Onion Creek, Barton Creek, and Pedernales River Watersheds Interim Feasibility Study Final Report

0904830950

Prepared for:
Texas Water Development Board
and U.S. Army Corps of Engineers: Fort Worth District

US Army Corps of Engineers®

October 18, 2013

Prepared By:
Halff Associates, Inc.

HALFF

STATE OF TEXAS
DANIEL LEE HARRIS
104646
LICENSED
PROFESSIONAL ENGINEER

Daniel Lee Harris
10/18/2013
Firm #: 312

On Behalf of Hays County, Texas

This document is for planning purposes only and is not intended for construction, bidding, or issuance of permits. It was prepared by or under the supervision of:

Daniel Lee Harris	104646	10/18/2013
Type or Print Name	PE#	Date

Onion Creek, Barton Creek, and Pedernales River Watersheds Interim Feasibility Study Final Report

Prepared for:
Texas Water Development Board
and U.S. Army Corps of Engineers: Fort Worth District

October 18, 2013

Prepared By:
Halff Associates, Inc.

STATE OF TEXAS
DANIEL LEE HARRIS
104646
LICENSED
PROFESSIONAL ENGINEER

10/18/2013
Firm #: 312

On Behalf of Hays County, Texas

This document is for planning purposes only and is not intended for construction, bidding, or issuance of permits. It was prepared by or under the supervision of:

Type or Print Name	PE#	Date
Daniel Lee Harris	104646	10/18/2013

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Onion Creek, Barton Creek and Pedernales River watersheds located in the northern half of Hays County have been the source of frequent flooding. As a result of frequent flooding and the potential for increased development in the study area, Hays County took a pro-active lead in teaming with the U.S. Army Corp of Engineers and the Texas Water Development Board (TWDB).

Hydrologic and hydraulic modeling was performed for all three watersheds in Hays County. Detailed LiDAR elevation data as well as cross-section and bridge/culvert surveys, where available, were used to enhance the accuracy of the models. The modeling resulted in updated and more accurate flows and water surface elevations for the 2, 5, 10, 25, 50, 100, 250, and 500-yr events. The resulting hydraulic data was then used to analyze various flood reduction alternatives for the City of Dripping Springs, City of Buda, and Hays County.

Several flood reduction alternatives were analyzed during the flood damage reduction analysis portion of the study. Each alternative was evaluated by cost and potential for producing a benefit-to-cost ratio greater than one. Structural alternatives were recommended for the City of Dripping Springs and City of Buda that consist of upstream detention, channel improvements, or diversion of flow. Non-structural alternatives were also considered for the City of Dripping Springs and City of Buda consisting of buyouts or relocations. Alternatives for Hays County included regional detention options along Onion Creek to relieve flooding in the Buda area. Typical standards for conveyance are that county-maintained roads should pass at least the 5-yr flow and state-maintained roads should pass at least the 25-yr flow. A ranking of stream crossings was compiled using an urgency rating calculated from maximum frequency of flow passed by the structure and average annual daily traffic counts.

1.0 Introduction and Background

The Onion Creek, Barton Creek and Pedernales River watersheds are located in the northern half of Hays County on the border of the Edwards Plateau and southern Black Prairie Regions (see Figure 1). These watersheds drain approximately 315 square miles within Hays County. The terrain varies from hilly tree-covered ranch country in the northwest to undulating grassy plains in the southeast. The study area includes several different land use types including the urban areas of Dripping Springs and Buda as well as rural subdivisions and communities in the county. The study area is experiencing an increase in development from an influx of people moving away from the City of Austin to live and work. The elevations vary from approximately 600 feet above sea level at the downstream county line to 1500 feet above sea level (North American Vertical Datum (NAVD) 1988) in the headwaters above the City of Dripping Springs. Average annual rainfall in the watershed is 33.75 inches per year.

Significant floods have recently occurred in the study area in 1998, 2002, 2004, and 2007. The 1998 and 2004 events resulted in millions of dollars in flood damages and federal disaster declarations for Hays County. These flood events not only resulted in costly structural damage, but also caused disruption to travel and emergency services due to road flooding. An example of this type of flooding, which is currently being addressed by the County, is the McGregor lane crossing at Barton Creek. Flooding of McGregor Lane during the 2007 event can be seen in Figure 2. New roadway and culverts have been designed and constructed as part of a separate project to allow for more conveyance of flood flows before the road is overtopped.

As a result of frequent flooding and the potential for increased development in the study area, Hays County took a pro-active lead in teaming with the U.S. Army Corp of Engineers for 50% project funding and applying for a Flood Protection Planning Grant from the Texas Water Development Board (TWDB) for 25% project funding, which was awarded in 2010. Hays County teamed with the Cities of Buda and Dripping Springs to provide a local match for project funding, assess the local drainage problems, and evaluate the overall flooding problems from a regional perspective. To facilitate regional input into the planning process, five public meetings were held within the project study area. Table 1 shows the date and location of each public meeting.

Table 1: Dates and locations of public meetings

Date	Location
2/16/2011	Dripping Springs City Hall
2/29/2012	Hays County Development Services Office (San Marcos)
3/8/2012	Buda City Hall
4/24/2013	Hays County Precinct 4 (Dripping Springs)
9/4/2013	Hays County Precinct 2 (Buda)

A copy of the public notices can be seen in Appendix J. These public meetings served to inform the public about the planning study and to gather information used to enhance and confirm the study results and conclusions. This study has resulted in new planning and regulatory information for use in floodplain management as well as flood reduction alternative analyses for the City of Dripping Springs, City of Buda, and Hays County.

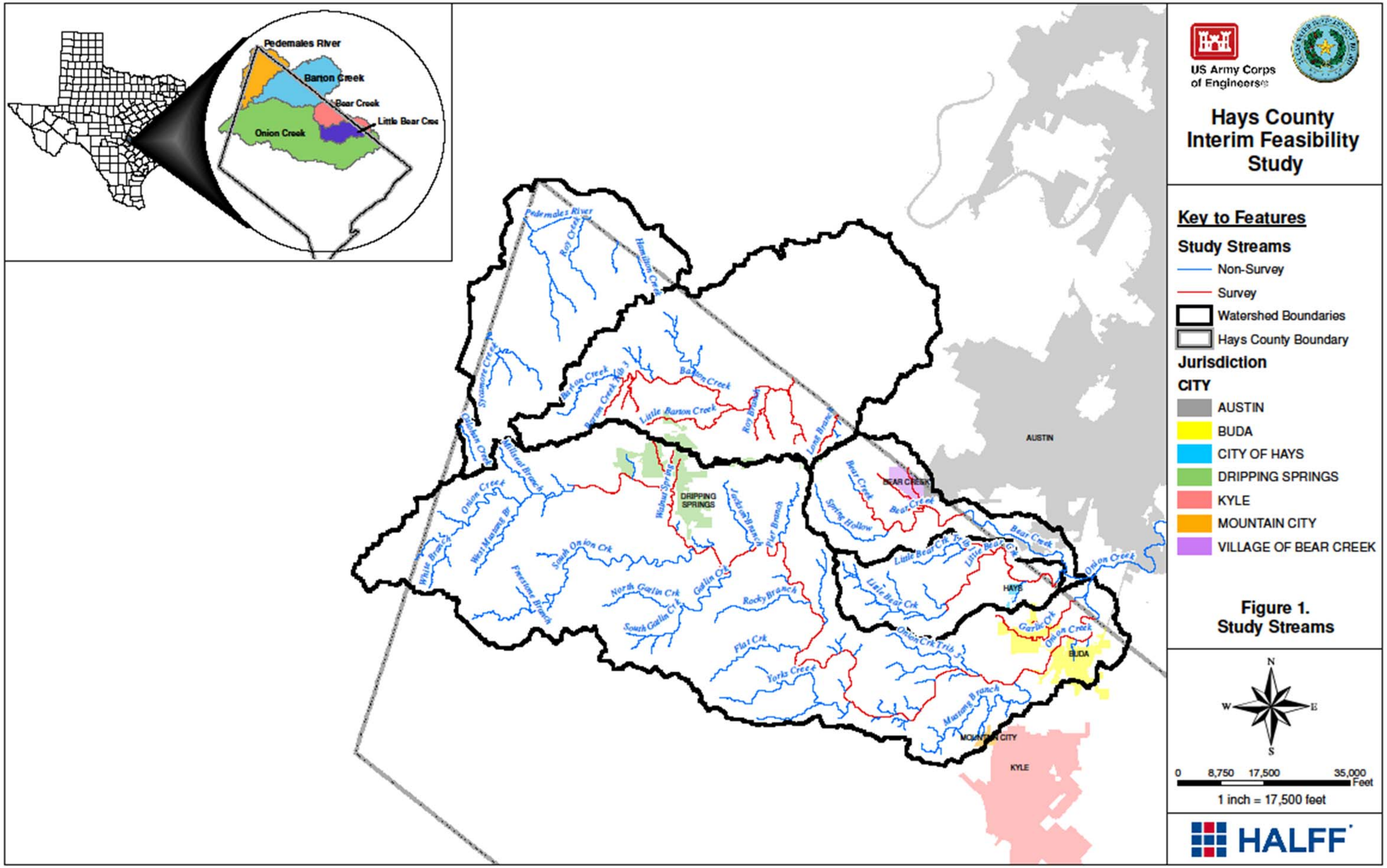

US Army Corps of Engineers
Hays County Interim Feasibility Study
Key to Features
Study Streams
Non-Survey
Survey
Watershed Boundaries
Hays County Boundary
Jurisdiction
CITY
AUSTIN
BUDA
CITY OF HAYS
DRIPPING SPRINGS
KYLE
MOUNTAIN CITY
VILLAGE OF BEAR CREEK
Figure 1.
Study Streams
N
S
E
W
0 8,750 17,500 35,000 Feet
1 inch = 17,500 feet
HALFF
Pedernales River
Barton Creek
Bear Creek
Onion Creek
AUSTIN
DRIPPING SPRINGS
BUDA
KYLE
HAYS
MOUNTAIN CITY

Figure 2: McGregor Lane overtopping during 2007 event

This report presents the results of hydrologic, hydraulic, and alternative analyses of the Onion Creek, Barton Creek, and Pedernales River watersheds. Halff Associates was responsible for existing and future conditions hydrologic and hydraulic models for Onion Creek, Barton Creek, Pedernales River and all designated study tributaries within Hays County. Halff Associates also performed the flood damage reduction alternative analysis for the study watersheds in Hays County. Items covered in this report include:

- Hydrologic Analysis
- Hydraulic Analysis
- Existing and Future Conditions Results
- Flood Damage Reduction Alternative Analysis
- Alternative Recommendation

2.0 Terrain

Watersheds and floodplain delineations were developed using the most recent Light Detection and Ranging (LiDAR) elevation data. The primary source of terrain data used was developed from the newly available 2006-2009 LiDAR data generated by Sanborn Map Company, Inc. The Hays County LiDAR data has an average spacing of 1.4 meters, and meets the FEMA requirements for bare earth vertical accuracy (Root Mean Square Error – RMSE) of 18.5 centimeters and horizontal accuracy (RMSE) of 1.0 meters. Hays County provided the county-wide LiDAR LAS files to FEMA. LAS files are the standard open format for storing LiDAR point records. The LAS file format (binary file format) is an alternative to proprietary systems or a generic ASCII file interchange system used by many companies that obtain LiDAR. FEMA's contractor then generated a county-wide bare earth terrain dataset using the Hays County LiDAR data. Please see Appendix A – Terrain Technical Report Notebook (TRN) provided by FEMA. Halff Associates received this bare earth terrain dataset for use in this project.

3.0 Hydrologic Analysis

Detailed hydrologic analyses were performed on the Onion and Barton Creek watersheds with the goal of providing validated base conditions models. These models were used in developing flood damage reduction alternatives and quantifying the impacts of these alternatives to the surrounding area. The hydrologic analyses were conducted with the aid of the US Army Corps of Engineers HEC-HMS software, version 3.5, and were used to develop peak flows and flow hydrographs for existing and future land use conditions 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year events. The Onion Creek hydrologic analysis included an update of the effective FIS hydrology model, whereas the Barton Creek hydrologic analysis was a new study. Frequency flows for the Pedernales River were derived from an existing gauge analysis and Pedernales Tributary flows were determined from the latest USGS regression equations. Further details of the Onion and Barton watershed hydrologic analyses and Pedernales watershed flow calculations can be found in the hydrology technical report notebooks in Appendix B. Sources for hydrologic methodologies are provided in the references section.

Routing hydraulic models were created for study reaches in the Onion and Barton Creek watersheds that coincided with those in the respective hydrology models. Storage-outflow tables were derived from the routing hydraulic models to be used as input for the Modified Puls routing method in the hydrology models. In many cases, structure and cross-section survey was incomplete when the routing models were finalized. Therefore, some structures were simply modeled using hand measurements made during field reconnaissance visits, which was adequate for routing purposes. However, all collected survey data was applied to the final hydraulic models. Routing level hydraulic models were not created for the Pedernales watershed since a hydrologic model was not created for this part of the study area. Further details of the Onion and Barton watershed routing hydraulic analyses can be found in the routing hydraulics technical report notebooks in Appendix C.

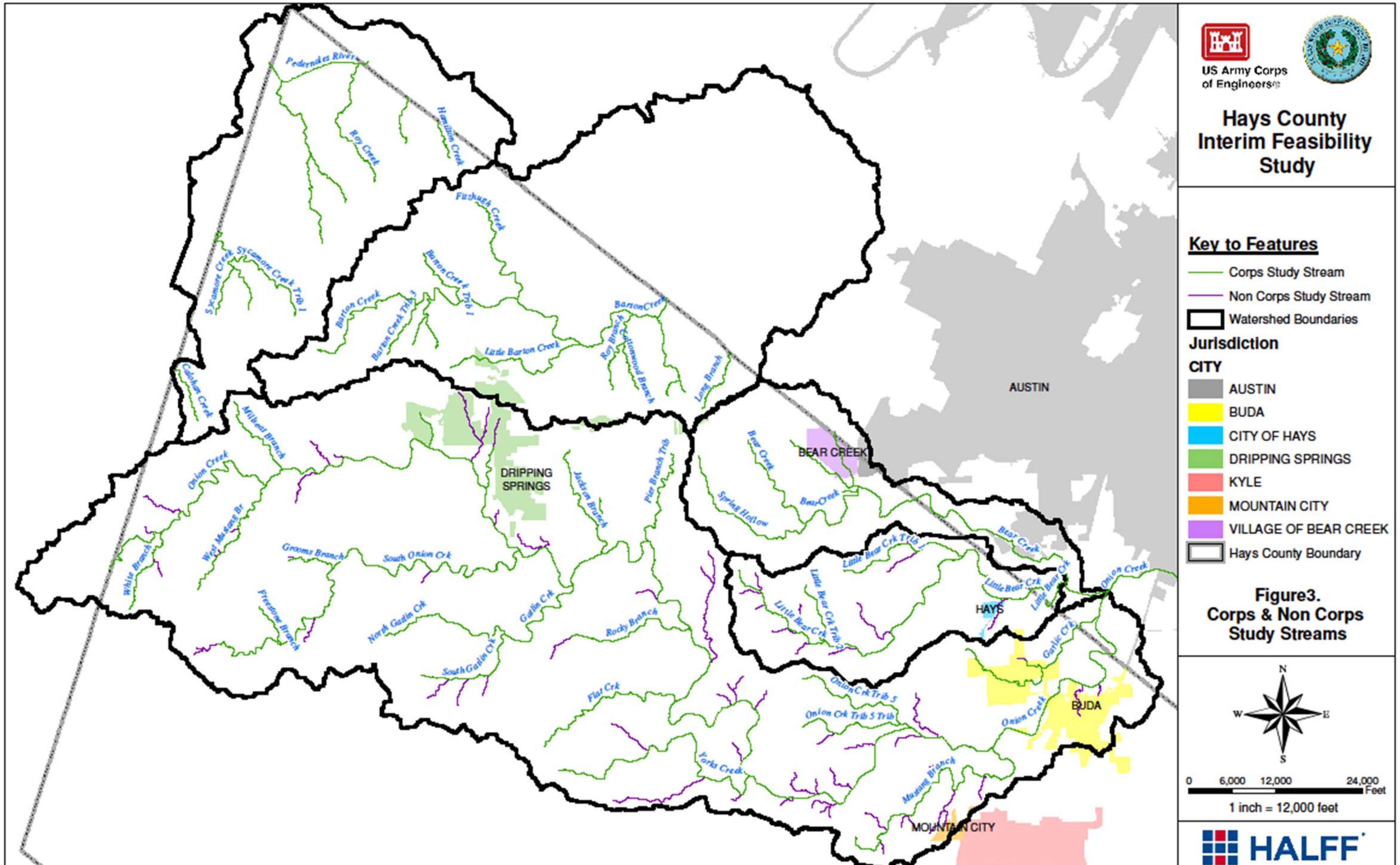
4.0 Hydraulic Analysis

Final hydraulic analyses were performed for study streams in the Onion Creek, Barton Creek, and Pedernales River watersheds for a total study length of approximately 329 stream miles using HEC-RAS software, version 4.1. Cross-section layouts were created for each study reach using HEC-GeoRAS tools in a Geographical Information System (GIS). Field Survey data was incorporated into the hydraulic models where available once cross-section layouts were imported into HEC-RAS 4.1. The hydraulic analysis was conducted to develop existing and future conditions peak stages for the 2-, 5-, 10-, 25-, 50-, 100-, 250-, and 500-year frequency events. Further details of the hydraulic analyses for the Onion Creek, Barton Creek, and Pedernales watersheds can be found in Appendix D. Hydraulic analyses for streams included in the Flood Protection Planning Study, but not included in the scope of the Corps of Engineers portion of the study were performed for Hays County, City of Dripping Springs, and City of Buda. Details of these extended hydraulic analyses are located in Appendices E, F, and G. Corps and non-Corps study reaches can be seen in Figure 3. Sources for hydraulic methodologies are provided in the references section.

5.0 Results of Hydrologic and Hydraulic Analyses

The hydrologic and hydraulic analyses for both existing and futures conditions resulted in validated flood hazard information that is useful for planning and regulatory purposes. Specifically, the analyses resulted in base flood elevations for the 2-, 5-, 10-, 25-, 50-, 100-, 250- and 500-year rainfall events and a floodplain for the 100-yr event throughout the Onion Creek, Barton Creek, and Pedernales River watersheds within Hays County. The resulting water surface elevations and floodplains for the 100-year frequency event are provided in the TRN workmaps included in Appendices D, E, F, and G.

The Onion and Barton Creek hydrologic models were calibrated to observed gage data from various flood events at the Driftwood and SH 71 USGS discharge gages, respectively. Regression flows for the Pedernales River watershed were adjusted to follow the trend of the calibrated Barton Creek hydrology results. Examples of calibrated hydrographs from the 1998 event for Onion Creek and 2002 event for Barton Creek are presented in Figures 4 and 5 below. Further details regarding the calibration and validation efforts for Onion and Barton Creek hydrology modeling can be found in the TRNs in Appendix B.


US Army Corps of Engineers
Hays County Interim Feasibility Study
Key to Features
Corps Study Stream
Non Corps Study Stream
Watershed Boundaries
Jurisdiction
CITY
AUSTIN
BUDA
CITY OF HAYS
DRIPPING SPRINGS
KYLE
MOUNTAIN CITY
VILLAGE OF BEAR CREEK
Hays County Boundary
Figure3.
Corps & Non Corps Study Streams
0 6,000 12,000 24,000 Feet
1 inch = 12,000 feet
HALFF
AUSTIN
DRIPPING SPRINGS
BEAR CREEK
HAYS
BUDA
MOUNTAIN CITY
KYLE

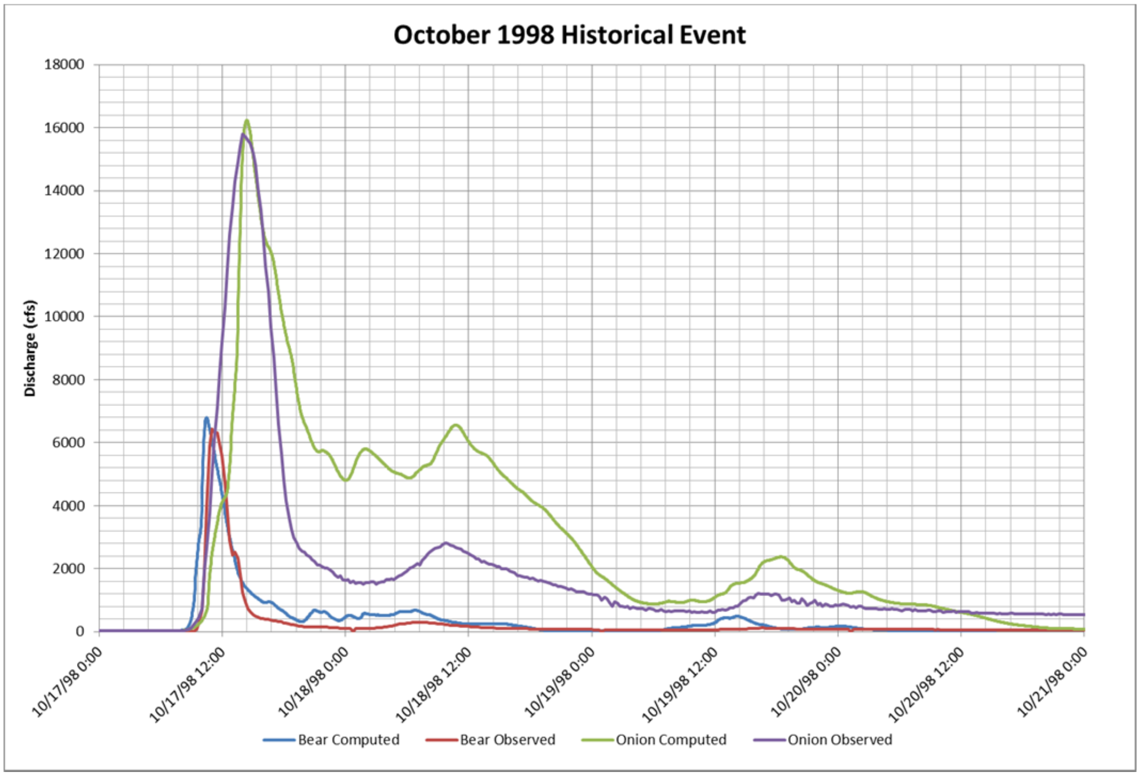


Figure 4: Onion Creek Model Calibration to 1998 event

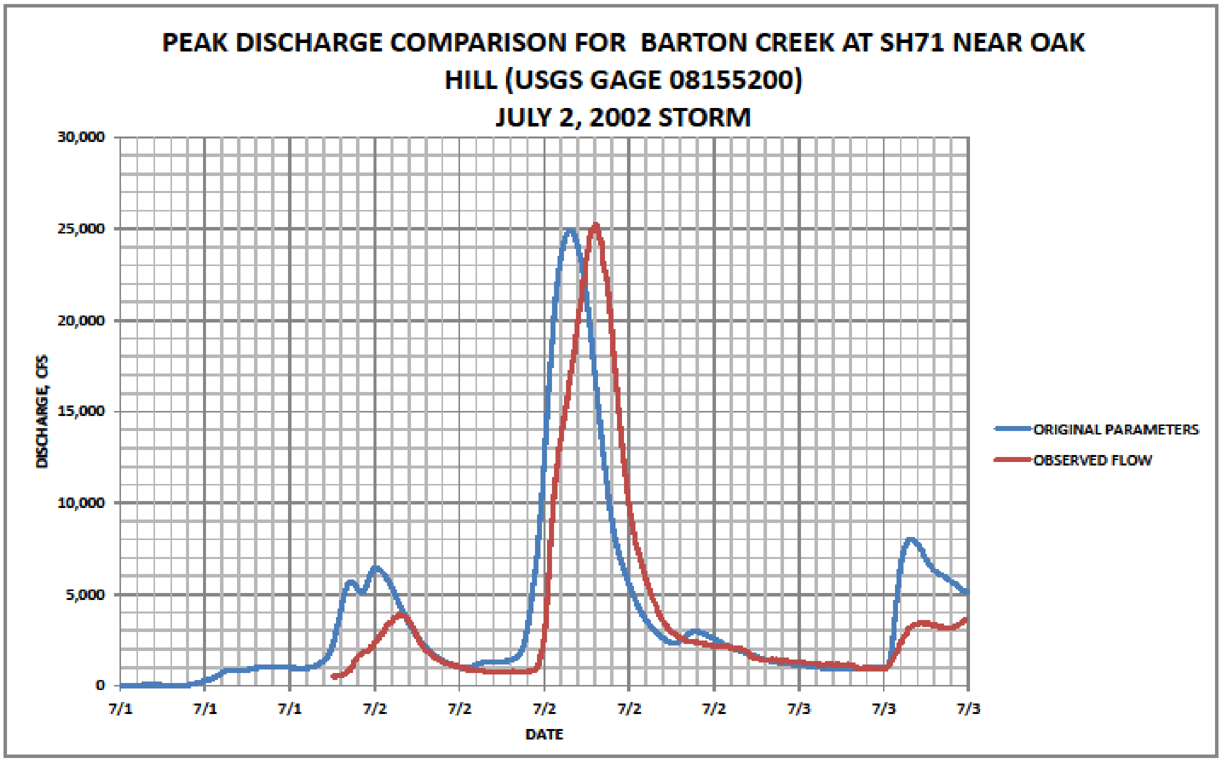


Figure 5: Barton Creek Model Calibration to 2002 event

6.0 Alternatives Analysis – City of Dripping Springs

The most frequent flooding issues in the City of Dripping Springs occur upstream of US 290 on Willow Springs Creek. The limited capacity of the US 290 culvert and close proximity of upstream structures to the creek cause potentially significant flood damages upstream of US 290. The City of Dripping Springs became a participant in the Hays Flood Protection Planning Study to develop alternatives which reduce potential flood damages along Willow Springs Creek. A baseline alternative analysis was performed using hydraulic model results and impacts to existing structures.

A total of three structural alternatives and one non-structural alternative were evaluated for Willow Springs Creek. The first structural alternative involved removal of the Mercer Street crossing just upstream of US 290. According to the existing conditions hydraulic model, Mercer Street appeared to constrict the conveyance of floodwaters downstream. Analysis of the Mercer Street removal shows a minimal improvement in flood elevations limited to the area upstream of the removed crossing. However, compared to the relatively inexpensive cost of removal, the flood damage reduction benefit produces a favorable benefit-cost ratio that is greater than 1. The remaining two alternatives analyzed involve detaining or diverting flood waters from the affected area along Willow Springs Creek. Both the upstream detention pond and diversion to culverts under RR 12 are costly and have a benefit-cost ratio less than 1. However, the diversion culvert alternative produces the highest benefits essentially removing all structures upstream of US 290 from the floodplain. If benefits of this alternative resulting from increased development potential can be quantified, a more viable benefit-cost ratio may be produced. The scope of this study only involves the estimation of approximate flood damage reduction benefits as a means to compare the effectiveness of the proposed alternatives. Therefore, it is recommended that a more detailed analysis of flood reduction benefits and costs beyond that which is provided within the scope of this study be performed for the three structural alternatives. Benefit-cost ratios for the Dripping Springs alternatives are located in Table 2.

Non-structural City of Dripping Springs flood damage reduction alternatives considered include incorporation of data produced into the local floodplain ordinance and buyout of affected structures. All information produced from this study may be submitted to FEMA via the LOMR process and will be available to the City of Dripping Springs for regulation under their floodplain ordinance. A buyout option may be feasible for four buildings along the creek just north of Mercer Street (Figure 6). A benefit-cost ratio greater than one can be achieved assuming a cost equal to approximately 20% over appraised value. The results for the buyout alternative are also presented in Table 2. Further details of the alternatives analysis are located in Appendix H. A summary of environmental constraints associated with implementing the analyzed alternatives is located in Appendix I.

Table 2: Dripping Springs Benefit-Cost Ratios

Dripping Springs Alternatives					
Alternatives	Without Project Damages	With Project Damages	Project Benefit	Probable Project Cost	Benefit to Cost Ratio
Mercer Street Removal	$2,140,799	$1,991,630	$149,170	$90,000	1.66
Buyout	$2,140,799	$340,576	$1,800,223	$1,000,000	1.80
Detention Facility	$2,140,799	$764,604	$1,376,195	$2,300,000	0.60
Bypass Culvert	$2,140,799	$25,283	$2,115,516	$3,700,000	0.57

Figure 6. Dripping Springs Buyout Alternative

7.0 Alternative Analysis – City of Buda

The main flood damage concern for the City of Buda is associated with Buda Fire Department Station #1, located at 209 F.M. 2770. The fire station has been frequently flooded by local flow from a tributary to Onion Creek causing damage to the station and limiting emergency access. In fact, local personnel report that within the last 10 years the fire station has flooded with a minimum of 6 inches of water five times. The fire station is located on the south side of Jack C Hays Trail (F.M. 2770), approximately 700 feet west of the intersection of F.M. 2770 and Main Street. Preliminary hydraulic analysis shows the frequent flooding of the fire station is a result of insufficient existing culvert capacity at F.M. 2770 between South Austin Street and the fire station.

Three structural alternatives were analyzed to remove the fire station from the 100-yr floodplain and reduce flood damages. The structural alternatives consist of either upstream detention, improvements to the channel and culverts under FM 2770, or diversion of flood flows directly to Onion Creek upstream of the fire station. The detention alternative is the most costly as result of the large amount of excavation needed to obtain the required storage capacity. Channel modification and improvement of the culvert under FM 2770 is much less expensive, but might cause adverse impacts downstream without proper mitigation of increased flow. The diversion to Onion Creek is slightly more expensive, but has minimal downstream impacts. It is assumed that the Onion Creek channel has adequate capacity to convey the increased flows from the diversion without causing an increase in peak flows. Benefit-cost ratios for the three structural alternatives are presented in Table 3. Clearly the alternative costs outweigh the flood reduction benefits based solely on structure value. However, the benefits do not include improvements to the availability of emergency services during extreme flood events or damage to the equipment housed within the fire station. Improvement to the benefit-cost ratios could also be achieved by sizing the alternatives to prevent the fire station from flooding only during more frequent events (i.e. 2-, 5-, and 10-yr events).

Table 3: Buda Fire Station Benefit-Cost Ratios

Buda Fire Station Alternatives					
Alternatives	Without Project Damages	With Project Damages	Project Benefit	Probable Project Cost	Benefit to Cost Ratio
Culvert/Channel Mod.	$34,652	$0	$34,652	$776,641	0.045
Diversion to Onion	$34,652	$0	$34,652	$897,409	0.039
Upstream Detention	$34,652	$0	$34,652	$1,400,000	0.025

The non-structural solution suggested for the Buda fire station is to rebuild the station just to the southeast after adding enough fill to remove the new station from the floodplain. Further analysis will be required to ensure that adding fill to the proposed location will not cause negative downstream impacts. Further details of the alternatives analysis are located in Appendix H. A summary of environmental constraints associated with implementing the recommended alternatives is located in Appendix I.

8.0 Alternative Analysis – Hays County

There are two alternatives for Hays County to promote flood damage reduction as well as emergency accessibility. First, it is recommended that Hays County consider improving road crossings that do not effectively convey flood flows. County maintained roads should typically convey at least the 5-yr flow and State maintained roads should typically convey the 25-yr flow. A ranking scheme has been developed to determine which crossings require the most urgent attention. The ranking scheme is based on average annual daily traffic counts and frequency of flood-passed. The top three highest ranking crossing are RR 967 at Little Bear Creek, FM 1626 at Little Bear Creek, and RR 1826 at Bear Creek Tributary 1.

The second alternative is to consider one or more regional detention basins along Onion Creek to relieve flooding in the City of Buda and points further downstream. Three conceptual regional detention options were analyzed to determine their flood reduction effectiveness. The effects of detention at each location were analyzed both independently and in various combinations of simultaneous operation. When all three regional detention ponds are operated simultaneously, a 4-5 foot drop in 100-yr flood levels is experienced through the Buda area. Benefit-cost ratios of all seven regional detention alternatives are provided in Table 4. Other benefits of the regional detention ponds not accounted for in the ratios include possible water supply, recreational opportunities, and flood reduction downstream in Travis County. Further analysis is needed to quantify these additional benefits and compare them to probable project cost. Details of the structure ranking and regional detention alternatives can be found in Appendix H. A summary of environmental constraints associated with implementing the analyzed alternatives is located in Appendix I.

Table 4: Conceptual Regional Detention Benefit-Cost Ratios

Conceptual Regional Detention Alternatives					
Alternatives	Without Project Damages	With Project Damages	Project Benefit	Probable Project Cost	Benefit to Cost Ratio
Quarry Detention	$2,853,631	$2,609,321	$244,310	$7,184,076	0.034
Rattlesnake Detention	$2,853,631	$2,338,977	$514,654	$7,357,452	0.070
Quarry + Rattlesnake	$2,853,631	$2,288,286	$565,345	$14,541,528	0.039
Dripping Springs Detention	$2,853,631	$1,710,090	$1,143,541	$15,832,956	0.072
Quarry + Dripping Springs	$2,853,631	$1,632,925	$1,220,706	$23,017,032	0.053
Rattlesnake + Dripping Springs	$2,853,631	$1,498,477	$1,355,154	$23,190,408	0.058
Quarry +D. Springs +Rsnake	$2,853,631	$1,469,026	$1,384,605	$30,374,484	0.046

9.0 References

William Asquith and Meghan Roussel, U.S. Geological Survey, 2004, Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas SIR 2004-5041

Paul Rodman, U.S. Army Corps of Engineers, October 1977, Effects of urbanization on Various Frequency Peak Discharges

Thomas Nelson, U.S. Army Corps of Engineers, September 1970, Synthetic Unit Hydrograph Relationships, Trinity River Tributaries, Fort Worth-Dallas Urban Area

U.S. Army Corps of Engineers, September 1986, NUDALLAS Documentation and Supporting Appendices

William Asquith and Meghan Roussel, U.S. Geological Survey, 2009, Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment-Based, PRESS Minimized, Residual-Adjusted Approach SIR 2009-5087

William Asquith, Raymond Slade Jr., J. L, Lanning-Rush, U.S. Geological Survey, 1996, Peak-Flow Frequency and Extreme Flood Potential for Streams in the Vicinity of the Highland Lakes, Central Texas WRIR 96-4072