US Army Corps of Engineers®
Fort Worth District

City of Brownwood

Willis Creek Channel Improvement, Brownwood, TX

Section 205

Report Synopsis
For Federal Interest Determination

July 2014

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Report Synopsis for Federal Interest Determination (FID)
Willis Creek Channel Improvement, Brownwood, TX
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1.0 Stage of the Planning Process

The proposed study is a Continuing Authorities Program (CAP) feasibility study for flood risk management. The current stage in the planning process is determination of Federal Interest to support a request for initial study funding. A General Investigations study was completed in February 2003, and approved by Southwestern Division 17 July 2003 with a recommendation for conversion to CAP due to the project cost, size, and scope. (Final Interim Feasibility Report and Integrated Environmental Assessment – Pecan Bayou Watershed, Brownwood, Texas – February 2003). The approved report included a Finding of No Significant Impact dated April 1, 2002. The recommended plan was estimated at $7,961,900 (May 2001 prices). In October 2013 prices, this plan would be valued at approximately $12,500,000, which is within the range of cost and scope for a CAP project. The recommended plan had a BCR of 1.6.

A site visit on May 15, 2014 included economics, environmental, and water resources project delivery team members. The survey indicated there were no significant changes in the study area with the exception of a small number of new structures in the floodplain, new construction of the Austin Street Bridge and new modeling for FEMA mapping. The sponsor, City of Brownwood has expressed a strong interest in moving forward with a feasibility study and project implementation, and provided a reaffirmation letter dated November 5, 2013. Sponsor interest was re-confirmed during the site visit, and the project is scheduled for City Council approval to proceed during August 2014.

Federal Interest**.** Federal interest for a Section 205 local flood damage reduction project is determined by having a potential alternative for the project area that has a positive benefit-to-cost ratio of greater than 1, a local Sponsor willing to cost share for the feasibility costs, as indicated in the letter of intent in Attachment 1 and be favorable to the public and local, state and Federal agencies. This support would be further assessed early in the feasibility study. Based on all available information to date, including the previous study and the site visit, a strong potential for Federal Interest is confirmed. Information from the previous feasibility report is incorporated and comprises the bulk of the remainder of this FID.

Timeline. The Feasibility Study Cost Sharing Agreement is scheduled for execution in FY14 to support a funding request under the CAP. FY14 funding

would be used to initiate the feasibility study, currently estimated to cost $400,000 due to the wealth of existing information available. The sponsor would be responsible for 50% of the study cost (see Section 15 – Budget). Upon initiation of the feasibility study, completion would be dependent upon available funding, however if the study could be fully funded it is anticipated to be able to complete within 1 calendar year using SMART planning principles (but not *process)* to update previous information, including planning, engineering, economics and environmental (see Section 10 – Key Updates). The study would still need to meet current requirements and reviews under CAP guidance and a 1 year completion would require a commitment from the vertical team.

2.0 Study Authority

The authority for this project is Section 205 of the Flood Control Act of 1948 (Public Law 80-858), as amended. Currently, the maximum federal participation in a project is limited to $10 million under the program.

3.0 Non-Federal Sponsor

The Non-Federal Sponsor for the study is the City of Brownwood, Texas.

4.0 Purpose and Need

The purpose of the feasibility study is to investigate water resource problems, needs, and opportunities for the reduction of flood damages within the city of Brownwood. The study will utilize and expand on the analyses conducted under the 2003 General Investigation feasibility study, which included Willis Creek. The intent is to review the earlier formulation, update information as needed including the engineering, economics, and environmental to either reaffirm the earlier recommended plan or develop a new recommended plan should updated information so indicate.

4.1 History of Flooding

The city of Brownwood has experienced frequent flooding along Pecan Bayou and Willis Creek ever since the first settlers arrived at it banks in the early 1800’s. Flooding has been documented as early as 1868. Recorded "great" floods occurred in 1868, 1875, 1900, 1908, and 1915.

The "great" flood which occurred in September 1900 was prior to the construction of Lake Brownwood. This flood had a stage of 21.7 feet and an estimated peak discharge of 150,000 cubic feet per second. Discharges high enough to cause significant damages tend to occur in clusters of consecutive or non-consecutive years. The years following the wet cycle are usually characterized by smaller, non-damaging flows. Flood events have been modified by the construction of Lake Brownwood (1932) and Hords Creek Reservoir (1948). However, these projects have only partially eliminated flooding problems along Pecan Bayou and its tributaries, including Willis Creek.

Since urbanization is a major contributing factor to the current and future flooding problems, it is important to examine floods that have occurred in more recent years. Significant floods have occurred within the Pecan Bayou watershed in 1980, 1982, 1984, 1986, 1990, 1991, and 2000.

In 1990, major portions of central Texas experienced heavy rainfall over a 3-week period as a result of a cold front mixed with an upper level low and produced two frontal type storms. Between April 17 and May 4, rainfall amounts up to 18 inches were recorded in the Brownwood area. The rain led to record water levels at Lake Brownwood. Water surged more than 7 feet over the lake's emergency spillway. By mid-morning of April 26, most routes from the city were severed and a normally bustling traffic circle was submerged under several feet of water. Brownwood remained underwater for 5 days with 7 feet of water covering most of the commercial area along highway 377. In the city of Brownwood, 528 homes and 70 businesses were either damaged or destroyed. Public and agricultural facilities were also damaged. In addition to the economic damages from this flood, two residents of the city were swept away by the flood and drowned. Flood damages and associated costs were estimated to exceed $10 million (1990 cost estimate). On May 2, 1990, the President declared the State of Texas a major disaster area due to the severe flooding.

In December 1991, Brownwood, as well as large portions of southeastern Texas (e.g. Austin and San Antonio), experienced record rainfalls. The Brownwood area received between 8 and 12 inches of rain. Brown County and the city of Brownwood reported a total of 213 local dwellings affected by flood waters, with 26 totally destroyed and another 125 sustaining major damage; 10 residences sustained approximate damages of $100,000. Businesses sustained over $580,000 in damages in this flood event, not including lost revenue. The damage to residential structures around Lake Brownwood included 92 homes severely damaged, 26 homes with minor damage, 26 mobile homes destroyed, 32 mobile homes with major damage, and 14 mobile homes with minor damage. Brown County was declared a disaster area in December 1991.

In the early morning hours of June 15, 2000, an isolated storm dumped over 8 inches of rain on the city of Brownwood causing street and residential flooding, and necessitating the evacuation of 125 city residents, including some by helicopter. Official reports indicated that all of the creeks and streams in Brownwood had overflowed their banks. Along U.S. Highway 377 at the east of the city, public streets and commercial parking lots were flooded and roads were closed to traffic. At the peak of the storm, the city's emergency sirens were activated to warn residents of the flooding conditions. Consideration was given to requesting assistance from the National Guard, but the storm abated before such a call was initiated. Flood damage and costs estimates are not available on this storm.

5.0 Study Scope

5.1 Study Area

The study area is the 0.2 percent annual exceedance probability (AEP) floodplain along Willis Creek in Brownwood, Texas. The 0.2 percent AEP is commonly referred to as the 500-year floodplain. Willis Creek is a tributary of Pecan Bayou, which is a tributary of the Colorado River. The study area is located entirely within the city of Brownwood, which is the county seat of Brown County, Texas. Brownwood is 138 miles southwest of Forth Worth and 78 miles southeast of Abilene, Texas. The study area is within the Texas 11th Congressional District served by Congressman Mike Conway.

5.2 Project Area

Based on the earlier feasibility study, the anticipated project area is within the Willis Creek channel inside the city limits of Brownsville and a diversion channel cut across open field downstream of 14th Street and reconnecting with the creek near 4th Street. The location of Willis Creek within Brownwood is shown in Figure 1. An aerial view of the study area in Figure 2 shows the damageable properties, predominantly north of the creek, in relation to the creek.

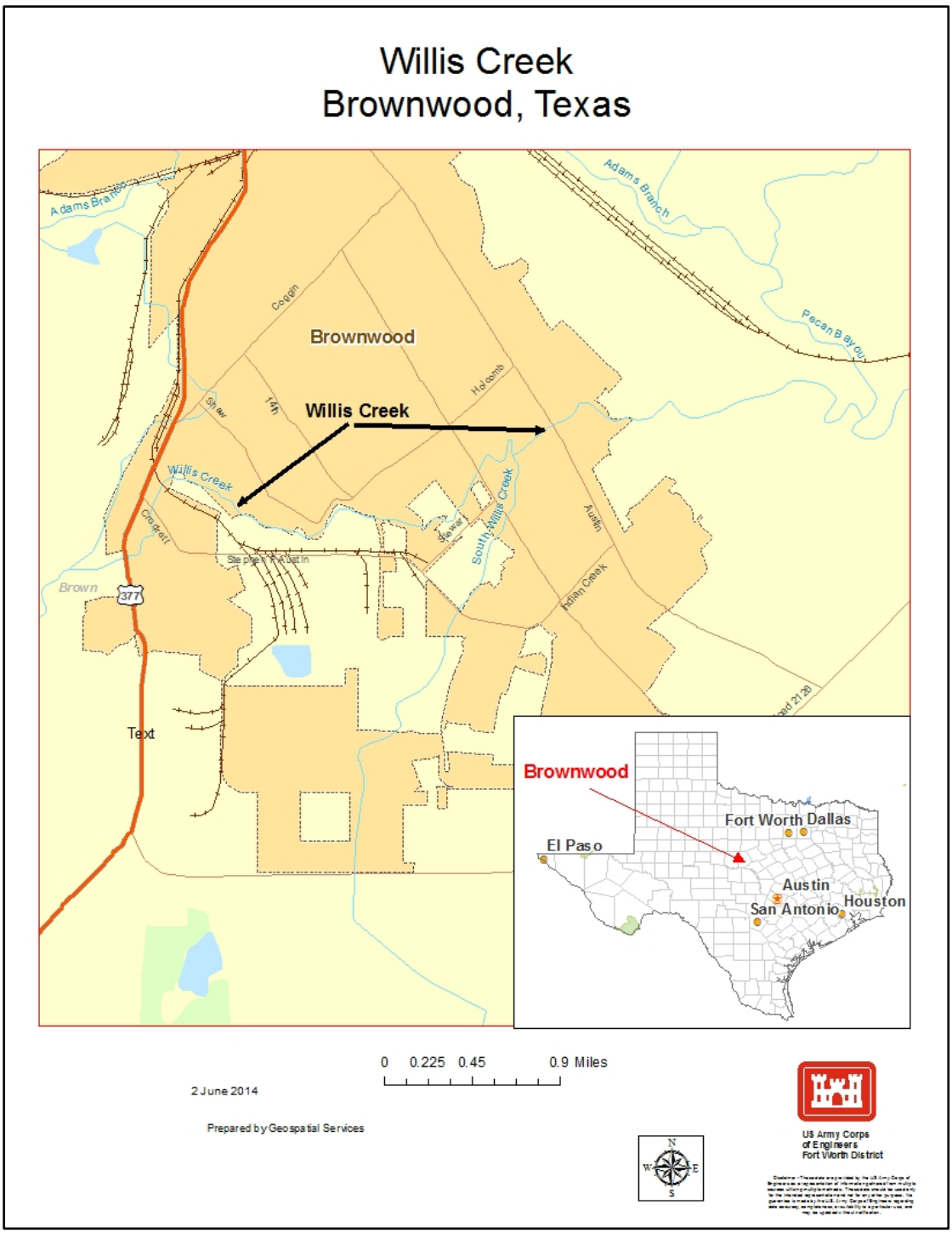

Figure 1. Willis Creek, Brownwood Texas

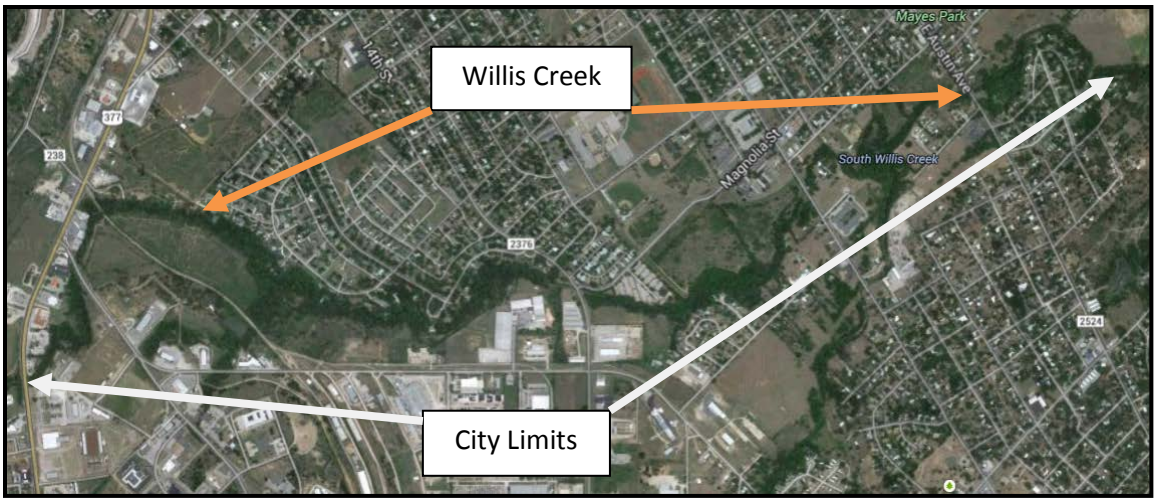

Figure 2. Willis Creek, Brownwood, Texas Aerial Imagery

6.0 Prior Studies, Reports, and Existing Water Projects

6.1 USACE Studies and Reports

There are numerous technical reports published that document water resources investigations made within the Pecan Bayou watershed. The following paragraphs describe, in chronological order, prior Corps of Engineers studies and reports within the Pecan Bayou watershed.

1. **Report From the Chief of Engineers on Preliminary Examination of Colorado River, Texas, with a View to the Control of its Floods, April 3, 1930 (House Document No. 361, 71st Congress, 2nd Session).** This report was a preliminary examination of the Colorado River for flood control as authorized by the acts of May 21, 1924 and February 12, 1929. This report investigated various dams and potential dam sites; however, it recommended that due to the lack of existing or prospective navigation on the river that there was no Federal interest in flood control. Additionally, the potential Federal interest in flood control was investigated and determined that the state should be responsible for all flood control activities.

2. **Report on Survey of Pecan Bayou, Texas, for Flood Control and Allied Purposes, March 1939 (House Document No. 370, 76th Congress, 1st Session).** This report recommended a plan of improvement that included the construction of Hords Creek Lake on Hords Creek above the city of Coleman and enlargement of the existing Lake Brownwood on Pecan Bayou. Construction of Hords Creek Lake and enlargement of Lake Brownwood were authorized by the Flood Control Acts of 18 August 1941 and 22 December 1944. The Hords Creek Lake project was constructed and became operational during April 1948.

3. **Definite Project Report on Hords Creek Reservoir, Hords Creek near Coleman, Texas, Colorado River Basin, February 1946.** This report presents the definite project plan for Hords Creek Reservoir on Hords Creek near Coleman, Texas, authorized by the Flood Control Act, approved August 18, 1942 (Public Law 228, Seventy-seventh Congress, first session). The project plan detailed the construction of a multiple purpose dam and reservoir, principally for flood control and water conservation. The estimated first cost was $1,479,000 with an annual operation and maintenance cost of $11,000.

4. **Review of Reports 1948 (Unofficial).** Subsequent to the 1939 Report on Survey, a second report entitled "Review of Reports on Pecan Bayou, Texas, Flood Protection, Brownwood, Texas," dated 3 September 1948, was prepared. This report suggested a restudy of the authorized Lake Brownwood enlargement, along with studies of alternate reservoir and channel improvement plans. This report was submitted to the Office of the Chief of Engineers and the Board for Rivers and Harbors, but was returned to the district for further revision in 1954.

5. **The Master Plan for Recreation and Land Use, Hords Creek Dam and Reservoir, near Coleman, Texas, May 1950.** This report recommends recreational facilities to be constructed at the project to accommodate the large numbers of visitors to the lake and adjacent lands. These proposed facilities were to be located on Government owned lands. Additionally, this report requested that authority for the development of these recreational facilities be approved at an early date.

6. **Review of Reports on Pecan Bayou Watershed, Colorado River Basin, Texas October 1963.** This report investigated flooding problems along Pecan Bayou, Willis Creek, Adams Branch, and Lake Brownwood. The report recommends improvements to the Lake Brownwood and surrounding creeks, and construction of two upstream reservoirs. The channel improvements had a first cost of $11,281,000. The improvements to Lake Brownwood consisted of enlarging both the dam and reservoir at a first cost of $3,060,000. The upstream reservoirs were recommended to be multipurpose and designated as Pecan Bayou and Coleman. The first cost of the reservoirs was $22,410,000. Neither of these projects has been constructed.

7. **House Document Number 350, 90th Congress, 2nd Session, July 8, 1968, Pecan Bayou, Texas.** This house document and subsequent act (Public Law 90 483, August 13, 1968) authorized a study in Pecan Bayou, Texas. Subsequent to the completion of the Pecan Bayou Watershed Report, a letter from the Texas Water Development Board (dated August 12, 1966) indicated that local interests had constructed a dam and reservoir on Jim Ned Creek in the general location of the proposed Coleman reservoir. Additionally, the Soil Conservation Service (letter dated April 24, 1967) was

working on detailed planning for a watershed work plan (Brownwood Laterals) for Willis Creek and Adams Branch in the city of Brownwood. Therefore, these portions of the watershed plan were deleted from the requested authorization. The authorized plan of improvement included the Lake Brownwood modification, the construction of Pecan Bayou reservoir, and/or Pecan Bayou channel improvements.

8. **Lake Brownwood Modification, Pecan Bayou, Colorado River Basin, Texas, Design Memorandum Number 1, General, Phase I Plan Formulation, April 1975.** This report recommended construction of the Lake Brownwood modifications. This modification would ensure the continued existence of Lake Brownwood for needed flood control, water supply, and recreation in the Pecan Bayou watershed. The plan included construction of a new dam, immediately downstream of the existing Lake Brownwood dam, and erosion control measures to prevent erosion of the existing spillway. The first cost of this project was estimated to be $21,295,000.

9. **Revised Plan of Study, Feasibility Report for Water Resources Development, Colorado River and Tributaries, Texas, Colorado River Basin, Texas, June 1975.** This report presented an amended plan of study to update the Revised Plan of Survey for Comprehensive Survey Report of the Colorado River and Tributaries, Texas, dated August 1963.

10. **Navigability Study, Colorado River, Tributaries and Lakes, Colorado River Basin, Texas (River Mile 290.1 to 890.0), February 1975.** This report determined that as of 10 February 1975, the Colorado River from river mile 291.6 to 890.0, Texas Highland Lakes and other lakes above river mile 290.1 and all tributaries of the Colorado River above river mile 290.1, together with lakes thereon, are non-navigable. This report also recommended that this portion of the Colorado River (river mile 290.1 to 890.0), Texas Highland Lakes and other lakes above river mile 290.1 and all tributaries of the Colorado River above river mile 290.1, together with lakes thereon, be declared non-navigable waters.

11. **Lake Brownwood Modification, Pecan Bayou, Colorado River Basin, Texas, Design Memorandum Number 1, General, Phase II Project Design, June 1976.** This report finalized the design of the Lake Brownwood modifications. This modification would ensure the continued existence of Lake Brownwood for needed flood control, water supply, and recreation in the Pecan Bayou watershed. The plan was changed to an "add-on" or composite embankment rather than a new dam immediately downstream of the existing Lake Brownwood dam. The erosion control measures for the existing spillway were finalized. The first cost of this project was estimated to be $24,850,400.

12. **Lake Brownwood Modification, Pecan Bayou, Colorado River Basin, Texas, Design Memorandum Number 4, Availability of Construction Materials, June 1976.** This report presents the authoritative information and the results of investigations and study regarding the availability and economics of satisfactory sources of major construction materials required for construction of Lake Brownwood modification and its appurtenant structures.

13. **Lake Brownwood Modification, Pecan Bayou, Colorado River Basin, Texas, Design Memorandum Number 5, Real Estate - Lands For Construction Area, July 1976.** This report presents the location, general description, land utilization, acquisition criteria, and schedule of acquisition encompassing approximately 399 acres of the construction area. The proposed real property acquisition line considers requirements for construction of the project and the comparable sales, trends of values, relocation assistance and estimated costs for acquisition of the land and interests.

14. **A Final Supplement to the Final Environmental Impact Statement, Lake Brownwood Modification, Pecan Bayou Watershed, Colorado River Basin, Texas March 1977.** This supplement to the EIS determined that the project would have some degradation of the water quality immediately downstream, due to construction activities. There would be a loss of wildlife habitat within the construction area, and a loss of 383 acres of cropland, which would be used as fill material for the embankment. Nine identified archeological and historic sites would be avoided during the construction.

15. **Status Report Colorado River Basin, Texas September 1987.** This report presents the results of preliminary investigations to identify water resource problems and needs in the basin. This work was accomplished under authority of the Colorado River Basin, Texas, basin wide authority.

16. **The Texas Statewide Inventory of Flood Protection Needs - May 1990.** This study was completed to provide an up-to-date, community-specific inventory of flooding problems and solutions for 756 cities and towns in Texas that could be incorporated into the revised state water plan. This inventory contains data from previous planning studies and National Flood Insurance Program (NFIP).

17. **Report on Flooding, April May 1990.** This report provides a summary of the flood damages experienced and effectiveness of U.S. Army Corps of Engineers projects during the period of April through May 1990. This report contains general information on the storms and their resultant impacts. The report contains a brief description of the rainfall and various river basins that experienced flood inundation, flood losses sustained in the respective counties and cities, and estimates of damages prevented by existing Corps of Engineers projects.

18. **Reconnaissance Report – Pecan Bayou, Colorado River Basin, Texas – March 1994.** This report documented a significant need for flood protection within the Pecan Bayou watershed study area, particularly within the city of Brownwood along Pecan Bayou and Willis Creek. Seven preliminary alternatives were investigated including three different detention structures, three hydraulic channel improvements, and a non-structural alternative (permanent evacuation). Two economically viable flood damage reduction plans were identified and recommended for further study. This document is the result of that study recommendation.

19. **Final Interim Feasibility Report and Integrated Environmental Assessment – Pecan Bayou Watershed, Brownwood, Texas – February 2003.** This report details plan formulation for flood risk management alternatives along Pecan Bayou and Willis Creek in Brownwood, Texas. The resulting tentatively selected plan found only channelization work along Willis Creek to be economically justifiable. *(Basis of this FID)*.

6.2 Non-USACE Studies and Reports

There are numerous other technical reports published by other Federal, state, regional, and local entities that document water resources investigations made within the Pecan Bayou watershed. The following paragraphs briefly describe these studies and reports.

1. **Federal Emergency Management Agency (FEMA).** FEMA is responsible for the administration of the National Flood Insurance Program. A few cities and counties within the Pecan Bayou watershed are participants in the program. The results of the studies are shown in the flood insurance rate maps (FIRMs) published by FEMA. The following is a list of known Flood Insurance Studies completed (effective program date) within the Pecan Bayou watershed. Town of Blanket (April 2, 1992), City of Brownwood (July 6, 1982), City of Clyde (May 25, 1978), City of Coleman (April 1, 1981), Town of Cross Plains (Not in Program), City of Early (July 1, 1987), Town of Mullin (Not in Program), City of Novice (Not in Program), Brown County (March 1, 1991), Callahan County (Not in Program), Coleman County (Not in Program), Comanche County (June 20, 1990), Eastland County (Not in Program), Runnels County (Not in Program), Mills County (April 28, 1992), Taylor County (June 1, 1987).

2. **The Report of the U.S. Study Commission - Texas, The Eight Basins, March 1962.** An act of Congress, approved 28 August 1958, established the United States Study Commission on the Nueces, Trinity, Brazos, Colorado, Guadalupe, San Antonio, Nueces, and San Jacinto River Basins and intervening areas within the state of Texas. The directive instructed the Commission to make an integrated and cooperative investigation, study, and survey in connection with and in promotion of the conservation, utilization,

and development of the land and water resources. The purpose is to formulate a comprehensive development plan for submission to and consideration by the President and the Congress. The report evaluated the water conservation requirements and means of satisfying them to the year 2010. However, due to the use of generalized procedures and criteria or the total lack of economic analysis of certain multiple purposes, the plan did not adequately evaluate flood control, navigation, hurricane protection, and pollution abatement. The plan was a well-conceived framework from which the ultimate objectives of comprehensive and integrated water and land resource development could be obtained. It is considered a flexible base subject to refinement and revision as prevailing conditions dictate and as more detailed analyses are made.

3. **Department of the Interior, Reservoir Operation in Texas - June 1985.** This report, authorized by the Water Resource Development Act of 1978 (PL 95-467), compiled a comprehensive listing of the water resources and their uses within the various river basins in the state of Texas. This report summarizes the reservoirs, their storage, and operating plans.

4. **Department of Water Resources, Texas, Water For Texas - November 1984.** A two-volume report was prepared. Volume 1, A Comprehensive Plan for the Future, of the amended 1969 Texas Water Plan is an executive summary that sets forth planned actions and policy recommendations. Volume 2, Technical Appendix, is a technical document which provides details of current water development and use, projected future water supply and treatment needs, and potentially developable water supplies to meet future water needs in each river and coastal basin of the state.

5. **Texas Water Development Board, Occurrence and Quality of Ground Water in Brown County Report Number 46, May 1967.** This report was prepared in response to a directive from the Texas Water Pollution Control Board and evaluated the ground water in Brown County to determine what, if any, pollution was occurring. This was accomplished by collecting and compiling information regarding the occurrence and chemical quality of the ground water used by landowners and others. Additionally, this study identified and delineated the underground formations containing useable water.

6. **Texas Water Development Board, The Texas Water Plan, November 1968.** This report outlines a flexible guide for the orderly development, conservation, and wise management of the State's water resources to meet the needs of the state to the year 2020. The plan suggests the possibility of importing large quantities of surplus water from the lower reaches of the Mississippi River to areas of greatest need in Texas.

7. **Texas Water Development Board, Water for Texas, Today and Tomorrow, December 1990.** This report updates and presents the 50-year plan for the state of Texas, including the current and prospective water uses, identifies water supplies, and estimates facility needs and costs. The plan also describes water problems and opportunities, outlines significant environmental concerns and water issues, and offers program and policy recommendations.

8. **Texas Water Development Board, Water for Texas, Today and Tomorrow, November 19, 1992.** This report updates the 50-year plan for the state of Texas. This summary document provides details on the current and prospective water uses, identifies water supplies, and estimates facility needs and costs. The plan also describes water problems and opportunities, outlines significant environmental concerns and water issues, and offers program and policy recommendations. Additionally, the document outlines proposed future Texas Water Development Board actions and key policy recommendations to local, State, and Federal entities in the area of water management.

9. **Texas Water Commission, A Plan For Meeting the 1980 Water Requirements For Texas - 1961.** This report addressed potential flood damages and water supply issues. Pertinent data to the Pecan Bayou watershed included discussion of a reservoir on Jim Ned Creek at the Jim Ned Creek site.

10. **Texas Water Commission, The State of Texas Water Quality Inventory, August 1992.** This report was prepared in accordance with Section 305(b) of the Clean Water Act and describes the status of the state waters based on the most recent four years of monitored surface and ground water quality data. An overview is provided discussing water quality trends, attainment of surface water quality standards, relative impacts of pollutants from various sources, and water bodies where additional actions are needed. Surface water quality data is summarized for individual streams, river, reservoir, bay, estuary and Gulf of Mexico segment. Groundwater quality within each major river basin is described.

11. **Brown County Water Improvement District Number One, Hydrologic Study of Lake Brownwood and the Pecan Bayou Watershed, March 1965.** This study investigated the current and likely future dependable yield from Lake Brownwood.

12. **Brown County Water Improvement District Number 1, November 1979, Investigation of Lake Brownwood Dam.** This study analyzed the adequacy of the existing dam. The study concluded the foundation of the existing dam appears to be stable, and the spillway does not appear to be in immediate need of rehabilitation. The study further concluded the existing dam is

hydraulically inadequate for the design storm. Their recommendations included raising the dam to elevation 1470' (from existing elevation 1449'), and a modification to the outlet works to allow for water supply by pipeline. Modifications to the spillway were not warranted at that time.

6.3 Existing Water Resource Projects

6.3.1 Federal Water Resource Projects

In 1943, the Department of the Army constructed a local flood damage reduction project along Willis and South Willis Creek in Brownwood to mitigate for the adverse hydraulic impacts brought about by the Camp Bowie. The project was constructed in accordance with recommendations made by the Corps of Engineers in the "Supplemental Report on Floods in Willis Creek Valley below Camp Bowie, Texas", dated March 1, 1943. The project consisted of a hydraulic channel improvement on Willis Creek from its confluence with South Willis Creek, upstream a distance of approximately 4,700 feet, a new bridge over South Willis Creek at Fourth Street, and raising and lengthening the existing bridge over Willis Creek at Austin Avenue. In addition, low levees were constructed using spoil material obtained from the channel excavation. The levees were located along the left bank of South Willis Creek from a point about 300 feet above the confluence with Willis Creek to Stephen F. Austin Boulevard, and along the right bank of Willis Creek and South Willis Creek from Austin Avenue to near Third Street. Finally, the abandoned portions of the creek channels were backfilled; several locations of the channel bank were raised to the design water surface elevation, also using the spoil material obtained from the channel excavation.

Hords Creek Reservoir, authorized by the Flood Control Acts of August 18, 1941 and December 22, 1944, is an existing Corps of Engineers project constructed for purposes of flood control, water supply, and recreation. Construction was initiated in January 1947 and the dam was placed in service on June 16, 1948. The Hords Creek Dam is located about 13 stream miles west of Coleman, Texas, and is an earth-filled embankment, which is 6,800 feet long, including an uncontrolled 500-foot-wide broad crested spillway, and water-supply appurtenances consisting of an approach channel, intake structure, and a 24-inch water line through the dam. The reservoir has a water surface area of about 510 acres at top of water conservation pool. Total capacity is 49,290 acre-feet at maximum design water surface, of which 2,860 acre-feet was allocated to sediment storage, 5,780 acre-feet to water conservation storage, 16,670 acre-feet to flood control storage, and 23,980 acre-feet to surcharge storage.

The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) has an on-going flood-detention-reservoir program on the Pecan Bayou watershed. The program is outlined in the Report of the U. S. Study Commission - Texas, dated March 1962, and includes 146 floodwater retarding structures, of which 88 reservoirs are located upstream of Lake Brownwood and 58 downstream. Associated with this program the NRCS has prepared definite work

plans for construction of 55 additional reservoirs upstream from Lake Brownwood.

Pecan Bayou Lake was authorized by the Flood Control Act of 1968 (Public Law 90-483) approved 13 August 1968. The project would provide flood damage reduction, water supply, and recreation. The authorized project consists of an earth filled dam 15,500 feet in length (including the spillway), a top width of 20 feet, and a maximum height of 107 feet. The spillway was broad-crested and uncontrolled. In 1978, the Brown County Water Improvement District Number 1 (BCWID#1), requested the Corps of Engineers to initiate Phase I Advance Engineering and Design Studies, on the Pecan Bayou Lake. However, the studies were not funded and no further contact was made until 1984 when the BCWID#1 was notified of the possible deauthorization of the project. The BCWID#1 passed a resolution on 9 July 1985, again requesting the Corps of Engineers to initiate Phase I Advance Engineering and Design Study on Pecan Bayou Lake. Again, the studies were not funded. In a 1994 Reconnaissance Study, it was determined that the Pecan Lake Bayou project was no longer economically feasible, although the project remains authorized for construction.

The Pecan Bayou Channel Improvement, Brownwood, was also authorized by the Flood Control Act of 1968 (Public Law 90-483), approved 13 August 1968. The authorized project consisted of 7.3 miles of channel improvement, having a bottom width of 300 feet, and a depth of 32 feet. Local interests did not wish to further participate in the development of this project. Subsequently, the project was de-authorized by House Document 97 59, dated 9 June 1981.

The Lake Brownwood Modification project was also authorized by the Flood Control Act of 1968 (Public Law 90-483) approved 13 August 1968. The project consisted of extending the existing embankment (Lake Brownwood was constructed in 1932 by local interests), lengthening the existing concrete spillway, and modifying the existing outlet structures. The detailed design was initiated and several Design Memoranda were published in 1976. However, in 1976, the Corps of Engineers determined that the project was a local dam safety issue and not a flood control project of Federal interest. The BCWID#1 constructed the modification in 1981 substantially in accordance with the Design Memoranda mentioned above. Subsequently, the Lake Brownwood Modification project was de-authorized by Public Law 99 662, dated 17 November 1986.

6.3.2 Non-Federal Water Resource Projects

Lake Brownwood is impounded by a dam on Pecan Bayou, a short distance below the confluence of Pecan Bayou and Jim Ned Creek. The drainage area above the dam is about 1,544 square miles. The original dam was completed in 1932. Lake Brownwood provides municipal and agricultural water supply, flood damage reduction, and recreational opportunities and is operated by the BCWID#1. The dam is an earth-fill embankment about 1,580 feet long. Its

maximum height is about 140 feet and it has a crown width of 12 feet. The embankment includes: two 42-inch conduits through the base of the dam near the center for drawing down the reservoir during emergencies, and a conduit near the south end of the dam for releasing water into the supply system. An uncontrolled spillway is located in a saddle about 2,000 feet north of the dam and consists of a cut through the saddle. The spillway has a width of about 479 feet. The total storage below the conservation level is about 119,000 acre-feet. The BCWID#1 has had to make major repairs on the conduits and conduit-gate structure and does not now utilize the existing Broome gates at the intake ends of the 9-foot conduits. Instead, BCWID uses the 24-inch outlets, which bypass the Broome gates, for regulating the lake level. The reduction in discharging capacity of the outlet results in more frequent use of the existing spillway.

The principal purpose of Lake Brownwood is water supply in providing water for the cities of Brownwood, Bangs, Santa Anna, and Early for municipal and industrial purposes and water supply for irrigating about 5,000 acres of arable land within the boundaries of the District. The BCWID#1 comprises about 14,000 acres of land within its boundaries, including the urban area of the city of Brownwood. In addition to serving about 5,000 acres of arable land within the District boundaries, the District, at times, sells water to irrigate portions of about 1,500 acres outside the District boundaries.

Lake Coleman is located on Jim Ned Creek and was constructed by the city of Coleman for municipal and industrial water supply. Construction was initiated in August 1965, completed in April 1966, and put into operation in May 1966. The storage capacity at the time of construction was 40,000 acre-feet. Lake Coleman, which is served by a drainage area of about 305 square miles, provides the majority of the water supply for the city of Coleman. Lake Coleman has a normal water surface area of about 2,000 acres.

Lake Clyde is located on North Prong Pecan Bayou, a tributary of Pecan Bayou, about 6 miles southeast of the city of Clyde. The reservoir was designed for municipal water supply and floodwater detention. Construction of the dam was initiated in June 1969 and completed in November 1969. The storage capacity at time of construction was 5,750 acre-feet. Lake Clyde is the primary source of water supply for the city of Clyde.

Lake Scarborough is located on Indian Creek, a tributary of Jim Ned Creek, about 4 miles north of the city of Coleman. The reservoir, completed in 1927, was constructed by the city of Coleman for municipal water supply. The storage capacity at time of construction was 2,000 acre-feet. The water from Lake Scarborough is filtered, and then delivered to Coleman through a 10¬-inch pipeline. Lake Scarborough, which is served by a drainage area of about 12 square miles, provides a negligible amount of water supply, and proved to be inadequate for the water supply needs of the Coleman area. Thus, the city of

Coleman acquired the water supply storage rights in the Hords Creek Reservoir project prior to its construction.

7.0 Problems and Opportunities

Flood Risk Management Opportunities

The City of Brownwood suffers from periodic severe flooding along Willis Creek. This provides the opportunity to reduce flood damages to structures and their contents as well as vehicles, along Willis Creek within the city of Brownwood. In addition, inundation, and high velocities threaten the life, health, and safety of the residents of Brownwood. A reduction in flooding, including critical infrastructure, can allow residents a better opportunity to reach safety during times of flooding.

Recreational Opportunities

The need for recreational outputs within the watershed is limited, particularly in the City of Brownwood. Those recreational facilities typically associated with local flood damage reduction projects such as parks, playgrounds, hike and bike trails are in sufficient supply in Brownwood and the immediate vicinity. Given that the City did not desire such features to be included in any recommended plan, further studies regarding recreation opportunities were not pursued.

Ecosystem Restoration Opportunities

The feasibility study does not include any detailed investigations of ecosystem restoration opportunities. The local sponsor did not desire such features to be included in any recommended plan. Further studies regarding ecosystem restoration were not pursued.

Water Supply Opportunities

On a regional basis, the total water demands in Region F exceed the currently available supplies throughout the 50-year planning period. Shortages increase from 170,000 acre-feet per year in 2000 to 200,000 acre-feet per year in 2050. Most of these shortages result from large irrigation demands that cannot be met by ground water during drought conditions. Flood control reservoirs were eliminated from consideration during the reconnaissance phase. No water supply measures were pursued during the feasibility study.

8.0 Planning Goals and 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 conditions in the study area. The planning objectives for the period of analysis between the years 2017 to 2064 along Willis Creek in the City of Brownwood are as follows:

8.1 Planning Objectives

1. Reduce flood damages to structures and their contents as well as vehicles.

2. Reduce the potential for loss of life associated with inundation, high velocities, isolation, and/or overtopping of roads and bridges.

3. Reduce flood damages to public facilities such as roads, bridges, utilities, schools, churches, and government facilities.

4. Reduce the public and private costs associated with flood fighting and recovery.

5. Minimize environmental and social disruptions, and preserve or enhance fish and wildlife habitat.

6. Reduce business and commercial losses resulting from a loss of production.

8.2 Planning Constraints

In development of flood damage reduction alternatives, the following constraints or limitations were identified to direct plan formulation efforts:

1. Alternatives will be limited to the study area within the city of Brownwood along Willis Creek.

2. The formulation of alternatives that reduce flood damages and costs in one area should not result in the measurable increase in the extent and magnitude of flooding in another area.

3. The formulation of alternatives must avoid adverse effects to significant ecological and environmental resources; and if avoidance is not feasible, then adverse effects must be minimized. Unavoidable adverse effects to these resources must be mitigated.

4. The formulation of alternatives must avoid adverse effects to significant cultural resources; and if avoidance is not feasible, then adverse effects must be minimized. Unavoidable adverse effects to cultural resources must be mitigated.

5. The formulation of alternatives should avoid areas that are either known or suspected to be contaminated and/or contain hazardous, toxic, and radioactive waste.

6. The formulation of alternatives must avoid adverse effects to occupied land.

7. The formulation of alternative must avoid adverse aesthetic and visual effects.

8. Total annual benefits must equal or exceed total annual costs for a plan to be implemented.

9. The recommended plan must be generally acceptable to the public.

10. The recommended plan must have a local non-Federal sponsor.

9.0 Inventory and Forecast

The inventory of damageable structures presented here was developed about 1999. During a 2014 site visit, it was noted additional development has occurred within the study area, but outside the previous FEMA floodplain that was in force at the time. FEMA has recently updated the floodplain mapping in the area (2014) and several structures not in the previous floodplain are now within the new delineation. For the prospective CAP study, the inventory will need to be updated to include new structures and current economic values.

In 1999, a total of 322 damageable structures were field identified within the .2 percent annual chance exceedance (ACE) limits of Willis Creek with the majority of the structures identified are single family residential as shown in Table 1. The total estimated value of the floodplain investment is about $37.3 million, based on May 2000 prices and level of development. Residential values constitute 88 percent of the total floodplain investment with an average value of $65,500 for single-family residences and their contents. Table 2 presents a summary of the cumulative number and type and the associated damages of affected structures and vehicles, by flood occurrence not accounting for risk and uncertainty.

Table 1. Estimated Investment Value of Willis Creek Floodplain Properties ($1,000, May 2000 Prices)

Type	Number	Structure	Content	Total
Commercial	5	$ 400	$ 300	$ 700
Single Family	296	$ 19,400	$ 9,700	$ 29,100
Multi-Family	21	$ 3,300	$ 1,700	$ 5,000
Subtotal	322	$ 23,100	$ 272	$ 34,800
Vehicles		$ 2,500		$ 2,500
Total Investment		$ 25,600	$ 272	$ 37,300

Table 2. Willis Creek Cumulative Estimated Single Occurrence Flood Losses to Structure and Contents under Existing Conditions ($1,000, May 2000 Prices)

Flood	Commercial		Single-Family		Multi-Family		All Structures		POV	Total
Event	Damage	No.	Damage	No.	Damage	No.	Damages	No.	Damage	Damage
20%			$ 606	52	$ 266	44	$ 872	96	$ 23	$895
10%			$2,889	138	$ 521	66	$3,410	204	$ 155	$3,565
4%			$5,006	205	$ 746	99	$5,752	304	$ 438	$6,190
2%		11	$6,385	242	$ 924	13	$7,309	266	$ 696	$8,005
1%	$ .5	33	$7,280	260	$1,065	13	$8,347	306	$ 882	$9,229
0.2%	$30.4	55	$8,350	296	$1,225	21	$9,605	372	$1,305	$10,910

A predominance of residential structures is found within the 10% ACE floodplain and constitutes 95 percent of the expected annual damages. Based on May 2000 prices, expected annual flood losses to structures in the study area total an estimated $956,700 in damage. It was estimated that a 0.2 percent ACE event could cause structure and content damages of about $11 million. This would represent a loss of about 45 percent of the 0.2 percent ACE floodplain investment. The one-percent ACE could produce flood damages in excess of $9.2 million, while the 10 percent event produces about $3.6 million in damages. A predominance of residential structures would be subject to flooding in all the flood zones. Overall, about 85 percent of the damageable property identified would be subject to the one-percent ACE flood event. Properties within the 10 percent ACE flood event constitute about 45 percent of the total number of structures potentially damaged along Willis Creek. Table 3 displays the expected average annual damages in the Willis Creek study area.

Table 3. Existing Expected Annual Damages ($1,000, May 2000 Prices)

Property Type	Annual Damages
Single-Family	$ 755.2
Multi-Family	$ 131.2
Commercial	$ 1.4
Vehicles	$ 68.9
Total	**$ 956.7**

9.1 Fish and Wildlife Considerations

Threatened and Endangered Species

Threatened or endangered species were not identified in the study area.

Cultural Resources

The Willis Creek channel exhibits significant alluvial deposition and the potential for archaeological sites to be buried within this alluvium is extremely high. This potential exists wherever the channel may be placed. A cultural resources survey and backhoe trench subsurface testing of the alluvial deposits for possibly buried archaeological sites will be necessary during the next phase of project development. If significant archaeological sites are encountered during this survey and subsurface testing, then these sites will need to be avoided or mitigated through data recovery.

Hazardous, Toxic, and Radioactive Wastes

The initial site assessment, including reviews of the regulatory records and databases, aerial photographs, and interviews indicate the lack of a presence of apparent HTRW releases or CERCLIS sites in or near the study area. The one area of concern is located south of the creek, and west of 14thStreet. This site is a Formerly Used Defense Site (Camp Bowie), and was used as a potential uncontrolled dumping site. An investigation of the site concluded that the area contained solid municipal waste. The investigation did not identify any hazardous material. Additional investigations may be required to determine the exact location (boundary) of the known waste relative t any alternative considered. However, since this was a Federal facility, if any hazardous or contaminated materials are found, the responsibility for cleanup will fall to the Federal Government.

10.0 Key Areas of Investigation

10.1 Primary Updates

Given that the existing information gathered during the feasibility study is fourteen or more years old, most of the information will need to be updated, or at a minimum reviewed for relevancy to a more current statement of existing conditions. A May 2014 site visit included economics, environmental, and water resources project delivery team members. The windshield survey indicated there were no significant changes in the study area with the exception of a small number of new structures in the floodplain, new construction of the Austin Street Bridge and new modeling for FEMA mapping.

Key updates moving forward with the study under the CAP authority would be:

1. Construction costs: Construction costs have changed significantly and would need to be updated for any proposed plan.

2. Economic Benefits and Costs: Economic benefits, including the new development in the floodplain would be updated using present-day valuations and estimates. Economic modeling would conform to current requirements.

3. H&H modeling resulting from updated FEMA models: Preliminary evaluation indicates that recent FEMA modeling and the resultant floodplain generally match up with the previous Corps modeling and floodplain in the 2003 study. The existing FEMA modeling will be evaluated and reviewed and if found sufficient, the flood elevations would be utilized.

4. Hydraulic changes resulting from Austin Street Bridge: Recent construction of the new bridge would be evaluated and incorporated for hydraulic modeling. Previous Corps hydraulic modeling would be used to the extent practicable.

5. Environmental: The full NEPA process will be required including the opportunity for public comment.

6. Plan Formulation: The plan formulation would need to be reviewed and confirmed, including the alternative screening, comparison, and plan selection as remaining valid. No new measures or alternatives are anticipated to be developed.

10.2 Summary of Feasibility Study Assumptions**.** The feasibility study would be conducted under the Corps' Section 205, Continuing Authorities Program (CAP). Preliminary assumptions for the scope of the study, to be conducted using SMART Planning principles (but not *process)*, include:

- An Environmental Assessment will be required,
- The Corps will verify and utilize the existing FEMA floodplain delineations and mapping in determining flood stage elevations to the maximum practicable extent,
- HEC-FDA will be utilized to develop damages,
- The study would be conducted at a level of detail commensurate with a small-scale construction project,
- Existing information and data will be used to the maximum practicable extent, with appropriate updates only as required,
- Benefits will be evaluated to the extent needed to provide project justification, an exhaustive analysis of all benefit categories will not be pursued unless needed to provide justification. Other benefit categories will be discussed qualitatively
- An exclusion from Type I IEPR will be requested early in the study process, and if not approved will result in additional study costs.

11.0 Alternative Plans Formulated

11.1 Management Measures

Management measures considered during the earlier feasibility study included no action, regulation of floodplain uses, flood forecasting and warning, flood-proofing, and elevation of structures, permanent evacuation, detention, levees and floodwalls, hydraulic channel improvements and/or bridge modifications.

11.2 Screening of Measures

Various alternatives were identified and evaluated in an effort to achieve the stated planning objectives and to adhere to the constraints. The alternatives can be categorized as the “no action” alternative (without project condition - WOP), nonstructural alternatives, and structural alternatives. The initial screening of alternatives eliminated those alternatives that failed to meet the minimal technical, economic and/or environmental criteria. Those alternatives remaining after the initial screening receive additional detailed investigations.

11.2.1 No Action

The “no action” alternative (WOP) would not recommend that any type of project, nonstructural or structural, be implemented. While the no action alternative would not require the expenditure of Federal funds, adoption of this alternative implies acceptance of the existing and future flood damages and other adverse impacts caused by continued flooding. Without a project, many more property owners will be required to pay for flood insurance and others higher premiums. Approximately 400 structures, primarily residential, are currently (2014) affected by flooding. A single large flood event has been estimated to cause approximately $20-25 million in damages. Smaller floods have been estimated to cost around $5 million roughly every ten years. The area has been flooded numerous times historically, damaging homes and businesses, submerging streets & highways, causing economic losses to individuals and businesses, and straining City and County public services. Economic damage doesn't capture the toll from human suffering, possible loss of life, and the impacts and ripple effects on the community associated with living through a natural disaster and the associated long-term post-disaster recovery. The financial burden of roughly $ 1.0 million in annual flood damages for flood fighting and recovery costs, public damages, the potential loss of life, and the overall threat to health and safety would continue under the no action alternative. The no- action alternative does not meet the previously stated planning objectives. This alternative is unacceptable to the city of Brownwood since a feasible alternative is indicated.

11.2.2 Nonstructural Alternatives

Nonstructural measures attempt to avoid flood damages by exclusion or removal of damageable properties from flood prone areas. These measures do not affect

the frequency or level of flooding within the floodplain; rather they affect floodplain activities. Nonstructural alternatives include the following; regulation of the floodplain use, flood forecasting and warning (temporary evacuation) flood-proofing, elevating structures, relocating structures, permanent evacuation.

Regulation of Floodplain Uses

Floodplain management is most effective in controlling future development of the floodplain, thereby assuring that the existing flood problems do not become worse. However, floodplain management cannot, by itself, significantly alleviate existing flooding conditions within an existing floodplain. The technique of controlled land use is particularly helpful in planning for future development but is of limited use in present developed areas. Effective regulation of the floodplain is dependent on developing enforceable ordinances to insure that floodplain uses are compatible with the flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building codes. Zoning regulations permit prudent use and development of the floodplain in order to prevent excessive property damage, expenditure of public funds, inconvenience, and most important of all, loss of life, due to flooding. Subdivision regulations guide the division of large parcels of land into smaller lots, and typically require the developer to show compliance with subdivision regulations, zoning ordinances, the local land use or master plan, and other regulations. A subdivision ordinance would require installation of adequate drainage facilities, prohibit encroachment into floodway areas, require the placement of critical streets and utilities above a selected flood elevation, and building lots or structures above a selected flood elevation, normally one foot above the 100-year floodplain elevation. Building codes specify the building design, materials and construction methods used for both construction of new buildings or repair of flood-damaged structures.

The city of Brownwood currently holds about $4.4 and $20.1 million of Federal Emergency Management Agency's, National Flood Insurance Program (NFIP) and Write-Your-Own flood insurance protection, respectively. The City has been enrolled in NFIP's Regular Program since June 20, 1975. Since the inclusion into this program, Brownwood has enacted and enforced numerous floodplain land-use restrictions, regulation, zoning ordinances, subdivision regulations, and building codes. While these measures will not reduce flood damages the majority of the existing structures in the study area, they are important management tools. Regardless, this does not warrant further evaluation. It should be noted that the city of Brownwood will be required to complete and implement a floodplain management plan within one-year of the completion of any flood damage reduction plan recommended and implemented by the Corps of Engineers.

Flood Forecast and Warning

Flood forecast and warning involves the determination of imminent flooding, implementation of a plan to warn the public, and organization of assistance in evacuation of persons and some personal property. Notification of impending flooding can be by radio, siren, individual notification, or by more elaborate means such as remote sensors to detect water rise levels and automatically warn residents. These measures normally serve to reduce the hazards to life and damage to portable personal property. Flood warning and emergency evacuation should be considered as part of any flood control plan. This alternative also includes the use of flood forecasting to revise the current flood control-operating plan of area lakes to provide additional flood control protection.

The city of Brownwood has a highly effective and efficient workforce that mobilizes during storm events to visually monitor rainfall and river stages. Additional information from Lake Brownwood provides ample time for the mobilization of resources to address Pecan Bayou. Flood forecasts and warnings were not considered further.

Flood-proofing

Flood-proofing structures involves providing watertight coverings for door and window openings, sump pumps to drain seepage, sealing of cracks, steel bulkheads on brick walls (flood shields) to close off entrances, coating walls of structures with a waterproof membrane. Flood proofing is generally applicable where flooding is of short duration, low velocity, infrequent, of shallow depths, and requires significant modifications to structures. For water levels that are lower than the first floor of a home, flood proofing would certainly be a possibility. However, if a sustained water level in excess of one foot of the first floor elevation, the structural stability of a watertight home becomes a critical factor. A flood-proofed structure generally cannot withstand hydrostatic pressures when floodwaters rise three feet above the lowest floor. In addition, flood proofing introduces uncertainties in the degree of protection, since the owner must be present (or awake) to close off windows, doorways, etc. Additional shortcomings include not protecting public facilities such as roads, bridges and utilities, and the continued threat of road closures and the isolation of residents trapped in their homes and businesses. The feasibility of flood-proofing is based on the cost and availability of the structure, the number of structures along the alignment, and the additional costs necessary to alleviate interior drainage problems to prevent induced damages in adjacent areas. Construction of individual flood-proofing around specific structures or small groups of structures is normally considered cost prohibitive unless the individual structure(s) is very valuable and/or has cultural significance and is prone to frequent flooding.

While flood proofing would not likely result in any significant or permanent adverse impacts to ecological or cultural resources, and is appropriate under certain conditions, the past flooding depths and velocities generally exceed those

criteria that would allow the team to state with any confidence that this measure would be generally successful. Based on that assessment this measure did not address the planning objectives or criteria previously discussed in providing feasible flood protection. Therefore, flood proofing was not considered further.

Elevating Structures

This alternative avoids flood damages by elevating damageable property. Elevating is most practical for structures that have access below the first floor (i.e. piers and columns), are light enough to be jacked, and are relatively small. Wood frame structures are particularly suited for elevating. Elevating structures with slab foundations or basements is not generally economically feasible. The design of the foundation walls or piers must withstand forces from flowing water to ensure lateral stability of the structure. Furthermore, elevating structures has similar limitations as flood proofing, namely protecting public facilities, the continued threat of road closures, and the isolation of residents trapped in their homes and businesses. While elevating structures would not likely result in any significant or permanent adverse impacts to ecological or cultural resources, and is appropriate under certain conditions, it does not address the planning objectives or criteria previously discussed. The feasibility of elevating structures is based on the cost and availability of real estate, the number of structures along the alignment to be elevated, and the additional costs necessary to alleviate interior drainage problems to prevent induced damages in adjacent areas. Elevation of structures is normally considered cost prohibitive unless the individual structure is very valuable and/or has cultural significance and is prone to frequent flooding. Based on the type and number of structures located along the channels, elevating structures was not be considered further.

Permanent Evacuation

This alternative (also known as the “buy-out”) involves the acquisition, demolition, removal of structures from the floodplain, and the relocation of residents to flood-free housing. The practicality of evacuation depends on several factors. They include the frequency and severity of flooding, the willingness of residents to move out of the floodplain, the availability of flood-free housing, the value of the property, and the need for areas of a more compatible floodplain use such as parks or nature areas. Permanent evacuation can be a very effective means of reducing flood damages, as well as public damages and costs.

Within the Willis Creek study area, flood damages to structures and their contents begin at about the 20% ACE flood event. There are a total of 56 structures within the 20% ACE floodplain (52 single family residential and 4 multifamily residential), and 144 structures within the 10% ACE floodplain (138 single family residential and 6 multi-family residential).Structural Alternatives

11.2.3 Structural Alternatives

Structural alternatives are designed to control, divert, or exclude the flow of water from flood prone areas to the extent necessary to reduce damages to property, hazard to life or public health, and general economic losses. The structural measures considered most appropriate in dealing with the character of the flood problems encountered in the study area are modification to Lake Brownwood, detention, levees and floodwalls, hydraulic channel improvements including bridge modifications, and diversion.

Detention

This alternative consists of constructing one or more structures to provide flood control storage to detain peak flood flows and lessen downstream flood damages. Detention is used to temporarily impound floodwaters for later release when the downstream conditions permit. The feasibility of this measure depends heavily on the volume and timing of the flood flows, and the availability of an impoundment site capable of providing sufficient storage. Additional costs would also be incurred to mitigate for adverse environmental impacts.

Detention structures of various sizes and capacities, located at two sites above Lake Brownwood, were previously investigated for Pecan Bayou during the reconnaissance study. Out of the ten different detention configurations investigated, none had a benefit-cost ratio greater than 0.2, well below that required for economic feasibility. Conditions in the city of Brownwood are similar to what they were at that time, therefore no additional efforts were viewed as warranted for a detention reservoir in this feasibility study, and this alternative was screened from further consideration.

In the upstream reaches of Willis Creek, there are several detention structures that were constructed by the NRCS. These structures retain a substantial percentage of the rainfall in the upper Willis Creek watershed. For this study, a brief hydraulic analysis of a new detention reservoir near Crockett Street was conducted. Investigations revealed insufficient space available, and this alternative was not considered further.

Levees and Floodwalls

Levee systems traditionally provide high levels of protection to flood prone areas but often require substantial amounts of real estate between the stream and the structures being protected unless an existing levee is in-place and only a small strip of real estate is required. Floodwalls (usually made of concrete) are used in lieu of levees in situations where the acquisition of real estate for the levee or other topographic problems may be prohibitive. The feasibility of either of these measures is based on the cost and availability of real estate, the number of

structures along the levee alignment, and the additional costs necessary to alleviate interior drainage problems to prevent induced damages in adjacent areas. Construction of individual levees or floodwalls around specific structures or small groups of structures is normally considered cost prohibitive unless the individual structure is very valuable and/or has cultural significance and is prone to frequent flooding.

A levee system alternative was considered along both Pecan Bayou and Willis Creek. However, the close proximity of structures to the waterways and the lack of available space, made a levee physically infeasible because of the anticipated high relocation cost associated with removal of the structures where the levees would be constructed. Floodwalls, which require less real estate acquisition, are historically much more expensive than any other alternative, either structural or nonstructural. Based on the minimal benefit-cost ratios estimated for other flood protection alternatives, and because of the large number of structures and length of the floodplain, the floodwall alternative would be prohibitively expensive. The non-Federal sponsor and residents of the area expressed that this was the least desirable solution to the flooding problems, due to the adverse aesthetics of this alternative. Therefore, levees and floodwalls were eliminated from further consideration.

Hydraulic Channel Improvements and/or Bridge Modifications

This measure consists of modifying an existing channel by either increasing the cross-sectional area of the stream channel and/or an existing bridge (widening and/or deepening), straightening and realigning the stream channel, and/or reducing the friction losses of an existing channel through concrete lining. The design of the channel modification can vary significantly and is primarily based on the topography of the existing stream channel and the existing development of properties within the floodplain. The study area of Pecan Bayou and Willis Creek meets the minimum flows, minimum drainage area, and urban drainage criteria required under current policies. Other factors to consider in the design of these hydraulic channel improvement alternatives include the existence of known or potential significant ecological and cultural resources as well as contaminated material.

A hydraulic channel improvement investigated in the 1994 reconnaissance study on Willis Creek was a grass-lined channel. The first segment of the improved channel begins near Asbury Street and extends approximately 1,670-feet downstream of 4th Street, a total distance of about 13,530-feet. The downstream portion of this segment has a bottom width of 40-feet; the upstream portion has a bottom width of 50-feet. Side slopes are 1V:3H throughout this segment. The second segment begins near Austin Avenue (note an unimproved segment lies between the improved segments) and extends a distance of about 1,670-feet downstream. This segment of the channel has a bottom width of 30-feet, and side slopes of 1V: 3.5H (left bank) and 1V:3H (right bank). This

alternative would require the modification of the 14th Street Bridge by adding four 7x9-foot barrels to the existing box culverts (five 10x10-foot). Several water and sewer line relocations, in addition to other utilities would also have to be relocated. The project first cost was estimated at $3,798,400 (January 1994 price level). Annual costs and expected annual benefit were estimated at $356,700 and $1,167,600, respectively. The benefit-cost ratio was 3.3 to 1.0. Accordingly, hydraulic channel improvements on Willis Creek warranted further investigation, as discussed below, for the feasibility study.

City Officials expressed the concern that the FM Road 2126 bridge, which crosses Pecan Bayou about five miles downstream of U.S. Highway 377, was an obstruction and thus, creating a backwater effect. The substantial roadway embankments, on both the left and right side of the channel, essentially block most of the overbank flow areas, thereby preventing storm water from effectively passing beneath the bridge. These embankments do not affect the capacity of the waterway during common storm events, but cause a significant increase in the water surface elevation during rare events. However, because of the distance upstream to the damage centers within the city of Brownwood, this increased water surface dissipates to only a few hundredths of a foot at Woodson Road. Preliminary investigations revealed that the cost of increasing the capacity of this bridge would not be justified by the negligible reduction in flood damages for such rare flood events in the study area. Therefore, this alternative was not studied in detail.

11.3 Final Array of Alternative Plans

Based on the initial screening of nonstructural and structural alternatives, permanent evacuation and hydraulic channel improvement are two alternatives identified as warranting further study. A nonstructural plan was investigated through an array of alternatives but was not determined economically feasible in complying with planning objectives and constraints of this study. Presented below are the results of the additional detailed investigation of these alternatives.

12.0 Evaluation and Comparison of Array of Alternative Plans

Permanent Evacuation

Three different permanent evacuation scenarios were investigated on Willis Creek. The first called for the acquisition and removal of all (54) structures within the 50% ACE floodplain, the second was the acquisition and removal of all (144) structures within the 10% ACE floodplain, and the third was the acquisition and removal of all (274) structures within the 1% ACE floodplain. As shown in Table 4, the resultant benefit-to-cost ratios for the 10- and 1 percent zones were below unity and the ratio for the 50 percent zone had relatively minimal net benefits. There was no interest in pursuing lower level or partial protection for smaller number of structures without affecting “community cohesion”. Basically stated, a permanent evacuation alternative cannot be recommended which removes only

a portion of the affected structures while leaving a number of structures within the same floodplain in the study area. Therefore, permanent evacuation was eliminated from further consideration.

Table 4. Benefits of Nonstructural Alternatives on Willis Creek ($1,000, May 2000 Prices

Flood Event	No.	Flood Free Value	Demolition Costs	Economic Costs	Annual Benefits	Annual Costs	Net Benefits	BCR	Financial Costs
0-50%	54	$ 4,387.6	$1,062.3	$ 5,450.0	$ 389.0	$ 384.0	$ 5	1.0	$1,527.0
0-10%	144	$ 9,186.7	$2,218.3	$ 10,405.0	$ 776.7	$1,072.0	($672)	0.7	$3,198.0
0-1%	274	$25,192.3	$8,661.4	$ 30,854.0	$1,033.0	$2,234.0	($1,201)	0.5	$5,661.4

Hydraulic Channel Improvement

As previously discussed, a hydraulic channel improvement was originally determined to be economically feasible on Willis Creek during the reconnaissance study. The primary objective of the hydraulic channel improvement was to contain flood flows within the banks of the creek and minimize losses. An update of the original analysis of the Willis Creek channel improvement alternative investigated a grass-lined channel beginning near Asbury Street and extending about 4,800-feet downstream of Austin Avenue. The total length of the improvement would be approximately 16,280-feet through the natural channel. The channel bottom width would be 45-feet with side slopes of 1V:3H. The initial center line for the improved channel would also be located such that the alignment would minimize adverse impacts to ecological resources as well as occupied land, i.e., back yards of those homes located adjacent to the creek, through the use of one-sided excavation to fullest extent possible. This channel improvement would require a modification to the 4th street and 14th street bridges culverts, and utility relocations, primarily consisting of water, sewer, gas, electric, telephone, and cable. Erosion protection would also be required along portions of the improved channel.

Flood Damage Reduction.

The channel was evaluated for bottom-widths of 10-, 25-, 45-, and 60-feet. Benefits quantified during these analyses were the reductions in damages to structures (residential and commercial) and their contents, and savings in flood insurance costs. These alternative plans would produce a damage reduction ranging from 47 percent to 97 percent based on planning level cost estimates. A summary of the residual damages and resulting benefits is presented in Table 5.

Table 5. Economic Benefits of Structural Plans for Willis Creek ($1,000, May 2000 Prices)

Alternatives	Residual Damages	Flood Benefits	Insurance Benefits	Total Benefits	% Damage Reduction
No Action	$ 956.7				
10-foot	$ 509.3	$ 447.3	$ 5.7	$ 453.0	47%
25-foot	$ 253.6	$ 703.0	$ 13.3	$ 716.3	75%
45-foot	$ 112.4	$ 844.2	$ 35.6	$ 879.9	92%
60-foot	$ 63.1	$ 893.5	$ 37.7	$ 931.1	97%

13.0 Recommended Plan – GI Study

Further refinement was investigated to reduce adverse ecological impacts resulting from a hydraulic channel improvement. Although the channel centerline and alignment were set to minimize adverse ecological resources, additional resources could be avoided via a diversion channel. The diversion channel would begin about 1,200 feet downstream of 14th Street extending downstream a distance of 2,000 feet, and reentering Willis Creek about 500-feet upstream of 4th Street. The diversion channel is described as a grass-lined, trapezoidal channel having side slopes of 1V:3H and a 45-foot bottom width (given the 45-foot bottom width channel is proven to be the most efficient; no other bottom width for the diversion channel was investigated in detail). The effect of the diversion would be the avoidance of adverse impacts to the high quality riparian corridor in the area in question, as well as reducing environmental mitigation costs. The hydraulic channel improvement alternative up- and downstream of the diversion channel would remain the same. Table 6 displays a summary of the economic analysis of the hydraulic channel improvement alternative with the diversion for Willis Creek.

Table 6. Planning Level Economic Analysis of Structural Plans for Willis Creek with Diversion ($1,000; May 2000 Prices)

	10-foot	25-foot	45-foot	60-foot	45-foot with Diversion
Estimated First Cost	$3,765,600	$4,321,300	$5,978,700	$6,735,300	$5,942,400
Construction Period (Months)	12	15	18	21	18
Investment Cost	$3,888,997	$4,499,271	$6,275,785	$7,127,892	$6,237,681
Operation/Maintenance ($/Year)	$10,000	$12,500	$15,000	$17,500	$17,500
Total Annual Charges	**$278,510**	**$323,146**	**$448,303**	**$509,635**	**$445,672**
Total Annual Benefits	**$452,954**	**$716,276**	**$879,854**	**$931,200**	**$879,854**
Net Benefits	$174,444	$393,130	$431,551	$421,565	$434,182
Benefit-to-Cost Ratio	**1.6**	**2.2**	**2.0**	**1.8**	**2.0**

Based on the planning level economic analysis in Table 6, the 45-ft bottom width alternative with diversion provides the greatest net benefits comparatively among any alternatives evaluated in detail.

When updated with current costs and pricing data of May 2001 through an MCACES cost estimate, the total and annual project cost of the recommended plan with diversion channel is estimated at $7,961,900 and $572,800, respectively as indicated in Table 7. Costs were increased due to higher real estate costs primarily.

The resultant BCR is 1.6 to 1.0 with about $314,800 in net benefits (May 2001 update vs.Table above from May 2000).

Table 7. Economic Analysis of Alternative with Diversion for Willis Creek ($1,000, May 2001 Prices)

	WC45 w/Diversion
Estimated First Cost	$7,961,900
Construction Period (Months)	18
Investment Cost	$8,342,600
Operation/Maintenance ($/Year)	$15,600
Total Annual Charges	**$572,800**
Total Annual Benefits	$887,600
Net Benefit	**$314,800**
Benefit-to-Cost Ratio	**1.6**

14. Preliminary Financial Analysis. As the local sponsor, the City of Brownwood recognizes that they will provide 50 percent of the cost of the Feasibility study. The local sponsor is also aware of the cost sharing requirements for the potential project implementation phase (design and construction) of 35 percent with a mandatory 5 percent cash contribution for structural projects.

15. Budget. In the Corps FY14 CAP Work Plan, $97,500 in federal funding was approved, contingent upon execution of a FCSA. The initial $100,000 full-federal allowance typically afforded for initiating CAP studies was determined to not be appropriate for the proposed CAP study since extensive federal funding has been previously expended, and concomitant analyses conducted, for the GI feasibility study. The CAP study is treated as a conversion vs. a pure “new start”. Upon approval and execution of the FCSA, $200,000 in federal funding would be requested. The sponsor will be responsible to match any amount of federal funds received, whether split between fiscal years or in one lump sum.

At this time (July 2014), the City is pursuing the full nonfederal match of $200,000 and is anticipated to sign the model FCSA. The project is on the August City Council agenda for approval.

City of Brownwood

November 5, 2013

Sam Arrowood
Continuing Authorities Program Manager
Fort Worth District
USA Corps of Engineers
1100 Commerce ST
Room: 831
Dallas, TX 75242

Dear Mr. Arrowood

The City of Brownwood is supportive of the Corp of Engineers completing the Continuing Authorities Program study for Willis Creek Channelization Project.

As recommended in the "Final Interim Feasibility Report and Integrated Environmental Assessment" of the Pecan Bayou Watershed in Brownwood, Texas February 2003 study by the Corps of Engineers, this project would reduce flood damage along Willis Creek.

Without construction of such a project and when the new FIRM becomes effective, over 400 structures will be located within the designated 100-yr floodplain.

Based upon 2012 tax rolls, the proposed project would remove improvements valued at over $87M, while improvements of almost $12M would remain in the floodplain.

The City of Brownwood and the USDA completed a similar channelization project of Adams Branch in 1995. The Adams Branch Channelization Project has been a significant asset to the city's drainage system.

City staff is available to assist the CORPS in updating the data needed for the Willis Creek Channelization Project. Contact Donald Hatcher or Jodie Kelly if the city can be of further assistance.

Sincerely,

Bobby Rountree
City Manager

Cc: Donald R. Hatcher, P.E., Division Director for Public Works/City Engineer/Floodplain Administrator
Jodie Kelly, Staff Engineer, Secretary of The Planning and Zoning Commission, Assist Floodplain Manager

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