

Table 1. Comparison of Lake Texoma Desalination Options

Project component	Option 1	Option 2	Option 3
Total supply	175 mgd (97,000 AFY)	60 mgd (33,600 AFY)	60 mgd (33,600 AFY)
Desalination plant size	115 mgd	50 mgd	50 mgd
Conventional WTP size	200 mgd	80 mgd (North WTP)	80 mgd
Pipeline Size (diameter in inches)			
Parallel Texoma pipeline	108	84	84
Desalination plant discharge line	42/24	30	24
Treated water line	102	84/72	60/72
Brine Disposal (mgd)			
Quantity discharged to Red River	10	20	20
Quantity discharged to injection wells	20	0	0
Costs			
Total capital cost	$1.66 billion	$728 million	$582 million
Capital cost/mgd	$9.14 million	$12.13 million	$9.7 million

Discharging such a large amount of concentrated brine as effluent back into the Red River would not be permitted. NTMWD has been granted the right to discharge an average of 9.3 mgd of brine waste into the Red River, with a maximum daily amount of 18.6 mgd. The 16,000 AFY of brine waste would require a disposal system with the capacity of 30 mgd for peak use. For purposes of this analysis, it is assumed that up to 10,000 AFY could be discharged to the Red River and the remaining 6,000 AFY would need to be disposed of through deep well injection (Freese and Nichols, 2016b).

The Texoma desalination alternative assumes that the following facilities would be constructed:

- Improvements to the existing pumping station at Lake Texoma (increase to 200 mgd capacity);
- 10 miles of 108" diameter raw water pipeline;
- 35 miles of 102" diameter treated water pipeline;
- New 200 mgd conventional treatment facility;
- New 115 mgd reverse osmosis treatment facility;
- Blending facility;
- Two pumping stations at the WTP: one to move the brine waste and one for the treated water;
- 9 miles of 42" diameter pipeline and 7 miles of 24" diameter pipeline for the brine waste;
- 18.6 mgd brine waste discharge structure on the Red River;
- 11 mgd disposal well field;
- 30 injection wells (5,000 feet deep);

- Well field piping;
- Well field storage; and
- Pumping station with sufficient head to inject water into brackish formation (Freese and Nichols, 2016b).

Under these assumptions, the total capital cost for the Texoma desalination alternative was estimated in 2016 to be $1.66 billion (Freese and Nichols, 2016b). The unit cost for treated water would be $6.89 per thousand gallons, slightly less expensive than the $7.20 per thousand gallon estimate in the *2016 Region C Water Plan*, but still more than four times costlier than LBCR water. While the costs for the transmission and treatment facilities are fairly well established, there is substantial uncertainty concerning the costs for the disposal well field. No studies have been conducted to determine potentially appropriate locations of the disposal well field or injection depths of the brine. Moreover, there is some uncertainty with respect to injection well spacing and permitting requirements for a project of this scale. If it is not possible to site the disposal well field close to the treatment facility and brine waste must be piped further than estimated to the well field, the cost of this alternative could increase enormously (Freese and Nichols, 2015i).

Lake Texoma is regarded as a reliable source of water supply and NTMWD already holds the water rights to this source. As discussed, there is a degree of uncertainty concerning the ability to desalinate the large quantities of brackish water involved and dispose of the brine waste generated in this alternative. Disposal technology for large quantities of brine waste from an inland desalination project is not well established. While the 2015 preliminary feasibility exercise assumed that two-thirds of the brine disposal would be by deep well injection, to date, no hydrogeologic studies have been conducted to identify one or more suitable formations to receive this quantity of brine waste. If NTMWD is unable to locate suitable disposal sites nearby, the amount of water available to NTMWD from the Texoma desalination alternative could be much smaller and considerably more costly (Freese and Nichols, 2015i).

Permitting a large inland desalination project to desalinate 113,000 AFY of Lake Texoma water presents challenges, as described above, and would be time-consuming. The scale of the Texoma desalination alternative would be precedent-setting in Texas; a project of this type and size has never been built and operated previously in the state. Without further research and investigation, it is uncertain whether it can even be implemented at scale in North Texas. Because no detailed feasibility studies for a project at this scale have been conducted, it is expected to take at least five years to ascertain whether this project is technically feasible and to identify potential sites for brine waste disposal. Permitting both the treatment and disposal facilities would probably take at least another five years. Design and construction of the facilities would take an additional six to eight years, including pilot testing (Freese and Nichols, 2015i). Taking into account these phases, a large-scale desalination project with Lake Texoma water would likely take 15 to 20 years from the present to implement.

It is anticipated that adverse environmental impacts – including impacts on terrestrial and aquatic habitat and impacts on water quality – from diversion of an additional 113,000 AFY of Lake Texoma water and its desalination and transport to NTMWD's water supply system would be negligible to minor to the lake itself. No detailed studies or surveys have been conducted to date of the vegetative cover or cultural resources that facilities associated with this alternative would affect. The locations of the proposed facilities and infrastructure generally lie within both urban and rural areas. Proposed pipelines could be aligned to avoid highly sensitive environmental areas, that is, areas with high habitat, wildlife, or cultural resource value. A number of stream crossings would have to be made to transport water from Lake Texoma to McKinney. The discharge outfall (of brine effluent) to the Red River could be located and designed to avoid or minimize degradation of waters of the U.S.

Desalination of Lake Texoma water and its transport to NTMWD's water supply system would be located in Collin and Grayson counties. Three threatened or endangered federal species have been documented to occur or have the potential to occur within Collin and Grayson counties: the interior least tern (Figure 5), piping plover, and whooping crane. However, due to the nature of the project and the circumstances of these birds' presence in the area, it is expected that there is little or no potential for them to be directly or indirectly adversely affected by the Texoma desalination alternative. Least terns nest on sand bars along the Red River. Construction and operation of the intake, water treatment, and transmission facilities would not likely affect least tern habitat or disturb the birds themselves. However, brine discharge to the Red River downstream of Lake Texoma could potentially impact nesting areas. Discharge outfalls could be sited to avoid or minimize any impacts to known nesting areas and nesting birds. Both the piping plover and whooping crane are migratory birds that may be spotted in North Texas during migration to and from the Texas Gulf coast; however, Texoma desalination is not anticipated to adversely affect these species.

The carbon footprint of the Texoma desalination alternative is estimated to be about twice that of the LBCR, because of longer pipeline distances and carbon dioxide (CO_2) emissions associated with electricity generation to power reverse osmosis. As mentioned above, reverse osmosis is an energy-intensive process (Dashtpour and Al-Zubaidy, 2012).

One other environmental consideration is that introducing substantial amounts of brackish water or brine into injection wells could potentially increase seismic activity in the area (Freese and Nichols, 2016b). Recent experience with oil and gas hydraulic fracking activities in the Dallas-Fort Worth Metroplex area and Oklahoma has suggested a correlation between injection wells and an increased incidence of small earthquakes (USGS, 2016). Additional studies, investigation, and monitoring are ongoing. Because the Trinity aquifer underlies the affected environment, any local formation into which injection occurs would need to be deep enough to avoid impacts to the Trinity aquifer, which is an important source of potable water.

Figure 5. Nesting Interior Least Tern (*Sterna antillarum athalassos*)

Source: U.S. Fish and Wildlife Service national digital library

In 2014, NTMWD presented two other possible options (NTMWD, 2014) – Options 2 and 3 in Table 1– for desalination of brackish Lake Texoma water that have since been superseded by the desalination alternative described above. Under the 2014 desalination options, NTMWD would continue to blend and treat Lake Texoma water at the Wylie WTP, as well as treating some Texoma water at a desalination WTP. A daily supply analysis was performed to determine the amount of additional supply gained, as well as an operational analysis of the integrated treated water transmission system associated with the Wylie and North WTPs. Additional usage of Lake Texoma water was constrained by the capacity of the existing Texoma pipeline, so that additional supply would be limited to about 33 mgd. To overcome this constraint, the evaluation also considered expansion of the existing Texoma pipeline capacity. Texoma water would continue to be blended at Wylie and a desalination WTP would be constructed. By doing this, additional water supply could be increased to about 60 mgd (33,600 AFY).

In the 2014 analysis, under Option 2, the desalination plant would be constructed at the Wylie WTP. In Option 3, the desalination plant would be built near Sherman, Texas. Option 2 would cost $728 million and Option 3 would cost $582 million. These two options are compared with the desalination alternative described in Option 1 in Table 1.

In conclusion, the Lake Texoma desalination alternative is not a reasonable alternative. It fails to meet both the time and quantity elements of the purpose and need. It would neither provide enough water nor do so in time to meet NTMWD's need. Unresolved questions remain concerning disposal of brine that would be a residual of the reverse osmosis desalination process. While Lake Texoma is a reliable source of water for which NTMWD already has a substantial water right, and while environmental impacts at the site of withdrawal and along pipeline routes would be relatively small, the fact that this alternative could only deliver an estimated 97,000 AFY of water and not until at least 2030 disqualifies it from further consideration in this Revised DEIS.

1.2.2 Desalination of Gulf of Mexico Seawater

The state of Texas has sponsored initial studies of potential seawater desalination projects, which may be a future supply source for the state in general. However, as noted above, desalination continues to be both costly and energy-intensive. If fossil fuels such as coal or natural gas are used to generate the electricity to power the desalination process, this would: 1) contribute to the cumulative depletion of fossil fuels; 2) contribute to localized air pollution from criteria pollutants such as particulates, sulfur dioxide, nitrogen oxides, and volatile organic compounds, and possibly the toxic heavy metal mercury; and 3) emit CO_2, thereby contributing in a small but non-trivial way to the cumulative buildup of this greenhouse gas in the atmosphere.

Furthermore, because of the long distance from NTMWD's service area to the Gulf of Mexico (about 300 miles), and the subsequent cost of laying and operating a pipeline over this distance, seawater desalination is not a viable source of water supply for NTMWD. While the water supply from seawater desalination is essentially unlimited, this is a high-energy use strategy and the unit cost is much higher than the cost of other water management strategies for NTMWD – $8.46 per thousand gallons for treated water – more than five times as expensive as LBCR (Region C Water Planning Group, 2015). Thus, this is not a reasonable alternative to the proposed project.

1.3 CONSERVATION

In the *2016 Region C Water Plan*, conservation is a recommended water management strategy for NTMWD. The *2016 Region C Water Plan* reaffirms the region's commitment to conservation and reuse. TWDB now mandates that each regional water planning group evaluate all water management strategies that it determines to be potentially feasible, including water conservation practices, reuse of treated wastewater effluent, and drought management measures. In response, the Region C Water Planning Group decided to incorporate water management strategies involving both water conservation and reuse of treated wastewater effluent as major components of the long-term water supply for Region C, to encourage planning and implementation of water conservation and reuse projects, and to monitor legislation and regulatory actions related to water conservation and reuse.

The USACE generally considers water conservation and reuse not as distinct, alternative methods of providing additional water, but rather as approaches and actions that make more efficient use of existing water supplies and thereby reduce per capita water consumption, partially offsetting the increasing municipal demand for water due to population growth. As such, in this Revised DEIS, water conservation and reuse are not considered alongside structural alternatives to the Proposed Action in Chapter 2 but are considered in the context of the purpose and need discussion in Chapter 1 and Appendix N. NTMWD's conservation and reuse policies, programs, and projects will be implemented regardless of the USACE's permitting decision on the Proposed Action and alternatives.

2.0 ALTERNATIVES THAT ARE UNAVAILABLE TO THE APPLICANT

Consistent with USACE regulatory National Environmental Policy Act (NEPA) regulations at 33 CFR 325 Appendix B, paragraph 9.b(5), alternatives that are unavailable to the applicant are to be included in the analysis of the No Federal Action (denial) alternative. The USACE considers two alternatives unavailable to NTMWD: importing water from Oklahoma, and use of the Lake O' The Pines reservoir.

2.1 IMPORTING WATER FROM OKLAHOMA

Importing from Oklahoma is an alternative that is unavailable at this time to NTMWD. The *2011 Region C Water Plan* estimated that it is comparable in cost with the LBCR (Region C Water Planning Group, 2010) and the *2016 Region C Water Plan* states that "raw water from Oklahoma would be a relatively inexpensive supply and would have relatively low environmental impacts because of the use of existing sources" (Region C Water Planning Group, 2015).

However, in 2002, the Oklahoma Legislature placed a moratorium on out-of-state water sales. The moratorium was replaced in 2009 by a requirement that the Oklahoma Legislature approve any out-of-state water sales. The Tarrant Regional Water District (TRWD) subsequently filed a lawsuit in federal court against the Oklahoma's Legislature's moratorium, but the U.S. Supreme Court eventually ruled in favor of Oklahoma (Region C Water Planning Group, 2015). Thus, while Oklahoma is still a possible source of water supply for Region C, it is best regarded as a potential future source.

Assuming the Legislature was to approve water sales to Texas in the future, both the *2012 Texas State Water Plan* and *2011 Region C Water Plan* recommended that NTMWD, the TRWD, and the Upper Trinity Regional Water District (UTRWD) jointly develop a project to use water from Oklahoma. The recommended project is planned for 2060 and includes 50,000 AFY each for TRWD and NTMWD and 15,000 AFY for UTRWD (Freese and Nichols, 2008a).

The TRWD, UTRWD, and NTMWD have each submitted water rights applications for water in Oklahoma. NTMWD has applied for water from the Kiamichi River, Muddy Boggy Creek, and stored water in Lake Hugo. At this time, the state cannot act upon these permits without further direction from the Oklahoma Legislature or the judicial system.

If the Oklahoma Water Resources Board were to grant an Oklahoma water rights permit, NTMWD would also need to obtain a Section 401 water quality certification if Oklahoma water were to be discharged to a Texas stream or lake, and a Section 404 permit for the diversion structure. Depending upon the source of water and its diversion location, a pipeline transmission system would be needed to the NTMWD's service area.

The *2016 Region C Water Plan* retains water from Oklahoma as a recommended strategy for NTMWD (Region C Water Planning Group, 2015). However, due to the lingering uncertainty regarding the Oklahoma moratorium on export of water to Texas and the uncertain status of the Oklahoma water rights permit, this strategy would likely not be able to deliver water in a timely manner to meet the NTMWD's purpose and need. Therefore, this alternative is not considered feasible or available at present.

2.2 LAKE O' THE PINES

Lake O' the Pines is an existing USACE reservoir in the Cypress River Basin, about 81 miles upstream of its confluence with the Red River in Louisiana and 120 miles from the Dallas Metroplex. Authorized in 1946, the reservoir was created as part of the overall plan for flood control in the Red River Basin below Denison Dam. The purpose of the reservoir was revised to include outdoor recreation and water supply during construction (USACE, 2007). Its Texas water rights are held by the NTMWD. The NTMWD has investigated the possibility of purchasing supplies in excess of local needs from the Cypress Basin. According to the *2012 Texas State Water Plan* and the *2011 Region C Water Plan* there could be as much as 89,600 AFY available for export from the basin. However, there are competing interests for this supply, including increased demands for steam electric power in the vicinity of the lake in northeast Texas. The *2011 Region C Water Plan* does not recommend Lake O' the Pines water for any Region C supplier. The *2016 Region C Water Plan* lists it as an alternative strategy for NTMWD at 87,900 AFY.

Development of this source would require contracts with the Northeast Texas Municipal Water District (NETMWD) and other Cypress River Basin suppliers with excess water supplies. Presently, the NETMWD and other suppliers have not committed to selling this amount of water. The NETMWD has recently entered into an agreement with the Caddo Lake Institute to provide water downstream of the dam, potentially reducing the available supply for export.

Lake O' the Pines is located about 120 miles from the North Texas region, and this distance, the limited supply that the reservoir would provide, and the uncertainty concerning the need to reach agreements with existing water rights holders all make this supply highly uncertain and in essence, unavailable at the present time. This alternative is incapable of providing NTMWD's needed 105,804 AFY of additional water supply by 2025.

3.0 OTHER ALTERNATIVES AVAILABLE TO THE APPLICANT

Other potential alternatives to the proposed LBCR project can be divided into two categories: development of new reservoirs and transporting water from existing reservoirs. The alternatives discussed in the following subsections were identified through the Texas water planning process, previous studies, and as part of the development of this Revised DEIS. The cost of water reported for the alternatives is from the *2016 Region C Water Plan* unless noted otherwise.

Each of the following alternatives is evaluated in terms of their ability to meet the purpose and need. Additionally, to the extent that information is readily available, the more plausible alternatives are characterized according to the following factors:

- <u>Environmental impacts</u> – relative general impacts to water and biological resources as well as to the human environment;

- Carbon footprint – long-term energy consumption and related CO_2emissions and loss of carbon storage from constructing and operating each alternative;
- Water quality – lower quality raw water would entail greater treatment costs;
- Economic cost – relative cost to NTMWD and water users of developing the alternative;
- Reliability and availability – whether or not the alternative is fully available or is encumbered or compromised in some manner; and
- Need for partners –if partners are needed, the time needed to implement an alternative can increase.

3.1 WATER SUPPLIED FROM NEW (UNDEVELOPED) RESERVOIRS

All of the potential alternatives to the Proposed Action reviewed in this section would entail discharges of dredged or fill material into waters of the United States. Thus, to some extent, each would replicate the adverse impacts associated with the LBCR on waters of the U.S. including wetlands, other natural habitats such as bottomland hardwood forests, and hydrology. In addition, a new Texas state water right would need to be obtained for any new dam, reservoir, and water diversion. Under Texas state law, a right to surface water is granted under a priority system, "first in time, first in right."

Also known as "prior appropriation", "first in time, first in right" is the legal doctrine that the first individual or entity to take a given amount of water from a water source for a "beneficial use" such as agriculture, industry, or municipal, has the right to continue to use that amount of water for that purpose. All subsequent users can utilize the remaining water of a source for their own beneficial uses, but if and only if they do not impinge on the established rights of previous users. This priority system is a factor in determining the magnitude of prospective yields available from any given project. It is why the yields of projects can vary depending on when or the order in which they are permitted.

3.1.1 Downsized LBCR without Blending of Lake Texoma Water

This alternative refers to the smaller dam and reservoir project located at the same site on Bois d'Arc Creek as Alternative 2 described in Chapter 2, Section 2.3, but without supplemental water transported from Lake Texoma for blending at the North WTP. The firm yield of this downsized version of the LBCR would be approximately 86,100 AFY, or about 68 percent of the 120,665 AFY firm yield of the full-sized proposed LBCR and 81 percent of the stated purpose and need of 105,804 AFY.

The downsized LBCR alternative would have a reduced reliability of supply during periods of drought. With less storage, this smaller reservoir would be more vulnerable than the Proposed Action (the full-sized LBCR, or Alternative 1) to a new drought of record and to climate change. The volume of water in the smaller reservoir would be below 50,000 AF about nine percent of the time, compared with only three percent of the time for the full-sized LBCR. However, the water quality of a smaller LBCR is anticipated to be comparable to that of the full-sized LBCR.

Although the firm yield of the smaller LBCR would be 32 percent less than the full-sized LBCR, the costs for the smaller-sized project would be approximately 15 percent lower than the larger project, because all of the same elements are required, and because economies of scale would be foregone. As shown in Table 2, this leads to a unit cost about 18 percent higher – \$1.55 vs. \$1.31 per 1,000 gallons – for the water from a downsized LBCR.

Table 2. Comparison of Estimated Costs for Full-sized and Smaller LBCRs

Project element	Full-sized LBCR[a,b]	Smaller LBCR[c]
Supply (AF)	120,665	86,100
Engineering fees	$64,043,000	$64,043,000
Other costs (legal, land acquisition, mitigation)	$174,121,000	$122,935,000
Dam and reservoir	$76,645,000	$68,981,000
Conflicts	$50,573,000	$50,573,000
Pipeline	$161,851,000	$145,666,000
Pumping station	$44,921,000	$40,429,000
Terminal storage	$13,409,000	$13,409,000
Total project cost	$585,563,000	$506,036,000
Annual costs	$51,461,000	$43,494,000
Unit Costs (before amortization)		
Per AF	$427	$505
Per 1,000 gallons	$1.31	$1.55

[a] March 2011 costs for the full-sized LBCR were adjusted to September 2013 dollars for comparison purposes.
[b] Conservation pool elevation 534 feet above mean sea level (MSL).
[c] Conservation pool elevation 515 feet MSL.
Source: Table 1, Freese and Nichols, 2015a

The downsized LBCR would inundate 8,600 acres of waters, wetlands, and uplands, all within the footprint of the full-sized LBCR. It would also impact an additional 705 acres for construction of the dam, spillway and pumping station, for a total impacted area of 9,305 acres. Table 3 lists estimates of the areas of vegetative cover types affected by the footprint of the smaller LBCR site. Potential impacts to waters of the U.S. are estimated at approximately 3,751 acres. Most of the wetlands (a subcategory of waters), and forested wetlands in particular, are found at the lowest elevations, which lie along the banks of Bois d'Arc Creek; these are the areas that would be impacted first as the reservoir fills up. Table 3 presents the vegetative cover and estimated acreage within the footprint of the smaller LBCR. Approximately 68 miles of streams would be affected (Freese and Nichols, 2015a).

According to the U.S. Fish and Wildlife Service (USFWS), two federally listed species or subspecies, the interior least tern and the Louisiana black bear, may occur in Fannin County. The bald eagle has been delisted but is being monitored and is still protected by the Bald and Golden Eagle Protection Act. None of these species has been documented to date at the project site. The preferred habitat of five state-threatened fish species and one reptile is found at the LBCR site, though none of these species were documented during the instream flow surveys of 2009 (Freese and Nichols, 2010a). The decreased acreage of inundated habitat for the smaller-footprint LBCR has reduced the potential to adversely affect these species.

With regard to cultural resources, 48 sites were identified during the archeological field survey of the reservoir footprint, including 20 historic-era sites, 26 prehistoric sites, and two multiple component sites. Based on the smaller reservoir footprint of this alternative, 34 sites would be impacted with the normal pool at elevation 515 feet above mean sea level (MSL). Some additional sites may be impacted when the reservoir's water level is above conservation storage (Freese and Nichols, 2015a).

Table 3. Vegetation Cover Types and Estimated Acreage Impacted by a Smaller LBCR

Vegetative cover type	Area Impacted (acres)
Evergreen forest	60
Upland/deciduous forest	968
Riparian woodland/bottomland hardwood	714
Shrubland	16
Shrub wetland	27
Grassland/old field	2,223
Emergent/herbaceous wetland	684
Cropland	1,422
Riverine	115
Lacustrine	16
Tree savanna	39
Cropland: prior converted[a]	114
Forested wetland	2,909
Total	**9,307**

[a] Wetlands certified by the Natural Resources Conservation Service as having been *converted* from a non-agricultural use to production of a commodity crop *prior* to December 23, 1985

Source: Table 2, Freese and Nichols, 2015a

CO_2 emissions from this alternative would include those emitted by the reservoir during its initial inundation as existing vegetation mass decays, by embodied and emitted emissions during construction, and by emissions associated with electrical power generation during operation (primarily from pumping raw water 35 miles to the treatment plant). Extrapolating from the carbon footprint analysis that was conducted for the proposed full-sized LBCR (Alternative 1), it is estimated that one-time carbon emissions associated with woody matter decomposition (occurring over various years) from reservoir inundation would be roughly half those of the full-sized LBCR. CO_2 emissions associated with construction and embodied infrastructure would be approximately 10 percent less than the full-sized LBCR project. Emissions associated with the transport of the water would be proportional to the yields – those of the downsized LBCR would be about 30 percent less than the full-sized LBCR.

The estimated earliest year that water could be available from smaller LBCR is 2025 (Freese and Nichols, 2015a). This time frame allows for project design modifications; for amendments to the NTMWD water right application to TCEQ; for TCEQ's technical review of the smaller project; and for changes to the proposed project mitigation. However, a more recent, more in-depth analysis suggests that December 2026 is a more realistic date for project completion than 2025 (Thornton and Rochelle, 2016).

Characterization According to Listed Factors

- Environmental impacts – Overall environmental impacts and impacts to waters of the U.S. from the downsized LBCR would generally be less than those from the Proposed Action. There would be fewer impacts to bottomland hardwood forests and forested wetlands as well as to other valuable wildlife habitats; cultural resource, agricultural, and rural impacts would also be generally lower because of the smaller area affected. Increased water level fluctuation in the reservoir could adversely impact the stability of aquatic habitat and shoreline vegetation that would develop over time.

- Carbon footprint – Per unit of water delivered to NTMWD's water supply system, long-term electricity consumption and related CO_2emissions from pumping water from a smaller reservoir to the North WTP would be the same as for the proposed project.
- Water quality – Water quality would be the same as for the proposed project.
- Economic cost – Because of foregone economies of scale, the relative unit cost for water under this potential alternative is estimated to be 18 percent higher than for the proposed project.
- Reliability and availability – While this alternative is no less available or more encumbered than the proposed project, in times of drought it would be less reliable due to its reduced storage capacity.
- Need for partners – No additional partners would be needed.

In conclusion, this alternative does not meet the stated purpose and need of the Proposed Action – supplying at least 105,804 AFY of water by 2025 – and therefore, has been dismissed from further consideration.

3.1.2 Upper Bois d'Arc Creek Reservoir

Other potential dam site locations on Bois d'Arc Creek have been considered in previous studies. Most of these sites were studied as potential flood control measures to reduce flooding along Bois d'Arc Creek and in the city of Bonham. An Upper Bois d'Arc Creek reservoir site was studied by the USACE in 1968, and subsequently reviewed again by the USACE in 2000 (USACE, 1968; USACE, 2000). The Upper Bois d'Arc Creek Reservoir, as then proposed, would be located about 3.5 miles south of the city of Bonham. It would have a controlled drainage area of 108 square miles, which is about one third of the drainage area of the proposed project. This alternative would have a total storage of 137,500 AF, with 82,040 AF dedicated to water supply. Based on USACE analyses, the Upper Bois d'Arc Creek reservoir would provide flood protection for a 50-year storm event and 24 mgd of water supply (approximately 27,000 AFY).

The Upper Bois d'Arc Creek Alternative would yield only about 26 percent of the stated purpose and need; thus, it is insufficient to meet NTMWD's needs. Due to the need for detailed engineering and environmental studies, it is unlikely that this alternative could be developed earlier than 2035.

Characterization According to Listed Factors

- Environmental impacts – Likely to be less than the Proposed Action due to its smaller scale.
- Carbon footprint – Assumed to be less than the Proposed Action.
- Water quality – Information not readily available.
- Economic cost – Information not readily available.
- Reliability and availability – Information not readily available.
- Need for partners – Probably not needed.

In conclusion, this alternative does not meet the stated purpose and need of the Proposed Action – supplying at least 105,804 AFY of water by 2025 – and therefore, has been dismissed from further consideration.

3.1.3 Marvin Nichols Reservoir Alternative

Located in Region D on the Sulphur River in Red River and Titus counties, the undeveloped Marvin Nichols Reservoir site (Figure 6) is an alternative strategy in the *2016 Region C Water Plan* for the NTMWD, TRWD, UTRWD, and the city of Irving. This project, with a conservation elevation of 328 feet MSL, has been included in every Region C and State Water Plan since 1968. NTMWD's share of the available water would be 160,300 AFY at a unit cost of $2.04 per thousand gallons. According to an interregional conflict resolution agreement reached between Regions C and D, water from Marvin Nichols Reservoir would not be available until 2070 for any of the partners collaborating in its development (Region C Water Planning Group, 2015).

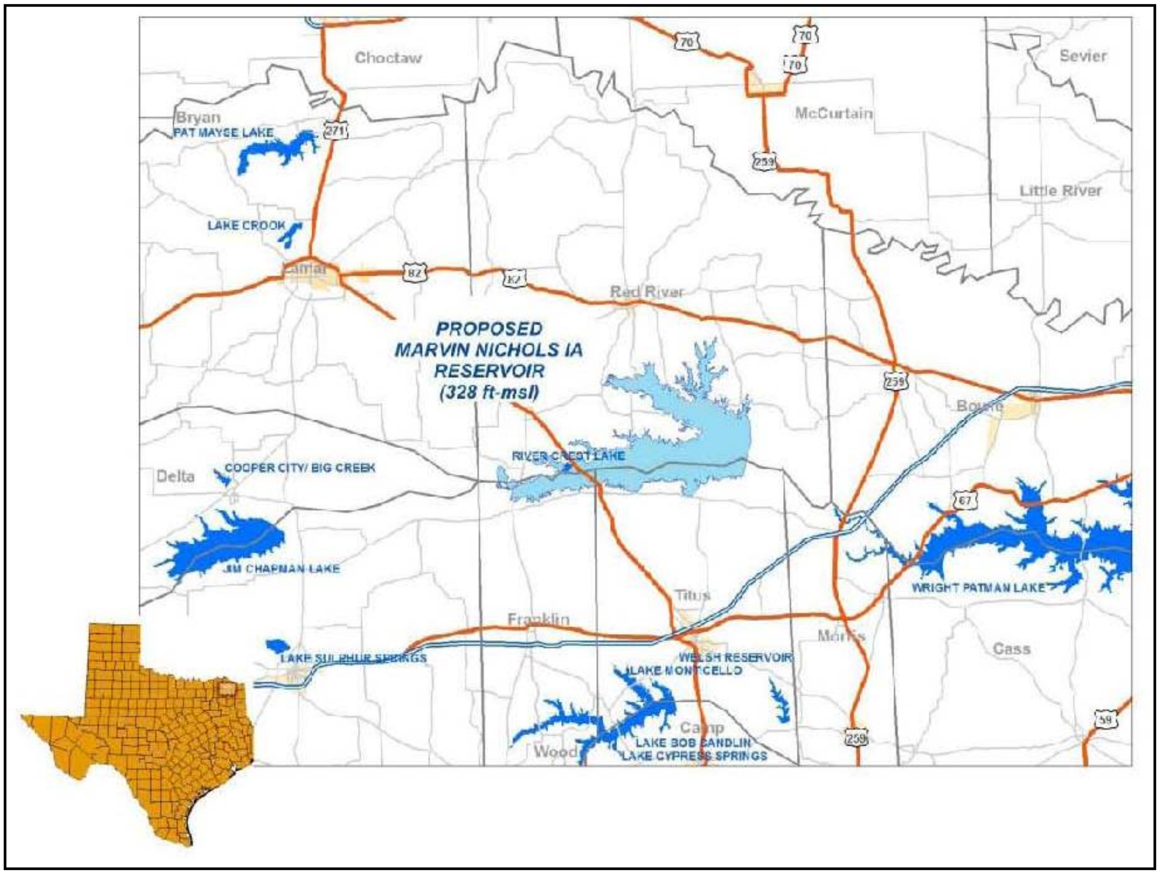

Figure 6. Location Map of the Recommended Marvin Nichols Reservoir

Source: TWDB, 2008

No major water quality impairments are found on the segment of the Sulphur River where Marvin Nichols Reservoir would be located. However, Kickapoo Creek, a tributary to the Sulphur River within the footprint of Marvin Nichols, is listed for an impaired macrobenthic community. The macrobenthos are those organisms visible to the naked eye that live on stream bottoms, and include creatures such as worms, crustaceans, insect larvae, and bivalve and univalve mollusks such as clams, mussels, and snails. Big Sandy Creek, a tributary of the North Sulphur River upstream of the reservoir, also has an impaired macrobenthic community. Because existing impairments upstream are not presently affecting water quality in this area, they would not be anticipated to adversely impact water quality in a future reservoir, if built (Freese and Nichols, 2015b).

At the recommended conservation pool elevation of 328 feet MSL, Marvin Nichols Reservoir would inundate approximately 67,400 acres, in comparison with 16,641 acres for the proposed LBCR. The USFWS has classified some of this acreage as Priority 1 bottomland hardwoods, their highest quality rating (USFWS, 1984). Approximately 39 percent of the reservoir site is classified as bottomland hardwood forest; 20 percent upland deciduous forest; 19 percent grasslands: and nine percent marsh (TWDB, 2008). Table 4 shows land cover types and acreages in the footprint of the Marvin Nichols Reservoir. Additional studies would be needed to ascertain the quality and extent of these habitats (Freese and Nichols, 2008a).

Table 4. Land Cover Types and Acreages for the Recommended Marvin Nichols Reservoir

Land Cover Classification	Acreage[a]	Percent
Bottomland hardwood forest	26,309	39.2
Marsh	6,259	9.3
Seasonally flooded shrubland	1,198	1.8
Swamp	565	0.8
Evergreen forest	27	0.04
Upland deciduous forest	13,667	20.4
Grassland	13,069	19.5
Shrubland	1,027	1.5
Agricultural land	3,169	4.7
Urban/developed land	8	0.01
Open water	1,847	2.8
Total	**67,145**	**100.0**

[a]Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.

Source: TWDB, 2008

The Marvin Nichols Reservoir would provide substantial amounts of new water supply to the North Texas region at a relatively low cost. However, due to its size, the development of this reservoir would likely entail much greater environmental impacts than the proposed LBCR. The area that would be inundated by Marvin Nichols Reservoir is more than four times the inundation area of the LBCR, and the impacts on natural habitats could be comparably greater. Initial estimates of impacted wetlands and bottomland hardwoods acreage for this alternative are considerably greater than the acreage impacted by the proposed project (TWDB, 2008; Freese and Nichols, 2008a).

Twenty-five threatened and endangered species have been documented or have the potential to occur within Titus and Red River counties. Of these, three are federally-listed species and 22 are state-listed. The three federally-listed species – American burying beetle, least tern, and piping plover – have little or no potential to occur in affected habitats and thus would not be adversely impacted by the Marvin Nichols Reservoir. Among the state-listed species, there is moderate potential for adverse impacts on three that occur in the affected habitats: the creek chubsucker, the northern scarlet snake, and the timber rattlesnake. Minimal or no impacts on other species would be expected (Freese and Nichols, 2015b).

The creek chubsucker is a freshwater fish that favors creeks, streams, and small rivers that are often heavily vegetated. This species, listed as threatened by the Texas Parks and Wildlife Department (TPWD), could potentially occur within vicinity of the Marvin Nichols Reservoir. It seldom inhabits impoundments, ponds, and lakes, and thus, if present, could potentially be eliminated by the conversion of lotic to lentic habitats on the streams within the reservoir footprint as the reservoir is impounded and the stream channels are inundated and lose their flow velocity. Based on its preferred habitat, there are approximately 322 miles of potential stream habitats for the creek chubsucker within the site of the smaller Marvin Nichols Reservoir (Freese and Nichols, 2015b).

The northern scarlet snake spends most of its life underground in soils suitable for burrowing. TPWD lists it as threatened in Titus County. Within the full-sized Marvin Nichols Reservoir site at 328.0 feet MSL, there are approximately 11,811 acres of shrubland, upland forest and grasslands that could represent habitat for this snake (Freese and Nichols, 2015b).

TPWD lists the timber rattlesnake as threatened. This pit viper favors moist lowland forests, hilly woodlands, and thickets near streams. Within the Marvin Nichols Reservoir Site footprint, there are approximately 26,309 acres of bottomland hardwood forest that could constitute habitat for this species (Freese and Nichols, 2015b).

The Marvin Nichols Reservoir site has a high potential for cultural resources. Sixty-six known cultural resource sites are found within the Marvin Nichols Reservoir site. Thirteen sites are associated with the Caddo Nation, 43 sites are prehistoric, seven span more than one category, and three lack sufficient information to evaluate. Several of these sites appear to have moderate to high potential for listing under the National Register of Historic Places (NRHP). To date, no detailed cultural resource surveys, such as those that have been performed for LBCR, have been conducted at the Marvin Nichols site (Freese and Nichols, 2015b).

Development of the Marvin Nichols Reservoir would also require multiple participants to effectively achieve the cost benefits and full utilization of the available supply. Consequently, the timing for this strategy is dependent upon the needs of the other participants. Furthermore, due to the permitting requirements and current opposition to this project, this project could not be permitted and developed by 2025.

Characterization According to Listed Factors

- Environmental impacts – Overall environmental impacts of Marvin Nichols Reservoir would be greater than the Proposed Action, particularly because of elimination of bottomland hardwood forests and other valuable natural habitats, as well as generally high agricultural and rural impacts.
- Carbon footprint – Long-term energy and electricity consumption and related CO_2 emissions from pumping water from Marvin Nichols Reservoir to the NTMWD service area would be greater than for the Proposed Action due to the greater distance; in addition, the greater area of forest inundated would result in a larger loss of carbon storage.
- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – The relative unit cost of water from Marvin Nichols Reservoir is somewhat higher than from LBCR at $2.04 per thousand gallons.
- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2010). According to the *2012 State Water Plan*, the North East Texas Regional Water Planning Area (Region D) opposes Marvin Nichols Reservoir (TWDB, 2012).
- Need for partners – NTMWD would likely partner with TRWD, UTRWD, Dallas Water Utiliteis (DWU), and the city of Irving to develop this water source; this would necessitate more complex arrangements than the Proposed Action.

In conclusion, this alternative does not meet the stated purpose and need of the Proposed Action and has therefore been dismissed from further consideration. While this alternative supplies more than enough water (160,300 AFY), it is not expected to be implemented before 2070, well beyond the needed 2025 time frame.

3.1.4 Marvin Nichols Reservoir (Site 1A)

Marvin Nichols Reservoir Site 1A is a potential reservoir site located on the Sulphur River in Titus and Red River counties, in the same location as the Marvin Nichols Reservoir described above. If constructed, the raw water pipeline from this reservoir would be at least 84 miles from NTMWD's proposed North WTP.

This alternative consists of a smaller reservoir footprint. At a proposed conservation elevation of 313.5 feet MSL, the reservoir would store 744,300 AF of water and impact 41,722 acres, less than two-thirds as much as the full-scale Marvin Nichols Reservoir. This strategy, in combination with reallocation of Wright Patman Lake, is a recommended strategy (labelled "Sulphur Basin Strategy" or "Sulphur Basin Supplies") in the *2016 Region C Water Plan* for NTMWD, TRWD, and UTRWD. It is also an alternate strategy for the cities of Dallas and Irving. Figure 7 shows the location and configuration of Marvin Nichols Reservoir Site 1A.

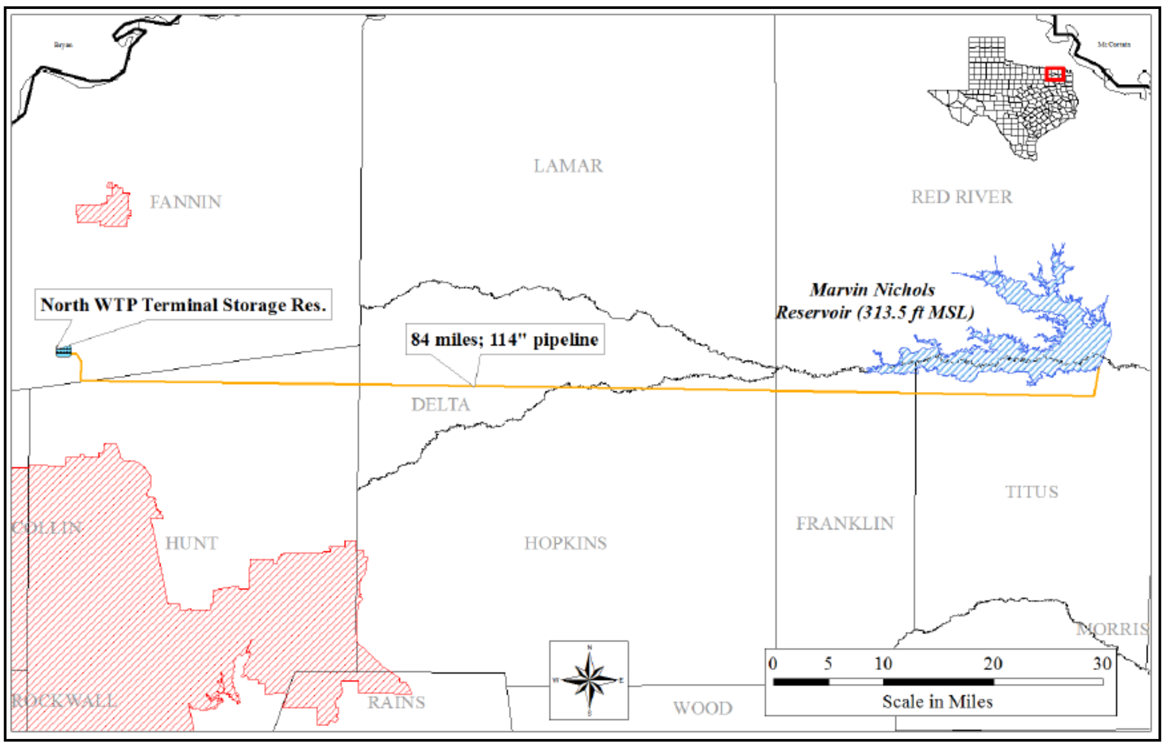

Figure 7. Location and Configuration of Marvin Nichols Reservoir Site 1A

Source: Freese and Nichols, 2015b

Available supply from a smaller Marvin Nichols Reservoir at 313.5 feet MSL was calculated using a RiverWare model developed by USACE and modified to simulate the priority assumptions used in TCEQ's Sulphur River Basin Water Availability Model (WAM). Several considerations regarding supplies from Marvin Nichols were taken into account:

- The Lake Ralph Hall site is located upstream of the project. This project has already received a state water right from the TCEQ and would have senior priority over Marvin Nichols Reservoir Site 1A. Lake Ralph Hall was included in the hydrologic model used to develop the yield of this project.
- A portion of the yield of the project is reserved for local use in the Sulphur Basin. Assumptions used in analyses for the Sulphur River Basin Group and Region C reserve 20 percent of the yield for local use. This assumption is based on an inter-local agreement and was adopted for this analysis.
- Releases out of Marvin Nichols Reservoir Site 1-A for environmental flows are based on the Lyons Method.
- This project, if constructed, would impact the yields of other projects being considered for development in the Sulphur Basin, including the Wright Patman Lake reallocation.

With these assumptions taken into account, the firm yield of Marvin Nichols Site 1-A at 313.5 feet MSL (with instream flow releases) is estimated at 299,500 AFY. Of this amount, 239,600 AFY would be available to NTMWD. The remaining 20 percent of the yield would be retained in the Sulphur Basin for local use. This supply would be delivered to NTMWD in two phases: the first phase would transport half of the yield (i.e., 120,000 AFY), while the second phase would carry the second half by means of a parallel pipeline (Freese and Nichols, 2015b). The unit cost for the raw water would be $2.79 per 1,000 gallons, compared to $1.55 for LBCR (with debt service).

No major water quality impairments are found on the segment of the Sulphur River where the smaller Marvin Nichols Reservoir would be sited. However, Kickapoo Creek, a tributary to the Sulphur River within the footprint of Marvin Nichols, is listed for an impaired macrobenthic community.

As noted, at an elevation of 313.5 feet MSL, Marvin Nichols Reservoir Site 1A would inundate 41,722 acres. The additional acreage affected by construction of the dam, spillway, pumping station, and pipeline are unknown and therefore not included in this estimate. Figure 8 illustrates the land cover types that occur within the footprint of the Marvin Nichols Reservoir Site 1A reservoir; Table 5 lists the estimated areas of each land cover type. Over 90 percent of the impacted land cover is comprised of four land use categories: forested wetland, grassland, bottomland hardwood forest, and upland forest.

Approximately 24,591 acres – 59 percent – are classified as forested wetlands or bottomland hardwoods. About 322 miles of streams would be inundated at elevation 313.5 feet MSL. These data are estimated and have not been field-verified (Freese and Nichols, 2015b).

Priority 1 bottomland hardwoods, as classified by USFWS, are located within and downstream of the smaller Marvin Nichols Reservoir site. Priority 1 means excellent quality bottomlands of high value to key waterfowl species (USFWS, 1984). Further study and extensive field surveys would be needed to evaluate both impacts within the reservoir footprint as well as the potential indirect impacts of this alternative on the downstream bottomland hardwoods stands (Freese and Nichols, 2015b).

Table 5. Land Cover Types and Acreage for Marvin Nichols Reservoir Site 1A

Land Cover Classification	Acreage	Percent
Barren	1	0.002
Bottomland hardwood forest	6,880	16.5
Forested wetland	17,711	42.5

Land Cover Classification	Acreage	Percent
Grassland/old field	9,766	23.2
Herbaceous wetland	931	2.2
Open water	138	0.3
Row crops	408	1.0
Shrub/wetland	1,272	3.0
Shrubland	231	0.6
Upland forest	4,344	10.4
Urban	40	0.1
Total	**41,722**	**100.0**

Source: Freese and Nichols, 2015b

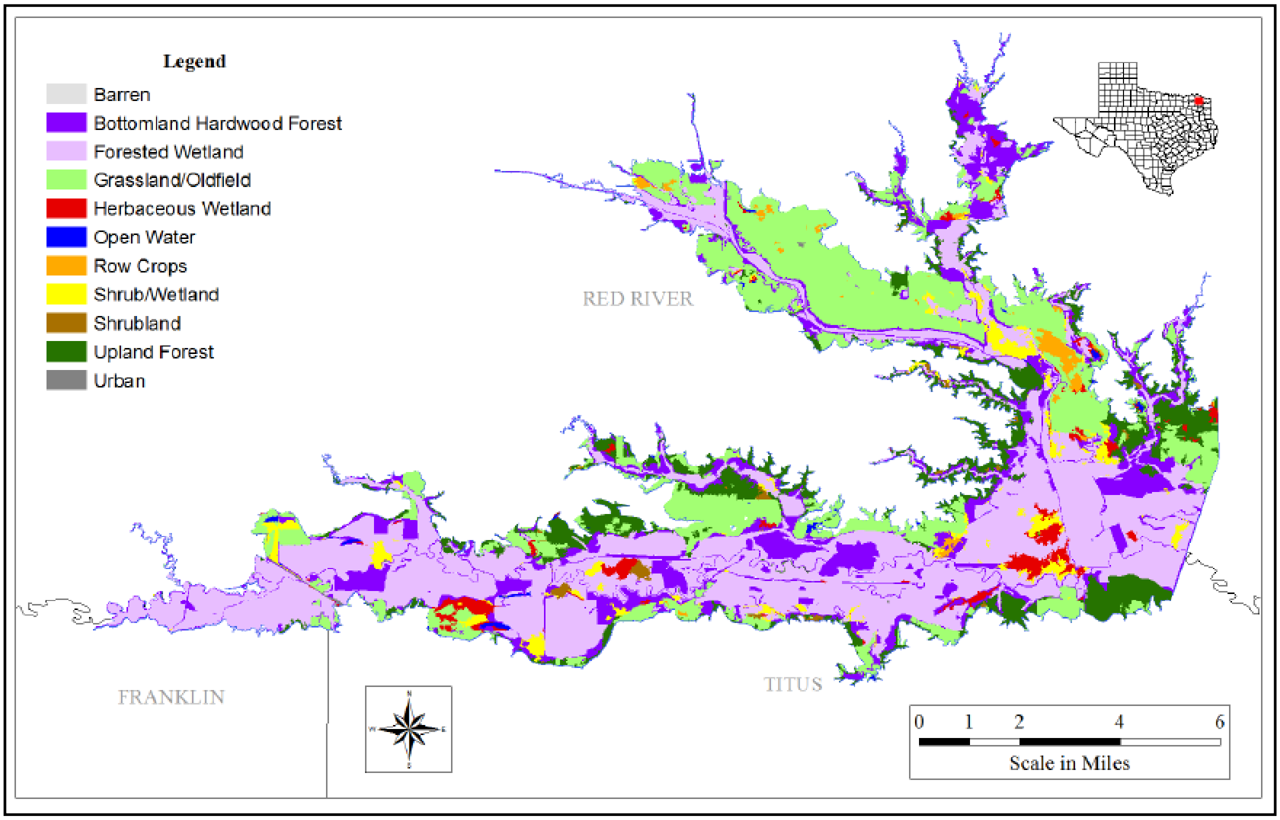

Figure 8. Land Cover Types of Marvin Nichols Reservoir Site 1A

Twenty-five threatened or endangered species are known to occur or have the potential to occur within Titus and Red River counties. Of these, three are federally-listed species and 22 are state-listed. The three federally-listed species – American burying beetle, least tern, and piping plover – have little or no potential to occur in these habitats and thus would not be adversely impacted by the smaller Marvin Nichols Reservoir. As with the larger Marvin Nichols Reservoir, there is moderate potential for adverse impacts on three state-listed species that occur in the affected habitats of the smaller Marvin Nichols Reservoir: the creek chubsucker, the northern scarlet snake, and the timber rattlesnake. Though not anticipated, if any impact on other species were to occur, impacts would be negligible to minor.

As noted above, both Marvin Nichols Reservoir alternatives are located in an area with a high potential for cultural resources. To date, no detailed cultural resource surveys, such as those that have been performed for the Proposed Action, have been conducted at the Marvin Nichols site.

Carbon emissions from the Marvin Nichols Reservoir would include emissions from the lake during the initial inundation as standing vegetation and biomass decay, embodied and emitted emissions during construction, and power generation emissions (primarily from pumping water through the pipeline) during operation. Carbon emissions were not specifically analyzed for this alternative. However, since the reservoir is larger and transmission distance longer compared to the Proposed Action, the carbon footprint is anticipated to be substantially larger than for the Proposed Action. The raw water pipeline from this facility would be 84 miles long versus 35 miles for the Proposed Action.

Feasibility studies have been carried out for the Marvin Nichols Reservoir, but no detailed field studies or permit applications have been submitted to date. To construct a new reservoir, both a state water right permit and a federal Clean Water Act Section 404 permit are required. The permitting process for Lake Jim Chapman took more than two decades. Lake Ralph Hall, another proposed reservoir in Fannin County, has been in the permitting processes at TCEQ and USACE for more than a dozen years since the original application for a Texas water right was filed in 2003. While a water right has now been issued for Lake Ralph Hall, the project still does not have a Section 404 permit in place, nor has a draft Environmental Impact Statement (EIS) been issued (Freese and Nichols, 2015b).

Thus, based on recent experience, it is likely to take about 20 years to obtain the necessary permits, two years to design the reservoir project and three years to construct the project. If NTMWD had started pursuing the Marvin Nichols Reservoir in 2015, the expected online date would be 2040.

The above alternative would be built and provide water only for NTMWD. However, at the present time, the Marvin Nichols project is being considered by the sponsors of the Sulphur Basin Study, including NTMWD, TRWD, Dallas, Irving, Sulphur River Basin Authority (SRBA), and UTRWD. If NTMWD were to pursue this project on its own, the other parties would have to develop other sources of water supply (Freese and Nichols, 2015b).

Characterization According to Listed Factors

- Environmental impacts – The overall environmental impacts of the Marvin Nichols Reservoir Site 1A would be greater than those for the Proposed Action, especially because of the loss of bottomland hardwood forests and other high-value wildlife habitats; cultural resources impacts could range from comparable to those for the Proposed Action to much higher.
- Carbon footprint – Long-term energy and electricity consumption and related CO_2 emissions from pumping water from Marvin Nichols Reservoir Site 1A to the NTMWD service area would be greater than for the Proposed Action due to the much greater distance (more than twice as far).
- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – Water from Marvin Nichols Reservoir Site 1A would cost $2.79 per thousand gallons. This is approximately twice the unit cost of water from the Proposed Action.
- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2015).
- Need for partners – A formal process has been implemented regarding the joint development of Sulphur Basin supplies that includes NTMWD, TRWD, Dallas, SRBA, Irving, and UTRWD. If

NTMWD were to attempt to develop Marvin Nichols Reservoir on its own, this would run counter to the aims of that collaborative, cooperative process.

In conclusion, this alternative does not meet the stated purpose and need of the Proposed Action, and has therefore been dismissed from further consideration. While this alternative supplies more than enough water, it cannot be implemented before 2040, and therefore does not fit within the 2025 time frame.

3.1.5 George Parkhouse Lake South (Parkhouse I) Alternative

The George Parkhouse Lake South alternative, also known as Parkhouse I, is a potential reservoir that would be located in Region D on the South Sulphur River in Hopkins and Delta counties, approximately 18 miles northeast of the city of Sulphur Springs (Figure 9). If constructed, it would lie immediately downstream from Jim Chapman Lake. It is listed as an alternative strategy for NTMWD in the 2016 Region C Water Plan, providing 108,480 AFY of water at a unit cost of $2.10 per thousand gallons (Region C Water Planning Group, 2015). With a conservation pool elevation of 401 feet MSL, Parkhouse I would inundate approximately 29,000 acres and store 652,000 AF. The reservoir would have a total drainage area of 654 square miles (TWDB, 2008). It is estimated that Parkhouse I could not be built before 2035.

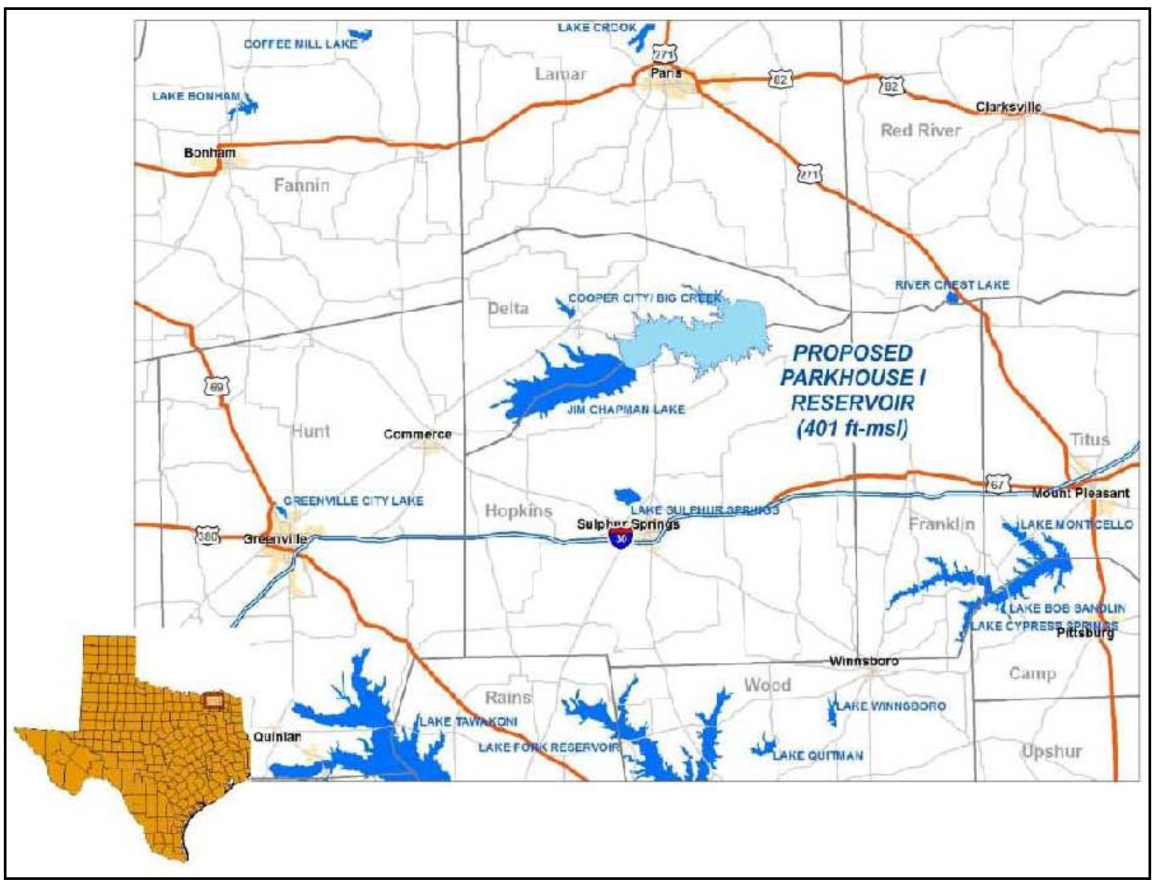

Figure 9. Location Map of the George Parkhouse Lake South (Parkhouse I)

Source: TWDB, 2008

The yield of Parkhouse I would be reduced substantially by the development of Marvin Nichols Reservoir (Region C Water Planning Group, 2015). Yield studies conducted for TWDB as part of the Reservoir

Site Protection Study indicate that the yield of this lake would be reduced by 60 percent, to 48,400 AFY,t if constructed after the Marvin Nichols Reservoir (TWDB, 2008).

The upstream (western) edge of the lake, as currently configured, would abut the dam for Jim Chapman Lake and over 50 percent of the land impacted would be bottomland hardwood forest or marsh (TWDB, 2008). The reservoir site is situated some distance upstream of a Priority 1 bottomland hardwood preservation site identified as Sulphur River Bottoms West (USFWS, 1984). Table 6 summarizes existing land cover for Parkhouse I as reported in the Reservoir Site Protection Study. Land cover on the reservoir site is dominated by contiguous bottomland hardwood forest (37 percent), along with sizeable areas of grassland (16 percent), marsh (16 percent), and agricultural land (16 percent) (TWDB, 2008).

Table 6. Land Cover and Acreage for the George Parkhouse South Lake

Land Cover Classification	Acreage[a]	Percent
Bottomland hardwood forest	10,379	36.8
Marsh	4,566	16.2
Seasonally flooded shrubland	584	2.1
Swamp	83	0.3
Upland deciduous forest	2,428	8.6
Grassland	4,611	16.4
Shrubland	211	0.7
Agricultural land	4,470	15.9
Urban/developed land	5	0.02
Open water	848	3.0
Total	**28,185**	**100.0**

[a]Acreage based on approximate GIS coverage rather than calculated elevation-area-capacity relationship.
Source: TWDB, 2008

Other possible adverse impacts from this large dam and reservoir construction project would likely include impacts to both federal and state threatened and endangered species, downstream hydrology, air quality, noise, agriculture, cultural resources, transportation, utilities, and infrastructure. Both adverse and beneficial impacts on recreation resources and socioeconomics would probably occur, with beneficial impacts in these two areas likely outweighing adverse effects.

Characterization According to Listed Factors

- Environmental impacts – Overall environmental impacts of George Parkhouse Lake South would be somewhat greater than the Proposed Action. This reservoir would inundate an area 70 percent larger than the Proposed Action, consisting mostly of bottomland hardwood forest, other natural habitats, and agricultural lands. The Region C Water Planning Group (2015) rates its impacts on agricultural and rural areas as high and impacts on other natural resources as medium.
- Carbon footprint – Long-term energy and electricity consumption and related CO_2 emissions from pumping water from George Parkhouse Lake (South) to the NTMWD service area would be comparable to the Proposed Action due to similar distance.
- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – At $2.10 per thousand gallons, the unit cost of water from George Parkhouse Lake South is estimated to be about 35 percent higher than water from the Proposed Action.

- Reliability and availability – Reliability is rated as high in the *2016 Region C Water Plan*, but it is not a recommended water management strategy for any Region C water supplier (Region C Water Planning Group, 2015); it is an alternative strategy for NTMWD and UTRWD.
- Need for partners – George Parkhouse Lake South is listed in the *2016 Region C Water Plan* as an alternative strategy for both NTMWD and UTRWD.

In conclusion, this alternative does not meet the stated purpose and need of the Applicant's Proposed Action, and therefore, has been dismissed from further consideration. While it does supply the needed amount of water (an estimated 108,480 AFY, compared to the specified 105,804 AFY), it cannot be implemented before 2035, and therefore does not fit within the 2025 time frame.

3.1.6 George Parkhouse Lake North (Parkhouse II) Alternative

The George Parkhouse Lake North alternative, also known as Parkhouse II, is a potential reservoir that would be located in Region D on the North Sulphur River in Lamar and Delta counties, about 15 miles south of Paris, Texas (Figure 10). If constructed, it would provide 148,700 AFY of water with 118,960 AFY available for Region C, but its yield would be reduced substantially by development of Lake Ralph Hall or Marvin Nichols Reservoir. Its development would require both a water right permit and an interbasin transfer permit. Parkhouse II is not a recommended water management strategy for any Region C wholesale water supplier; however, like Parkhouse I, it is an alternative strategy for NTMWD and UTRWD (Region C Water Planning Group, 2015).

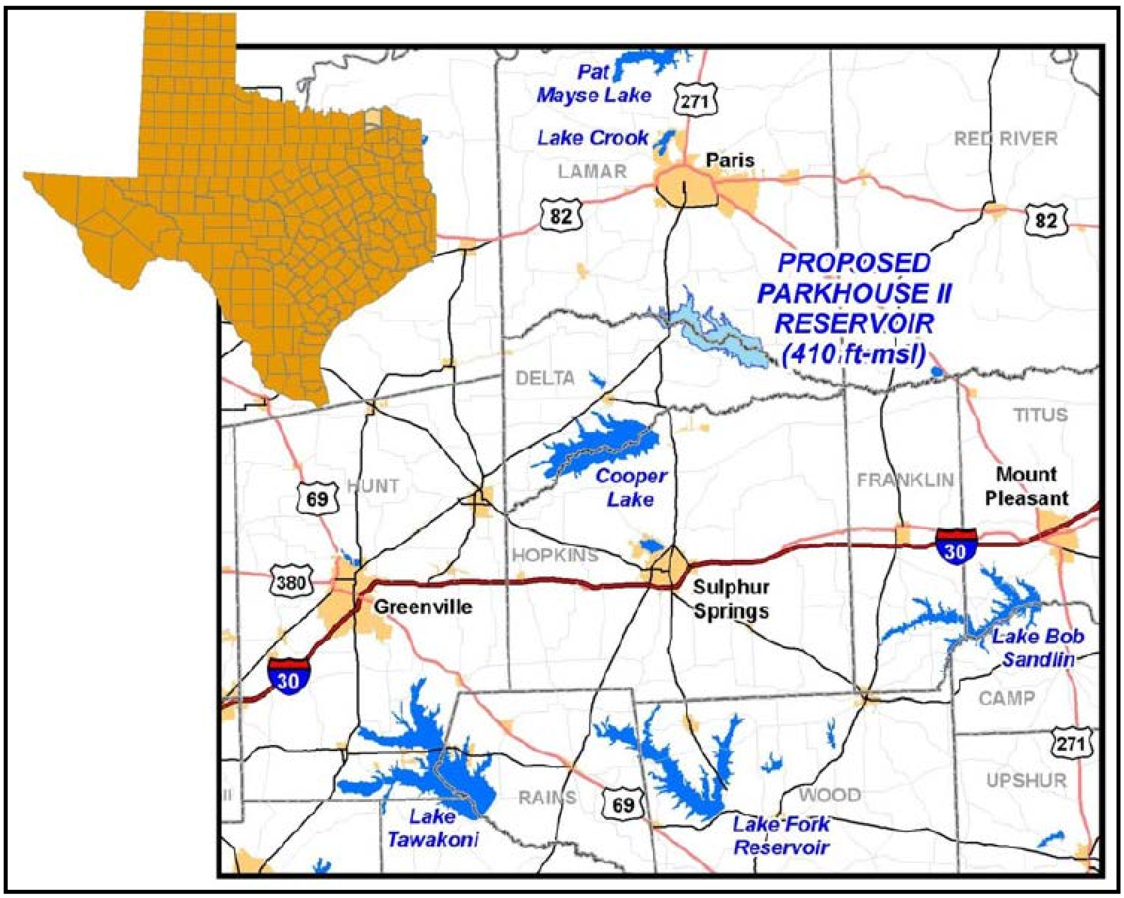

Figure 10. Location Map of the George Parkhouse Lake North (Parkhouse II)

Source: TWDB, 2008

If constructed, Parkhouse II would be located approximately 50 miles from the proposed NTMWD North WTP. At a proposed conservation elevation of 410.0 feet MSL, the reservoir would store 330,871 AF of water and inundate 14,387 acres. The firm yield of George Parkhouse North (taking into account instream flow releases of 10 percent) is estimated at 111,780 AFY. Of this quantity, 89,400 AFY would be available to NTMWD. The remaining 20 percent of the yield would remain in the Sulphur Basin for local use (Freese and Nichols, 2015c).

This project, if built, would be affected by other projects being considered for development in the Sulphur Basin, including the proposed Marvin Nichols Reservoir and the Wright Patman Lake reallocation. A sensitivity study of the reservoir yield found that the yield of Parkhouse II could range from 32,100 AFY (assuming both Lake Ralph Hall and Marvin Nichols Reservoir are constructed prior to Parkhouse II) to 117,400 AFY, assuming only Lake Ralph Hall is constructed prior to Parkhouse II (TWDB, 2008). The reliability of this water supply source would be moderately high, but a drought worse than the drought of record could impact the reservoir yield (Freese and Nichols, 2015c).

The dam for Parkhouse II would be 7.2 miles in length with a gated spillway near the left north abutment. The intake pumping station would be sited at the dam and the pipeline route would follow the existing Lake Chapman pipeline right-of-way for some of the route. The pipeline was assumed to carry a peak capacity of 160 mgd; this represents a peaking factor of two (i.e., peak flows would be twice the rate as average flows) for the yield available to NTMWD. A 210-million gallon terminal storage facility, similar to the one proposed for the Proposed Action, would be included. The total capital cost for the dam, reservoir, and transmission system is estimated at $702 million. Unit costs for the raw water, assuming debt is amortized over 30 years, are $2.07 per 1,000 gallons, compared to $1.33 for the Proposed Action (Freese and Nichols, 2015c).

As a result of channelization in the 1920s and 1930s, the North Sulphur River and its tributaries are deeply cut and continue to erode. The channelization caused erosion to accelerate, such that the river channel is now about 300 feet wide and 40 feet deep in some places. These severe changes to the stream channel have produced an extremely "flashy" stream system, which often has little or no flow. Large flow events carrying heavy sediment loads continue to erode the channel; these suspended sediments would accumulate in the proposed Parkhouse II reservoir. Construction of Lake Ralph Hall would reduce some of this sediment transport into a future Parkhouse II lake; however, sediment loads would remain relatively high.

The segment of the North Sulphur River where Parkhouse North would be built has excessive levels of chlorophyll-a, suggestive of eutrophication or elevated algal populations (indicative of algae blooms and low dissolved oxygen). There is concern for habitat as well as for an impaired macrobenthic community on one tributary to the proposed reservoir, Aud's Creek. The entire reach of the North Sulphur River does not fully support aquatic life. Aside from these impairments, the water in the North Sulphur River is generally freshwater runoff. The Parkhouse II watershed is very similar to the proposed LBCR and is largely agricultural. Based on expected water quality parameters in the proposed LBCR, total dissolved solids (TDS) levels in Parkhouse II are expected to be about 300 mg/L (Freese and Nichols, 2015c).

Parkhouse II would inundate 14,387 acres and impact an additional 1,600 acres for construction of the dam, spillway, pumping station, and pipeline. Figure 11 depicts land cover types within the footprint of the proposed Parkhouse II reservoir (including the dam footprint), while Table 7 lists the estimated acreage of the land cover types that would be impacted. Most of the land cover is grassland and agricultural lands. Approximately 3,076 acres are classified as bottomland hardwoods or forested wetlands and approximately 93 miles of streams would be inundated.

This reservoir site is situated upstream of a designated Priority 1 (highest value) bottomland hardwood preservation site in Red River County known as Sulphur River Bottoms West. These bottomland hardwoods are located approximately 27 miles east of the reservoir; further investigation would be necessary to assess the potential for indirect impacts on these habitats from the proposed reservoir.

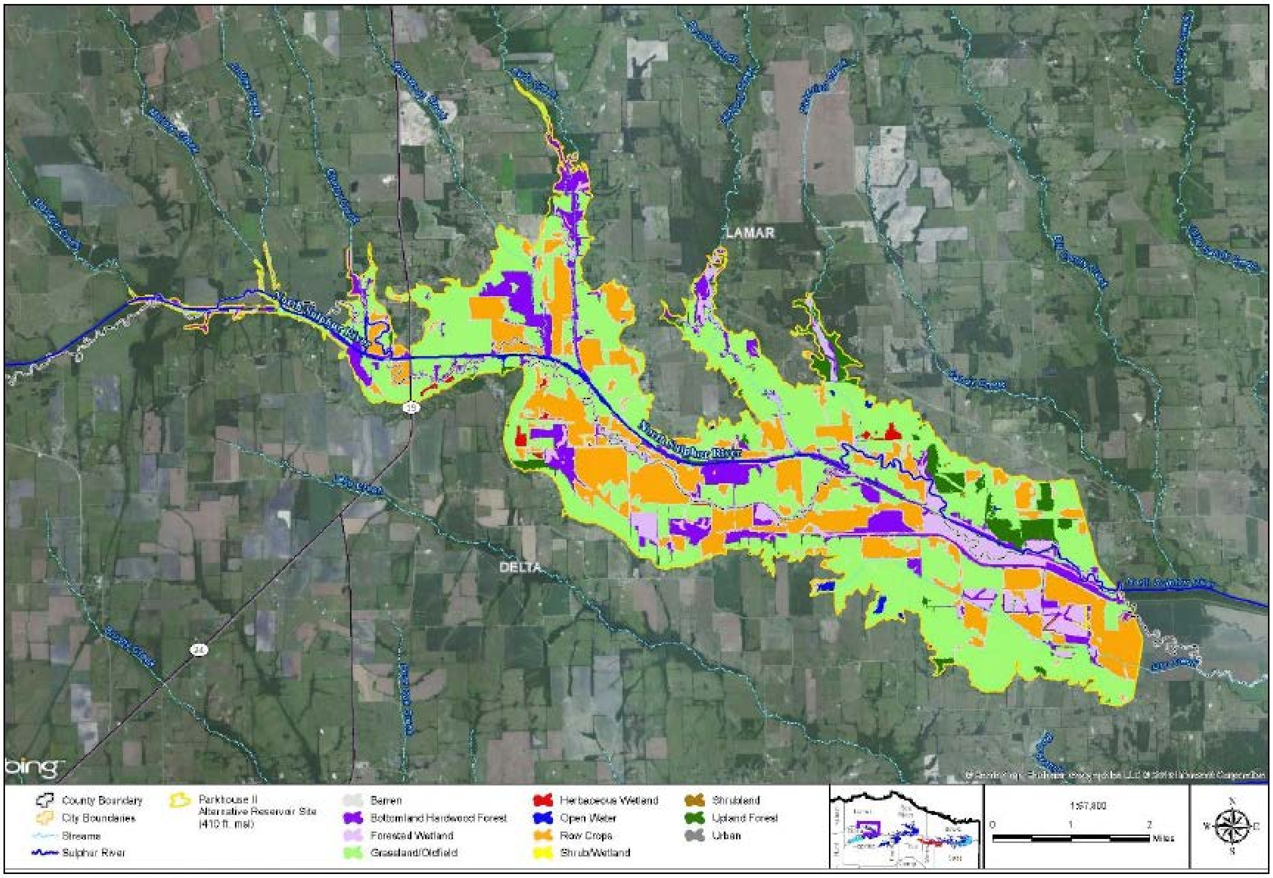

Figure 11. George Parkhouse Lake North (Parkhouse II) Land Cover Types and Locations

Source: Freese and Nichols, 2015c; FNI, 2013

Table 7. Land Cover Types and Acreage for the George Parkhouse Lake (Parkhouse II)

Land Cover Classification	Acreage	Percent
Riparian woodland/bottomland hardwood	1,960	12.8
Forested wetland	1,116	7.3
Emergent/herbaceous wetland	91	0.6
Grassland/old field	7,718	50.3
Cropland	3,626	23.6
Shrub wetland	28	0.2
Evergreen forest Upland deciduous forest	602	3.9
Shrubland	19	0.1
Open water/lacustrine	182	1.2
Urban	14	0.1

Land Cover Classification	Acreage	Percent
Total	**15,356**	**100.0**

Source: Freese and Nichols, 2015c

Twenty-two threatened or endangered species have been documented or have the potential to occur within Lamar and Delta counties. Of these, three are federally-listed and 19 are state-listed. The three federally listed species are the same ones cited above for the Marvin Nichols Reservoir alternatives: the American burying beetle, the least tern, and the piping plover. As in the case of the Marvin Nichols Reservoir, these have little or no potential of being adversely impacted by the proposed Parkhouse II reservoir. Of the 19 state-listed species, there is a moderate potential that the reservoir could adversely affect the creek chubsucker and timber rattlesnake. Little or no impact would be expected to the other state-listed species (Freese and Nichols, 2015c).

Within the Parkhouse II site, there are approximately 3,076 acres of bottomlands and forested wetlands that could provide habitat for the timber rattlesnake. The creek chubsucker listed as threatened by the TPWD has the potential to occur within the Parkhouse II area; however, this species rarely inhabits impounded aquatic habitats. Based on its preferred habitat, there are approximately 93 miles of potential stream habitats for the creek chubsucker within the Parkhouse II reservoir site (FNI, 2013; Freese and Nichols, 2015c).

The Parkhouse II site is situated in an area with moderate potential for cultural resources. Seven known cultural resource sites have been documented within the proposed footprint. Two are associated with the Caddo Nation and five are prehistoric sites. Several sites have moderate to high potential for NRHP listing and one site might contain human remains. Initial field surveys at the Lake Ralph Hall site, 15 miles upstream of the Parkhouse II site, indicate there is strong potential for unrecorded prehistoric and historic properties along the first terrace of the Sulphur River valley. No detailed cultural resource surveys, such as those conducted at and for the proposed LBCR, have been conducted at the Parkhouse II site (Freese and Nichols, 2015c).

A carbon footprint analysis has not been conducted specifically for Parkhouse North. However, because the size of the reservoir and the water conveyance distance are similar to those for the proposed LBCR, the carbon footprint is expected to be similar to that of the Proposed Action's.

Feasibility studies have been conducted for this alternative, but to date no detailed field studies or permit applications have been submitted. As noted earlier, before a new reservoir can be constructed, both a state water right permit and a federal (USACE) Section 404 permit must be obtained. Based on recent experience in this part of Texas, it is expected to take 15 years to obtain the necessary permits for Parkhouse North, two years to design the project and three years to construct it. If NTMWD had begun pursuing the Parkhouse North reservoir beginning in 2015, the anticipated date for it to go online would be 2035.

Characterization According to Listed Factors

- <u>Environmental impacts</u> – Overall environmental impacts of Parkhouse II would be less than the Proposed Action, due to a smaller area of inundation and less bottomland hardwood forest impacted. The Region C Water Planning Group (2015) rates its impacts on agricultural and rural areas as high and impacts on other natural resources as medium.
- <u>Carbon footprint</u> – Long-term energy and electricity consumption and related CO_2 emissions from pumping water from Parkhouse II to the NTMWD service area would be comparable to the proposed project due to similar distance.

- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – The cost for water from Parkhouse II is estimated at $2.07 per thousand gallons, 58 percent higher than the cost of $1.31 per thousand gallons for water from the Proposed Action.
- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2015), but in the *2016 Region C Water Plan*, Parkhouse II is not a recommended water management strategy for any Region C water supplier (Region C Water Planning Group, 2015); rather, it is an alternative strategy for NTMWD and UTRWD. The development of Lake Ralph Hall would substantially reduce the amount of water that could be supplied by George Parkhouse (North). Due to the "first in time, first in right" standard, water rights in Lake Ralph Hall would be senior to those of George Parkhouse (North).
- Need for partners – In the *2016 Region C Water Plan*, George Parkhouse (North) is listed as an alternative strategy for NTMWD and UTRWD, but NTMWD would not require any partners to construct this project.

In conclusion, this alternative does not meet the stated purpose and need of the Proposed Action, and therefore, has been dismissed from further consideration. It would not supply enough water to NTMWD, it cannot be implemented any sooner than 2035, and it therefore does not fit within the 2025 time frame.

3.1.7 Other New Reservoirs

Several other proposed reservoirs in the region were recommended or considered in *the 2016 Region C Water Plan* and *2017 Texas State Water Plan*, but are not considered feasible for NTMWD because the water supply has already been committed to other users. These other proposed reservoirs included Lake Fastrill, Lake Columbia, Lake Tehuacana, and Lake Ralph Hall. Water from proposed Lake Fastrill was already committed to Dallas, but now this is no longer a viable option because in 2006 the Neches River National Wildlife Refuge was established at the proposed reservoir site, a decision upheld in federal court in 2010. Most of the water from proposed Lake Columbia is already committed to users in the Neches River Basin, and the remainder is insufficient for NTMWD's purpose and need. Proposed Lake Tehuacana is located adjacent to Richland-Chambers Reservoir, and would be used and operated by the TRWD. Lake Ralph Hall (for which a separate EIS is now under preparation by the Fort Worth District of the USACE) would be developed and used by the UTRWD (Region C Water Planning Group, 2015).

3.2 TRANSPORTING WATER FROM EXISTING RESERVOIRS

This section examines the potential for augmenting NTMWD's water supplies by using or modifying existing impoundments rather than constructing entirely new impoundments. This may be accomplished in several ways: 1) building new pipelines or enlarging existing ones; 2) increasing the height of dams and thus the size, storage capacity, and firm yield of the reservoirs behind them; or 3) reallocating a portion of a reservoir's flood storage to water supply storage, which increases its capacity to store water for use in municipal or other purposes (e.g., irrigation, industry). However, this would decrease the flood control capacity of the reservoir.

3.2.1 Lake Lavon Alternative

Lake Lavon, owned and operated by the USACE, is located in the Trinity River Basin near the town of Wylie and near the headquarters and main water treatment plant of the NTMWD. At present, Lake Lavon is permitted for 443,800 AF of storage for water supply and 118,680 AFY of diversions. At the current conservation pool elevation (492 feet MSL), there is approximately 275,600 AF of flood storage. If the water conservation pool elevation were to be raised by five feet to elevation 497 feet MSL, there would be an estimated 115,649 AF of additional storage available for water supply (Kiel, 2014b).

To use this additional water, NTMWD would need to obtain a Texas water right. Using the Trinity River WAM, the additional amount of water that could be permitted for diversion from Lake Lavon with the increase conservation pool elevation of 492 feet MSL is estimated at 7,200 AFY, which does not represent a significant increase in water supply for NTMWD. Furthermore, under the Texas system of prior appropriation for surface water rights, nearly all of the water in the Trinity River Basin is: a) appropriated to existing water rights holders; or b) committed to environmental flows. A new water right accorded to NTMWD to divert additional water from Lake Lavon would be the most junior in priority. Thus, if a drought worse than the drought of record were to occur, this water right would be adversely affected prior to more senior water rights.

Adding to the complexity of this alternative, since it is a USACE project, an Act of the U.S. Congress would be required to reallocate flood storage that exceeds 50,000 AF. Reallocating 115,649 AF of flood storage would necessitate such an action, and its approval is doubtful. Conversion of some of the reservoir's flood storage to water supply would reduce the flood protection that Lake Lavon now provides for local residents, businesses, and facilities. Such a loss would need to be mitigated before an approval could be issued. Thus, it is doubtful that this project could be online in time to meet the 2025 deadline established in the purpose and need for the Proposed Action.

Characterization According to Listed Factors

- Environmental impacts – The Lake Lavon alternative would have fewer impacts on habitat than the Proposed Action because it is an existing facility. There are risks to surrounding residents associated with diminished flood control capacity during wet periods.
- Carbon footprint – Long-term energy and electricity consumption and related CO_2 emissions would be less than the Proposed Action per unit of water delivered due to Lake Lavon's proximity to the Wylie WTP.
- Water quality – There would be no additional impacts to water quality from utilizing this existing water supply.
- Economic cost – The cost for raising the conservation pool elevation of Lake Lavon has not been estimated, but would be much less than the estimated cost for constructing the Proposed Action.
- Reliability and availability – As indicated above, any water right issued by Texas would be junior in priority, and thus vulnerable to disruption during severe droughts.
- Need for partners – Partners would not be needed.

In conclusion, reallocating flood storage to water supply in Lake Lavon is not a viable alternative to the Proposed Action. It would only provide about seven percent of the water needed and it cannot be implemented by 2205. It entails risks associated with the reliability of this supply during drought as well as risks to downstream residents from a reduction in flood control capacity during storm events.

3.2.2 Lake Jim Chapman Alternative

Lake Jim Chapman (also known as Cooper Lake), owned and operated by the USACE for both water supply and flood control, is situated in the Sulphur River Basin in Hopkins County. It is a current water source for NTMWD, the city of Irving, UTRWD, and the Sulphur River Municipal Water District. At the present time, the reservoir is permitted for 273,000 AFY of water supply. At its current conservation storage, the permitted total diversion from Lake Jim Chapman is 146,520 AFY. Of this amount, NTMWD's water right is 54,000 AFY (Kiel, 2014b).

The flood pool of Lake Jim Chapman is between elevations 440 and 446.2 feet NGVD (National Geodetic Vertical Datum). This storage has a volume of 130,000 AF and a footprint of 4,905 acres. If the entire volume of the flood storage pool were reallocated to conservation storage (water supply), the additional amount of water that could be diverted from Lake Jim Chapman would be almost 25,000 AFY, about one-sixth the amount that can be withdrawn under existing Texas water rights, and about one-fifth of expected average annual diversions from the proposed LBCR.

These yields do not account for environmental flows in the Sulphur River Basin, which have not yet been developed by the state of Texas. With environmental flows applied, the additional yield would be less. To tap into this potential water supply, NTMWD would need to apply for a Texas water right both for the additional storage and the additional diversion. As in the case of Lake Lavon above, this water right would be the most junior in priority, so that if a drought worse than the drought of record were to occur, this water right would be affected prior to senior water rights.

USACE partners with other agencies to manage the lands around Lake Jim Chapman for fish and wildlife management and recreational purposes. Over 3,200 acres of bottomland hardwoods and wetlands would be inundated by reallocation of the flood storage pool (Kiel, 2014b). Moreover, conversion of flood storage to water supply would reduce the flood protection that the reservoir currently provides for local residents. As in the case of Lake Lavon above, Congressional action would be required to reallocate flood storage in excess of 50,000 AF.

This alternative would provide less than 20 percent of the yield of the proposed LBCR and it cannot be implemented within the timeframe needed for the water. To receive Congressional approval, conduct the necessary studies, and obtain a Texas water right could take 10 to 15 years, assuming Congressional approval is granted. In addition, there are risks associated with the reliability of this supply during drought and risks associated with diminished flood control capacity during wet periods.

Characterization According to Listed Factors

- Environmental impacts – Reallocating flood storage capacity in Lake Jim Chapman would have fewer impacts on habitat than the Proposed Action because it is an existing facility. However, inundating 3,200 acres now used for wildlife habitat and recreation is not a trivial impact. There are also risks to surrounding residents associated with diminished flood control capacity during wet periods.
- Carbon footprint – Per unit of water delivered, this alternative would be roughly comparable to the Proposed Action.
- Water quality – There would be no additional impacts to water quality from utilizing this existing water supply.
- Economic cost – The exact amount is unknown, but it is expected to be much less than the Proposed Aroject.
- Reliability and availability – As indicated above, any water right issued by Texas would be junior in priority, and thus vulnerable to disruption during severe droughts.
- Need for partners – Partners would not be needed.

In conclusion, reallocating flood storage to water supply in Lake Jim Chapman is not a viable alternative to the Proposed Action. It would supply less than one-quarter of the water needed and it cannot be implemented within the 2025 timeframe. Furthermore, it entails risks associated with the reliability of this supply during drought as well as risks to residents from a potential reduction in flood control capacity during storm events.

3.2.3 Reallocation of Storage at Other Reservoirs in the Region

Other reservoirs in the general vicinity of the NTMWD service area include Lakes Ray Hubbard, Ray Roberts, Lewisville, Tawakoni, and Fork. The city of Dallas owns and operates Lake Ray Hubbard, the USACE owns and operates Lakes Ray Roberts and Lewisville, and the SRA owns and operates Lakes Tawakoni and Fork. All five lakes are used by the city of Dallas for water supply (Kiel, 2014b).

Three of these lakes – Hubbard, Tawakoni, and Fork – are used exclusively for water supply and do not have dedicated flood storage. These lakes are surrounded by developed land so the homes and businesses surrounding these lakes would be inundated if the water conservation pool were to be raised. This would almost certainly generate intense public opposition to raising the conservation pool water level to increase water supply storage. The two lakes owned and operated by the USACE, Lakes Ray Roberts and Lewisville, have dedicated flood storage; however, both are located in urban environments where flood protection is an important consideration. Conversion of flood storage to water supply would reduce the flood protection that these lakes currently provide.

Based on the analyses for Lakes Lavon and Jim Chapman, the anticipated increase in yield associated with increased storage for water supply at these existing lakes in the region would be relatively small compared to NTMWD's needs. This is because, as a rule, existing reservoirs are optimally sized and fully permitted. Reallocation of these reservoirs individually or as a group does not constitute a viable alternative to the Proposed Action because they can neither provide the amount of water supply needed, nor provide it within the time period required. There would probably be strong opposition both at the local level and in Congress. Finally, there would likely be an unacceptable increase in the flood hazard from any reallocation of storage capacity at these lakes.

3.2.4 Lake Texoma Alternatives

As described in Chapter 1 and Appendix N of this Revised DEIS, Lake Texoma is a large existing USACE reservoir on the Red River bordering Texas and Oklahoma. NTMWD has a 1986 water right to divert 84,000 AFY of water from Lake Texoma, and to use 77,300 of this amount through the bed and banks of Lake Lavon after an allowance of 6,700 AFY in channel losses moving the water from Lake Texoma to Lake Lavon, a distance of approximately 54 miles. Water from Lake Texoma is relatively high in naturally-occurring dissolved salts, (i.e., it is brackish). This means it must be either blended with a freshwater source or desalinated before it can be used for drinking water. Currently, the NTMWD blends Lake Texoma water with its other sources to make it suitable for municipal use (Freese and Nichols, 2008a).

As explained in Chapter 1, because zebra mussels are now present in Lake Texoma, NTMWD is no longer blending Texoma water in Lake Lavon as it used to. Instead, Texoma water is now piped directly to the NTMWD Wylie WTP, where it is blended at a ratio of 4:1 (fresh: brackish) with water from other sources. This ratio is based on the current water quality of NTMWD's existing fresh water sources, which include Lakes Lavon and Chapman and a considerable amount of reuse supplies. NTMWD is able to utilize approximately 77,000 AFY of Lake Texoma water for blending with its current existing freshwater sources. Any additional use of Lake Texoma water with blending would require the development of a new freshwater source (Freese and Nichols, 2015d).

The U.S. Congress has authorized the reallocation of 150,000 AF of storage in Lake Texoma from hydroelectric power generation to municipal use in Texas, with 50,000 AF of that 150,000 AF reserved for the Greater Texoma Utility Authority (GTUA). The NTMWD negotiated a contract with the USACE for the remaining 100,000 AF of storage in Lake Texoma authorized for Texas in April 2010, having been granted a state of Texas water right in November 2006 to impound and divert this water. The permit specifically states that this water cannot be placed in Lake Lavon. Lake Texoma water contains elevated levels of dissolved salts (mostly halite, or sodium chloride [NaCl]) from natural, 230-million year old Permian Period brine deposits upstream in the Red River watershed (Wurbs, no date). Thus, use of the Lake Texoma water supply would require either: 1) the development of new fresh water supplies to blend at a treatment facility; or 2) the construction of a new desalination water treatment facility. These implementation methods are very different and should be considered two different alternatives to the proposed LBCR (Freese and Nichols, 2008a). Desalination of Lake Texoma water was discussed in Section 2.5.1.2 while blending of Lake Texoma with new fresh water supplies is discussed below.

3.2.4.1 Blending Lake Texoma Water with New Fresh Water Supplies

The elevated dissolved salts in Lake Texoma would have certain environmental impacts whether the water is used by blending or by desalination. The NTMWD's preferred use of this water source is to blend the Texoma water with a new fresh water supply because of environmental concerns and high costs associated with large desalination projects. NTMWD anticipates blending Texoma water in a constructed balancing reservoir near a treatment facility and not in an existing lake or stream. This would reduce the potential impacts of adding high concentrations of dissolved solids to existing lakes or streams (Freese and Nichols, 2008a). It is assumed that NTMWD would use one part of Lake Texoma supply for every 1.7 to 3 parts of other fresh water, depending on the water quality of the source (Freese and Nichols, 2015d). NTMWD would deliver the water directly from Lake Texoma and/or from the Red River downstream of the lake. Downstream diversions offer the advantage of reduced levels of dissolved solids (Region C Water Planning Group, 2010).

Five potential alternative new sources of fresh water could be blended with Texoma water. These include the proposed LBCR (Alternative 1, the proposed project, described in Section 2.2), a smaller LBCR (Alternative 2, described in Chapter 2, Section 2.3), George Parkhouse Lake North, Wright Patman, and Toledo Bend. The amount of water that can be blended is a function both of the water quality and available quantity of the fresh water source. Table 8 lists the new freshwater sources, blend ratios, and blended quantities of water that would be made available by each source.

Table 8. Quantities of Water Supplied by Blending Lake Texoma Water with Selected New Freshwater Sources

Water quality	New freshwater source Full-sized LBCR	Downsized LBCR	George Parkhouse North	Wright Patman	Toledo Bend
TDS (mg/L)	300	300	300	150	200
Texoma TDS (mg/L)	1,100	1,100	1,100	1,100	1,100
Blend ratio	3	3	3	1.7	2
Supply (AFY)					
Freshwater source	120,000	86,100	89,400	105,360	130,000
Texoma	40,000	28,700	29,800	61,460	65,000
Total New Supply	**160,000**	**114,800**	**119,200**	**166,820**	**195,000**

Source: Freese and Nichols, 2015d

For this analysis, the TDS concentration for Texoma water is assumed to be 1,100 mg/L. This concentration is consistent with documented values of Lake Texoma water samples over the past eight years, as well as with previous reports. The blend ratios for each source were designed to achieve a maximum TDS level of 500 mg/L of the blended water.

As shown in Table 8, blending new freshwater sources with existing Texoma supplies to which NTMWD already has a water right would increase the amount of water made available to NTMWD. The quantities range from 114,800 AFY for the smaller proposed LBCR up to 195,000 AFY for Toledo Bend. The smaller LBCR and George Parkhouse Lake North, both described above in this section, would furnish less water to NTMWD even augmented by blending with Texoma water than the proposed full-sized LBCR would without any blending. The NTMWD holds the water right to this source and Lake Texoma is large enough to be capable of supplying water reliably even during a severe drought.

The capital cost incurred by NTMWD to blend Lake Texoma water with another freshwater source at the proposed Leonard WTP would range from $117 million to $182 million, depending on the quantity of water that would be blended. These cost estimates are for infrastructure improvements based on blending either up to 40,000 AFY of Lake Texoma water or up to 65,000 AFY of Lake Texoma water.

The estimated annual and unit costs for blending Lake Texoma water with each fresh water source are shown in Table 9.

Table 9. Costs for Selected Lake Texoma Blending Alternatives and Year of Implementation

	New Freshwater Source				
	Full-sized LBCR	**Downsized LBCR**	**George Parkhouse North**	**Wright Patman**	**Toledo Bend**
Total supply with blending (AFY)	160,000	114,800	119,200	166,820	195,000
Annual cost of new freshwater source ($1,000)	51,637	43,494	60,358	104,412	227,725
Annual cost for obtaining and blending Lake Texoma water ($1,000)	10,889	10,889	10,889	17,875	17,875
Total annual cost ($1,000)	62,526	54,383	71,247	122,287	245,600
Unit cost (AFY)	$390.79	$473.72	$597.71	$733.05	$1,259.49
Unit cost (1,000 gallons)	$1.20	$1.45	$1.83	$2.25	$3.87
Year of implementation	2020	2025	2035	2040	2030

Source: Freese and Nichols, 2015d

The time to implement each blending alternative depends upon the availability of the freshwater supply. The actual time to design and construct the blending infrastructure (pipeline(s) and balancing reservoir) would be under three years. The blending project would probably be initiated when additional supplies are needed above the amount provided by the freshwater source alone. In each of these alternatives, the year of implementation is influenced primarily by the estimated time it would take to conduct the requisite studies and acquire the needed permits and authorizations.

Direct and indirect environmental effects from blending Lake Texoma water with other sources of freshwater would be minor. The necessary infrastructure and facilities construction and improvements are relatively small and include a new pipeline and improvements at the Texoma pumping station. The pipeline would have to be constructed across local streams; however, impacts associated with this can be minimized through a variety of mitigation measures and Best Management Practices (BMPs), and in any case, would likely be short-term and localized. The blending alternative does entail the risk of transferring invasive species, especially the zebra mussel, from Lake Texoma to the terminal storage reservoir at the new North WTP near Leonard, which is located in the Trinity River Basin. However, the current design of the terminal reservoir includes a drain to the Red River Basin to minimize such transfers.

Characterization According to Listed Factors

- Environmental impacts – No impacts on habitat are anticipated at Lake Texoma because it is an existing facility. Lake Texoma contains enough volume and water throughput that there would be little or no effect on water levels, the lakeshore, aquatic biology, or important recreational uses. However, the blending alternative may affect habitats at the reservoir that is used to provide water for blending.
- Carbon footprint – Per unit of water delivered, the carbon footprint would be greater than the Proposed Action due to longer distance and the need to pump water both from Lake Texoma and the new freshwater source.
- Water quality – Impacts on key water quality parameters are rated as medium by the Region C Water Planning Group (2015) compared to medium low for the Proposed Action.
- Economic cost – This alternative would be potentially cheaper than the Proposed Action, provided water were available for blending. The supplied water costs for Lake Texoma blending range from $1.20 per thousand gallons for blending with the full-sized LBCR water to $3.87 per thousand gallons for blending with Toledo Bend water.
- Reliability and availability – Lake Texoma water is both reliable and available.
- Need for partners – NTMWD would need partners for some options but not others.

In conclusion, the feasibility of the Lake Texoma blending alternative is contingent upon the ability to obtain fresh water from a new source. For those alternatives that cannot be implemented in time to meet NTMWD's near and mid-term term needs, blending Texoma water does not meet the purpose and need of the Proposed Action. As noted above, only the full-sized LBCR (Alternative 1) and the smaller (downsized) LBCR (Alternative 2) could be developed and implemented in time, because each of the other alternatives would need considerably more time for studies, permitting, and authorization.

3.2.5 Toledo Bend Reservoir Alternative

Toledo Bend Reservoir is a large artificial lake located on the Texas state border with Louisiana, approximately 200 miles from NTMWD service area. It extends for about 65 miles along the Sabine River on the Texas-Louisiana state line to the southeast of Dallas (Figure 12). The Toledo Bend Project was originally conceived, licensed (in 1963), and developed primarily as a water supply reservoir, with hydroelectricity and recreation as secondary purposes. By surface area, Toledo Bend Reservoir is the largest man-made water body in Texas and the South, as well as the fifth-largest in the U.S., with water normally covering 185,000 acres; the reservoir has a controlled storage capacity of 4,477,000 AF (SRA, no date-b).

The reservoir is owned and operated by the SRA of Texas and the SRA of Louisiana for water supply and hydropower generation. According to the Texas State Water Plan, this lake has available water; however, use of this water by NTMWD would require a contract with the SRA and an interbasin transfer water right to move the water from the Sabine River Basin to the Trinity River Basin (Freese and Nichols, 2015e).

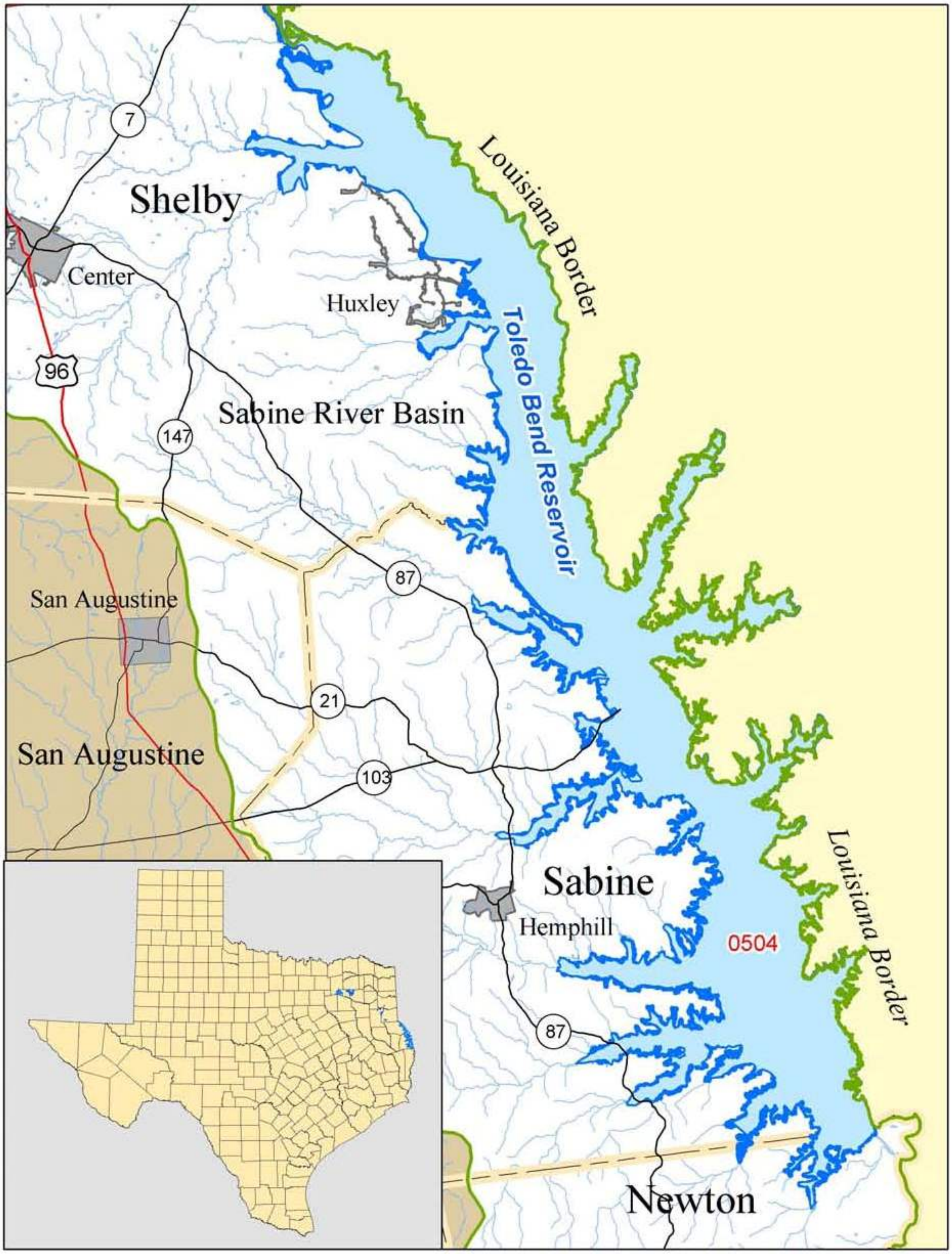

Figure 12. Toledo Bend Reservoir Location Map

Source: Region C Study Commission, 2010

The total permitted supply from this water source for Texas, authorized by Certificate of Adjudication 05-4658, is 750,000 AFY. In both the *2012 Texas State Water Plan* and the *2011 Region C Water Plan,* transport of water from Toledo Bend Reservoir to the North Texas area was a recommended joint strategy for the NTMWD, TRWD, and the SRA. In the current *2016 Region C Water Plan*, water from Toledo Bend is a recommended strategy for NTMWD and an alternative strategy for Dallas, TRWD, NTMWD, and UTRWD (Region C Water Planning Group, 2015). This project, as presented in the *2012 Texas State Water Plan*, would eventually provide up to 200,000 AFY for NTMWD (Region C Water Planning Group, 2010; Region C Study Commission, 2010) with phase I supplying 100,000 AFY by 2060 (Region C Water Planning Group, 2015). Due to the scale of the Toledo Bend pipeline alternative and its current conceptual status, planning, development, and implementation of this alternative would take an estimate 15 to 20 years (Freese and Nichols, 2015e). Thus, the earliest that water from Toledo Bend could be made available would be after 2030.

Water from Toledo Bend would be considered reliable, because only a portion of the available supply is currently being used. However, use of water from this source would require construction and operation of six pumping stations (including the intake) and over 200 miles of pipeline. Breakage of a line or failure of a pump could result in substantial down time. Furthermore, if SRA were to enter into additional contracts with other water purchasers, there could be competition for this water supply. Further study is also needed to determine if the proposed intake location would provide continual access to the water source during periods of extreme drought. Increasing reliability during droughts may necessitate the intake being shifted farther downstream, which would increase the pipeline length and transmission, operational, and pumping costs (Freese and Nichols, 2015e).

Water quality is generally good in the Sabine River Basin and Toledo Bend Reservoir in particular. Toledo Bend has lower TDS than Lake Lavon; however, Toledo Bend does contain giant salvinia (*Salvinia molesta*), an invasive floating fern introduced from southern Brazil that can form dense mats on the water surface. Specific management measures would be required to restrict the transfer of this species to other water bodies along the pipeline route. Overall, it is not expected that there would be any water quality effects on NTMWD's supplies from using Toledo Bend Reservoir (Freese and Nichols, 2015e).

In an analysis performed in the fall of 2015, it was assumed that NTMWD would be able to reach an agreement with SRA to buy 130,000 AFY of water from Toledo Bend Reservoir and that NTMWD would be able to acquire an inter-basin transfer amendment to the existing water right. Costs were estimated to build 215 miles of 120-inch pipeline to convey raw water to the proposed new North WTP near Leonard in Fannin County (Figure 13).

This alternative is one of the costliest for NTMWD in terms of total project cost; its economic viability depends on reaching a purchase agreement with SRA. The *2016 Region C Water Plan* shows the unit cost for water delivered from Toledo Bend to be approximately twice that for water from the proposed LBCR (Region C Water Planning Group, 2015). The Region C cost estimate for Toledo Bend assumed a purchase price of $0.10 per 1,000 gallons; however, more recently the SRA Board charged Dallas $0.56 per thousand gallons for water from Lake Fork, northwest of Toledo Bend and closer to the Dallas-Fort Worth Metroplex. For the purposes of the fall 2015 analysis it was assumed that the purchase rate of water from SRA was also $0.56 per thousand gallons. The total capital cost for the Toledo Bend Reservoir transmission system was estimated at $2.3 billion. Unit costs for the raw water delivered to the Leonard terminal storage reservoir were estimated to be $5.38 per 1,000 gallons (Freese and Nichols, 2015e).

This alternative would require multiple transmission pipelines to transport the water at least 200 miles to North Texas. The current concept for this project includes the use and storage of existing reservoirs as part of the transmission system. This transfer of water is anticipated to have a low to medium low impact to the receiving reservoirs. A long series of interconnected pipelines would entail linear impacts on lands they would traverse. No cultural resources surveys have been conducted along the pipeline route, but it is likely that some cultural resources would be affected. The pipeline could either be detoured around them or mitigation could be implemented.

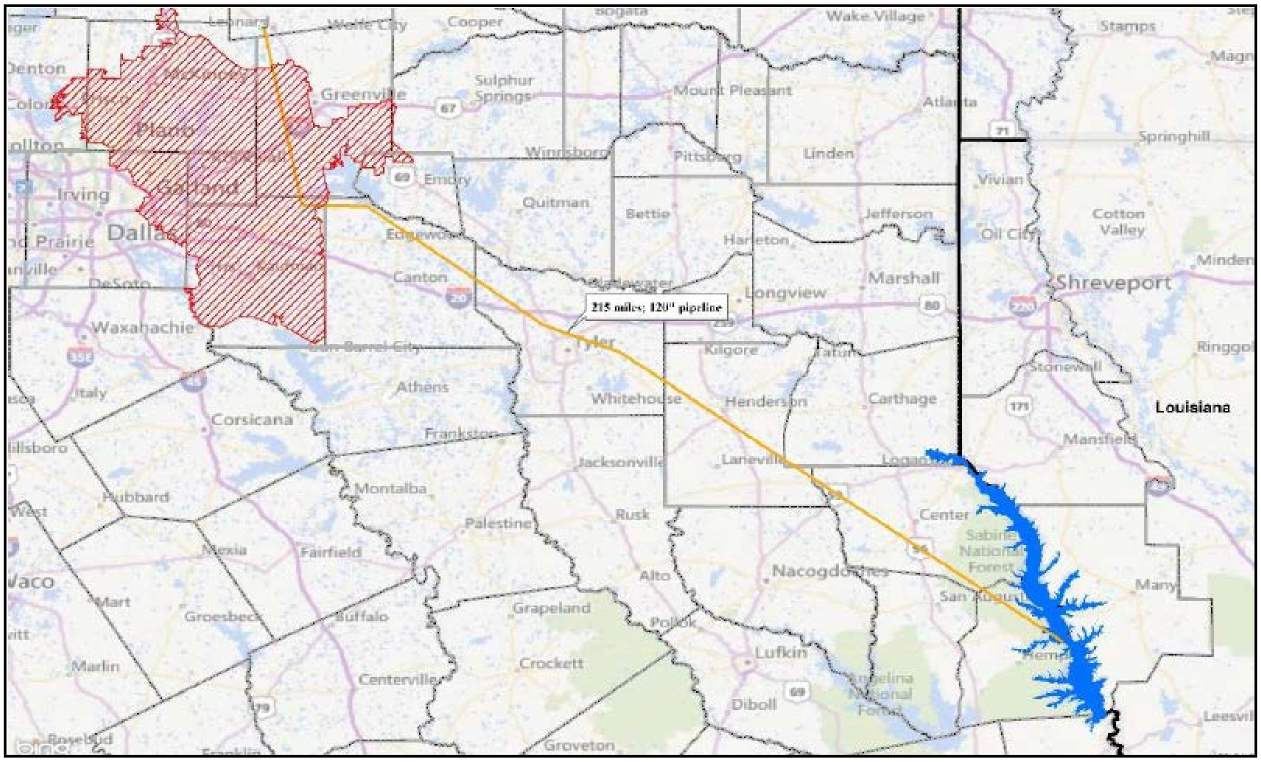

Figure 13. Concept Map of 215-mile Pipeline Route from Toledo Bend Reservoir to NTMWD's Proposed North Water Treatment Plant

Source: Freese and Nichols, 2015e

Most of these direct impacts would be temporary, while the pipeline is being laid; however, a few impacts would be permanent. Impacts to habitat would be minor to moderate; most of the habitats traversed are already altered or agricultural, although the wooded Sabine National Forest would be crossed by approximately 35 miles of the conceptual pipeline alignment. Where natural habitats (e.g., woodlands, grasslands, and wetlands) occur, the main potential permanent impact would be habitat fragmentation, which degrades but does not destroy natural habitats and their values for wildlife and wild flora. A number of pumping stations would be required, each of which would have a modest direct footprint.

In addition, pumping substantial quantities of water such a long distance requires significant amounts of electrical energy, the production of which may contribute incidentally to air pollution or greenhouse gas emissions if fossil fuels (i.e., natural gas or coal) are used to generate this electricity. A carbon footprint analysis was conducted in 2012 for a similar Toledo Bend Reservoir project. This alternative is expected to be similar in size and scale to the project outlined in the 2012 analysis, which generated about 4.7 times as much CO_2 emissions as the proposed LBCR project. Almost all of this difference is related to the carbon emitted from electricity generation required to pump a large volume of water through 215 miles of pipeline.

The conceptual pipeline route traverses nine counties (Figure 13). A total of nine species listed as threatened, endangered, delisted, or candidate are documented in these counties and could potentially be affected by the project. Table 10 lists those species that are known to occur, or have the potential to occur, within these nine counties. A more detailed, targeted analysis of the pipeline alignment would need to be performed to determine if any potential habitat for these species would be affected.

Table 10. Listed Species in the Counties Along the Conceptual Pipeline Route from Toledo Bend to North Texas

		County								
	Federal status	**Fannin**	**Hunt**	**Kaufman**	**Panola**	**Rusk**	**Sabine**	**Shelby**	**Smith**	**Van Zandt**
Bald eagle	DM	√	√	√	√	√	√	√	√	√
Louisiana black bear	T	√			√	√	√	√	√	
Louisiana pine snake	C							√		
Geocarpon minimum	T				√					
Least tern	E	√		√						
Piping plover	T	√	√	√	√	√		√	√	√
Red cockaded woodpecker	E						√	√		
Texas golden Gladecress							√			
Whooping crane	E			√						

Source: Freese and Nichols, 2015e

Note: A check in a given cell means that species has been documented as occurring that county.

T = threatened; E = Endangered; C = Candidate; DM = Recovered, delisted, and being monitored

While this alternative would likely cause fewer initial environmental impacts than the construction of a new reservoir, it would have greater capital costs and energy usage associated with the long transmission pipelines. The unit cost (capital cost per thousand gallons delivered) of this alternative is estimated to be $5.38 per thousand gallons, more than three times that of the proposed LBCR (Freese and Nichols, 2015e).

Characterization According to Listed Factors

- Environmental impacts – In spite of the long pipeline and need to pass through Sabine National Forest, overall permanent impacts on valuable habitats would be less for the Toledo Bend Reservoir Alternative than for the Proposed Action. Cultural impacts would also probably be less.
- Carbon footprint – Per unit of water delivered, the carbon footprint associated with this alternative would be much higher than the Proposed Action due to the much longer distance water would have to be pumped.
- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – The cost per thousand gallons of water is estimated at $5.38 per thousand gallons, at least triple that of the Proposed Action ($1.55 per thousand gallons). Because the Toledo Bend alternative is very energy dependent, any increases in electricity prices would have a greater impact on this alternative than on projects located closer to NTMWD's service area.

- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2015).
- Need for partners – NTMWD would not need partners to develop this alternative.

In conclusion, the Toledo Bend project would result in lower impacts than the proposed LBCR on both terrestrial and aquatic habitats, including waters of the U.S. However, it would have significantly higher capital costs, entail greater long-term energy usage and associated CO_2 (greenhouse gas) emissions, and incur higher long-term operating costs. In any case, it is not a viable alternative to the proposed project, because although it would provide about the same amount of water, it cannot supply this water by 2025 to meet the purpose and need.

3.2.6 Wright Patman Lake Alternatives

Wright Patman Lake is an existing reservoir in the Sulphur River Basin, owned and operated by the USACE. It is located about 150 miles from the NTMWD (Figure 14). In the *2016 Region C Water Plan*, Wright Patman Lake is considered under the heading of Sulphur Basin Supplies (Section 5B.3). Region C wholesale water providers interested in pursuing the development of these supplies include NTMWD, TRWD, city of Dallas, UTRWD, and the city of Irving. Along with the SRBA, these entities have created a Joint Committee on Program Development. Continuing Sulphur Basin feasibility studies are underway by the USACE, SRBA, and the Joint Committee. These studies seek to address Region D concerns with respect to natural resources protection, environmental impacts, and the socioeconomic effects of water supply development within Region D and the Sulphur Basin. At present, Sulphur Basin Supplies are a recommended water management strategy for NTMWD, UTRWD, and TRWD (Region C Water Planning Group, 2015).

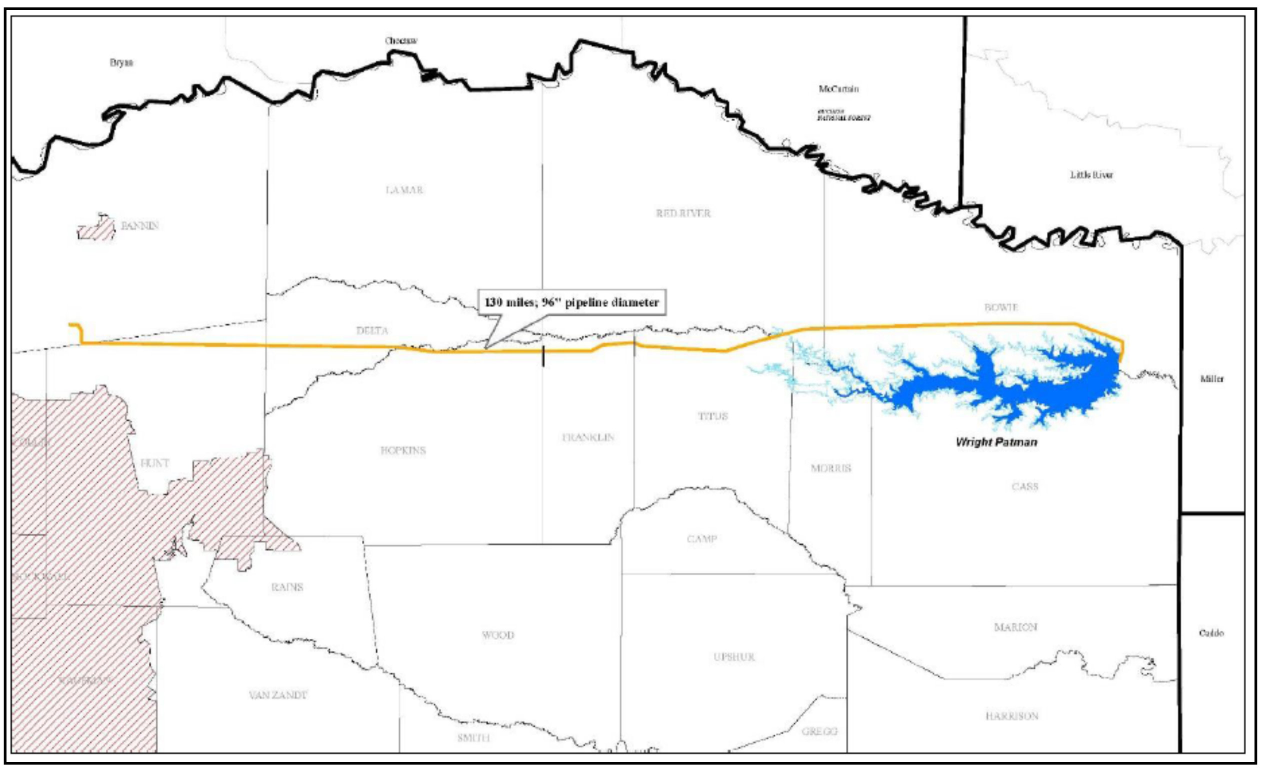

Figure 14. Concept Map of 130-mile Pipeline Route from Wright Patman Lake to NTMWD

The city of Texarkana has contracted with the USACE for storage in Wright Patman Lake and a supply of 13 mgd (14,568 AFY). Texarkana holds a state of Texas water right permit to use up to 180,000 AFY from the reservoir. However, to obtain a reliable supply of this amount, Texarkana would need to activate a contract with the USACE to increase the conservation storage in the lake. Implementation of this contract would require an environmental evaluation of the change in operation of the reservoir as required by NEPA. The USACE contract specifies that the maximum supply from this operational change is 84 mgd, or about 94,132 AFY, resulting in a total supply of 108,800 AFY (Freese and Nichols, 2008a). Accessing the full 180,000 AFY in the Texas water right would require additional modifications to the USACE contract.

There are several different strategies by which water could be made available to NTMWD from Wright Patman Lake:

- Flood storage in Wright Patman Lake could be converted to conservation storage (raising the flood pool), and the NTMWD could use the increased yield.
- Water could be purchased from the city of Texarkana under its existing water right.
- Wright Patman Lake could be operated as a system with Jim Chapman Lake (aka Cooper Lake) upstream to further increase yield.

These strategies are discussed below.

3.2.6.1 Raise Flood Pool of Wright Patman Lake

Increasing the conservation storage in Wright Patman Lake to an elevation of 228.6 feet MSL and allowing for diversions to as low as an elevation of 215.3 feet MSL would increase the yield of the project to about 364,000 AFY (Freese and Nichols, 2003; Region C Water Planning Group, 2015). In this analysis, it was assumed that 180,000 AFY of the additional supply could be made available to water suppliers in North Texas while the remainder of the supply would be reserved for local use. The studies found that increasing the elevation above 228.6 feet MSL would inundate portions of the White Oak Creek Mitigation Area (WOCMA), located upstream from Wright Patman Lake. Approximately 500 acres of the mitigation area are below an elevation of 230 feet MSL, and about 3,800 acres are below an elevation of 240 feet MSL. Therefore, this strategy would require changes to the USACE operation of Wright Patman. Also, this strategy is recommended for the city of Dallas in the City's long-range water supply plan, the 2007 and 2012 Texas State Water Plans, and the *2011 Region C Water Plan*. Due to the available quantity of water from this source, it is unlikely that both NTMWD and Dallas would pursue this strategy.

In the fall of 2015, Freese and Nichols made a preliminary examination of developing a new water supply for NTMWD by reallocating flood storage in Wright Patman Lake to water supply storage, with a maximum water supply storage elevation of 232.5 feet MSL (Freese and Nichols, 2015f). Water supplies from this reallocation were determined using a RiverWare water availability model developed by the USACE and modified to simulate the priority assumptions used in TCEQ's Sulphur River Basin water availability model. Earlier studies assessed different reallocation quantities, based on raising the water conservation pool from the ultimate rule curve maximum elevation of 228.64 ft. MSL to elevations that range from 232.5 ft. MSL to 259.5 ft. MSL. These studies found that reallocations to conservation pool elevations higher than 232.5 ft. MSL would result in major impacts on the White Oak Mitigation Area (Freese and Nichols, 2015f).

The proposed Lake Ralph Hall would be located upstream of the Wright Patman Lake. Lake Ralph Hall has already received a state water right from the TCEQ and therefore, it would have senior priority over the reallocation of Wright Patman Lake. The fall 2015 yield analysis assumed that Ralph Hall has been built and the Marvin Nichols Reservoir has not. Environmental flows specified under the Texas Instream Flow Program have not been developed for the Sulphur Basin; instead, the Lyons method was used to estimate environmental flows. A minimum release of 10 cubic feet per second (cfs) at all times in accordance to the existing contract between the USACE and Texarkana was assumed.

Wright Patman Lake water releases affect the operations of an International Paper (IP) paper mill at Queen City, Texas, a large downstream user of water and a large employer in the area. The effect of reallocation of Wright Patman on IP operations is uncertain but is currently being investigated as part of the Sulphur Basin Feasibility Study. Greater releases from the reservoir may need to occur to mitigate the impact on IP, which could reduce the yield of this option. Twenty percent of the yield of the project was also assumed to be reserved for local use in the Sulphur Basin, an assumption based on an inter-local agreement. Reallocation of flood storage at Wright Patman to water supply will require congressional authorization (Freese and Nichols, 2015f).

Given the above assumptions, the firm yield of Wright Patman reallocation (taking into account instream flow releases) was estimated in 2015 at 131,700 AFY. Of this amount, 80 percent or 105,360 AFY would be available to NTMWD, with the remaining 20 percent of the yield staying in the Sulphur Basin for local use. The reliability of this supply would be moderately high, though a drought worse than the drought of record could reduce the reservoir yield. Required instream flows are also uncertain, and any increase in downstream releases could substantially reduce reliable supplies from this source (Freese and Nichols, 2015f).

Additional dam modifications would be necessary prior to reallocation because of existing concerns for dam safety. At a flood pool elevation of 232.5 feet MSL, the construction of a seepage berm is expected to be required. The design assumes that the water intake pumping station would be at the dam and that the pipeline route would follow the existing Lake Chapman pipelines alignment for part of the route. Given the various assumptions, the total capital cost for the Wright Patman reallocation and transmission system was estimated in 2015 at $1.16 billion, and unit costs for the raw water were estimated at $3.04 per 1,000 gallons, about twice as expensive as the proposed LBCR.

The water in Wright Patman is fresh, with acceptable levels of TDS, but for two decades the reservoir has been characterized by pH or dissolved oxygen (DO) impairments. Occasional fish kills are attributable to low DO concentrations. The sources of these impairments are probably natural internal nutrient recycling in the lake as well as non-point source contributions in the watershed. If reallocation were to occur, future water quality is anticipated to approximate current conditions. Accentuated water level fluctuations in the reservoir from increased withdrawals would continue to facilitate growth of lakeside vegetation during low elevation periods and its subsequent decomposition during wet periods, which is a potential source of nutrients leading to impairment (Freese and Nichols, 2015f).

It is estimated that Wright Patman reallocation to 232.5 feet MSL would inundate an additional 20,036 acres. Another 1,700 acres would be affected by pumping station and pipeline construction. Figure 15 shows different land cover types within the impact area at Wright Patman, and Table 11 documents the estimated acreages of each vegetative cover type. Most of the land cover that would be inundated – approximately 13,661 acres – is classified as forested wetlands and bottomland hardwoods. Another 293 acres of emergent and shrub wetlands and 2,328 acres of open water would be permanently inundated. Approximately 132 miles of streams would also be inundated.

Priority 1 hardwoods are found adjacent to and upstream of Wright Patman Lake. Priority 1 areas signify excellent quality bottomlands of high value to key waterfowl species (USFWS, 1984). Reallocating the flood pool to water supply would permanently inundate this high-quality habitat. Raising the conservation pool of Wright Patman Lake would also impact the upstream WOCMA. At an elevation of

232.5 feet MSL, it is estimated that about 1,000 acres of the WOCMA would be impacted as shown in Figure 16. These impacts increase with increasing reallocation elevations (Freese and Nichols, 2015f).

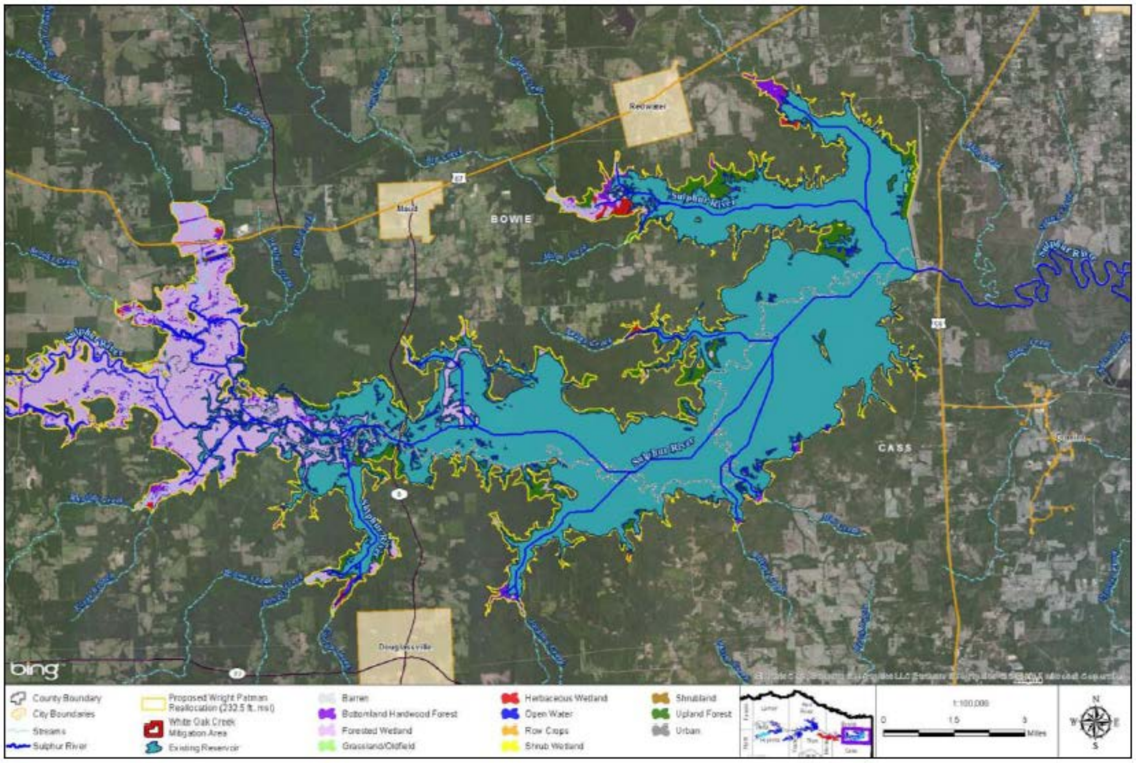

Figure 15. Land Cover Types Impacted by Wright Patman Lake Reallocation to 232.5 feet MSL

Source: Freese and Nichols, 2015f

Table 11. Land Cover Types and Acreage Impacted by Wright Patman Reallocation to 232.5 feet MSL

Land Cover Classification	Acreage	Percent
Riparian woodland/bottomland hardwood	1,684	8.4
Forested wetland	11,977	59.8
Emergent/herbaceous wetland	251	1.3
Grassland/old field	92	0.5
Cropland	4	0.0
Shrub wetland	42	0.2
Evergreen forest	3,624	18.1
Upland deciduous forest		
Shrubland	20	0.1
Open water/lacustrine	2,328	11.6
Urban	14	0.1
Total	**20,036**	**100.0**

Source: Freese and Nichols, 2015f

Twenty-four threatened or endangered species are documented or suspected to occur within Bowie, Cass, Morris, and Red River counties. Of these, two are federally-listed and 22 are state-listed. The two federally listed species, the American burying beetle and the least tern, have little or no potential to be to be impacted by the Wright Patman reallocation because of different habitat preferences. Of the state-listed species, there is some potential that reallocation could adversely affect the creek chubsucker, northern scarlet snake, and timber rattlesnake. Little or no effects on the other state-listed species are anticipated.

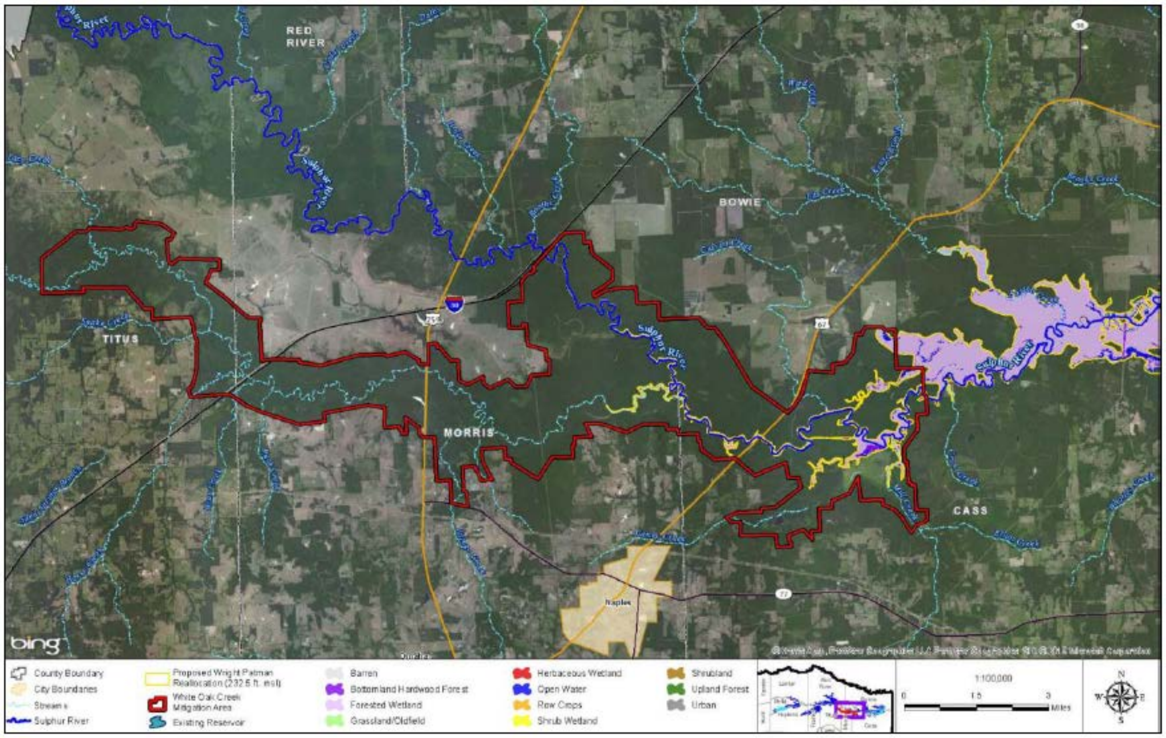

Figure 16. Impacts to WOCMA from Wright Patman Reallocation

Source: Freese and Nichols, 2015f

Approximately 13,661 acres of bottomlands and forested wetlands that potentially provide habitat for the timber rattlesnake are located within the Wright Patman reallocation, as are roughly 2,000 to 4,000 acres of potential habitat (with sandy or sandy-loam soils) of the northern scarlet snake. The creek chubsucker favors highly vegetated small rivers and creeks and may potentially occur within existing tributaries to Wright Patman that would be inundated by reallocation. There are approximately 132 miles of potential stream habitats for the creek chubsucker within the 232.5-foot reallocation footprint (Freese and Nichols, 2015f).

Potential for high value cultural resources sites within the impacted area of the 232.5-foot MSL Wright Patman reallocation is low. Multiple archeological surveys have been conducted at Wright Patman, and based on these surveys, 83 previously recorded historical resources have been flooded by the existing 227.5-foot pool elevation. It is estimated that about one-quarter of the impacted area has been surveyed during archeological investigations for the construction of the lake and the WOCMA. Given this previous survey work and the potential that new cultural resources have already been impacted by periodic flood events, there should be a low risk of extensive cultural resource impacts.

Carbon emissions from Wright Patman reallocation would include those from the increased area of inundation as existing vegetation decays, embodied and emitted emissions during construction, and power generation emission during operation. The carbon footprint of the Wright Patman reallocation alternative is expected to be substantially higher than that of the proposed LBCR because there is a greater amount of forested vegetative cover that would be affected by the reallocation, and because this alternative is more than three and a half times farther away from NTMWD than the proposed LBCR.

Feasibility studies have been conducted for the Wright Patman reallocation, but no detailed field studies and no permit applications have been submitted. Congressional authorization would be required to reallocate the flood storage at Wright Patman to water supply. After this authorization is obtained, a state water right permit, a USACE Section 404 permit, and the appropriate NEPA assessment would all be needed prior to construction. The reallocation process requires substantial study and coordination with the USACE. The state and federal permitting process could take 10 to 15 years, depending upon the data developed during the reallocation authorization, permit applications, complexity of the project, and potential opposition to the project. It is expected to take 20 to 25 years to obtain the necessary authorizations and permits, two years to design the project and three years to construct it. If NTMWD were to pursue the Wright Patman reallocation starting in 2015, the expected online date would be in the 2040 to 2045 timeframe (Freese and Nichols, 2015f).

The Wright Patman reallocation alternative could be carried out by NTMWD alone; no partners are needed. However, this project is currently under consideration by the sponsors of the Sulphur Basin study, which includes NTMWD, TRWD, the city of Dallas, the city of Irving, SRBA, and UTRWD. Wright Patman reallocation is a recommended strategy in the *2016 Region C Water Plan*, in conjunction with a smaller Marvin Nichols Reservoir, for multiple parties including NTMWD. If NTMWD were to pursue this project on its own, these other wholesale water suppliers would need to develop other water supply sources.

Characterization According to Listed Factors

- Environmental impacts – According to the Region C Water Planning Group (2010), environmental and natural resources impacts of the Wright Patman Lake alternatives would be medium to medium-low, while rural and agricultural impacts would be low, in part because the dam and reservoir are already in place. However, as indicated above, impacts of raising the conservation pool to 232.5 feet MSL on forested wetlands, bottomland hardwoods, and riparian woodland could be severe.
- Carbon footprint – Per unit of water delivered, the carbon footprint associated with this alternative would be substantially higher than the Proposed Action due to the much longer distance water would have to be pumped to reach NTMWD's service area.
- Water quality – Impacts on key water quality parameters are rated as medium-low by the Region C Water Planning Group (2015), equal to the Proposed Action.
- Economic cost – The unit cost of water for the various Wright Patman Lake options considered ranges from $1.67 to $3.04 per thousand gallons, compared to $1.55 per thousand gallons for the Proposed Action.
- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2010). However, availability is in question, due to the need to cooperate with multiple partners and to reach an agreement with the existing water rights holders.
- Need for partners – NTMWD could potentially proceed alone with this alternative, or partner with other agencies in the Sulphur Basin Study, such as TRWD, Dallas, Irving, SRBA, and UTRWD.

In conclusion, there is uncertainty regarding the ability to reach contractual agreements with existing water rights holders and there are potential conflicts with other regional wholesale water suppliers. The reallocation alternative would entail potentially substantial environmental impacts to the WOCMA and other forested wetlands from raising the flood pool. It would also involve higher operational costs than the Proposed Action. However, the principal reason that water supply from Wright Patman Lake is not considered a viable alternative to the Proposed Action is that would not be able to provide the needed amount of 105,802 AFY of water by 2025. The most recent estimate is that this project could not come online until between 2040 and 2045.

3.2.6.2 Purchase Water from City of Texarkana

The city of Texarkana, Texas gets most of its water from Wright Patman Lake, which serves both flood control and water supply functions. This reservoir can provide a very large amount of water; however, the amount available depends greatly on how the reservoir is operated, described below. This alternative pertains to the potential availability of water for NTMWD from Wright Patman Lake under existing contracts and authorizations that define two operating policies for water supply from the reservoir. An interim federal contract with the city of Texarkana governs current water supply operation of the reservoir. Proposed operation of the reservoir is defined by a different contract which has never been implemented.

Texarkana currently has the only federal contracts for water supply storage in Wright Patman Lake as well as the only state water right authorizing diversions from the reservoir. The state water right, Certificate of Adjudication 02-4961, authorizes the diversion of 180,000 AFY, with 60,000 AFY authorized for municipal purposes and 120,000 AFY authorized for industrial purposes. Texarkana furnishes water to several municipal customers in Cass, Bowie, and Red River counties, as well as the city of Texarkana, Arkansas. Texarkana also provides raw water from Wright Patman Lake to the IP paper mill located downstream. According to the *2016 Region D Water Plan*, 136,000 AFY is contractually committed to existing users. From 2009 to 2013, about 46,000 AFY was actually diverted from the reservoir for water supply purposes (Freese and Nichols, 2015g), about one-third of aggregate contract amounts.

Several federal contracts are associated with Wright Patman Lake. Current water supply operation is defined in the September 1968 interim contract DACW29-69-C-0019 between the federal government and the city of Texarkana. This contract defines water supply storage as the portion of the reservoir between an elevation of 220 feet MSL and a seasonally varying top of conservation elevation ranging from 220.6 feet MSL in the winter to a maximum of 227.5 feet MSL at the beginning of June. The varying elevation of the conservation pool is called the "Interim Curve". Red and black dashed lines in Figure 17 depict the upper and lower elevations of the water supply pool in the reservoir.

The federal contracts mandate the release of at least 10 cfs from Wright Patman Lake to maintain minimum flows in the Sulphur River downstream. Current USACE operation policy also includes one release of up to 96 cfs from May through October of every year. These release policies are illustrated in Figure 17. One important limit in Wright Patman Lake operation is the bottom of the water supply storage pool, which is set at an elevation of 220 feet MSL in the contract. The USACE contract allows for use of water below an elevation of 220 feet MSL only in emergencies; storage below an elevation of 220 feet MSL is not contracted for water supply. Therefore this storage cannot be included when determining yield under current water supply operations.

Another federal contract with the city of Texarkana (DACW29-68-A-0103), dated April 16, 1968, outlines a proposed water supply operation policy to be implemented after the construction of Lake Chapman, which was completed in 1991. Added flood storage capacity in Lake Chapman resulted in excess flood storage capacity in Wright Patman Lake, enabling conversion of flood storage volume to water supply storage. This proposed operation defines a new top of conservation storage that varies between an elevation of 224.89 feet MSL and 228.64 feet MSL; it is referred to as the "Ultimate Curve". The 220-feet MSL minimum for water supply storage would be retained. Presumably the 10 cfs low-flow release also would be retained, but it is unclear if the 96 cfs release from May through October would be kept (Freese and Nichols, 2015g).

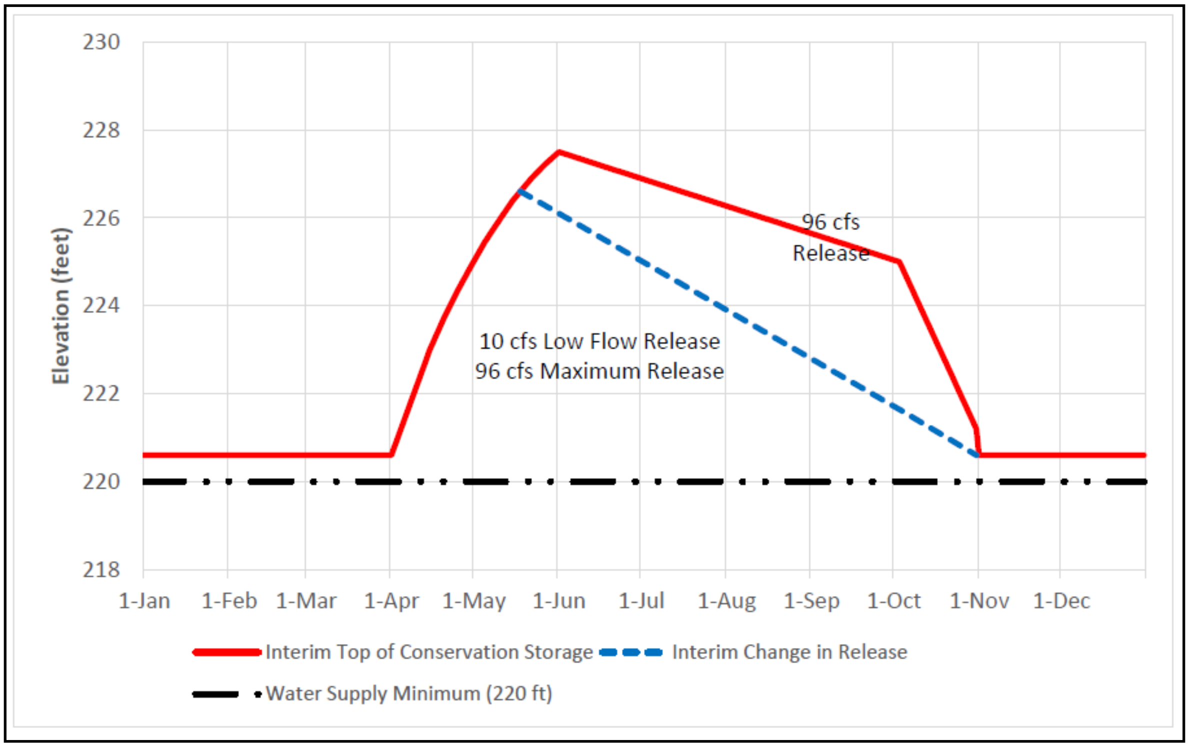

Figure 17. Current Conservation Pool Elevation Operating Plan for Wright Patman Lake

Although Lake Chapman was built and brought online a quarter-century ago, the proposed operation in the April 1968 contract – the Ultimate Curve – has never been implemented. Implementation would be subject to NEPA analysis, and the required studies for this have never been conducted. Changing Wright Patman Lake operations is currently under consideration, but the preferred option for both the project sponsors and the USACE is a flat conservation storage instead of the seasonally varying storage. The Texas water right held for Wright Patman Lake specifies the Ultimate Curve as the top of conservation storage, but does not include the 220-feet MSL minimum water supply storage elevation or any required downstream release from the reservoir (Freese and Nichols, 2015g).

Under the current operation regime – the Interim Curve – and assuming: 1) storage between 220 feet MSL and the Interim Curve and; 2) a constant 10 cfs release, the current firm yield of Wright Patman Lake is 40,263 AFY. If the 96 cfs release from May through October is used instead, the yield would be reduced by about 30,000 AFY, resulting in a firm yield of just 10,000 AFY. This yield would be insufficient to sustain even current use from the reservoir, much less meet current obligations for water supply from the city of Texarkana. Therefore, there is no water available for other interested parties under current operations.

Under the proposed operation regime – the Ultimate Curve – a constant 10 cfs release from Wright Patman Lake would result in a firm yield of about 145,000 AFY. According to the *2015 Region D Water Plan*, 136,000 AFY of this water is reserved for the city of Texarkana or contracted to its customers, leaving only about 9,000 AFY uncommitted. This quantity is well under 10 percent of the yield of the proposed LBCR and does not meet the need of the Proposed Action.

Characterization According to Listed Factors

- Environmental impacts – In spite of the longer pipeline, overall permanent impacts on wildlife habitats would be less for this alternative than for the Proposed Action. Cultural impacts would also probably be less.
- Carbon footprint – Per unit of water delivered, the carbon footprint associated with this alternative would be much higher than the Proposed Action due to the much longer distance water would have to be pumped.
- Water quality – Impacts on key water quality parameters are rated as medium low by the Region C Water Planning Group (2015), the same as for the Proposed Action.
- Economic cost – The cost per thousand gallons of water is estimated to be higher than the cost of water from the Proposed Action due to the much longer raw water pipeline that would need to be constructed.
- Reliability and availability – Reliability is rated as high by the Region C Water Planning Group (2015). However, availability is in question, due to the need for cooperation with multiple partners.
- Need for partners – NTMWD could potentially proceed alone with this alternative, or partner with other agencies in the Sulphur Basin Study, such as TRWD, Dallas, Irving, SRBA, and UTRWD.

In conclusion, purchasing Wright Patman water from Texarkana is not a viable alternative to the Proposed Action. It would supply only about eight percent of the quantity stated in the purpose and need.

3.2.6.3 Operate Wright Patman Lake and Jim Chapman Lake as a System to Increase Combined Yield

System operation of Wright Patman Lake and Jim Chapman Lake could increase the joint yield from the two projects by about 108,000 AFY (Freese and Nichols, 2008a). The combination of purchasing water from Texarkana, converting flood storage to conservation storage, and system operation with Jim Chapman Lake could potentially make 390,000 AFY available from Wright Patman Lake. The *2012 State Water Plan* and the 2011 and *2016 Region C Water Plan* assume that this strategy would be developed jointly with multiple water providers in North Texas. The amount of supply available for the NTMWD would be 130,000 AFY. Other suppliers have not committed to participating with this strategy.

In addition to the inherent uncertainty associated with multiple possible participants, this option would have the same implementation and environmental concerns noted for the other Wright Patman alternatives – contractual changes between the USACE and Texarkana, willing sellers, impacts to the WOCMA, changes to USACE operations of the lake, and conflicts with other potential users (Freese and Nichols, 2008a).

3.2.7 Lake Livingston Alternative

Lake Livingston is an existing reservoir on the Trinity River in Region H, primarily located in Polk and San Jacinto counties. The TRA and the city of Houston hold the water rights for this reservoir. The TRA has indicated that as much as 200,000 AFY of water from Lake Livingston might be available to water suppliers in Region C (Region C Water Planning Group, 2010); however, according to the 2007 and 2012 State Water Plans, much of this available supply is expected to be used to meet projected needs in the greater Houston area and would not be available for NTMWD. Furthermore, the *2011 Region C Water Plan* indicates that water from Lake Livingston is not a recommended strategy for any Region C supplier. The Region C Water Planning Group (2010) does list it as an alternative strategy for NTMWD, but the *2016 Region C Plan* does not (Region C Water Planning Group, 2015).

Lake Livingston is located about 180 miles from the North Texas service area. Because it is an existing supply from an existing reservoir, the on-site environmental impacts of utilizing this water management strategy would be non-existent to low (Region C Water Planning Group, 2010). However, due to the distance to NTMWD, and the need to build and operate a long raw water pipeline, this alternative would cost more than twice as much as the proposed LBCR (Region C Water Planning Group, 2010). It would also entail greater energy use (for pumping) and greenhouse gas emissions. The higher costs of this alternative and the competition with other users for the supply it could provide make it much less desirable than the Proposed Action to meet NTMWD's purpose and need.

Characterization According to Listed Factors

- Environmental impacts – According to the Region C Water Planning Group (2010), environmental, natural resources, and agricultural and rural impacts of the Lake Livingston alternative would all be low, primarily because the dam and reservoir are already in place. Most impacts would be due to the construction and maintenance of a long pipeline to deliver the water to the NTMWD service area.
- Carbon footprint – Per unit of water delivered, the carbon footprint associated with this alternative would be much higher than the Proposed Action due to the much longer distance water would have to be pumped.
- Water quality – Impacts to key water quality parameters was rated as low by the Region C Water Planning Group (2010), compared to medium low for the Proposed Action (Region C Water Planning Group, 2015).
- Economic cost – The unit cost of water would be much higher for this alternative than for the Proposed Action: $3.38 per thousand gallons for Lake Livingston versus $1.33 per thousand gallons for the Proposed Action (Region C Water Planning Group, 2010).
- Reliability and availability – Reliability was rated as high by the Region C Water Planning Group (2010). However, its availability is questionable due to growing water needs to the south (greater Houston area) closer to this reservoir.
- Need for partners – NTMWD may need to partner with the city of Dallas and/or TRWD.

In conclusion, this alternative is not viable because of the much greater pipeline distance, unit cost, greenhouse gas emissions, and uncertain future availability with which it is associated. It cannot meet the purpose and need of the Proposed Action.

3.2.8 Sam Rayburn Reservoir/Lake B.A. Steinhagen Alternative

Sam Rayburn Reservoir is an existing USACE reservoir on the Angelina River in the Neches River Basin. Lake B.A. Steinhagen is located on the Neches River downstream from Sam Rayburn Reservoir. During the development of the *2007 Texas State Water Plan*, the Lower Neches Valley Authority, which holds Texas water rights in both reservoirs, indicated that as much as 200,000 AFY from these reservoirs might be available to water suppliers in North Texas. The Lower Neches Valley Authority wants the water to be diverted from Lake B.A. Steinhagen, which is about 200 miles from the North Texas region, in order to preserve hydropower generation from Sam Rayburn Reservoir. These reservoirs are more than 150 miles from the NTMWD service area. Because of the long distance, they would be relatively expensive sources of supply for NTMWD. There also has been recent interest in supplies from Sam Rayburn Reservoir/Lake B.A. Steinhagen from other users (Freese and Nichols, 2008a).

This strategy was considered in the *2007 Texas State Water Plan* but was not listed in the *2011 Region C Water Plan* or the *2016 Region C Water Plan* due to excessive cost and unavailability for water suppliers in Region C. As with the other alternatives involving the need to construct and operate long water pipelines with attendant pumping stations, this strategy would entail greater greenhouse gas emissions than the Proposed Action.

3.2.9 Other Existing Lakes

Other existing lakes in the vicinity of NTMWD service area include Lake Grapevine, Cedar Creek Reservoir, Richland-Chambers Reservoir, and Lake Palestine. However, each of these sources is fully committed to its existing customers. Lake Grapevine and Lake Palestine are water supply sources for the city of Dallas, and these sources are needed to meet the demands of Dallas, its customers, and other holders of water rights in the lakes. Cedar Creek and Richland-Chambers reservoirs are owned and operated by the TRWD. These water sources are fully committed to meet the water demands of the TRWD (Freese and Nichols, 2008a). Thus, none of these existing lakes is able to meet the purpose and need of the Proposed Action.