DETAILED PROJECT REPORT
AND
INTEGRATED ENVIRONMENTAL ASSESSMENT

FOR

O.C. FISHER LAKE ECOSYSTEM RESTORATION PROJECT
SAN ANGELO, TEXAS

June 2005

Prepared for
City of San Angelo

by the

US Army Corps of Engineers
Fort Worth District
P.O. Box 17300
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EXECUTIVE SUMMARY

The Detailed Project Report (DPR) presents the results of the feasibility study for construction of the O.C. Fisher Lake Ecosystem Restoration Project under the authority of Section 1135 of the Water Resources Development Act of 1986, as amended (33 USC 2201). The purpose of the study was to identify the environmental degradation created by construction and operation of O.C. Fisher Lake and to develop and evaluate restoration measures to restore the biological integrity and diversity of the ecosystem to a more natural and sustainable condition. The U.S. Army Corps of Engineers, Fort Worth District (USACE) conducted the study through cooperative efforts with U.S. Fish and Wildlife Service (USFWS), Natural Resource Conservation Service (NRCS), Texas Parks and Wildlife Department (TPWD), Texas Agricultural Extension Service (TAES), Upper Colorado River Authority (UCRA), Texas State Soil and Water Conservation Board (TSSWCB) and Angelo State University (ASU).

The study area is located in northwest Tom Green County of west central Texas adjacent to the city limits of San Angelo. It is located on the North Concho River, 6.3 miles above the river's confluence with the South Concho River of the Colorado River watershed. All lands, with exception of the dam and uncontrolled spillway operated by USACE, are operated and maintained through license agreements with USACE. ASU operates and maintains the land north of the North Concho River for fish and wildlife management, biological research, education, and plant conservation. TPWD operates lands south of the river for multiple recreational purposes.

Environmental degradation began in 1952 during construction of the reservoir. Approximately 253 acres of prime riparian habitat and a total of 7,524 acres of woody vegetation were lost. Large acreages of native prairie were also lost. Environmental degradation continued from operation of the project upon completion of the reservoir. Livestock were allowed to graze upon the lands and naturally occurring wildfires were suppressed. Overgrazing and removal of fire, coupled with drought conditions and subsequent drop in lake level, allowed invasive brushy species the opportunity to dominate the habitat and negatively impact the hydrology of the ecosystem. Each year, invasive brushy species continue to expand their range, further depleting the hydrological regime of the ecosystem through high rates of evapotranspiration.

Invasive brushy species include exotic saltcedar, mesquite and willow baccharis. All of which detrimentally alter the historical habitat conditions due to their prolific growth and high moisture consumption. Only 4.6 percent of the riverine habitat contains surface water and the current lake level is in the reserve pool, some 53 feet below conservation pool. Prickly pear is another vegetative species that has become invasive within the ecosystem.

Water quality is reduced within the study area as a result of invasive vegetative species. O.C. Fisher Lake is included in the draft 2002 List of Impaired Waters (June 13, 2002), as required by Section 303(d) of the Clean Water Act, for high levels of chloride and total dissolved solids. Saltcedar leaves exude salt creating high salinity soil conditions which presumably contribute to high levels of chloride within surface water. Surface run-off during heavy rain events carries sediments into waterways because native groundcover vegetation is displaced by large stands of invasive vegetative species creating exposed bare soil.

As surface water continues to be lost within the ecosystem, degradation and loss of native historical habitat soon follows. Currently, native vegetation exists in conditions similar to historical conditions in only 35.8 percent (89.4 acres) of riparian woodland habitat and 4.5 percent (139.1 acres) of transitional habitat. As native vegetation is degraded from its historical condition, the carrying capacity for fish and wildlife species dependent upon the habitat is subsequently reduced. Currently, the study area supports approximately half of its potential carrying capacity in terrestrial habitats due to habitat degradation and approximately two percent of its potential carrying capacity in aquatic habitats.

The recommended plan will result in significant benefits to the ecosystem. Habitat value will increase 200 percent over existing conditions and increase nearly 600 percent over future conditions without restoration. With full implementation of the recommended plan, perennial surface water would increase from 453.6 acres to 3,840.9 acres. The progressive loss of riparian woodland habitat would halt, conserving the existing 89.4 acres of remnant woodland, and an additional 160.4 acres of remnant woodland would be restored towards historical condition. The recommended plan would also restore 8,666.9 acres of habitat to a more natural, historic and sustainable condition which is critical to the hydrological regime of the ecosystem. The total estimated cost of the recommended plan is $3,863,920 and the local sponsor's share is $965,980.

The proposed restoration project is extremely significant for many reasons. Aquatic habitats and associated riparian woodland habitats within west central Texas are scarce, and ever declining, as invasive vegetative species continue to dominate native vegetation and alter ecosystems. The North Concho River Brush Control Project conducted by the state above the study area offers a unique opportunity to combine contiguous benefits of both projects for a greater benefit than could be derived individually. The recommended plan will significantly restore biodiversity and may benefit some threatened and endangered wildlife species and contribute to a lake level rise improving the water supply for San Angelo and creating recreational and economic benefits to the area.

City of San Angelo is identified as the non-Federal sponsor and has been presented with the findings of this report. The city offers support for the plan, including cost sharing, and agreed to assume responsibilities for all operation and maintenance cost upon completion of the restoration project. The first year's estimated operation and maintenance cost is $56,900 and the estimated average annual operation and maintenance cost is $25,372. A review of the information provided by the City of San Angelo regarding its financial capability to meet the cost sharing requirements indicates that the city has the statute authority and the financial capability to provide the required non-Federal items of local cooperation.

Extensive coordination and input was obtained from the USFWS and TPWD during the development of the recommended plan and both agencies are supportive of the project. The recommended plan is consistent with state and federal government initiatives to improve water quality and conserve/improve native habitats. It is also consistent with the North American Waterfowl Management Plan to preserve and increase North America's waterfowl population.

An Environmental Assessment (EA) was integrated into the DPR to assess potential impacts that may occur through full implementation of the recommended plan. Items marked with an asterisk (*), both in the index and throughout the body of the report, indicate information required to

fulfill National Environmental Policy Act requirements. A public notice was released on XXXXXXXX, disclosing the availability of the EA.

XX comment letters were received during the public review period, which closed on XXXXX. XX of the letters were from resource agencies and expressed general support of the ecosystem restoration project. Based upon findings of potential impacts resulting from the actions as proposed in this DPR, the actions are anticipated to result in no significant adverse impacts on the natural or man-made environment, as long as implementation of the actions adheres to applicable regulations, policies, coordination requirements, standards, and guidelines. Based upon this assumption, a Finding of No Significant Impact was executed on XXXXXXX.

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INTEGRATED ENVIRONMENTAL ASSESSMENT
O.C. Fisher Lake Ecosystem Restoration Project
San Angelo, Texas

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*** National Environmental Policy Act Requirement**

INTRODUCTION

Study Authority. The study is authorized under the continuing authority provided to the Chief of Engineers by Section 1135 (b) of the Water Resources Development Act of 1986, as amended (33 USC 2201). The intent of the Section 1135 Program dictates that a project initiated under this authority must either modify an existing USACE project to improve the environment or restore the environment in an area where an existing USACE project has contributed to the degradation of the quality of the habitat. USACE is the lead agency for this study. In a letter dated May 14, 2002, City of San Angelo expressed their desire to participate in an ecosystem restoration study comprising all federal lands associated with O.C. Fisher Lake.

*** Study Purpose, Area and Scope.** The purpose of the study is to conduct investigations into the feasibility of implementing an ecosystem restoration project on the lands surrounding O.C. Fisher Lake and recommend an ecosystem restoration project for implementation. The study area includes all 15,860 acres of government-owned property, including riparian and riverine habitats that have been degraded as a result of the construction, operation, and maintenance of the lake, and lacustrine habitats degraded by the subsequent encroachment of invasive phreatophytic vegetation. Successful ecosystem restoration within the study area requires reestablishment of the hydrological regime, which would significantly benefit the aquatic, riparian, and transitional habitats of the study area. The study investigated the benefits to the hydrologic regime, and thus the aquatic habitats and associated riparian habitats, of removing the invasive vegetation and reestablishing appropriate vegetation to support a more natural and sustainable state within the riparian and transitional areas.

Study Participants. The O.C. Fisher Lake Ecosystem Restoration Project Study was initiated at the request of the City of San Angelo. In addition to USACE and City of San Angelo, the study has been a multi-disciplinary effort among a wide range of participants including the United States Fish and Wildlife Service (USFWS), United States Natural Resources Conservation Service (NRCS), TPWD, ASU, Texas Agricultural Extension Service (TAES), UCRA, and TSSWCB.

*** Location.** O.C. Fisher Lake is located in west central Texas on the North Concho River, 6.3 miles above the river's confluence with the South Concho River and approximately 65 miles above its confluence with the Colorado River. The lake is adjacent to the city limits of San Angelo in the northwest corner of Tom Green County, Texas. Figure 1 shows the location of the study area.

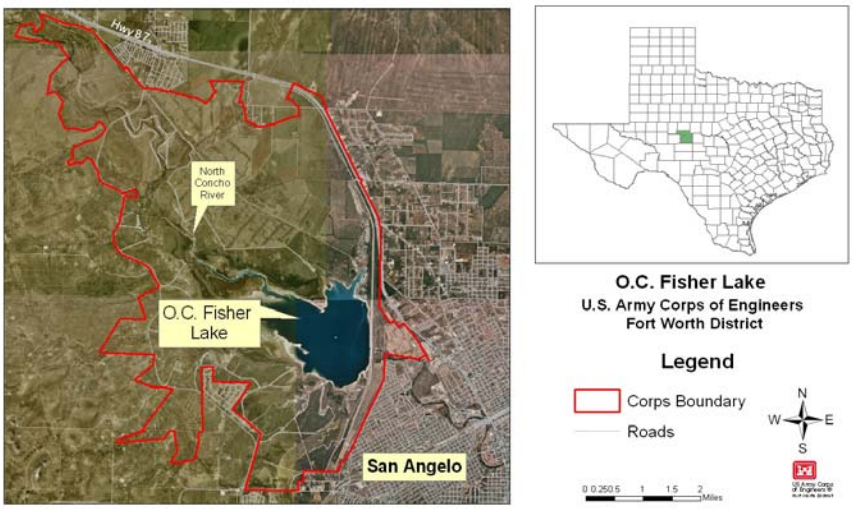


FIGURE 1. O.C. Fisher Lake Ecosystem Restoration Project Location.

O.C. Fisher Lake. O.C. Fisher Lake is a multipurpose reservoir operated by the US Army Corps of Engineers (USACE) and authorized primarily for flood control purposes. Other missions of the reservoir include water supply for the City of San Angelo, recreation, and wildlife habitat. Construction of the reservoir began in May 1947 and was completed in February 1952.

The conservation pool is 5,440 surface acres at 1908 feet Mean Sea Level (MSL), and its flood pool is 12,700 surface acres at 1938 feet MSL. All lands are owned by USACE and USACE operates and maintains the dam and uncontrolled spillway. The remaining lands are operated and maintained through license agreements with USACE. Angelo State University (ASU) operates and maintains the land north of the North Concho River for fish and wildlife management, biological research, education, and plant conservation. Texas Parks and Wildlife Department (TPWD) operates lands south of the river for multiple recreational purposes.

Ongoing/Previous Studies, Projects and Reports. No studies or projects are currently being conducted within the study area. The Texas State Soil and Water Conservation Board (TSSWCB) is implementing a major project, the North Concho River Pilot Brush Control Project, along the North Concho River, the major tributary of O.C. Fisher Lake. The project is in its sixth year and its purpose is to enhance the amount of water flowing from the North Concho River watershed through brush control on 432,000 acres, approximately half of the entire river's watershed. Currently, 295,510 acres of brush have been treated and treatment is continuing with additional state funding. The Upper Colorado River Authority (UCRA) reports that springs are beginning to flow and perennial characteristics within the main stem of the river are observed (UCRA 2004).

* EXISTING CONDITIONS

Climate. The climate in Tom Green County is generally mild with hot summers. Average annual temperature is 64.9°F, with an average high of 78.1°F and an average low of 51.6°F. Highest temperatures occur in July with an average high of 92.7°F and an average low of 69.1°F. Lowest temperatures occur in January with an average high of 56.8°F and an average low of 30.6°F. The area averages 251 days of sunshine (sunny or partly cloudy). Snow and sleet are not common, but may occur once or twice each year (National Weather Service 2004).

San Angelo received an average annual rainfall of 20.91 inches since 1977 with most of the rain occurring in the spring and fall. May and September received the most rainfall since 1977, averaging 3.09 inches and 2.95 inches respectively (National Weather Service 2004). Rainfall during the spring and fall generally falls during short duration, high intensity thunderstorms. Rainfall data recorded at the USACE weather station and ASU weather station, both located within the study area, averaged 21.2 inches per year from 1954-2001.

Topography. Elevations within the study area range from 1846 feet MSL at the lake's current level to 1991 feet MSL located on the northwest portion of the study area. The North Concho River traverses the study area from the northwest to the southeast and flows into O.C. Fisher Lake. The study area north of the river is alluvial plains with gentle slopes rising from river bank and lakeshore. The study area south of the river contains the most animated terrain consisting of high hills, steep bluffs and the North Concho River deeply etched into its alluvial plains. Moving southward from the river, the study area changes to a broad low gradually sloping plain with high bluff interruptions cut by tributaries that cross the study area flowing from the west in the North Concho River.

Soils. Soils within the study area are predominately contained within three soil series; Angelo series, Kimbrough series and Tulia series. Angelo series is described as nearly level to gently sloping soils on smooth outwash plains. Angelo soils are well-drained, have slow surface runoff, moderately slow permeability, and are well suited to crops or to range. The Kimbrough series is described as gently sloping to sloping and undulating soils on outwash plains. Kimbrough soils are well-drained, surface run-off medium, moderate permeability and are mostly used as range and wildlife habitat. The Tulia series is described as nearly level to gently sloping soils on outward plains. It is well-drained, surface runoff medium, moderate permeability and suitable for crops, range and wildlife habitat (Soil Conservation Service 1976).

Land Use. The land within the study area is owned and managed by USACE. The entire study area is operated and maintained through separate license agreements with ASU for lands north of the North Concho River and TPWD for lands south of the North Concho River. ASU operates its lands for fish and wildlife management, biological research, education, and plant conservation and TPWD operates its lands for fish and wildlife management and recreation. Grazing and prescribed burning occurs within large tracts of the leased lands as a component of natural resource management. Vegetative condition is monitored to ensure proper management. Approximately 611 acres within ASU's lease are cultivated or research lands.

Air Quality. Tom Green County meets or exceeds the primary standard for air quality established by the U.S. Environmental Protection Agency (EPA) and is therefore classified as an attainment area. The primary standard considers pollutant levels of carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, particulate matter and lead. The closest air monitoring station is located in Odessa of Ector, County, 132 miles north-northwest of San Angelo. Since 1998, the air monitoring station recorded only 2 days in 2001 when the air quality index reached unhealthy levels of air pollutants (EPA 2004).

Socioeconomic Conditions. Tom Green County encompasses 1,522 square miles with a population of 103,528 in 2003 (US Census Bureau 2004). Economy of the county is derived predominately from agriculture and ranching (Texas State Historical Association 1996). The county is referred to as the "Sheep and Wool Capital" (Tom Green County Information Technology Department 2004). San Angelo, comprised of 58.6 square miles and a population of 88,439 in 2000 (US Census Bureau 2004), is the county seat. San Angelo is known as the "Agribusiness Capital of Texas" and serves as a trade center for the agribusiness region known as "Concho Valley", including Coke, Coleman, Concho, Crockett, Irion, McCulloch, Menard, Reagan, Runnels, Schleicher, Sterling, Sutton, and Tom Green Counties. Primary agricultural commodities for the Concho Valley, for 1998-2000 were beef cattle, sheep/goats, cotton, hunting and recreation, dairy/milk, wheat, grain sorghum, hay, and pecans (San Angelo Chamber of Commerce 2003).

San Angelo is also the regional center for communications, education, federal programs, health care, industry, recreation, retail, retirement, and tourism. Goodfellow Air Force Base is located southeast of San Angelo and employs the highest number of employees within the San Angelo area. Educational institutes include San Angelo State University, Howard College-San Angelo Campus, American Commercial College, and Texas A&M Research and Extension Center (San Angelo San Angelo Chamber of Commerce 2003).

Recreational, Scenic, and Aesthetic Resources. The study area is in a transition zone between several ecological regions. Although most agree the predominant ecological region of the study area is Rolling Plains, there are other areas closely resembling those of other ecological regions, including Edwards Plateau and High Plains ecological regions. The location allows for a tremendous diversity of plants and animals and is a natural confluence of the biology associated with each. Some 350 species of birds and 50 species of mammals are recorded to have utilized the site. (TPWD 2004).

The study area contains San Angelo State Park, an oasis of quality outdoor recreation comprising 7,677 acres. Due to the tremendous fluctuations in the lake levels of O.C. Fisher Lake, the park was not established specifically as a water-recreational park. The park was developed utilizing the cultural and natural resources found within the park. Within the park boundaries can be found Native American Petroglyphs, Prehistoric Permian vertebrate animal tracks, a small bison herd, a large herd of official Texas Longhorn cattle, a black-tailed prairie dog town, and a grave site that dates back to 1847. Frequent interpretive tours are given to each of these sites as part of the park's program. Bird-watching and wildlife viewing is very popular at the park. The establishment of almost 50 miles of hike/bike/horse trails is one of the largest attractions of the

park and brings in enthusiasts from all over the state. The park has 61 established water/electricity sites for campers and numerous primitive sites. When the lake is at safe levels, water sports are very popular including boating, skiing, fishing and swimming. Numerous boat ramps are available on both the north and south sides of the park.

Cultural Resources. The area in general is rich in history. Archeological findings indicate some 18,000 years of Native American occupation in the expansive West Texas region, beginning with the Paleo-American hunters of giant Ice Age mammals. The Euro-American history of the area begins with 16th and 17th-century Spanish exploration and the missions established for the semi-settled Jumano Indians. Some of these Jumanos made their way along the forks of the Concho River on expeditions to trade with Indian groups in central and eastern Texas. By the mid-1800's, German immigrants began to acquire land in the Concho River region. The increasing need to protect California-bound travelers led to the establishment of Fort Concho in 1867. From then on, farmers, ranchers, and sheepherders all contributed to the settlement of Concho Country, with San Angelo (originally Santa Angela) becoming the county seat of Tom Green County in 1883 (San Angelo Chamber of Commerce 2003).

The original cultural resources survey was conducted in 1948. More recent surveys have been restricted to relatively small areas in advance of construction projects (water pipelines, oil well pads, power transmission lines, park development, etc.). There are 39 recorded cultural resource sites located on Corps fee property. These include both prehistoric and historic period archeological sites.

In consultation with the State Historic Preservation Officer (SHPO), areas were categorized as having low potential to contain significant cultural resource sites. These areas were identified on the basis of landforms and soil types where previously recorded sites have been surficial and often highly disturbed. The landforms are uplands and pre-Holocene terraces with little or no possibility for burial of cultural resources. These low potential areas will not require additional cultural resources survey.

Areas of medium and high potential for containing cultural resource sites, totaling 2,455 acres, were identified. These medium and high potential areas will require a cultural resources survey before the project may be implemented. In addition to this survey, the 39 known sites and any sites recorded during the survey would be evaluated for National Register eligibility. Project impacts to all potentially eligible sites shall be minimized by the use of vegetation removal methods which cause minimal ground disturbance.

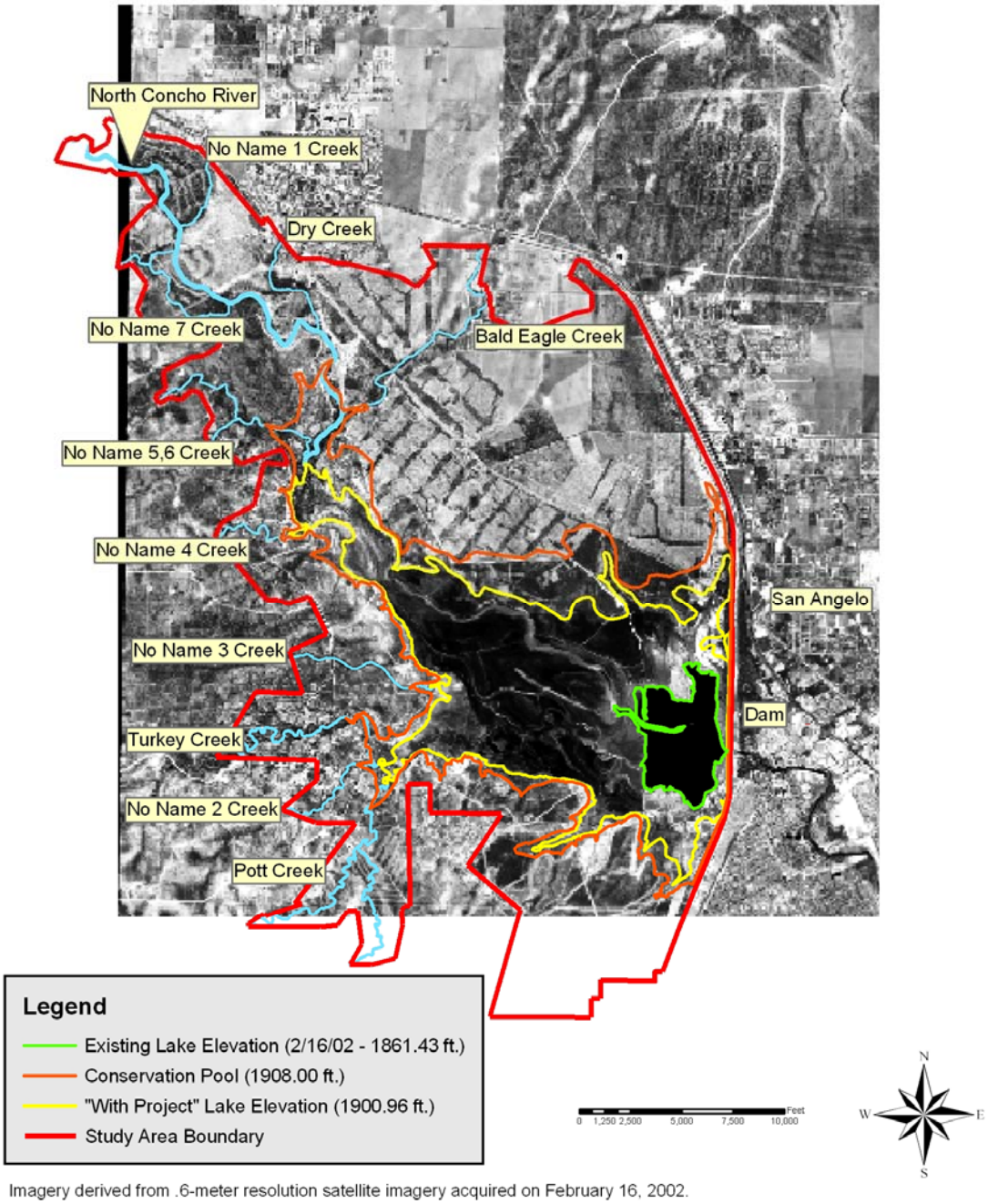
Hazardous, Toxic and Radioactive Waste. Hazardous, Toxic and Radioactive Waste (HTRW) assessment was completed for the purpose of identifying possible HTRW and/or other environmental concerns within the study area. Environmental records were searched for identified environmental conditions. All of the recognized environmental conditions are outside the study area or along the perimeter of the study area with the exception of one. An aboveground storage tank site is located within a maintenance yard within the study area. It is unlikely that any of the recognized environmental conditions would pose an HTRW threat to the project; however, an HTRW site survey will be required to determine if feasible pathways exist between the recognized environmental conditions and planned excavation.

Ecological Regions. O.C. Fisher Lake lies within the Rolling Plains ecological region, but is somewhat transitory due to its proximity to the Edwards Plateau ecological region. The area is bordered on the west by the Caprock Escarpment, on the south by the Edwards Plateau, and on the east by the Western Cross Timbers and Lampasas Cut Plain. Generally, the alluvial soils at lower elevations along the major drainages support a Rolling Plains plant community and the shallow upland soils often exhibit Edwards Plateau plant community (Franklin and Sanchez 1999) (Johnson and Sanchez 2004). One study describes the study area to be near the boundary between the Mesquite Plains subregion of the Rolling Plains and the Live Oak-Mesquite Savanna subregion of the Edwards Plateau (Diamond et. al 1987). Historically, the area was probably influenced greatly by natural and human caused fires creating a mosaic of habitats. (Franklin and Sanchez 1999) (Franklin and Sanchez 2004).

Water Resources.

Surface Water.

Surface water within the study area is attributed to local surface runoff and springs. Perennial surface water bodies include O.C. Fisher Lake, North Concho River, Pott Creek and Turkey Creek. Eight tributaries, including Dry Creek, Bald Eagle Creek, and 6 un-named creeks, are intermittent streams. Figure 2 displays the lake tributaries, conservation pool, current lake level, and with-project lake level.



Imagery derived from .6-meter resolution satellite imagery acquired on February 16, 2002.

FIGURE 2. Tributaries and Lake Level Delineations.

Groundwater. Groundwater within the northern portion of the study area is within the Lipan Minor Aquifer. Remaining areas with the study area are not formally recognized as containing major or minor aquifers; however, the ecological site description for the study area provides that groundwater tables are usually high and within a few feet of the surface (Johnson and Sanchez 2004). The groundwater "naturally discharges by seepage to the Concho River and by evapotranspiration in areas where the groundwater table is at or near land surface" (Ashworth

and Hopkins 1995). TPWD staff working within the study area report that several of the 20 springs within the study area are no longer flowing and remaining springs have progressively reduced their flow. Figure 3 shows the location of these known springs.

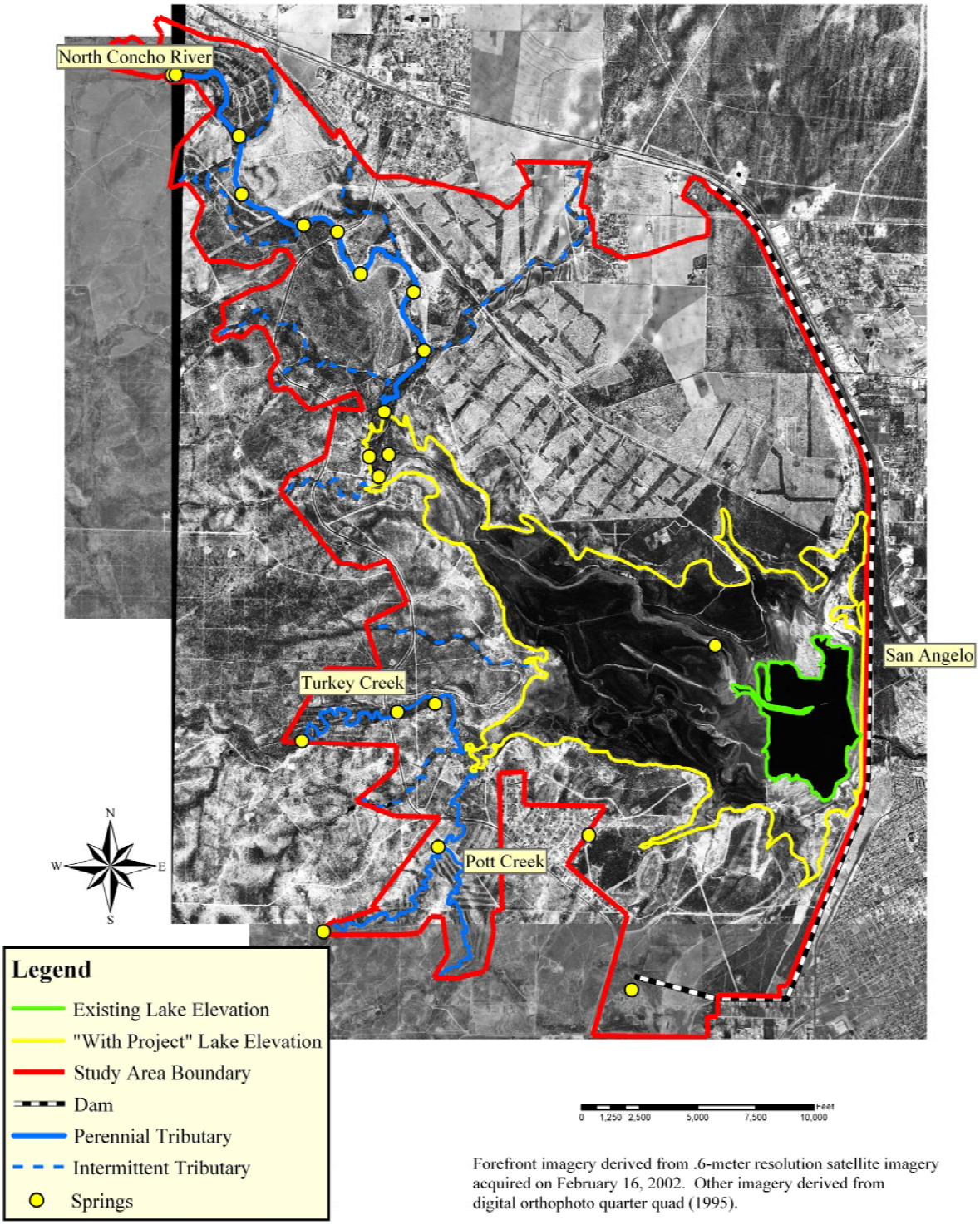


FIGURE 3. Springs within Study Area.

The project report compiled by the War Department in 1946 recognized a "ground water reservoir" and conducted a survey for those areas, approximately 120 square miles, which could potentially exhibit an effect upon the reservoir. The report stated the aquifer "consists of sand, gravel, and conglomeritic deposits having varying degrees of permeability" and "overlies primary formations, usually impervious shale or relatively impervious, well-cemented sandstone". It described the pervious horizon ranges in thickness from 5 to 30 feet and it is overlain by a "blanket of relatively impervious alluvium which has a minimum thickness of about 40 feet (War Department 1946). Existing groundwater wells within the proposed reservoir area were also studied in the project report. Groundwater wells were found to be from 50 to 100 feet deep and the aquifer ranges from 5 to 30 feet in thickness. Groundwater was described as being under partial artesian pressure confined on top and bottom by relatively impervious materials (War Department 1946).

Water Quality. O.C. Fisher Lake is included in the draft 2002 and 2004 List of Impaired Waters for high levels of chloride and total dissolved solids (Texas Natural Resource Conservation Commission 2004). High levels of chloride are presumably in part due to the exudation of salt crystals from large stands of salt cedar within the lake bed. Additionally, the quality of surface water has been reduced by invasive vegetative species through increased erosion as a result of the reduction in native groundcover vegetation. Monocultures created by invasive brushy species outcompete the native groundcover species and top soil becomes more exposed and susceptible to erosion. Surface run-off during heavy rain events carries sediments into waterways where they remain suspended for a time and then fall to the bottom, impacting aquatic resources.

Aquatic Wildlife. Common fish species that can be found within the perennial surface water within the study area are bass (Micropterus spp. and Morone sp.), catfish (Ictalurus spp. and Pylodictus sp.), sunfish (Lepomis spp. and Pomoxis spp.), various minnows (Notropis spp., Pimephales spp., Hybobsis sp., and Carpiodes sp.), mosquito fish (Gambusia spp.), killifish (Fundulus spp.), and some exotics including common carp (Cyprinus carpio), blue tilapia (Oreochromis oreas), and pacu (Piaractus brachypomus). Several species of frogs (Rana spp.) and turtles including the Texas map turtle (Graptemys versa), mud turtle (Kinosternon spp.), spiny softshell turtle (Apalone spineifera), American snapping turtle (Chelydra serpentina), Texas river cooter (Pseudemys texana), and slider (Trachemys scripta). Snakes commonly found in the river include cottonmouth (Agkistrodon piscivorus) and watersnakes (Nerodia spp. and Regina grahami) (USFWS 2004).

Given the climatic conditions and current low water levels, the lake may reach very high temperatures either stressing or killing fish during the hotter months. Largemouth bass occur in the lake and can be tolerant of high temperatures for short periods of time but if conditions exceed 97°F for an extended period of time, largemouth bass can not survive (McCormick and Wegner 1981). Also, the hatching rate of largemouth bass eggs is reduced 50% when exposed to temperatures around 84°F for a 24-hour period (McCormick and Wegner 1981). Based on the UCRA and TCEQ data, these conditions have not occurred at O.C. Fisher Lake, but may occur in the future if lake level continues to drop. However, USACE data for O.C. Fisher Lake shows maximum lake temperatures reaching over 100°F (USACE 2004). Catfish species are more tolerant than largemouth bass to both high temperatures and anoxic conditions and do relatively

better in the current conditions of O.C. Fisher Lake. Temperatures may be lower and more moderate in the perennial pools within the upper river channel (USFWS 2004).

Terrestrial Resources. Classification of the existing vegetation is based upon the dominant species of the area and determined on a percent cover basis. Mesquite comprises various densities and was therefore classified on a density basis as heavy (greater than 70%), medium (30-69%) and light (15-29%) and areas dominated by grass and forb species with less than 10% mesquite present are classified as grassland. Prickly pear is found in all vegetative cover types in varying densities, but was not considered a dominant species.

Riparian Woodland Habitat. Quality riparian woodlands exist and extend 100 to 400 feet from the riverbed and are found along the upper reaches of the North Concho River where perennial surface water still exists. Quality riparian woodlands are also found immediately adjacent to ephemeral tributaries of the river. Vegetation in these areas is dominated by mature pecan, with scattered hackberry, live oak (*Quercus virginiana)*, black willow (*Salix nigra)*, western soapberry (*Sapindus drummondi*), American elm and desirable woody-understory species including bumelia (*Bumelia* spp.), skunkbush (*Rhus trilobata*), littleleaf sumac (*Rhus microphylla*), algerita (*Mahonia trifoliata*), and pricklyash (*Zanthoxylum americanum*). Approximately 48% (89.4 acres of 187.8 acres) of the riparian corridor along the North Concho River within the study area can be characterized as quality riparian habitat. Degraded riparian woodlands along the river include 56.4 acres of mesquite of various densities and 45.0 acres of grass and/or forbs (less than 10% mesquite) of various densities. The remaining riparian woodland habitat is highly fragmented and has been impacted by past management techniques.

The riparian corridor along Pott Creek is approximately 35 feet in width and Turkey Creek is approximately 30 feet. Only a few, scattered hardwood trees remain along the riparian corridors where perennial surface water remains most of the year. The riparian corridors are degraded to the point that 95% is dominated by mesquite and the remaining 5% is grass and/or forbs (less than 10% mesquite) of various densities.

Transitional Habitat. Transitional habitat is located adjacent to riparian areas extending to the boundary of the study area. A total of 11,758.9 acres of transitional habitat exists within the study area. The historical condition for these lands was grassland dominated with isolated oak and mesquite timber in the uplands and along ridges. The impacts of fire suppression, overgrazing and drought contributed to the proliferation of mesquite woodlands across the landscape. The vegetative community on approximately 3,091.9 acres, 26.3%, of the transitional habitat within the study area still contains the species and structure to provide some grassland habitat benefits. In general, these lands contain no more than 10% mesquite.

The remaining transitional habitat (8,666.9 acres) within the study area has been invaded by willow baccharis, saltcedar, or mesquite to a level which provides a more shrubland community composition than the historical grassland community. Mesquite has invaded and become the dominant vegetation on 8,466.4 acres of these grasslands. Areas dominated by mesquite are classified on a percent cover basis as heavy (greater than 70%), medium (30-69%) and light (10-29%). Of the 8,466.4 acres exhibiting a mesquite shrubland composition, 2,143.0 acres are light, 1,412.2 acres are medium, and 4,911.2 acres are heavy. The remaining 200.5 acres are

dominated by willow baccharis (188.9 acres) and communities dominated by a mixture of saltcedar and willow baccharis (11.6 acres). Prickly pear is found in all vegetative cover types in varying densities, but was not considered a dominant species.

Additional species found within the transitional habitat include species of bumelia, skunkbush, littleleaf sumac, algerita, pricklyash and greenbriar (*Smilax* spp.). Indiangrass, big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium rhizomatum*), switchgrass, sideoats grama, Eastern (*Tripsacum dactyloides*), buffalograss (*Buchloe dactyloides*), plains bristlegrass (*Setaria vulpiseta*), green sprangletop (*Leptochloa dubia*), curly mesquite (*Hilaria belangeri*), various threeawns (*Aristida* spp.), tridens (*Tridens* spp.), Texas wintergrass (*Stipa leucotricha*), Canada wildrye (*Elymus canadensis*), and dropseeds (*Sporobolus* spp.) can be supported by the various soil types. A diversity of forb and legume species as well as over 140 species of wildflowers exist. Sumac (*Rhus* spp.) species, white brush (*Aloysia gratissima*), ephedra (*Eriogonum* spp.), lotebush (*Ziziphus obtusifolia*), feather dalea (*Dalea Formosa*), catclaw (*Acacia greggii*), and algerita are the most common shrub components found throughout the study area.

Terrestrial Wildlife. Existing riparian hardwood forest within the study area supports a large diversity of insects, fish, amphibians, reptiles, birds, and mammals. Signs of armadillos, raccoons, and opossums are fairly numerous throughout the study area. Leopard frogs and cricket frogs are abundant, as are snakes, butterflies, bees, and other flying insects. Bird species sighted are typical of bottomland riparian areas. The project area is used by both resident and migratory species. Migratory waterfowl, shorebirds, and resident wood ducks (Aix sponsa) can be seen in the open water and along perennial water areas of the river. A variety of migratory and resident passerine, owl, and hawk species use the woodlands. Some common resident birds that may be observed in the study area are sparrows (Emberizinae), cardinals (Cardinalinae), jays (Corvidae), crows and grackles (Icterinae), flycatchers (Tyrannidae), accipiters, buteos, and turkey (Meleagris gallopavo). Transitional sites still support some bobwhite (Colinus virginianus) and probably supported higher numbers in the past. Mammal species that may utilize habitat types in the study area include white-tailed deer (Odocoileus virginianus), raccoon (Procyon lotor), ringtail (Bassariscus astutus), armadillo (Dasypus novemcinctus), skunks (Mephitis spp., Spilogale sp., and Conepatus sp.), opossum (Didelphus marsupialis), coyote (Canis latrans), bobcat (Lynx rufus), rabbits (Lepus sp. and Silvilagus sp.), foxes (Vulpes sp. and Urocyon sp.), squirrels (Citellus spp. and Sciurus sp.), and small rodents (Peromyscus spp., Neotoma sp., Thomomys sp., Geomys spp., Perognathus sp., and Dipodymus spp.). Reptile species inhabiting the study area include lizards (green anole Anolis sp., skinks Eumeces spp., and spiny lizards Sceloporus spp.), numerous toads (Bufo spp.) including the state threatened Texas horned lizard (Phrynosoma cornutum) rattlesnakes (Crotalus spp.) rat snakes (Elaphe spp.), kingsnakes (Lampropeltis spp.), and turtles like the ornate box turtle (Terrapene ornate). One salamander species may be found within the project area, the Tiger salamander (Ambystoma tigrinum) is known from Tom Green County (USFWS 2004).

Threatened and Endangered Species. USFWS reports that two endangered species, two threatened species, and one candidate species are federally listed and known to occur within Tom Green County, as summarized in Table 1. In addition, the American peregrine falcon (*Falco perigrinus* var. *anatum*) and Texas horned lizard (*Phrynosoma cornutum*) are listed as State

endangered species for Tom Green County. Most of these species are not known to occur within the study area. Species of particular interest identified by the USFWS within the proposed project area include the black-capped vireo and the Concho water snake.

TABLE 1. Threatened and Endangered Species That May Occur within Study Area.

Common Name	Scientific Name	Federal or State	Status
Black-capped vireo	*Vireo atricapillus*	Federal and State	Endangered
Interior least tern	*Sterna antillarum*	Federal and State	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Federal (de-list pending) and State	Threatened
Concho water snake	*Nerodia paucimaculata*	Federal	Threatened with critical habitat
Whooping crane	*Grus americana*	Federal and State	Endangered
Texas horned lizard	*Phrynosoma cornutum*	State	Threatened
American peregrine falcon	*Falco perigrinus* var. *anatum*	State	Endangered

Black-capped Vireo (*Vireo atricapillus*). This strikingly beautiful endangered songbird is known to occur in Tom Green County and is considered a habitat specialist, nesting in mid-successional brushy areas (before areas develop into mature woodlands) where the dominant species are oaks, sumacs, persimmon, and other broad-leafed shrubs. Juniper may be common in vireo habitat, but juniper prominence is not essential or even preferred by the birds. Typical nesting habitat is composed of a shrub layer extending from the ground to about six feet covering about 35-55% of the total area, combined with a tree layer that may reach 30 feet or more. Open, sometimes grassy spaces separate clumps of trees and shrubs. The vireo depends upon broad-leafed shrubs and trees, especially oaks, which provide insects upon which it feeds. Due to the lack of suitable habitat and its relatively disturbed nature, it is unlikely that this species would utilize the study area.

Concho Water Snake (*Nerodia paucimaculata*). The Concho water snake was listed as threatened on September 3, 1986, with critical habitat designated on June 29, 1989. Critical habitat includes a stretch of the Concho River extending from Mullin's Crossing located 5 miles northeast of the town of Veribest, downstream to the confluence of the Concho and Colorado Rivers in Tom Green and Concho Counties (USFWS 1993). In addition, critical habitat includes a stretch of the Colorado River extending from FM 3115 bridge near the town of Maverick downstream to the confluence of the Colorado River and Salt Creek, northeast of the town of Doole, Runnels, Concho, Coleman, and McCulloch Counties; and the entire O.H. Ivie Reservoir basin. Although historically the Concho water snake occurred over about 276 miles of the Colorado and Concho Rivers, it is presently distributed discontinuously over about 199 river miles of the Colorado and Concho Rivers in 10 Texas counties (USFWS 1993).

Habitat for the Concho water snake consists of shallow riffles, rock debris, and crevices for shelter, and free-flowing streams over rocky substrates. Adults can live in either shallow or deep flowing water over various substrates but riffles are critically important to the survival of

juveniles. Diet consists mostly of fish; juveniles feed almost entirely on minnows (Rose 1989). Decline of the species is due to loss of habitat and degradation due to large, main-stream reservoirs on the Colorado and Concho Rivers, plus several smaller impoundments on tributary streams. Other threats include pollution and water quality degradation due to refining, petroleum production, treated sewage disposal, pesticide use and feedlot activities. There is critical habitat designated for the Concho water snake in Tom Green County; however, it is downstream of O.C. Fisher Lake on the North Concho River. Due to the lack of suitable habitat and location, it is unlikely that this species would utilize the study area.

ENVIRONMENTAL DEGRADATION

Historical Landscape. In 1683, Mendoza, an explorer, undertook a river expedition traveling southward along the Middle Concho River from its confluence with the North Concho River. In his journal, Mendoza wrote, "On both sides are great bottoms; there is a great luxuriance of plants, nuts, and other kinds of trees, and wild grapes, good pasturage, a variety of birds, and wild hens". He also described very many groves of pecan trees, lofty live oaks and many springs (Maxwell 1979). In 1898, H.L. Bentley, special agent in charge of the Grass Station in Abilene, Texas, published a report pertaining to the cattle ranges of "central Texas", a rather large area that included Tom Green County. The common characteristics Bentley used to describe the 1860's landscape are summarized as:

1) generally an open country with some oak timber on the uplands and ridges
2) a scattered growth of mesquite was present on lands away from the timbered streams
3) numerous streams furnished ample water and supported groves of pecan, elm, hackberry, wild china (soapberry), cottonwood and other trees
4) a climate pure and bracing with a well distributed 20 to 35 inch rainfall pattern, and a great variety of native forage plants and rich grasses.

Additional comments pertaining to Tom Green County state in 1867 the grass was everywhere one to three feet high, not only on the bottomlands, but also in places on the drier uplands (Maxwell 1979).

The historic grassland communities of the study area developed in response to a frequent fire regime (fire-climax). Woody vegetation existed in successional stages dependent upon the frequency of fire across the landscape creating a mosaic of habitats. After a fire, growth and reproduction of the young woody vegetation was suppressed. As time passed after a fire, growth and reproduction of the woody vegetation gradually increased until fire returned to suppress the woody vegetation again. Several factors played a part in the discontinuation of this successional process, but the elimination of fire may be one of the factors leading to the proliferation of plant communities dominated by phreatophytic plants.

Construction/Operation of O.C. Fisher Lake. The construction of the dam and the subsequent impoundment replaced approximately 23 acres of riverine habitat within lacustrine habitat. In addition, all woody vegetation (7,524 acres) was removed below 1928 feet MSL (War Department 1946). An estimated 253 acres of significant bottomland hardwood woodlands along the riparian corridor of the North Concho River was also destroyed. Approximately 103

acres of riparian woodland remained undisturbed along the North Concho River above the lake during construction.

Historical land management practices, prior to leasing, may have a contributing role in the establishment of invasive brushy species and prickly pear. Native vegetation within areas which were overgrazed and/or wildfire was suppressed have contributed to an environmental pallet favorable for their proliferation.

Phreatophytic Plant Species. The invasive brushy species of concern include the exotic saltcedar (*Tamarix ramosissima*), and two natives, mesquite (*Prosopis glandulosa*) and willow baccharis (*Baccharis salicina*). While mesquite and willow baccharis are considered native species, historically, they occupied only a small niche of the historical climax community. Interception, evaporation, and the ability of phreatophytic species to extract large amounts of water from the ground to meet transpiration requirements are the primary factors reducing water availability for the riparian and aquatic ecosystems.

Saltcedar. This non-native, deciduous, phreatophytic shrub or small tree grows rapidly, attaining a height of 30 feet, and forming dense, impenetrable thickets (Figure 4). Saltcedar is a native of Europe and Asia that was introduced in the United States in the early 1800's where it was sold as an ornamental, escaping cultivation in the 1870's. In the early 1900's, an attempt was made to use the trees for erosion control along waterways. Saltcedar became naturalized and spread rapidly in the 1930s and 1940s and by 1965, saltcedar had completed invasion of most suitable western riparian areas (DeLoach and Tracy 1997). An extremely invasive plant, saltcedar is now found across the western half of Texas and throughout the southwest.

FIGURE 4. Springs within Study Area.

Some of the undesirable traits of saltcedar include:

1) consumes more water than comparable native plant communities
2) crowds out native stands of riparian and wetland vegetation
3) dries up springs, wetlands, riparian areas and small streams by lowering surface groundwater tables
4) widens floodplains by clogging stream channels
5) increases sediment deposition due to the abundance of saltcedar stems in dense stands
6) increases the salinity of surfaces soil through salt exudation from its leaves rendering the soil inhospitable to native plant species
7) provides generally lower wildlife habitat value than native vegetation

Reproduction of saltcedar is accomplished through several pathways. From April through October, each plant can produce 500,000 small, wind-disseminated seeds. Additionally, the plant has strong vegetative reproduction properties with the ability to establish new plants from removed stems, and resprouting from the root collar if established plants are disturbed (Merkel and Hopkins 1957). For new seedlings to survive, the soil must remain saturated for several months. The seedlings grow faster than most native plants and send down a tap root rapidly, with little branching until it reaches the groundwater table. At the groundwater table, the root develops profuse secondary branching. One study documented a saltcedar tap root to be 16 feet deep, with a diameter of 3/16 inches, and still growing toward the groundwater table 26 feet deep (Hart 2003). At maturity, the roots exploit the groundwater table by placing the majority of the roots within the capillary zone above the groundwater table and extending some roots into the saturation zone. Saltcedar occupies 1,247 acres within the study area and continues to expand as surface water levels decrease.

Of the three species of concern, saltcedar possesses the highest evapotranspiration rate, and studies have shown the evapotranspiration rate of a mature saltcedar tree to be up to 200 gallons per day (McGinty and Hart 2001). An acre of dense saltcedar on the upper portion of the Pecos River in Texas, is estimated to use 5 to 7 acre-feet of water every year (Hart 2003). Brotherson et al. (1982) conducted a study showing that the longer the saltcedar occupies an area, the drier it becomes.

Mesquite. This species is a natural component of Texas rangeland, and historically, mesquites grew as single-trunk specimens that were limited to lowland areas. Today, dense stands of mesquite are found on lowland and upland sites, and the plant is now considered a noxious brush species occurring on millions of acres of Texas rangeland (Figure 5). Community types within the study area are referred to as the Mesquite Plains of the Rolling Plains and the Live Oak-Mesquite Savanna of the Edwards Plateau (Diamond et. al 1987).

FIGURE 5. Springs within Study Area.

Mesquite is a facultative phreatophyte (Sosebee and Wan 1987) capable of growing up to 60 feet and developing trunks three feet in diameter. If its canopy is damaged or killed, it resprouts from its basal bud zone (root collar) and develops a multi-trunk form that becomes very resistant to control. It is well adapted to both wet and dry conditions once established, and can easily dominate an area due to its extensive dual root system including lateral roots and tap roots. The lateral roots consume water from shallow depths as available and in drought conditions, tap roots pump water from far beneath the surface (Jensen 1988). Mesquite of various densities currently dominates 8,730 acres within the study area.

Mesquite possesses a dual root system including a shallow root system and a much deeper root system, which allows it to extract water directly from the groundwater table while following the resulting lowered groundwater levels to great depths. Mesquite tap roots have been found extending up to 60 feet below the surface to reach groundwater (Sosebee and Wan 1987). A study conducted in Throckmorton, Texas, approximately 140 miles northeast of O.C. Fisher Lake, found daily water loss of each mesquite tree to be between 7.9 to 19.8 gallons.

Willow Baccharis. Willow baccharis is a hardy, native perennial shrub that can grow to 13 feet tall (Hobbs and Mooney 1987) (Figure 6). Historically, it was confined to river banks and creek channels within the region, but it has expanded its range to include uplands areas as well. Willow baccharis is an aggressive invader species that quickly invades and dominates disturbed sites. It is a prolific seed producer that also spreads through adventitious buds along lateral roots and exhibits strong resprouting characteristics. It frequently forms dense, closed canopy stands (Holmes 1998). Willow baccharis is a phreatophyte estimated to utilize more water than mesquite (Gatewood et al. 1950).

Figure 6. Dense Stand of Young Willow Baccharis within Lake Bed.

Some dense stands of dead willow baccharis within the study area have been observed in recent years and it is surmised that the groundwater table dropped too low to support these stands. Willow baccharis occupies 2,258 acres within the study area.

Impact of Phreatophytic Plant Species. The invasive nature, high evapotranspiration rate, very efficient means of reproduction, and ability to better exploit groundwater resources than other, more historically and ecologically appropriate species, allows these phreatophytic species to exploit the historical vegetative community. The proliferation of these heavy water utilizing species has resulted in encroachment within the riparian zone and led to increased competition and further decreases in soil moisture within the riparian community. Consequently, many endemic trees, shrubs, and grasses are no longer dominant and becoming increasingly scarce. Not only has the phreatophytic species replaced the higher quality riparian habitat, they significantly decrease the amount of water available for groundwater recharge and in-stream base flows, thereby causing further degradation to the aquatic ecosystem.

Total stream discharge of the North Concho River significantly declined from 1925-1959, averaging 38,617 acre feet per year, to 1960-1996, averaging 8,358 acre feet per year, while the rainfall conditions remained nearly unchanged (UCRA 1998). The average annual flow in the upper North Concho River is 28.1 cfs dating back to 1925, but within the last ten years annual flow has been less than 7.5 cfs (U.S. Geological Survey 2004).

Since impoundment began in 1952, the only time the conservation pool level has been attained occurred in 1957. Since that time, the lake level is consistently low and continues to fall each year. Between 1987 and 2001, the lake levels steadily declined an average of two feet per year despite abnormally high rainfall amounts. Figure 7 provides a graphical representation of historical rainfall and lake levels. Currently, the lake is in the sediment reserve pool, approximately 53 feet below the top of the designed conservation pool elevation. Surface water

within the lake comprises only about 8%, designated as reserve pool, of that which exists at the top of conservation pool. A major fish kill was experienced in September 2004 where thousands of fish were lost (Figure 8) due to lack of stream flow.

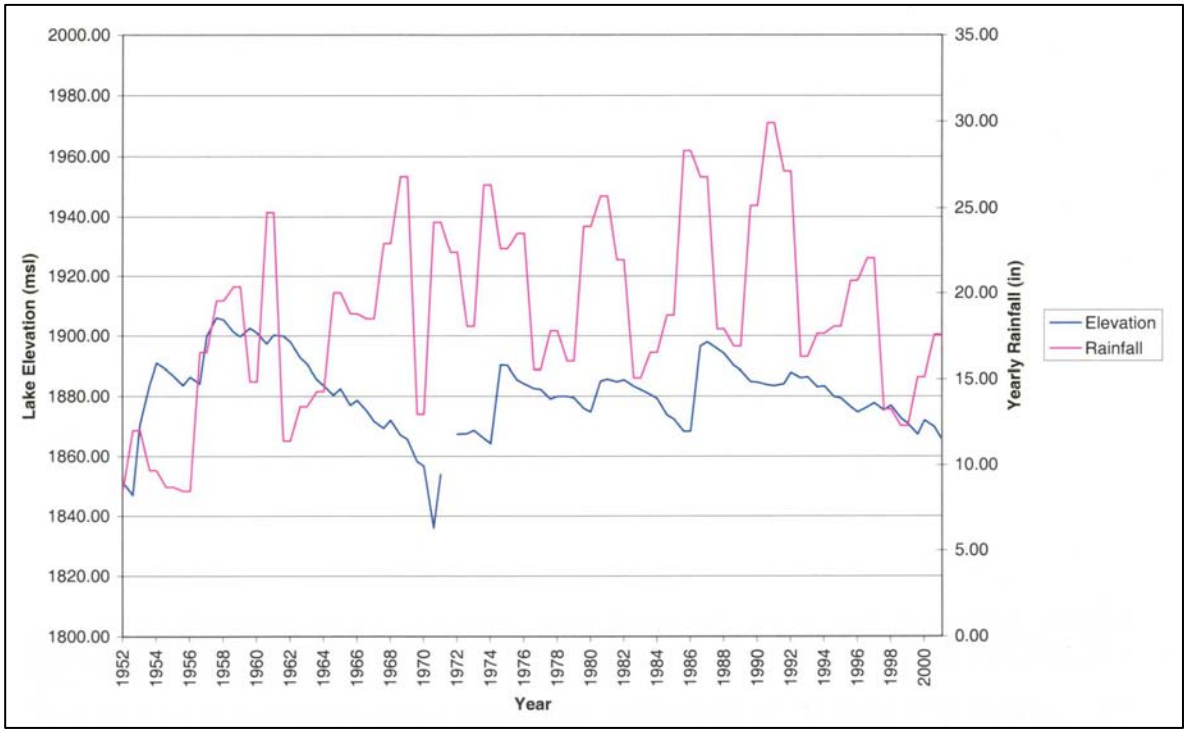


Figure 7. Historical Rainfall and Lake Levels.

Figure 8. Fish Kill of September 2004.

As the perennial surface water continues to fall, the dry beds are highly susceptible to invasion by invasive vegetative species. Invasive brushy species dominate large acreages within the dry lake, river and creek beds and continue to extend their range as perennial surface water continues to be lost. Mesquite, saltcedar, willow baccharis, and saltcedar/willow baccharis combine for a total of 2,750.8 acres, 71.4% of the 3,851.2 acres of lake, river and creek beds.

Disruption of the hydrological regime within the O.C. Fisher Lake ecosystem adversely impacts the native riparian woodlands and the wildlife species found there. Riparian woodlands are dependent upon the hydrology of the stream for recruitment and survival. Base flows of perennial streams within the study area are derived from local run-off during rain events, but to maintain their historical nature, the perennial streams are highly dependent upon spring flows. Spring flow rates are directly related to groundwater levels. The higher the groundwater table, the greater the flow rate and vice versa. The hydrology for some of the riparian woodlands within the study area is not derived from surface water, but instead from shallow groundwater. Several of the springs have ceased flowing and remaining have a significant reduction in flow.

Once the hydrology is removed for extended periods of time, be it surface water removed and/or groundwater levels depleted to levels below that which woody vegetation roots may utilize, the woody vegetation dies.

Overall, the riparian woodland habitat along the study area is highly fragmented and impacted by past management along the streambanks. There are dense pockets of properly functioning riparian habitat within the study area in the upper reaches of the river, as they are located at an elevation higher than that of the lake's conservation pool. It appears that clearing for the lake and subsequent management has greatly impacted the wildlife habitat within the riparian corridors.

Approximately 103 acres of quality riparian woodland remained undisturbed along the North Concho River above the lake during construction of the reservoir. As invasive phreatophytic vegetation has spread, the hydrology (surface water and groundwater) sustaining the aquatic ecosystem has been altered, and large tracts of prime riparian habitat, an estimated 16.8 acres, have been lost (Figure 9). The hydrology of the aquatic ecosystem continues to be altered and the remaining riparian habitat is in jeopardy.

Currently, native vegetation exists in conditions similar to historical conditions in only 34.5 percent (86.2 acres) of riparian woodland habitat and 4.5 percent (139.1 acres) of transitional habitat. As native vegetation is degraded from its historical condition, the carrying capacity for fish and wildlife species dependent upon the habitat is subsequently reduced. Currently, the study area supports approximately half of its potential carrying capacity in terrestrial habitats due to habitat degradation and approximately two percent of its potential carrying capacity in aquatic habitats.

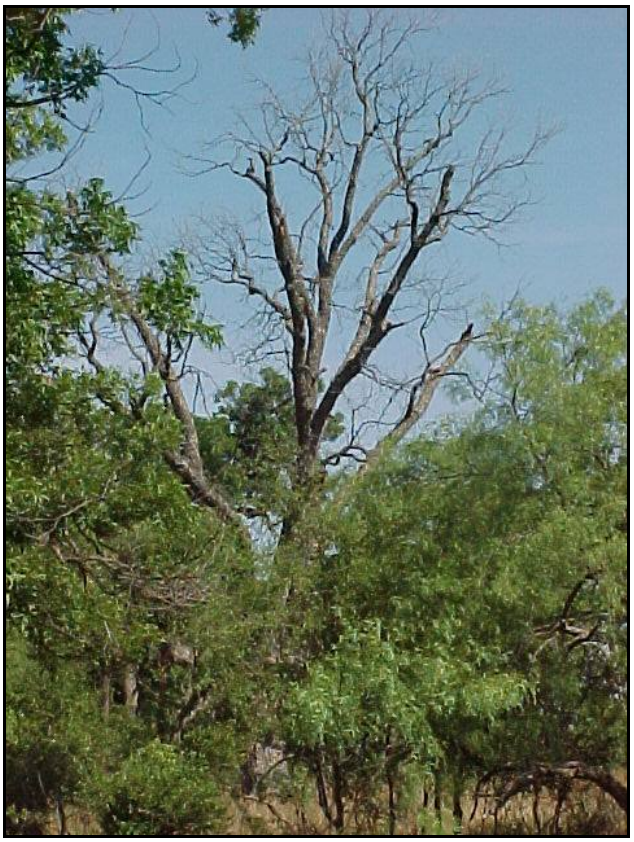


Figure 9. Dead Pecan Tree within Remnant Riparian Woodland.

Prickly Pear. Prickly pear (*Opuntia* spp.) is a native cactus that is extremely tolerant of drought and harsh conditions (Figure 10). It is a prolific seed producer with fruit and seed characteristics that ensure dissemination of the seeds and recruitment of seedlings. Vegetative reproduction occurs when pads become separated from the parent plant and readily root to establish new plants.

Figure 10. Dense Stand of Prickly Pear within ASU Lease.

Native species of prickly pear (*Opuntia* spp.) have also benefited due to land management practices. Diverse stands of native prairie gave way to thick, dense stands of prickly pear, and where mesquite dominates as the overstory vegetation, prickly pear dominates the understory. Like other invaders, prickly pear outcompetes the existing vegetation and creates dense monoculture stands, and the site's utility as wildlife habitat is lost. Additionally, monoculture prickly pear stands reduce the ability for the site to carry fire, which is required to sustain the historical vegetative community. Figure 11 shows the distribution of existing vegetation within the study area.

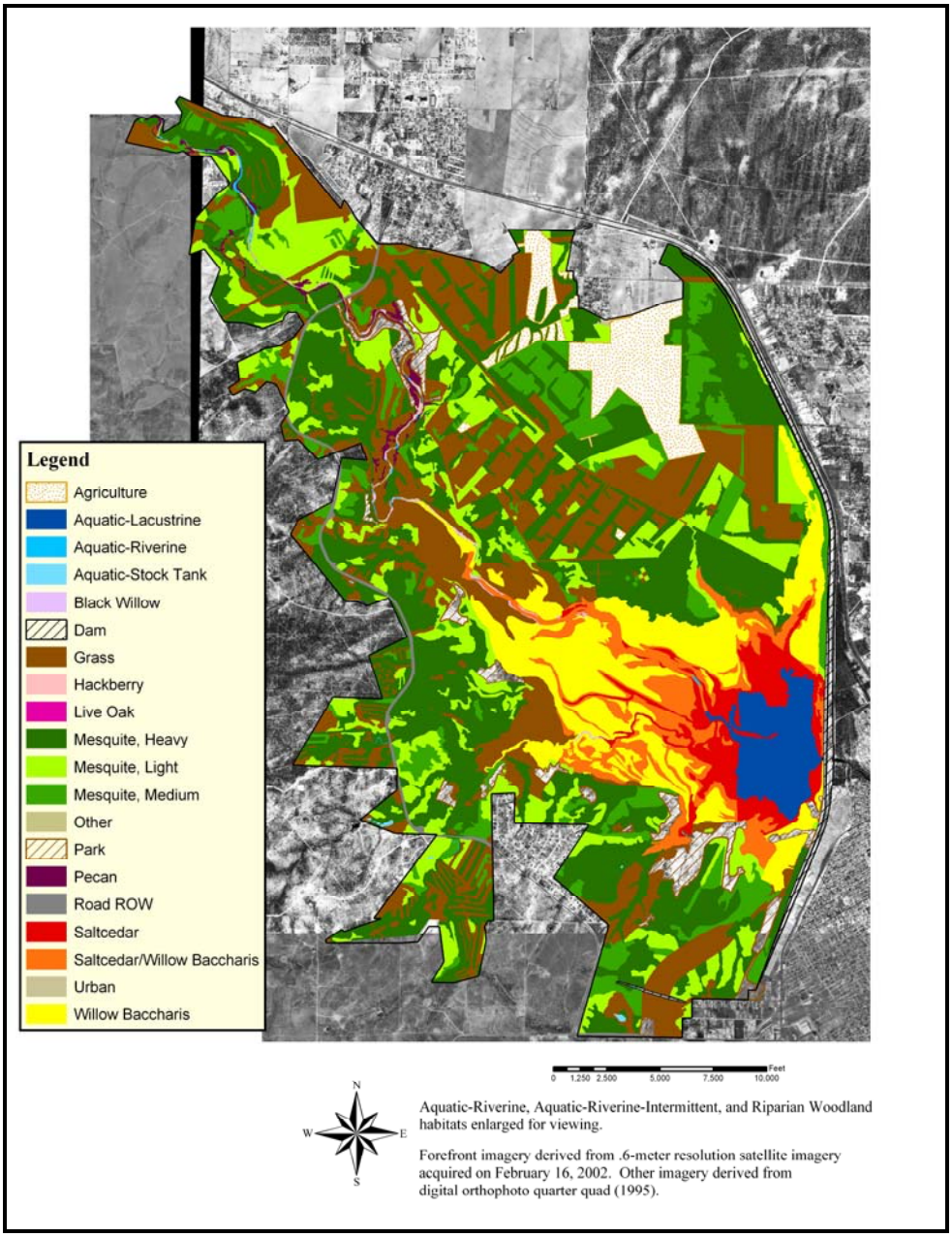


FIGURE 11. Existing Vegetation within Study Area.

Upon completion of the restoration project, it would be sustained through the use of prescribed fire and grass must serve as the fuel. Thick stands of prickly pear would not carry fire and encroachment of woody vegetation within these stands is highly likely. It is estimated that 9,194.8 acres of the study area contains medium to dense stands of prickly pear.

Habitat Classifications. In order to facilitate restoration planning, lands are classified in accordance to historical condition, with exception of converted lacustrine which is a non-historical condition. The study area is classified as five habitat classifications, which include aquatic-lacustrine, aquatic-riverine, aquatic-riverine-intermittent, riparian woodland and transitional. Figure 12 shows the distribution of the habitat classifications across the study area.

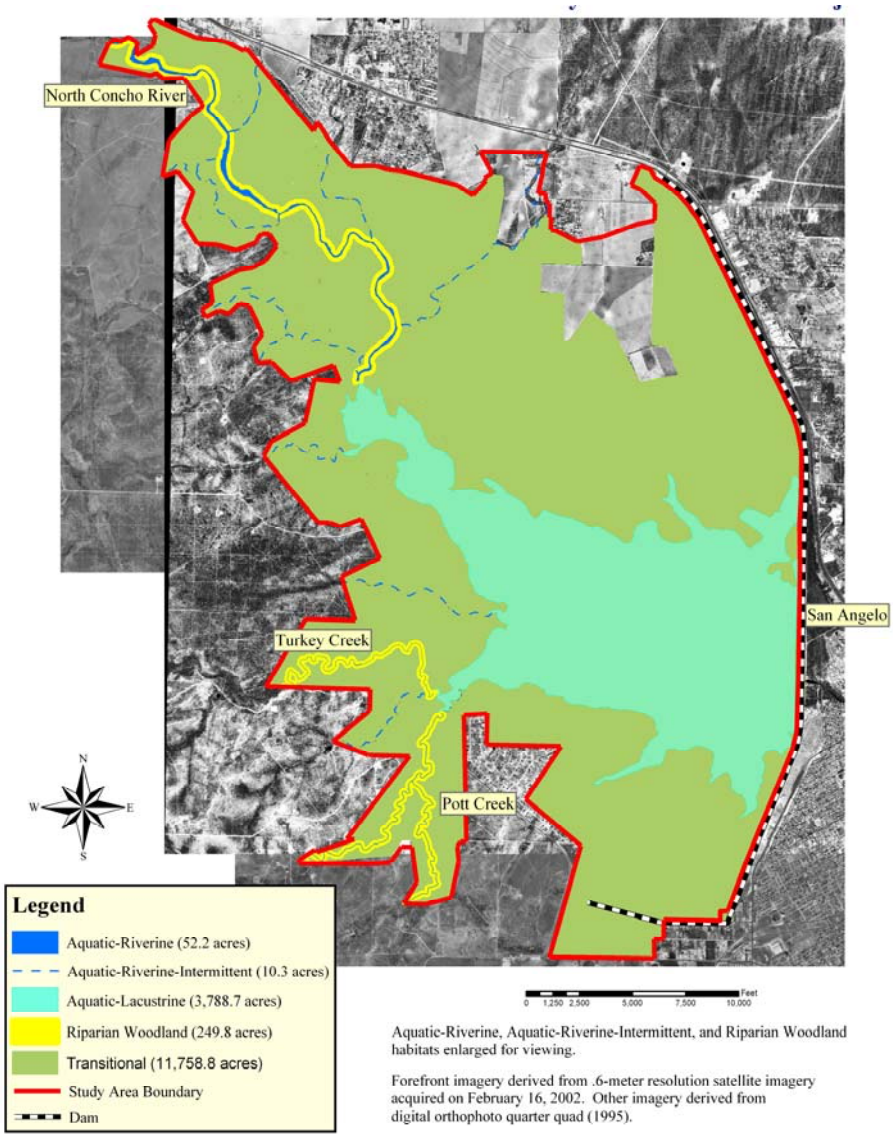


FIGURE 12. Habitat Classifications within Study Area.

Satellite imagery was utilized as the base map and this study is based upon existing conditions at the time the satellite imagery was taken, February 16, 2002. Reference to current conditions within this study refers to the existing conditions at the time the satellite imagery was taken.

Lands within "with-project" lake level, the predicted lake level in response to a fully implemented restoration project, are classified as aquatic-lacustrine. A report written by Fort Worth District, Reservoir Control Section, projects that full implementation of this proposed restoration plan will yield increased stream flows and will significantly increase base stream flows and the lake level. Using the computer program HEC-5 and monthly observed data from 1972-1996 for model calibration, and data bases for various alternative brush, range and riparian management schemes, the with-project lake level is predicted to rise, projected at 1900.96 MSL, assuming average rainfall, groundwater pumping amounts will remain relatively unchanged, and the North Concho River Brush Control Program will complete and maintain brush removal within the watershed. Streambeds of tributaries above the with-project lake level are classified as aquatic-riverine or aquatic-riverine-intermittent, dependent upon historical conditions.

Aquatic-Lacustrine Habitat. Lands up to elevation 1900.96 are classified as aquatic-lacustrine. Of the 5,440 acres of aquatic-lacustrine habitat at top of conservation pool, only 440.3 acres, 8%, are presently inundated. The aquatic habitat of O.C. Fisher Lake is limited to a mostly lentic system where little to no flows from the North Concho River, Pott Creek, Turkey Creek, and other tributaries. The remaining 92% of the lake bed has been invaded by saltcedar (520 acres), willow baccharis (1,221 acres), mixture of saltcedar and willow baccharis (758 acres) and mesquite (150 acres).

The average depth at the current lake level is 4 feet and is restricted to that immediately adjacent to the dam where there is little heterogeneity of the lake bottom. Based on Texas Commission of Environmental Quality (TCEQ) data, during the hotter months of the year water temperatures may exceed 86°F with average annual water temperature around 69.8^{o}F. Despite average oxygen levels around 8 mg/l (TCEQ data), the lake has the potential to go anoxic.

Aquatic-Riverine Habitat. Aquatic-riverine habitat includes tributaries deriving water source from both springs and runoff during rain events. Aquatic-riverine habitat includes the North Concho River, Pott Creek and Turkey Creek.

The total length of the North Concho River to "with-project" lake level within the study area is approximately 6.4 miles. The river maintains contiguous surface water only in its upper reaches within the study area and only small pockets of surface water exist in conjunction with flowing springs as the river travels to O.C. Fisher Lake. Portions of the riverbed contain perennial surface water, while other areas lack water except for brief periods immediately after a heavy rainfall event (ephemeral). Within the study area, only 12.6 acres of the total 36.9 acres of the North Concho River presently contains perennial surface water. The remaining 24.3 acres of the river bed remain dry most of the year with stands of grass and/or forbs of various densities.

Pott Creek and Turkey Creek also have extremely limited pockets of perennial surface water. Pot Creek is 4.7 miles long extending to "with-project" lake level and contains an estimated 0.4 acres of perennial surface water acres, 3.4% of its potential 11.6 acres. Turkey Creek is 2.9

miles long extending to "with-project" lake level and contains an estimated 0.3 of perennial surface water acres, 8.1% of its potential 3.7 acres. Mesquite of various densities exists within 92% of the creek beds.

Aquatic-Riverine Intermittent Habitat. Remaining eight tributaries within the study area, which include Dry, Bald Eagle, No Name 1, No Name 2, No Name 3, No Name 4, No Name 5 & 6, and No Name 7 Creeks, combine for a total of 10.3 acres over a length of 13.3 miles. Mesquite dominates the creek bed with some isolated stands of grass and/or forbs. The tributaries only contain surface water as a result of local runoff during rain events for short durations.

Riparian Woodland Habitat. Lands adjacent to aquatic-riverine habitats, which include North Concho River, Pott Creek and Turkey Creek, are classified as riparian woodland habitat. An average width, or buffer, was estimated for each riparian woodland along each streambed through on-site visits and satellite imagery.

Transitional Habitat. All other remaining lands, excluding dam, road rows, and agricultural fields, are classified as transitional habitat.

Habitat Evaluations. A team of biologists and ecological planners from the USFWS, TPWD and USACE evaluated habitats within the study area. Evaluations included both existing habitat conditions and those predicted for the future under various conditions or measures, including no action.

Habitat evaluations were accomplished through utilization of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (HEP). HEP is a species-habitat approach to assess habitat condition using Habitat Suitability Index (HSI) models developed for representative wildlife species that best represents a guild of wildlife species dependent upon a particular vegetative community. The HSI is derived from evaluation of key habitat variables', or Suitability Indexes' (SI), ability to supply the life requisites of selected wildlife species. The HSI is expressed numerically, ranging from 0.0 to 1.0, where 0.0 represents no suitable habitat for the representative wildlife species and 1.0 represents optimum conditions for the representative wildlife species. The HSI is then multiplied by the acreage of the habitat deriving the Habitat Unit (HU), the unit of measure allowing for comparison among habitat evaluations. HSIs and HUs were evaluated at intervals during the period of analysis (Years 0, 1, 5, 10, 25, 50) using professional judgment and HUs were annualized to estimate an average annual habitat unit (AAHU).

HEP provides numerical data allowing for two general types of wildlife habitat comparisons. The first is the relative value of different areas at the same point in time. The second is the relative value of the same area at future points in time. Therefore, the impact of land and water use changes on wildlife habitat can be estimated.

It was recognized that the habitat is degraded to such a detrimental state that existing habitats have deteriorated. In order to judiciously evaluate the restoration project, evaluation of the

existing habitat was based upon the historical habitat of the specific area within the study area, with exception of converted lacustrine which is a non-historical condition.

Existing vegetation was derived through special computer programs utilizing satellite imagery, Geographical Information System (GIS)/Global Positioning System (GPS), and field investigations. Existing vegetative conditions were inventoried to provide a baseline condition from which to conduct the study (Figure 11).

Table 2 provides a summary of the habitats within the study area.

TABLE 2. Existing Habitats within Study Area.

Habitats		Acres within Study Area
Aquatic	Riverine	52.2
	Riverine - Intermittent	10.3
	Lacustrine	3,788.7
Terrestrial	Riparian Woodland	249.8
	Transitional	11,758.8
Total		15,859.8

Aquatic HEP. A total of 3,851.2 acres of aquatic habitats exists within the study area and include lacustrine, riverine and riverine-intermittent habitats. Aquatic habitat within the study area is severely degraded both quantitatively and qualitatively. Since the overwhelming proportion of the aquatic habitat simply lacks water, the team decided that a standard HEP using aquatic species models was unnecessary. The team elected to use a consensus of professional judgments to provide HSI values. Table 3 summarizes the aquatic HEP data evaluating existing conditions.

TABLE 3. Existing Conditions-Aquatic HEP Data.

Aquatic Habitat	Acres	Average HSI	Habitat Units
Riverine	13.3	.20	2.7
Riverine (dry)	38.9	.05	1.9
Riverine-Intermittent	10.3	.20	2.1
Lacustrine	440.3	.20	88.1
Lacustrine (dry)	3,348.4	0	0
Total	3,851.2	NA	94.8

Aquatic-Lacustrine Habitat. Only 440.3 acres, 11.6%, of the lacustrine habitat functions as such and the remaining 3,348.4 acres, 88.4%, lacks surface water entirely, rendering it completely useless as aquatic habitat. The perennial surface water that is present exhibits high levels of chloride and total dissolved solids. The habitat lacks a consistent surface flow and the lake experiences occasional anoxic conditions. Overall, the lacustrine habitat containing surface water rates poor with an HSI of .20 and the acreage lacking surface water rates an HSI of 0. The lacustrine habitat only provides 88.1 habitat units out of a potential 3,788.7 habitat units.

Aquatic-Riverine Habitat. Riverine habitat is tributaries historically containing perennial surface water and includes the North Concho River, Pott Creek and Turkey Creek. These tributaries combine for 52.2 acres.

The upper portions of the North Concho River within the study area may flow at certain times of the year, but the large majority of the time, the river is comprised of various sizes of pools maintained by spring flow and only approximately 25% of the riverbed contains surface water. The pools isolated in dry periods have very little flow and temperatures reach high values. The pools are very important during the summer because they serve as the only refuge for aquatic species in this system. With the river lacking the continuity and flow, the riverine habitat holding surface water year-round rates poor with an HSI of .20. Areas where riverbeds only hold surface water for brief periods, up to 2 months, offer only limited aquatic benefits for brief periods of time, mainly for amphibians and reptiles, rates an extremely poor HSI of .05. The riverine habitat (52.2 acres) only provides 4.6 habitat units.

Aquatic-Riverine-Intermittent Habitat. Riverine-intermittent habitat contains surface water only on a seasonal or temporary basis. Eight tributaries (Dry, Bald Eagle, No Name 1, No Name 2, No Name 3, No Name 4, No Name 5/6, and No Name 7 Creeks) are classified as riverine-intermittent habitat and total 10.3 acres. Because the habitat remains dry most of the year and only holds surface water for brief periods, up to one week, serving only reptiles and amphibians to some extent, the riverine-intermittent habitat rates an extremely poor HSI of .02. The riverine-intermittent habitat only provides 2.1 habitat units.

Vegetative HEP. A total of 12,008.6 acres of vegetative communities exists within the study area. Vegetative communities within west central Texas, and thus the study area, are comprised of riparian woodland, grassland and shrubland. Historical vegetation within the study area included riparian woodland and grassland (transitional); therefore, habitat evaluation is based upon these vegetation community types.

Riparian Woodland Community Model. Riparian woodland is found along three tributaries within the study area where perennial surface water is historically found, the North Concho River, Pott Creek and Turkey Creek, combining for a total of 249.8 acres. Classification of the existing vegetation within the riparian woodland corridor includes remnant woodlands (pecan, hackberry and live oak), black willow, mesquite (heavy density, medium density and light density), willow baccharis, and grassland. Fourteen sites were selected for evaluation to gain a thorough evaluation of the riparian woodland.

Wildlife species selected to represent the riparian woodland community for the HEP included the barred owl (*Strix varia*), turkey (*Meleagris gallopavo*), fox squirrel (*Sciurus niger*) and raccoon (*Procyon lotor*). These wildlife species were carefully selected because the team wanted to ensure the broadest evaluation of the habitat, to include tree, shrub and herbaceous vegetation, by evaluating as many variables within riparian woodland as possible so as to eliminate any biases towards any one specific species. The life requisites and corresponding HEP variables of the representative wildlife species assures this.

HEP variables for all the representative wildlife species require dense stands of large trees under optimum conditions. Turkey and fox squirrel allows for evaluation of the presence of hardmast trees and turkey also allows for evaluation of softmast trees. Shrub canopy cover is a variable evaluated for turkey and fox squirrel and herbaceous canopy cover is evaluated for turkey. Raccoon was selected in order to include a wildlife species that requires the presence of water.

The HSIs for all the representative wildlife species within each sampling site were combined and averaged within each existing vegetation type to provide an average HSI value for the habitat. Table 4 summarizes the riparian woodland vegetative HEP data evaluating existing conditions.

TABLE 4. Existing Conditions-Riparian Woodland Vegetative HEP Data.

Riparian Woodland Habitat	Acres	Sites Sampled	Average HSI	Habitat Units
Remnant Woodland	89.4	3	.71	63.4
Black Willow	5.7	2	.50	2.9
Mesquite, Heavy	77.3	3	.40	30.9
Mesquite, Medium	9.8	1	.35	3.4
Mesquite, Light	26.3	2	.30	7.9
Willow Baccharis	0.1	1	.10	0.01
Grassland	41.2	2	.02	0.8
Total	249.8	14	NA	109.3

Average HSI for remnant woodland habitat was significantly higher than other community types as expected because remnant woodland most closely resembles that of optimum riparian woodland. The remnant woodlands were not disturbed during reservoir construction and some of the areas still contain significant desirable areas with large diameter hardwood trees and good shrub and ground cover that rated very high HSI values for the representative wildlife species. However, some of the large diameter hardwood trees within significant acreage of the remnant woodland habitat are dead due to lack of surface water and lowered groundwater tables and these areas significantly lowered the average HSI. Black willow habitat was found to be somewhat desirable, but lacks the dense canopy cover and hardwood mast trees. Mesquite habitat provides some limited value as riparian woodland, more so at a higher density. Willow baccharis and grass habitat completely lacks hardwood trees and offer little to no riparian woodland value.

The majority of the riparian woodland lacked large diameter trees and the majority of the trees present were less than ten (10) inches in diameter that significantly lowered HSI values for cover variables for all representative wildlife species. Mast producing trees greater than or equal to 6 inches diameter at breast height (dbh) were fairly rare throughout the riparian woodland and thus the food value for turkey and fox squirrel rated poorly. Fox squirrel habitat rated low for both winter food production and cover/reproduction values.

Transitional Vegetation Community Model. A total of 11,758.8 acres of transitional habitat exists within the study area. Existing vegetation of the transitional habitat includes habitat dominated by grassland, heavy density mesquite, medium density mesquite, light density mesquite, willow baccharis and mixed stands of saltcedar and willow baccharis. Thirty-two sites were selected for evaluation to allow for sufficient sampling within each vegetation type to gain a meaningful representation of the vegetation type. Mesquite vegetation was sampled proportionally higher than other vegetation types because it exhibited more variability than the other vegetation types.

In order to accurately capture the transitional nature of this habitat, the evaluation was based upon a mixture of species representative of grasslands and those requiring woody vegetation. Therefore the team was required to select wildlife species which thrive in grasslands, but also require a component of woody vegetation. Three wildlife species were selected in order to evaluate the grassland more holistically and prevent any biases towards any one wildlife species. These species included eastern meadowlark (*Sturnella magna*) red-tailed hawk (*Buteo jamaicensis*) and scissor-tailed flycatcher (*Muscivora forficata*). These species rely heavily upon grasslands as a direct or indirect food source.

The meadowlark requires productive grassland as its main diet is grass seeds. It also requires good cover for nesting on the ground and perching locations in scattered trees or brush. Variables evaluated included percentage and height of herbaceous canopy cover, proportion of herbaceous canopy cover that is grass, percentage of shrub crown cover, and distance to perch site.

Red-tailed hawk predominately prey upon rodents and rabbits and sometimes birds, reptiles and grasshoppers inhabiting healthy, productive grasslands. The hawks require large, open, relatively flat grasslands to allow them to hunt and capture prey in flight. They also require tall

trees or brush scattered throughout the grassland for perching locations for hunting, nesting, resting, and roosting. Due to the high numbers of red-tailed hawks observed within the study area, the team inferred that roosting and nesting sites were not a limiting factor and habitat suitability was solely based upon food availability. Variables evaluated included average height and percent cover of herbaceous and shrub canopy, topography, and quantity, size and distance to woody vegetation.

Scissor-tailed flycatcher has similar requirements as hawks, except they prey upon flying insects found within grasslands. They rely more heavily upon the presence of tall trees or brush scattered throughout the grassland for hunting purposes as they hunt perched upon the tree or brush and take flight in order to capture flying insects on the wing. They require large, open, relatively flat grassland to allow them to capture prey in flight. They also require tall trees or brush scattered throughout the grassland for perching locations for hunting, nesting, resting, and roosting. They rely more heavily upon the presence of tall trees or brush for use as perching locations for hunting purposes as they generally do not hunt in flight. Variables evaluated included percentage and height of herbaceous canopy cover and quantity and distance to nearest deciduous trees.

The HSIs for all the representative wildlife species within each sampling site were combined and averaged within each existing vegetation type to provide an average HSI value for the habitat. Table 5 summarizes the transitional habitat vegetative HEP data evaluating existing conditions.

TABLE 5. Existing Conditions-Transitional Habitat Vegetative HEP Data.

Transitional Habitat	Acres	Sites Sampled	Average HSI	Habitat Units
Grassland	3,091.9	7	.67	2,071.6
Mesquite, Heavy	4,911.2	10	.49	2,406.5
Mesquite, Medium	1,412.2	6	.65	917.9
Mesquite, Light	2,143.0	5	.38	814.3
Willow Baccharis	188.9	3	.10	18.9
Saltcedar/Willow Baccharis	11.6	1	.10	1.2
Total	11,758.8	14	NA	6,230.4

Average HSI for grassland was found to be the highest and most desirable vegetation as expected. Willow baccharis and saltcedar/willow baccharis were the least desirable vegetation because of their dense, shrub monoculture growth habit and lack of herbaceous layer. Average HSIs for mesquite varied dependent upon mesquite density, but overall, the values were significantly higher than willow baccharis and saltcedar/willow baccharis. Light mesquite scored the lowest average HSI and medium mesquite scored the highest.
The average HSIs for the three densities of mesquite required qualification as the HSIs deviate from what one may expect when evaluating the vegetation as grassland without the benefit of a site visit. On the basis of dominance of the woody vegetation within grassland, it is expected

that HSI values will decrease as the woody vegetation increases. This was not the case and is attributed to several evaluation variables.

Evaluation of perching sites was required for all three HSI species. Light mesquite did not offer a great value as a perching site, but larger mesquite trees within the medium density mesquite stands offered ideal perching sites. Mesquite within heavy density mesquite stands was too dense to serve much value as a perching site.

Evaluation of the herbaceous component was also required for all three HSI species. The light mesquite areas sampled contained large stands of prickly pear and bare ground which significantly decreased the value as grassland. Medium mesquite areas contained a fair herbaceous layer with only a few dense stands of prickly pear. In the heavy mesquite areas, very little herbaceous layer was present due mostly to the dense mesquite canopy and the subsequent bare ground and prickly pear found at ground level.

Future Without-Project Condition. The ecosystem is already severely degraded and without restoration the study area would become increasingly so. A report written by Fort Worth District, Reservoir Control Section, predicts O.C. Fisher Lake level to drop to elevation 1852.00 feet MSL, based upon best available data, effectively resulting in no surface water held within the lake bed. The hydrological function of the ecosystem within the study area would be completely removed and the ecosystem would become even more severely degraded. The invasive vegetative species within the study area would continue to expand their range and increase their density across the study area replacing native vegetation and in doing so, the value of the habitat would be consequentially decreased. The high rates of evapotranspiration of invasive brushy species and their phreatophytic characteristics would successfully remove all surface water, including flowing springs, from the ecosystem and drop groundwater levels to points beyond which native vegetation may utilize. Surface water runoff within the study area would quickly be lost below ground to fill the void above fallen groundwater table levels and surface water would not remain for sufficient time in order to provide a positive influence upon the habitat.

As the lake level continues to fall, saltcedar seeds would quickly germinate in the moist soil and saltcedar would eventually colonize all aquatic-lacustrine habitat which currently holds water. Saltcedar would also displace the entire aquatic-riverine habitat in response to receding surface water. Remnant woodland, supported by perennial surface water and high groundwater table levels, would die as the surface water is removed from the ecosystem and groundwater levels supporting them drop. Dense stands of mesquite with prickly pear understory would eventually replace the remnant woodlands. All transitional habitat and habitat where mesquite currently exists within remnant woodland habitat and upper portions of the aquatic-lacustrine habitat, would become heavy mesquite with an understory of prickly pear. All aquatic habitat and riparian woodland habitat within the ecosystem would be effectively lost, 4,101 acres, and replaced with transitional habitats of dense stands of saltcedar at lower elevations and mesquite with prickly pear understory in upper elevations. Existing transitional habitats, 11,758.8 acres, would be increased to 15,859.8 acres. The value of existing habitat condition, 6,434.5 habitat units, is predicted to drop approximately 36% to a value of 2,376.8 habitat units after fifty years

under the future without-project condition**.** Table 6 compares habitat units under future without-project conditions and existing conditions.

TABLE 6. Comparison between Existing and Future Without-project Conditions.

Habitat		Existing Condition			Without Project (50 YRS) Condition		
		Acres	HSI	Habitat Units	Acres	HSI	Habitat Units
Aquatic	Lacustrine/ Lacustine (Dry)	440.3/3,348.4	0.20/0	88.1/0	0	0	0
	Riverine/ Riverine (Dry)	13.3/38.9	0.20/0.05	2.7/1.9	0	0	0
	Riverine-Intermittent	10.3	0.2	2.1	0	0	0
Riparian Woodland	Remnant Woodland (Pecan)	86.2	0.71	61.2	0	0	0
	Remnant Woodland (Hackberry)	2.6	0.71	1.8	0	0	0
	Remnant Woodland (Live Oak)	0.6	0.71	.4	0	0	0
	Black Willow	5.7	0.5	2.9	0	0	0
	Mesquite, Heavy	77.3	0.40	30.9	202.8	.20	40.6
	Mesquite, Medium	9.8	0.35	3.4	0	0	0
	Mesquite, Light	26.3	0.30	7.9	0	0	0
	Willow Baccharis	0.1	0.10	0.01	0	0	0
	Saltcedar	0	0	0	47.0	.10	4.7
	Grass	41.2	.02	0.8	0	0	0
Transitional	Mesquite, Heavy	4,911.2	0.49	2,406.5	15,409.5	.15	2,311.4
	Mesquite, Medium	1,412.2	0.65	917.9	0	0	0
	Mesquite, Light	2,143.0	0.38	814.3	0	0	0
	Saltcedar	0	0	0	200.5	.10	20.1
	Saltcedar/Willow Baccharis	11.6	0.10	1.2	0	0	0
	Willow Baccharis	188.9	0.10	18.9	0	0	0
	Grassland	3,091.9	0.67	2,071.6	0	0	0
Other	Agriculture	687.9	NA	NA	687.9	NA	NA
	Aquatic-Stock Tank	7.9	NA	NA	7.9	NA	NA
	Road ROW	127.9	NA	NA	127.9	NA	NA
	Dam	224.0	NA	NA	224.0	NA	NA
	Urban	6.2	NA	NA	6.2	NA	NA
TOTAL		**16,913.7**	**NA**	**6,434.5**	**16,913.7**	**NA**	**2,376.8**

PLAN FORMULATION

Plan formulation is the process of developing and evaluating alternatives that meet planning objectives and avoid planning constraints. Plans were evaluated on the basis of wildlife habitat units and an incremental cost analysis was performed for each alternative plan. The alternative plan offering cost-effective maximum net benefits will be that which is recommended and will be known as the National Ecosystem Restoration (NER) Plan.

Problems and Opportunities. As described previously, the ecosystem within the study area is severely degraded. The degradation can be summarized as follows:

- Construction of the dam and impoundment of the reservoir destroyed:
  - Riverine habitat
  - Riparian woodlands
  - Prairies and woody vegetation

- The removal of the native vegetation coupled with the failure of the reservoir to reach and maintain the conservation pool and the historical low lake levels lead to the proliferation of invasive, phreatophytic plant species.

- The phreatophytic plant species are responsible for decreased stream-flows and lowered groundwater table level resulting in:
  - Additional degradation to the quantity and quality of aquatic habitats
  - Additional degradation to the quantity and quality of riparian woodland habitats
  - High salinity and turbidity of surface water
  - A cycle of ever-increasing proliferation of phreatophytic plant species as the native aquatic and riparian vegetation dies (from lack of suitable hydrologic influences).

The team identified some potential opportunities. Invasive vegetative species are becoming an ever-increasing problem within the lands surrounding the study area and the region in general. It is important to demonstrate to the public that disturbed lands lost to invasive vegetative species can be restored back to their historical condition. The project area is easily visible by the public due to its proximity to San Angelo and the major highways traversing and adjacent to the project area. A successful project may convince other landowners to restore their land and a region-wide restoration may be sparked.

Education is a prime mission of both ASU and TPWD. A successful project would enable ASU and TPWD to utilize their restored lands as an outdoor classroom and provide a valuable environmental education tool.

Planning Objectives. Planning objectives are an expression of public and professional concerns about the use of water and related land resources resulting from the analysis of existing and future-without project conditions in the study area. The planning objectives for the period of analysis between the years 2005 to 2055 are as follows:

- Increase the quantity and quality of riverine habitat
- Increase the quantity and quality of riparian woodland habitat
- Increase the quantity and quality of lacustrine habitat

Planning Constraints. In development of an ecosystem restoration project, the following constraints were identified to direct plan formulation efforts such that beneficial impacts would be maximized and adverse impacts would be minimized:

- Alternatives will be limited to the study area within the land owned or leased by USACE.
- The formulation of alternatives must avoid adverse impacts to significant ecological resources; and if avoidance is not feasible, then adverse impacts to ecological resources must be minimized. Unavoidable adverse impacts to ecological resources must be mitigated.
- The formulation of alternatives must avoid adverse impacts to significant cultural resources; and if avoidance is not feasible, then adverse impacts to cultural resources must be minimized. Unavoidable adverse impacts to cultural resources must be mitigated.
- The formulation of alternatives should avoid areas that are either known or suspected to be contaminated and/or contain hazardous, toxic, and radioactive waste.
- The recommended plan must avoid adverse impacts to the objectives of Angelo State University and Texas Parks and Wildlife Department.
- The recommended plan must be generally acceptable to the public.
- The recommended plan must have a local non-Federal sponsor.
- Combined Federal expenditures on the planning, design, and implementation of the recommended plan shall not exceed $5.0 million.

Plan Formulation Rationale. Plans are formulated to meet planning objectives and avoid constraints. The following paragraphs discuss the technical, economic, environmental, and social criteria used to develop the formulated alternatives to meet the stated study objectives. In order to develop a plan that would satisfy the primary objective of reducing flood damages and costs within the study area, the following criteria was adopted for use in developing, evaluating, and comparing alternative plans:

- The plan should be effective and efficient with regard to achieving the planning objectives.

- The plan must be technically feasible using engineering methods and equipment available in the study region.
- Plans should be adequate to provide a project life of at least 25 years.
- Existing facilities should be utilized to the maximum extent possible.
- The plan is to be complete within itself and not require additional future improvements other than normal replacements, and operation and maintenance.
- Preserve and/or enhance social, cultural, educational, and aesthetic values as well as historical and cultural attributes of any sites within the project area.
- Promote the development of areas of natural beauty and human enjoyment and protect areas of valuable natural resources.

*** Restoration Alternatives.**

Hydrological Interaction. Restoring the hydrology to the ecosystem is paramount. Due to the connectivity between groundwater and surface water within the study area, groundwater levels must increase in order to increase and sustain surface water necessary to support riparian woodland habitat restoration. In order to increase groundwater levels, reduction and removal of invasive brushy species across the entire study area must be performed. Restoring the hydrology to the ecosystem would significantly benefit the aquatic, riparian, and transitional habitats of the study area.

Transitional habitat plays a key role in the success of the restoration project. Although a groundwater study was not completed, an assumption can be drawn that groundwater within the study area is generally connected based upon available information contained within this report. This connectivity is further suggested by the observation of TPWD staff along Turkey Creek in January 2005. Water was found within the stream bed at and below spring locations, unrelated to a rain event, where it had been previously dry and mesquite within the adjacent area recently entered winter dormancy and dropped their leaves (TPWD 2005).

Transitional habitat would be restored from a shrubland dominated by mesquite to a more historic grassland condition, dominated by native grass and forbs with scattered mottes of native trees and shrubs. The restoration from shrubland to a more historic grassland condition would aid in groundwater recharge. As a shrubland dominated by mesquite, a significant amount of water which percolated into the groundwater is lost to mesquite through evapotranspiration. Because a more historic grassland condition contains significantly less mesquite, significantly more water would remain in the groundwater after percolation into the groundwater. As groundwater levels rise, spring flow into perennial tributaries would result in increased stream flow and duration. The increased stream flow would provide the hydrology necessary to sustain riparian woodland habitat restoration. The increased groundwater level would be within reach of riparian woodland vegetation to sustain it through any extended periods of below average rainfall.

Optimum riparian woodland habitat condition within the study area will consist of 100% tree canopy cover of mature bottomland hardwood trees, predominately pecan (*Carya illinoiensis*), and will include mostly live oak (*Quercus virginiana*), hackberry (*Celtis laevigata*), eastern cottonwood (*Populus deltoides)*, and black willow (*Salix nigra*). Western soapberry (*Sapindus saponaria*), American elm (*Ulmus Americana*), and possibly green ash (*Fraxinus pensylvanica*) may also be present. A full understory consisting of some woody scrub shrub species such as roughleaf dogwood (*Cornus drummondii*), gum bumelia (*Bumelia lanuginose*), yaupon (*Ilex vomitoria*), deciduous holly (*Ilex decidua*), honey mesquite (*Prosopium gladulosa*), and common buttonbush (*Cephalanthus occidentalis*) will exist. Various low-light tolerant woodland grasses and forbs will be prevalent such as Canada wild-rye (*Elymus Canadensis*), inland sea-oats (*Chasmanthium latifolium*), Texas wintergrass (*Stipa leucotricha*), switchgrass (*Panicum virgatum*), eastern gammagrass (*Tripsacum dactyloides*), aster (*Aster spp*.), verbena (*Verbena sp*.), cardinal flower (*Lobelia cardinalis*), goldenrod (*Solidago sp*.), evening primrose (*Oenethera sp*.), and western ironweed (*Vernonia baldwinii*).

Optimum grassland habitat condition within the study area is somewhat variable and dependent upon soil type. It is dominated by 65 to 80% grass canopy cover comprised of a mixture of short, mid-, and tall grass species. These grasslands may include sideoats grama (*Bouteloua curtipendula*), sand dropseed (*Sporobolus cryptandrus*), white tridens (*Tridens albescens*), vine mesquite (*Panicum obtusum*), Wright's threeawn (*Aristida wrightii*), silver bluestem (*Bothriochloa saccharoides*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), Arizona cottontop (*Digitaria californica*), buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsute*), and Hall panicum (*Panicum hallii*). Forbs (aster (*Aster spp*.), Engelmann's daisy (*Engelmannia sp*.), Maximillian sunflower (*Helianthus maximiliana*), verbena (*Verbena sp*.), blazing star (*Liatris punctata*), and Cuman ragweed (*Ambrosia psilostachya*), shrubs (lotebush (*Ziziphus obtusifolia*), Texas almond (*Prunus minutiflora*), *Ephedra antsyphilitica*, and *Condalia sp*.) and prickly pear (*Opuntia sp.*) in varying proportions should represent approximately 5 to 20% canopy cover in scattered areas. Mottes consisting of mesquite, littleleaf sumac (*Rhus microphylla*), sand shinnery oak (*Quercus sinuata*), and Texas oak (*Quercus buckleyi)*) at least five feet tall scattered about the grassland in a mosaic pattern representing approximately five to 15% canopy cover.

Saltcedar Removal. Saltcedar within the study area grows extremely thick, estimated up to 3,000 stems per acre, and limits the methods available for consideration. Several removal methods were considered, including mechanical, chemical and biological means. The preferred method must kill or remove the root crown located approximately 18 inches beneath the ground surface.

Mechanical removal means considered to remove saltcedar included powergrubbing, extraction, excavation, cabling, chaining, root plowing, and hydraulic shearing with herbicide application. The thick growth of the saltcedar stands makes mechanical removal ineffective and inefficient. Mechanical methods would require more than one treatment to ensure the removal of all root crowns, root fragments, and other remnants capable of sprouting, and can be non-selective disturbing roots of desirable herbaceous and woody species. Further, heavy equipment cannot access most of the saltcedar areas because saltcedar is located in lower areas capable of holding

water at or near the surface periodically. Additionally, saltcedar is found within areas where there is a high potential for significant cultural resource sites to be found there. Ground disturbance within these areas would require extensive cultural resource surveys adding additional cost to the removal method. Therefore, mechanical removal was not considered further as a viable means of saltcedar removal.

Hydraulic shearing with herbicide application is also not considered a viable alternative for saltcedar within the study area. Hydraulic shearing is not designed for dense growths of saltcedar and proper herbicide application is not possible, rendering this removal method ineffective.

Conducting a prescribed burn across stands of saltcedar is highly effective at removing the top growth, but it would sprout vigorously from its roots. Additional treatment would then be required and prescribed burning saltcedar is therefore not a viable consideration.

Biological control of saltcedar was also explored. The saltcedar leaf beetle, *Diorhabda elongata*, introduced from northern China and Kazakhstan in central Asia is approved for release by the United States Department of Agriculture-Animal and Plant Health Inspection Service (APHIS). The beetle was rigorously studied to ensure that beetles would not threaten other non-target species. Both adults and larvae feed on the saltcedar leaves and repeated feeding by subsequent generations of beetle larvae is expected to cause dieback and suppress growth. The number of beetles required to make an impact in a timely manner upon such large acreage of saltcedar are unavailable and therefore it cannot be considered a viable alternative for initial control.

The most cost effective method is herbicide application of *Habitat* applied in August or September. To obtain optimum kill rate, saltcedar should remain undisturbed for two years. Due to the dense growth of the saltcedar and difficulty accessing saltcedar stands, ground spraying is not possible and aerial spraying is required.

Herbicide application by rotary-wing aircraft (helicopter) is more effective than herbicide application by fixed-wing aircraft for several reasons. Helicopters fly at a much slower air speed enabling accurate application to non-linear populations of saltcedar, especially beneficial along tributaries. Helicopters have much less spray pattern distortion during turns than fixed-wing aircraft, and are equipped with special booms that deliver the herbicide in larger droplet sizes, preventing the danger of spray drift that fixed-wing aircraft possess.

Approximately 1,310.1 acres will require saltcedar removal. A secondary treatment, biological control by releasing of the saltcedar leaf beetle, would occur three years after initial treatment to control any existing stands and prevent future saltcedar expansion.

Willow Baccharis Reduction. Willow baccharis is very similar to saltcedar in its growth habit within the study area, growing dense stands up to 3,000 stems per acre, although it does not grow as tall. The same comparison results are drawn. Alternatives considered for removal of willow baccharis included mechanical removal, prescribed burn and herbicide application. For the same reasons as saltcedar, removal of willow baccharis through mechanical means and

prescribed burning is ineffective and requires additional treatments. Therefore, mechanical means and prescribed burning were not considered viable alternatives.

Like saltcedar, the most cost efficient means is herbicide application, and it must be done from the air due to dense growth and the difficulty accessing the willow baccharis stands. Again, due to the non-linear growth of the willow baccharis stands, rotary-wing aircraft (helicopter) more effectively applies herbicide. Herbicide application of *Weedmaster* herbicide in spring, with one year non-disturbance, is over 90% successful. Approximately 2,257.7 acres will require removal. An additional individual plant spray treatment will be required two years after initial treatment.

Mesquite Reduction. Eradication of mesquite is not the intent of the restoration project. The intent of the proposed project is to reduce the dense monoculture stands to a more historical condition in order to restore the hydrological regime and historical vegetative diversity.

Mesquite possess a root crown approximately 18 inches underground that must be killed or removed in order to successfully kill the mesquite. Several alternatives available for removal of mesquite were investigated. Alternatives considered for mesquite removal included several mechanical methods, herbicide application, and prescribed burning. Prescribed burning is not effective upon mature mesquite plants, those greater in age than a few years. Mesquite trees within the study area are predominately very mature trees and fire is not a viable alternative for initial removal of mesquite.

Herbicide application is an effective means of removing mesquite. Due to the vast acreage, density, height of the mesquite and the terrain, herbicide application through individual plant treatment is not feasible for consideration. The only feasible alternative for herbicide application within the study area is aerial application. Aerial herbicide (fixed wing) application can result in significant vapor drift during application and the herbicide has been documented to kill agricultural crops, especially cotton, and other desirable vegetation within vapor drift areas. Helicopter aerial herbicide application will reduce vapor drift, but due to the nature of the herbicide and application requirements it cannot be reduced significantly. There are residential areas and businesses adjacent to mesquite areas and vapor drift is a major concern. Due to the serious consequences of vapor drift, aerial herbicide application was not considered further.

Mechanical removal methods considered were powergrubbing, extraction, excavation, chaining/cabling, root plowing, and hydraulic shearing with herbicide application. Effectiveness of all mechanical removal methods were comparable, 85% and above when performed properly. Chaining/cabling is only effective for removing trees 4 to 18 inches in diameter. It is also very non-selective and impacts desirable woody vegetation. Due to its limited use on specific sizes of mesquite and its non-selectivity, chaining/cabling was not considered a viable alternative.

Powergrubbing is probably the next least effective means of mesquite removal, but it can be fairly effective with a good operator and good ground conditions. It is very selective, but not as selective as the most selective methods, excavation and extraction. As compared to excavation and extraction, powergrubbing disturbs a much greater area because the dozer must push the mesquite out of the ground creating an entrance and an exit trench, totaling approximately 8 feet

in length and at least 2 feet wide, and the dozer must also travel to each mesquite in order to remove it, creating further ground and desirable vegetation disturbance. Follow-up treatments to remove the mesquites not initially removed is also required. Powergrubbing was removed as an alternative because it was not one of the most cost effective alternatives.

Root plowing creates the most ground disturbance of all the mechanical removal means, but it may be the most effective method. However, root plowing is an entirely non-selective removal method severing all roots within the path of the blade, including desirable herbaceous and woody species and the areas would require extensive reseeding and planting.

The impact of root plowing upon cultural resources within the removal areas is also a major consideration. Although mechanical removal would be performed in areas receiving cultural resource clearance from State Historical Preservation Office, there may be a possibility that an area may contain an unknown cultural resource site and if the site is contained within the root plow depth, the site would be severely negatively impacted. Taking into consideration the vegetative destruction of desirable species, extensive restoration cost and potential for damaging unknown cultural resource sites, root plowing was removed from further consideration as a viable alternative. In some limited areas, less than an estimated 300 acres, mesquite is growing as a monoculture less than 2 feet apart and root plowing is the best solution. The State Historical Preservation Office will be consulted prior to root plowing. Cost estimate is $70 per acre, including root plowing, raking and seed planting.

Hydraulic shearing with herbicide application is highly selective and can be highly effective, up to 90%, but its effectiveness is dependent upon the care exercised when applying the herbicide. . The ground immediately adjacent to the trunk of the mesquite is left undisturbed. Hydraulic shearing with herbicide application is considered a viable alternative. Due to its high effectiveness and minimal ground disturbance, hydraulic shearing with herbicide application would be performed in known and high potential archaeological areas, with SHPO's clearance. Estimated cost is $75 per acre for light density, $100 per acre for medium density, and $125 per acre for heavy density.

Excavation and extraction are two very similar methods that offer the highest effectiveness and are highly selective. Only plants growing immediately adjacent to the mesquite, up to 3 feet from the trunk, are detrimentally affected. Both methods are considered about 95% effective.

Excavation and extraction secondarily generate desirable environmental benefit. The methods creates small holes after mesquite is removed. Holes left are approximately three to four feet wide, sloping from the edge to about 18 inches deep in the middle. These holes would serve to retain water during rain events and hold moisture for longer periods of time than is possible on flat, undisturbed areas. This is a vital component to maintaining desirable grass and forb species under the dry and hot summer conditions the study area experiences.

Estimated cost for mesquite removal using an excavator is $75 per acre for light density, $100 per acre for medium density, and $125 per acre for heavy density. Heavy density mesquite areas within the ASU portion of the study area will require additional raking into piles, estimated at $30 per acre, because mesquite is so thick and large that leaving the removed mesquite on the

ground would create safety concerns for outdoor classroom activities, recreation, and livestock. Initial mesquite treatment of 8,729.9 acres using an excavator is estimated at a total cost of $945,263. Estimated cost for mesquite removal using an extractor is $200 per acre for light density, $600 per acre for medium density, and $800 per acre for heavy density. Initial mesquite treatment of 8,729.9 acres using an extractor is estimated at a total cost of $5,376,740.

Additional individual plant spray treatment at $50 per acre two years after initial treatment may also be required at a total cost of $436,495.

Prickly Pear Reduction. In order to sustain the restoration project, grass must be restored in sufficient densities to allow for prescribed fire to carry across the landscape and aid in preventing woody vegetation encroachment, especially mesquite and willow baccharis. Dense prickly pear does not carry fire well and would decrease effectiveness of prescribed fire.

All mechanical removal means for prickly pear were removed as an alternative for consideration because it would be too costly to conduct the mechanical removal and dispose of the removed prickly pear so as to prevent prickly pear pads from setting roots after removal.

Herbicide application is the only viable alternative for prickly pear removal. Individual plant spray treatment is not practical because of difficulty gaining access to all prickly pear infested areas. Therefore, herbicide application through individual plant spray treatment was removed as an alternative for consideration.

Herbicide (aerial) application is the most viable alternative for prickly pear removal because of the dense growth and difficulty accessing the prickly pear infested areas. As large acreages of mesquite are removed, large dense stands of prickly pear would be sprayed by fixed wing using *Surmount* herbicide. Helicopter application was removed from consideration because it would be significantly more expensive with no added habitat benefits as compared to fixed wing applications. Once treated, these stands would be left undisturbed for a minimum of two years to increase herbicide effectiveness. Estimated acreage requiring treatment is 9,194.8 acres. No further herbicide application is anticipated.

Vegetative Plantings (Reforestation). After removal of invasive vegetative species from degraded riparian woodland habitat (113.5 acres) along the North Concho River, Pott Creek and Turkey Creek, native tree and shrub species would be planted after sufficient hydrology has been restored to the tributaries to sustain riparian woodland habitat restoration. Grasslands within the riparian woodland habitat (41.2 acres) would also be planted. Black willow riparian habitat along the North Concho River would not be included in the reforestation. No restorative measures would be performed within remnant woodland habitat.

Three scales were considered for native tree and shrub planting within degraded riparian woodland areas and grasslands within riparian woodland habitat are included below. All scales include planting vegetation of various sizes to create a beneficial layering effect within the riparian woodland habitat as much as possible. All containerized trees would be maintained for a period of two years to increase survivability rate.

1) 40 one-inch caliper containerized trees, 20 one-gallon shrubs, and 150 tree seedlings per acre
2) 10 one-inch caliper containerized trees, 10 one-gallon shrubs, and 200 tree seedlings per acre
3) 300 tree and shrub seedlings per acre

After removal of invasive vegetative species from black willow degraded riparian woodland habitat (5.7 acres) along the North Concho River, native tree and shrub species would be planted after sufficient hydrology has been restored to sustain riparian woodland restoration. Two scales considered for native tree and shrub planting within black willow degraded riparian woodland habitat along the North Concho River are included below.

1) 10 one-inch caliper containerized trees, 5 one-gallon shrubs, and 100 seedlings per acre
2) 150 tree and shrub seedlings per acre

Riparian Area Fencing. Cattle and bison are present within the study area and are not desirable within riparian woodland habitat. Fencing would be installed to prevent cattle access to the North Concho River, Pott Creek and Turkey Creek and adjacent riparian woodland habitat. Additional cross fencing may be necessary in other areas as well to ensure proper rotation of livestock and to restrict livestock access to lacustrine habitat whereby access to riparian woodland habitat could be gained. Approximately 28.2 miles of fence would be required. Additional scales are not considered because cattle and bison must be prevented from entering riparian woodland habitat.

Grasses/Forbs Seeds. In areas where mesquite was removed through excavation, the soil surface will contain numerous shallow holes lacking vegetation for short period of time. To aid in establishing vegetation within these disturbed area, sowing native grass and forb seeds was considered. Upon further investigation, it was determined that only a short term habitat benefit would be realized as compared to relying upon existing seed source to revegetate these areas. Additionally, timely rainfall is necessary for successful germination. Considering these factors and the cost, sowing native grass and forb seeds was not considered further.

Prescribed Burning. Fire would be returned to the ecosystem to allow it to play its natural role in sustaining the ecosystem. As invasive brushy species are removed from the system, grass would dominate and provide the fuel necessary to successfully conduct prescribed burns and prevent encroachment of invasive brushy species and prickly pear. Prescribed burns would take place on a rotational basis every four to seven years to sustain the project as fuel loads allow. For the purpose of plan formulation), prescribed burns would take place in Year 5 and every four years thereafter (vegetative condition will dictate time intervals).

Cost Effectiveness / Incremental Cost Analysis. The U.S. Army Corps of Engineers, Institute for Water Resources developed the software used to conduct Cost Effectiveness / Incremental Cost Analysis (CE/ICA) (IWR-PLAN Version 3.3). IWR-PLAN has been used to evaluate all solutions using average annual habitat unit (AAHU) gains versus average annual costs (AAC). The analyses require three types of data: solutions, estimates of each solution's output, and estimates of each solution's cost.

The plan formulation capabilities of IWR-PLAN were utilized to perform the CE/ICA for this study. The plan formulation function builds combinations of solutions based upon a set of relationships established by the user. The various combinations (plans) are compared, incrementally, to determine those which are cost-effective. The program then compares the cost-effective plans to determine which plans provide the greatest incremental AAHU gains for the incremental AAC expended; these are the "best-buy" plans. The solutions used for the analysis and their relationships to each other are shown in Table 7. The following sections describe the specific inputs into IWR-PLAN, and the outputs generated by IWR-PLAN.

TABLE 7. Solutions and Relationships Used to Conduct the CE/ICA.

Code	Solution	Relationships
A	Invasive removal - mesquite by extractor	Not combinable with B or C
B	Invasive removal - mesquite by excavator	Not combinable with A or C
C	Invasive removal - mesquite by hydrashear	Not combinable with A or B
D	Reforestation of non-black willow riparian habitat after mesquite removal by excavator or extractor	Dependent on A or B
E	Reforestation of non-black willow riparian habitat after mesquite removal by hydrashear	Dependent on C
F	Enhancement of black willow riparian habitat	Dependent on A or B or C

Costs of Alternatives. Implementation costs were developed for chemical and mechanical removal of invasive vegetative species along with individual plant follow-up treatments, reforestation of riparian corridors, riparian fencing, and prescribed burning. The development of these costs is described briefly below. Most unit costs were based upon industry standards, discussions with manufacturers and material providers, and experience with recent projects. For evaluation purposes, it was necessary to refer to a specific effective herbicide. Prior to implementation of the restoration project, other herbicides demonstrating similar characteristics will be considered.

Saltcedar, Willow Baccharis, and Prickly Pear Removal/Reduction by Aerial Herbicide Application. Estimated costs were developed for herbicide applications to remove stands of saltcedar, willow baccharis, and prickly pear. Cost estimates for removal of saltcedar were based on materials, labor, and equipment required for a helicopter application of *Habitat* herbicide (estimated at $200 per acre and a total initial treatment cost of $262,020). Secondary biological control treatment using the saltcedar leaf beetle is estimated at $15 per acre and a total cost estimate of $19,651. Material, labor, and equipment cost for helicopter application of *Weedmaster* herbicide was used to calculate the initial cost of willow baccharis reduction (estimated $75 per acre and a total initial treatment cost estimate of $169,327) and subsequent

follow-up treatment (estimated at $25 per acre and a total cost estimate of $56,442). The cost associated with aerial spraying *Surmount* by a fixed-wing aircraft (estimated at $26 per acre and a total cost estimate of $239,064) was used in calculating the implementation cost of prickly pear control. The cost associated with one follow-up treatment by prescribed burning was included in the first cost for saltcedar removal, willow baccharis reduction, and prickly pear reduction. Additionally, materials, labor, and equipment costs for installing a 5-wire livestock fence along riparian woodland areas (estimated at $6,000 per mile and a total estimated cost of $169,200) was included in the implementation costs. Operation and maintenance costs for all areas of mesquite, willow baccharis, and prickly pear removal were calculated using the cost associated with performing a prescribed burn on a 4-year interval. The cost estimate for conducting initial prescribed burn is estimated at $46,500, including firelane construction. Subsequent prescribed burns are estimated lower, $23,600 (prorated at $5,900 per year), because firelanes will only require maintenance.

Mechanical Removal of Mesquite. Cost estimates were developed for three types of mechanical removal; hydrashear, extractor, and excavator for the cost effectiveness analysis. The cost of materials, labor, and equipment were used in the estimation of implementation cost for each method. Cost estimates for specific mechanical removal method are contained in Table 8 below.

TABLE 8. Estimated Mesquite Removal Method Costs.

Removal Method	Light Density		Medium Density		Heavy Density		Total Cost
	Per Acre Cost	Total Cost	Per Acre Cost	Total Cost	Per Acre Cost	Total Cost	
Hydraulic Shearing w/ Herbicide Application	$ 75	$164,768	$ 100	$144,520	$ 125	$ 635,976	$ 945,264
Extractor	$ 200	$439,380	$ 600	$867,120	$ 800	$4,070,240	$5,376,740
Excavator	$ 75	$164,768	$ 100	$144,520	$ 125	$ 635,976	$ 945,264

For the purpose of the IWR-PLAN, additional costs were compiled with the first cost for each mesquite removal method costs. These additional costs include root plowing, raking and seeding of 300 acres within ASU lease (estimated at $70 per acre and a total estimated cost of $21,000), installing a 5-wire livestock fence (estimated at $6,000 per mile and a total estimated cost of $169,200) along riparian woodland areas, and a one-time follow-up with individual plant herbicide treatment (estimated at $50 per acre and a total estimated cost of $436,495), and a one-time follow-up application of prescribed burning within mesquite removal areas outside riparian woodland areas.

Costs associated with operation and maintenance included prescribed burning on a 4-year interval. The cost estimate for conducting initial prescribed burn is estimated at $46,500,

including firelane construction. Subsequent prescribed burns are estimated lower, $23,600 (prorated at $5,900 per year), because firelanes will only require maintenance.

Reforestation. Costs were developed for three scales of planting within degraded riparian woodlands, excluding black willow areas. Planting costs included herbicide treatment of individual planting sites, materials, labor, and equipment. The first cost for a planting scale was multiplied by a percentage to calculate the replacement costs for that given planting scale. For scale 1, the replacement costs were assumed to be 15% of the first cost for that scale; 10% of the first cost for scale 2 was used to calculate replacement, and 5% of first costs were assumed to cover replacement for scale 3. Cost for planting 40 one-inch caliper containerized trees, 20 one-gallon shrubs, and 150 tree seedlings is estimated at $9,000 per acre and a total estimated cost of $1,392,300. Cost for planting 10 one-inch caliper containerized trees, 10 one-gallon shrubs, and 200 tree seedlings is estimated at $5,750 per acre and a total estimated cost of $889,525. Cost for planting 300 tree and shrub seedlings is $3,000 per acre and a total estimated cost of $464,100.

Enhancement. Costs were developed for two scales of planting within degraded riparian woodlands containing black willow. Planting costs included herbicide treatment of individual planting sites, materials, labor, and equipment. The first cost for a planting scale was multiplied by a percentage to calculate the replacement costs for that given planting scale. Replacement costs were assumed to be 15% and 12% of first costs for scale 1 and scale 2, respectively. Cost for planting 10 one-inch caliper containerized trees, 5 one-gallon shrubs, and 100 seedlings is estimated at $2,875 per acre and a total estimated cost of $16,100. Cost for planting 150 tree and shrub seedlings is estimated at $1,500 per acre and a total estimated cost of $8,400.

Alternative Plan Outputs. Existing, future without-project, and future with-project environmental outputs were established for four broad habitat types: riparian, riverine, lacustrine, and transitional. However, for the purposes of identifying the NER Plan only the benefits associated with the riparian and riverine habitats were used in the CE/ICA. The benefits gained to the lacustrine and transitional habitats as a result of implementing invasive vegetative species removal were examined as secondary benefits to each "best buy" plan identified by IWR-PLAN.

Using the habitat evaluation methodology, HSI values were assigned for each period of analysis to the various vegetative cover types contained within a habitat based upon their existing condition, their response to assumed future without-project conditions, and their assumed response to incremental implementation of the solutions identified in Table 9. Using the acreage and HSI values, the average annual habitat units (AAHUs) were calculated for the future with-project condition of each solution. Additionally, AAHUs were calculated for the future without-project condition to allow comparison of the true benefits gained by implementation of any of the solutions.

Table 9 displays the future without-project condition and all other solutions with their corresponding IWR-PLAN code, AAHUs and AAC which were used in the CE/ICA. These values were input to IWR-PLAN with their corresponding relationships described in Table 7.

TABLE 9. Acres, Average Annual Habitat Units, and Average Annual Costs for Ecosystem Restoration Solutions.

Code	Solution	Acre	AAHU	AAC	AAC/AAHU
A1	Invasive removal - mesquite by extractor	15,859.80	172.0	$452,379	$ 2,630
B1	Invasive removal - mesquite by excavator	15,859.80	172.0	$166,062	$ 965
C1	Invasive removal - mesquite by hydroshear	15,859.80	171.0	$166,062	$ 971
D1	Reforestation of non-black willow riparian habitat after mesquite removal by excavator or extractor; Option 1	154.70	48.0	$ 94,133	$ 1,961
D2	Reforestation of non-black willow riparian habitat after mesquite removal by excavator or extractor; Option 2	154.70	46.0	$ 59,251	$ 1,288
D3	Reforestation of non-black willow riparian habitat after mesquite removal by excavator or extractor; Option 3	154.70	45.0	$ 30,450	$ 677
E1	Reforestation of non-black willow riparian habitat after mesquite removal by hydrashear; Option 1	154.70	45.0	$ 94,133	$ 2,092
E2	Reforestation of non-black willow riparian habitat after mesquite removal by hydrashear; Option 2	154.70	40.0	$ 59,251	$ 1,481
E3	Reforestation of non-black willow riparian habitat after mesquite removal by hydrashear; Option 3	154.70	45.0	$ 30,450	$ 677
F1	Enhancement of black willow riparian habitat; Option 1	5.70	0.5	$ 1,089	$ 178
F2	Enhancement of black willow riparian habitat; Option 2	5.70	0.3	$ 563	$ 1,877

NOTE: Future without-project yields 96.0 AAHUs.

CE/ICA Results. Based upon the relationship constraints, of a possible 384 combinations there were 37 actual combinations examined for cost-effectiveness. Thirteen of the 37 were determined to be cost effective, and five of those plans were carried forward to the best-buy array. The AAHU, AAC, and Average Cost per AAHU for cost-effective plans are displayed in Table 10 using their corresponding codes from Table 9. The best-buy plans are differentiated with an asterisk (*) and their incremental cost, incremental cost, and incremental cost per output are also shown. Figure 7 is a graphical representation of the best-buy array. All scales of riparian habitat reforestation and black willow riparian habitat enhancement were identified as cost-effective. Of the three methods of removing invasive mesquite, only the excavator method

was identified as being cost-effective. Therefore, all cost-effective and best-buy plans are combinations of the saltcedar removal, willow baccharis reduction, and prickly pear reduction by aerial herbicide application, mesquite removal by excavator, one of three scales of riparian habitat reforestation, one of two scales of black willow riparian habitat enhancement.

TABLE 10. Cost-effective and Best-buy Plan Array from CE/ICA.

Plan Combination	AAHU	AAC	Average Cost per AAHU	Incremental Cost ($)	Incremental Output	Incremental Cost per Incremental Output
*B0-D0-F0	96.00	0.00	0.00	0.00	96.00	0.00
B1-D0-F0	268.00	166,062	619.63	---	---	---
B1-D0-F2	268.30	166,625	621.04	---	---	---
B1-D0-F1	268.50	167,151	622.54			
*B1-D3-F0	313.00	196,512	627.83	196,512	217.00	905.58
*B1-D3-F2	313.30	197,075	629.03	563	0.30	1,876.667
*B1-D3-F1	313.50	197,601	630.31	526	0.20	2,630.00
B1-D2-F0	314.00	225,313	717.56	---	---	---
B1-D2-F2	314.30	225,876	718.66	---	---	---
B1-D2-F1	314.50	226,402	719.88	---	---	---
B1-D1-F0	316.00	260,195	823.40	---	---	---
B1-D1-F2	316.30	260,758	824.40	---	---	---
*B1-D1-F1	316.50	261,284	825.54	63,683.00	3.00	21,227.67

* Best-buy Plan

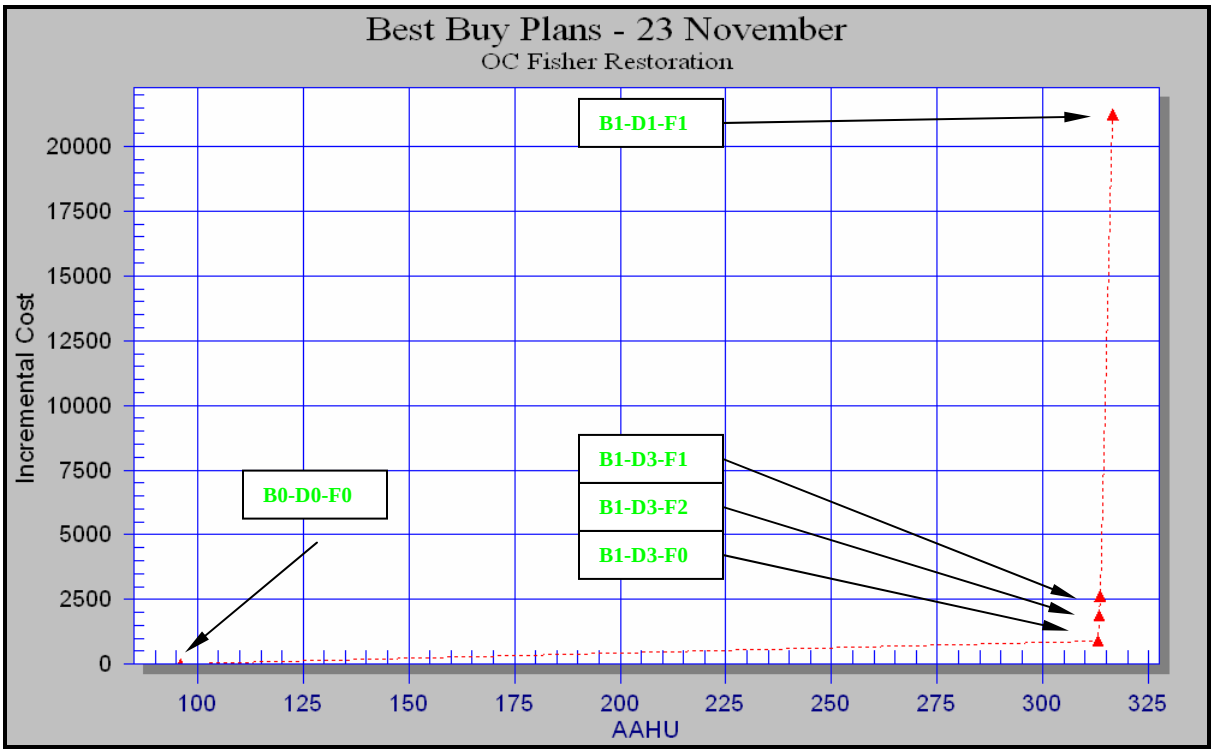


FIGURE 7. Best-buy Plan Array.

Identification of National Ecosystem Restoration Plan. The National Ecosystem Restoration (NER) plan would be selected from the best-buy plans listed in Figure 7. The CE/ICA identified five best-buy plans in the final array. The plans were evaluated with respect to the Corps ecosystem restoration mission, the study planning objectives, total habitat gains, incremental cost per incremental output gained, total project cost, level of support, and significance of habitat outputs. The following paragraphs provide justification for each incremental increase in cost associated with each incremental increase of output ultimately leading to the identification of the NER plan.

B0-D0-F0 - Plan 1. This combination represents the no-action or future without-project conditions. The no action plan was eliminated from consideration as the NER plan. Under the no-action plan, invasive vegetative species would continue to proliferate, and the aquatic and riparian habitats would continue to degrade. The no-action plan has an average annual output of 96.0 habitat units.

B1-D3-F0 - Plan 2. There are two increments isolated in this combination over the no-action plan. These increments include removal of all invasive vegetative species using chemical and mechanical means, and reforestation of the riparian zone with 300 seedlings per acre. Saltcedar, willow baccharis, and prickly pear would be removed/reduced using aerial applications of herbicide, and mesquite density would be reduced throughout the study area by removing individual specimens using an excavator. Removal or reduction of these non-native and native species would meet most of the stated objectives, and represents a substantial habitat improvement over the without-project condition. Perhaps the most significant improvement

provided by invasive brushy species removal or reduction is the increases to the water resources of the study area. A reduction in the number of phreatophytic species on the landscape would increase the amount of water which would percolate through the soil thus increasing the amount of groundwater available to increase in-stream baseflows for the riverine habitats. Additionally, removing the invasive brushy species would redistribute the available water for native riparian and transitional plant species, thus increasing the species diversity for those habitats.

Reforestation of riparian habitat along the riverine system is another component of this plan. A functioning riparian corridor functions as a donor of nutrients, water, and sediment. The riparian vegetation also serves a regulator of light and temperature for the adjacent stream and serves as a vital link between the aquatic ecosystem and the upland ecosystem. Providing a contiguous block of habitat, including aquatic, riparian, and transitional habitats, allows wildlife species to meet their spatial and temporal life requisites. Inclusion of the riparian reforestation helps to meet the stated objectives for restoration within the study area.

This best-buy plan provides an average of 313.00 habitat units annually; this is an increase of 217.00 average annual habitat units over the future without-project condition at a cost $905.56 per habitat unit gained.

B1-D3-F2 - Plan 3. The incremental increase in output and cost isolated for this plan is the measure of enhancement of the black willow riparian habitat with 150 seedlings per acre. Implementation of this plan would address all the degradation within the study area. The black willow riparian habitat are the smallest and least degraded habitats. There are currently 5.7 acres of black willow riparian habitat that is providing 2.9 habitat units under the existing condition. Under the future without-project condition, these habitats would continue to degrade, and in year 50 it is expected they would be providing only 0.57 habitat units. Assuming the previous plan were implemented, which does not include enhancement for these black willow areas, the average annual habitat unit output would increase over the future without-project condition assuming the proper vegetative species are recruited into the various strata of the riparian habitat. However, reforestation of these areas provides insurance that the proper species fill the available niches, thus providing a more sustainable and functioning ecosystem throughout the study area.

This increment provides an average of 313.30 habitat units annually, which is 0.30 average annual habitat units over the previous best-buy plan. The incremental increase in average annual cost to implement this plan over the previous plan is $563 and would raise the incremental cost per incremental output by approximately $971.08 annually.

B1-D3-F1 - Plan 4. This best-buy plan includes the invasive vegetative species removal, riparian habitat reforestation, and black willow riparian habitat enhancement components of the previous plan. The incremental increases for this combination are due to changes in the planting pallet for the black willow areas. The black willow riparian habitat would be planted with 10 1"-caliper trees, 5 1-gallon shrubs, and 100 seedlings per acre. Providing larger, more mature specimens allows the habitat to begin functioning at a higher level earlier in the analysis period. The result is an increase in the average annual habitat units provided.

This increment provides an average of 313.50 habitat units annually, which is an increase of 0.20 over the previous best-buy plan. The incremental increase in average annual cost to implement this plan over the previous plan is $526.00 and would raise the incremental cost per incremental output by approximately $753.33 annually.

B1-D1-F1 - Plan 5. This best-buy combination changes the previous plan's planting pallet for the riparian habitat to planting 40 1"-caliper trees, 20 1-gallon shrubs, and 150 seedlings per acre; thus, this plan greatly increases the number of large, more mature trees and shrubs which would be present in the early years of analysis. The resulting increase in average annual habitat unit output is 3.0 over the previous plan. The incremental increase in average annual cost to implement this plan over the previous plan is $63,683.00 and would raise the incremental cost per incremental output by approximately $18,597.67.

Plan Selection

Plans 4 and 5 provide incrementally higher AAHUs than Plan 3, but these increases are attributable to beginning the analysis period for the reforestation measure with slightly more mature vegetation. Plan 3 begins the analysis period with all seedlings, while the other plans have varying densities of larger trees mixed in with the seedlings. Because of growth differences between seedlings and older vegetation, the seedlings would begin providing the same outputs as the larger vegetation by year 15 of the 50-year analysis period. Because the higher outputs provided by Plans 4 and 5 actually occur only during the early maturation stages of the restoration, but increase the cost per output substantially over Plan 3, it was determined that outputs provided were not worth the costs for Plans 4 and 5. Identification of the NER Plan then centers on Plan 2 and Plan 3. Plan 2 provides most of the habitat units and meets most all of the planning objectives established for the study area. However, implementation of Plan 2 would leave 5.7 acres of riparian habitat to recover on its own. The dominant vegetation on these 5.7 acres is currently black willow, an appropriate and desirable riparian tree species. However, the area currently does not provide a diversity of vegetative species required for a fully functioning riparian zone. The increment provided by Plan 3 would allow planting a diversity of tree species in the black willow riparian habitat, thus insuring the proper vegetative species would occupy the site, and therefore, providing a greater sustainability and functionality to the entire aquatic ecosystem of the study area. It was determined that the 0.20 AAHUs gained by Plan 3 over Plan 2 were worth the incremental increase of $526 annually.

Based upon the analysis described above, Plan 3 has been identified as the NER Plan. Plan 3 provides a comprehensive and balanced restoration of lost riverine and riparian habitats than any other plan evaluated during plan formulation. The cost of implementing this plan is justified based upon the significant outputs it provides to the aquatic ecosystem of the North Concho River. These outputs include significant increases in the quality and quantity of scarce aquatic and riparian habitats in the project area, and are technically and institutionally significant. Restoration of these habitats is considered of great ecological importance to the City of San Angelo, the state of Texas, and the Nation.

* RECOMMENDED NER PLAN

To successfully restore the ecosystem and gain optimum riparian habitat benefits, adequate hydrology is required along the North Concho River, Pott Creek and Turkey Creek. It is anticipated that this will be achieved through near average rainfall, stream flow along North Concho River into the study area derived in response to state brush control program and the removal of invasive brushy species within the study area to a more historical vegetative condition. Groundwater table levels within the study area will rise and increase spring flows benefiting stream flows of the tributaries within the study area.

Description. The recommended restoration plan is the NER Plan. The plan includes removal of saltcedar and reduction of mesquite, willow baccharis and prickly pear. The plan also includes native tree and shrub plantings within degraded riparian woodlands (154.7 acres with 300 seedlings planted per acre) and black willow riparian habitat (5.7 acres and 150 seedlings per acre). After full implementation of the recommended restoration plan, the five existing habitat classifications (aquatic-lacustrine, aquatic-riverine, aquatic-riverine-intermittent, riparian woodland and transitional) will be significantly improved by restoring the biological integrity, diversity and stability of the ecosystem within lands owned by USACE at O.C. Fisher Lake. It is recognized that existing leases with ASU and TPWD are in effect, and will remain so. The restoration plan will not negatively affect these leases; the purposes are highly compatible. Cultivated lands and any research lands not compatible with the restoration project, comprising approximately 611 acres, are excluded from the restoration project. Existing grazing programs will remain in effect as specified in existing leases, except as excluded from riparian woodland habitat.

Figure 6 provides a depiction of the habitat classification as the resulting from implementation of the recommended restoration plan. Table 11 provides a comparison between existing condition, with-project condition and without-project condition.

TABLE 11. Comparison between Existing, Future With-project, and Future Without-project Conditions.

Habitat		Existing			With Project (50 YRS)			Without Project (50 YRS)		
		Acres	HSI	Habitat Units	Acres	HSI	Habitat Units	Acres	HSI	Habitat Units
Aquatic	Lacustrine/ Lacustine (Dry)	440.3/ 3,348.4	0.20/ 0	88.1/ 0	3,788.7	.85	3,220.4	0	0	0
	Riverine/ Riverine (Dry)	13.3/ 38.9	0.20/ 0.05	2.7/ 1.9	52.2	.92	48.0	0	0	0
	Riverine-Intermittent	10.3	0.2	2.1	10.3	.92	9.5	0	0	0
Riparian Woodland	Remnant Woodland (Pecan)	86.2	0.71	61.2	86.2	.95	81.9	0	0	0
					154.7	.92	142.3			
	Remnant Woodland (Hackberry)	2.6	0.71	1.8	2.6	.95	2.5	0	0	0
	Remnant Woodland (Live Oak)	0.6	0.71	.4	0.6	.95	.6	0	0	0
	Black Willow	5.7	0.5	2.9	5.7	.95	5.4	0	0	0
	Mesquite, Heavy	77.3	0.40	30.9	0	0	0	202.8	.20	40.6
	Mesquite, Medium	9.8	0.35	3.4	0	0	0	0	0	0
	Mesquite, Light	26.3	0.30	7.9	0	0	0	0	0	0
	Willow Baccharis	0.1	0.10	0.01	0	0	0	0	0	0
	Saltcedar	0	0	0	0	0	0	47.0	.10	4.7
	Grass	41.2	.02	0.8	0	0	0	0	0	0
Transitional	Mesquite, Heavy	4,911.2	0.49	2,406.5	0	0	0	15,409.5	.15	2,311.4
	Mesquite, Medium	1,412.2	0.65	917.9	0	0	0	0	0	0
	Mesquite, Light	2,143.0	0.38	814.3	0	0	0	0	0	0
	Saltcedar	0	0	0	0	0	0	200.5	.10	20.1
	Saltcedar/Willow Baccharis	11.6	0.10	1.2	0	0	0	0	0	0
	Willow Baccharis	188.9	0.10	18.9	0	0	0	0	0	0
	Grassland	3,091.9	0.67	2,071.6	11,758.8	.9	10,582.9	0	0	0
Other	Agriculture	687.9	NA	NA	687.9	NA	NA	687.9	NA	NA
	Aquatic-Stock Tank	7.9	NA	NA	7.9	NA	NA	7.9	NA	NA
	Road ROW	127.9	NA	NA	127.9	NA	NA	127.9	NA	NA
	Dam	224.0	NA	NA	224.0	NA	NA	224.0	NA	NA
	Urban	6.2	NA	NA	6.2	NA	NA	6.2	NA	NA
	TOTAL	16,913.7	NA	6,434.5	16,913.7	NA	14,093.5	16,913.7	NA	2,376.8

Removal and reduction of invasive brushy species within the study area would restore the vital hydrology component necessary to sustain the restored ecosystem. Moisture lost from high evapotranspiration rates of invasive brushy species would be retained within the ecosystem, allowing groundwater level to rise, springs to flow, and perennial surface water to significantly

increase. Base flows and perennial surface water would be restored to the North Concho River, Pott Creek and Turkey Creek. The lake level is predicted to rise a result of restored base flows. The quantity of aquatic habitat would increase substantially. The perennial tributaries, including the North Concho River, Pott Creek and Turkey Creek, would increase four times the present acreage of 13.3 acres to 52.2 acres. Areas within aquatic riverine-intermittent habitat would not only increase acreage containing periodic surface water, but increase the duration of time surface water is present.

Aquatic habitat value would increase significantly in response to increased surface water. Lacustrine and riverine habitat would become contiguous and increased base flows would significantly improve dissolved oxygen levels, lower high summer water temperatures and stabilize fluctuating water temperatures. Additional water quality benefits include reduced chloride levels from the removal of saltcedar and decreased amounts of suspended sediment due to reduced erosion resulting from increased vegetative groundcover. Aquatic plant diversity would increase and aquatic vegetation would grow in a healthier, more vigorous state benefiting aquatic organisms. Overall, aquatic habitat condition would increase from existing 94.8 habitat units to 3,277.9 habitat units.

Restoring the perennial surface water along the North Concho River, Pott Creek and Turkey Creek would halt the progressive degradation of existing remnant woodlands of pecan, hackberry and live oak. Degraded riparian woodlands presently dominated with mesquite, willow baccharis, and grass would be restored to a more historical condition through plantings of native trees and shrubs producing a desirable 100% tree canopy cover with a diverse understory of shrubs and herbaceous plants. Existing desirable remnant riparian woodland habitat, 89.4 acres, would be conserved and 160.4 acres of degraded riparian woodland habitat would be restored to desirable habitat. Overall, riparian woodland habitat would increase from existing 109.3 habitat units to 232.7 habitat units.

Transitional habitat condition would be improved from existing condition supporting 6,230.4 habitat units to a condition supporting 10,582.9 habitat units. Transitional habitat within the study area that is critical to the hydrological regime of the ecosystem would also improve significantly.

Habitat value would more than double that of existing conditions. As compared to without-project conditions, overall habitat value would increase 2.7 times. With full implementation of the recommended plan, perennial surface water would increase from 453.6 acres to 3,840.9 acres. The progressive loss of riparian woodland habitat would halt, conserving the existing 89.4 acres of remnant woodland, and an additional 160.4 acres of remnant woodland would be restored towards historical condition. The recommended plan would also restore 8,666.9 acres of habitat to a more natural, historic and sustainable condition which is critical to the hydrological regime of the ecosystem.

Restoration will generally be conducted from the lower elevations to the higher elevations. Work will begin within lacustrine, riverine, and riverine-intermittent habitats and their adjacent habitats and then expand outward into transitional habitat. This would allow for maximum surface water retention during the restoration process as the invasive, phreatophytic vegetation is

removed within the perennial aquatic habitat. Riverine base flows will increase as the groundwater table rises and spring flows improve. Lacustrine habitat will increase with increased base flows within riverine and riverine-intermittent habitats. Riparian areas will be restored as riverine habitat is capable of sustaining it. Fire will be returned to the transitional habitat within the ecosystem in the form of prescribed burns to aid in sustaining the ecosystem.

Saltcedar will be sprayed by helicopter using *Habitat* herbicide in September. Water intake located at dam will be shut down during application for a minimum of 48 hours as required by herbicide label for applications near active potable water intakes.

Willow baccharis will be sprayed by helicopter using Weedmaster herbicide in the spring and will remain undisturbed for at least a year for effectiveness. A "no-spray buffer zone" will be established adjacent to surface water to prevent application directly to water as specified by herbicide label.

Mesquite located outside of known or potential cultural resource sites will be removed by excavator and those within known or potential cultural resource will be removed through hydraulic shearing with herbicide application, with SHPO's clearance.

Large dense stands of prickly pear will be reduced by fixed wing herbicide application of *Surmount* herbicide in the spring after mesquite removal is completed. With adequate fuel loads, prescribed fire will be conducted in the winter prior to herbicide application to improve prickly removal effectiveness. No herbicide applications will be made adjacent to surface water. These stands will be left undisturbed for a minimum of two years to increase herbicide effectiveness.

Two years following initial treatment, any existing dense stands of willow baccharis will receive individual herbicide plant treatment with Weedmaster herbicide. Any existing mesquite requiring removal will receive individual herbicide plant treatment, using mixture of Remedy and Reclaim herbicides, two years following initial treatment. Saltcedar leaf beetle will be released three years after initial saltcedar treatment to remove any stands of saltcedar still present.

Barbed-wire fence will be installed along the outside edge of all riparian woodland habitat to prevent livestock access within the study area. Additional cross fences within transitional areas will also be constructed to allow for adequate livestock rotation and prevent overgrazing.

Within riparian woodland habitat, mesquite will be removed to a density of approximately 10 percent (with exception of areas designated by lessees), that which was historically found there, along the riparian woodland of the North Concho River, Pott Creek and Turkey Creek. Mesquite will be removed by excavator outside of known or potential cultural resource sites and by hydraulic shearing with herbicide application in area within known or potential cultural resource sites, with SHPO's approval. All existing native woody trees and shrubs found within the riparian woodland will be left undisturbed. Mesquite left undisturbed will generally be the larger trees.

All existing native woody trees and shrubs found will be left undisturbed. Mesquite left undisturbed will generally be the larger trees and will form tree mottes of various shapes and sizes with existing native trees and shrubs. Existing native grass and forb seed source will revegetate as the invasive brushy species are removed. Depressions left by the excavator upon mesquite removal will serve as an extremely beneficial microclimate environment for revegetation. The depressions will retain vital moisture for greater periods of time and offer vegetation protection from heat and wind, and provide for a reliable seed source under harsh conditions.

Planting riparian woodland habitat will occur after sufficient hydrology has been returned to the ecosystem to sustain the plantings. As determined by the NER plan, 160.4 acres of previously existing black willow, mesquite, willow baccharis and saltcedar will be planted with native tree and shrub species. Tree and shrub species planted will consist of a variety of native mast and fruit-bearing species. Tree species will include bitter pecan (*Carya illinoiensis*), live oak (*Quercus virginiana*), hackberry (*Celtis laevigata*), eastern cottonwood (*Populus deltoides),* black willow (*Salix nigra*) as commercially available for the ecoregion. Shrub species will include roughleaf dogwood (*Cornus drummondii*), gum bumelia (*Bumelia lanuginose*), deciduous holly (*Ilex decidua*) and common buttonbush (*Cephalanthus occidentalis*). The existing seed source should be adequate to establish low-light tolerant woodland grasses such as Canada wild-rye (*Elymus Canadensis*), inland sea-oats (*Chasmanthium latifolium*), Texas wintergrass (*Stipa leucotricha*), switchgrass (*Panicum virgatum*), eastern gammagrass (*Tripsacum dactyloides*), aster (*Aster spp*.), verbena (*Verbena sp*.), cardinal flower (*Lobelia cardinalis*), goldenrod (*Solidago sp*.), evening primrose (*Oenethera sp*.), and western ironweed (*Vernonia baldwinii*).

Fire will be returned to the ecosystem to allow it to play its natural role to aid in sustaining the ecosystem. As invasive brushy species are removed from the system, grass will dominate and provide the fuel necessary to successfully conduct prescribed burns. Prescribed burns will be conducted on a rotational basis as fuel allows.

Importance of Project Outputs. The importance of the restoration habitat outputs cannot be overstated. The importance of the habitat outputs are described below.

Institutional Recognition. Numerous laws, executive orders, and partnerships demonstrate the importance of wildlife and native habitat to our Nation. The Water Resources Development Act of 1986, Section 906(b) establishes that significant damages to fish and wildlife resources have occurred as a result of past USACE water resource projects and authorizes the Corps to "mitigate" for these damages. Environmental damages occurred directly as a result of construction of O.C. Fisher Lake and the subsequent operation of the project. Construction of O.C. Fisher Lake in 1952 required significant clearing of existing vegetation in order to construct the 38,254-foot long dam, outlet works and uncontrolled spillway. The Definite Project Report written in 1946 states that 7,524 acres of woody vegetation would be completely removed to an elevation twenty (20) feet above conservation pool. In addition to the large acreages of native prairie that were lost, it is estimated that 253 acres of prime riparian habitat, bottomland hardwood, was destroyed.

Upon reservoir completion, operation of the project contributed further environmental degradation. In the early years after reservoir construction, livestock were allowed to graze upon the lands and naturally occurring wildfires were suppressed. Overgrazing and removal of fire, coupled with drought conditions and subsequent drop in lake level, allowed invasive brushy species the opportunity to dominate the habitat and negatively impact the hydrology of the ecosystem. Each year, invasive brushy species continue to expand their range, further depleting the hydrological regime of the ecosystem through high rates of evapotranspiration, and transform existing aquatic, prime riparian habitats, and native grasslands to an unnatural shrubland condition. Full implementation of the proposed restoration plan will restore the hydrological regime to the ecosystem. As a result, habitats within the project will be restored to a more natural and sustainable state. The aquatic habitat will be restored, the progressive degradation of the remaining prime riparian habitat will be halted, degraded riparian habitat will be restored, and existing transitional shrubland habitat will be restored to a more historical grassland condition.

Executive Order 13112 recognizes the significant contribution native species provide towards the well-being of the Nation's natural environment and directs Federal agencies to take preventive and responsive action to the threat of non-native species invasion and to provide restoration of native species and habitat conditions in ecosystems that have been invaded. Construction and operation of O.C. Fisher Lake negatively impacted native vegetative species through their removal for construction of the project and subsequent operation of the project. Saltcedar, an exotic plant comprising 1,310 acres of land within the study area and more than 500,000 acres in Texas (Hart 2003), “is one of the most invasive, hard-to-control woody plants in the world”, states Allen McGinty and Charles Hart of the Texas Agricultural Extension Service (McGinty and Hart 2001). Without intervention, saltcedar will continue its proliferation and invade all remaining aquatic and riparian habitats within the study area, permanently altering the ecosystem. Although mesquite and willow baccharis are native species within the study area, they also thrived under the altered conditions, further degrading existing native species populations in their quantity and diversity. Currently, native vegetation exists in conditions similar to historical conditions in 89.4 acres of riparian habitat, only 34.5%, and 139.1 acres of transitional habitat, only 4.5%. As native vegetation is degraded from its historical condition, the carrying capacity for fish and wildlife species dependent upon the habitat is subsequently reduced. Currently, the study area supports approximately half of its potential carrying capacity in terrestrial habitats due to habitat degradation and approximately 3% of its potential carrying capacity in aquatic habitats.

The Migratory Bird Treaty Act shows the Federal commitment to the protection of migratory birds and the Fish and Wildlife Conservation Act, shows the Federal commitment to the conservation of nongame species. Amendments to the Fish and Wildlife Conservation Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory nongame birds. Executive Order 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Nongame Birds of Management Concern is a list maintained by the USFWS to fulfill a primary goal of the USFWS to conserve avian diversity in North America. Additionally, the USFWS' Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The Department of Defense signed an MOU with Partners in Flight, a

cooperative effort involving partnerships among federal, state, and local government agencies, philanthropic foundations, professional organizations, conservation groups, industry, the academic community, and private individuals. A major focus of Partners in Flight is for the conservation of neotropical migrants. Implementation of the recommended plan should greatly benefit many bird species.

Public Recognition. The ecosystem restoration project sparked some political interest throughout the course of the feasibility study. Former Congressman Charles Stenholm, Representative, 17th District, contacted USACE on several occasions during the study requesting information and status reports of the project. There were also some requests from interested individuals for restoration project information to be disseminated at San Angelo City Council meetings.

A general population survey conducted cooperatively by TPWD and Texas Tech University in 2001, found that water resources, including both water quantity and quality, is by far the most important natural resource and environmental concern of Texans. One hundred percent of those surveyed expressed that it was very important or somewhat important that Texas' water resources are safe and well protected, with 93% of those rating it as very important.

The aforementioned survey also found that 97% felt it was either very important or somewhat important that natural areas exist in Texas for enjoying and experiencing nature, with 79% of those responding that it was very important (Texas Parks and wildlife Department and Texas Tech University 2001). The diversity of the natural resources located at O.C. Fisher Lake attracts large numbers of visitors each year, contributing to the local economy and providing recreational opportunities. Bird-watching, wildlife viewing, hiking, biking, horseback riding, hunting, and fishing are common activities enjoyed within the study area. The close proximity of O.C. Fisher Lake to a major metropolitan area allows large numbers of visitors the opportunity to visit O.C. Fisher Lake on a more frequent basis. Last year alone, San Angelo State Park received 41,643 visitors (TPWD 2004).

Numerous events are held within the study area. The Texas Ornithological Society conducts annual Christmas bird counts. ASU also uses the study area for annual bird counts, as well as for studies on mammals, reptiles, bats and range management classes. Medieval, military and other living history re-enactments are routinely held under the large pecan trees along the North Concho River at the confluence of Bald Eagle Creek and the North Concho River. The Boy Scouts of America and Girl Scouts of the USA hosts biennial events attracting thousands of Scouts and leaders to San Angelo State Park. Nearly one-thousand school children of all ages utilize the area for field trips annually. Various equestrian trail rider, mountain bike, and triathlon associations take advantage of the San Angelo State Park trail system for races and fun rides throughout the year. Other groups commonly utilizing the area include, San Angelo Convention and Visitors Bureau, San Angelo Recreation Department, Concho Valley Gymnastics, Adult Day Care, and RV Clubs.

Friends of San Angelo State Park, a non-profit organization comprised of 150 members and in existence for 6 years, is extremely supportive of the state park and its resources. The organization's mission statement includes 1) ensuring the future of the park, 2) enhancing the

quality of education, interpretive and recreational opportunities, 3) recruiting and organizing volunteers, and 4) soliciting and administering gifts and endowments for the park. To date, the organization raises an average of $8,000 per year and received a grant of $30,000. (Friends of San Angelo State Park 2004). Hundreds of volunteers from Goodfellow Air Force Base annually perform lakeshore and trail cleanups. Various volunteers construct, install and maintain nesting boxes, benefiting wood ducks, black-bellied whistling ducks, and various owls.

Technical Recognition. The O.C. Fisher Lake Ecosystem Restoration Project is a very significant environmental resource, as is evidenced through its technical recognition. The project contains a high level of biodiversity and uniqueness and contains scarce and declining resources.

Biodiversity. NatureServe, a non-profit organization that is the leading source of scientific information about rare and endangered species and threatened ecosystems, states in its 2002 report, States of the Union: Ranking America's Biodiversity, Texas ranks second to California in terms of overall biodiversity nationwide. It has the highest number of bird and reptile species and second highest number of plants and mammals. It also has the 3rd highest rate of endemism (species unique to Texas) and has the 4th highest number of extinct species (NatureServe 2002).

Lands within the study area include aquatic, riparian and transitional habitats offering a high level of biodiversity. Bottomland hardwoods and associated aquatic habitats support approximately 116 species of fish, 31 species of amphibians, 54 species of reptiles, 273 species of birds, and 45 species of mammals (Fentress 1986). The ecosystem restoration project contains 86.2 acres of undisturbed bottomland hardwood community, and restoration of an additional 160.4 acres, will significantly benefit the large majority of these bottomland hardwood wildlife species.

The state of Texas lies directly in the center of the Central Flyway for migrating birds. Over 300 species of birds are listed as Nearctic-Neotropical migrants in North America, and over 98% of those have been recorded in Texas. Meaning, of the more than 600 species of birds documented in Texas, 54% of them are neotropical species which depend upon Texas to provide habitat for nesting or migration, and many of those are dependent upon west central Texas riparian areas specifically (Smithsonian Migratory Bird Center). Tens of millions of neotropical migrants pass through the state each year. TPWD reports use of the study area by 350 bird species since the reservoir has been in operation (TPWD 2004), including aquatic, riparian, and terrestrial bird species. Stop-over sites for migratory birds in arid areas of the United States are restricted to small defined habitats along shelter belts, hedgerows, desert oases and riparian corridors. These areas are especially significant in west central Texas because they are limited due to their very nature. In order to maintain migratory and non-migratory bird populations in Texas, it is vital that resources within federally owned lands exist in their native habitats. The significance of conserving, improving, and restoring habitat for migratory birds, game and nongame species, has been established by the Fish and Wildlife Conservation Act, Migratory Bird Treaty Act, USFWS List of Migratory Nongame Birds of Management Concern, USFWS Migratory Bird Plan, Executive Order 13112, and the MOU signed with PIF. Table 12 provides a partial list of bird species likely to benefit from restored habitats.

TABLE 12. Partial List of Bird Species of Tom Green County Which May Benefit from Restored Habitats.

Common Name	Scientific Name	Habitat
Swainson's thrush	*Catharus ustulatus*	Riparian woodlands
Rusty blackbird	*Euphagus carolinus*	Riparian woodlands
Swainson's warbler	*Limnothylypis swainsonii*	Riparian woodlands
*Red-headed woodpecker	*Melanerpes*	Riparian woodlands
Swamp sparrow	*Melospiza georgiana*	Riparian woodlands
Song sparrow	*Melospiza melodia*	Riparian woodlands
Kentucky warbler	*Oporornis formosus*	Riparian woodlands
Northern parula	*Parula americana*	Riparian woodlands
Rose-breasted grosbeak	*Pheucticus ludovicianus*	Riparian woodlands
Scarlet tanager	*Piranga olivacea*	Riparian woodlands
American Woodcock	*Scolopax minor*	Riparian woodlands
Barred owl	*Strix varia*	Riparian woodlands
Carolina wren	*Troglodytes troglodytes*	Riparian woodlands
Red-eyed vireo	*Vireo olivaceus*	Riparian woodlands
Bullocks oriole	*Icterus galbula*	Riparian and upland woodlands
*Olive sparrow	*Arremonops rufivirgatus*	Riparian and upland woodlands
*Vermillion flycatcher	*Pyrocephalus rubinus*	Riparian and upland woodlands
*Yellow-billed Cuckoo	*Coccyzua americanus*	Riparian & upland woodlands
House wren	*Troglodytes aedon*	Riparian woodlands & uplands understory
*American bittern	*Botaurus lentiginosus*	Perennial waterways
*Peregrine falcon	*Falco perginus*	Perennial waterways
Violet-green swallow	*Tachycineata thalassina*	Perennial waterways
Bank swallow	*Riparia riparia*	Perennial waterways
*Least grebe	*Tachybaptus dominicus*	Perennial waterways
Tree swallow	*Tachycineata bicolor*	Perennial waterways
Northern waterthrush	*Seiurus noveboracensis*	Perennial waterways, edge of flowing streams
Belted Kingfisher	*Ceryle alcyon*	Intermittent and perennial waterways
Common Snipe	*Capella gallinago*	Marshes, flooded meadows, fields
Red-winged blackbird	*Agelaius phoeniceus*	Marshes, perennial waterways, riparian woodlands
Western meadowlark and /or eastern meadowlark	*Sturnella magna* and/or *S. neglecta*	Prairies
Scissor-tailed flycatcher	*Muscivora forficata*	Prairies

*Species from USFWS List of Migratory Nongame Birds of Management Concern for Region 2. Source: Birds and Other Wildlife of South Central Texas: A Handbook. Edward A. Kutac and S. Christopher Caran

Several Federal and Texas species listed as endangered or threatened species that may potentially benefit from implementation of this restoration plan. The restoration plan will restore the hydrological regime within the study area, creating a significant increase in the riverine habitat, quantitatively and qualitatively. Although the Concho water snake, federally listed as threatened

with designated critical habit, has not been documented within the study area, restored base flows within the North Concho River will restore the river to a free-flowing stream and its shallow riffles and rocky substrate may once again serve as habitat for the Concho water snake.

The potential also exists to benefit the black-capped vireo, federally and state listed as an endangered species, with implementation of this restoration plan. The bird is a habitat specialist and nests in mid-successional brushy areas. Currently, black-capped vireos do not utilize the area due to lack of suitable habitat. With restoration, vegetation along the riparian areas adjacent to riverine habitat may advance through a successional stage as suitable habitat for black-capped vireos. Prescribed fire will be utilized to maintain the restoration project and as a result, the potential exists that some of the areas will remain in the successional stage conducive for black-capped vireos. Whooping crane, federally and state listed as an endangered species, could utilize the aquatic habitat during its migration, but migratory patterns of the whooping crane have not been documented through the study area. The bald eagle, federal (de-list pending) and state listed as a threatened species, will benefit from increased aquatic habitat for foraging, especially during winter months. The American peregrine falcon, state listed as endangered, will benefit from the conversion of transitional lands from shrubland to grassland. The falcon prefers open country, especially along rivers and lakes. The Texas horned lizard, state listed as threatened, may also benefit, as it prefers flat, open terrain with sparse plant cover, especially in sandy, rocky, or loamy soil. The restoration project will remove the dense shrublands and vegetation within some areas, due to the rocky substrate, will only contain scattered clumps of grass, a preferred habitat for the Texas horned lizard. The lizard will also benefit from some of the early successional stages of the restoration project as dense stands of invasive brushy species are removed and restored as grassland.

Scarcity/Trends. Riparian forests, especially those in the South, were designated in 1995 as a nationally endangered ecosystem (Noss et al. 1995). It is estimated that less than 40% of the original bottomland hardwood ecosystem in Texas still remains, with only a few small isolated patches of old growth scattered amongst the floodplains of the eastern third of the state (Frye 1986). Only a small percentage of undisturbed bottomland hardwood communities exist within the O.C. Fisher Lake region and the removal of the hydrology component supporting them by invasive brushy species continues their demise. It is critically important to restore the ecosystem within the study area in order to retain the existing 89.4 acres of undisturbed bottomland hardwood community and restore an additional 160.4 acres.

Not only is riparian habitat scarce and declining, but the aquatic habitat, from which the riparian habitat depends upon for sustainability, is also becoming increasingly scarce and declining. The primary tributary of O.C. Fisher Lake, the North Concho River, generally provided continuous perennial flows from 1925 to 1959, but now only small areas of water impoundments replenished solely by major storm events and minor sporadic stream flow exist (UCRA 1998). Aquatic and riparian habitats within the study area and along the North Concho River above the study area are historically supported by numerous perennial flowing springs. TPWD staff working within the study area report that several of the 20 springs within the study area no longer flow and remaining springs have progressively reduced their flow.

Native prairie within the study area is also highly degraded and scarce. Native prairie has probably been degraded more than any other habitat type in Texas. The U.S. Biological Service claims a 99% loss because of introduced grasses, overgrazing, urban development, and lack of

fire (Noss et al. 1995). Approximately 95% of the transitional lands within the study area are altered from historical native prairie to a shrubland dominated by dense stands of mesquite and prickly pear.

As native habitat declines and degrades, corresponding declines in fish and wildlife species result. Diversity of neotropical migratory birds have declined in numbers for several decades. Recently it has been recognized that the loss, fragmentation, and degradation of stop-over habitat is potentially the greatest threat to the survival and conservation of neotropical birds.

The significance of protecting and restoring declining species and their habitat is established with both national and state laws and funds. The Endangered Species Act of 1973 (ESA), as amended, "provides a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and to provide a program for the conservation of these species." The Department of the Interior, acting through the USFWS, is responsible for the protection of most threatened and endangered species. The Texas Endangered Species Act, also enacted in 1973 gave TPWD the authority to establish a list of fish and wildlife that are endangered or threatened with statewide extinction. The Nongame and Endangered Species Conservation Fund of Texas enables Texas Parks and Wildlife Department to contribute to ongoing education, research and management activities for the conservation, restoration, research, and regulation of all nongame species and their habitats.

Connectivity. The riparian corridors of west central Texas provide an opportunity for the birds to replenish fat reserves, provide shelter from predators and water for re-hydration prior to continuing, what is for most neotropicals, a trip of over 1000 miles one-way. For most migratory birds, the region surrounding O.C. Fisher Lake is located towards the end of a long flight during fall migration and provides the vital link between having enough fat reserves to complete the trip or perish. The aquatic habitat and riparian habitat afforded within the study area is vital for those migratory bird species dependent upon surface water and associated riparian habitat because surface water in west central Texas is extremely limited (Woodin et. al. 1998).

Significant connectivity benefits will be realized within aquatic and riparian habitats along the North Concho River as the result of full implementation of the O.C. Fisher Lake Ecosystem Restoration Project. The benefits of the on-going North Concho River Brush Control Project along the North Concho River above the study area are already evident in that flow has returned to springs which lacked flow for years and base flow is returned to portions of the river which were generally dry for years (UCRA 2004). The project is in its sixth year and its purpose is to enhance the amount of water flowing from the North Concho River watershed through brush control on 432,000 acres, approximately half of the entire river's watershed. Currently, 295,510 acres of brush have been treated and treatment is continuing with additional state funding. Landowners participating in the program must cost share with the State, funding 30% of the cost (TSSWCB 2004). The landowners also sign a ten-year agreement with the state.

With full implementation of the restoration project, the benefits of both the North Concho River Brush Control Project and the O.C. Fisher Lake Ecosystem Restoration Project will combine forming a greater environmental benefit than that which would be realized individually. The improved aquatic and riparian habitats of the North Concho River Brush Control Project along

approximately 70 miles of the North Concho River above the study area will combine with the restored aquatic and riparian habitats along approximately 6.4 miles of the North Concho River within the study area, forming contiguous restored and improved aquatic and riparian habitats along approximately 76.4 miles of the North Concho River. Large contiguous habitats provide greater wildlife habitat value than small, fragmented habitats of equivalent size.
Without full implementation of the restoration project, base flow restored within the North Concho River by the North Concho River Brush Control Project will be lost to the invasive brushy species existing within the study area as the base flow enters the study area. Most of the base flows will be lost to the groundwater table through ground percolation and draining into dry springs along the riverbed within the study area. The temporary rise of the groundwater table will then be depleted by invasive brushy species and their phreatophytic nature.

Total Project Costs. The total project cost is comprised of all expenditures for the feasibility study producing the Detailed Project Report, the plans and specifications phase, and construction phase. Tables 13, 14, and 15 display a summary of the costs associated with the plans and specifications phase and the construction phase respectively. The total project cost to implement the recommended plan is $3,863,920 based upon actual costs incurred in previous years for similar work within the local area, previous federal projects and cost estimates provided by local contractors. Some construction cost estimates required adjustment from those contained previously in this report so as to reflect the most accurate cost estimates available. The average annual operation and maintenance cost is estimated to be $25,372 based on an interest rate of %5.375.

TABLE 13. Estimated Total Project Costs.

Items		Estimated Costs
Feasibility Study Phase		$ 215,000
Plans and Specifications Phase		$ 253,800
Lands, Easements, Rights-of-Way, Relocations, Disposal Areas		$ 0
Construction	Contract	$ 2,484,200
	Supervision and Administration	$ 205,000
	Engineering During Construction	$ 0
	Interest During Construction	$ 266,500
	Monitoring & Adaptive Management	$ 155,000
	Contingency (10%)	$ 284,420
Total Project Cost		$ 3,863,920
Average Annual Operation and Maintenance		$25,372

TABLE 14. Plans and Specifications Phase Costs.

Items	Estimated Costs
Plans and Specifications	$ 30,000
Hazardous, Toxic and Radioactive Waste On-site Survey	$ 2,000
Cultural Resources Survey	$ 161,800
Contract Advertisements and Awards	$ 60,000
Total Plans and Specifications Phase Cost	$ 253,800

TABLE 15. Estimated Construction Costs.

Items	Estimated Costs
Saltcedar Removal	$ 249,400
Saltcedar Removal – Follow-up Treatment	$ 5,400
Willow Baccharis Removal	$ 169,300
Willow Baccharis Removal - Follow-up Treatments	$ 56,400
Mesquite Removal	$ 1,116,500
Mesquite Removal – Follow-up Treatments	$ 139,800
Prickly Pear Removal	$ 119,600
Fence Construction	$ 108,600
Firelane Construction/Maintenance/Prescribed Burns	$ 46,500
Riparian Woodland Plantings	$ 472,700
Monitoring and Adaptive Management	$ 155,000
Supervision and Administration (S&A)	$ 205,000
Contingency (10%)	$ 284,420
Interest During Construction	$ 266,500
Total Construction Cost	$ 3,395,120

* ENVIRONMENTAL EFFECTS

Existing Project and Land Use. The proposed project will not have any adverse impacts to project or land use in the area. Land use authorized under existing leases will remain in effect. Improved streamflow and increased native vegetation diversity will significantly improve land use. It is hoped that the proposed restoration project will serve as a model for landowners with lands under similar degraded conditions and demonstrate the positive environmental benefits that may be achieved through restoration.

Soils. The recommended plan will utilize the qualities of existing soils to develop aquatic, riparian woodland and transitional habitats. Tree and shrub planting within riparian woodland habitat is expected to cause extremely minimal disturbance to the soil and then only in the immediate vicinity of the selected planting sites. Trees and shrubs will be planted as seedlings,

greatly reducing soil disturbance as compared to plantings of larger trees and shrubs. As willow baccharis and saltcedar are removed, soil may be exposed for a brief period but herbaceous vegetation should reestablish readily. Safeguards to reduce soil erosion will be implemented as necessary if the potential for erosion exists, such as sloped elevations and lack of ground cover .

Mesquite removal through excavation presents the most soil disturbance of the restoration project, creating holes approximately three to four feet wide, sloping from the edge to about 18 inches deep in the middle. Excavated soils will remain immediately adjacent to the hole and over time the holes will gradually recapture the soil. Safeguards to reduce soil erosion will be implemented as necessary if the potential for erosion exists, such as sloped elevations and lack of ground cover.

Aquatic Habitat and Species. No adverse impact to the aquatic habitat or aquatic species is anticipated from implementation of the proposed project. No work will be performed within existing aquatic habitat containing surface water. Because the restoration project involves excavation adjacent to surface water, there is some potential for temporary adverse impacts from sediment deposition within streambeds. Safeguards to reduce soil erosion will be implemented as necessary if the potential for erosion exists, such as sloped elevations and lack of ground cover. As the restoration project progresses, the hydrology component so lacking within the ecosystem will drastically improve, increasing available surface water and improving water quality. Vegetation along adjacent riparian areas would provide shade to maintain water temperatures within ranges optimal for the growth and development of aquatic organisms.

Wetlands. No wetlands are indicated within the study area on National Wetland Inventory (NWI) maps. Small areas adjacent to existing springs and tributaries may function marginally as wetlands. Restoring the hydrology within the ecosystem may transform these to a more aquatic habitat, but overall, the restoration project would improve the quantity and quality of any wetlands found within the study area.

Terrestrial Habitat and Species. There will be no adverse impacts to the terrestrial resources in the proposed project area from implementation of the recommended plan. Existing terrestrial habitat will be restored from the dominant degraded shrubland condition to its historical condition dominated by grass species with scattered tree mottes. Wildlife diversity will increase within the study area significantly.

Threatened and Endangered Species. The proposed restoration project was reviewed by the USFWS and TPWD. The Planning Aid Report provided by USFWS reviewed the potential impact of the restoration project upon endangered and threatened species within Tom Green County. The report states that due to lack of suitable habitat and/or location, most of the species are not expected to be found within the study area. The report provided a discussion of two endangered species which may occur within the study area, the Concho water snake and the black-capped vireo, but concluded that it is unlikely that either species currently utilize the study area (USFWS 2004). Potential exists that the improved habitat condition derived during and upon implementation of this restoration may benefit most of the state and federal listed

endangered or threatened species, including the Concho water snake, black-capped vireo, American peregrine falcon, bald eagle, whooping crane (migration), and Texas horned lizard.

Air Quality. No significant adverse impacts to air quality would occur from implementation of the proposed project.

Water Quality. The recommended plan has very little potential for adversely impacting water quality within O.C. Fisher Lake, North Concho River, Pott Creek and Turkey Creek on a temporary basis. As willow baccharis and saltcedar are removed, soil may be exposed for a brief period but herbaceous vegetation should reestablish readily. Tree and shrub seedling planting within riparian woodland habitat will cause extremely minimal disturbance to the soil. Safeguards to reduce soil erosion will be implemented as necessary if the potential for erosion exists. As the restoration project progresses and natural vegetative succession takes place, improved water quality will result because total suspended and dissolved solids will be reduced. Grass and forb species will create a thicker herbaceous layer offering greater protection from erosion. Additionally, high chloride levels due to salt exudation of saltcedar will drop as saltcedar is removed from the ecosystem.

Archeological and Cultural Resources. The richness of cultural resources within the study area requires special consideration. The SHPO reviewed the restoration project and provided recommendations with which to follow to prevent adverse impacts upon the cultural resources within the study area. Cultural resource surveys will be conducted within those areas identified as having medium to high potential to contain cultural resources before mesquite removal will take place. Where sites are identified, impacts would be minimized as approved by the SHPO by the use of hydraulic shearing with herbicide application instead of the use of an excavator. Vegetative plantings will involve planting only seedlings within riparian woodland as approved by SHPO. (State Historical Preservation Office 2003).

Hazardous, Toxic and Radioactive Waste. No restoration project work will be conducted within identified hazardous, toxic, or radioactive waste locations within the study area. Only one documented environmental condition exists, an aboveground storage tank located within a maintenance yard where no work will be performed.

USACE will conduct an on-site visit to verify that any environmental conditions will not impact proposed restoration work.

Herbicide Use. Implementation of the recommended plan requires use of herbicides in order to provide the most cost effective and efficient means to remove specific invasive vegetative species. All herbicides are approved for use by the Environmental Protection Agency. Herbicide application will only be performed by applicators who are licensed or certified by the state and will be done in strict compliance with herbicide labels. All applications would be coordinated with the Upper Colorado River Authority, City of San Angelo, Texas Parks and Wildlife Department and USACE.

Herbicides will be selected based upon being the most environmentally friendly, yet effective on the invasive species. This report references specific herbicides; however, if future herbicides will better suit the project's needs, they will be utilized instead.

Initial herbicide applications will be conducted through the use of helicopters, flying at the lowest possible height, which permit accurate herbicide placement to target vegetative species and minimize overspray and vapor drift. Helicopters will be equipped with special application booms to minimize vapor drift potential. Areas adjacent to private property will only be treated when wind direction will prevent potential spray drift towards private property.

With exception noted below for *Surmount*, potential detrimental effects to fish and wildlife are not published. Grazing animals are present within some treated areas and some herbicide labels contain precautions with herbicide use on lands where grazing takes place. These precautions will be considered and followed as deemed necessary by the lessee.

Habitat. Saltcedar will be treated with *Habitat* applied in September. The herbicide is approved for application to public waters for control of aquatic weeds; however, water application is not required because saltcedar does not grow in water and application is only necessary to the water's edge. Although application to surface water is not intended, the potential exists that inadvertent overspray of water may occur. As a precaution, potable water intake would be turned off and the dam operational gates would be closed prior to application of *Habitat* and remain so for a minimum of 48 hours after completion of application, as directed for specific applications over water.

Other vegetative species may be killed or damaged should *Habitat* come into contact with them, including aquatic and terrestrial species. Very little potential exists for damage to vegetative species within the water because of the accurate herbicide placement. Due to the thick monoculture habitat of saltcedar and subsequent lack of vegetative diversity, potential damage to non-target species is very unlikely, with black willow being the exception. Saltcedar exists adjacent to, and within, areas containing black willow and black willow will likely be inadvertently treated. It is believed that the trees will only suffer leave burn and most will survive.

Weedmaster. Willow baccharis will be treated with *Weedmaster* in April. *Weedmaster* is for terrestrial use and not to be used where surface water is present. Buffers will be established around surface water to prevent inadvertent overspray into surface water. Other vegetative species are susceptible to *Weedmaster*, but potential damage to non-target species is very unlikely because willow baccharis grows in thick monocultures and the areas lack vegetative diversity.

Surmount. *Surmount* will be used in late summer or early fall to treat dense stands of prickly pear in limited areas due to its potential for leaching through the soil into shallow groundwater and its toxicity to fish. Prickly pear treatment will only be performed within transitional habitat and it will not be used in areas adjacent to surface water, including known springs (flowing or non-flowing) or areas susceptible to run-off.

Other broadleaf species are also susceptible to *Surmount* at very low concentrations. As with the other invasive vegetative species, prickly pear dominates the treated areas and few other vegetative species are found there. Trees can be affected by leaf uptake of the herbicide and will not be used in areas containing desirable trees. The herbicide exhibits some residual soil activity to newly emerging susceptible plants so the effect of the herbicide re-establishing any susceptible vegetative species within these treated areas may be delayed a few months. Adjacent seed sources are sufficient to re-establish vegetation within the treated areas.

Recreational, Scenic and Aesthetic Resources. The recommended plan will have extremely significant beneficial impacts upon the recreational, scenic and aesthetic resources within the study area. Restoring the hydrology within the ecosystem is predicted to increase surface water within the lacustrine and riverine habitats and will in-turn increase the recreational opportunities available to the public. Existing conditions render boat ramps and swimming areas useless, but the increased shoreline resulting from the project would increase opportunities for boating and swimming. With the increased lacustrine and riverine habitat, opportunities for fishing, hunting, birdwatching, wildlife viewing, and sight-seeing will also increase. The habitat through which existing recreational trails traverse will offer significantly improved scenic and aesthetic resources for the public.

Socioeconomic Conditions. The restoration plan will create positive socioeconomic impacts within San Angelo and local communities, as well as Tom Green County as a whole. San Angelo Chamber of Commerce reports that a significant portion of local revenues are derived from tourism (San Angelo Chamber of Commerce 2003). As lacustrine and riparian habitats increase, recreational opportunities will also increase and benefit the local areas. An increased lake level will provide a more reliable water supply for San Angelo, and San Angelo and the surrounding areas will derive positive socioeconomic benefits.

The recommended plan is consistent with state and federal government initiatives to improve water quality and conserve/improve native habitats. It is also consistent with the North American Waterfowl Management Plan to preserve and increase North America's waterfowl population.

Cumulative Impact Analysis. Construction of the reservoir and historical land management practices, prior to leasing, within the study area played a contributing role in the establishment of invasive brushy species and prickly pear. Native vegetation within areas which were overgrazed and/or wildfire was suppressed have contributed to an environmental pallet favorable for their proliferation. Although some limited invasive brushy species removal occurred in the past, lack of resources prevented control on a large scale basis.

Reasonably foreseeable future actions on or near the study area are predicted to remain much the same. The lands are owned by USACE in perpetuity and are leased to ASU and TPWD through separate license agreements, with exception of the dam and associated areas. These entities promote wise land stewardship and both USACE and the lessees intend to renew leases upon expiration. Use of adjacent and surrounding lands is also predicted to remain the same.

Grazing takes place within both leased areas under existing leases and is anticipated to continue in the future. ASU utilizes grazing for education and research purposes and TPWD conducts limited grazing of "showcase" livestock (longhorns and bison) as an enhancement to recreation. Fence construction required for the recommended restoration plan will not interfere with current and future grazing.

Grazing and prescribed burning occurs within large tracts of the leased lands as a component of natural resource management. These land management techniques occurred historically, and returning grazing and prescribed burning to the ecosystem promotes and sustains the lands to a more natural and historical condition. Vegetative condition is monitored by natural resource staff of the lessee and USACE to ensure proper management. However, under current conditions, the effectiveness of fire and managed grazing as management tools is somewhat constrained by inadequate grass cover and the proliferation of prickly pear. The proposed project is expected to enhance the effectiveness of future grazing, prescribed burning, and monitoring in promoting sustainable ecological conditions at the project site.

Since reservoir construction, recreation has been a major mission of O.C. Fisher Lake. O.C. Fisher Lake affords many recreational activities, including camping, picnicking, fishing, hunting, hiking, wildife viewing, and boating activities as the lake level allows. These recreation opportunities will remain available in the future with the lessees' intent to renew the leases upon expiration. In the future upon completion of the restoration project, recreational opportunities will be enhanced. Increased surface water within the study area (lake and tributaries) will provide increased opportunities for water-related recreation. Non-water related recreational activities are predicted to remain unchanged or increase with lands restored to a more historical condition.

Benefits of the North Concho River Pilot Brush Control Project within the watershed of O.C. Fisher Lake are recognized through increased base flows of the river within the study area. Landowners participating in the brush control project sign a ten-year agreement for participation in the program. Combination of the brush control project and the completed restoration project are expected to have a synergistic and cumulative effect restoring the natural hydrology within the study area.

PROJECT IMPLEMENTATION

Plans and Specifications. As per 21 March 2005 memorandum issued by Southwestern Division, formal engineering plans and specifications are not required and an abbreviated Plans and Specifications will take place. The District will prepare a design report that includes sufficient scope, schedule, sketches, and cost to construct the project.

Value Engineering. As per 21 March 2005 memorandum issued by Southwestern Division, value engineering is not required. As per Division MEMO, value engineering is not required.

Contracts. Because construction of this restoration project must be flexible in nature, Indefinite Delivery/Indefinite Quantity (IDIQ) contracts will be utilized to the fullest extent possible. IDIQ contracts include a list of various work items available to the government for request. The government then selects the work items and quantities necessary to accomplish the task at hand. Separate IDIQ contracts will be procured for mechanical work, herbicide application, and fence work.

Project Construction. After funding is secured, construction contracts will be awarded and the project will promptly move to construction. Table 16 displays the anticipated construction schedule for the restoration project by fiscal year (October through September). Adaptive management will be utilized to its fullest to allow for schedule modification as vegetative response and site conditions dictate.

TABLE 16. Anticipated Construction Schedule

Fiscal Year	Construction Items	Estimated Costs	Total Cost
2006	Saltcedar Removal Monitoring/S&A/Contingency	$ 249,400 $ 41,543	$ 290,943
2007	Mesquite Removal Willow Baccharis Removal Prickly Pear Removal Fence Construction Monitoring/S&A/Contingency	$ 1,116,500 $ 169,300 $ 119,600 $ 108,600 $ 350,909	$ 1,864,909
2008	Firelane Construction/Maintenance/Prescribed Burn Willow Baccharis Removal – Follow-up Treatment Saltcedar Removal – Follow-up Treatment Riparian Woodland Planting Monitoring/S&A/Contingency	$ 23,300 $ 56,400 $ 5,400 $ 232,700 $ 88,885	$ 406,685
2009	Firelane Construction/Maintenance/Prescribed Burn Mesquite Removal – Follow-up Treatment Riparian Woodland Planting - Maintenance Monitoring/S&A/Contingency	$ 23,200 $ 46,600 $ 120,000 $ 64,365	$ 254,165
2010	Mesquite Removal – Follow-up Treatment Riparian Woodland Planting - Maintenance Monitoring/S&A/Contingency	$ 46,600 $ 90,000 $ 54,212	$ 190,812
2011	Mesquite Removal – Follow-up Treatment Riparian Woodland Planting - Maintenance Monitoring/S&A/Contingency	$ 46,600 $ 30,000 $ 44,506	$ 121,106

Real Estate Plan. The real estate necessary for this project is currently owned in fee by the United States of America and is under the primary jurisdiction of the Department of the Army as

a part of O.C. Fisher Lake. Approximately 15,860 acres of project land will be leased to the non-Federal Sponsor, the City of San Angelo, to authorize their operation and maintenance responsibilities. Most of the land is under existing leases, which have been granted for compatible purposes. These leases will continue with amendments to accommodate the restoration project. Additional detail is contained in the Real Estate Plan.

Monitoring and Adaptive Management. An important component of project implementation is the monitoring of the ecosystem's response to the restoration measures. By connecting the ecosystem response to the restoration as well as the management measures, potential beneficial adaptations and adjustments to the project or management plan can be identified to ensure continued success of the project.

As is true with all vegetative restoration measures, complete success is rarely achieved. It is expected that vegetative removal methods may not be completely successful to the level desired and follow-up treatments may be required. Therefore, monitoring will be conducted following treatments to allow for timely follow-up treatments. It is also necessary to monitor the hydrological response as the restoration project progresses to allow for successful plantings within riparian woodland areas. The hydrological response prescribes optimum planting locations in order to ensure greater planting success. Environmental conditions can also negatively influence planting success after warranty period lapses and unanticipated additional plantings may be required.

Quarterly monitoring will be conducted throughout the restoration project and monitoring may be increased as the restoration process warrants. In this manner, proper and timely measures can be taken so that the predicted benefits of the project are fully achieved.

Project Cooperation Agreement. The Project Cooperation Agreement (PCA) is a contract between the Federal Government and the non-Federal partner describing the rights and responsibilities of each party during project implementation, including cost sharing, and upon completion of the restoration project. The PCA will be executed after the receipt of the commitment of Federal funds for construction and prior to the advertisement of a construction contract.

Cost Apportionment. As described in the PCA, the total project cost will be shared between the Federal Government and the non-Federal partner, known as the sponsor, on a 75% and 25% proportion, respectively. The sponsor's 25% share may consist of a credit for the value of any work-in-kind (WIK) services performed by the sponsor or its contractors. Credit for WIK is limited to 80% of the total sponsor's contribution, and cannot result in a reimbursement. Further, with regard to WIK, the sponsor will comply with applicable Federal and state laws and regulations, including the requirement to secure competitive bids for all work to be performed by contract. Contributions of cash, funds, materials or services from other than the sponsor or their contractor(s) may be accepted; however, such contributions will not be credited to the sponsor's share, but rather will be applied to the entire total project cost and therefore reduce both the Federal and sponsor's share. Table 17 displays the current estimate cost apportionment.

TABLE 17. Cost Apportionment.

Total Project Cost	$ 3,863,920
Federal Share	$ 2,897,940
Sponsor's Share	$ 965,980
Work-in-Kind	$ 68,800
Cash Contribution	$ 897,180

Work-in-Kind. Work-in-kind are services or materials provided by the sponsor during the post-feasibility phase design and construction. At the present time, $68,800 of work in kind has been approved for design, management and fence work by Angelo State University.

Operation and Maintenance. Upon completion of the restoration project as described in the PCA, the sponsor, City of San Angelo, is responsible for all project operations and maintenance required to sustain project. Because operation and maintenance is dependent upon vegetative response throughout the project life, cost estimates must be derived from projected vegetative responses and actual vegetative responses may vary. The estimated average annual operation and maintenance cost is based upon those calculations contained within the incremental cost analyses and additional information acquired since the incremental cost analyses was conducted. Breakdown of the estimated cost is summarized as follows:

1) maximum $50,000 the first year for invasive vegetative species control to maintain invasive vegetative species in as close as possible to the post restoration project (construction) conditions so as to prevent encroachment, reduced by 5% every year thereafter (adjusted for inflation each year within the project life).
2) $1,000 per year associated with fence repair
3) $5,900 per year associated with prescribed burns prorated

The average annual operation and maintenance cost over the 25-year life of the project is estimated to be $25,372 using an interest rate of %5.375.

The sponsor is not required to expend more than the specified amount for annual invasive vegetative species control contained within the Operation, Maintenance, Repair, Replacement, and Rehabilitation Manual. It is expected that as the invasive vegetative species are monitored and controlled, annual control of invasive species will decrease over time.

Prescribed burns will be conducted on a rotational basis across the study area on a four to seven year frequency, dependent upon vegetative conditions, climatic conditions, and lessee management. Any invasive vegetative species found within riparian areas will be treated through herbicide application to individual plants and shall not be burned until such time that the growth state of planted woody vegetation can endure burns. The entire area will be routinely monitored for encroachment of invasive vegetative species. It is anticipated that the only

invasive brushy species potentially requiring herbicide application for individual plants will be mesquite. The entire fence line will be routinely monitored and maintenance performed as necessary. Firelanes will also be maintained.

COORDINATION OF RECOMMENDED PLAN

View of Sponsor. The City of San Angelo is identified as the non-Federal sponsor. The sponsor reviewed the draft Detailed Project Report and concurs with its findings. The City supports the recommended plan and provided a letter of intent to participate in the implementation of the recommended plan. TPWD and ASU will continue to work closely with the City of San Angelo during the implementation of the project.

Results of Agency Coordination. The team comprised of team members from USFWS, NRCS, TPWD, TAES, UCRA, TSSWCB, ASU and City of San Angelo developed potential restoration measures for consideration. USFWS, TPWD and USACE staff evaluated each measure on the basis of habitat benefit. In addition, information on water and air quality was obtained from the Texas Natural Resources Conservation Commission. A draft of this Detailed Project Report was sent to TPWD, USFWS, Environmental Protection Agency (Region 6), Texas Historic Commission and the Texas Natural Resources Conservation Commission for review and comment in accordance with coordination requirements as set forth by the National Environmental Protection Act (NEPA). Initial coordination with SHPO was conducted and recommendations were received. In accordance with SHPO's recommendation, a cultural resources survey will be conducted upon potential locations within the study area. Upon completion of the survey, a letter and report will be furnished to the SHPO for review and concurrence with the survey findings. USFWS supports the proposed project and provided a letter of support and a draft copy of their Coordination Act Report. Any comments received during the mandatory 30-day Public Notice period will be included in the final draft of this report, along with any letters received from the coordinating agencies.

Regulatory Requirements. USACE Fort District Regulatory Branch reviewed the recommended plan and determined the restoration activities recommended meet the conditions of Nationwide Permit 27, Wetland and Riparian Restoration and Creation Activities of Section 404 of the Clean Water Act. The State of Texas has issued a water quality certificate for Nationwide Permit 27 and therefore, no further coordination is required under Section 401. It was further determined that the restoration project will not involve activities subject to the requirements of Section 10 of the Rivers and Harbors Act of 1899. The proposed project is in compliance with Executive Order 11990 as it does not adversely impact nor result in any loss of wetland areas.

The State Historical Preservation Officer reviewed the restoration project and provided recommendations with which to follow to prevent adverse impacts upon the cultural resources within the study area. In addition to 39 recorded cultural resources sites, an additional 2,455 acres were identified to exhibit medium to high potential to contain cultural resources within mesquite removal areas. Cultural resource surveys would be conducted within these areas before mesquite removal would take place. Mesquite removal within potentially National Register

eligible sites shall be minimized by the use of hydraulic shearing with herbicide application which may cause only minimal surface ground disturbance as the equipment operates across the landscape. Vegetative plantings would involve planting only seedlings within riparian woodland as approved by SHPO.

An Environmental Assessment (EA) was conducted and a draft Finding of No Significant Impact (FONSI) has been completed. The FONSI is expected to be signed by the District Commander in August 2005. Mitigation is not required for the restoration project.

CONCLUSIONS

This Detailed Project Report documents the results of a study conducted under the authority of Section 1135 of the Water Resources Development Act of 1986, as amended (33 USC 2201). The purpose of the study was to identify the environmental degradation caused by the construction and operation of O.C. Fisher Lake, develop and evaluate measures to restore the hydrological function of the ecosystem and the historical habitat, and recommend a cost effective ecosystem restoration project for implementation that would result in functional stability, integrity, and sustainability of important ecological resources.

With full implementation of the recommended plan, perennial surface water would increase from 453.6 acres to 3,840.9 acres. The progressive loss of riparian woodland habitat would halt, conserving the existing 89.4 acres of remnant woodland, and an additional 160.4 acres of remnant woodland would be restored towards historical condition. The recommended plan would also restore 8,666.9 acres of habitat to a more natural, historic and sustainable condition which is critical to the hydrological regime of the ecosystem.

The total project cost is estimated at approximately $3,863,920 of which $965,980 is the local sponsor share. The report identifies significant positive environmental benefits upon full implementation of the recommended plan.

The City of San Angelo is identified as the non-Federal sponsor and reviewed the findings of this report. The city has offered their support for the recommended plan, including cost sharing, and agreed to assume responsibilities for all operation and maintenance upon completion of the restoration project in accordance with the PCA. A review of the information provided by the city regarding its financial capability to meet the cost sharing requirements found the City of San Angelo to exhibit the statue authority and the financial capability to provide the required non-Federal items of local cooperation.

An Environmental Assessment (EA) was integrated into the DPR to assess the potential impacts of the recommended plan. A public notice will be released July 2005 disclosing the availability of the EA. A Finding of No Significant Impact, if appropriate, will be issued after reviewing comments received.

Extensive coordination and input was obtained from the USFWS and TPWD during the development of the recommended plan and both agencies are supportive of the project. The recommended plan is consistent with state and federal government initiatives to improve water

quality and conserve/improve native habitats. It is also consistent with the North American Waterfowl Management Plan to preserve and increase North America's waterfowl population.

RECOMMENDATIONS

I propose the recommended plan described in this Ecosystem Restoration Report be authorized for implementation under the authority of Section 1135 of the Water Resources Development Act of 1986, as amended, as a Federal project, with such modifications as in the discretion of the Chief of Engineers may be advisable. The total first cost of the project is estimated to be $3,863,920 which includes all costs through construction.

Prior to commencement of construction, local interests must agree to meet the requirements for non-Federal responsibilities as outlined in this report and future legal documents. The City of San Angelo has demonstrated that they have the authority and the financial capability to provide all non-Federal requirements for the implementation, operation, and maintenance of the project. The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works' construction program nor the perspective of higher review levels within the Executive Branch.

John R. Minahan
Colonel, Corps of Engineers
District Engineer

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