4.2 Cedar Ridge Reservoir

4.2.1 Description of Option

The proposed Cedar Ridge Reservoir was analyzed in the 2001 Plan at the Breckenridge Reservoir Reynolds Bend site, and in 2006 as the Breckenridge Reservoir Cedar Ridge site. In the 2011 Plan, the Cedar Ridge Reservoir dam site was moved to its current site in Shackelford County on the Clear Fork of the Brazos River about 40 miles north of the City of Abilene (City), as shown in Figure 4.2-1. Initially located further downstream and known as the Breckenridge Reservoir, this project was initially studied in 1971 by the Texas Water Development Board and most recently in 2009 for the City by Enprotec/ Hibbs & Todd (eHT) and HDR, Inc[1]. The proposed reservoir will contain approximately 227,127 acft of conservation storage and inundate 6,635 acres at the full conservation storage level of 1,489 ft-msl. The total drainage area at the Cedar Ridge Reservoir Site is approximately 2,748 sq. miles.

The water supply from this reservoir could be used to meet several municipal shortages in the area and is part of the water supply plan for the City. The City is actively pursuing the necessary permits and engineering required to implement this project. The information contained in this section is based on the water right permit application filed at the Texas Commission on Environmental Quality and the Clean Water Act, Section 404 permit filed with the U.S. Army Corps of Engineers, Ft. Worth District (USACE).

4.2.2 Available Yield

The City has applied fora water right permit with the TCEQ to divert up to 34,400 acft/yr of stored water from the reservoir for multi-purpose uses including: municipal, domestic, industrial, agriculture, livestock, steam-electric, mining, and recreation. This diversion was calculated to be the firm yield supply of the reservoir assuming permitted storages and diversions for all other senior water right holders in the Brazos basin for the 1940 to 1997 hydrologic period (TCEQ Brazos WAM Run 3) in accordance with an interlocal agreement with BRA which includes the subordination of Possum Kingdom Reservoir . However, since 1997 severe drought conditions have occurred in the upper Brazos Basin resulting in a new critical drought for the Clear Fork watershed. Therefore, the City conservatively plans for supplies from Cedar Ridge Reservoir to equal to the 1-year safe yield as calculated by the Brazos G Mini-WAM.

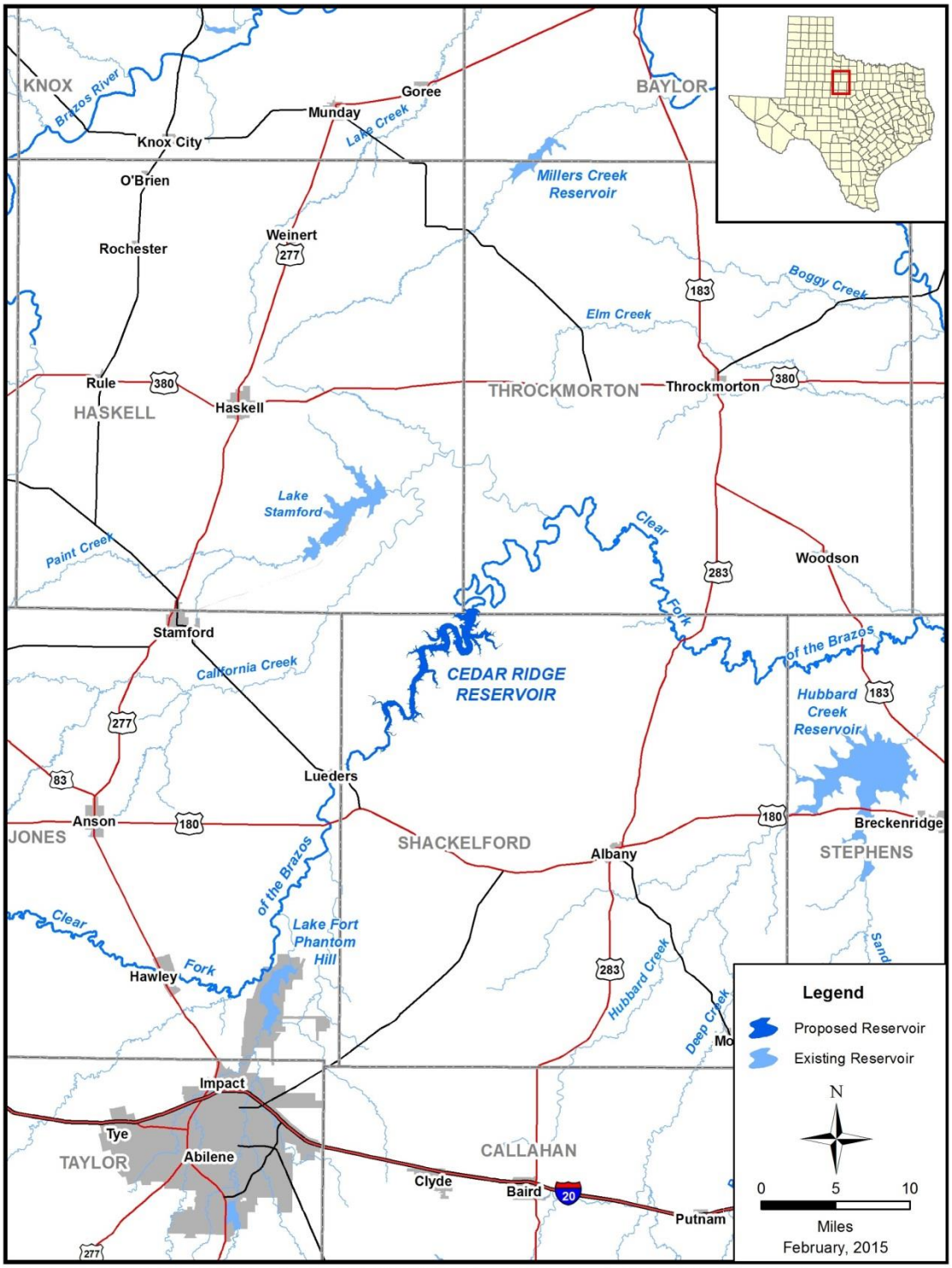
The Mini-WAM utilizes an updated January 1940 through June 2008 hydrologic period of record to account for the recent drought in the Upper Brazos Basin. Estimates of water availability were derived subject to general assumptions for application of hydrologic models as adopted by the Brazos G Regional Water Planning Group and summarized previously. The model computes the streamflow available from the Clear Fork of the Brazos River without causing increased shortages to existing downstream rights. Safe yield was computed subject to the reservoir having to pass inflows to meet Senate Bill 3

[1] Enprotec / Hibbs & Todd, HDR,Inc., “Updated Evaluations of Cedar Ridge Reservoir and Possum Kingdom Lake Water Supply Options for City of Abilene,” November 2009.

(SB3) environmental flow criteria and assuming subordination of Possum Kingdom Reservoir.

The calculated 1-year safe yield of the Cedar Ridge Reservoir for the 2016 Plan is 26,575 acft/yr, an increase of 3,195 acft/yr compared to the 2011 Plan 1-year safe yield of 23,380 acft/yr. The increase in safe yield can be attributed to the application of the SB3 environmental flow criteria compared to the Consensus Criteria for Environmental Flow Criteria (CCEFN) used in the 2011 Plan. The firm yield impact on Possum Kingdom Reservoir from the operation of Cedar Ridge Reservoir, as defined in the inter-local agreement between the Brazos River Authority, the City and the WCTMWD, has been determined to be 5,000 acft/yr.

Figure 4.2-1 Cedar Ridge Reservoir



L:\Project_Data\00044_BrazosG\GIS\Map_Docs\Task_04_WMS\WMS_Task_04_Existing_Supplies\Cedar_Ridge_Reservoir.mxd

Figure 4.2-2 illustrates the simulated Cedar Ridge Reservoir storage levels subject to the safe yield demand of 26,575 acft/yr for the 1940 to 2008 historical period. The storage trace reveals that the more recent drought beginning in the late 1990's is more severe than the drought of the 1950's.

Figure 4.2-3 illustrates the storage frequency of the simulated Cedar Ridge Reservoir subject to the safe yield demand. Simulated reservoir contents remain above half full more than 80 percent of the time and do not drop below 10 percent of capacity.

Figure 4.2-4 presents the changes in Clear Fork monthly median streamflows caused by impoundments in the reservoir considering pass throughs for downstream senior water rights and environmental needs in accordance with TCEQ environmental flow requirements Figure 4.2-4 shows that monthly median streamflows remain above 5 cfs for all months with the reservoir in place. Figure 4.2-5 compares the existing Clear Fork streamflow frequency characteristics for the full period of the analysis without the project to simulated streamflow characteristics with the project considering pass throughs for downstream senior water rights and environmental needs in accordance with TCEQ environmental flow requirements.

Figure 4.2-2 Cedar Ridge Reservoir Safe Yield Storage Trace

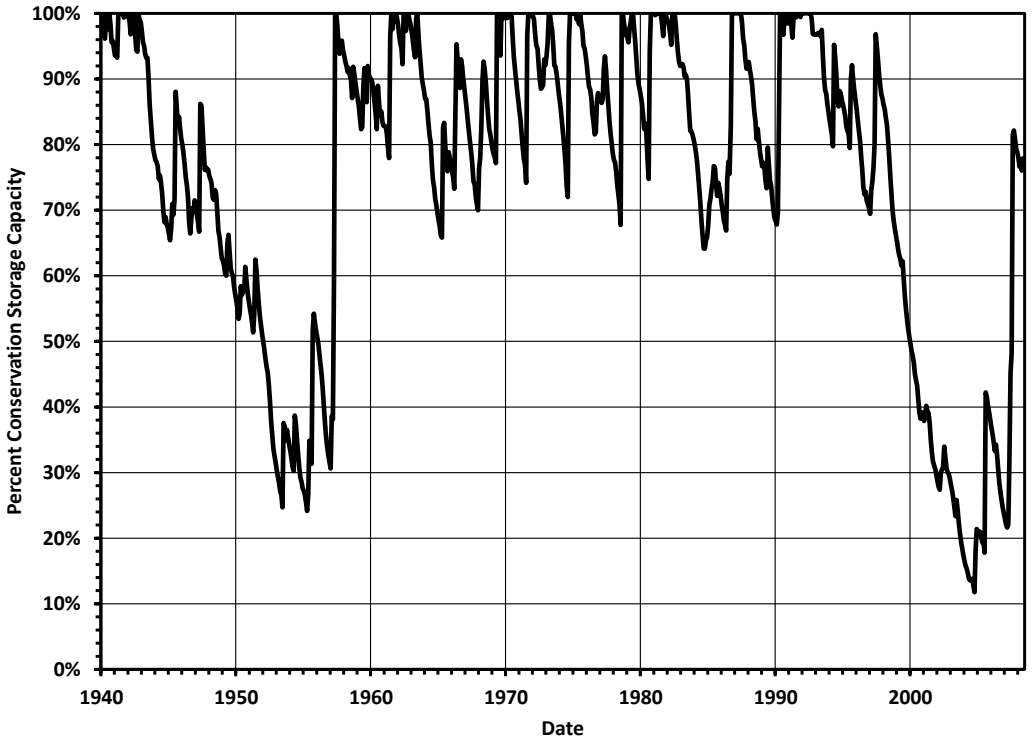


Figure 4.2-3 Cedar Ridge Reservoir Safe Yield Storage Frequency

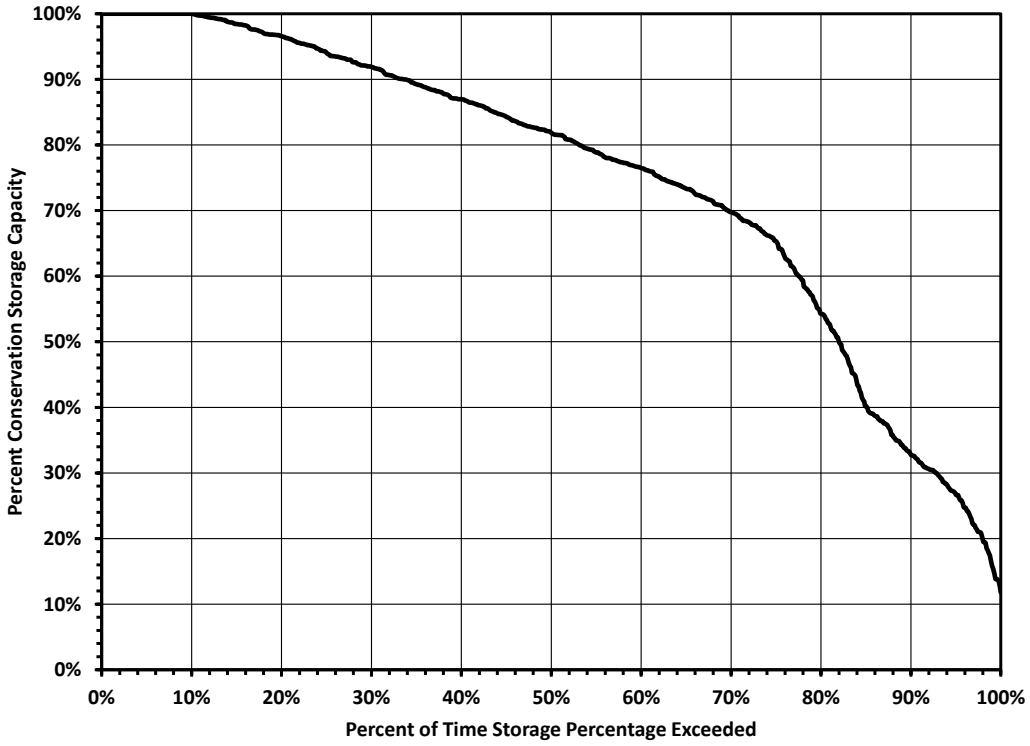


Figure 4.2-4 Cedar Ridge Reservoir Median Streamflow Comparison

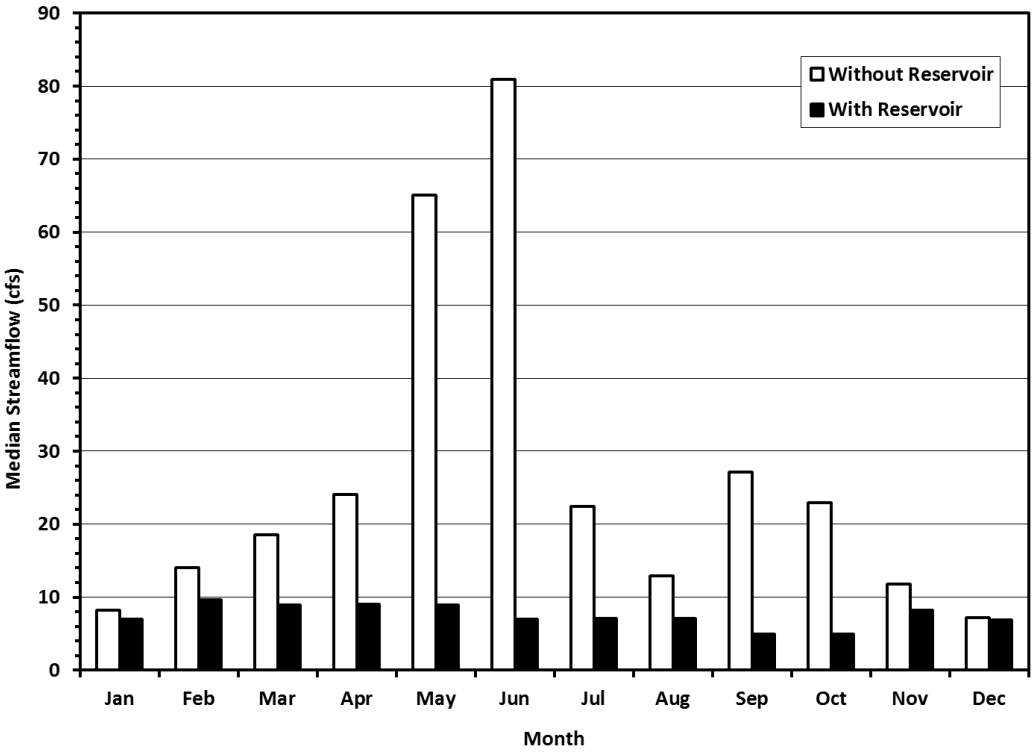
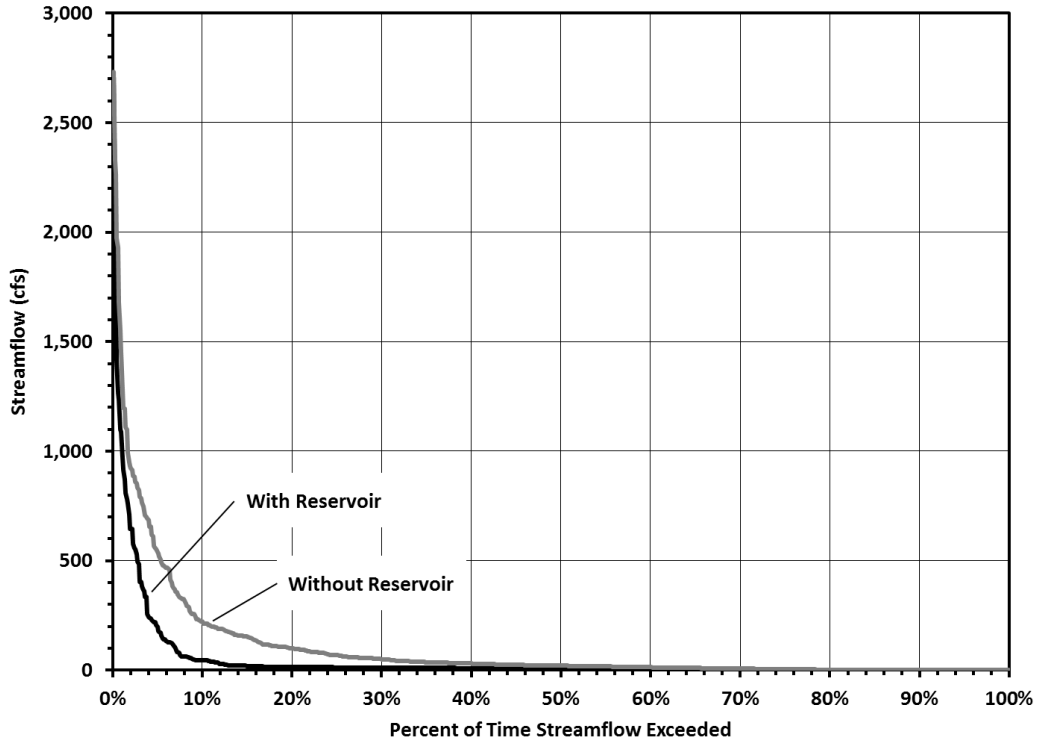


Figure 4.2-5 Cedar Ridge Reservoir Streamflow Frequency Comparison



4.2.3 Environmental Issues

The following environmental section focuses on providing a high level summary of environmental issues consistent with other water management strategies evaluated as part of the 2016 Brazos G plan. The information presented here is based on the City's TCEQ water right application and the USACE Section 404 permit application.

Existing Environment

The Cedar Ridge reservoir will inundate 6,635 acres at its conservation storage level of 1,489 ft-msl. The project will require an intake pump station, a water treatment plant expansion and a transmission pipeline of approximately 29 miles. Water diverted from this reservoir will be used to meet water supply shortages for the City and include existing and future customers.

Steep canyon walls are present throughout this area, ranging from 5 to 30 percent slopes with near vertical cliffs in some areas. Soils in the study area are predominantly loamy and clayey with clayey soils occurring primarily in the upstream portions of the study area. General soil map units in the project area include the Palopinto-Throck and Clairemont-Grandfield-Clearfork soil units.

No major or minor aquifers underlie the project area. The Trinity Aquifer lies south of the project area and consists of interbedded sandstone, sand, limestone, and shale of

Cretaceous Age. The Seymour Aquifer is located west and north of the project area and is composed of isolated areas of alluvium.2

The climate in the study area is subtropical subhumid, with hot, dry summers and mild, dry winters. Temperatures range from an average low of 31°F in January to an average maximum of 97°F in July with a mean average temperature of 64oF.[3] The growing season is approximately 224 days and annual precipitation averages between 25 and 28 inches. Most precipitation occurs from April to October during thunderstorms of short duration and high intensity. Recurring droughts are common in this area and can last many years.

The project area lies within the Limestone Plains subregion of the portion of the Central Great Plains ecoregion in Texas[4] and within the vegetational area known as the Rolling Plains.[5] Although this subregion is principally covered by a mixed grass prairie dominated by grasses such as little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), and buffalograss (*Bouteloua dactyloides*), it also includes scattered trees such as honey mesquite (*Prosopis glandulosa*).

The dominant vegetation type found within the project area as mapped by the TPWD is mesquite brush, which covers approximately 61 percent of the conservation pool area of Cedar Ridge Reservoir.[6] Plants commonly associated with this vegetation type include narrow-leaf yucca (*Yucca glauca*), purple pricklypear (*Opuntia macrocentra*), juniper (*Juniperus* spp.), red grama (*Bouteloua trifida*), Texas grama (*Bouteloua rigidiseta*), purple three-awn (*Aristida purpurea* var. *purpurea*), James' rushpea (*Caesalpinia jamesii*), and wild buckwheat (*Eriogonum* spp.).[7]

The mesquite-lotebush shrub vegetation type is also found within the project area. This vegetation type is dispersed relatively evenly along the reservoir site, covering approximately 39 percent of the conservation pool area. Commonly associated plants in this vegetation type include honey mesquite, yucca (Yucca spp.), fragrant sumac (*Rhus aromatica*), elbowbush (*Forestiera pubescens*), cane bluestem (*Bothriochloa barbinodis*), silver bluestem (*Bothriochloa laguroides* ssp. *torreyana*), Texas wintergrass (*Nassella leucotricha*), Engelmann's daisy (*Engelmannia peristenia*), and bitter rubberweed (*Hymenoxys odorata*).[8]

Permanent impacts will occur to all the current vegetation located within the conservation pool of the reservoir and some portions of the construction area. This vegetation will be impacted either by clearing at the dam site or inundation by the reservoir. Temporary

---

[2] Texas Water Development Board (TWDB). 2010a. Major and Minor Aquifers of Texas; Maps online at http://www.twdb.state.tx.us/mapping/index.asp.

[3] Handbook of Texas Online (HTO), s.v. "Shackelford County, Texas,". http://www.tshaonline.org/handbook/online/articles/SS/hcs8.htm.

[4] Griffith, G. E., S. A. Bryce, J. M. Omernik, J. A.Comstock, A. C.Rogers, B.Harrison, and S. L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs): Reston, VA, U.S. Geological Survey.

[5] Hatch, S. L., N. G. Kancheepuram, and L. E. Brown. 1990. Checklist of the Vascular Plants of Texas. Texas Agricultural Experiment Station. Texas A&M University, College Station.

[6] McMahan, C. A., R. G. Frye, K. Brown. 1984. The Vegetation Types of Texas, Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin.

[7] Ibid.

[8] McMahan, C. A., R. G. Frye, K. Brown. 1984. The Vegetation Types of Texas, Including Cropland. Wildlife Division, Texas Parks and Wildlife Department, Austin.

impacts may also occur to the vegetation located outside of the conservation pool area but within the flood pool area. These areas will be inundated only occasionally for a few days as floods will be passed through an ungated spillway. Pipeline areas will primarily impact vegetation during construction and maintenance activities with some areas returning to their original states after the initial disturbance.

Potential Impacts

Aquatic Environments including Bays & Estuaries

With the construction of the new reservoir, the current floodplains along the Clear Fork and its major tributaries within the new reservoir's conservation pool area will be inundated. Although some stream and wetland functions would be impacted due to inundation by the conservation storage area, the creation, enhancement, and/or protection of aquatic habitat resulting from the new reservoir will replace some of the biological, chemical, and physical functions of the impacted resources and habitats.

The anticipated impact of this project would be lower variability in and reductions in the quantity of median monthly flows. Variability in flow is important to the instream biological community as well as riparian species and pass throughs for environmental needs are proposed to be in accordance with recently adopted TCEQ flow requirements. The TCEQ flow requirements for this segment of the Clear Fork were based, in part, on in-stream flow studies performed for the project to assure that adequate flows remained in the stream to maintain the existing biological community.

Although there may be some impacts on the biological community in the immediate vicinity of the project site and downstream, this project would not have a substantial influence on total discharge in the Brazos River or to freshwater inflows to the Brazos River estuary. As a new reservoir Cedar Ridge Reservoir would be required to pass through environmental flows based on TCEQ's recently adopted environmental flow requirements.

Wildlife Habitat

The project area is located within the Kansan biotic province.[9] The Kansan Province is divided into three districts that include (from west to east) the short-grass plains, mixed-grass plains, and the mesquite plains. The project area is situated within the mesquite plains district. Within this district the typical vegetation community generally consists of clusters of mesquite and other shrubs interspersed with open areas of grasses. Common wildlife species found in the Kansan Biotic Province include the Great Plains toad (*Anaxyrus cognatus*), turkey vulture (*Cathartes aura*), scaled quail (*Callipepla squamata*), big brown bat (*Eptesicus fuscus*) and eastern collared lizard (*Crotaphytus collaris*) among others. Wildlife species inhabiting the project area utilize it to varying extents depending on their specific biologic needs.

Inundation of existing habitat by the reservoir will force non-aquatic species inhabiting these areas to relocate to surrounding suitable habitats unaffected by reservoir filling. Greater adverse impacts will occur to those wildlife species that currently utilize riparian habitats within the reservoir's footprint; however, similar habitats exist along upstream

[9] Blair, W. F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.

and downstream reaches of the Clear Fork, and additional riparian habitat will develop along portions of the reservoir shoreline subsequent to reservoir filling.

Threatened & Endangered Species

Table 4.2-1 lists the state and federally threatened, endangered, or otherwise rare species that could occur in Haskell, Jones, Shackelford, and Throckmorton Counties. This table includes the listing status of these taxa, as well as descriptions of suitable habitat for each species. Inclusion in this table does not mean that a species will occur within the project area but acknowledges the potential for its occurrence within one of the four counties in which the project area exists. On-site evaluations by qualified biologists would be required to confirm or deny the occurrence of sensitive species or habitats.

A search of the Texas Natural Diversity Database (TNDD)[10] identified the state threatened Brazos water snake as the only threatened or endangered species with documented occurrences within or near the new reservoir site. The plains spotted skunk (*Spilogale putorius interrupta*), a species of concern, was also documented in the vicinity of the new reservoir however, this species is not state or federally protected. While based on the best information available to TPWD, TNDD data do 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.

Listed species with the potential to occur within the project area are discussed in the following paragraphs. These species include two birds, the Whooping Crane (*Grus americana*) and the Interior Least Tern (*Sterna antillarum athalassos*). These birds are federally listed as endangered and could occur within the project and surrounding areas as seasonal migrants. During migration Whooping Cranes primarily utilize wetland areas as rest stops. Wetland habitat within the project area is limited and occurrences of this species would be limited to occasional migratory stops. The Interior Least Tern typically nests on bare or sparsely vegetated areas associated with streams or lakes, such as sand and gravel bars, beaches, islands, and salt flats. Occasional migrants of these species are possible within the new reservoir site.

Two fishes, the sharpnose shiner (*Notropis oxyrhynchus*) and the smalleye shiner (*N. buccula*) are small, slender minnows endemic to the Brazos River Basin.[11] Historically, these fishes existed throughout the Brazos River and several of its major tributaries; however, both species have experienced significant population declines. General habitat associations for both species include relatively shallow water with moderate currents flowing through broad, open sandy channels. Surveys of the Clear Fork performed within and downstream of the reservoir footprint indicate that suitable habitat for both the sharpnose and smalleye shiner is not present.

Two mussel species, the smooth pimpleback (*Quadrula houstonensis*) and the Texas fawnsfoot (*Truncilla macrodon*), are endemic to the Brazos River Basin and could potentially occur within or in the surrounding vicinity of the new reservoir footprint. The smooth pimpleback prefers small to moderate sized streams and rivers, as well as

[10] Texas Parks and Wildlife Department (TPWD). 2010. Element occurrence records for Haskell, Jones, Shackelford, and Throckmorton Counties. Texas Natural Diversity Database, Texas Parks and Wildlife Department.

[11] Cross, F. B. 1953. A new minnow, *Notropis bairdi buccula*, from the Brazos River, Texas. Texas Journal of Science 5:252-259.

moderately sized reservoirs, and is typically found in substrates of mixed mud, sand and fine gravel in water flowing at a very slow to moderate rate.[12] While it is unlikely that the smooth pimpleback inhabits the reach of the Clear Fork to be impacted by the new reservoir, this species is known to tolerate impoundment.

The Texas fawnsfoot historically occurred in the Brazos and Colorado River drainages. Little is known pertaining to the preferred habitat of this species; however, it is known to be intolerant of impoundment.[13] Texas fawnsfoot specimens potentially occurring downstream of the new reservoir are not anticipated to be significantly impacted from the project, as this species has been reported to occur downstream of other impoundments along the Brazos River. Surveys of the project reach for mussels were conducted in 2009, 2010, and 2011. No live or recently dead specimens of either the smooth pimpleback or the Texas fawnsfoot were identified upstream, within, and downstream of the project reach.

The new reservoir could potentially cause adverse impacts to two state threatened reptile species. These species include the Texas horned lizard (*Phrynosoma cornutum*) and the Brazos water snake (*Nerodia harteri harteri*). The Texas horned lizard is a relatively small lizard that is known to occur in a variety of habitats including short-grass prairie, mesquite grasslands, shrublands, desert scrub, and desert grasslands.[14] Potentially suitable habitat for the Texas horned lizard is present both within and surrounding the reservoir footprint. As the Cedar Ridge Reservoir fills, Texas horned lizards inhabiting areas within the reservoir footprint would be displaced. Potential impacts to this state threatened lizard will likely be minimal given the estimated slow filling rate of the new reservoir and abundant suitable habitat immediately surrounding the project area.

[12] Howells, R. G., R. W. Neck, and H. D. Murray. 1996. Freshwater Mussels of Texas. Inland Fisheries Division, Texas Parks and Wildlife Department, Austin..
[13] Ibid.
[14] Price, A. H. 1990. *Phrynosoma cornutum*. Catalogue of American Amphibians and Reptiles. 469:1–7.

Table 4.2-1 Endangered, Threatened, Candidate and Species of Concern Listed for Haskell, Jones, Shackelford and Throckmorton Counties

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Listing	TPWD Listing	Potential Occurrence in County
BIRDS					
American peregrine falcon	*Falco peregrinus anatum*	Migrant and local breeder in West Texas.	DL	T	Possible Migrant
Arctic peregrine falcon	*Falco peregrinus tundrius*	Migrant throughout the state.	DL	--	Possible Migrant
Baird's sparrow	*Ammodramus bairdii*	Found in shortgrass prairie with scattered low bushes and matted vegetation migratory in western part of state.	--	--	Possible Migrant
Bald eagle	*Haliaeetus leucocephalus*	Primarily found near waterbodies.	DL	T	Nesting/ Migrant
Ferruginous hawk	*Buteo regalis*	Open country primarily prairies, plains, and badlands nesting near water.	--	--	Possible Migrant
Black-capped vireo	*Vireo atricapilla*	Prefers oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces.	LE	E	Possible Migrant
Interior least tern	*Sterna antillarum athalassos*	Nests along sand and gravel bars in braided streams	LE	E	Possible Migrant
Mountain plover	*Charadrius montanus*	Non-breeding, shortgrass plains and fields	--	--	Nesting/ Migrant
Piping plover	*Charadrius melodus*	A small pale shorebird of open sandy beaches and alkali flats, the Piping Plover is found along the Atlantic and Gulf coasts.	LT	T	Possible Migrant
Snowy plover	*Charadrius alexandriunus*	Potential migrant winters along coast	--	--	Possible Migrant

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Listing	TPWD Listing	Potential Occurrence in County
Sprague's pipit	*Anthus spragueii*	Migrant in Texas in winter mid Sept. to early April. Strongly tied to native upland prairie.	C	--	Possible Migrant
Western burrowing owl	*Athene cunicularia hypugaea*	Open grasslands, especially prairie, plains and savanna	--	--	Resident
Western snowy plover	*Charadrius alexandrines nivosus*	Potential migrant, winters along coast.	--	--	Possible Migrant
Whooping crane	*Grus americana*	Potential migrant	LE	E	Potential Migrant
FISHES					
Sharpnose shiner	*Notropis oxyrhynchus*	Endemic to Brazos River drainage. Found in large rivers.	LE	--	Resident
Smalleye shiner	*Notropis buccula*	Endemic to upper Brazos River system and its tributaries. Found in medium to large prairie streams with sandy substrate.	LE	--	Resident
MAMMALS					
Black-footed ferret	*Mustela nigripes*	Extirpated, inhabited prairie dog towns.	LE	--	Historic Resident
Black-tailed prairie dog	*Cynomys ludovicianus*	Found on dry, flat, short grasslands.	--	--	Resident
Cave myotis bat	*Myotis velifer*	Roosts colonially in caves, rock crevices	--	--	Resident
Gray wolf	*Canis lupus*	Extirpated formerly known in western two-thirds of the state.	LE	E	Historic Resident
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	Roosts in caves and old buildings. Hibernates in winter.	--	--	Resident

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Listing	TPWD Listing	Potential Occurrence in County
Plains spotted skunk	*Spilogale putorius interrupta*	Prefers wooded, brushy areas.	--	--	Resident
Red wolf	*Canis rufus*	Extirpated.	LE	E	Historic Resident
MOLLUSKS					
Smooth pimpleback	*Quadrula houstonensis*	Found in small to moderate streams and rivers as well as moderate sized reservoirs. Brazos and Colorado River basins.	C	T	Resident
Texas fawnsfoot	*Truncilla macrodon*	Found in rivers and larger streams, intolerant of impoundment.	C	T	Resident
REPTILES					
Brazos water snake	*Nerodia harteri*	Found in upper Brazos River drainage in shallow water with rocky bottoms.	--	T	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands.	--	T	Resident

LE/LT=Federally Listed Endangered/Threatened
DL=Federally Delisted
C=Candidate for Federal Listing
PT=Proposed Threatened
E, T=State Listed Endangered/Threatened
Blank = Considered rare, but no regulatory listing status

TPWD, 2015. Annotated County List of Rare Species –Haskell County 9/4/2014, Jones County 9/4/2014, Shackelford County 9/4/2014, and Throckmorton County 9/4/2014.

USFWS, 2015. Endangered Species List for Haskell, Jones, Shackelford and Baylor Counties, Texas. At http://ecos.fws.gov/tess_public/countySearch!speciesByCountyReport.action, February 18, 2015.

The Brazos water snake is a highly aquatic, endemic Texas snake with a limited and patchy distribution along the upper Brazos River drainage in north-central Texas. Preferred habitat consists of shallow rocky riffles along the river that have a gently sloping rocky shoreline free of vegetation.[15] Investigation of the project area indicate that Brazos water snake populations and suitable habitat exist along the Clear Fork, both within and downstream of the proposed Cedar Ridge reservoir footprint. Potential impacts to the Brazos water snake from the construction of Cedar Ridge Reservoir include the inundation and loss of existing habitat along the Clear Fork. However, geologic investigations of the Cedar Ridge Reservoir shoreline indicate that there will be significant areas of rocky shoreline that will provide significant habitat after the reservoir fills. Based on the occurrence and populations of Brazos Water Snakes that have continued to reproduce in Possum Kingdom Lake since its initial filling in 1941, it is anticipated that the Brazos Water Snake will have suitable habitat to maintain viable populations in Cedar Ridge Reservoir.

Cultural Resources

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). Based on the review of available GIS datasets provided by the Texas Historical Commission (THC), there are no National Register Properties, National Register Districts, State Historic Sites, cemeteries or historical markers located within or near the reservoir or pipeline project areas. The owner of the project is required to coordinate with the Texas Historical Commission regarding potential impacts to cultural resources.

The Texas Archeological Sites Atlas online database of the Texas Historical Commission (THC) was also consulted and background research was conducted to determine any previous cultural resources survey efforts as well as the locations of previously recorded historic and archaeological resources in the project area. Records indicate that eight previously recorded prehistoric archaeological sites were located within a 1-mile radius of the reservoir area.

The City conducted preliminary Phase 1A archeological surveys and historical evaluations, and the results and recommendations from these Phase 1A surveys were provided to the TCEQ in the Water Rights application submitted on August 17, 2011, and to the THC and USACE under separate cover. Phase 1B surveys, including trenching at selected alluvial terrace locations, were initiated in 2011 and completed in 2012. The findings of the Phase 1B surveys were provided to the USACE and THC in support of Section 404 Permit coordination in accordance with the requirements of Section 106 of the National Historic Preservation Act (NHPA). The City will also coordinate the findings of the archeological surveys with the THC and TCEQ in conjunction with the review of the project under the Antiquities Code of Texas.

The Phase 1A and 1B investigations identified 66 prehistoric sites, five historic sites, and four multicomponent sites. Four archeological sites located within the project area are

[15] Scott, N. J., Jr., T. C. Maxwell, O. W. Thornton, Jr., L. A. Fitzgerald, and J. W. Flury. 1989. Distribution, habitat, and future of Harter's Water Snake, *Nerodia harteri*, in Texas. Journal of Herpetology 23:373-389.

recommended for further testing to determine their eligibility for listing in the National Register of Historic Places (NRHP) and designation as a State Archeological Landmark (SAL) by the City pending concurrence from the USACE and THC. Additionally, historical sites were evaluated and 62 architectural resources at five sites were recorded. Fifty-seven of the sites are associated with the proposed Hendrick River Ranch Historic District. Evaluation of the pre-historic and historic resources in the area of potential effect of the reservoir will be conducted and documented in accordance with standard practices for determination of NRHP and SAL eligibility and mitigation measures will be implemented, if necessary.

Specific project features such as 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.

Threats to Natural Resources

Threats to natural resources include lower streamflows below the reservoir. However, due to the nutrient removal that will occur as a result of the new reservoir and a planned multi-level outlet, water quality downstream of the reservoir is anticipated to improve with respect to increasing dissolved oxygen concentrations, and lowering concentrations of any existing stream pollutants.

4.2.4 Engineering and Costing

The proposed Cedar Ridge Reservoir includes the construction of an earthen dam, principal spillway, emergency spillway, and appurtenant structures. eHT and HDR completed a study[16] in 2009 of the proposed Cedar Ridge Reservoir and estimated costs for the reservoir project. These costs were indexed to September 2013 dollars. Infrastructure required for the transmission of supplies from the reservoir was estimated using the TWDB unified costing model.

The capital cost of the project is estimated to be $163.5 million. This capital cost includes the construction of the dam, land acquisition and resolution of conflicts. Also included in this cost are facilities to deliver the water to the City through a 42-inch pipeline and for additional treatment capacity that would be needed by the City to fully utilize the Cedar Ridge supply. The total cost of the project is estimated to be $290.9 million and includes environmental permitting and mitigation, and technical services. A more detailed listing of the various components of the cost estimate is provided in Table 4.2-2. The annual project costs are estimated to be $27.4 million, which includes annual debt service, operation and maintenance, and an annual payment to the Brazos River Authority for lost yield in Possum Kingdom. The cost for the estimated 1-yr safe yield of 26,575 acft/yr translates to an annual unit cost of $3.16 per 1,000 gallons or $1,031 per acft.

[16] eHT and HDR, Op. Cit., November 2009.

Table 4.2-2 Cost Estimate for Cedar Ridge Reservoir

Item	Estimated Costs for Facilities
Capital Cost	
Dam and Reservoir	$69,977,000
Intake Pump Stations (25 MGD)	$10,352,000
Transmission Pipeline (42 in dia., 29 miles)	$43,697,000
Water Treatment Plant Expansion (16.7 MGD)	$26,665,000
Integration, Relocations, & Other	$12,837,000
Total Cost Of Facilities	**$163,528,000**
Engineering and Feasibility Studies, Legal Assistance, Financing, Bond Counsel, and Contingencies (30% for pipes & 35% for all other facilities)	$55,050,000
Environmental & Archaeological Studies and Mitigation	$26,614,000
Land Acquisition and Surveying (9,978 acres)	$18,036,000
Interest During Construction (4% for 3 years with a 1% ROI)	$27,640,000
Total Cost Of Project	**$290,868,000**
Debt Service (5.5 percent, 20 years)	$11,580,000
Reservoir Debt Service (5.5 percent, 40 years)	$9,503,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$969,000
Dam and Reservoir	$1,050,000
Water Treatment Plant	$2,667,000
Pumping Energy Costs ($0.09 kwh)	$1,574,000
Purchase of Water (5,000 acft/yr @ 65.65 $/acft)	$328,000
Total Annual Cost	**$27,398,000**
Available Project Yield (acft/yr), based on a Peaking Factor of 1	**26,575**
Annual Cost of Water ($ per acft)	**$1,031**
Annual Cost of Water ($ per 1,000 gallons)	**$3.16**

4.2.5 Implementation Issues

This water supply option has been compared to the plan development criteria, as shown in Table 4.2-3, and the option meets each criterion.

Potential Regulatory Requirements:

- Texas Commission on Environmental Quality Water Right and Storage permit (pending at TCEQ);
- U.S. Army Corps of Engineers Permit 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) (pending at the USACE-SWF);
- Texas Commission on Environmental Quality administered Texas Pollutant Discharge Elimination System Storm Water Pollution Prevention Plan;
- Texas 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; 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 or other local landowner agreements;
- Additional acquisition of rights-of-way and/or easements may be required; and
- Relocations or removal of residences, utilities, roads, or other structures.

Table 4.2-3 Comparison of Cedar Ridge Reservoir 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 to High
B. Environmental factors	
1. Environmental Water Needs	1. Moderate impact
2. Habitat	2. High impact
3. Cultural Resources	3. Moderate impact based on surveys of site
4. Bays and Estuaries	4. Low impact due to distance from coast
5. Threatened and Endangered Species	5. Possible moderate 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	Potential impact on bottomland farms and habitat in reservoir area
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