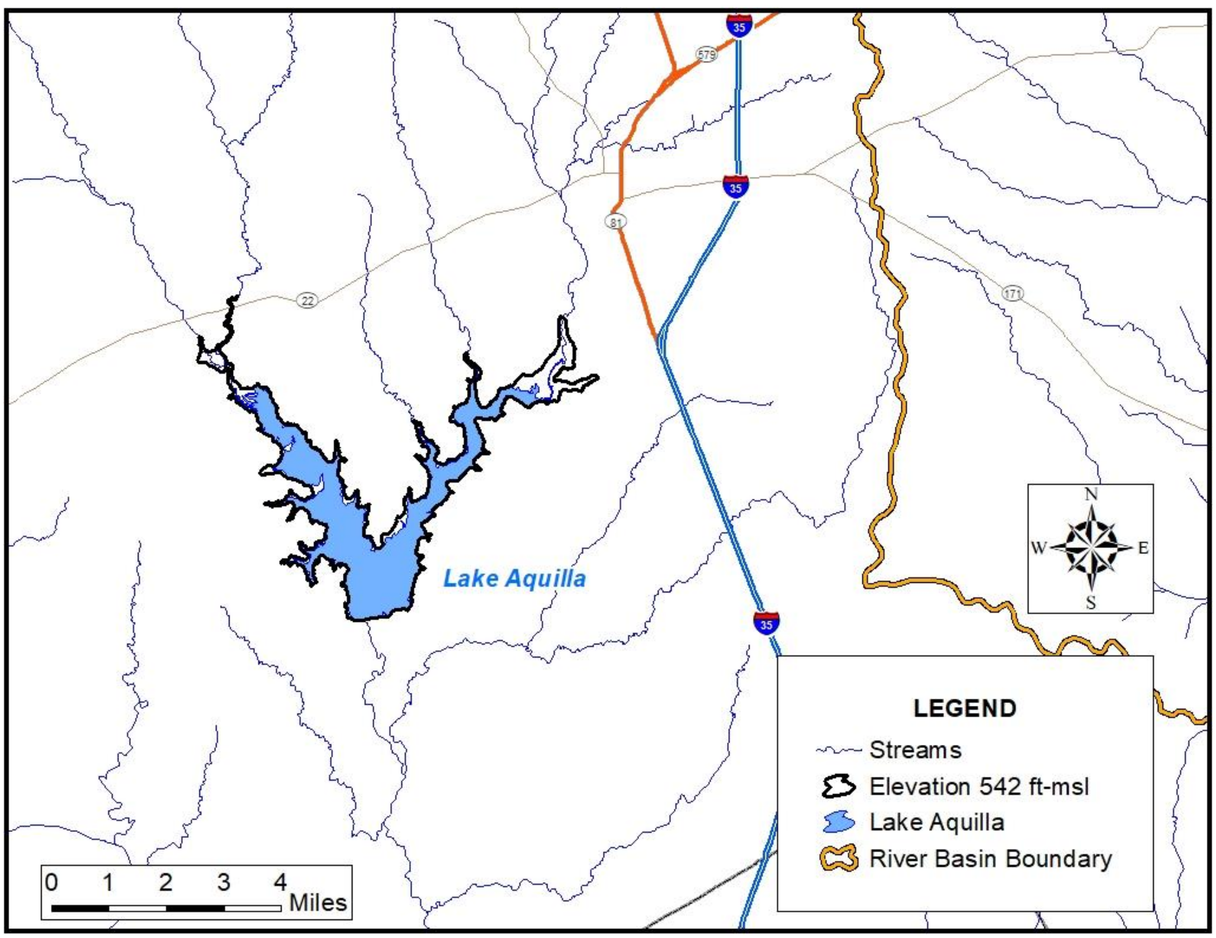
10 Augmentation of Existing Reservoir Supplies

10.1 Lake Aquilla Storage Reallocation

10.1.1 Description of Option

Figure 10.1-1 is a map of Lake Aquilla showing the water surface area at the current conservation pool elevation of 537.5 feet above mean sea level (ft-msl), as well as at an alternative pool elevation at 542 ft-msl. According to a July 2014 volumetric survey, Aquilla Lake has 43,279 acre-feet of storage and a surface area of 3,084 acres at the current conservation elevation of 537.5 feet[1]. The flood storage in the reservoir extends up to elevation 556.0 feet (Table 10.1-1).

Figure 10.1-1. Map of Lake Aquilla with Elevation Contour of Reallocation



[1] Texas Water Development Board, Volumetric Survey of Aquilla Lake July 2014 Survey, June 2015.

Table 10.1-1. Lake Aquilla Characteristics[2]

Ownership	
Reservoir Owner	U.S. Army Corps of Engineers
Water Supply Contract	
Owner	Brazos River Authority
Storage amount	100% of conservation storage
Texas Water Right	
Number	Certificate of Adjudication 12-5158
Owner	Brazos River Authority
Diversion	13,896 acft/yr
Storage	52,400 acft at elevation 537.5 ft-msl
Priority date	October 25, 1976
Flood Pool	
Top elevation	556 ft
Storage[3]	93,600 acft
Conservation Pool[4]	
Top elevation	537.5 ft
Surface area	3,084 ac
Storage	43,279 acft
Sediment Pool[4]	
Top elevation	503 ft
Storage	36 acft

10.1.2 Available Yield

In its 2017 draft report on the reallocation of Lake Aquilla, the U.S. Army Corps of Engineers (USACE) said "the recommended plan is to increase the top of conservation by 4.5 feet" to 542 ft-msl[5]. As part of the 2021 Brazos G Regional Water Plan, the Texas Commission on Environmental Quality (TCEQ) Brazos Water Availability Model (WAM) Run 3 was used to calculate yields for Lake Aquilla under the following two scenarios:

- Existing – Current conservation storage elevation of 537.5 ft-msl
- Raise conservation elevation to 542.0 feet, an increase of 4.5 ft-msl

[2] Certificate of Adjudication 12-5158

[3] Storage within flood pool based on original volumetric survey, October 1983

[4] Texas Water Development Board, Volumetric Survey of Aquilla Lake July 2014 Survey, June 2015.

[5] Middle Brazos Systems Assessment, Phase II: Aquilla Water Supply Reallocation Report and Environmental Assessment. Prepared by the U.S. Army Corps of Engineers, Southwest Division, Fort Worth District. February 28, 2018.

Yields were computed subject to downstream senior rights and having to pass inflows to meet environmental flow standards associated with Senate Bill 3 (SB3).

Figure 10.1-1 shows the elevation contours for the proposed conservation storage elevation if flood storage in Lake Aquilla were to be reallocated to conservation storage. Table 10.1-2 is a summary of the yield studies conducted for the 2021 Brazos G Plan.

Table 10.1-2. Comparison of Firm Yield of Lake Aquilla with Flood Storage Reallocation using Brazos WAM for 2020 and 2070 Conditions

Scenario	Top of Conservation Elevation (feet)	2020 Conditions			2070 Conditions		
		Storage (acft)	Firm Yield (acft/yr)	Yield Increase (acft/yr)	Storage (acft)	Firm Yield (acft/yr)	Yield Increase (acft/yr)
Existing	537.5	43,174	12,604	0	37,374	11,408	0
4.5 ft increase	542.0	58,879	15,262	2,658	53,079	13,891	2,483

The USACE has the authority to reallocate at its own discretion up to 50,000 acre-feet or 15 percent of the total flood storage, whichever is less. Additional reallocation of flood storage to conservation storage requires the approval of the U.S. Congress. Raising the conservation pool 4.5 feet to 542 ft-msl is within this discretionary authority, and therefore would not require congressional approval[6].

By 2070 the estimated storage of Lake Aquilla decreases to 37,374 acre-feet. The calculated firm yield in 2070 from the Brazos G WAM at the current conservation storage of elevation of 537.5 feet is 11,408 acre-feet per year. If the conservation pool elevation was increased to 542.0 feet, the yield of Lake Aquilla would be 13,891 acre-feet per year, resulting in 2,483 acre-feet per year of additional yield in 2070. This is a nearly 22% increase over the existing scenario yield. Figure 10.1-2 and Figure 10.1-3 show the storage trace in the year 2070 for Lake Aquilla under existing conditions and with a 4.5-foot pool raise, respectively.

This strategy could potentially provide additional supply under the recently approved BRA System Operation permit, however this evaluation models Lake Aquilla as a stand-alone reservoir that does not participate in System Operations because most of the supply from Lake Aquilla is committed locally and very little is available for system operation. If an entity other than the BRA were to sponsor and pursue this strategy, then an agreement with the BRA would be required to address concerns related to the potential subordination of the System Operation strategy.

[6] Middle Brazos Systems Assessment, Phase II: Aquilla Water Supply Reallocation Report and Environmental Assessment. Prepared by the U.S. Army Corps of Engineers, Southwest Division, Fort Worth District. February 28, 2018.

Figure 10.1-2. 2070 Lake Aquilla Storage Trace, Current Conservation Elevation (537.5 ft-msl)

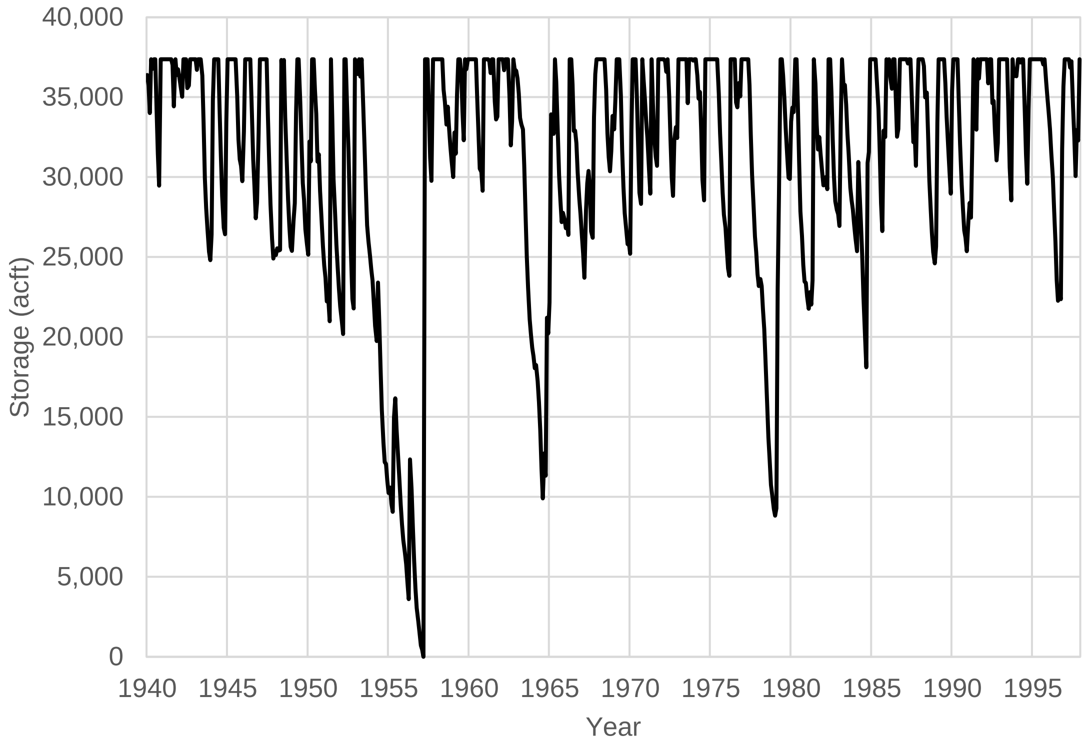
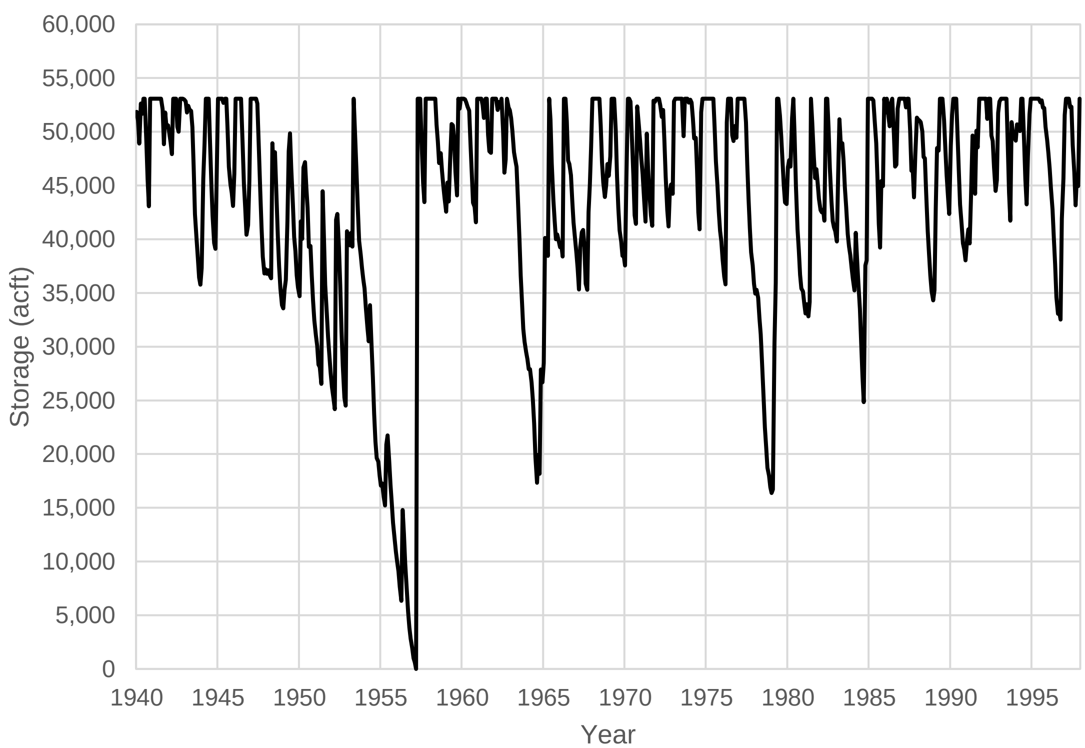


Figure 10.1-3. 2070 Lake Aquilla Storage Trace for Conservation Elevation at 542 ft-msl



10.1.3 Environmental Issues

The greatest impact on the environment from the reallocation of storage in Lake Aquilla is the loss of terrestrial habitat due to higher lake levels. Wetlands and bottomland hardwoods located in the upper reaches of the lake will be impacted by raising the conservation elevation.

The water surface area at conservation under current conditions is 3,084 acres according to TWDB's most recent volumetric survey. If the conservation pool elevation were increased to 542 ft-msl, the maximum surface area would be 3,905 acres[7], and the reservoir would inundate an additional 821 acres when full. All of the land up to the flood pool elevation around Lake Aquilla is owned by the USACE. The USACE manages the area around the lake as a wildlife management area.

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD frequently updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Hill County can be found at https://tpwd.texas.gov/gis/rtest/.

The USACE did not encounter any habitats that appeared suitable for the rare black-capped vireo or endangered golden-cheeked warbler in the affected area. It is possible that whooping cranes may temporarily use the affected habitat during their annual migration but an encounter would be rare. The USACE did not find evidence of either the smalleye shiner or sharpnose shiner within the study area.

10.1.4 Engineering and Costing

Increasing the conservation pool elevation of Lake Aquilla to 542 ft-msl is the plan recommended by USACE because it maximizes yield at the lowest marginal cost. The cost of minor improvements to Lake Aquilla dam is included in the cost estimate. Studies on the slope stability, seepage, and geotechnical aspects of the project have already been conducted and so are not included in the estimate. The total project costs for the reallocation of storage to an elevation of 542 ft-msl is $24.4 million. Detailed costs are shown in Table 10.1-3.

Very few recreational facilities are located at Lake Aquilla, so the reallocation of flood storage will have a low impact on recreation. Other infrastructure that may be affected and needing relocation are utility lines, petroleum pipelines and roads. Another cost is the mitigation of the loss of terrestrial habitat, which is potentially high for this project.

[7] Texas Water Development Board, Volumetric Survey of Aquilla Lake March 2008 Survey Recalculated July 2014, June 2015.

Table 10.1-3. Cost Estimate Summary for Lake Aquilla Pool Reallocation

Item	Estimated Costs for Facilities
Improvements to Dam	$3,149,000
Relocations	$1,650,000
TOTAL COST OF FACILITIES	**$4,799,000**
Engineering, Legal Costs and Contingencies	$1,680,000
Environmental & Archaeology Studies and Mitigation	$919,000
Land Acquisition	$0
Storage Reallocation from USACE to BRA	$14,234,000
Slope Stability, Seepage and Geotechnical Studies	$0
Water Rights Permit from TCEQ	$1,250,000
Administrative Cost for USACE Storage Reallocation Process	$1,200,000
Interest During Construction (12 months)	$271,000
TOTAL COST OF PROJECT	**$24,353,000**
ANNUAL COSTS	
Debt Service (3.5 percent, 20 years)	$1,714,000
Operation and Maintenance	$444,000
TOTAL ANNUAL COST	**$2,158,000**
Available Project Yield (acft/yr)	**2,483**
Annual Cost of Water ($ per acft)	**$869**
Annual Cost of Water ($ per 1,000 gallons)	**$2.67**

10.1.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.1-4, and the option meets each criterion. Seepage related concerns have been expressed about Lake Aquilla dam in the past. A dam safety evaluation completed in August 2013 found that embankment stability has not been much of an issue and that seepage appears well controlled by measures implemented as part of the USACE's Risk Management Plan and is currently being monitored with a system of piezometers, relief wells and collection weirs. An assessment in June 2016 found that the risks associated with Aquilla Dam are considered to be low, and that a pool increase would not change that conclusion; although the dam should continue to be monitored if a pool raise is implemented. The habitat lost to inundation will have to be mitigated. Mitigation property has not yet been identified. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements

- Texas Commission on Environmental Quality (TCEQ) Water Right and Storage permits
- U.S. Army Corps of Engineers (USACE) Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act)
- USACE Section 404 permits for pipeline stream crossings, discharges of fill into wetlands and waters of the U.S. for construction, and other activities
- TCEQ administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan
- Texas General Land Office Easement if State-owned land or water is involved
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if a state-owned streambed is involved
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies
- Wildlife habitat mitigation plan that may require acquisition and management of additional land
- Flow releases downstream to maintain aquatic ecosystems
- Assessment of impacts on Federal- and State-listed endangered and threatened species
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resources recovery and cataloging, which would require coordination with the Texas Historical Commission

Land Acquisition Issues

- Land acquired for reservoir and/or mitigation plans could include market transactions or other local landowner agreements
- Additional acquisition of rights-of-way and/or easements may be required
- Possible relocations or removal of residences, utilities, roads, or other structures

Table 10.1-4. Comparison of Reallocation of Storage in Lake Aquilla Option to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low to moderate impacts on bottomland hardwood and fish and wildlife resources. Lake sedimentation may create significant amounts of shallow wetlands that might benefit migratory water fowl.
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low to moderate impacts on wetlands
C. Impact on Other State Water Resources	• No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	• None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal shortages
F. Requirements for Interbasin Transfers	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

10.2 Lake Granger Storage Reallocation

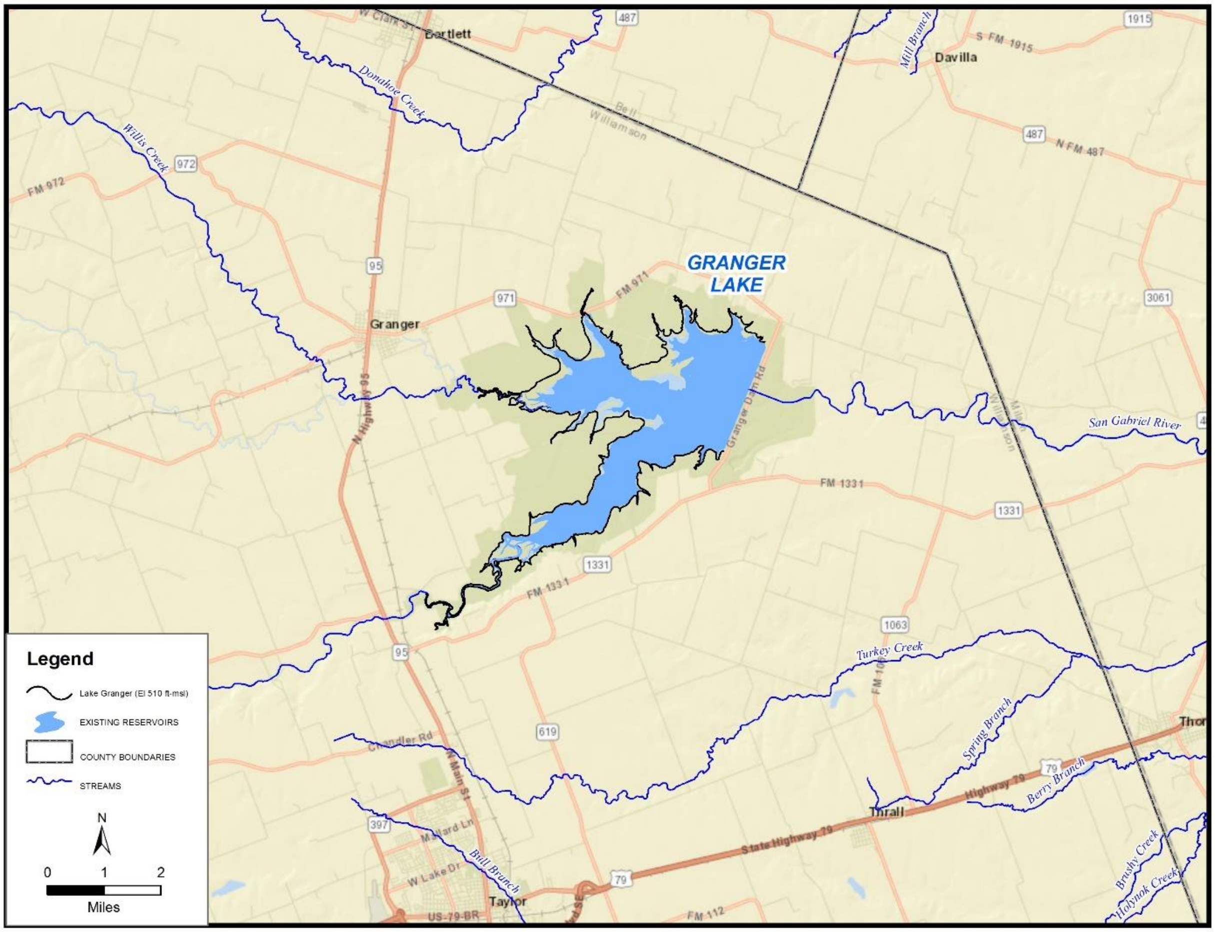
10.2.1 Description of Option

Reservoirs owned by the United States Army Corps of Engineers (USACE) typically serve multiple functions, including flood control, water supply and recreation. Most USACE reservoirs contain a significant amount of storage dedicated to flood control. This flood control storage is used to temporarily hold flood waters in the top few feet of the reservoir to reduce flooding downstream. It is possible to increase the available water supply from these reservoirs by changing some of the flood control storage to the reservoir storage dedicated to water supply, or conservation storage. This process is commonly called reallocation. The USACE has the authority to reallocate at its own discretion up to 50,000 acre-feet or 15 percent of the total flood storage, whichever is less. Additional reallocation of flood storage to conservation storage requires the approval of the U.S. Congress. The Brazos River Authority (BRA) and the USACE have been continuing an evaluation of the feasibility of reallocating storage in several federal reservoirs. This section evaluates reallocation in Lake Granger as a potential water management strategy.

Lake Granger is located in Williamson County, Texas approximately seven miles east of the City of Granger and 10 miles northeast of Taylor (Figure 10.2-1). The Flood Control Act of 1953 authorized the construction of Granger Lake for flood control, water conservation, fish and wildlife habitat, and recreation. Construction of Granger Dam began in 1972 and it began impounding the San Gabriel River in the Brazos River Basin in 1980. The original conservation storage capacity was 65,500 acft at elevation 504 ft-msl, but has since been reduced by sedimentation to 51,822 acft (Table 10.2-1). The total useable storage in Lake Granger is approximately 230,522 acft, with 77.5% of the storage reserved for flood control, and 22.5% for water supply (Table 10.2-1).

Lake Granger was intended to be one of three lakes on the San Gabriel River. However, the proposed South Fork Lake, upstream of Lake Granger, was never constructed. Granger Dam was originally designed to support a conservation pool elevation of 512 ft-msl, so that when the South Fork Lake was completed the conservation pool at Lake Granger could be raised eight feet above its current level. This unique history makes Lake Granger an appealing option for reallocation because it requires few dam improvements and relocations, and the USACE already owns the necessary real estate.

Figure 10.2-1. Map of Lake Granger showing Contour at 510 ft



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Existing_Reservoir_Augmentation_Strategy\Lake_Granger_Storage_Reallocation.mxd

10.2.2 Available Supply

The Brazos Water Availability Model (WAM) Run 3 with Senate Bill 3 environmental flows and the Brazos River Authority's System Operation permit was used to calculate yields for Lake Granger. The firm yield of Lake Granger was evaluated for 2020 and 2070 conditions under the following two scenarios:

- Existing – Current conservation storage elevation of 504.0 ft-msl
- Raise conservation elevation to 510.0 ft-msl, an increase of 6 feet

The USACE has the authority to reallocate at its own discretion up to 50,000 acft or 15 percent of the total flood storage, whichever is less. Additional reallocation of flood storage to conservation storage requires the approval of the U.S. Congress. The 6-foot pool raise proposed by this strategy is within the discretionary authority of the USACE.

Table 10.2-1. Lake Granger Characteristics

Ownership	
Reservoir Owner	U.S. Army Corps of Engineers
Water Supply Contract	
Owner	Brazos River Authority
Storage amount	100% of conservation between 440 and 504 ft-msl
Texas Water Right	
Number	CA 12-5163
Owner	Brazos River Authority
Diversion	19,840 acft/yr
Storage	65,500 acft
Priority date	February 12, 1968
Flood Pool[1]	
Top elevation	528 ft-msl
Storage	178,700 acft
Conservation Pool[2]	
Top elevation	504 ft-msl
Surface area	4,159 ac
Storage	51,822 acft
Inactive Storage[3]	
Storage	0 acft

1. Based on original 1980 survey. Represents volume of flood pool only (i.e., volume between 504 ft-msl and 528 ft-msl assuming no sedimentation in flood pool).
2. Based on 2013 TWDB volumetric survey. Represents volume from 528 ft-msl and below.
3. Based on 2013 TWDB volumetric survey. Invert elevation (outlet works) at 457 ft-msl.

Figure 10.2-1 shows the surface area of the reservoir after reallocation. Table 10.2-2 is a summary of the firm yield analyses. The current storage in Lake Granger is expected to decrease from 47,917 to 36,271 acft by 2070 due to sedimentation. Based on the WAM, the estimated firm yield in 2070 at the current conservation storage of elevation of 504.0 feet is 11,016 acft/yr. If the conservation pool were raised to elevation 510.0 feet, the yield of Lake Granger would be 12,551 acft/yr, resulting in 1,535 acft of additional yield in 2070, or a 14% increase over the existing scenario yield.

This strategy could potentially provide additional supply under the recently approved BRA System Operation permit. However, because of local commitments, the extent to which the reservoir could participate in system operation is uncertain, so this analysis evaluates only the increase in the stand-alone yield of the reservoir. If an entity other than the BRA were to sponsor and pursue this strategy, then an agreement with the BRA would be required to address concerns related to the potential subordination of the System Operation strategy.

Table 10.2-2. Storage Capacities and Yields for Existing and Reallocation Scenarios in Lake Granger

Scenario	Top of Conservation Elevation (feet)	2020 conditions			2070 conditions		
		Storage (acft)	Firm Yield (acft/yr)	Yield Increase (acft/yr)	Storage (acft)	Firm Yield (acft/yr)	Yield Increase (acft/yr)
Existing	504.00	47,971	14,585	0	36,271	11,016	0
6 ft increase	510.00	77,976	15,790	1,205	66,276	12,551	1,535

10.2.3 Environmental Issues

Raising the conservation pool elevation of the reservoir from 504 ft-msl to 510 ft-msl would inundate an additional 1,586 acres approximately. Most of the property around the lake consists of farm fields, but there is wildlife habitat in the floodplain above the lake and in other government property around the lake which would be adversely affected by the pool raise. The impacts could be significant due to the lack of available habitat in this area.

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Williamson County can be found at https://tpwd.texas.gov/gis/rtest/.

According to the USACE's Phase I Information Paper[1], suitable habitat for threatened and endangered species is unlikely to be found at Lake Granger. A more detailed study of the expected habitat loss needs to be conducted in order to determine mitigation requirements.

According to the Phase I Information Paper, there are currently 98 known cultural resources sites at Lake Granger. These sites need to be evaluated to determine if they are eligible for inclusion in the National Register of Historic Places. A complete survey of impacted cultural resources needs to be conducted to determine the full extent of cultural resources within the flood pool of Lake Granger.

[1] Draft Information Paper for Brazos River Basin Systems Assessment Interim Feasibility Study, Phase 1. Updated July 2008. Prepared by U.S. Army Corps of Engineers, Fort Worth District.

10.2.4 Engineering and Costing

Table 10.2-3 summarizes the estimated cost for this option. The dam improvements costs include minor improvements to Granger Dam to store the additional capacity as well as slope stability, seepage and geotechnical studies. There are few recreational facilities located at Lake Granger, so the reallocation of flood storage will have a low impact on recreation. The USACE owns the land up to 533 ft-msl, which is above the top of the flood pool at 528 ft-msl, so the land acquisition costs are zero. The estimated cost for water supply storage was based on the updated investment cost of the reallocated flood control storage as a proportion of the additional storage to total useable storage. The updated investment cost for the reallocated water supply storage in Lake Granger was estimated to be about $22,133,000 in 2018 dollars. The estimate for annual operation and maintenance (O&M) cost was based on a 3-year average (2013-2015) O&M bill for the BRA. Given the increase in storage, the increase in their O&M bill was estimated to be about $678,000 per year. The total project costs for the reallocation of storage to an elevation of 510 ft-msl is $33.2 million. Given a yield of 1,535 acft/yr and a cost of $3,017,000 per year, the annual cost of water is $1,965 per acre-foot ($6.03 per 1,000 gallons).

Table 10.2-3. Cost Estimate Summary for Reallocation of Storage in Lake Granger

Item	Estimated Costs
CAPITAL COSTS	
Improvements to Dam	$3,859,000
Relocations	$414,000
TOTAL COST OF FACILITIES	**$4,273,000**
Engineering, Legal Costs and Contingencies	$1,496,000
Environmental & Archaeology Studies and Mitigation	$854,000
Storage Reallocation from USACE to BRA	$22,133,000
Water Rights Permit from TCEQ	$1,500,000
Administrative Cost for USACE Storage Reallocation Process	$2,684,000
Interest During Construction (12 months)	$298,000
TOTAL COST OF PROJECT	**$33,238,000**
ANNUAL COSTS	
Debt Service (3.5 percent, 20 years)	$2,339,000
Operation and Maintenance	$678,000
TOTAL ANNUAL COST	**$3,017,000**
Available Project Yield (acft/yr)	**1,535**
Annual Cost of Water ($ per acft)	**$1,965**
Annual Cost of Water ($ per 1,000 gallons)	**$6.03**

10.2.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.2-4, and the option meets each criterion.

Table 10.2-4. Comparison of Reallocation of Storage in Lake Granger Option to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. Reasonable
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low to moderate impacts possible
3. Cultural Resources	3. Low to moderate impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	Low to none
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

10.2.6 Potential Regulatory Requirements

Implementation of reallocation of storage in Lake Granger will require several steps including a detailed reallocation study performed by the U.S. Army Corps of Engineers. An outline of the reallocation process is provided below:

1. Local sponsor requests the U.S. Army Corps of Engineers perform a reallocation study. Indicate local interest, purpose, financial capability, etc.
2. Reallocation studies are performed in two phases and follow the General Investigation Process consisting of a Reconnaissance Report and a Feasibility Study. Specific funding would be required for a reallocation study. A reallocation study includes the following:
    a. Define existing project
    b. Define current and projected water supply needs

   c. Alternative solutions considered
   d. Analysis of alternatives
      i. Reallocation of flood control storage
      ii. Raise top of flood control pool
      iii. Reallocate existing conservation pool/power pool
      iv. Hydropower compensation and other hydropower issues
      v. Other
      vi. No action
      vii. Screening of alternatives
      viii. Selection rationale and selection of a plan
   e. Selected plan
      i. Value of storage reallocation
      ii. Impacts of reallocation
      iii. Public involvement
      iv. Environmental impacts
      v. Hydropower compensation and other hydropower issues
   f. Recommended plan
3. NEPA Compliance
4. U.S. Army Corps of Engineers Headquarter Approval of Reallocation Study
5. Authorization from U.S. Congress, if necessary
6. U.S. Army Corps of Engineers and Local Sponsor execute water supply contract based on Water Supply Storage Reallocation
7. Water Rights Permits from the Texas Commission on Environmental Quality (TCEQ)

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10.3 Lake Whitney Reallocation

10.3.1 Description of Options

Lake Whitney is a major impoundment located on the Brazos River approximately 30 miles north of the City of Waco in Hill and Bosque Counties. The location of Lake Whitney is shown in Figure 10.3-1. Lake Whitney was completed in 1951 by the U.S. Army Corps of Engineers for the primary purposes of flood control, water supply, and production of hydroelectric power. According to a 1959 volumetric survey, the total storage in Lake Whitney was 1,999,500 acft, making it the largest reservoir in the Brazos River Basin. The vast majority of storage in Lake Whitney is for flood control, comprising 1,372,400 acft (68.6 percent of the total reservoir storage). The original conservation storage capacity was 627,100 acft at elevation 533 ft-msl, but it has since been reduced by sedimentation to 554,203 acft as of 2005[1]. The capacity below elevation 520 ft-msl is reserved for power head and sediment storage, and has a capacity of 320,711 acft according to the 2005 survey (Table 10.3-1). In 1972, the top of the power pool was raised from 520 ft-msl to 533ft-msl, and the top of power head reserve (i.e. the bottom of the power pool) was raised from 510 ft-msl to 520 ft-msl, making 248,000 acft of storage available to hydropower[2]. In 1982, approximately 20 percent of the hydropower storage (50,000 acft) was reallocated to water conservation storage (water supply). A water right was issued to the Brazos River Authority (BRA) that authorizes the BRA to divert and use 18,336 acft/yr from the water conservation storage (Table 10.3-1). By 2005, the amount stored between elevations 520 ft-msl and 533 ft-msl, which includes both the hydropower pool and BRA's storage, was 233,492 acft.

Hydroelectric power generation from Lake Whitney is administered through the Southwestern Power Administration (SWPA), a federal agency. The Whitney Dam powerhouse uses two generators that originally had a capacity of 30 megawatts (MW) but were upgraded in 2014 and now have a capacity of 43 MW. According to the 2005 TWDB volumetric survey, the average annual power production was 73.1 million kilowatt-hours.

The potential for reallocation of the hydropower storage and inactive storage at Lake Whitney to water conservation storage has been studied in various forms in the past and is an option for developing additional water supply in the Brazos River Basin[3]. The conversion of storage to water supply purposes at Lake Whitney can produce a significant supply of water that could be utilized by a number of entities throughout the Brazos River Basin. Potential users include entities in Bosque County and Johnson County, as well as entities downstream in Region H.

In addition to Lake Whitney reallocation, a project was evaluated to deliver supply from the reallocated storage at Lake Whitney downstream towards Milam County to deliver water

[1] Volumetric Survey of Lake Whitney. June 2005 Survey. Prepared by The Texas Water Development Board, September 2006.

[2] Whitney Reservoir Section 216 Initial Appraisal Report. Prepared by the U.S. Army Corps of Engineers. December 2014.

[3] Texas Water Resources Institute, "Reservoir/River System Reliability Considering Water Rights and Water Quality," (TR-165) Texas A&M University, March 1994.

to Williamson County. This water would be diverted through an intake on the Brazos River, treated and delivered to various water users with needs in Williamson County. Figure 10.3-2 displays the suggested route and strategy.

Figure 10.3-1. Map of Lake Whitney

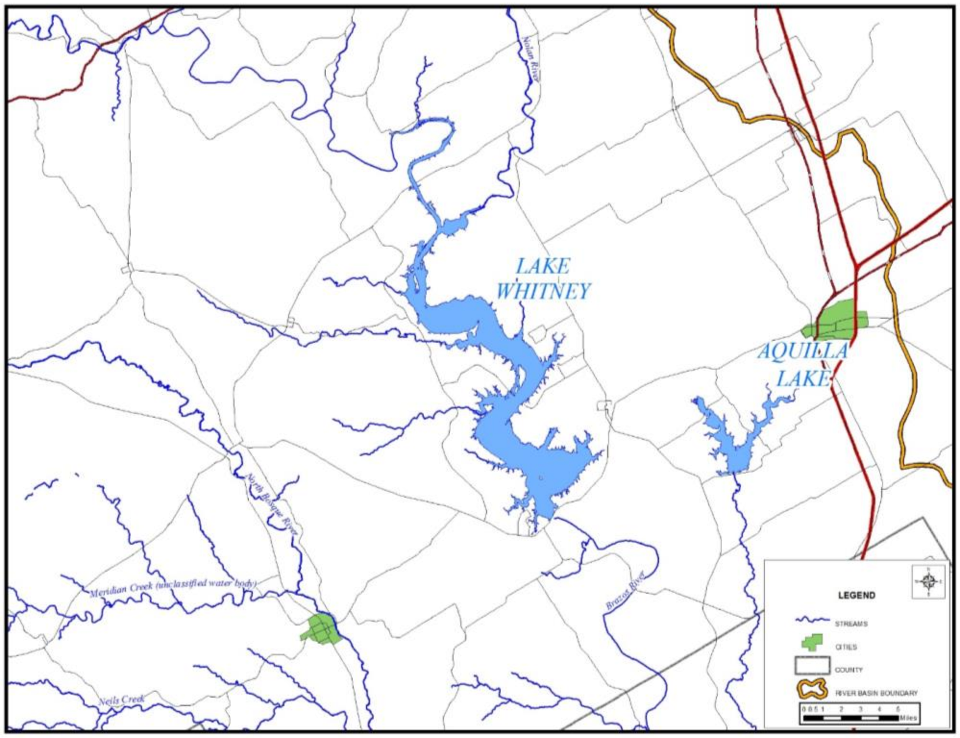

Figure 10.3-2. Map of Lake Whitney Option to Meet Needs in Williamson County

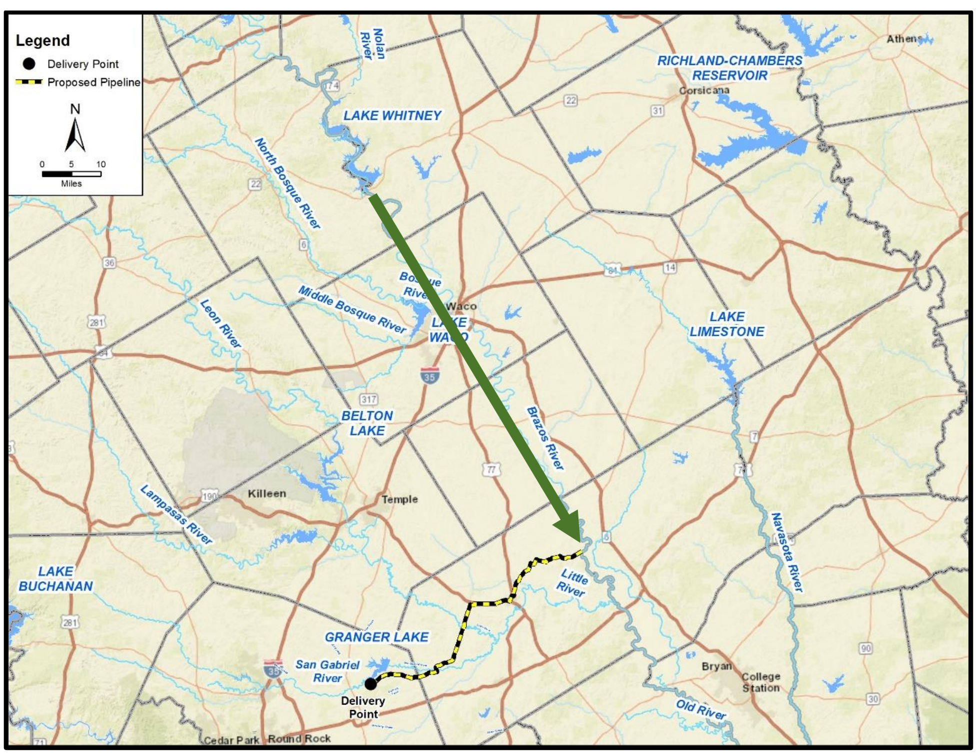

Table 10.3-1. Lake Whitney Characteristics

Ownership	
Reservoir Owner	U.S. Army Corps of Engineers
Water Supply Contract	
Owner	Brazos River Authority
Storage amount	22.017% of conservation storage
Texas Water Right	
Number	CA 12-5157
Owner	Brazos River Authority
Diversion	18,336 acft/yr
Storage	50,000 acft between 520 ft and 533 ft-msl
Priority date	August 30, 1982
Flood Pool[1]	
Top elevation	571 ft
Storage	1,372,400 acft
Conservation Pool[2]	
Top elevation	533 ft
Surface area	23,220 ac
Storage	554,203 acft
Inactive Storage[3]	
Top elevation	520 ft
Storage	320,711 acft

[1]. Based on original 1959 survey. Represents volume of flood pool only (i.e., volume between 533ft and 571ft assuming no sedimentation in flood pool).
[2]. Based on 2005 TWDB volumetric survey. Represents volume from 533ft and below.
[3]. Based on 2005 TWDB volumetric survey. Capacity from 520ft and below is reserved for sediment and power-head storage space.

10.3.2 Available Supply

The firm yield for the reallocation of Lake Whitney was estimated using the Brazos Water Availability Model (WAM) Run 3 with Senate Bill 3 environmental flows and the BRA's System Operation permit. The sedimentation conditions for Lake Whitney were updated to projected storage capacities in 2020 and 2070, while all other reservoirs in the basin remained at their original permitted storage amounts. The WAM simulates streamflows, reservoir operations, and existing water rights for the historical period of 1940-1997. This evaluation does not consider converting flood storage to water supply storage at Lake Whitney, but rather evaluates the reallocation of hydropower storage and a portion of the inactive storage in Lake Whitney to water supply storage. This reallocation could produce a considerable firm yield. Since most of the supply from this strategy would be used as part of the BRA system, this analysis determines the increase in BRA system yield made available from the additional storage. The increase in system yield was measured as the increase in firm diversions at a downstream point in the basin (i.e. Rosharon Gage) as a result of the reallocation project. The increase in system yield for reallocation of the hydropower storage in Lake Whitney was found to be 38,480 acft/yr for 2070 conditions assuming use of the total storage between elevations 520 feet and 533 feet (Table 10.3-1). If ten feet of previously inactive storage were reallocated to water supply, the increase in yield would be 77,600 acft/yr for 2070 conditions assuming use of the total storage between elevations 510 feet and 533 feet (Table 10.3-2). If an entity other than the BRA were to sponsor and pursue this strategy, then an agreement with the BRA would be required to address concerns related to the potential subordination of the System Operation strategy. The available supply could also be less unless the new supplies are operated as part of the BRA system.

The available supply could be used to meet needs in Williamson County. About 10,561 acft/yr is being considered currently for that purpose.

Table 10.3-2. Storage Capacities and the Increase in System Yields for Existing, Hydropower Reallocation, and Hydropower plus Inactive Storage Reallocation

Bottom of Conservation Elevation (feet)	Top of Conservation Elevation (feet)	2020 conditions		2070 conditions	
		Conservation Storage (acft)	System Yield Increase (acft/yr)	Conservation Storage (acft)	System Yield Increase (acft/yr)
520.00	533.00	50,000	0	50,000	0
520.00	533.00	231,084	59,300	226,999	38,480
510.00	533.00	351,448	82,270	341,301	77,600

10.3.3 Environmental Issues

Reallocation of hydroelectric and inactive storage in Lake Whitney could reduce hydroelectric generation and downstream streamflows and may impact reservoir pool levels. The effect on downstream flows would be greater if the diversions from Lake Whitney were taken lakeside. However, as modeled in this evaluation, it is more likely that the lake will continue to be used to meet system demands downstream, so reservoir releases would mitigate some impacts to hydroelectric generation and downstream flows.

The reallocation of hydroelectric storage in Lake Whitney could possibly have moderate impacts on environmental water needs/instream flows in the Brazos River below the reservoir to the extent those impacts are not mitigated by reservoir releases. The evaluation summarized in Table 10.3-3 was based on a wide range of natural resource databases on threatened and endangered species, and on riparian (stream bank) and littoral (lake side) habitats. Potential effects on aquatic and riparian habitats could result from reduction in stream flow, particularly in the summer months when flows are naturally lower and oxygen depletion in the water is greater. Reduced releases may increase the downstream concentration of pollutants from wastewater treatment plants and other sources, potentially impairing water quality in the stream. Seasonally reduced flows downstream from Lake Whitney could also adversely affect riparian vegetation and habitat, including bottomland hardwoods and wetlands. Changes in reservoir pool elevations could possibly have low impacts on bank vegetation, wildlife habitat, and cultural resources sites.

These issues will be evaluated closely by federal permitting agencies including the U.S. Army Corps of Engineers (for wetlands permitting), and the Federal Energy Regulatory Commission (for hydroelectric permitting).

Table 10.3-3. Environmental Issues: Lake Whitney Reallocation

Water Management Options	Implementation Measures	Environmental Water Needs / Instream Flows	Bays and Estuaries	Fish and Wildlife Habitat	Cultural Resources	Threatened and Endangered Species
Reallocation of Hydroelectric Storage to Conservation Storage in Lake Whitney	Reduced Hydroelectric Discharges to Brazos River below Lake Whitney[1]	Possible Moderate Impacts on Brazos River below Lake Whitney[1]	Possible Low Impacts	Possible Moderate Impacts on Brazos River Segment below Lake Whitney[2]	Possible Low Impacts	Negligible Impacts
1. Assumes decrease in average annual instream flows below Lake Whitney as a result of reduced hydroelectric generation. Does not account for cumulative effects of decreased regional stream flows.						
2. Impacts would be variable depending on resulting change in flows. Adverse impacts would be possible for bottomland hardwood forests and wetlands						

This preliminary identification of environmental issues is based on an evaluation of the general characteristics of the water management options. Site specific investigations of the potentially affected environments would be necessary to provide detailed evaluations of possible habitat and cultural resources impacts from the reallocation. A quantitative estimate of magnitude and seasonal distribution of potentially reduced downstream flows caused by the reallocation would be needed to assess the effects on environmental water needs/instream flow and on fish and wildlife in the Brazos River below Lake Whitney.

Environmental impacts of the delivery pipeline are equivalent to those of the pipeline from the Williamson County Groundwater Supply – North Option, because the same pipeline route is followed.

10.3.4 Engineering and Costing

Development of the increase in system yield from reallocation of storage in Lake Whitney will not require major facilities for implementation. However, implementation of this alternative requires a detailed evaluation of various issues that will require mitigation of adverse impacts. In addition to these costs, a detailed U.S. Army Corps of Engineers reallocation study is required. The final cost for implementation of this alternative will be dependent on the results of that study.

Table 10.3-4 summarizes the estimated cost for this option. The estimated cost for water supply storage in Lake Whitney is the maximum of two numbers: 1) the updated investment cost of the reallocated hydropower storage as a proportion of the reallocated storage to total useable storage, or 2) the amount of money needed to compensate for lost hydropower revenue. The updated total investment cost for Lake Whitney was estimated to be $244,974,000. The increase in cost for water supply storage was estimated to be $24,258,000. This corresponds to the first number referred to above. The impact to hydroelectric power generation will vary from year to year depending on hydrologic conditions. Based on the WAM simulations and releases from the reservoir to increase the system yield, the impact to hydroelectric power generation could be around 12 percent of the annual power generation amount. The mitigation cost for the reduction in hydroelectric power generation was based on a replacement cost of $0.08 per kWh, which results in an annual cost of $701,760. This amount was converted from an annual value to a present value of $22,052,000 by assuming a 50-year planning horizon and an inflation rate of 2%. This corresponds to the second number referred to above. Because $24.3 million is larger than $22.1 million, the cost for the increase in storage, rather than hydropower compensation, was taken as the cost for reallocated storage. The total annual cost for this reallocation strategy is estimated to be $2,679,000. Based on the increase in firm yield of 38,480 acft/yr in 2070, this results in a unit cost of raw water of $70 per acft ($0.21 per 1,000 gallons).

Table 10.3-5 summarizes the costs associated with delivering a portion of the Lake Whitney Reallocation supply to Williamson County. This includes an intake, pipeline and a water treatment plant. Those facility costs would be borne by Williamson County-Other entities.

Compensation to BRA may be required if this strategy were developed by an entity other than BRA to compensate for any subordination of the System Operations strategy. The available supply could be less if the new supplies were not operated as part of the BRA system.

Table 10.3-4. Cost Estimate Summary for Reallocation of Hydropower Storage in Lake Whitney

Item	Estimated Costs
CAPTIAL COSTS	
Improvements to Dam	$4,444,000
TOTAL COST OF FACILITIES	$4,444,000
Engineering, Legal Costs and Contingencies	$1,555,000
Environmental & Archaeological Studies and Mitigation	$888,000
Storage Reallocation from USACE to BRA	$24,258,000
Water Rights Permit from TCEQ	$1,500,000
Administrative Cost for USACE Storage Reallocation Process	$3,711,000
Interest During Construction (12 months)	$333,000
TOTAL COST OF PROJECT	$36,689,000
ANNUAL COSTS	
Debt Service (3.5 percent for 20 years)	$2,581,000
Operation and Maintenance	$98,000
TOTAL ANNUAL COST	$2,679,000
Available Project Yield (acft/yr)	38,480
Annual Cost of Water ($ per acft)	$70
Annual Cost of Water ($ per 1,000 gallons)	$0.21

Table 10.3-5. Cost Estimate Summary for Delivery of Lake Whitney Reallocation Supplies to Williamson County

Item	Estimated Costs
CAPTIAL COSTS	
Intake Pump Stations (27.8 MGD)	$44,805,000
Transmission Pipeline (42 in dia.)	$105,369,000
Water Treatment Plant (27.8 MGD)	$72,873,000
TOTAL COST OF FACILITIES	**$223,047,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$72,798,000
Environmental & Archaeology Studies and Mitigation	$1,354,000
Land Acquisition and Surveying (327 acres)	$1,275,000
Interest During Construction (3% for 1 years with a 0.5% ROI)	$8,209,000
TOTAL COST OF PROJECT	**$306,683,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$21,579,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$1,054,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,120,000
Water Treatment Plant	$13,609,000
Pumping Energy Costs (7,903,331 kW-hr @ 0.08 $/kW-hr)	$2,702,000
Purchase of Water (26,000 acft/yr @ 76.5 $/acft)	$1,989,000
TOTAL ANNUAL COST	**$42,053,000**
Available Project Yield (acft/yr)	26,000
Annual Cost of Water ($ per acft), based on PF=1.2	$1,617
Annual Cost of Water After Debt Service ($ per acft), based on PF=1.2	$787
Annual Cost of Water ($ per 1,000 gallons), based on PF=1.2	$4.96
Annual Cost of Water After Debt Service ($ per 1,000 gallons), based on PF=1.2	$2.42

10.3.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.3-6, and the option meets each criterion.

Table 10.3-6. Comparison of Lake Whitney Reallocation Option to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Significant quantity available for regional use or in Region H
2. Reliability	2. High reliability
3. Cost	3. Low
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impacts possible downstream
2. Habitat	2. Moderate impacts possible
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Low impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	Reduction in intentional hydropower releases, but few other negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	No threats to agriculture; possible changes in downstream flows
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

10.3.6 Potential Regulatory Requirements

Implementation of reallocation of storage in Lake Whitney will require several steps including a detailed reallocation study performed by the U.S. Army Corps of Engineers and potentially an authorization from the U.S. Congress. An outline of the reallocation process is provided below:

1. Local sponsor requests the U.S. Army Corps of Engineers perform a reallocation study. Indicate local interest, purpose, financial capability, etc.
2. Reallocation studies are performed in two phases and follow the General Investigation Process consisting of a Reconnaissance Report and a Feasibility Study. Specific funding would be required for a reallocation study. A reallocation study includes the following:
    a. Define existing project

  b. Define current and projected water supply needs
  c. Alternative solutions considered
  d. Analysis of alternatives
     i. Reallocation of flood control storage
     ii. Raise top of flood control pool
     iii. Reallocate existing conservation pool/power pool
     iv. Hydropower compensation and other hydropower issues
     v. Other
     vi. No action
     vii. Screening of alternatives
     viii. Selection rationale and selection of a plan
  e. Selected plan
     i. Value of storage reallocation
     ii. Impacts of reallocation
     iii. Public involvement
     iv. Environmental impacts
     v. Hydropower compensation and other hydropower issues
  f. Recommended plan
3. NEPA Compliance
4. U.S. Army Corps of Engineers Headquarter Approval of Reallocation Study
5. Authorization from U.S. Congress
6. U.S. Army Corps of Engineers and Local Sponsor execute water supply contract based on Water Supply Storage Reallocation
7. Water Rights Permits from TCEQ
8. Coordination with BRA on any potential subordination agreements for the System Operations strategy (if implemented by others)

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10.4 Lake Whitney Over-Drafting Supply with Off-Channel Reservoir

10.4.1 Description of Option

Lake Whitney, located on the Brazos River, is owned and operated by the USACE and has a conservation pool storage of 554,203 acft at an elevation of 533 ft-msl. The Brazos River Authority (BRA) owns a contract for use of 50,000 acft of storage between elevations 533 ft-msl and 520 ft-msl of the lake. The remaining storage in Lake Whitney is designated for federal hydropower and the power generated is managed and sold by Southwest Power Administration.

Lake Whitney has been historically underutilized and storage levels in the lake have not fallen below 47% of the conservation pool storage capacity since the reservoir began impounding streamflow in 1952. Figure 10.4-1 shows the historical storage of Lake Whitney as percentage of conservation pool capacity and Figure-10.4-2 provides the historical frequency as a percentage of conservation pool capacity. The historical data shows the Lake Whitney conservation pool has been full over 28% of the time with storage levels entering the flood pool of the lake during these periods.

Because Lake Whitney frequently contains water in the flood pool, the opportunity exists to divert water from the flood pool during wet periods for storage in an off-channel reservoir (OCR) located near the lake. Figure 10.4-3 provides the location of the proposed OCR, Lake Whitney diversion intake and pump station, and pipeline route included in this strategy.

10.4.2 Available Yield

Water potentially available for diversion from the Lake Whitney flood pool and impoundment in the OCR was estimated using the TCEQ Brazos WAM Run 3 (Brazos WAM). The Brazos WAM assumes no return flows permitted storages and diversions for all water rights in the basin. The model utilizes a January 1940 through December 1997 hydrologic period of record and computes streamflow available for diversion from the Lake Whitney flood pool without causing increased shortages to existing downstream rights and subject to TCEQ environmental flow standards. The off-channel reservoir was modeled such that it does not impound streamflow originating from its own contributing drainage area.

A 102-inch diameter pipeline would be used to divert streamflow from the Navasota River to the off-channel reservoir. Assuming the pipeline would transmit water at a velocity of 5 feet per second (284 cfs), a possible 17,134 acft of water could be diverted per month if the transmission system operated every day at full capacity. Figure 10.4-4 illustrates the annual diversion amount under firm yield conditions from the Lake Whitney flood pool used to refill storage. On average, 6,880 acft/yr of water would be diverted.

Figure 10.4-1. Historical Lake Whitney Storage as a Percentage of Conservation Pool Capacity

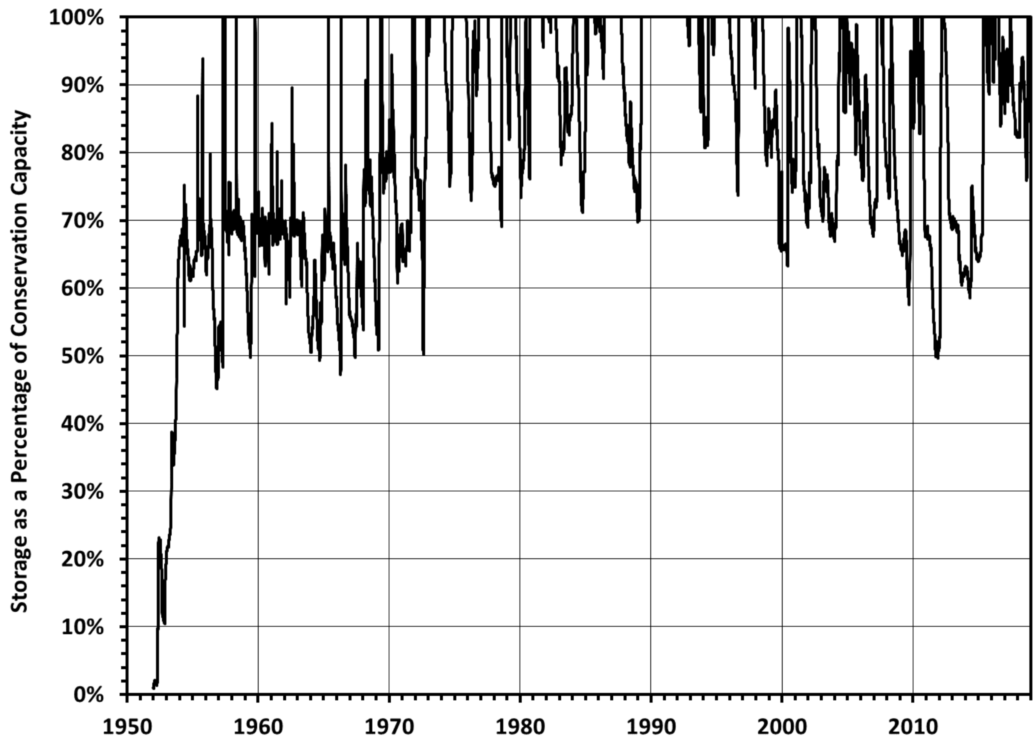


Figure-10.4-2. Historical Lake Whitney Storage Frequency as a Percentage of Conservation Pool Capacity

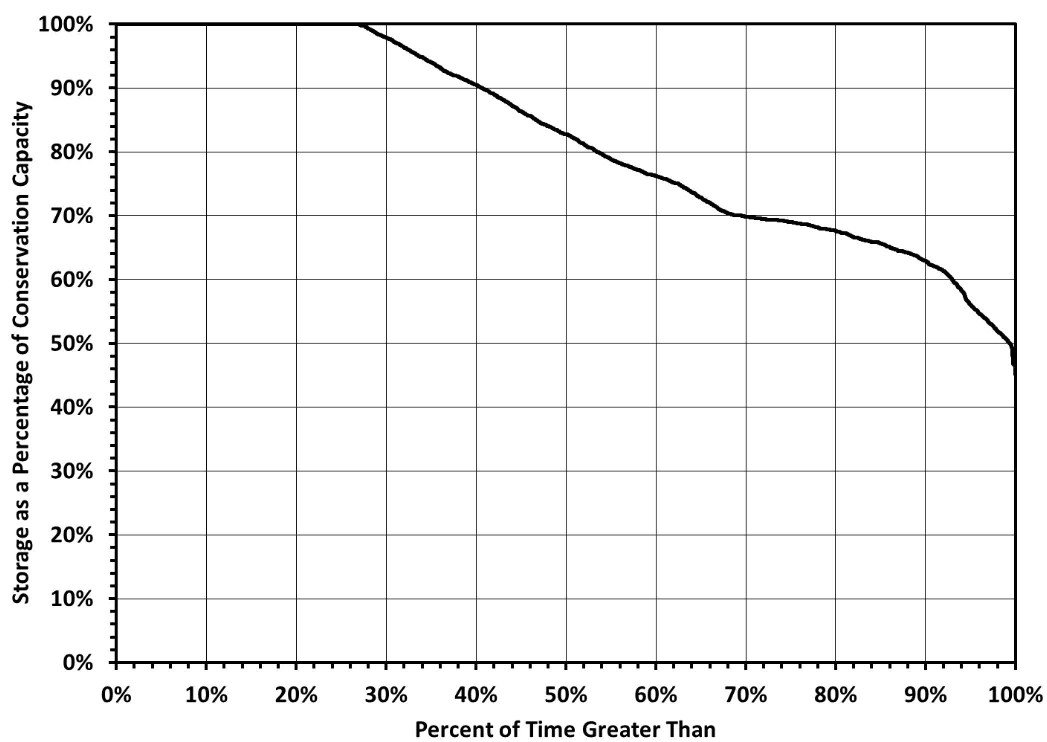
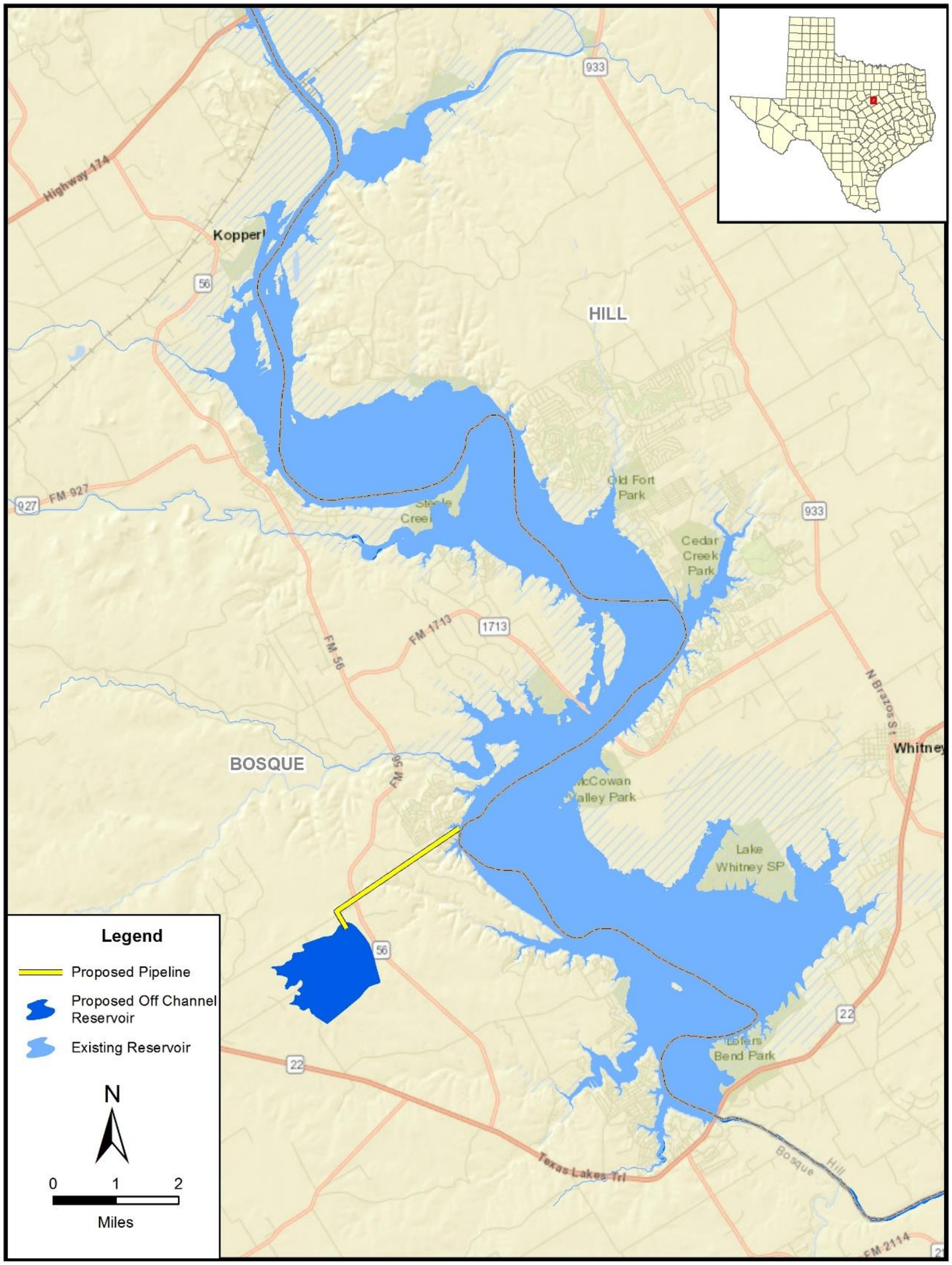
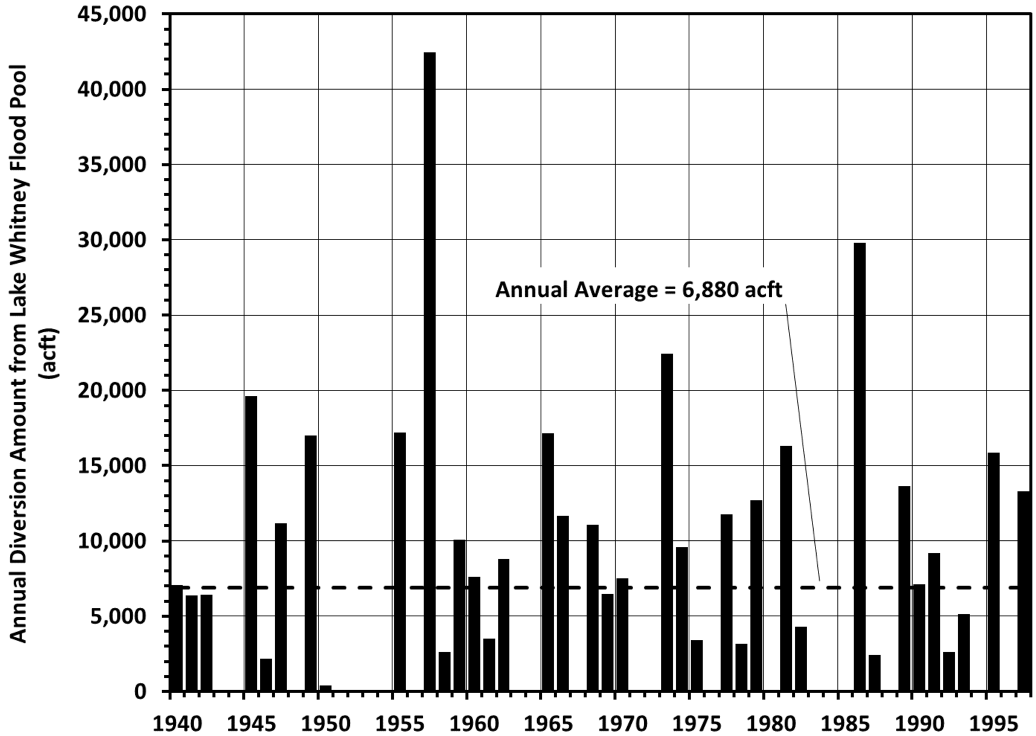


Figure 10.4-3. Location of Proposed OCR from Lake Whitney



Document Path: \\dalctxsrv01\Texas_GIS_Projects\10029705_036_Brazos_G_2021_Plan\Map_Docs\MXDs\Existing_Reservoir_Augmentation_Strategy\Lake_Whitney_OCR.mxd

Figure 10.4-4. Annual Diversion amount under Firm Yield conditions from Lake Whitney



The calculated firm yield of the Lake Whitney Off-Channel Reservoir is 5,200 acft/yr. Figure 10.4-5 illustrates the simulated Off-Channel Reservoir storage levels for the 1940 to 1997 historical period, subject to the firm yield demand. Figure 10.4-6 shows the storage frequency associated with firm yield. Simulated reservoir contents remain above 80 percent capacity about 65 percent of the time and above 50 percent capacity about 90 percent of the time.

Figure 10.4-5. Simulated Lake Whitney off-Channel Reservoir Storage Levels Subject to Firm Yield Demands

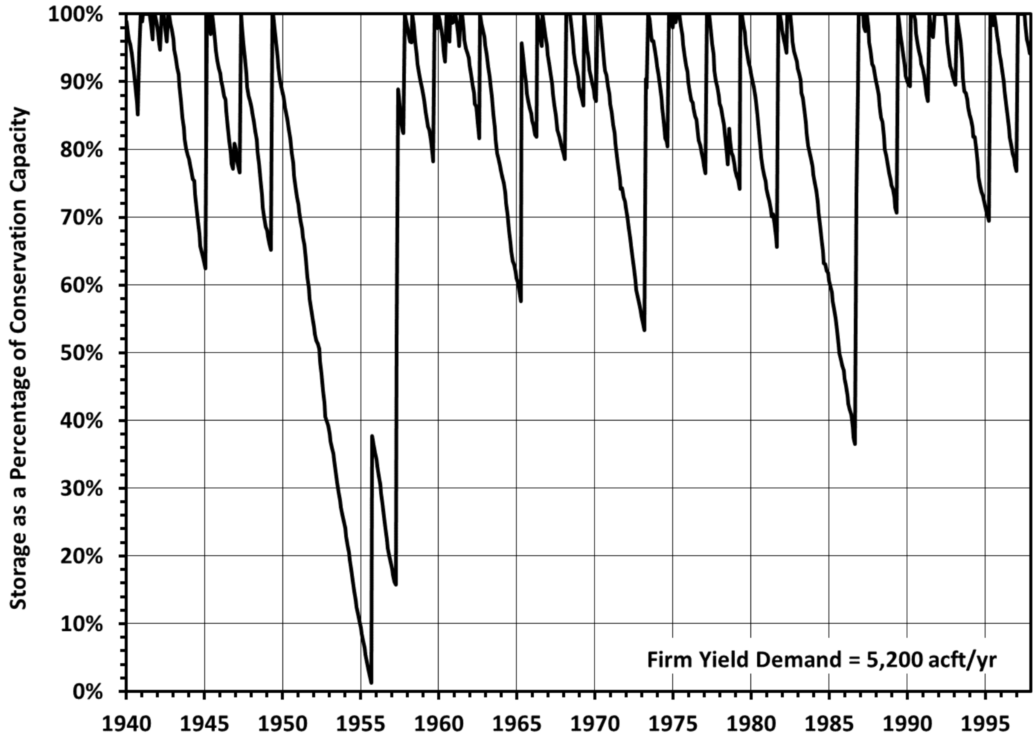


Figure 10.4-6. Storage Frequency associated with Firm Yield

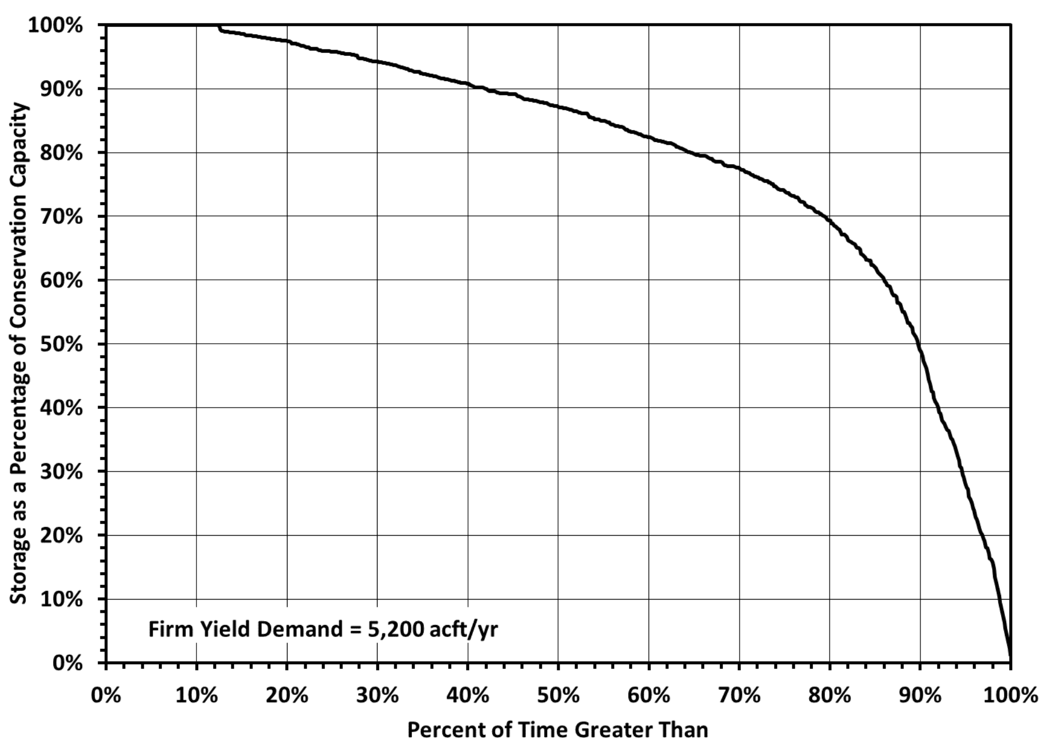


Figure 10.4-7 and Table 10.4-1 present a comparison of median monthly streamflows below Lake Whitney caused by the diversions from the flood pool. Because flood pool diversions would only occur during high flow periods, there is no significant change in median streamflow from implementation of the off-channel reservoir project. Streamflow frequencies below Lake Whitney are shown in Figure 10.4-8.

Figure 10.4-7. Comparison of Median Monthly Streamflow below Lake Whitney

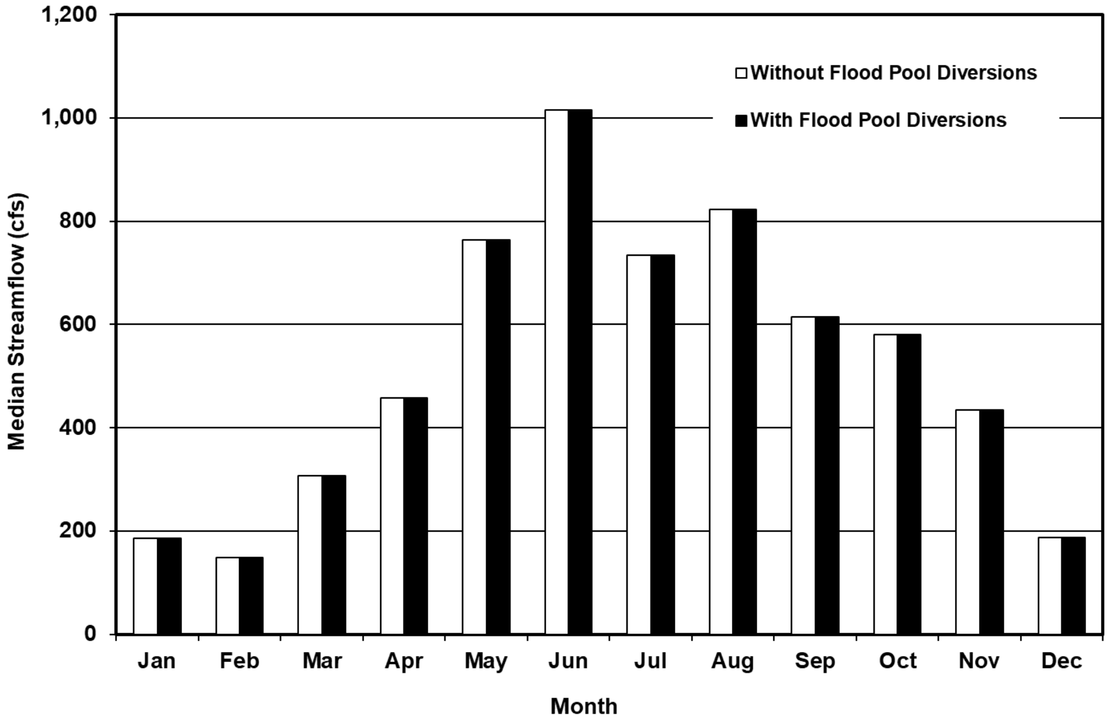
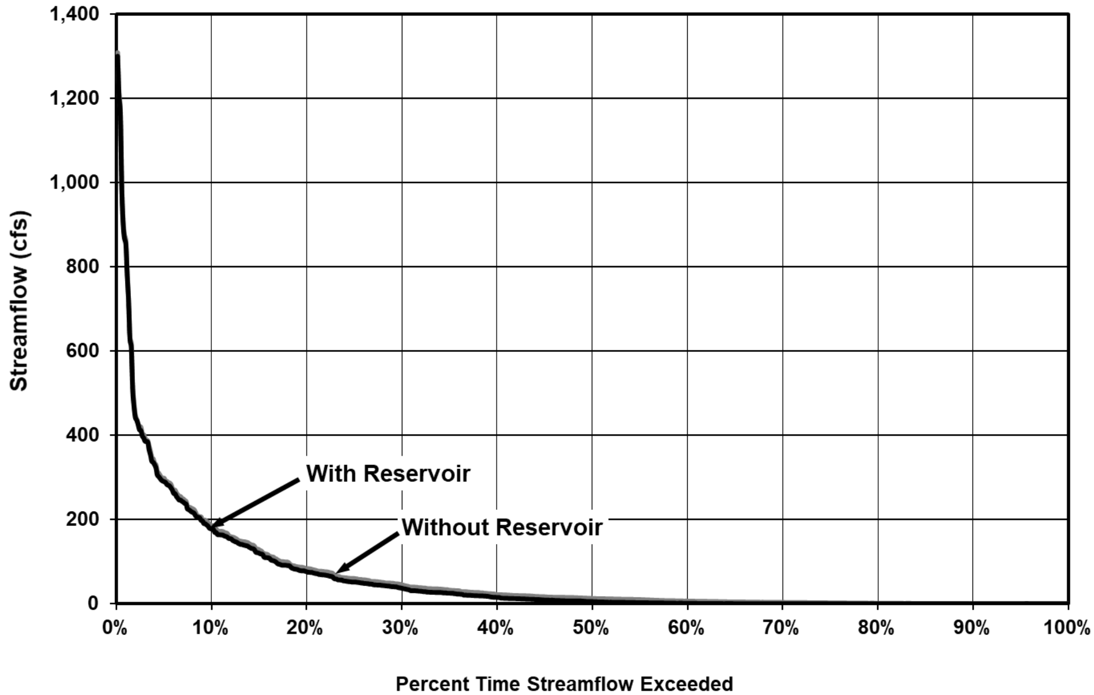


Table 10.4-1. Median Monthly Streamflow below Lake Whitney

Month	Without Project (cfs)	With Project (cfs)	Difference (cfs)	Percent Reduction
January	185	185	0	0%
February	149	149	0	0%
March	307	307	0	0%
April	458	458	0	0%
May	764	764	0	0%
June	1,016	1,016	0	0%
July	734	734	0	0%
August	823	823	0	0%
September	615	615	0	0%
October	581	580	1	0.2%
November	435	435	0	0%
December	188	188	0	0%

Figure 10.4-8. Frequency Comparison of Streamflow below Lake Whitney



10.4.3 Environmental Issues

The Lake Whitney OCR Strategy involves the diverting water from Lake Whitney during wet periods and storing it in an OCR. In addition to the OCR, project components would include an intake in Lake Whitney, a pump station and pipeline from Lake Whitney to the OCR. This report section discusses the potential impacts to environmental and cultural resources known to exist within the proposed project area.

The project area is in the Cross Timbers and Prairies ecoregion of north-central Texas.[1] Common woody species of this area include post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), and species of hickory (*Carya* sp.). Grasses of this area normally include little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*).

Vegetation types as described by TPWD[2] within the project area include Bluestem Grassland and Oak-Mesquite-Juniper Parks/Woods. Bluestem Grasslands are most common over the Gulf Prairies and Marshes. Commonly associated plants include, but are not limited to, bushy bluestem, slender bluestem, buffalograss with woody species including mesquite and live oak. The Oak-Mesquite-Juniper Parks/Woods vegetation type commonly occurs as associations or as a mixture of individual (woody species stands on uplands in the Cross Timbers and Prairies.

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[1] Gould, F.W., “The Grasses of Texas,” Texas A&M University Press, College Station, Texas, 1975.

[2] McMahan, Craig A, Roy G. Frye and Kirby L. Brown. 1984. *The Vegetation Types of Texas including Cropland*. Texas Parks and Wildlife, Austin, Texas.

Construction of the diversion intake, transmission pipeline, and primarily the OCR, would involve the disturbance of existing habitat. If possible, this pipeline should be sited along existing rights-of-way, or in other previously disturbed areas, to minimize the overall vegetative impact. Land use would be expected to change from Bluestem Grassland to open water with the implementation of this strategy.

The intake pipeline would originate at Lake Whitney and cross King Creek, a tributary to Lake Whitney, and a few of its unnamed tributaries to the proposed OCR. According to the National Wetland Inventory (NWI) maps, the OCR area would be located along the upper reaches of some unnamed tributaries to King Creek, which include freshwater ponds, freshwater emergent wetlands, and freshwater forested/shrub wetlands. A ground survey wetland delineation would be required to determine which of these and other features would be affected by the project and to what extent. This delineation would document the locations of streambeds, stream widths, quality and type of water bodies, types of aquatic vegetation, presence of special aquatic resources and areas of jurisdictional Waters of the U.S. likely to be disturbed during construction. Coordination with the U.S. Army Corps of Engineers would be required for construction within waters of the U.S.

The Texas Surface Water Quality Viewer[3] identifies stream segments and impaired bodies of water in Texas. Whitney Lake reservoir (Segment 1203) is not listed as impaired for any water quality standards. There are no stream segments within five miles of the proposed project improvements which are listed as impaired on the Texas 303(d) List. Potential impacts to existing water quality are not anticipated from this project.

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for Bosque County can be found at https://tpwd.texas.gov/gis/rtest/.

According to the USFWS Information for Planning and Consultation, no USFWS designated critical habitat areas occur near the project area.

[3] TCEQ, 2020. Surface Water Quality Viewer. Accessed online https://tceq.maps.arcgis.com/apps/webappviewer/index.html?id=b0ab6bac411a49189106064b70bbe778 January 31, 2020.

The Texas Natural Diversity Data (TxNDD) was reviewed for the project area. No threatened or endangered species have been documented within the proposed project area, however, the golden-cheeked warbler (state and federally-listed endangered), black-capped vireo (state species of greatest conservation need [SGCN]), and the Guadalupe bass (SGCN) were documented within five miles of the proposed project components. A habitat survey should be conducted prior to construction to determine the potential for the presence of threatened, endangered or rare species habitat within the proposed project area. Coordination with TPWD or USFWS would be required if there would be impacts to threatened or endangered species, or their habitat.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (Pl96-515), and the Archeological and Historic Preservation Act (PL93-291). A review of Geographic Information System (GIS) shapefiles provided by the Texas Historical Commission reveals that there are no National Register Properties, National Register Districts, State Historic Sites, cemeteries, or historical markers within the pipeline route or OCR area, and no archeological surveys have occurred adjacent to or within the project area.

Because the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to comply with the Antiquities Code of Texas and an archeological survey and coordination with the Texas Historical Commission will likely be required prior to project construction. If the project will affect waters of the United States or wetlands, the project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding impacts to these resources.

Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of construction and operations on sensitive resources. Specific project features, such as well fields, pump stations, water treatment plants and pipelines generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites.

10.4.4 Engineering and Costing

The potential off-channel reservoir project would require additional facilities to divert water from the flood pool of Lake Whitney to the off-channel reservoir site. The facilities required for implementation of the project included:

- Raw water intake and pump station at the Lake Whitney diversion site with a capacity of 184 MGD;
- 3 miles of raw water pipeline (102-inch diameter) from the pump station to the off-channel reservoir;
- Off-channel dam including spillway, intake tower, and 994 acres of land for the reservoir.

A summary of the total project cost is presented in Table 10.4-2. The proposed project would cost approximately $171.7 million. This includes the construction of the dam, land acquisition, resolution of conflicts, environmental permitting and mitigation, and technical services. The annual project costs are estimated to be $12,879,000. This includes annual debt service, operation and maintenance, and pumping energy costs. The resulting unit cost of 5,200 acft/yr of raw water from the strategy is $2,477 per acft ($7.60 per 1,000 gallons).

Table 10.4-2. Cost Estimate Summary for Lake Whitney Overdrafting Supply with an Off-Channel Reservoir

Item	Estimated Costs for Facilities
Off-Channel Storage (Conservation Pool 45,400 ac-ft, 994 acres)	$45,439,000
Intake Pump Stations (184 MGD)	$55,820,000
Transmission Pipeline (102 in dia., 3 miles)	$14,732,000
TOTAL COST OF FACILITIES	**$115,991,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond	$39,860,000
Environmental & Archaeology Studies and Mitigation	$3,444,000
Land Acquisition and Surveying (1,015 acres)	$3,489,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$8,954,000
TOTAL COST OF PROJECT	**$171,738,000**
ANNUAL COST	
Debt Service (3.5 percent, 20 years)	$7,027,000
Reservoir Debt Service (3.5 percent, 40 years)	$3,365,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$147,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$1,395,000
Dam and Reservoir (1.5% of Cost of Facilities)	$682,000
Pumping Energy Costs (3,285,249 kW-hr @ 0.08 $/kW-hr)	$263,000
TOTAL ANNUAL COST	**$12,879,000**
Available Project Yield (acft/yr)	5,200
Annual Cost of Water ($ per acft)	$2,477
Annual Cost of Water ($ per 1,000 gallons)	$7.60

10.4.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.4-3, and the option meets each criterion.

Table 10.4-3. Evaluations of Lake Whitney Overdraft with Off-Channel Storage Option to Enhance Water Supplies

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet needs
2. Reliability	2. High reliability
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Negligible impact
2. Habitat	2. Negligible impact
3. Cultural Resources	3. Low impact
4. Bays and Estuaries	4. Negligible impact
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Negligible impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Implementation of the project will require permits from various state and federal agencies, land acquisition, and design and construction of the facilities. A summary of the implementation steps for the project is presented below.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- General Land Office Easement if State-owned land or water is involved; and,
- Texas Parks and Wildlife Department Sand, Shell, Gravel and Marl permit if state-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species;
- Aquatic Resource Relocation Plan (ARRP) and a relocation permit may be required from TPWD if a dewatering event is required during construction; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

10.5 Millers Creek Reservoir Augmentation

10.5.1 Description of Strategy

Augmentation of Millers Creek Reservoir was studied for the 2006, 2011, and 2016 Brazos G Regional Water Plans. The previous plans evaluated 4 options:

- Diverting water from nearby Lake Creek to Millers Creek Reservoir via a canal,
- Diverting water from nearby Lake Creek to Millers Creek Reservoir via a pipeline,
- Construction of a new dam and reservoir on Millers Creek downstream of the existing reservoir, and
- Construction of the new reservoir with the canal diversion from Lake Creek.

The current evaluation updates the yields and costs for these four options. It should be noted that assumptions regarding the computation of naturalized flows in Millers and Lake Creeks have been updated from those utilized in the 2006 and 2011 Brazos G Regional Water Plans. The previous plans used the TCEQ WAM methodology which applies a drainage area ratio to incremental naturalized flows at the Brazos River near South Bend (USGS 8088000). Figure 10.5-1 illustrates the incremental drainage area shaded in tan used to estimate flows at Millers Creek Reservoir. Naturalized flows at the Brazos River at Seymour (USGS 8082500), Millers Creek near Munday (USGS 8082700) and Clear Fork Brazos River near Eliasville (USGS 8087300) are subtracted from the South Bend gage and a drainage area ratio of 0.18 is applied to the incremental naturalized flows to calculate naturalized flow at Millers Creek Reservoir. Table 10.5-1 lists the drainage areas for the TCEQ WAM incremental drainage area and Millers Creek Reservoir.

The previous plans calculate naturalized flow at the Lake Creek diversion site in a similar fashion. Naturalized flows at the North Cotton Creek near Knox City (USGS 8082180), Salt Fork Brazos River near Aspermont (USGS 8082000) and Double Mountain Fork of the Brazos River near Aspermont (USGS 8080500) are subtracted from naturalized flows at the Brazos River near Seymour gage (USGS 8082500) to compute incremental drainage area flows. This incremental drainage area is shaded in green in Figure 10.5-1. A drainage area ratio of 0.12 is applied to the incremental naturalized flows at Seymour to calculate flows historically occurring at the Lake Creek diversion site. Table 10.5-1 lists the drainage areas for the TCEQ WAM incremental drainage area and the Lake Creek diversion site.

Figure 10.5-1. WAM Incremental Drainage Areas used to calculate Naturalized Flows at Millers Creek Reservoir and Lake Creek Diversion Site

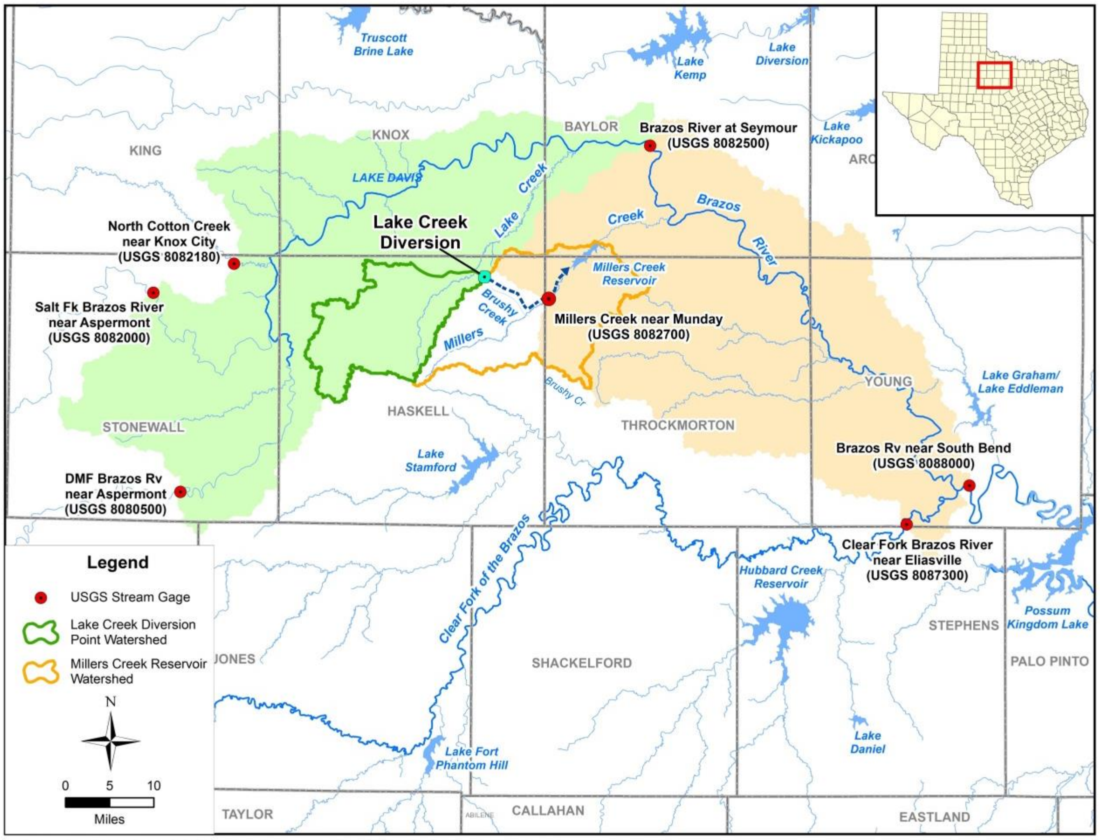


Table 10.5-1. Drainage Areas used to Translate Naturalized Flows to Millers Creek Reservoir and Lake Creek Diversion Site

Watershed	Drainage Area (sq-mi)
Millers Creek Reservoir	
Millers Creek nr Munday Gage	104
Millers Creek Reservoir	239
TCEQ WAM Incremental (tan shade)	1,319
Lake Creek Diversion Site	
Millers Creek nr Munday Gage	104
Lake Creek Diversion Site	167
TCEQ WAM Incremental (green shade)	1,352

The TCEQ WAM methodology overestimates naturalized flows because of the large discrepancy between the incremental drainage areas and the much smaller Millers Creek

Reservoir and Lake Creek diversion site drainage areas. Low flows translated from a significantly larger watershed on the main stem of a river to a smaller watershed on a tributary tend to be overestimated. In addition, large pulse events that occur on the main stem may not be present in the tributary watershed, therefore, potentially creating false pulse events at Millers Creek Reservoir and the Lake Creek diversion site. From a flow volume standpoint, flows translated from the Millers Creek near Munday gage are considered to be more representative of actual flows occurring at Millers Creek Reservoir and the Lake Creek diversion site and are used for all water availability analysis in Section 10.5. This assumption results in significant decreases in firm yield for the augmentation options when compared to the previous plans.

The yield of each reservoir augmentation option is assumed to be the difference in firm yield of the reservoir with and without the augmentation option implemented using the TCEQ Brazos WAM with the modification to naturalized flow calculations at Millers and Lake Creeks. The model utilized a January 1940 through December 1997 hydrologic period of record. Estimates of water availability were derived subject to senior permitted storages and diversions and environmental flow standards adopted by TCEQ. Firm yield with the augmentation options implemented was computed assuming subordination of Possum Kingdom Reservoir. Currently, BRA indicates that no subordination agreement is likely to be possible. The firm yield of Millers Creek Reservoir under these assumptions without an augmentation option implemented and without Possum Kingdom Reservoir subordination is calculated to be 1,700 acft/yr. This is a substantially larger firm yield than determined in the current supply analysis, because the current supply analysis utilizes a longer period of record which includes a drought worse than that experienced from 1940-1997. Supplies calculated with the various augmentation options will be compared to this number only to determine a yield increase resulting from the augmentation option.

10.5.2 Canal Option

Description of Option

Millers Creek Reservoir is located in Baylor and Throckmorton Counties approximately 14 miles southwest of the City of Seymour. Lake Creek flows parallel to Millers Creek and the Millers Creek Reservoir. In an effort to increase the yield of the reservoir, streamflow is diverted from Lake Creek through a grass-lined canal into Brushy Creek, which flows into Millers Creek and eventually into Millers Creek Reservoir, as shown in Figure 10.5-2.

The maximum monthly depletion from Lake Creek, assuming the Lake Creek diversion is the most senior in the basin, was computed to be approximately 700 cfs. Therefore, the grass-lined canal was sized to accommodate a 700 cfs flow rate at a 0.05 percent slope. The canal bottom width would be 90 feet and the maximum top width would be 287 feet; the flow depth would be 2.8 feet. The proposed locations of the canal and Lake Creek channel dam are shown on Figure 10.5-3. The proposed canal length is 1.8 miles from Lake Creek to Brushy Creek. The topography in the area is such that there is a topographic ‘high’ between Lake Creek and Brushy Creek and therefore, a massive volume of earth cut would be needed to construct the grass-lined canal. It is anticipated that about 40 percent of the excess fill would be disposed of on-site, adjacent to the canal creating 5-feet high, 120-feet wide berms along the top of the canal.

The approximately 8-feet high channel dam would be an earthfill embankment to impound runoff from the Lake Creek watershed. The dam embankment would extend approximately 5,000 feet across Lake Creek at an elevation of 1,477 ft-msl. When full, the lake formed by the dam would periodically inundate approximately 360 acres.

Figure 10.5-2. Canal Option: Lake Creek Diversion to Millers Creek Reservoir

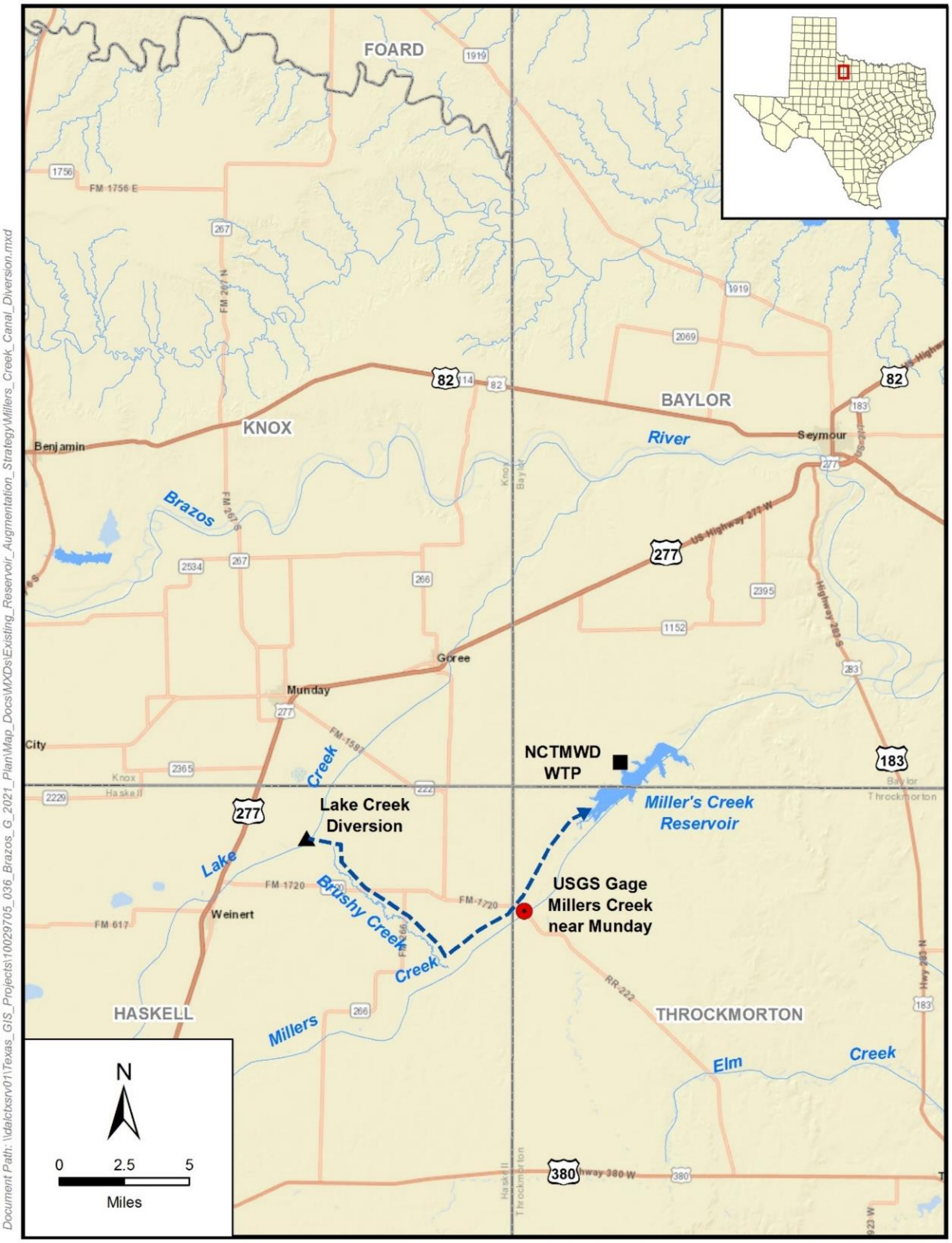
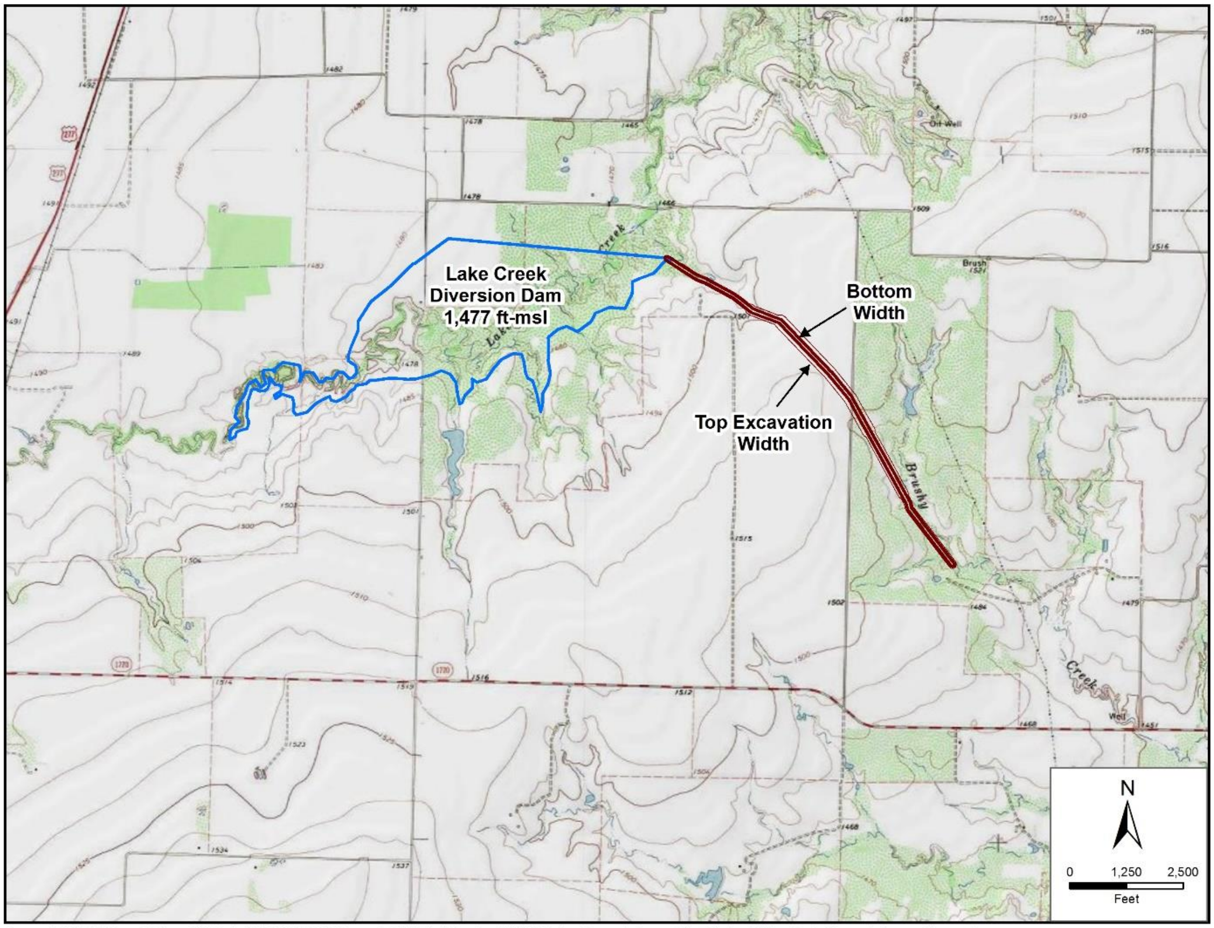


Figure 10.5-3. Lake Creek Diversion Dam and Canal to Brushy Creek



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Available Yield

The calculated firm yield of the Millers Creek Reservoir with the Lake Creek diversion is 3,775 acft/yr. Therefore, the Lake Creek diversion increases the current firm yield of the Millers Creek Reservoir by 2,075 acft/yr. Based on a delivery factor of 0.572 (from the TCEQ WAM) for water flowing from Millers Creek reservoir to Possum Kingdom Reservoir, the yield impact on Possum Kingdom Reservoir due to the canal diversion and subordination was estimated to be 1,187 acft/yr for costing purposes. A subordination agreement would have to be negotiated and acquired for this strategy to be implemented as presented in this section.

Figure 10.5-4 illustrates the simulated Millers Creek Reservoir storage levels for the 1940 to 1997 historical period, subject to the firm yield of 3,775 acft/yr. The storage trace shows that the critical drought of record occurs in 1978. Figure 10.5-5 illustrates the storage frequency of Millers Creek Reservoir with the Canal diversion subject to the same firm yield demand. Simulated reservoir contents remain above 80 percent capacity 94 percent of the time and above the 50 percent capacity 78 percent of the time.

Figure 10.5-6 illustrates the changes in Lake Creek median monthly streamflows caused by the project. The maximum monthly median streamflow without the canal diversions occurs in July and the months from November through March have a median streamflow value of zero. The addition of the canal diversion reduces the monthly median streamflow values to zero for all months. Figure 10.5-7 also illustrates the Lake Creek streamflow frequency characteristics with and without the project in place. In Lake Creek, the percentage of time that no flows would be present increases from 55 percent of the time to 79 percent of the time.

Figure 10.5-4. Millers Creek Reservoir Firm Yield Storage Trace with Canal Diversion

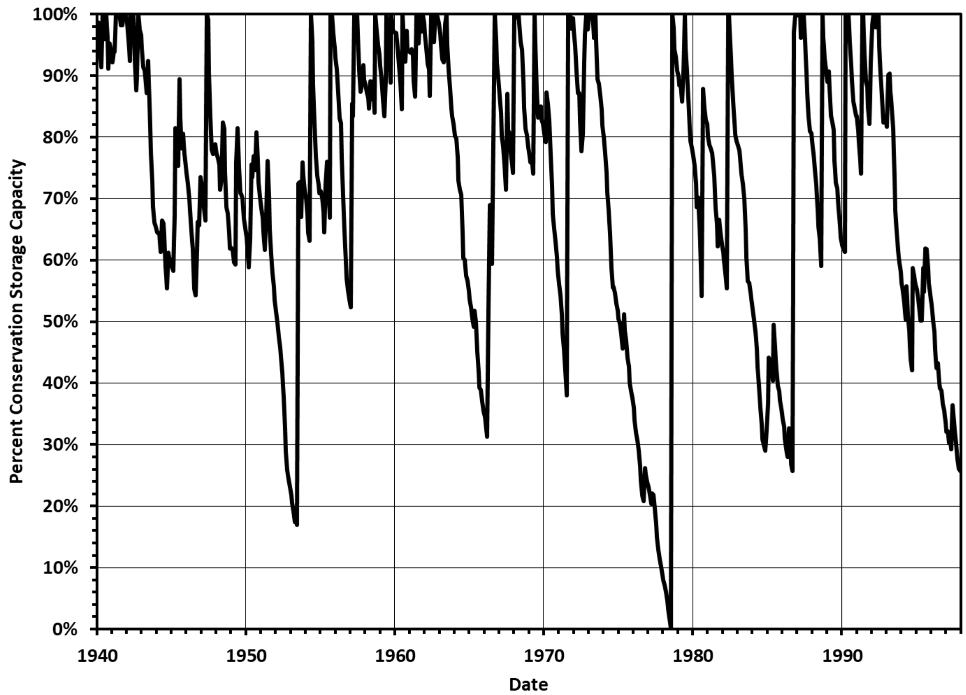


Figure 10.5-5. Millers Creek Reservoir Firm Yield Storage Frequency with Canal Diversion

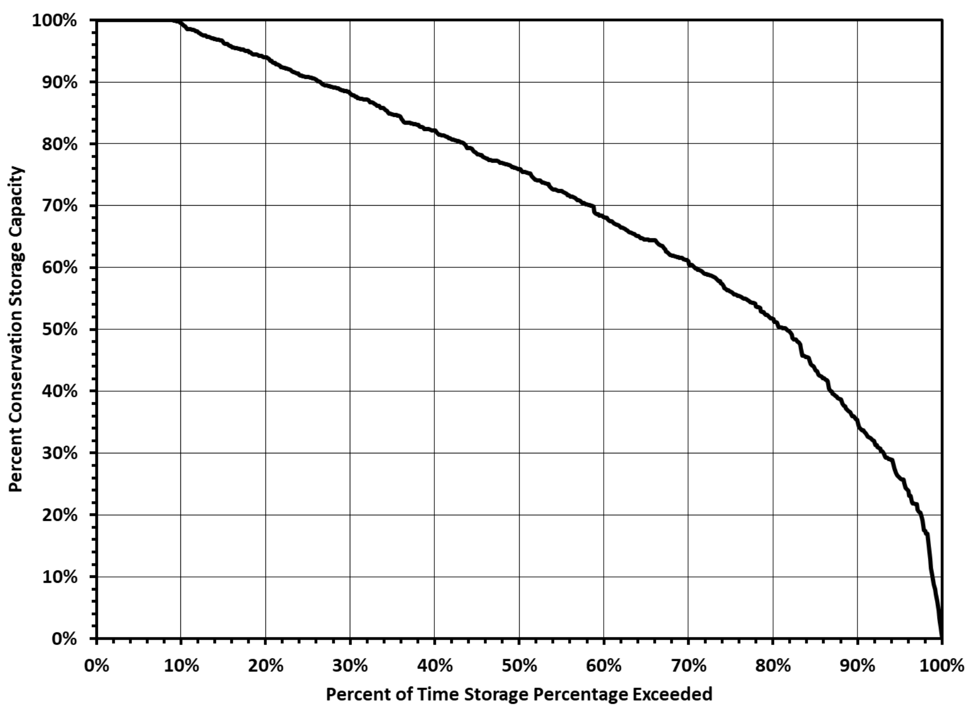


Figure 10.5-6. Comparison of Median Monthly Streamflow below Lake Creek Diversion Point With and Without Canal Diversion

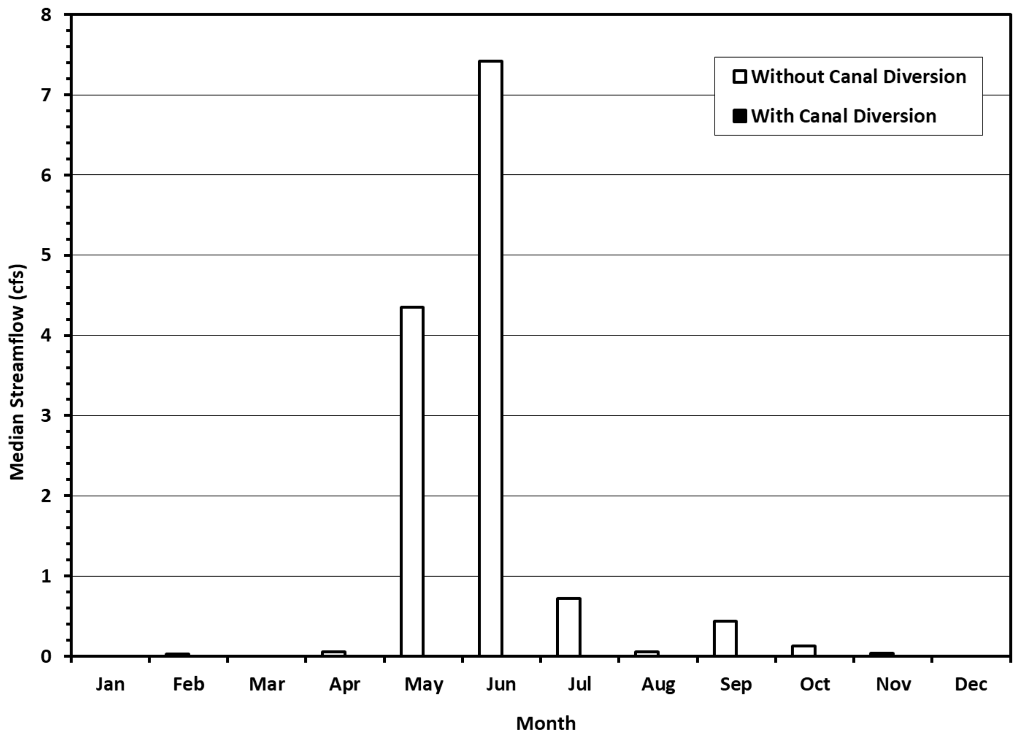
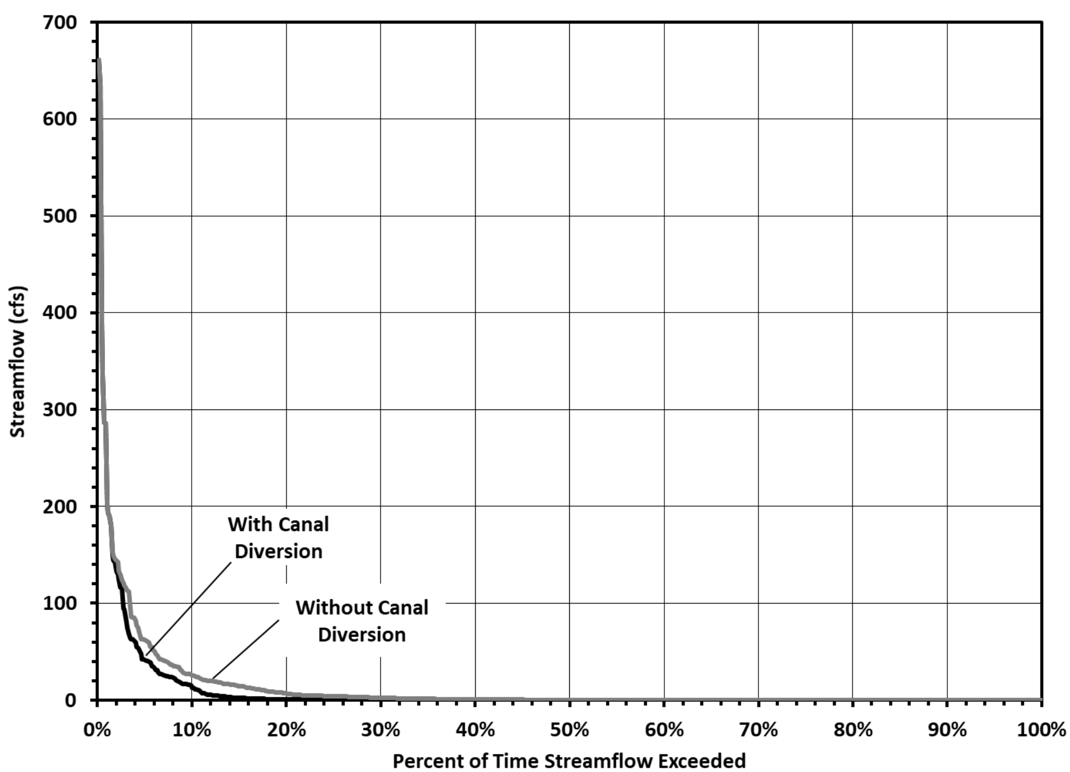


Figure 10.5-7. Comparison of Streamflow Frequency below Lake Creek Diversion Point With and Without Canal Diversion



Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 10.5.6.

Engineering and Costing

The total estimated project cost for the channel dam and grass lined canal is $29.2 million. The annual project costs are estimated to be $1.74 million; this includes annual debt service, operation and maintenance, and annual payment to the Brazos River Authority for lost yield in Possum Kingdom Reservoir. A summary of the project costs is presented in Table 10.5-2. The cost for the estimated additional firm yield increase of 2,075 acft/yr translates to an annual unit cost for raw water of $2.58 per 1,000 gallons, or $840/acft.

Table 10.5-2. Cost Estimate for Augmentation of Millers Creek Reservoir (Canal Option)

Item	Estimated Costs for Facilities
Capital Cost	
Lake Creek Channel Dam, Reservoir, and Canal	$19,158,000
Total Cost Of Facilities	**$19,158,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$6,705,000
Environmental & Archaeological Studies and Mitigation	$883,000
Land Acquisition and Surveying (491 acres)	$907,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$1,521,000
Total Cost Of Project	**$29,174,000**
Annual Cost	
Reservoir Debt Service (3.5 percent, 40 years)	$1,366,000
Operation and Maintenance	
Dam and Reservoir	$287,000
Purchase of Water (1,187 acft/yr @ 65.65 $/acft)	$91,000
Total Annual Cost	**$1,744,000**
Available Project Yield (acft/yr)	**2,075**
Annual Cost of Water ($ per acft)	**$840**
Annual Cost of Water ($ per 1,000 gallons)	**$2.58**

Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.5-3 and the option meets each criterion.

Table 10.5-3. Comparison of Augmentation of Millers Creek Reservoir (Canal Option) to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet some needs
2. Reliability	2. Reasonable
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low to moderate impact
3. Cultural Resources	3. Low to moderate impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	Low to None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality (TCEQ) Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- TCEQ administered Texas Pollutant Discharge Elimination System (TPDES) Storm Water Pollution Prevention Plan;
- General Land Office (GLO) Easement if State-owned land or water is involved; and; and
- Texas Parks and Wildlife Department (TPWD) Sand, Shell, Gravel and Marl permit if State-owned streambed is involved.

State and Federal Permits may require the following studies and plans:

- Environmental impact or assessment studies;

- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

10.5.3 Pipeline Option

Description of Option

Another option for augmenting Millers Creek Reservoir previously studied[1] and included in the 2006, 2011, and 2016 Brazos G Plans is to divert water from Lake Creek through a 2-mile, 24-inch pipeline into Brushy Creek, which flows into Millers Creek and eventually into Millers Creek Reservoir. The pipeline would follow the same route as the canal shown in Figure 10.5-2. The capacity of the 24-inch pipe is assumed to be approximately 10 cfs or 7,200 acft/yr.

Available Yield

The firm yield of Millers Creek Reservoir with the pipeline diversion was computed to be 3,700 acft/yr, which is an increase of 2,000 acft/yr over firm yield of 1,700 acft/yr for the reservoir with no augmentation and no Possum Kingdom Reservoir subordination. Based on a delivery factor for water flowing from Millers Creek reservoir to Possum Kingdom Reservoir of 0.572 (from the TCEQ WAM), the yield impact on Possum Kingdom Reservoir due to the pipe diversion and subordination was assumed to be 1,144 acft/yr for costing purposes. A subordination agreement would have to be negotiated and acquired for this strategy to be implemented as presented in this section. Currently, BRA indicates that no subordination agreement is likely to be possible.

Figure 10.5-8 illustrates the changes in Lake Creek median monthly streamflows caused by the project. The maximum monthly median streamflow without the canal diversions occurs in June and the months from July through April have a median streamflow value of less than 1 cfs. The addition of the canal diversion reduces the monthly median streamflow values to zero except for May and June. Figure 10.5-9 also illustrates the Lake Creek streamflow frequency characteristics with and without the project in place.

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[1] Freese & Nichols, Inc, "West Central Brazos River Basin Regional Water Treatment and Distribution Facility Plan," August 2004.

Figure 10.5-8. Comparison of Median Monthly Streamflow below Lake Creek Diversion Point With and Without Pipeline Diversion

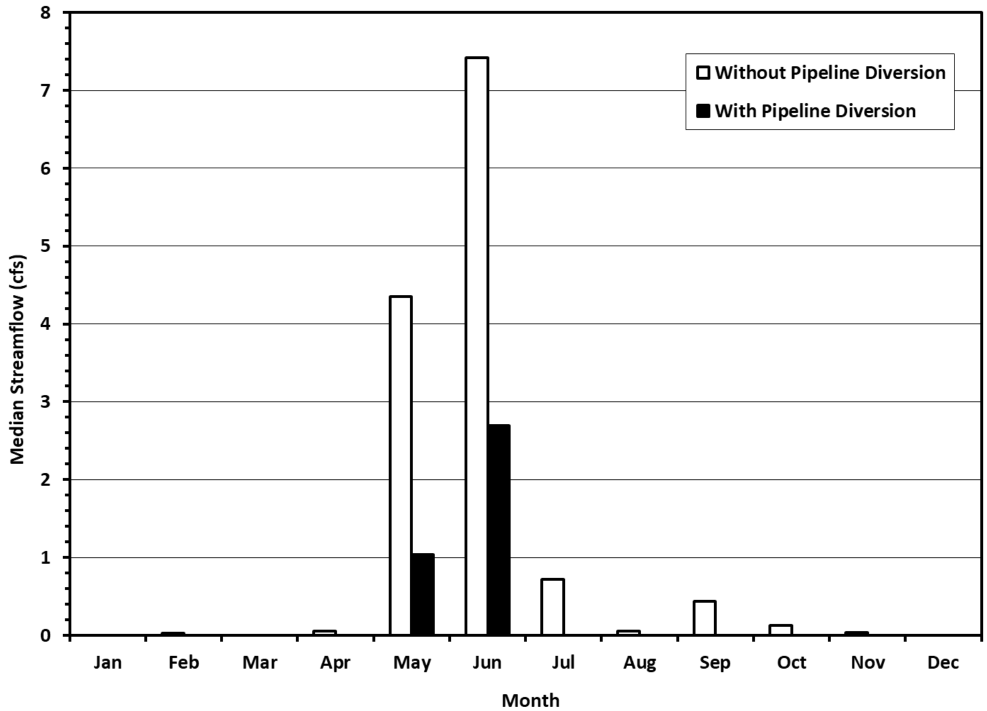
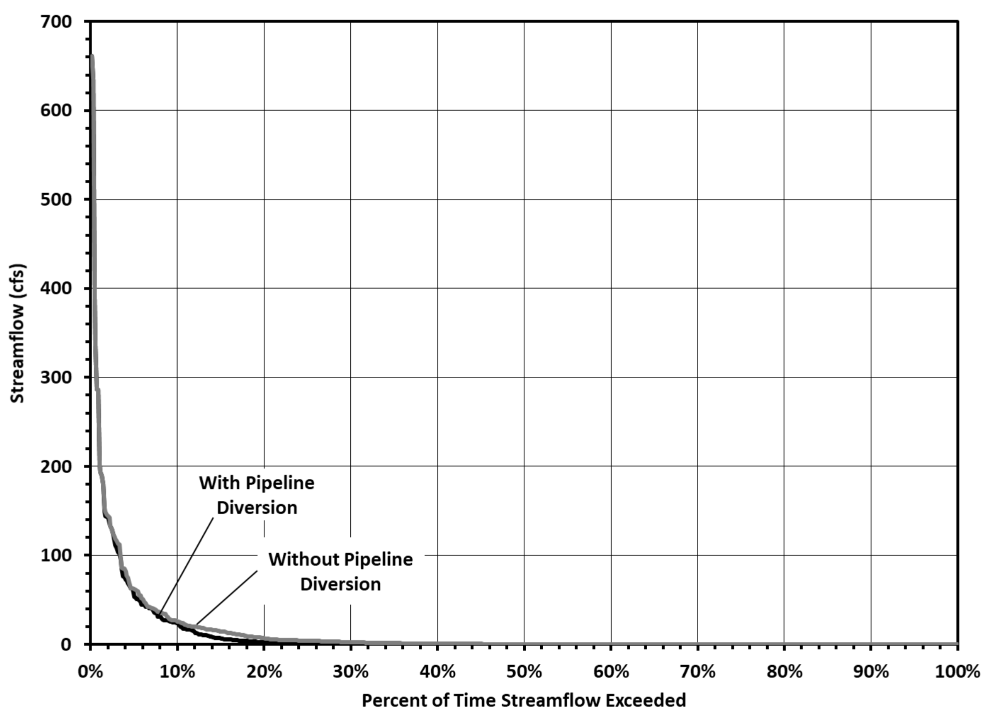


Figure 10.5-9. Comparison of Streamflow Frequency below Lake Creek Diversion Point With and Without Pipeline Diversion



Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 10.5.6.

Engineering and Costing

The total estimated project cost is $22.6 million for the diversion weir, intake canal, pipeline, and pump station. The annual project costs are estimated to be $1.85 million, including annual debt service, operation and maintenance, and annual payment to the Brazos River Authority for lost yield in Possum Kingdom. Note that any subordination agreement would need to be negotiated with BRA. A summary of the project costs is presented in Table 10.5-4. The cost for the estimated increase in Millers Creek Reservoir firm yield of 2,000 acft/yr translates to an annual unit cost for raw water of $2.84 per 1,000 gallons, or $925 per acft.

Table 10.5-4. Cost Estimate for Augmentation of Millers Creek Reservoir (Pipeline Option)

Item	Estimated Costs for Facilities
Capital Cost	
Lake Creek Channel Dam and Intake Canal)	$5,125,000
Intake Pump Stations (6.5 MGD)	$8,476,000
Transmission Pipeline (24 in dia., 2 miles)	$2,277,000
Total Cost Of Facilities	**$15,878,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$5,487,000
Environmental & Archaeological Studies and Mitigation	$53,000
Land Acquisition and Surveying (491 acres)	$23,000
Interest During Construction (4% for 2 years with a 1% ROI)	$1,180,000
Total Cost Of Project	**$22,621,000**
Annual Cost	
Debt Service (3.5 percent, 20 years)	$1,078,000
Reservoir Debt Service (3.5 percent, 40 years)	$342,000
Operation and Maintenance	
Pipeline, Wells, and Storage Tanks (1% of Cost of Facilities)	$23,000
Intakes and Pump Stations (2.5% of Cost of Facilities)	$212,000
Dam and Reservoir (1.5% of Cost of Facilities)	$77,000
Pumping Energy Costs (0.08 $/kW-hr)	$30,000
Purchase of Water (1,144 acft/yr @ 76.50 $/acft)	$88,000
Total Annual Cost	**$1,850,000**
Available Project Yield (acft/yr)	**2,000**
Annual Cost of Water ($ per acft)	**$925**
Annual Cost of Water ($ per 1,000 gallons)	**$2.84**

Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.5-5 and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality (TCEQ) Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- TCEQ administered Texas Pollutant Discharge Elimination System (TPDES) Storm Water Pollution Prevention Plan;
- General Land Office (GLO) Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department (TPWD) Sand, Shell, Gravel and Marl permit if State-owned streambed is involved.

State and Federal Permitting Requirements:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

Table 10.5-5. Comparison of Augmentation of Millers Creek Reservoir (Pipeline Option) to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet some needs
2. Reliability	2. Reasonable
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Low impact
2. Habitat	2. Low to moderate impact
3. Cultural Resources	3. Low to moderate impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	Low to None
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

10.5.4 New Dam and Reservoir

Description of Option

Freese, Nichols and Endress Consulting Engineers evaluated three locations for the Millers Creek Reservoir dam in a study completed in 1967.[2] The existing dam is located roughly at the upstream-most site considered in the study. The downstream-most location evaluated in the study is approximately four miles downstream of the existing dam. Construction of a new dam at this location is evaluated herein. Figure 10.5-10 shows the locations of the existing and proposed dams. The drainage area at the new dam location is 291.5 sq. mi., an approximate increase of 52 sq. mi. over that at the existing dam.

A normal pool elevation of 1,316 ft-msl was assumed for the current evaluation of the new reservoir. The Freese, Nichols and Endress study identified 1,316 ft-msl as the most feasible normal pool elevation due to the presence of oil well heads that would be

[2] Freese, Nichols and Endress Consulting Engineers, “Engineering Report and Feasibility Study for Millers Creek Water Supply Facilities,” Prepared for North Central Texas Municipal Water Authority, January 1967.

inundated at higher normal pool elevations. The study also noted that preliminary borings indicated the presence of a natural rock spillway at this elevation. The normal pool elevation of the existing reservoir is 1,334 ft-msl and its dam would be left in place with construction of the new reservoir. Spills and releases from the existing reservoir would be captured by the new reservoir. The surface area and storage volume of the new reservoir with a normal pool at 1,316 ft-msl would be 2,541 acres and 46,645 acft based on the USGS 1:24,000 scale quadrangle maps for the area. The capacity of the existing reservoir was computed by the Texas Water Development Board to be 29,171 acft based on a hydrographic survey conducted in 1993.[3] The new reservoir would provide an approximately 160% increase over the surveyed storage of the existing reservoir. The capacity of the existing reservoir in the 2020 Brazos G WAM, which models existing reservoirs at their current year 2020 capacity, is 22,126 acft.

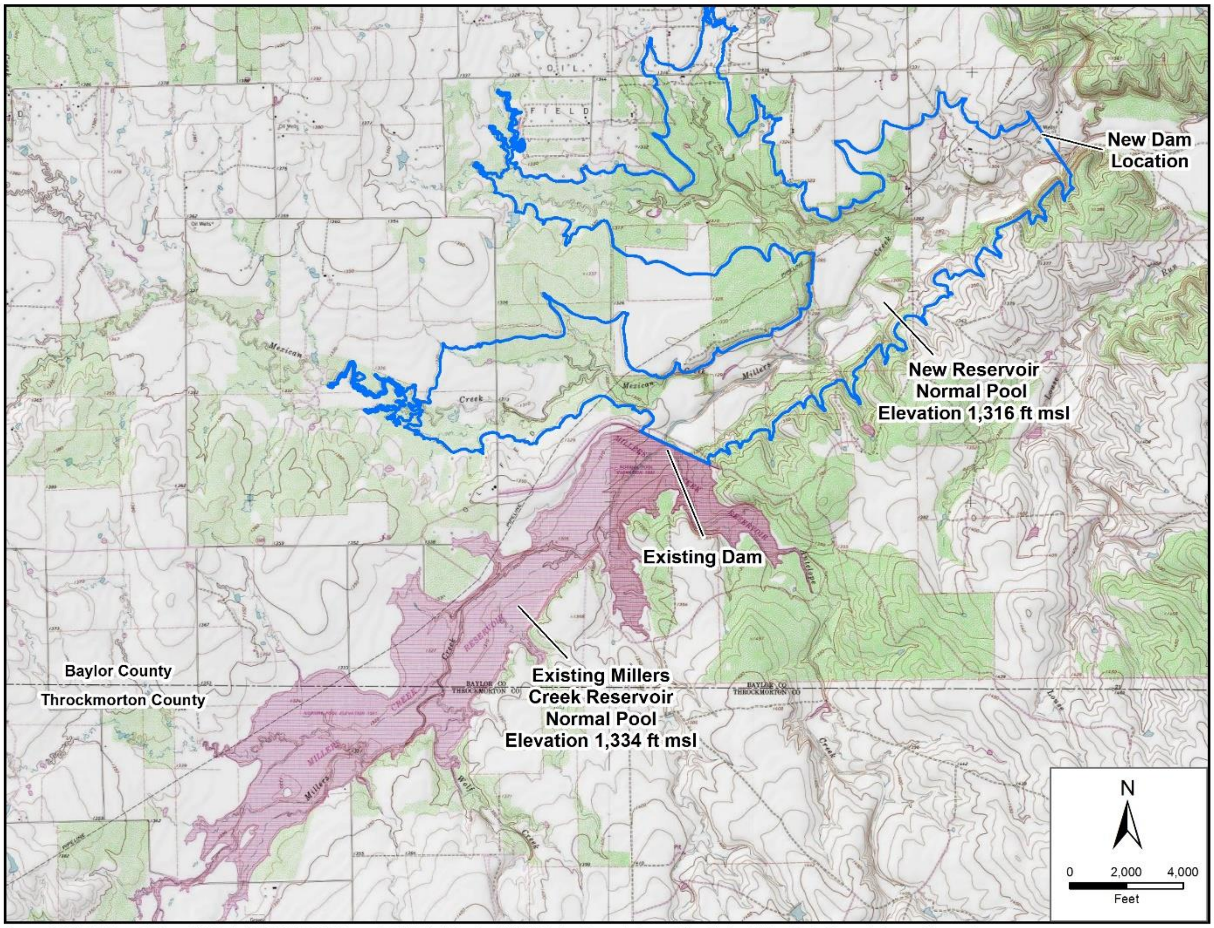
Preliminary design parameters for the dam were identified in the Freese, Nichols and Endress study. The study recommends an earthen embankment dam with 3:1 downstream side slopes, and upstream side slopes of 3:1 below the normal pool elevation and 2:1 above the normal pool elevation. The study recommends a 20-foot embankment top width. A core trench having 1:1 side slopes and 20-foot bottom width extending to impervious material is also recommended by the study. The study recommends protection of the upstream face of the dam with 8 inches of gravel and 24 inches of riprap.

Available Yield

The calculated firm yield of the new reservoir is 750 acft/yr, with the subordination and priority assumptions noted above. Along with a computed 1,600 acft/yr increase in the firm yield of the existing reservoir due to the subordination of Possum Kingdom Reservoir, the total increase in firm yield that would result from implementing this project is 2,350 acft/yr. Based on a delivery factor of 0.572, the yield impact on Possum Kingdom Reservoir was estimated to be 1,344 acft/yr for costing purposes. Figure 10.5-11 shows the simulated storage levels of the new reservoir for the 1940 to 1997 historical period, subject to the firm yield of 750 acft/yr. The new reservoir experiences long drawdown periods because it is reliant on spills from the existing reservoir for storage recovery. Figure 10.5-12 shows the storage frequency of the new reservoir under the firm yield demand. The frequency shows that reservoir storage is less than half full for a majority of the simulation period.

[3] Texas Water Development Board, “Hydrographic Survey of Miller’s Creek Reservoir,” Prepared for North Central Texas Municipal Water Authority, March 2003.

Figure 10.5-10. New Reservoir below Millers Creek Reservoir



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The effects of the new reservoir on streamflow in Millers Creek below the new reservoir were computed from the model simulation results. In Millers Creek, the simulated median monthly streamflow below the dam is reduced to zero for all months. It should be noted that the only month with a median monthly streamflow greater than zero without the new reservoir is May with a median streamflow of 0.1 cfs. Figure 10.5-13 illustrates Millers Creek streamflow frequency characteristics with and without the project in place. The frequency characteristics for Millers Creek Reservoir are compared to those downstream of the existing reservoir computed for conditions as they currently exist, without the new reservoir, diversion from Lake Creek, or subordination of Possum Kingdom Reservoir.

Figure 10.5-11. New Reservoir Storage Trace

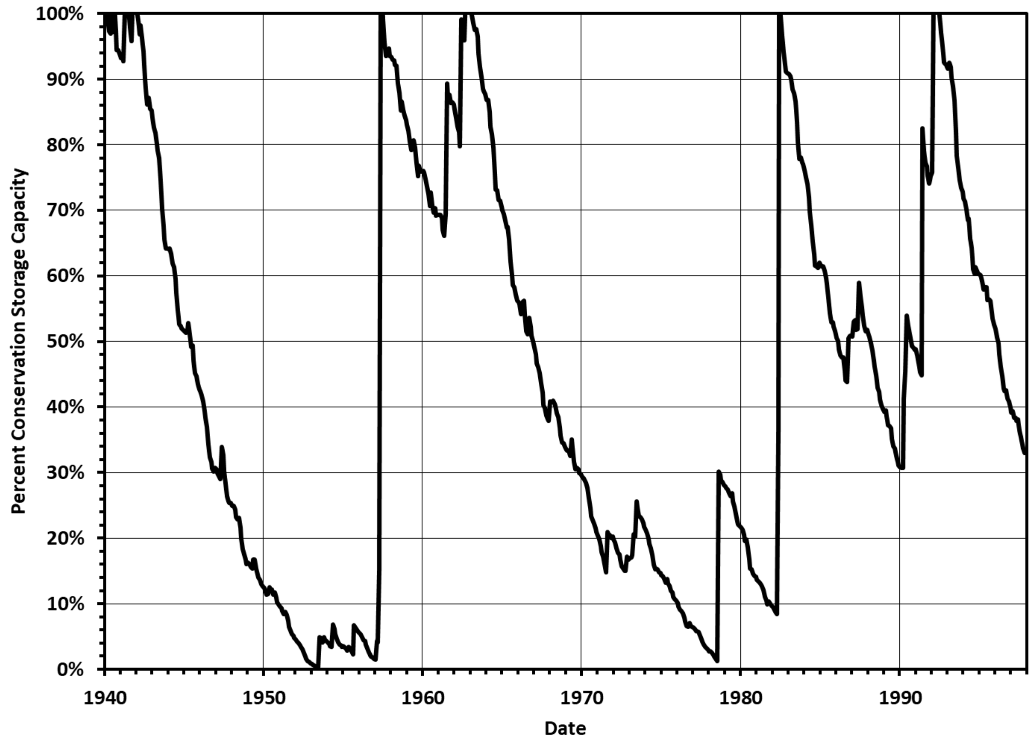


Figure 10.5-12. New Reservoir Storage Frequency

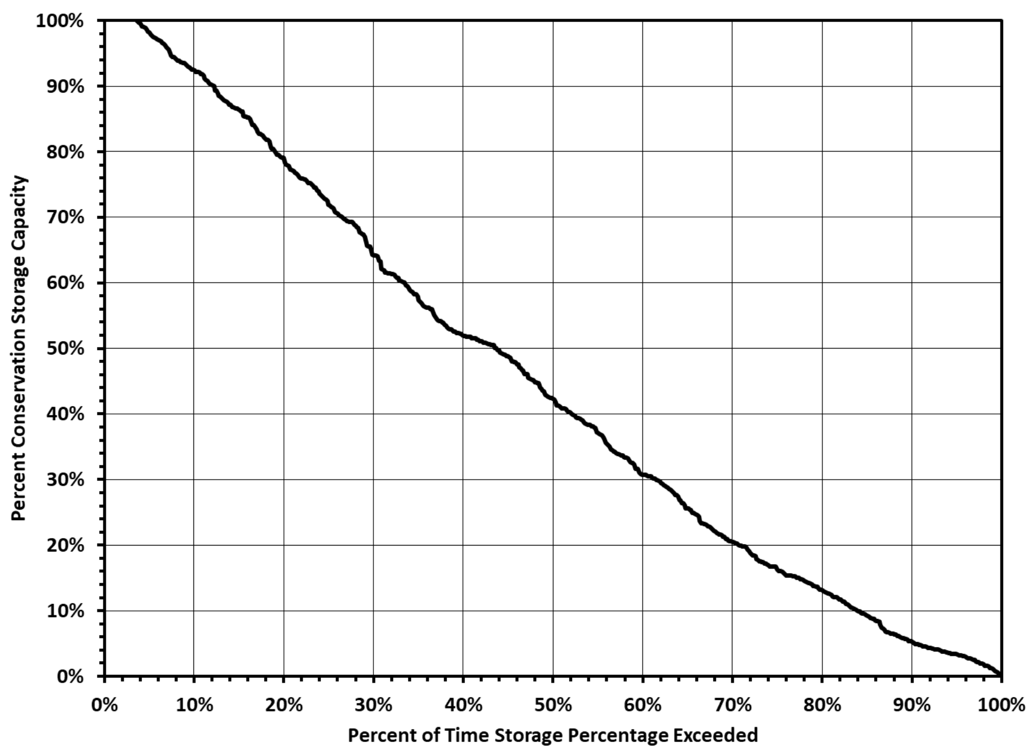
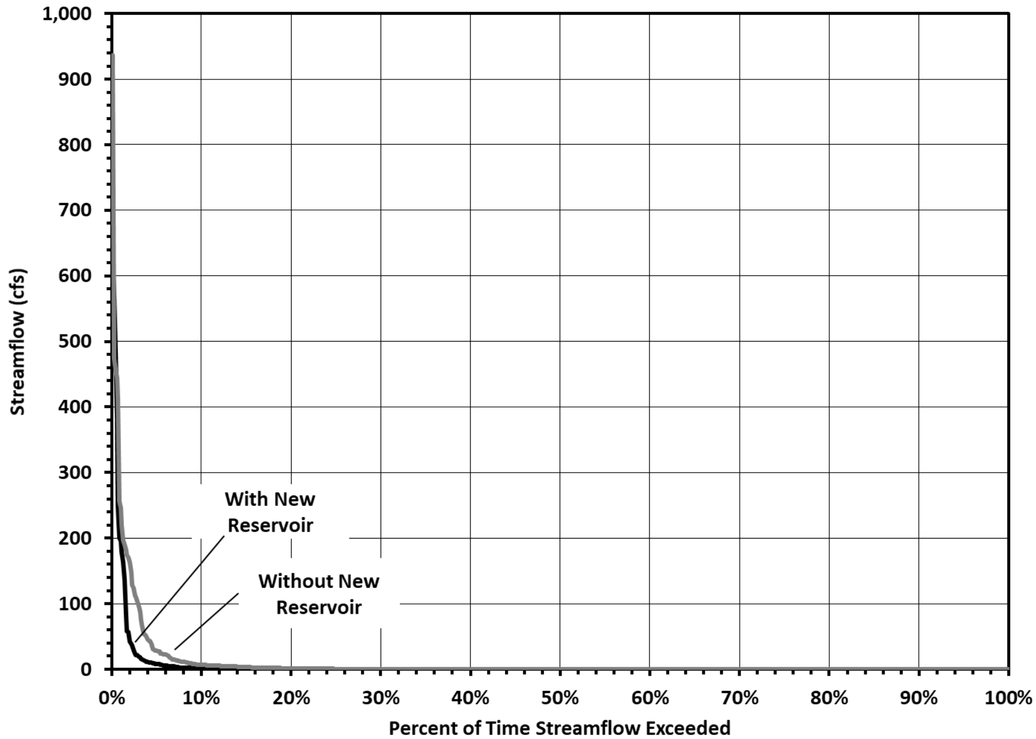


Figure 10.5-13. Comparison of Millers Creek Streamflow Frequency With and Without New Reservoir



Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 10.5.6.

Engineering and Costing

Table 10.5-6 summarizes estimated costs for the new dam and reservoir. The total estimated project cost for the new dam and reservoir is $81.3 million. The annual project costs are estimated to be $4.63 million; this includes annual debt service, operation and maintenance, and annual payment to the Brazos River Authority for lost yield in Possum Kingdom Reservoir. The cost for the estimated additional firm yield increase of 2,300 acft/yr translates to an annual unit cost for raw water of $6.05 per 1,000 gallons, or $1,971 per acft.

Table 10.5-6. Cost Estimate for Augmentation of Millers Creek Reservoir (New Reservoir Option)

Item	Estimated Costs for Facilities
Capital Cost	
New Dam and Reservoir	$46,256,000
Integration, Relocations, & Other	$601,000
Total Cost Of Facilities	**$46,857,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$16,400,000
Environmental & Archaeological Studies and Mitigation	$6,823,000
Land Acquisition and Surveying (3,795 acres)	$7,013,000
Interest During Construction (3% for 2 years with a 0.5% ROI)	$4,241,000
Total Cost Of Project	**$81,334,000**
Debt Service (3.5 percent, 20 years)	$60,000
Reservoir Debt Service (3.5 percent, 40 years)	$3,769,000
Operation and Maintenance	
Dam and Reservoir	$700,000
Purchase of Water (1,344 acft/yr @ 76.50 $/acft)	$103,000
Total Annual Cost	**$4,632,000**
Available Project Yield (acft/yr)	**2,350**
Annual Cost of Water ($ per acft)	**$1,971**
Annual Cost of Water ($ per 1,000 gallons)	**$6.05**

Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.5-7, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality (TCEQ) Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- TCEQ administered Texas Pollutant Discharge Elimination System (TPDES) Storm Water Pollution Prevention Plan;
- General Land Office (GLO) Easement if State-owned land or water is involved; and
- Texas Parks and Wildlife Department (TPWD) Sand, Shell, Gravel and Marl permit if State-owned streambed is involved.

State and Federal Permits may require the Following Studies and Plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

Table 10.5-7. Comparison of Augmentation of Millers Creek Reservoir (New Dam and Reservoir Option) to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet some needs
2. Reliability	2. Reasonable
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. Moderate impact
3. Cultural Resources	3. Moderate impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	Low to None. Some loss of crop land is expected in the inundation area of the new reservoir.
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None

10.5.5 Combined Canal Diversion with New Dam and Reservoir

Description of Option

This option combines the canal diversion from Lake Creek to the existing Miller's Creek Reservoir described in Section 10.5.2 with the new dam and reservoir described in Section 10.5.4. The design features of the two strategies would be the same as previously described. Water diverted from Lake Creek would first be used to fill the existing reservoir and then passed through the existing reservoir to fill the new reservoir.

Available Yield

The computed firm yield of Millers Creek Reservoir with the canal diversions is 3,700 acft/yr as noted in Section 10.5.2. Under this demand on Millers Creek Reservoir, the new reservoir firm yield was computed to be 1,025 acft/yr. Therefore, the combined firm yield of the existing reservoir and new reservoir with the canal diversion and subordination assumptions is 4,725 acft/yr, which is an increase of 3,025 acft/yr from the baseline firm yield of 1,700 acft for Millers Creek Reservoir without augmentation and without Possum Kingdom subordination.

When the canal option and new reservoir option are modeled separately, the firm yield sum is 4,425 acft/yr (2,350 acft/yr from the new reservoir and 2,075 acft/yr from the canal diversions). When the two options are combined, the system operations increases the combined firm yield by 300 acft/yr to 4,725 acft/yr. Based on a delivery factor of 0.572, the yield impact on Possum Kingdom Reservoir was estimated to be 1,730 acft/yr for costing purposes. Figure 10.5-14 shows the simulated storage levels of the new reservoir for the 1940 to 1997 historical period, subject to the firm yield demand of 4,725 acft/yr. Figure 10.5-15 illustrates the storage frequency of the new reservoir under the same firm yield demand. The storage trace and frequency figures show that the simulated new reservoir levels have large fluctuations and they are below half full almost 40 percent of the time.

Figure 10.5-14. New Reservoir Storage Trace at Firm Yield with Canal Diversion

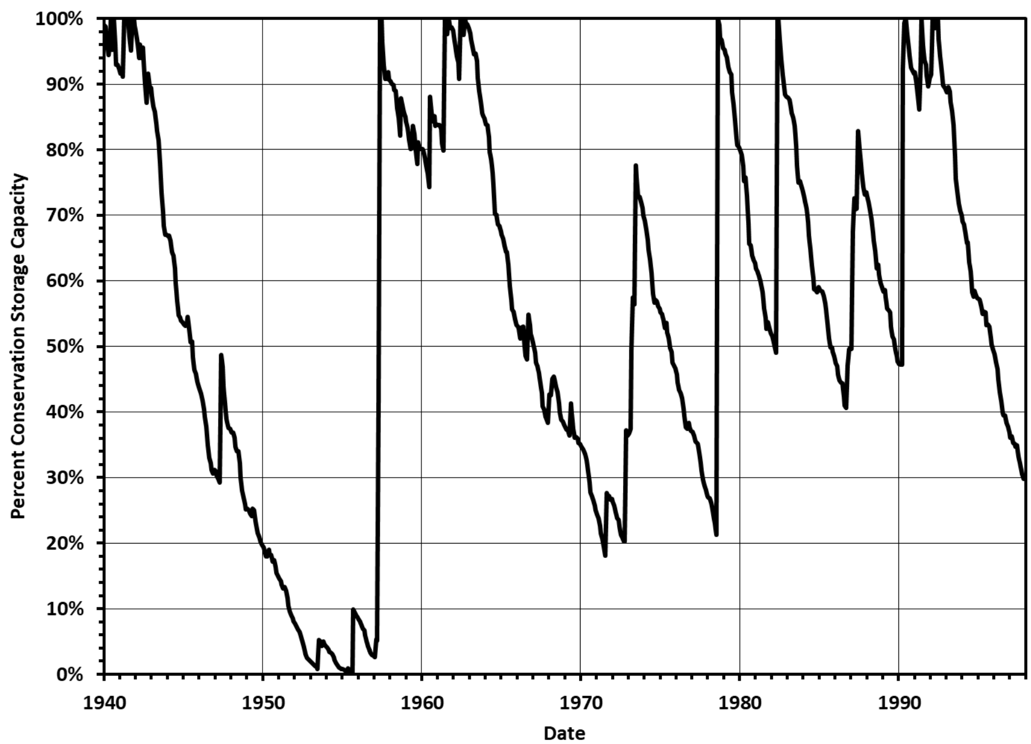
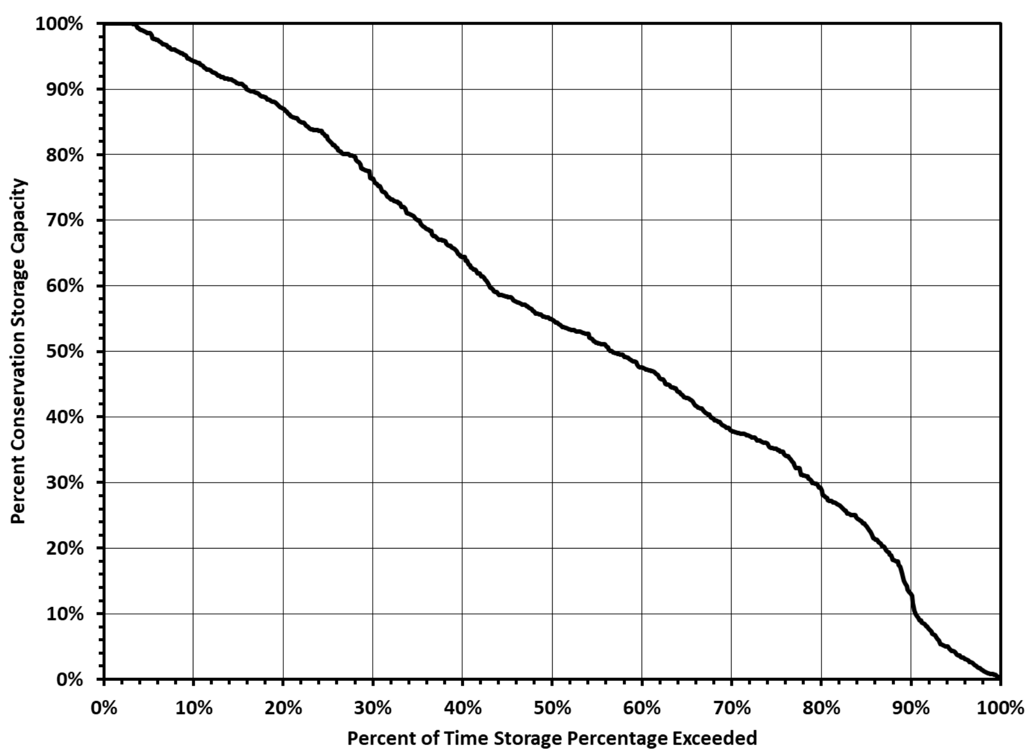


Figure 10.5-15. New Reservoir Storage Frequency at Firm Yield with Canal Diversion



The simulated changes in Lake Creek from the canal diversions show that the median monthly streamflow is reduced to zero for all months similar to the reduction in streamflow as described in Section 10.5.2 and shown in Figure 10.5-6. In Millers Creek, the model-computed median monthly streamflow below the dam is reduced to zero for all months. It should be noted that the only month with a median monthly streamflow greater than zero without the new reservoir is May with a median streamflow of 0.1 cfs.

Figure 10.5-16 and Figure 10.5-17 illustrate the Lake Creek and Millers Creek streamflow frequency characteristics with the project in place. In Lake Creek, the model-computed frequency with the combined projects is slightly reduced from the stand alone canal diversion frequency presented in Section 10.5.2 and shown in Figure 10.5-7. This reduction in streamflow is from additional storage available in the new reservoir allowing canal diversions to be made more often. The frequency characteristics for Millers Creek Reservoir are compared to those downstream of the existing reservoir computed for conditions as they currently exist, without the new reservoir, diversion from Lake Creek, or subordination of Possum Kingdom Reservoir.

Figure 10.5-16. Comparison of Streamflow Frequency below Lake Creek Diversion Point with and without New Reservoir and Canal Diversion

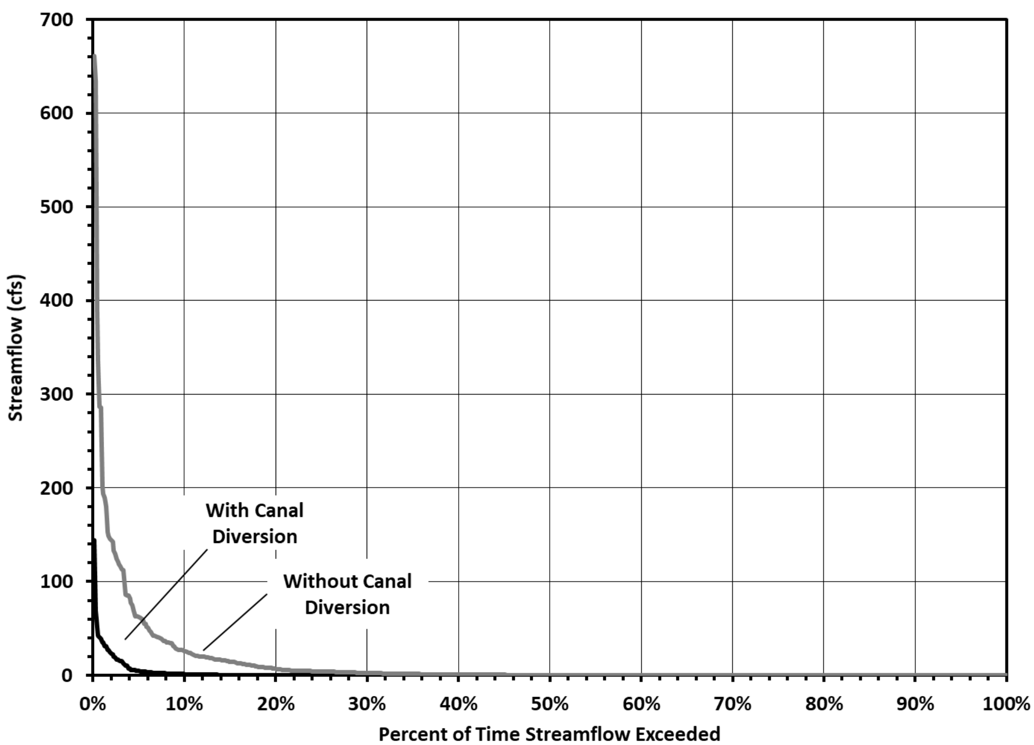
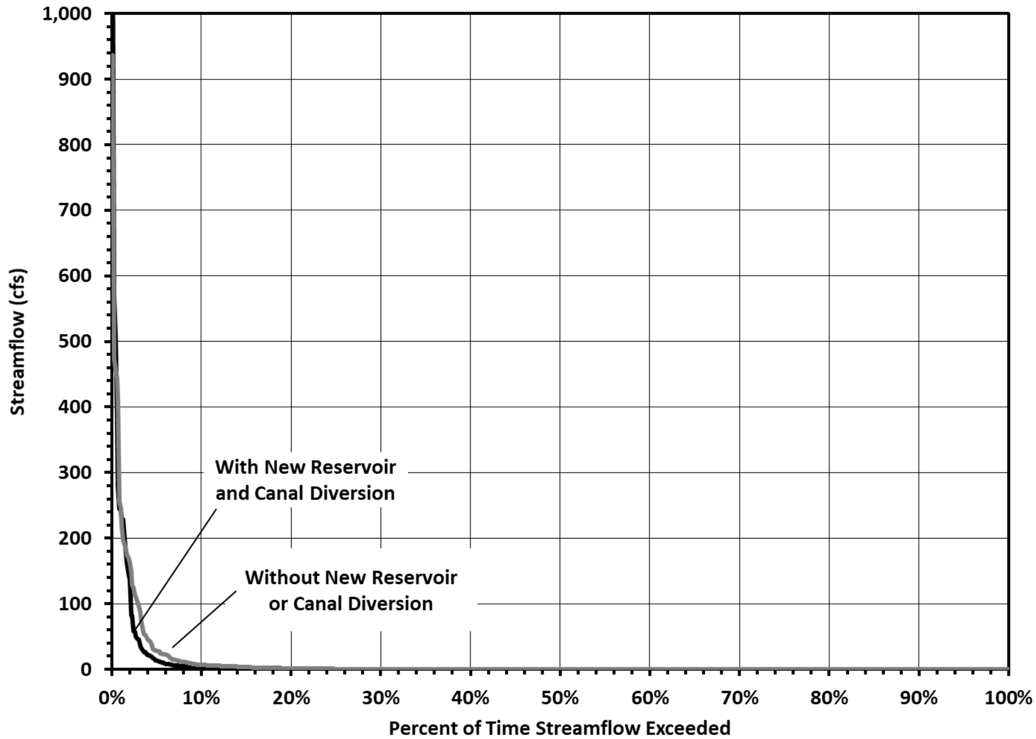


Figure 10.5-17. Comparison of Millers Creek Streamflow Frequency With and Without New Reservoir and Canal Diversion



Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 10.5.6.

Engineering and Costing

Table 10.5-8 summarizes estimated costs for the new dam and reservoir with the canal diversion. The total estimated project cost for the combined canal diversion and new dam and reservoir project is $113.4 million. The annual project costs are estimated to be $6.45 million; this includes annual debt service, operation and maintenance, and annual payment to the Brazos River Authority for lost yield in Possum Kingdom Reservoir. The cost for the estimated additional firm yield increase of 3,025 acft/yr translates to an annual unit cost for raw water of $6.54 per 1,000 gallons, or $2,132 per acft.

Table 10.5-8. Cost Estimate for Augmentation of Millers Creek Reservoir (Combined Canal Diversion with New Dam and Reservoir Option)

Item	Estimated Costs for Facilities
Capital Cost	
New Dam and Reservoir	$19,158,000
Lake Creek Channel Dam, Reservoir, and Canal	$46,256,000
Integration, Relocations, & Other	$601,000
Total Cost Of Facilities	**$66,015,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$23,105,000
Environmental & Archaeological Studies and Mitigation	$7,706,000
Land Acquisition and Surveying (4,286 acres)	$7,921,000
Interest During Construction (4% for 3 years with a 1% ROI)	$8,642,000
Total Cost Of Project	**$113,389,000**
Annual Costs	
Debt Service (3.5 percent, 20 years)	$62,000
Reservoir Debt Service (3.5 percent, 40 years)	$5,269,000
Operation and Maintenance	
Dam and Reservoir	$987,000
Purchase of Water (1,730 acft/yr @ 76.50 $/acft)	$132,000
Total Annual Cost	**$6,450,000**
Available Project Yield (acft/yr), based on a Peaking Factor of 1	**3,025**
Annual Cost of Water ($ per acft)	**$2,132**
Annual Cost of Water ($ per 1,000 gallons)	**$6.54**

10.5.6 Environmental Issues

This water management strategy involves four possible scenarios: 1) a diversion dam which will divert water from Lake Creek through a grass-lined canal into Brushy Creek and subsequently into Millers Creek Reservoir; 2) the use of a pipeline instead of a canal to carry the diverted water from Lake Creek to Brushy Creek; 3) development of a new reservoir below Millers Creek Reservoir with no associated Lake Creek diversion; and 4) development of both the new reservoir and diversion of water from Lake Creek via a canal.

Both the Millers Creek Reservoir Augmentation Site, diversion canal and the new reservoir site lie within the Rolling Plains Ecological Region[4]. This region is located east

[4] Gould, F.W., G. O. Hoffman, and C.A. Rechenthin, 1960. Vegetational areas of Texas. College Station (TX): Texas A&M University Agricultural Experiment Station. Report L-492.

of the High Plains, west of the West Cross Timbers and North Central Prairie, and north of the Edwards Plateau. It is characterized by nearly level to rolling topography, soft prairie sands and clays, juniper breaks, and midgrass prairie. The physiognomy of the region varies from open, short to tall, scattered to dense grasslands to savannahs with bunch grasses. Most of the plains are rangeland, but dry-land and irrigated crops are considered increasingly important. Poor range management practices in the past have caused an increase in the density of invasive plant species and subsequently decreased the value of the land for cattle production. Farming and grazing practices have also reduced the abundance and diversity of wildlife in the region.[5] The climate is characterized as subtropical subhumid, with hot summers and dry winters. Average precipitation ranges between 24 and 26 inches.[6]

The physiography of the region includes recharge sand, undissected red beds, loose surficial sand, flood prone areas, and severely eroded land.[7] Three major vegetation types occur within the general vicinity of the project area: Mesquite - Lotebush Shrub, Mesquite-Saltcedar Brush/Woods, and Crops.[8] Variations in these primary types occur with changes in the composition of woody and herbaceous species and localized conditions.

Potential Impacts

Aquatic Environments including Bays & Estuaries

Several freshwater emergent wetlands, forested/shrub wetlands, ponds, riverine and lake wetlands were identified on the National Wetland Inventory (NWI) maps adjacent to the potential pipeline. A Nationwide Permit or coordination with the U.S. Army Corps of Engineers would be required for impacts to waters of the U.S. One surface water (Millers Creek Reservoir – TCEQ Segment 1208A) was identified on the TCEQ Surface Water Quality Viewer[9] within the proposed project area, or within 5 miles. This surface water was fully functioning and was not impaired.

The streamflow statistics presented in the previous sections show that median monthly flows in Millers Creek and Lake Creek will decrease as a result of implementing any of the four options. The most significant impacts in Millers Creek would occur with construction of the new dam and reservoir either with or without the canal diversion. Implementation of either of these options would reduce the median monthly flows for all months to zero based on the simulation results. In Lake Creek, the largest impact would

[5] Telfar, Roy C. 1999. Vegetation Areas of Texas: concepts and Commentary. Journal of the Botanical Institute of Texas 3 (1).

[6] Larkin, T.J. and Bomar, G.W., 1983, Climatic atlas of Texas: Texas Water Development Board Limited Publication 192, 151 p.

[7] Kier, R. S., L.E. Garner, and L.F. Brown, Jr. 1977. Land Resources of Texas [map]. Bureau of Economic Geology, University of Texas. Austin, Texas.

[8] McMahan, Craig A., Roy G. Frye and Kirby L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[9] TCEQ, Surface Water Quality Viewer. Accessible online https://tceq.maps.arcgis.com/apps/webappviewer/index.html?id=b0ab6bac411a49189106064b70bbe778 accessed January 13, 2020.

occur for construction of the new dam and reservoir with the diversion canal. Under this scenario, the median monthly flow would be reduced to zero for all months.

Although there would be impacts in the immediate vicinity of the project site and downstream, it appears that any of the four options would have minimal influence on total discharge in the Brazos River, in which case there would be minimal influence on freshwater inflows to the Brazos River estuary.

Endangered, Threatened, Candidate and Species of Concern

The Texas Parks and Wildlife Department (TPWD) maintains a list of Rare, Threatened, and Endangered Species of Texas by County. This list includes the federal and state listing status and a habitat description for each species which may be a resident or migrant through the county. TPWD regularly updates the listing status, range data, and habitat descriptions on their published county lists, based on the most recently available data. The current list of rare, threatened and endangered species for the project area counties can be found at https://tpwd.texas.gov/gis/rtest/.

According to the Information for Planning and Consultation (IPaC) website[10] maintained by the U.S. Fish & Wildlife Service (USFWS), the Whooping Crane needs to be considered for the proposed project. The Least Tern, Piping Plover, and Red Knot were also mentioned, but only need to be considered for wind energy projects. The Whooping Crane could be a migrant through the project area, but no adverse impacts to the Whooping Crane would be expected. Reduced effluent return rates could potentially affect the sharpnose or smalleye shiner if area tributaries flow into occupied habitat. These two minnows are native to the arid prairie streams of Texas and are considered to be in danger of extinction. The USFWS has designated approximately 623 miles of the Upper Brazos River Basin and the upland areas extending beyond the river channel by 98 feet on each side as critical habitat for these two fish. These areas of the Upper Brazos River Basin occur within the counties of Baylor, Crosby, Fisher, Garza, Haskell, Kent, King, Knox, Stonewall, Throckmorton and Young.

On-site evaluations will be required by qualified biologists to confirm the occurrence of sensitive species or habitats. No species-specific surveys were conducted in the project area for this report.

Based on Texas Natural Diversity Data (TXNDD) obtained from the TPWD, two documented occurrences of colonial wading bird colonies (unranked) and one documented occurrence of the Rolling Plains goldenrod, a rare species, occurred within a 5-mile radius of the proposed project. No other documented occurrences of threatened, endangered or rare species or natural communities were reported within five miles of the project area.

A biological survey of the project area should be conducted to determine whether populations of threatened or endangered species, or potential habitats used by listed species occur in the area to be affected, if this strategy is selected. A determination on whether any impacts or effects to listed species may occur would then be made.

[10] USFWS, 2020. Information for Planning and Consultation. Accessed online https://ecos.fws.gov/ipac/location/2CDHNRFRWZBEFN2BCFV527IIXM/resources January 13, 2020.

Coordination with TPWD and USFWS regarding threatened and endangered species with potential to occur in the project area should be initiated early in project planning.

Wildlife Habitat

The Lake Creek diversion area would include an eight-foot high channel dam to impound runoff from this watershed. When full, this area would periodically inundate approximately 360 acres of wildlife habitat. The diversion area is located within an area that is currently used for cropland.

The ROW for the diversion canal connecting Lake Creek with Brushy Creek (that will transport diverted water to Millers Creek) is estimated to be approximately 1.8-miles long with a maximum top width of 287 feet. This would result in approximately 63 acres of impact to wildlife habitat. Vegetation found within the diversion canal ROW includes areas used for cropland and rangeland. Utilization of areas already impacted by agricultural uses generally reduces the overall habitat loss impact on species found within the project area. Impacts resulting from the use of a pipeline to transport the water from the diversion area rather than a canal would be fewer due to the fact that it would be buried and include only maintained ROW areas.

The addition of the new reservoir site below the existing Millers Creek Reservoir would involve the loss of approximately 2,541 acres of additional wildlife habitat at the normal pool elevation and approximately 4 stream miles of riparian habitat. Vegetation types found within this site include portions of Mesquite-Lotebush Shrub, Mesquite-Saltcedar Brush/Woods and Crop areas.

Cultural Resources

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no National Register Properties, National Register Districts, State Historic Sites, Historical Markers, or cemeteries listed near any of the proposed project areas. Prior to construction of the diversion canal or the new reservoir area, the project must be coordinated with the Texas Historical Commission and a cultural resources survey must be conducted to determine if any cultural resources are present within the area. Any cultural resources identified during survey will need to be assessed for eligibility for inclusion in the National Register of Historic Places (NRHP) or as State Archeological Landmarks (SAL). Cultural resources that occur on public lands or within the Area of Potential Effect of publicly funded or permitted projects are governed by the Texas Antiquities Code (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archeological and Historic Preservation Act (PL93-291). Taking into consideration that the owner or controller of the project will likely be a political subdivision of the State of Texas (i.e. river authority, municipality, county, etc.), they will be required to coordinate with the THC regarding impacts to cultural resources. The project sponsor will also be required to coordinate with the U.S. Army Corps of Engineers regarding any impacts to waters of the United States or wetlands.

Natural Resource Potential Impacts

Potential impacts to natural resources include lower stream flows, declining water quality, and reduced inflows to reservoirs. This project would have an impact associated with lower stream flows and a possible resulting impact on water quality. Millers Creek Reservoir would have an increase in median monthly inflow that would enhance water quality and offset a decline in water levels. Riparian habitat currently within the reservoir area would be inundated, and areas of terrestrial habitat would be impacted by the canal or pipeline construction and maintenance activities.

Specific project features such as canals and pipelines generally have sufficient design flexibility to avoid most impacts or significantly mitigate potential impacts to geographically limited environmental and cultural resource sites. Field surveys conducted at the appropriate phase of development should be employed to minimize the impacts of project construction and operations on sensitive resources.

10.5.7 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 10.5-9, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality (TCEQ) Water Right and Storage permits;
- U.S. Army Corps of Engineers Permits will be required for discharges of dredge or fill into wetlands and waters of the U.S. for dam construction, and other activities (Section 404 of the Clean Water Act);
- TCEQ administered Texas Pollutant Discharge Elimination System (TPDES) Storm Water Pollution Prevention Plan;
- General Land Office (GLO) Easement if State-owned land or water is involved; and,
- Texas Parks and Wildlife Department (TPWD) Sand, Shell, Gravel and Marl permit if State-owned streambed is involved.

State and Federal Permits may Require the Following Studies and Plans:

- Environmental impact or assessment studies;
- Wildlife habitat mitigation plan that may require acquisition and management of additional land;
- Flow releases downstream to maintain aquatic ecosystems;
- Assessment of impacts on Federal- and State-listed endangered and threatened species; and
- Cultural resources studies to determine resources impacts and appropriate mitigation plan that may include cultural resource recovery and cataloging; requires coordination with the Texas Historical Commission.

Land Acquisition Issues:

- Land acquired for reservoir and/or mitigation plans could include market transactions and/or eminent domain;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Possible relocations or removal of residences, utilities, roads, or other structures.

Table 10.5-9. Comparison of Augmentation of Millers Creek Reservoir (Combined Canal Diversion with New Dam and Reservoir Option) to Plan Development Criteria

Impact Category	Comment(s)
A. Water Supply	
1. Quantity	1. Sufficient to meet some needs
2. Reliability	2. Reasonable
3. Cost	3. High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. Moderate impact
3. Cultural Resources	3. Moderate impact
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Low impact
6. Wetlands	6. Low impact
C. Impact on Other State Water Resources	No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	Low to None. Some loss of crop land is expected in the inundation area of the new reservoir.
E. Equitable Comparison of Strategies Deemed Feasible	Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	None