

4B.7 Augmentation of Millers Creek Reservoir

Augmentation of Millers Creek Reservoir was studied for the 2006 Brazos G Regional Water Plan. The 2006 Plan evaluated diverting water from nearby Lake Creek to Millers Creek Reservoir via a canal and, as an alternative, via a pipeline. The current evaluation updates the yields and costs for the previously considered options and also considers two additional options: construction of a new dam and reservoir on Millers Creek downstream of the existing reservoir and construction of the new reservoir along with the canal diversion from Lake Creek.

4B.7.1 Description of Canal 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, this strategy includes diverting water 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 4B.7-1.

Design parameters for the diversion canal were identified through the work conducted for the 2006 Plan. The maximum monthly depletion from Lake Creek, assuming the Lake Creek diversion is the most senior in the basin, was computed for the 2006 Plan 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 4B.7-2. 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-foot high, 120-foot wide berms along the top of the canal.

The approximately 8-foot 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.

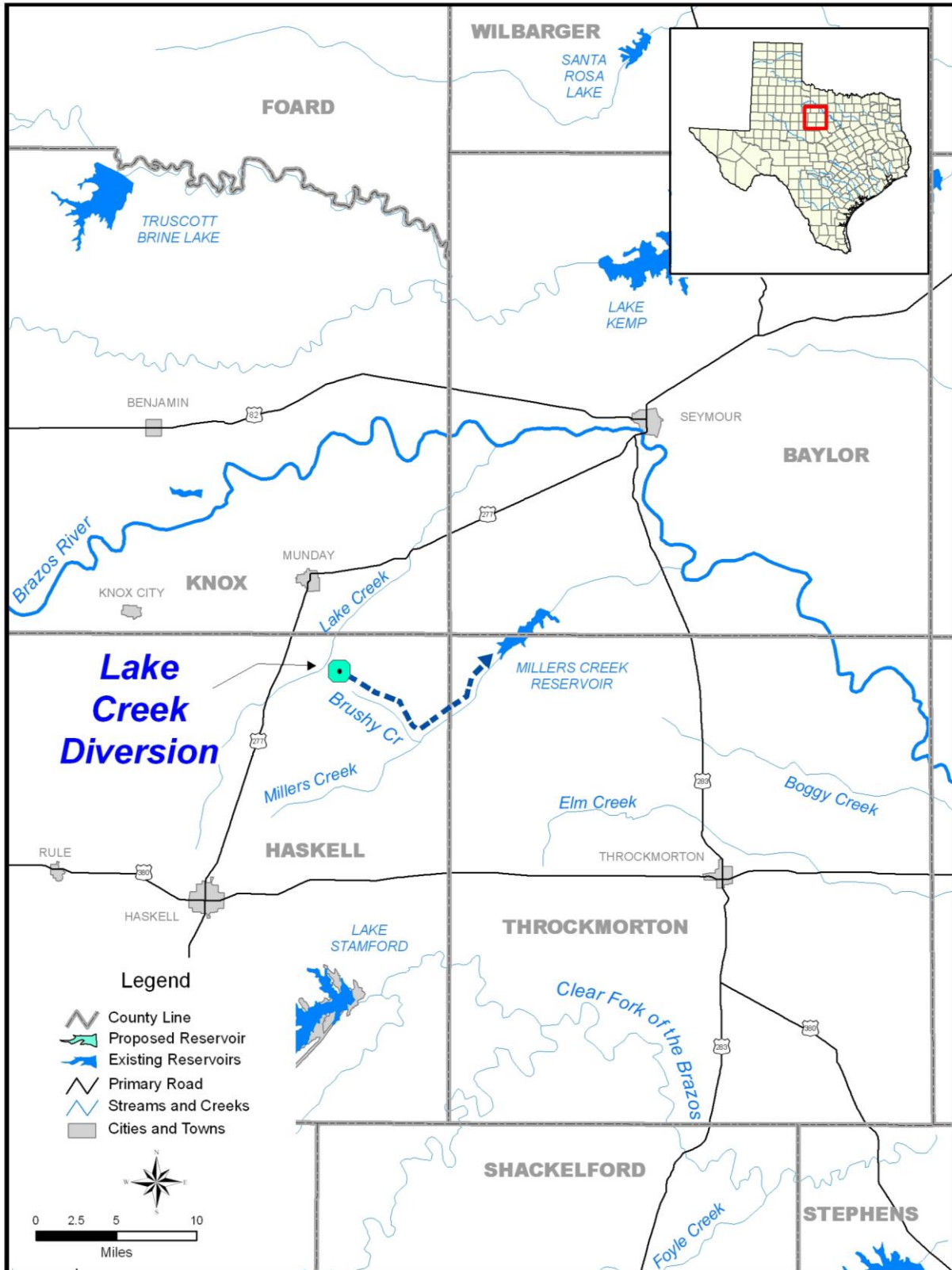


Figure 4B.7-1. Lake Creek Diversion to Millers Creek Reservoir

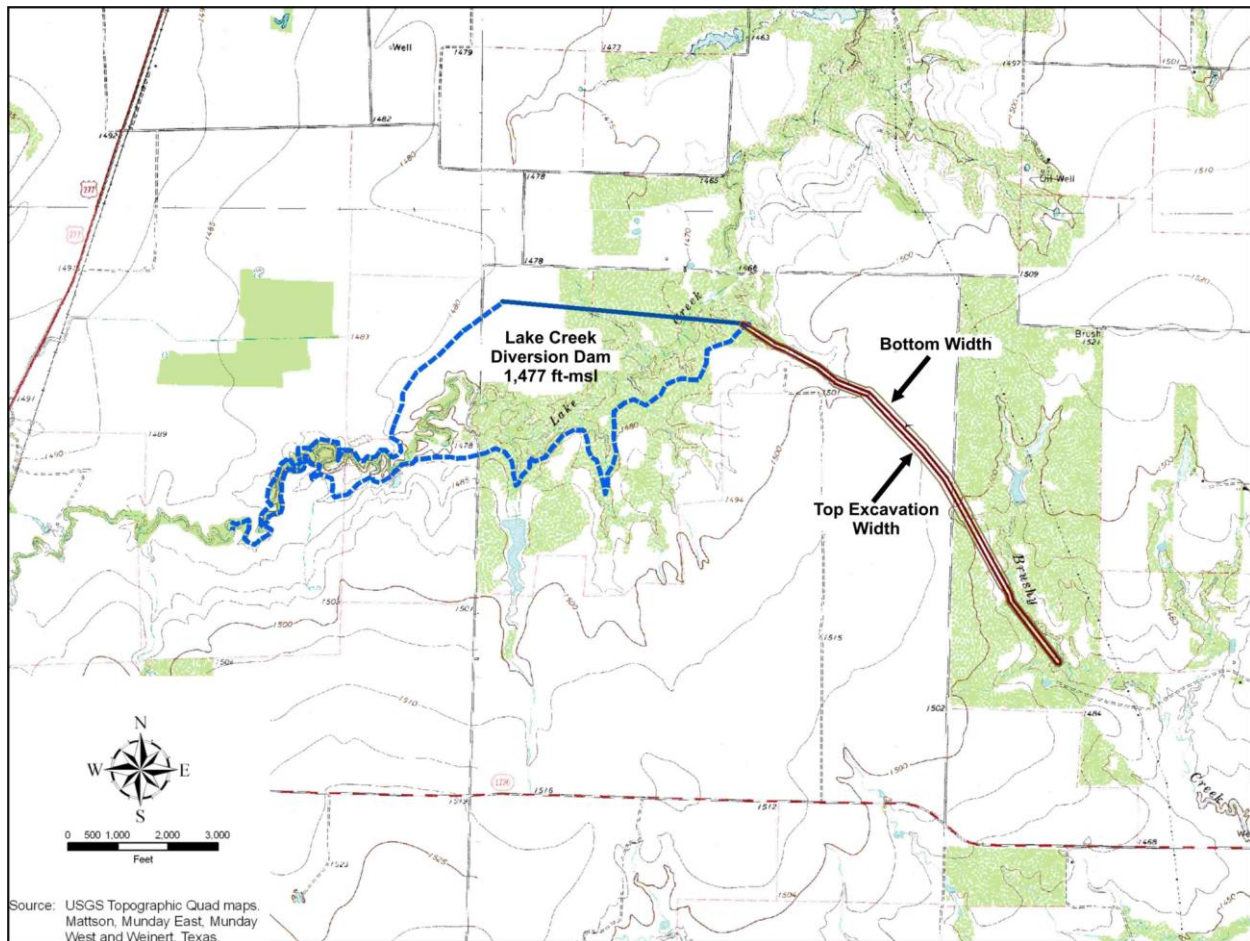


Figure 4B.7-2. Lake Creek Diversion Dam and Canal to Brushy Creek

4B.7.1.1 Available Yield

Water potentially available for impoundment into the Millers Creek Reservoir was estimated using the 2060 Brazos G WAM. The model utilized a January 1940 through December 1997 hydrologic period of record. Estimates of water availability were derived subject to general assumptions for application of hydrologic models as adopted by the Brazos G Regional Water Planning Group and summarized previously. The model computed the streamflow available for diversion from Lake Creek into the Millers Creek Reservoir without causing increased shortages to existing downstream rights. Safe yield was computed subject to Consensus Criteria for Environmental Flow Needs (CCEFN) instream flow requirements (Appendix H) at the Lake Creek Diversion. The streamflow statistics used to identify the Consensus Criteria pass through requirements for the Lake Creek Diversion were computed for the 2006 Brazos G Regional Plan and are shown in Table 4B.7-1.

**Table 4B.7-1.
Daily Natural Streamflow Statistics
for the Lake Creek Diversion**

Month	Median Flows - Zone 1 Pass Through Requirements (cfs)	25th Percentile Flows - Zone 2 Pass Through Requirements (cfs)
January	0.0	0.0
February	0.5	0.0
March	0.3	0.0
April	0.0	0.0
May	0.3	0.0
June	1.3	0.0
July	0.1	0.0
August	0.0	0.0
September	0.0	0.0
October	0.0	0.0
November	0.0	0.0
December	0.0	0.0
Zone 3 (7Q2) Pass-Through Requirement (cfs):		0

The calculated safe yield of the Millers Creek Reservoir with the Lake Creek diversion is 6,742 acft/yr, assuming subordination of Possum Kingdom Reservoir to the Millers Creek Reservoir and the Lake Creek diversion. The Lake Creek diversion increases the yield of the Millers Creek Reservoir over that of the existing reservoir alone by 6,257 acft/yr. Based on a delivery factor of 0.572 (from the Brazos G 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 3,579 acft/yr for costing purposes. Additional analysis would be required to refine this estimate of impact on Possum Kingdom Reservoir.

Figure 4B.7-1 illustrates the simulated Millers Creek Reservoir storage levels for the 1940 to 1997 historical period, subject to the safe yield of 6,742 acft/yr. Simulated reservoir contents remain above the Zone 2 trigger level (80 percent capacity) 92.8 percent of the time and above the Zone 3 trigger level (50 percent capacity) 99.6 percent of the time (all but 3 months of the simulation).

Figures 4B.7-3 and 4B.7-4 illustrate the changes in Lake Creek and Millers Creek median monthly streamflows caused by the project. The largest change as computed from the simulation results is a decline in median monthly streamflow in Lake Creek of 23 cfs in July. In Millers Creek, the model-computed median monthly stream flow below the dam is reduced to zero for all months but May and June with the project in place. The largest decrease in model-computed median monthly flow is 11 cfs, computed for the month of June. The decrease in median monthly flows is due to the subordination of Possum Kingdom Reservoir to Millers Creek Reservoir. Figures 4B.7-3 and 4B.7-4 also illustrate the Lake Creek and Millers Creek streamflow frequency characteristics with the project in place. In Lake Creek, the model-computed frequency of mean monthly flows below approximately 100 cfs is decreased. In Millers Creek, the model-computed frequency of monthly flows below approximately 110 cfs and above approximately 25 cfs is increased, while the frequency of those less than 25 cfs is decreased.

4B.7.1.2 Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 4B.7.5.

4B.7.1.3 Engineering and Costing

The total estimated project cost for the channel dam and grass lined canal is \$22.9 million. Capital costs were developed for the 2006 Brazos G Plan and have been updated to September 2008 dollars using the Engineering News Record (ENR) Construction Cost Index (CCI). 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 4B.7-2. The cost for the estimated additional safe yield increase of 6,257 acft/yr translates to an annual unit cost for raw water of \$0.85 per 1,000 gallons, or \$279/acft.

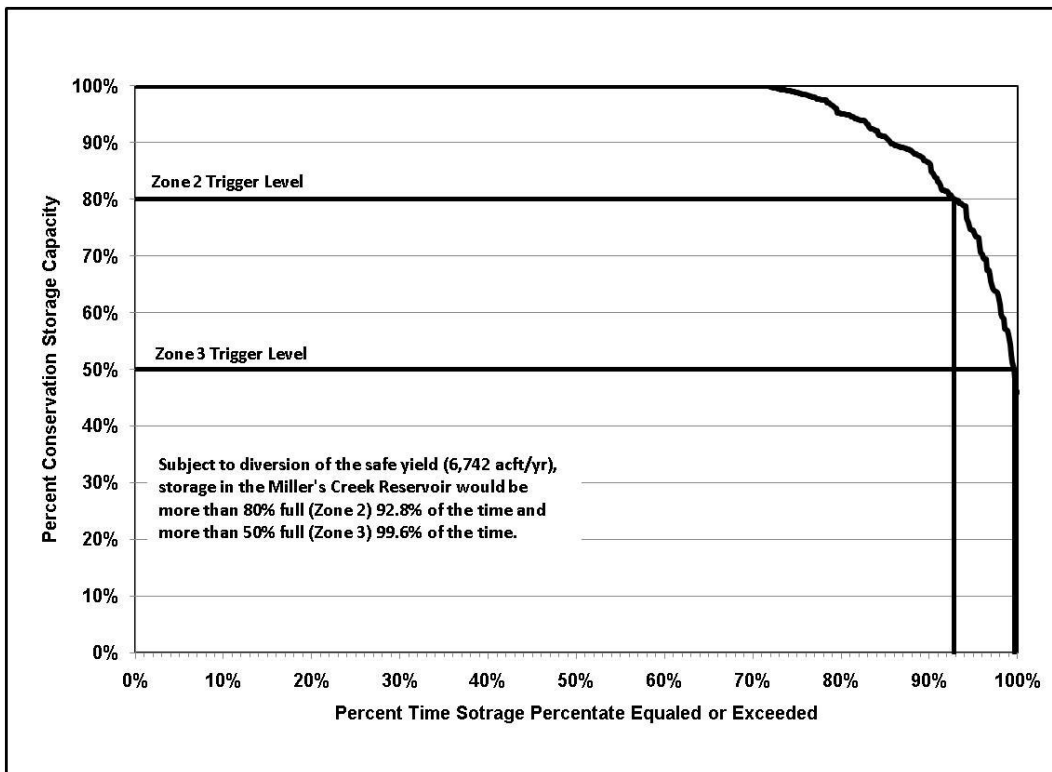
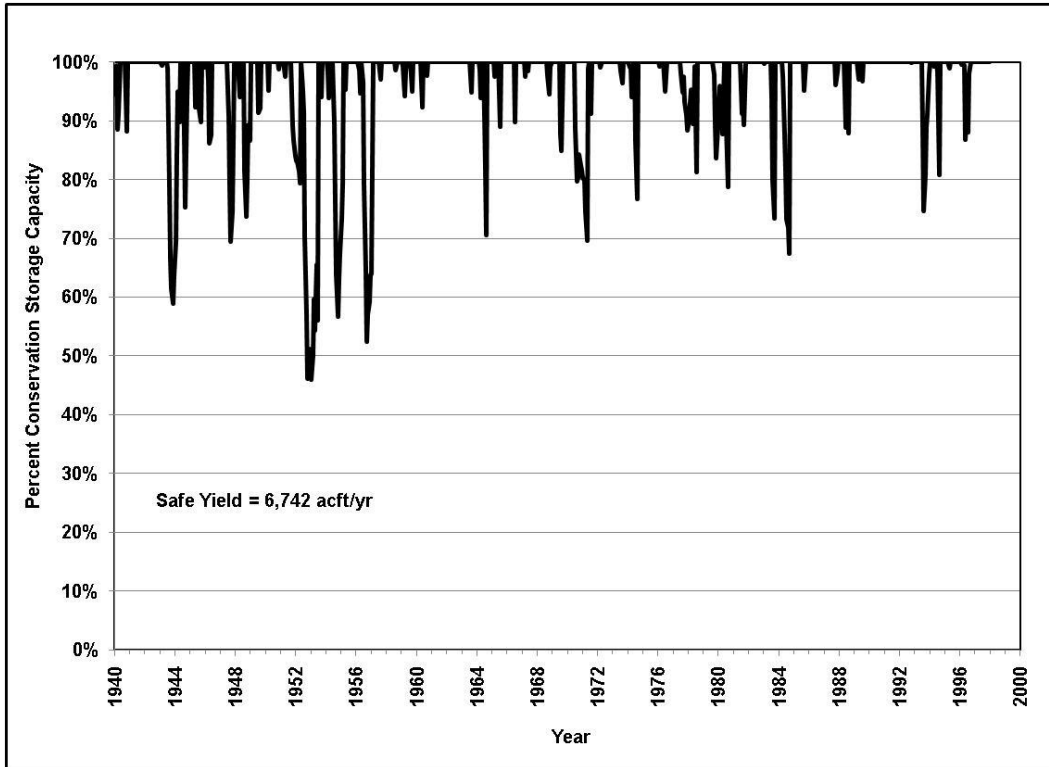


Figure 4B.7-3. Millers Creek Reservoir Storage Trace and Storage Frequency at Safe Yield

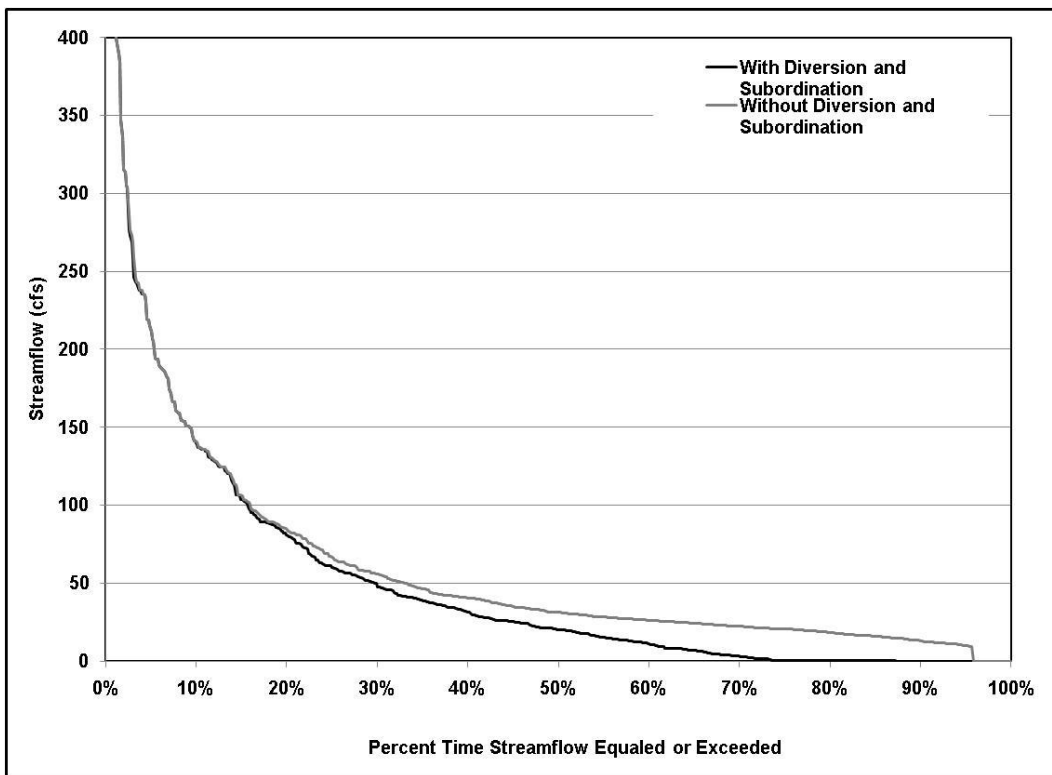
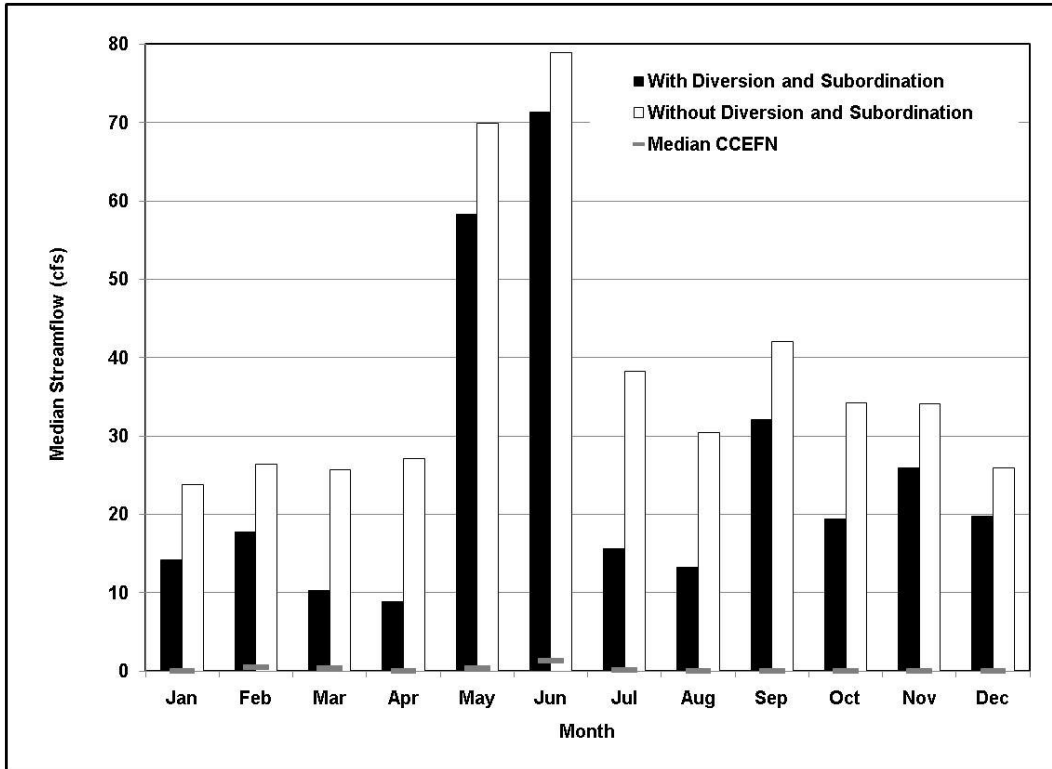


Figure 4B.7-4. Comparison of Median Monthly Streamflow and Streamflow Frequency Below Lake Creek Diversion Point With and Without Canal Diversion

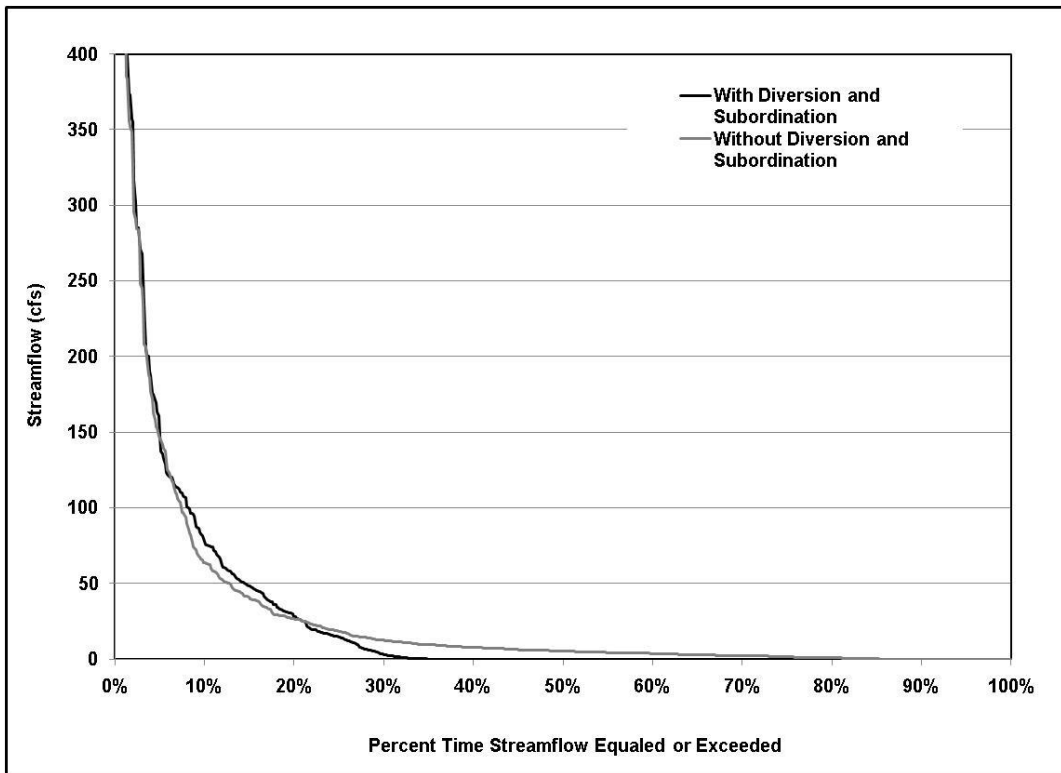
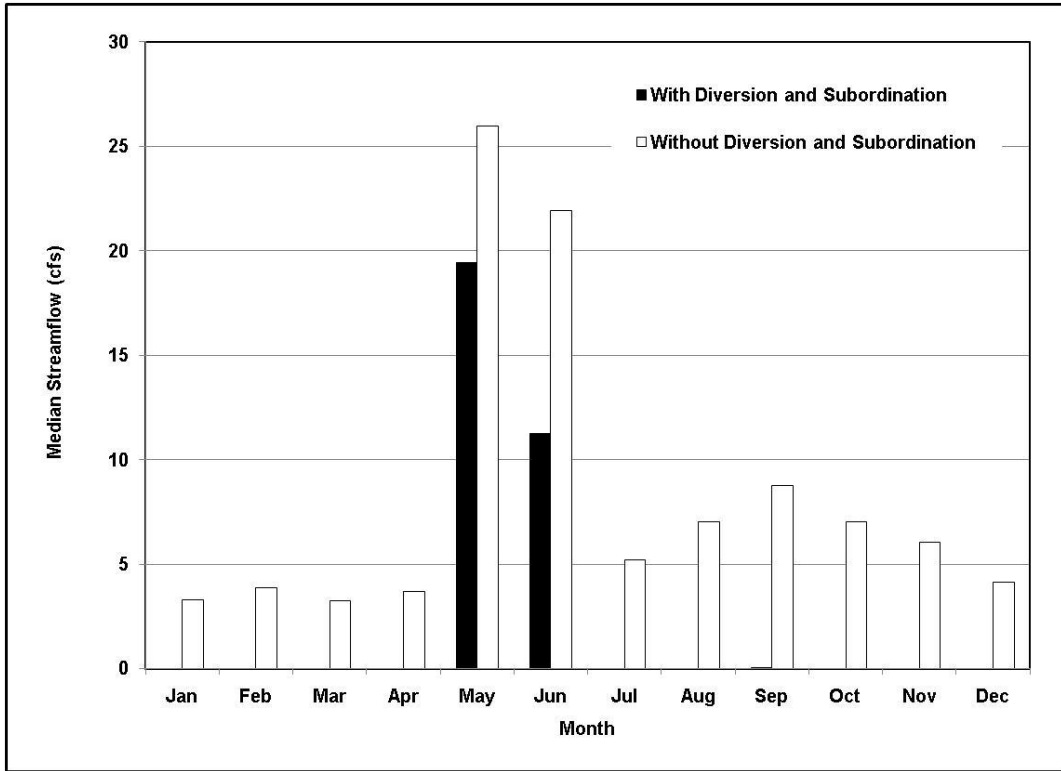


Figure 4B.7-5. Comparison of Median Monthly Streamflow and Streamflow Frequency Below Millers Creek Reservoir With and Without Canal Diversion

Table 4B.7-2.
Cost Estimate Summary for
Augmentation of Millers Creek Reservoir (Canal Option)
(September 2008 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Capital Costs	
Channel Dam, Reservoir (1,477 ft-msl), and Canal	<u>\$14,676,000</u>
Total Capital Cost	\$14,676,000
Engineering, Legal Costs and Contingencies	\$5,136,000
Environmental & Archaeology Studies and Mitigation	\$691,000
Land Acquisition and Surveying (491 acres)	\$715,000
Interest During Construction (2 years)	<u>\$1,698,000</u>
Total Project Cost	\$22,916,000
Annual Costs	
Reservoir Debt Service (6 percent, 40 years)	\$1,523,000
Operation and Maintenance	
Dam and Reservoir	\$25,000
Purchase of Water (3,579 acft/yr @ 54.50 \$/acft)	<u>\$195,000</u>
Total Annual Cost	\$1,743,000
Available Project Yield (acft/yr)	6,257
Annual Cost of Water (\$ per acft)	\$279
Annual Cost of Water (\$ per 1,000 gallons)	\$0.85

4B.7.1.4 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4B.7-3, and the option meets each criterion.

**Table 4B.7-3.
Comparison of Augmentation of Millers Creek Reservoir (Canal Option)
to Plan Development Criteria**

Impact Category	Comment(s)
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Sufficient to meet some needs 2. High reliability 3. Reasonable
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Low impact 2. Low to moderate impact 3. Low to moderate impact 4. Low impact 5. Low impact 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	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

4B.7.1.4.1 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.

4B.7.1.4.2 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.

4B.7.1.4.3 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.

4B.7.2 Description of Pipeline Option

Another option for augmenting Millers Creel Reservoir previously studied¹ and included in the 2006 Brazos G Plan is to divert water from Lake Creek through a 24-inch pipeline into Brushy Creek, which flows into Millers Creek and eventually into Millers Creek Reservoir, as shown in Figure 4B.7-2.

4B.7.2.1 Available Yield

The increase in Millers Creek Reservoir yield that could potentially be obtained with the pipe diversion was estimated using the 2060 Brazos G WAM. Subordination of Possum Kingdom Reservoir to both Millers Creek Reservoir and the Lake Creek diversion was assumed. An additional instream flow requirement of 5 cfs was added to the model at the Lake Creek

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

diversion point for consistency with previous work on the pipeline option. The capacity of the 24-inch pipe was assumed to be approximately 10 cfs or 7,200 acft/yr. As with the canal diversion, Possum Kingdom Reservoir was assumed to be subordinated to the Lake Creek diversion and to Millers Creek Reservoir.

The safe yield of Millers Creek Reservoir with the pipeline diversion was computed to be 4,076 acft/yr, which is an increase of 3,591 acft/yr over the model-computed safe yield of the existing reservoir alone. Based on a delivery factor for water flowing from Millers Creek reservoir to Possum Kingdom Reservoir of 0.572 (from the Brazos G WAM), the yield impact on Possum Kingdom Reservoir due to the pipe diversion and subordination was assumed to be 2,054 acft/yr for costing purposes. Additional analysis would be required to refine this estimate of impact on Possum Kingdom Reservoir.

4B.7.2.2 Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 4B.7.5.

4B.7.2.3 Engineering and Costing

The total estimated project cost is \$10.20 million for the diversion weir, intake canal, pipeline, and pump station. The annual project costs are estimated to be \$1.16 million, including annual debt service, operation and maintenance, and annual payment to the Brazos River Authority for lost yield in Possum Kingdom. A summary of the project costs is presented in Table 4B.7-4. The cost for the estimated increase in Millers Creek Reservoir safe yield of 3,591 acft/yr translates to an annual unit cost for raw water of \$0.99 per 1,000 gallons, or \$324 per acft.

4B.7.2.4 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4B.7-5, and the option meets each criterion.

Table 4B.7-4.
Cost Estimate Summary for
Augmentation of the Millers Creek Reservoir (Pipeline Option)
September 2008 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Capital Costs	
Dam and Reservoir (Diversion Weir and Intake Canal)	\$4,474,000
Intake and Pump Station	\$1,726,000
Transmission Pipeline (24 in dia., 1.8 miles)	<u>\$768,000</u>
Total Capital Cost	\$6,968,000
Engineering, Legal Costs and Contingencies	\$2,368,000
Environmental & Archaeology Studies and Mitigation	\$44,000
Land Acquisition and Surveying (8 acres)	\$61,000
Interest During Construction (2 years)	<u>\$757,000</u>
Total Project Cost	\$10,198,000
Annual Costs	
Debt Service (6 percent, 20 years)	\$402,000
Reservoir Debt Service (6 percent, 40 years)	372,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$57,000
Dam and Reservoir	25,000
Pumping Energy Costs	\$196,000
Purchase of Water (2,054acft/yr @ \$54.50/acft)	<u>\$112,000</u>
Total Annual Cost	\$1,164,000
Available Project Yield (acft/yr)	3,591
Annual Cost of Water (\$ per acft)	\$324
Annual Cost of Water (\$ per 1,000 gallons)	\$0.99

**Table 4B.7-5.
Comparison of Augmentation to the Millers Creek Reservoir (Pipeline Option)
to Plan Development Criteria**

<i>Impact Category</i>	<i>Comment(s)</i>
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Sufficient to meet some needs 2. High reliability 3. Reasonable
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Low impact 2. Low to moderate impact 3. Low to moderate impact 4. Low impact 5. Low impact 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	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

4B.7.2.4.1 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.

4B.7.2.4.2 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.

4B.7.2.4.3 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.

4B.7.3 **Description of New Dam and Reservoir 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 4B.7-6 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 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.

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.

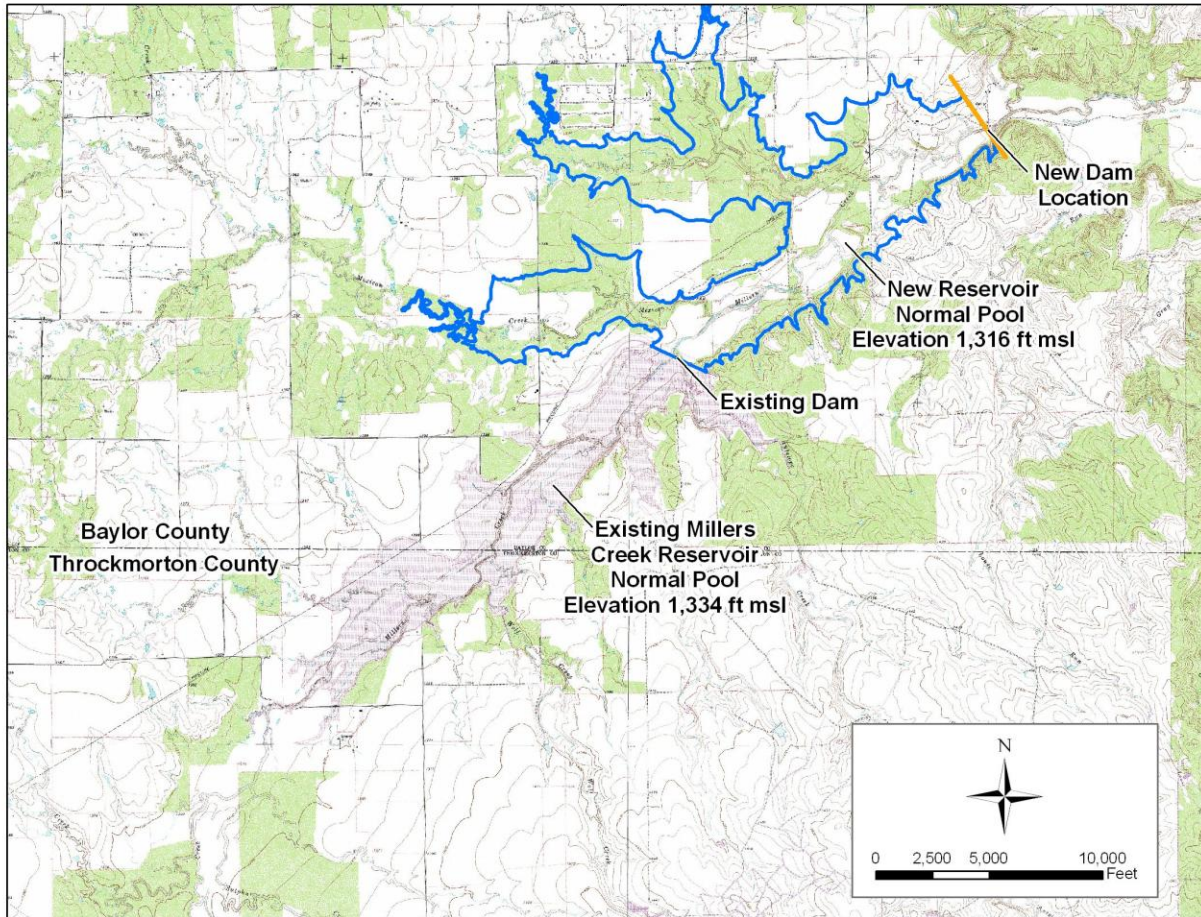


Figure 4B.7-6. New Reservoir Below Millers Creek Reservoir

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 2060 Brazos G WAM, which models existing reservoirs at their projected year 2060 capacity, is 14,674 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

³ Texas Water Development Board, "Hydrographic Survey of Miller's Creek Reservoir," Prepared for North Central Texas Municipal Water Authority, March 2003.

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.

4B.7.3.1 Available Yield

The safe yield that would be available with construction of the new reservoir was estimated using the 2060 Brazos G WAM. Streamflow records for August 1963 through October 2009 at USGS Gauge 08082700, located on Millers Creek near Munday, Texas, approximately 11.7 miles upstream of the existing dam, were evaluated to identify the potential CCEF requirements for the new reservoir. The gauged daily mean flows were scaled by the drainage area ratio to the new dam site, and the median, 25th percentile, and 7Q2 flows were computed. As the gage is upstream of the existing reservoir, the existing reservoir's impact on streamflow did not affect the computed streamflow statistics. All three of the CCEF statistics were computed to be zero. Therefore, CCEF requirements were not included in modeling the safe yield of the new reservoir. Subordination of Possum Kingdom Reservoir to both the existing and new Millers Creek reservoirs was assumed for the safe yield calculation.

The calculated safe yield of the new reservoir is 8,075 acft/yr, with the subordination and priority assumptions noted above. Along with a computed 1,420 acft/yr increase in the safe yield of the existing reservoir due to the subordination of Possum Kingdom Reservoir, the total increase in safe yield that would result from implementing this project is 9,495 acft/yr. Based on a delivery factor of 0.572, the yield impact on Possum Kingdom Reservoir was estimated to be 5,431 acft/yr for costing purposes. Additional analysis would be required to refine this estimate of impact on Possum Kingdom Reservoir. Figure 4B.7-7 shows the simulated storage levels of the new reservoir for the 1940 to 1997 historical period, subject to the safe yield of 8,075 acft/yr.

The effects of the new reservoir and subordination of Possum Kingdom reservoir on streamflow in Millers Creek below the new reservoir were computed from the 2060 Brazos G WAM simulation results. Figure 4B.7-8 shows the computed Miller's Creek median monthly streamflow and streamflow frequency characteristics downstream of the new reservoir. The computed median monthly stream flow is zero for each month of the year. The frequency

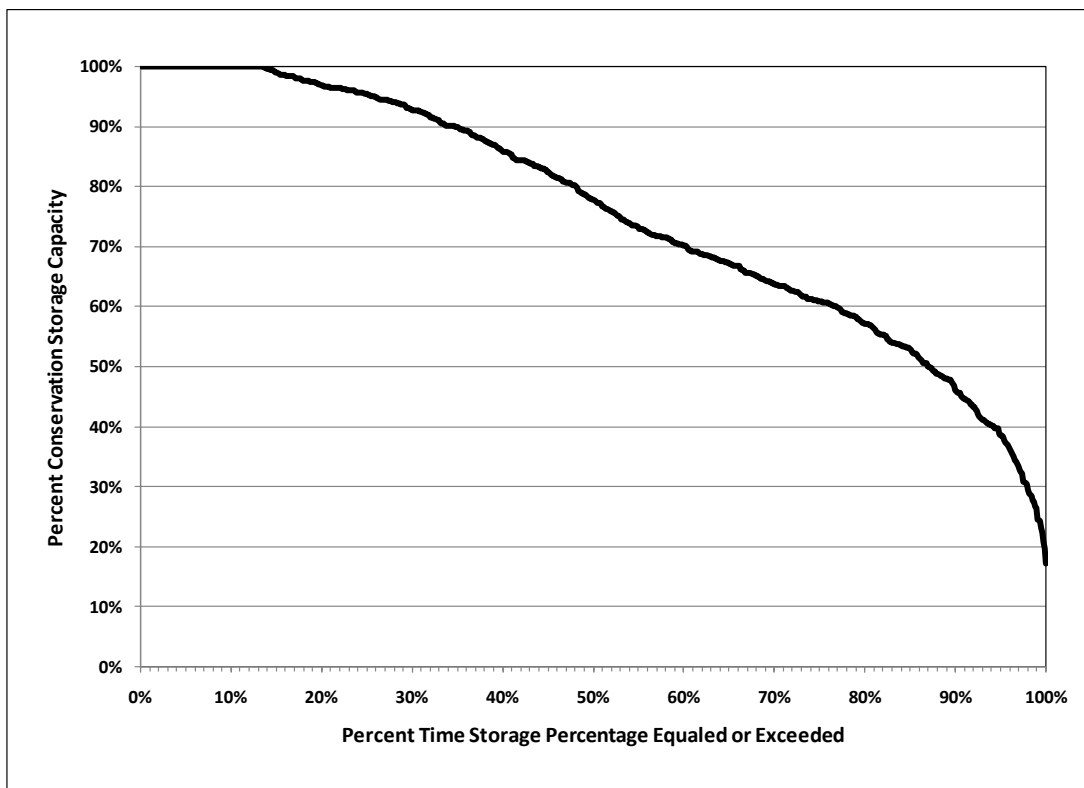
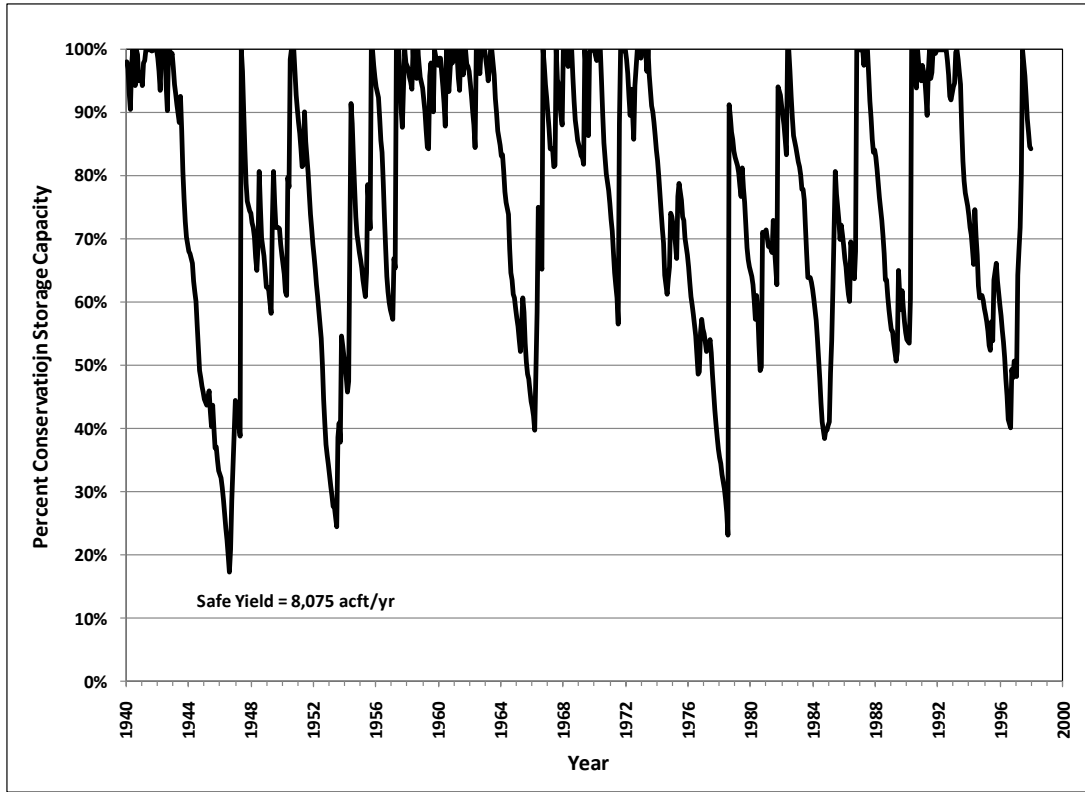


Figure 4B.7-7. New Reservoir Storage Trace and Storage Frequency at Safe Yield

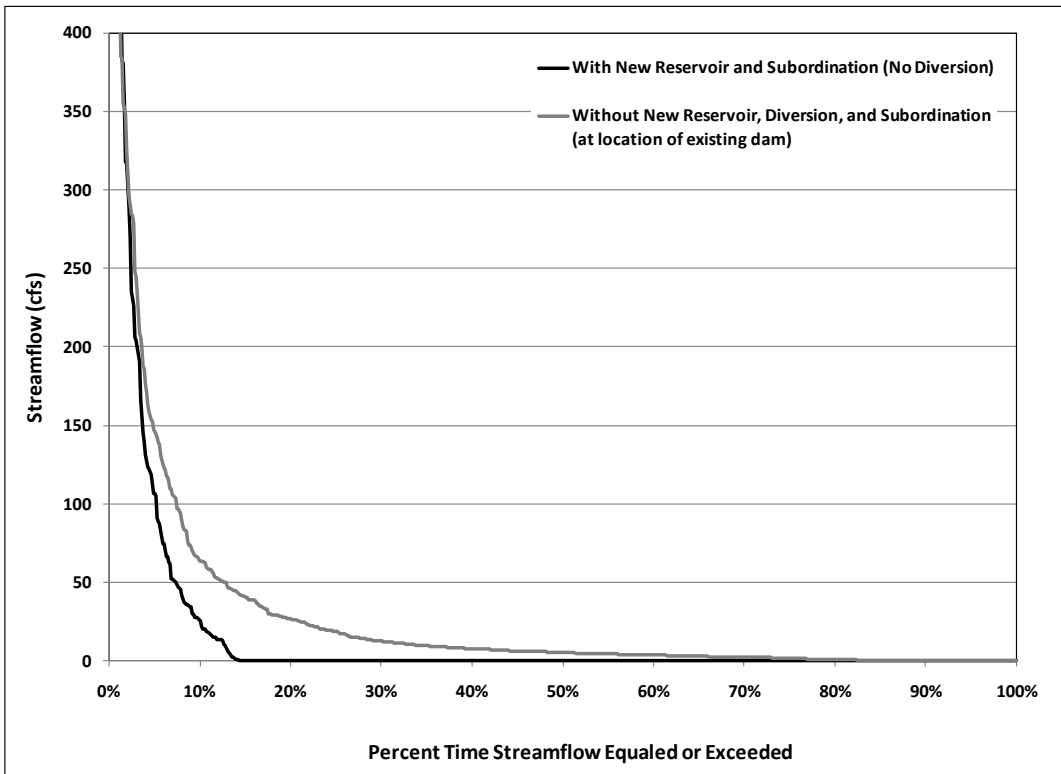
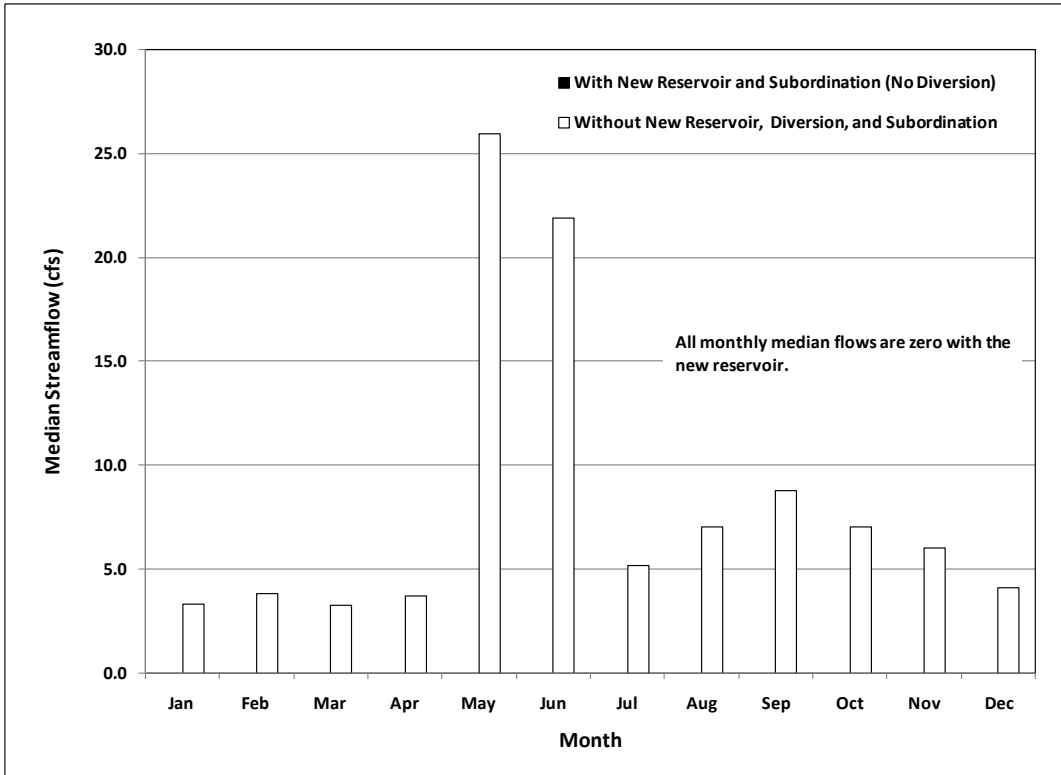


Figure 4B.7-8. Comparison of Millers Creek Median Monthly Streamflow and Streamflow Frequency With and Without New Reservoir

characteristics 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. A decrease in the frequency of mean monthly flows less than approximately 250 cfs is apparent in the frequency plot.

4B.7.3.2 Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 4B.7.5.

4B.7.3.3 Engineering and Costing

Table 4B.7-6 summarizes estimated costs for the new dam and reservoir. The Freese, Nichols and Endress Study provides a preliminary cost estimate for construction of the new dam. The capital costs from this study were updated from 1967 to September 2008 values using the ENR CCI for inclusion in the present estimate. Other costs were computed based on standard regional planning methodologies.

The total estimated project cost for the new dam and reservoir is \$24.0 million. The annual project costs are estimated to be \$2.01 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 safe yield increase of 9,495 acft/yr translates to an annual unit cost for raw water of \$0.65 per 1,000 gallons, or \$212 per acft.

4B.7.3.4 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4B.7-7, and the option meets each criterion.

4B.7.3.4.1 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;

Table 4B.7-6.
Cost Estimate Summary for
Augmentation of the Millers Creek Reservoir
(New Dam and Reservoir Option)
(September 2008 Prices)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Capital Costs	
Dam and Reservoir (Conservation Pool 46,645 acft, 2,541 acres, 1,316 ft-msl)	\$6,866,000
Relocations and Other	<u>\$460,000</u>
Total Capital Cost	\$7,326,000
Engineering, Legal Costs and Contingencies	\$2,564,000
Environmental & Archaeology Studies and Mitigation	\$5,340,000
Land Acquisition and Surveying (3,795 acres)	\$5,529,000
Interest During Construction (2 years non-reservoir, 4 years reservoir)	<u>\$3,273,000</u>
Total Project Cost	\$24,032,000
Annual Costs	
Debt Service (6 percent, 20 years)	\$59,000
Reservoir Debt Service (6 percent, 40 years)	\$1,553,000
Operation and Maintenance	
Dam and Reservoir	\$103,000
Purchase of Water (5,431 acft/yr @ 54.50 \$/acft)	<u>\$296,000</u>
Total Annual Cost	\$2,011,000
Available Project Yield (acft/yr)	9,495
Annual Cost of Water (\$ per acft)	\$212
Annual Cost of Water (\$ per 1,000 gallons)	\$0.65

**Table 4B.7-7.
Comparison of New Dam and Reservoir
to Plan Development Criteria**

Impact Category	Comment(s)
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Sufficient to meet some needs 2. High reliability 3. Reasonable
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Moderate impact 2. Moderate impact 3. Moderate impact 4. Low impact 5. Low impact 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	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

- 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.

4B.7.3.4.2 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.

4B.7.3.4.3 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.

4B.7.4 Description of Combined Canal Diversion with New Dam and Reservoir

This option combines the canal diversion from Lake Creek to the existing Miller's Creek Reservoir described in Section 4B.7.1 with the new dam and reservoir described in Section 4B.7.3. 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, then passed through the existing reservoir to fill the new reservoir.

4B.7.4.1 Available Yield

The yield of the reservoir system including the existing Millers Creek Reservoir, new reservoir, and Lake Creek diversion canal was computed with the 2060 Brazos G WAM. Subordination of Possum Kingdom Reservoir to the existing Millers Creek Reservoir. Diversions from Lake Creek were subject to the CCEFN requirements discussed in Section 4B.7.1.1.

The safe yield of the new reservoir with the canal diversion and subordination assumptions noted above was computed to be 11,325 acft/yr, which is an increase of 3,250 acft/yr over the model-computed safe yield of the new reservoir alone (Section 4B.7.3.1). The estimated safe yield of the existing reservoir with the canal diversion is 6,742 acft/yr, or 6,257 acft more than the existing reservoir alone (Section 4B.7.1.1) and this yield estimate is not impacted by the new reservoir, as the new reservoir is assumed to be junior to the existing reservoir. Overall, the canal diversion, new reservoir, and subordination of Possum Kingdom Reservoir would increase the yield of the existing reservoir by an estimated 17,582 acft/yr. Based on a delivery factor of 0.572, the yield impact on Possum Kingdom Reservoir was estimated to be 10,057 acft/yr for costing purposes. Additional analysis would be required to refine this estimate of impact on Possum Kingdom Reservoir. Figure 4B.7-9 shows the simulated storage levels of the new reservoir for the 1940 to 1997 historical period, subject to the safe yield of 11,325 acft/yr.

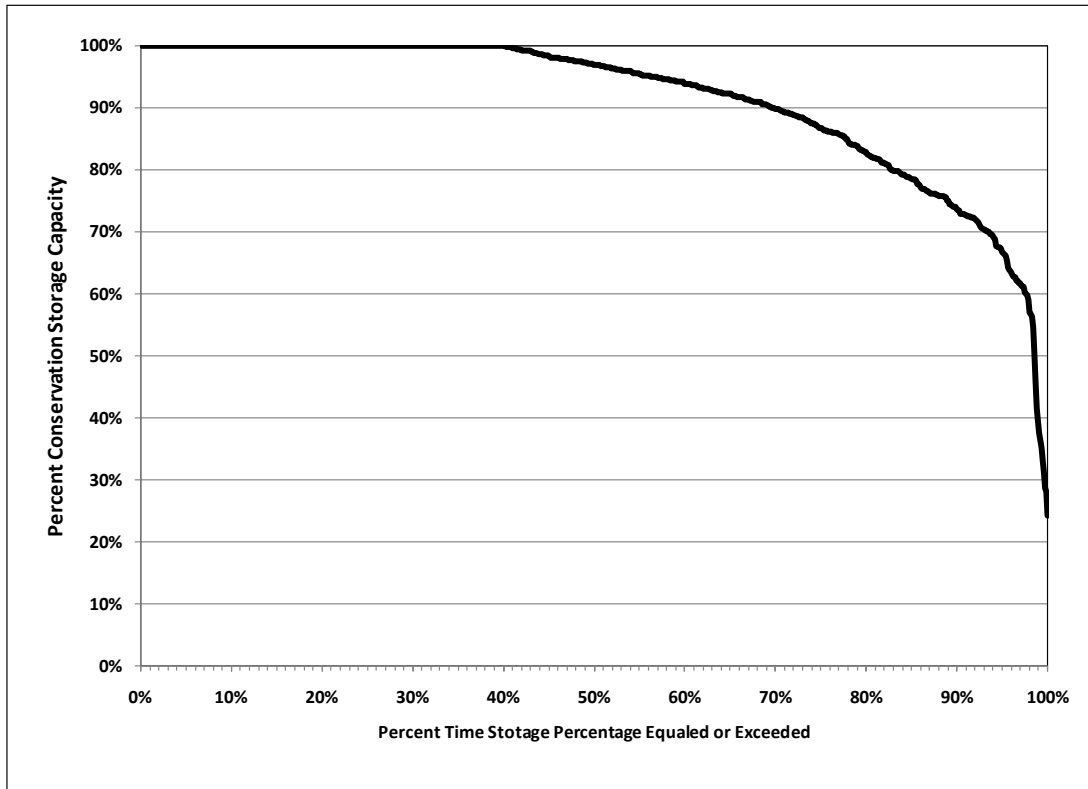
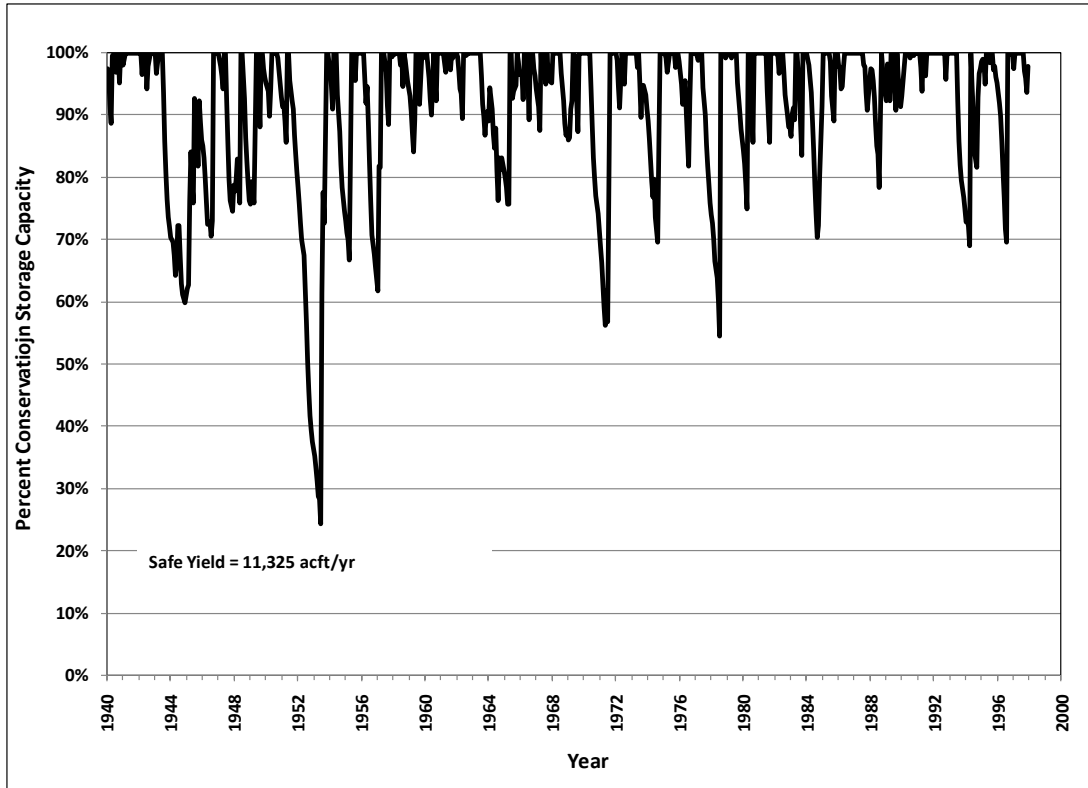


Figure 4B.7-9. New Reservoir Storage Trace and Storage Frequency at Safe Yield with Canal Diversion

Figures 4B.7-10 and 4B.7-11 illustrate the model-computed changes in Lake Creek and Millers Creek median monthly streamflow caused by the project. The median monthly streamflow in Lake Creek is reduced to nearly zero for all months but May and June. In Millers Creek, the model-computed median monthly stream flow below the dam is reduced to zero for all months. Figures 4B.7-10 and 4B.7-11 also illustrate the Lake Creek and Millers Creek streamflow frequency characteristics with the project in place. In Lake Creek, the model-computed frequency of mean monthly flows below approximately 250 cfs is decreased. 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. A decrease in the frequency of mean monthly flows less than 60 cfs is apparent in the frequency plot.

4B.7.4.2 Environmental Issues

The environmental issues associated with the four options for augmenting Millers Creek reservoir are discussed together in Section 4B.7.5.

4B.7.4.3 Engineering and Costing

Table 4B.7-8 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 \$46.9 million. The annual project costs are estimated to be \$3.81 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 safe yield increase of 17,582 acft/yr translates to an annual unit cost for raw water of \$0.67 per 1,000 gallons, or \$217 per acft.

4B.7.4.4 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4B.7-9, and the option meets each criterion.

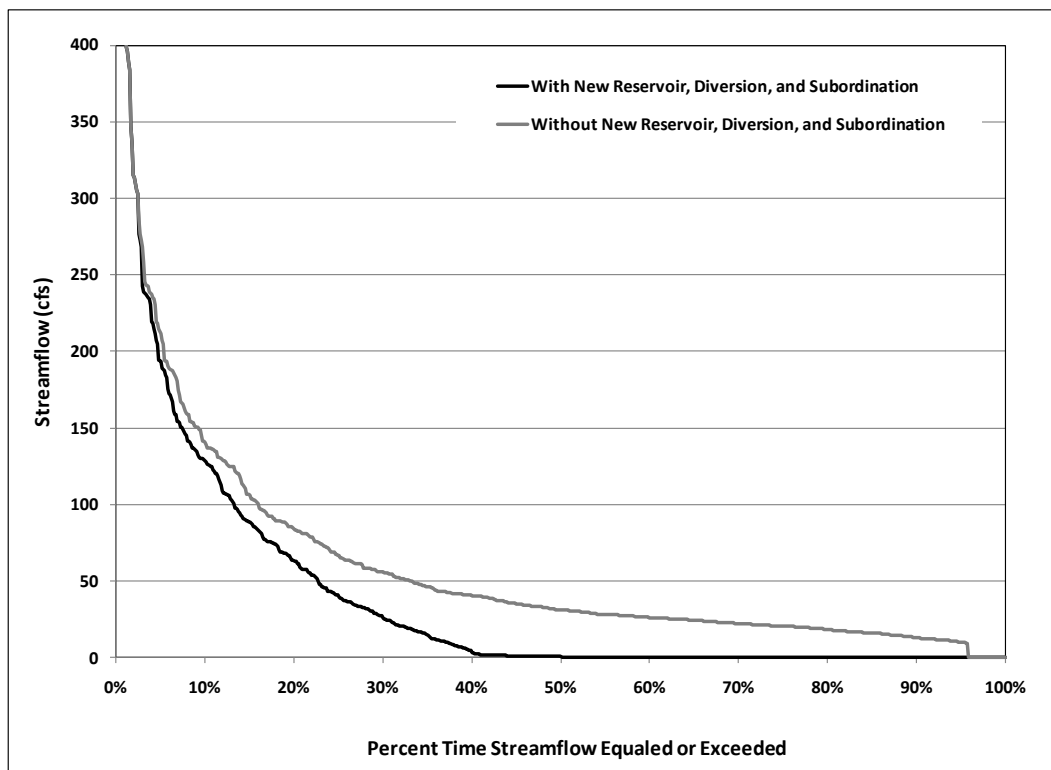
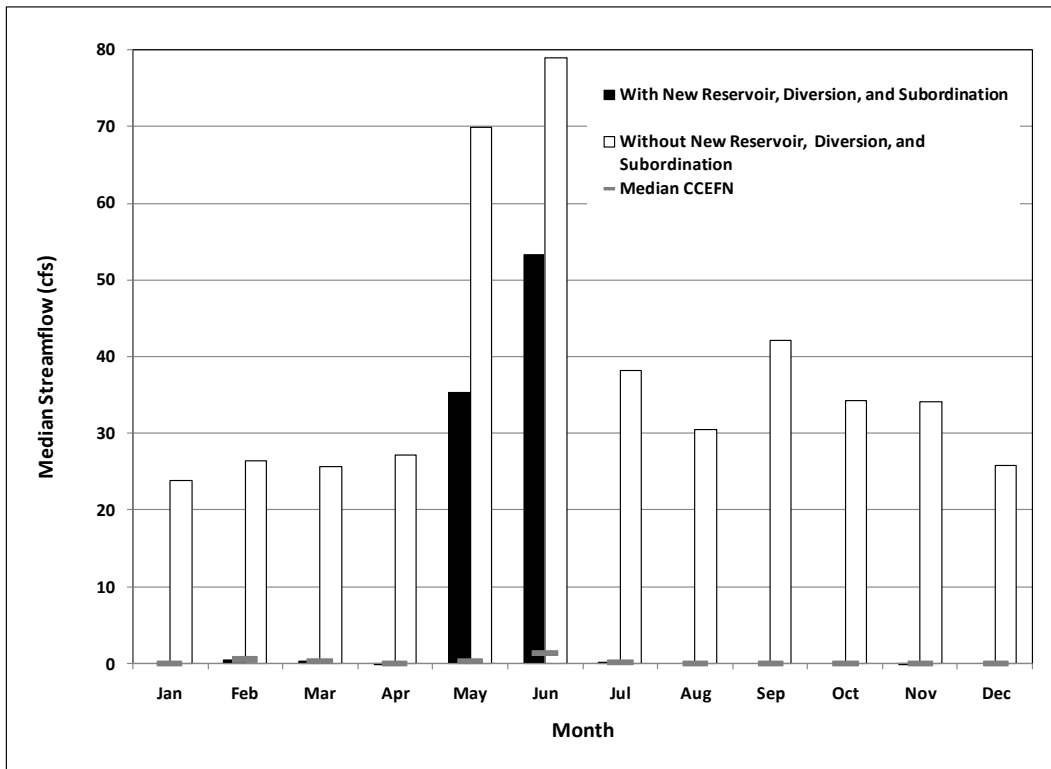


Figure 4B.7-10. Comparison of Median Monthly Streamflow and Streamflow Frequency Below Lake Creek Diversion Point With and Without New Reservoir and Canal Diversion

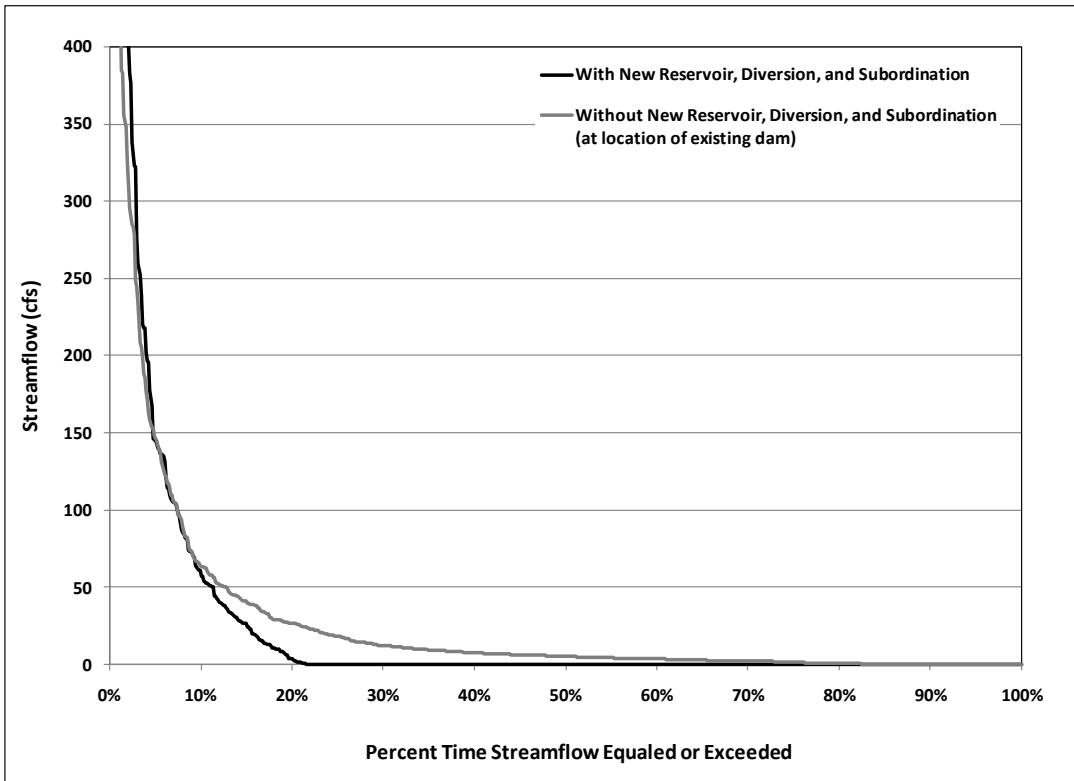
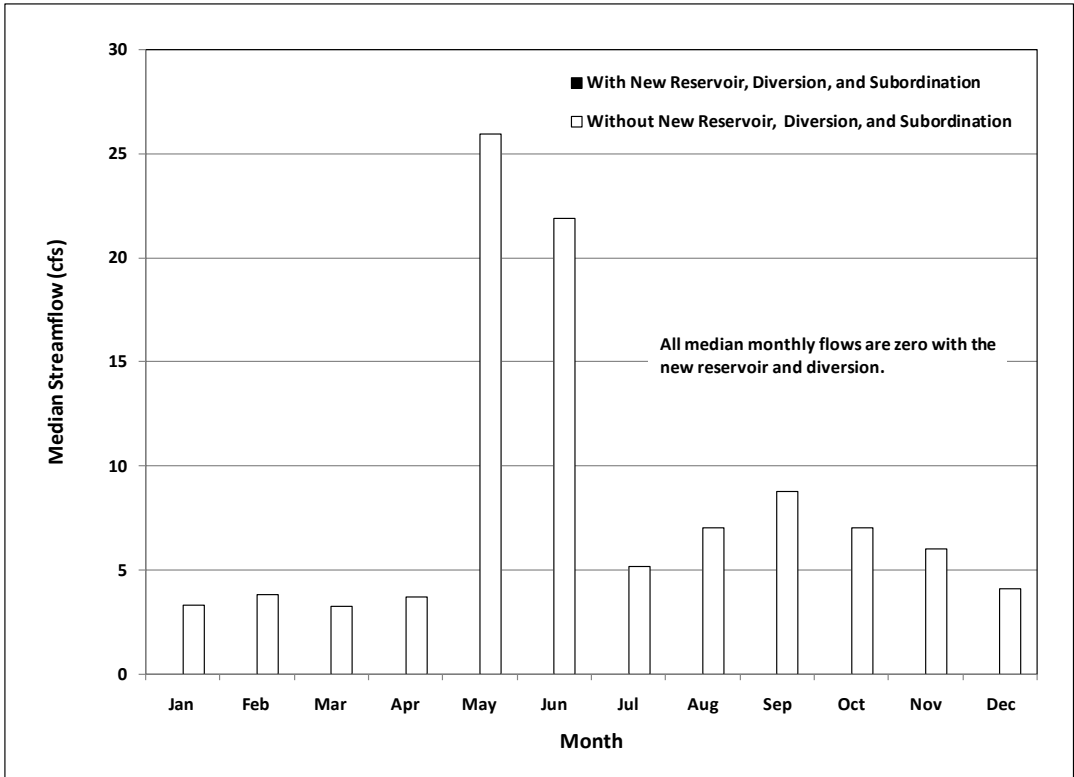


Figure 4B.7-11. Comparison of Millers Creek Median Monthly Streamflow and Streamflow Frequency With and Without New Reservoir and Canal Diversion

Table 4B.7-8.
Cost Estimate Summary for
Augmentation of the Millers Creek Reservoir
(Combined Canal Diversion with New Dam and Reservoir Option)

<i>Item</i>	<i>Estimated Costs for Facilities</i>
Capital Costs	
Canal, Dams, and Reservoirs	\$21,542,000
Relocations and Other	<u>\$460,000</u>
Total Capital Cost	\$22,002,000
Engineering, Legal Costs and Contingencies	\$7,700,000
Environmental & Archaeology Studies and Mitigation	\$6,031,000
Land Acquisition and Surveying (4,286 acres)	\$6,244,000
Interest During Construction (2 years non-reservoir, 4 years reservoir)	<u>\$4,971,000</u>
Total Project Cost	\$46,948,000
Annual Costs	
Debt Service (6 percent, 20 years)	\$59,000
Reservoir Debt Service (6 percent, 40 years)	\$3,076,000
Operation and Maintenance	
Dams and Reservoirs	\$128,000
Purchase of Water (10,057 acft/yr @ 54.50 \$/acft)	<u>\$548,000</u>
Total Annual Cost	\$3,811,000
Available Project Yield (acft/yr)	17,582
Annual Cost of Water (\$ per acft)	\$217
Annual Cost of Water (\$ per 1,000 gallons)	\$0.67

**Table 4B.7-9.
Comparison of Combined Canal Diversion with New Dam and Reservoir
to Plan Development Criteria**

<i>Impact Category</i>	<i>Comment(s)</i>
A. Water Supply 1. Quantity 2. Reliability 3. Cost	1. Sufficient to meet some needs 2. High reliability 3. Reasonable
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Moderate impact 2. Moderate impact 3. Moderate impact 4. Low impact 5. Low impact 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	• Not applicable
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None

4B.7.4.4.1 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.

4B.7.4.4.2 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.

4B.7.4.4.3 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.

4B.7.5 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 Region⁴. This region is located east 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 dryland 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

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

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 Seymour Aquifer, an unconsolidated sand and gravel aquifer, is the only major aquifer in the project area. It is formed by alluvial deposits in twenty counties in north central Texas. The Seymour aquifer consists mainly of the scattered erosional remnants of the Seymour Formation of Pleistocene age, which consists of clay, silt, sand, and gravel, that were deposited by eastward-flowing streams. The aquifer generally has less than 100 feet of saturated thickness, but it is an important source of water for domestic, municipal, and irrigation needs.⁷

The physiography of the region includes recharge sand, undissected red beds, loose surficial sand, flood prone areas, and severely eroded land.⁸ Three major vegetation types occur within the general vicinity of the project area: Mesquite (*Prosopis glandulosa*) - Lotebush Shrub, Mesquite-Saltcedar (*Tamarix*) Brush/Woods, and Crops.⁹ Variations of these primary types occur which involve changes in the composition of woody and herbaceous species and physiognomy according to localized conditions and specific range sites. Mesquite-Lotebush Shrub vegetational areas include the following commonly associated plants: yucca (*Yucca* spp.), skunkbush sumac (*Rhus trilobata*), agarito (*Berberis trifoliolata*), elbowbush (*Forestiera angustifolia*), juniper, tasajillo (*Opuntia leptocaulis*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa saccharoides*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), Texas grama (*Bouteloua rigidisetata*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), red grama (*Bouteloua trifida*), tobosagrass (*Pleuraphis mutica*), buffalograss (*Buchloe dactyloides*), Texas wintergrass (*Nasella leucotricha*), purple three-awn (*Aristida purpurea*), Engelmann daisy (*Engellmania peristena*),

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 Ashworth, John B and Janie Hopkins. 1995. Aquifers of Texas. Texas Water Development Board, Report 345. Austin, Texas.

⁸ 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.

⁹ 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.

broom snakeweed (*Gutierrezia sarothrae*), and bitterweed (*Hymenoxys odorata*). Commonly associated plants of Mesquite-Saltcedar Brush/Woods are creosotebush (*Larrea tridentata*), cottonwood (*Populus deltoides*), desert willow (*Chilopsis linearis*), giant reed (*Arundo donax*), seepwillow (*Baccharis* sp.), common buttonbush (*Cephalanthus occidentalis*), whitethorn acacia (*Acacia constricta*), Australian saltbush (*Atriplex semibaccata*), fourwing saltbush (*Atriplex canescens*), lotebush, wolfberry (*Lycium berlandieri*), tasajillo, guayacan (*Guaiacum angustifolium*), alkali sacaton (*Sporobolus airoides*), Johnsongrass (*Sorghum halepense*), saltgrass (*Distichlis spicata*), cattail (*Typha* spp.), bushy bluestem (*Andropogon glomeratus*), and chino grama (*Bouteloua ramosa*). Crop vegetational areas include cultivated cover crops or row crops providing food and/or fiber for either man or domestic animals and may also include grassland associated with crop rotations and hay production.

4B.7.5.1 Potential Impacts

4B.7.5.1.1 Aquatic Environments including Bays & Estuaries

The potential impacts of this project were evaluated at the existing Millers Creek Reservoir, and at the Lake Creek diversion point. The diversion would occur at an impoundment created by construction of a channel dam on Lake Creek. Water would be diverted from the Lake Creek impoundment via a canal or pipeline to Brushy Creek which feeds Millers Creek and Millers Creek Reservoir. Under a third option, a new dam and reservoir would be constructed downstream of the existing Miller's Creek Reservoir, providing additional storage of flows from Millers Creek. A fourth option would include construction of the diversion canal along with the new reservoir, providing additional storage of flows from Millers Creek and the Lake Creek diversion.

Tables 4B.7-10 and 4B.7-11 list the model-computed median monthly streamflows in Millers Creek just below the reservoir (below the new reservoir, if present for an option, otherwise below the existing reservoir), and in Lake Creek just below the diversion. The tables also provide the percentage change in median monthly streamflow for each augmentation option, as computed from the simulation results. These statistics 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

Table 4B.7-10.
Median Monthly Streamflow in Millers Creek

	<i>Without Project</i>	<i>With Canal Diversion</i>		<i>With Pipe Diversion</i>		<i>With New Reservoir</i>		<i>With New Reservoir and Canal Diversion</i>	
	<i>Median Monthly Flow (cfs)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>
Jan	3.3	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Feb	3.9	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Mar	3.3	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Apr	3.7	0.0	-100	0.0	-100	0.0	-100	0.0	-100
May	26.0	19.4	-25	18.1	-30	0.0	-100	0.0	-100
Jun	21.9	11.3	-49	11.6	-47	0.0	-100	0.0	-100
Jul	5.2	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Aug	7.0	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Sep	8.8	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Oct	7.0	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Nov	6.0	0.0	-100	0.0	-100	0.0	-100	0.0	-100
Dec	4.1	0.0	-100	0.0	-100	0.0	-100	0.0	-100

Table 4B.7-11.
Median Monthly Streamflow in Lake Creek Below Diversion

	<i>Without Project</i>	<i>With Canal Diversion</i>		<i>With Pipe Diversion</i>		<i>With New Reservoir</i>		<i>With New Reservoir and Canal Diversion</i>	
	<i>Median Monthly Flow (cfs)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>	<i>Median Monthly Flow (cfs)</i>	<i>Flow Difference (With Project - Without) (%)</i>
Jan	23.8	14.2	-40	14.9	-37	23.8	0	0.0	-100
Feb	26.4	17.8	-33	18.6	-30	26.4	0	0.5	-98
Mar	25.7	10.3	-60	17.0	-34	25.7	0	0.3	-99
Apr	27.1	8.8	-68	18.3	-32	27.1	0	0.0	-100
May	69.9	58.3	-17	66.4	-5	69.9	0	35.4	-49
Jun	78.9	71.3	-10	73.5	-7	78.9	0	53.2	-33
Jul	38.3	15.5	-59	28.6	-25	38.3	0	0.1	-100
Aug	30.4	13.3	-56	21.8	-29	30.4	0	0.0	-100
Sep	42.1	32.0	-24	35.3	-16	42.1	0	0.0	-100
Oct	34.2	19.4	-43	24.5	-28	34.2	0	0.0	-100
Nov	34.1	26.0	-24	28.1	-18	34.1	0	0.0	-100
Dec	25.9	19.7	-24	19.8	-23	25.9	0	0.0	-100

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 occur for construction of the new dam and reservoir with the diversion canal. Under this scenario, the median monthly flow would be reduced by 98 to 100 percent for all months but May and June. Variability in flow is important to the instream biological community as well as riparian species and a reduction could influence the timing and success of reproduction as well as modify the current composition of species by favoring some and reducing suitability for others. Although there would be impacts in the immediate vicinity of the project site and downstream, it appears that this project, alone, 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. However, the cumulative impact of multiple projects may reduce freshwater inflows into the estuary.

4B.7.5.1.2 Threatened and Endangered Species

A total of 27 animal species could potentially occur within the vicinity of the project that are state or federally listed as threatened or endangered, candidates for listing, or exhibit sufficient rarity to be listed as a species of concern according to county lists of rare species provided by the Texas Parks and Wildlife Department (TPWD) online (Table 4B.7-12). In addition to these county lists, the TPWD Natural Diversity Database (NDD) was reviewed for known occurrences of any federal or state listed species found within or near the project area. Listed species include three reptiles, 12 birds, eight mammals, two freshwater mussels, and two fish species. Two bird species and three mammal species which are federally-listed as endangered could occur (or historically occurred) in the project area. Bird species include the interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). The interior least tern and whooping crane are seasonal migrants that could pass through the project area. Mammal species which are federally listed include the gray wolf (*Canis lupus*), red wolf (*Canis rufus*), and black-footed ferret (*Mustela nigripes*). Both the gray wolf and red wolf are considered to be extirpated within the project counties. Although the black-footed ferret (*Mustela nigripes*) historically occurred in the area, there have been no confirmed reports of this

**Table 4B.7-12.
Potentially Occurring Species that are Rare or Federal and State Listed
in Baylor, Haskell, and Throckmorton Counties**

Scientific Name	Common Name	Federal/ State Status	Potential Occurrence
Birds			
<i>Falco peregrinus anatum</i>	American Peregrine Falcon	DL/T	Migrant
<i>Falco peregrinus tundrius</i>	Arctic Peregrine Falcon	DL/-	Migrant
<i>Ammodramus bairdii</i>	Baird's Sparrow	SOC	Migrant
<i>Buteo regalis</i>	Ferruginous Hawk	SOC	Migrant*
<i>Haliaeetus leucocephalus</i>	Bald Eagle	DL/T	Migrant
<i>Sterna antillarum athalassos</i>	Interior Least Tern	LE/E	Migrant*
<i>Charadrius montanus</i>	Mountain Plover	SOC	Migrant*
<i>Charadrius alexandrinus</i>	Snowy plover	SOC	Migrant
<i>Athene cunicularia hypugaea</i>	Western Burrowing Owl	SOC	Migrant*
<i>Charadrius alexandrinus nivosus</i>	Western Snowy Plover	SOC	Migrant
<i>Grus americana</i>	Whooping Crane	LE/E	Migrant
<i>Plegadis chihi</i>	White-faced Ibis	-/T	Migrant
Fishes			
<i>Notropis oxyrhynchus</i>	Sharptnose Shiner	C/SOC	X
<i>Notropis buccula</i>	Smalleye Shiner	C/SOC	X
Mammals			
<i>Mustela nigripes</i>	Black-footed Ferret	LE/-	Extirpated
<i>Cynomys ludovicianus</i>	Black-tailed Prairie Dog	SOC	X
<i>Myotis velifer</i>	Cave Myotis Bat	SOC	X
<i>Spilogale putorius interrupta</i>	Plains Spotted Skunk	SOC	X
<i>Canis lupus</i>	Gray Wolf	LE/E	Extirpated
<i>Corynorhinus townsendii pallescens</i>	Pale Townsend's big-eared bat	SOC	X
<i>Canis rufus</i>	Red Wolf	LE/E	Extirpated
<i>Dipodomys elator</i>	Texas kangaroo rat	-/T	X
Mussels			
<i>Truncilla macrodon</i>	Texas fawnsfoot	SOC	X
<i>Tritogonia verrucosa</i>	Pistolgrip	SOC	X
Reptiles			
<i>Nerodia harteri</i>	Brazos Water Snake	SOC/T	X
<i>Thamnophis sirtalis annectens</i>	Texas Garter Snake	SOC	X
<i>Phrynosoma cornutum</i>	Texas Horned Lizard	SOC/T	X
(TPWD County List of Endangered, Threatened and Species of Concern, Baylor, Throckmorton and Haskell Counties, updated 6/25/09)			
* Nesting migrant; may nest in the county. X = Occurs in county.			
Federal Status: LE-Listed Endangered; LT-Listed Threatened; DL-De-listed Endangered/Threatened; C-Candidate, SOC-Species of Concern.			
State Status: E-Listed as Endangered; T-Listed as Threatened; SOC -Species of Concern .			

species in Texas since 1963.¹⁰ These bird and mammal species are not anticipated to be directly affected by the proposed reservoir or diversion canal.

There are six additional species which are listed as threatened by the state of Texas within the project counties. These include the American peregrine falcon (*Falco peregrinus anatum*), bald eagle (*Haliaeetus leucocephalus*), white-faced ibis (*Plegadis chihi*), Texas kangaroo rat (*Dipodomys elator*), Brazos water snake (*Nerodia harteri*), and Texas horned lizard (*Phrynosoma cornutum*). The three state threatened bird species are migrants within the project area and are not anticipated to be adversely affected by the project. The Texas kangaroo rat lives on clay soils supporting sparse, short grasses and small scattered mesquite bushes. NDD occurrences of the Texas kangaroo rat are documented approximately 18 miles north of the project area. The Brazos water snake is known to inhabit rocky areas found within the Brazos River Basin. This species of snake has been reported by the NDD near Lake Stamford along Paint Creek approximately 20 miles southwest of the study area. Although suitable habitat for the state threatened Texas horned lizard may exist within the project area, no impact to this species is anticipated due to the abundance of similar habit near the project area.

A search of the Texas Wildlife Diversity Database (NDD)¹¹ revealed no documented occurrences of rare or listed species within the project vicinity (as noted on representative 7.5 minute quadrangle map(s) that include the project site). However there are two documented nesting colonies of the Great Blue Heron found located along Millers Creek which could be impacted by the proposed new reservoir below Millers Creek Reservoir. NDD information is based on the best data available to TPWD, however this does not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. 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.

A search of the Texas Wildlife Diversity Database (NDD)¹² revealed no documented occurrences of rare or listed species within the project vicinity (as noted on representative 7.5 minute quadrangle map(s) that include the project site). However there are two documented

¹⁰ Campbell, Linda. 1995. Endangered and Threatened Animals of Texas. Texas Parks and Wildlife Department, Endangered Resources Branch. Austin, Texas.

¹¹ Texas Parks and Wildlife. 2009. Natural Diversity Database. Texas Parks and Wildlife. Austin, Texas. Received December 8, 2009.

¹² Texas Parks and Wildlife. 2009. Natural Diversity Database. Texas Parks and Wildlife. Austin, Texas. Received December 8, 2009.

nesting colonies of the Great Blue Heron found located along Millers Creek which could be impacted by the proposed new reservoir below Millers Creek Reservoir. NDD information is based on the best data available to TPWD, however this does not provide a definitive statement as to the presence, absence, or condition of special species, natural communities, or other significant features in the project area. 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.

4B.7.5.1.3 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 minimum width of 131 feet and a maximum width of 287 feet. This would result in approximately 48 acres of impact to wildlife habitat. Vegetation found within the diversion canal ROW includes areas of cropland. 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 four stream miles of riparian habitat. Vegetation types found within this site include portions of Mesquite Lotebush Shrub, Mesquite Saltcedar Brush/Woods and Crop areas.

A number of vertebrate species would be expected to occur within the general vicinity of the project site as indicated by county occurrence records.¹³ These include one species of salamander, five species of frogs and toads, three species of turtles, five species of lizards and

¹³ Dixon, James R. and R. Kathryn Vaughan. 1998. *Amphibians and Reptiles of Texas Counties Checklist*. Texas A & M University, College Station, Texas.

skinks, and 17 species of snakes. Mammals expected to occur within the project area include the coyote (*Canis latrans*), common raccoon (*Procyon lotor*), white-tailed deer (*Odocoileus virginianus*), Texas mouse (*Peromyscus attwateri*), and plains pocket gopher (*Geomys bursarius*) among others.¹⁴ A variety of bird and fish species would be expected to inhabit the site, with distributions and population densities limited by the types and quality of habitats available.

4B.7.5.1.4 Cultural Resources

A review of the Texas Historical Commission Texas Historic Sites Atlas data base indicated that there are no National Register Properties, Historical Markers, or cemeteries listed near any of the proposed project areas. A search of the Texas Archeological Sites Atlas database indicates that three archeological sites have been documented within the general vicinity of the proposed diversion canal. These sites, which lie outside the current project alignment, were recorded as prehistoric habitation sites. Two of these sites (41KX95 and 41HK1) were recommended for further testing in 1973. 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).

4B.7.5.1.5 Threats to Natural Resources

Threats to natural resources were identified in Section 1.7.3.2 and include lower stream flows, declining water quality, and reduced inflows to reservoirs. This project would have an impact associated with lower streamflows 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.

¹⁴ Davis, William B., and David J. Schmidly. 1994. *The Mammals of Texas*. Texas Parks and Wildlife, Austin, Texas.