Appendix H – Plan Formulation

Lower Guadalupe Feasibility Study
(Guadalupe and Blanco Rivers), TX
Integrated Draft Feasibility Report and Environmental Impact Assessment

December 2019

US Army Corps
of Engineers®
Fort Worth District

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Contents

1.0 Introduction

This appendix provides supporting information for the plan formulation of the Lower Guadalupe Flood Risk Management Study.

1.1 Planning Policy

The U.S. Army Corps of Engineers (USACE) conducts its planning efforts in accordance with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, established by the Water Resources Council in 1983. These principles and guidelines, referred to as the P&G, establish federal water resource planning for the USACE, Bureau of Reclamation, Tennessee Valley Authority, and the National Resource Conservation Service.

Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, defines the specific planning policies of the USACE based on the P&G. Federal planning efforts must comply with federal laws, including the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA).

1.2 Planning Process

The USACE planning process consists of six major steps, done in iterations. The six steps are:

1. Identify problems and opportunities
2. Inventory and forecast conditions
3. Formulate alternative plans
4. Evaluate alternative plans
5. Compare alternative plans
6. Select a plan

Each iteration of the process is completed, in part or fully, as additional information is developed which inform the process.

2.0 Damage Centers Analysis and Selection

As part of the inventory and forecasting conditions the Project Delivery Team (PDT) determined that much of the study area is undeveloped or agricultural development. Urban development is denser, which creates a node of higher damages and flood risks. These were termed as damage centers for this study.

2.1 Identification of Damage Centers

Agricultural development near a damage center could also benefit from flood risk management solutions. The 11 identified damage centers, urban areas, in the Lower Guadalupe River Basin were

1. Woodcreek, Hays County, Texas
2. Wimberley, Hays County, Texas

3. Kyle, Hays County, Texas
4. San Marcos, Hays County, Texas
5. Lockhart, Caldwell County, Texas
6. Luling, Caldwell County, Texas
7. New Braunfels, Comal County, Texas
8. Seguin, Guadalupe County, Texas
9. Gonzales, Gonzales County, Texas
10. Cuero, Dewitt County, Texas
11. Victoria, Victoria County, Texas

The location of each of the damage centers is shown in Figure 1.

Figure 1: Lower Guadalupe River Damage Centers

2.2 Structure Inventory and Total Value

The damage centers were analyzed to determine the number of structures and their total value (Table 1). These values were used to determine which areas had the largest flood risk and would be the main focus of the study. The structural inventory of the 100-year floodplain includes all the structures inside the 100-year not only those affected by the 100-year flood. Because of development between Seguin and New Braunfels and their hydraulic connectivity, the two damage centers were analyzed as a single damage center.

Table 1: Damage Center Structure Count and Values

Damage Center	Est. Number of Structures	Percent of Structures	Est. Total Value of Structures	Percent of Total Value
City of Victoria	522	23%	$50,000,000	20%
Cities of Seguin and New Braunfels	420	19%	$56,000,000	22%
City of Wimberley	198	9%	$45,000,000	18%
City of San Marcos	363	16%	$45,000,000	18%
City of Gonzales	320	14%	$23,000,000	9%
City of Cuero	264	12%	$15,000,000	6%
City of Kyle	73	3%	$11,000,000	4%
City of Woodcreek	23	1%	$5,000,000	2%
City of Lockhart	34	2%	$4,000,000	2%
City of Luling	13	1%	$1,000,000	0%
Total	2,230	100%	$255,000,000	100%

Using the total structure value of the 100-year floodplain four damage centers contain 67% of the structures and 78% of the total structural value.

2.3 Screening of Damage Centers

2.3.1 Potential Benefits

The study area, including within the 100 year floodplain, have been developed and continue to be developed. All development after June 1992 is required by federal regulation to have a first floor elevation above the elevation of the 100-year flood event. Further, according to federal regulations, structures built in the 100-year floodplain but not above the 100-year flood event water surface elevation can only receive benefits from events greater than the 100-year event. These regulations reduce the potential benefits a project has or is able to use in justifying federal projects. When assessed, portions of Victoria are affected by these regulations.

2.3.2 Potential Solutions

Potential solutions were developed for most damage centers and are discussed in Section 0of this appendix. As damage centers were being screened the ability to construct and the possibility of economically justifying the solutions was taken into account. These were assessed based on professional judgment and rough cost level estimation. If there was no foreseeably justifiable project the damage center was not carried forward for further analysis. Potential solutions were developed for the Victoria, New Braunfels, Seguin, Wimberley, and San Marcos damage centers. Those solutions included levees, channel modifications, channel diversions, and detention areas.

2.3.3 Hydraulic Connectivity of Damage Centers

Hydraulic connectivity is how much the water from one area affects another area. A more immediate and/or direct impact of an area on another indicates higher hydraulic connectivity. Hydraulic connectivity to a location is lessened when other areas have equal or greater influence on that location. In some cases, the two areas are so hydraulically connected that a solution put in place at one location would have direct impacts on the other. These locations are up or downstream of each other and usually close geographically. Due to geographic proximity, urban development between the cities, and hydraulic influence, the only locations that are hydraulically connected are New Braunfels and Seguin; therefore, these were treated as a single damage center for this study.

2.3.4 Screening

Based on the economic analysis, the damage centers underwent screening. The process and results are shown in this appendix and summarized in Table 2.

Table 2: Damage Center Screening

Damage Center	Sufficient Anticipated Damages	Potentially Viable Measures
City of Victoria	Yes	No
Cities of Seguin and New Braunfels	Yes	Yes
City of Wimberley	Yes	Yes
City of San Marcos	Yes	Yes
City of Gonzales	No	No
City of Cuero	No	No
City of Kyle	No	No
City of Woodcreek	No	No
City of Lockhart	No	No
City of Luling	No	No

Figure 2 through Figure 4 show the event that a home would first be damaged for the three damage centers that were not screened. The lighter the color the greater the return period of storm that affects a structure. As shown in these figures there are no structures affected by the 2, 5, and 10 year flood events. Further, the many structures are not affected by any event less than the 500 year flood.

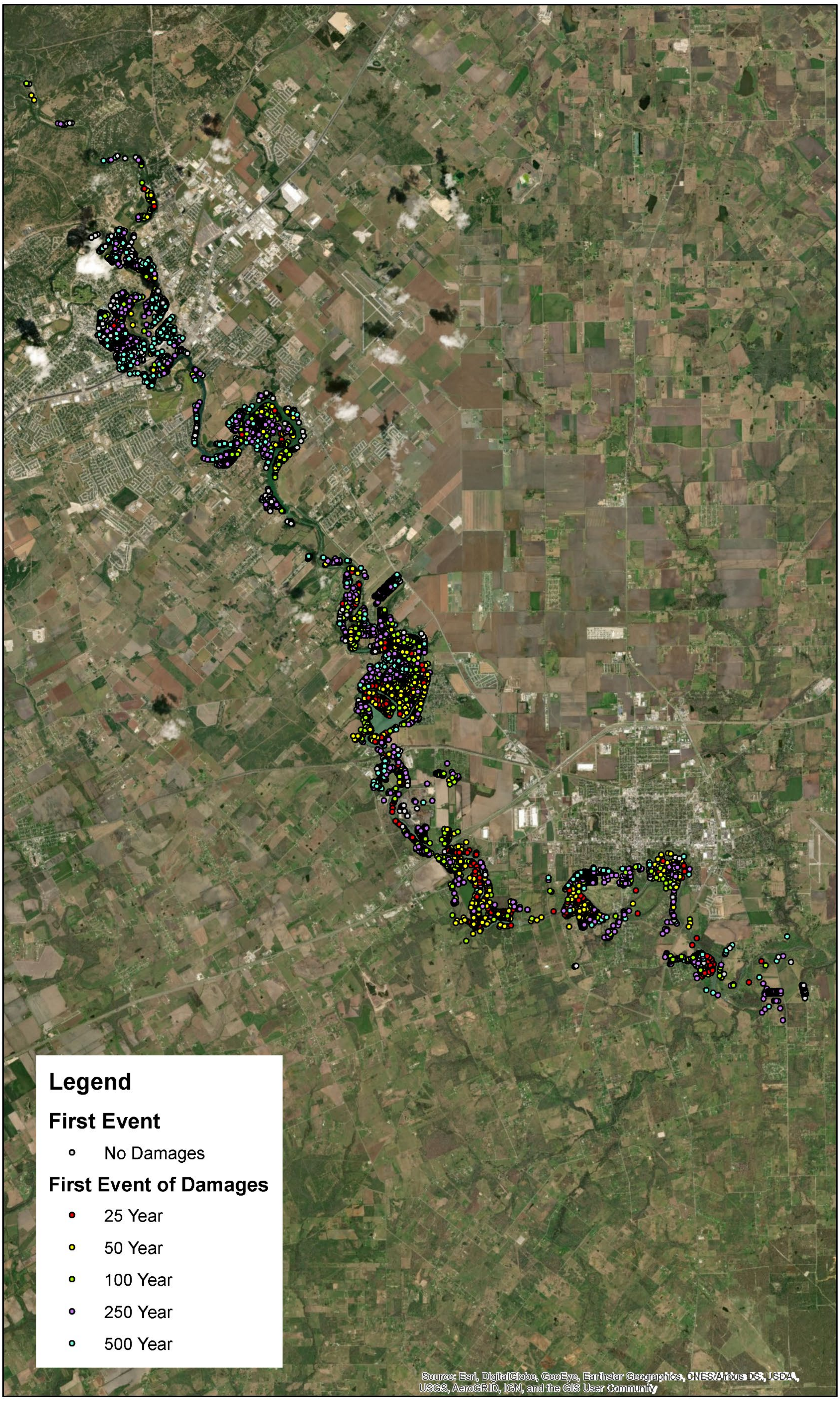

Figure 2: New Braunfels and Seguin First Event Damages

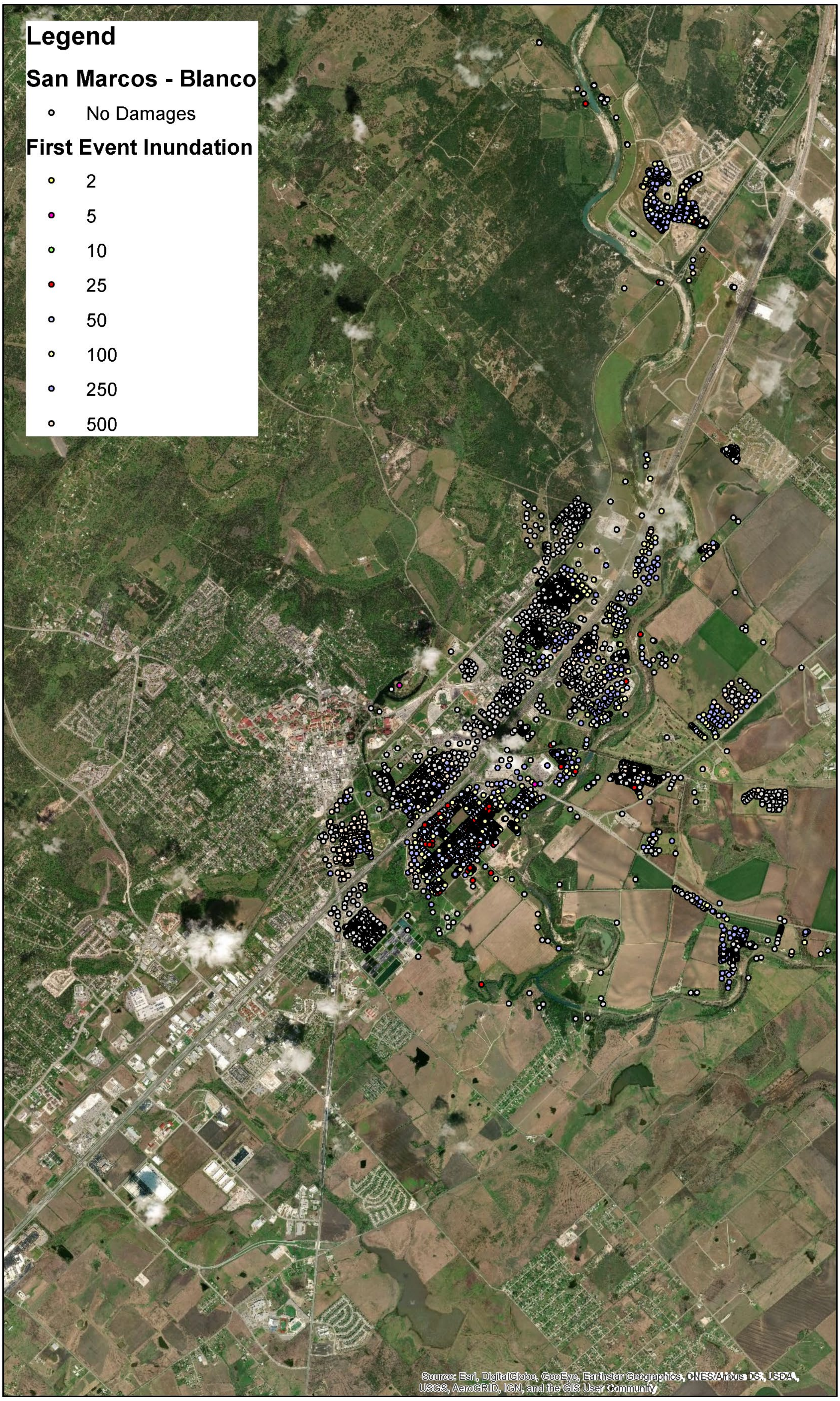

Figure 3: San Marcos First Event Damages

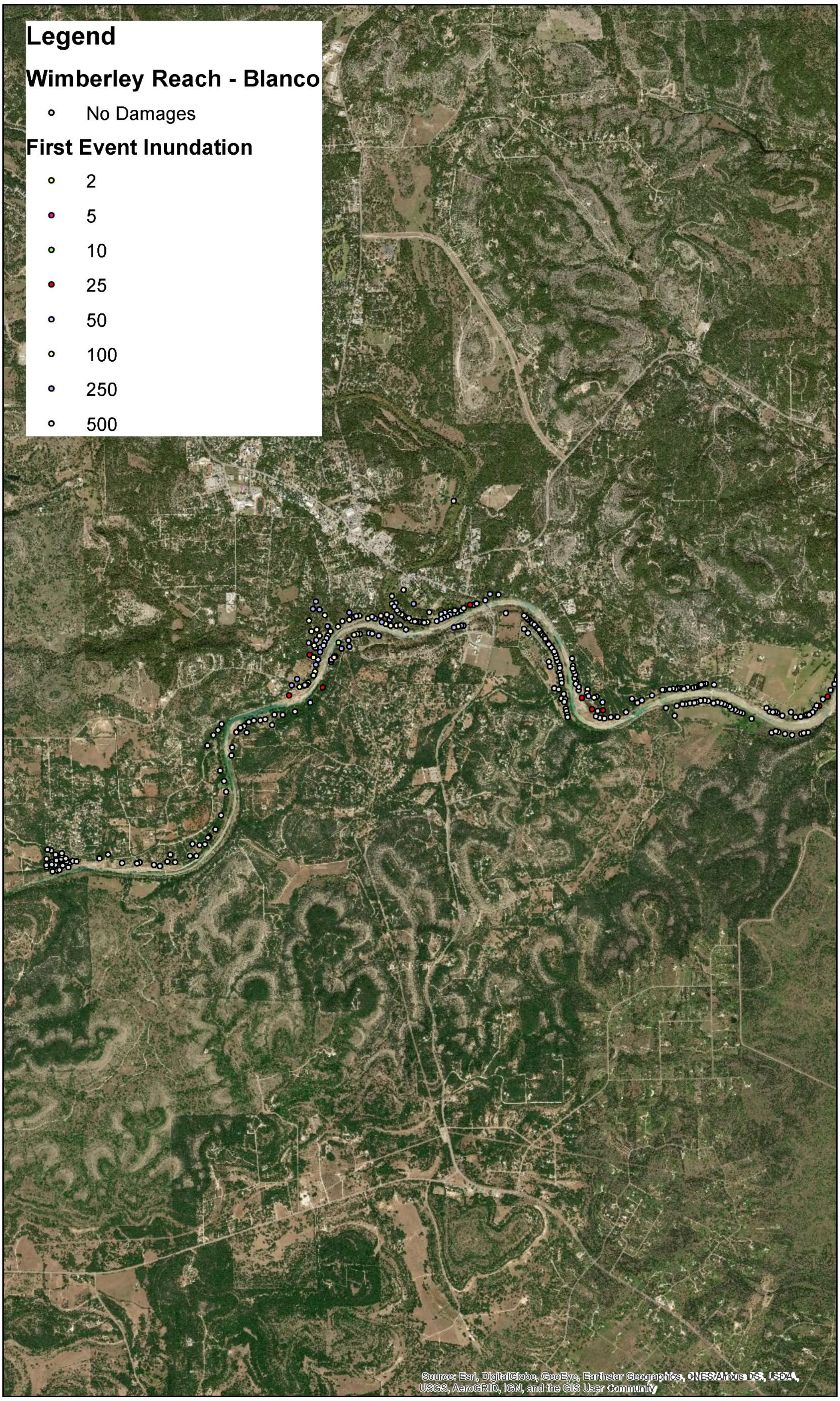

Figure 4: Wimberley First Event Damages

3.0 Previous Measures and Alternatives Analysis

As part of various planning steps four through six of the planning process, measures and alternatives are analyzed. This section shows the results of two different iterations of the planning process.

Management Measures are actions that can be taken in general, or at a specific location, in order to achieve the stated study objectives. The initial array of management measures included both structural and non-structural measures. Structural measures modify the extents and depths of floodplains in order to reduce flood risk. Non-structural measures do not change the extents or depths of the floodplain, but change the effects flooding has on structures or people's health and safety.

Portions of the measure and alternative analysis was completed as part of previous work done by Halff and Associates for the Guadalupe – Blanco River Authority (GBRA). The data and analysis done as part of that study was used to inform the plan formulation process for the current study effort. For more detail on measures and alternatives and their analysis refer to Appendices A, F, G, I, and J.

3.1 Measures Considered and Screened

All measures that became alternatives are described and listed in Section 3.2 . Measures in this section describe those measures that were screened out early in the planning process and the reason they were not carried forward.

3.1.1 Nonstructural Measures

Non-structural solutions, such as elevating structures and acquisitions, were assessed using professional judgment. The majority of benefits come from the frequent (2 through 10 year) events; however, structures are only damaged in the 25 year and higher events. Based on experience and professional judgment non-structural measures would not be economically justified.

3.1.1.1 Canyon Lake Dam Operational Change

Reallocating storage from one pool to the flood control pool of Canyon Lake was assessed. When designed and constructed the only pools designated were the Flood Control Pool and the Conservation Pool. All of the conservation pool's 366,400 acre-feet of storage was put under a water supply contract in October 1957. This leaves no pool to reallocate to the flood control pool.

3.1.2 State Highway 87 Bridge and Channel Modifications

The channel bottom of Spring Creek at State Highway 87 would be increased to 200 feet and have 3H:1V side slopes. This will require modification of both the northbound and southbound bridges that cross Spring Creek. The bridges would be 240 feet for the northbound bridge and 440 feet for the southbound bridge to cross the creek and allow for full flow of the channel.

Rough analysis of the measure showed that it could remove 35 structures from the 100-yearr floodplain and reduce nuisance flooding in the area. Many of these structures were in the 25 to 100-year floodplains. It was determined that such a small change in the floodplain (Figure 5) would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

Figure 5: Highway 87 Alternative Floodplain Analysis

3.1.3 Victoria Detention

This measure is a detention on Spring Creek near Highway 87. The detention would have a height of 11ft with a 3700acre-feet capacity. This should allow the detention structure to not be overtopped during a 100 year flood event. A rough analysis determined about 38 structures would be removed from the 100-year floodplain. Many of these structures were in the 25 to 100-year floodplains. It was determined that such a small change in the floodplain (Figure 6) would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

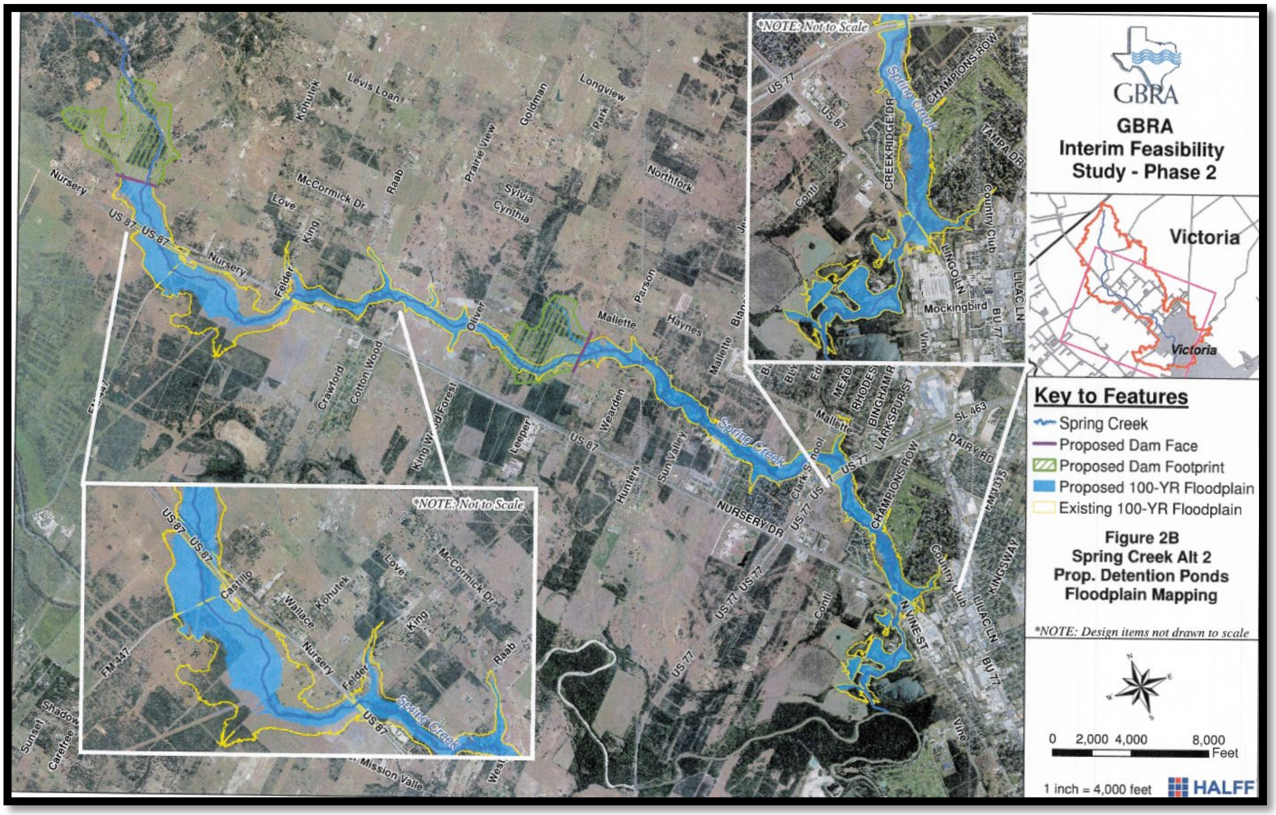

Figure 6: Victoria Detention Floodplain Analysis

3.1.4 Woodcreek Detention

This measure is a detention on Hog Creek between the Woodcreek city limits and Mountain Crest Drive. The detention height was evaluated at 20 feet with a 175 acre-feet storage capacity. A rough analysis determined about 8 structures would be removed from the 100 year floodplain, and no structures are removed from the 2 or 5 year floodplains. It was determined that such a small change in the floodplain would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

3.1.5 Logan Street Crossing and Channel Modifications

The channel upstream of Logan Street would be improved to increase flow to Logan Street, and the culvert under Logan Street would be enlarged from the 5.5 foot circular culvert to two 10 foot by 8 foot box culverts. Through the culvert and starting approximately 200 feet upstream would be a 25 foot bottom trapezoidal channel with 3H:1V side slopes. A rough analysis determined no structures would be removed from the 100 year floodplain. It was determined that such a small change in the floodplain (Figure 7) would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

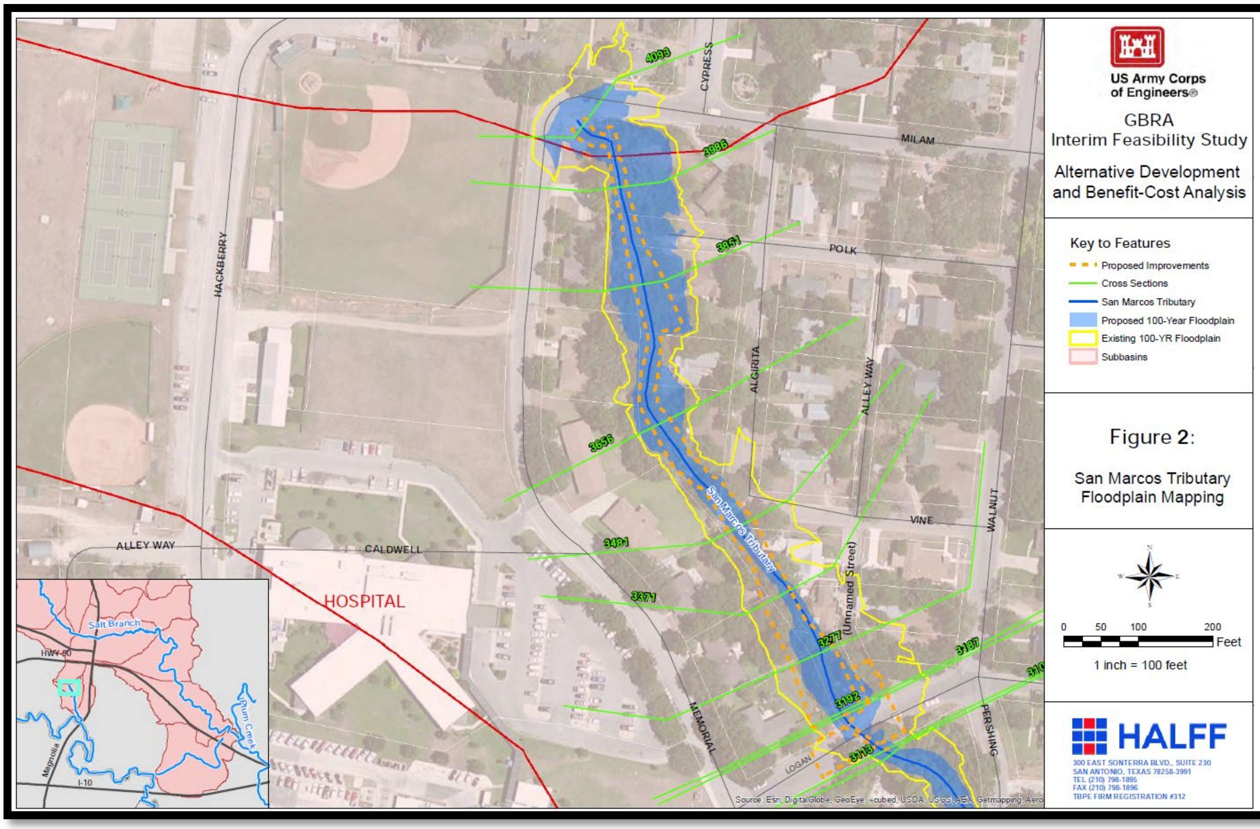

Figure 7: Logan Street Floodplain Analysis

3.1.6 Laurel Avenue Culvert and Channel Modifications

The culvert on Salt Branch at Laurel Avenue would be modified to accommodate 9 box culverts that are 10 foot by 6 foot. The channel would be modified to have a varying width from 50 to 100 feet with 3H:1V side slopes. A rough analysis determined 3 structures would be removed from the 100 year floodplain, and no structures are removed from the 2, 5, 10, or 25 year floodplains. It was determined that such a small change in the floodplain (Figure 8) would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

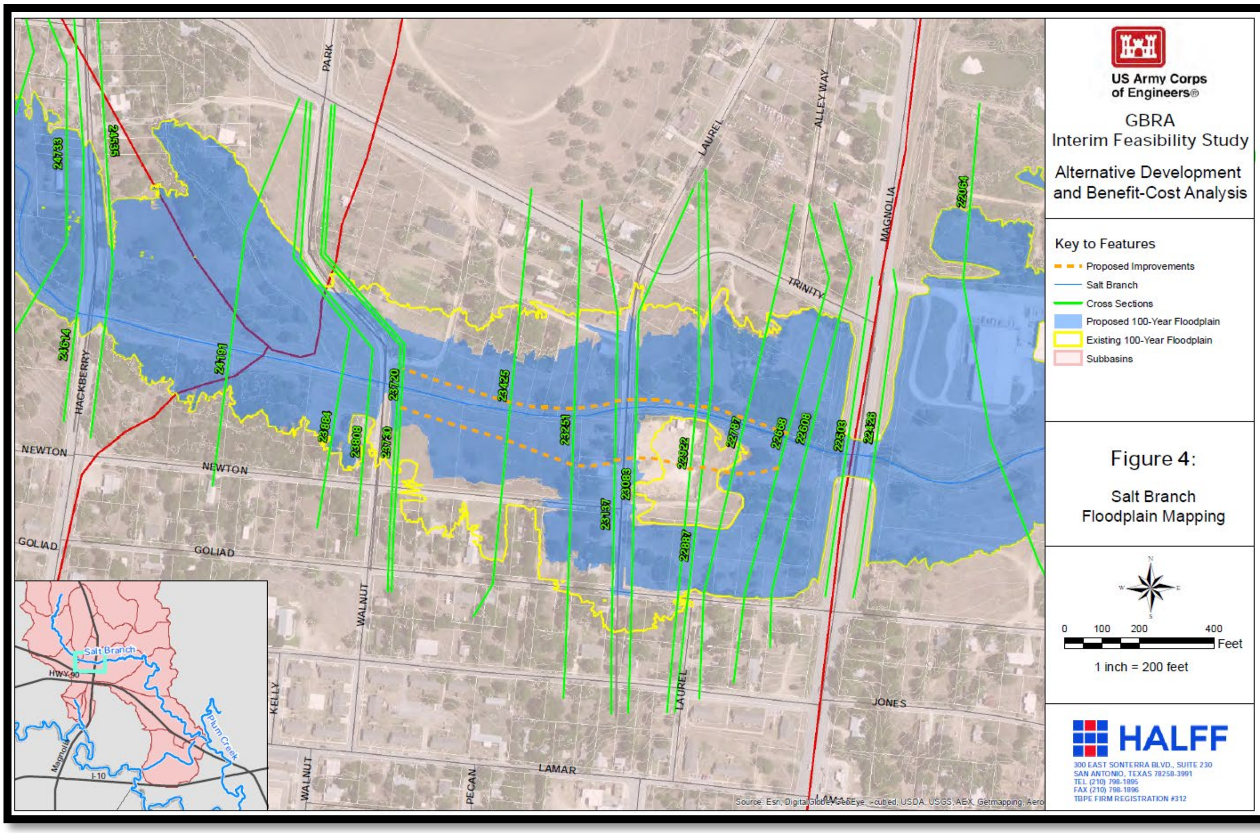

Figure 8: Laurel Avenue Floodplain Analysis

3.1.7 Oak Creek Circle Levee

Oak Creek Circle is a neighborhood along plum creek with homes affected by the 100 year flood. The levee would be approximately 6 feet high with 4H:1V side slopes. The total length of the levee would be approximately 2,600 feet. A rough analysis determined about 5 structures would be removed from the 100 year floodplain, and no structures are removed from the 2, 5, 10, or 25 year floodplains. It was determined that such a small change in the floodplain (Figure 9) would not justify the anticipated costs of the structural solution. Therefore, the measure was removed from consideration.

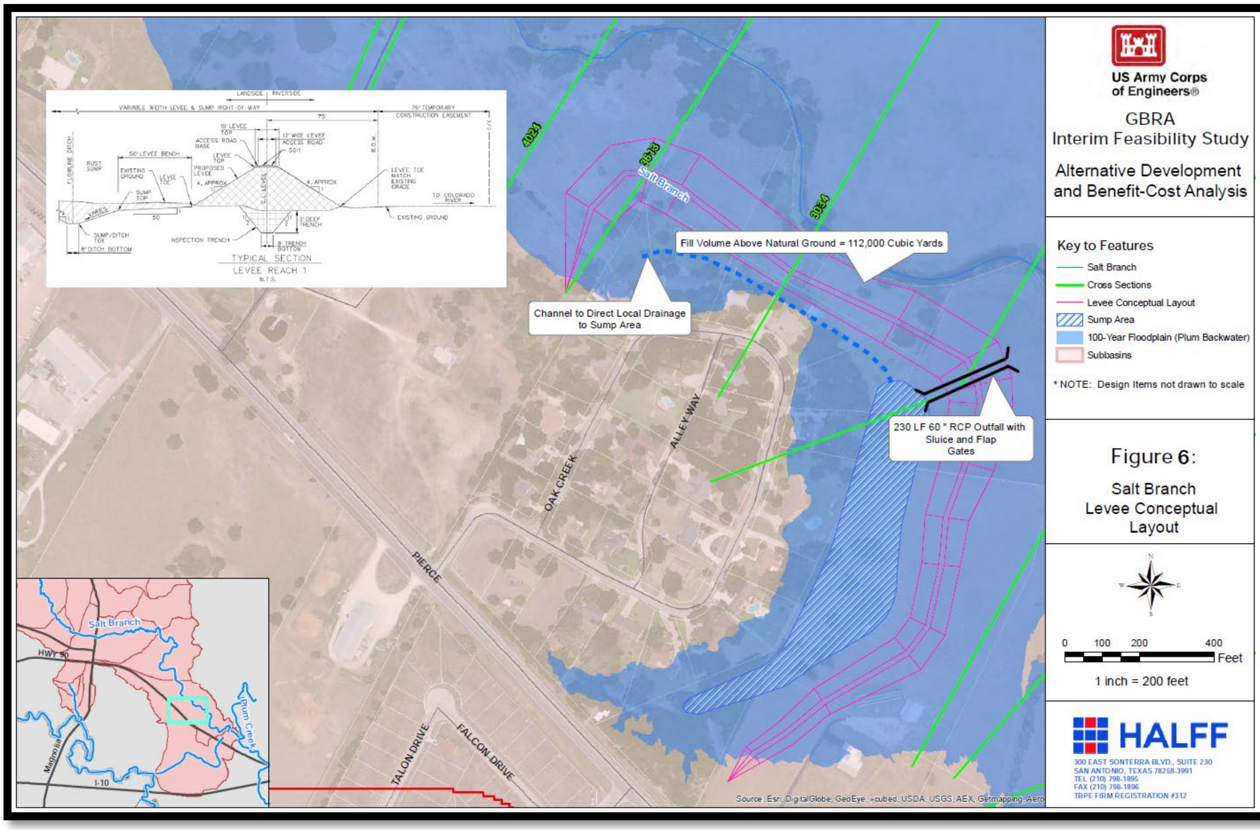

Figure 9: Oak Creek Floodplain Analysis

3.2 Alternatives Considered

3.2.1 Blanco Garden Berm

This alternative, shown in Figure 10, is a berm located on the west side of the Blanco River near the Blanco Gardens Neighborhood that decreases overflows from the Blanco River. The berm would have an elevation of the 50-year existing condition Blanco River water surface elevations to reduce the neighborhood's flood risk for more frequent storm events.

3.2.2 Channelization of Bypass Creek

Bypass Creek would be channelized from the Blanco River overflow near IH-35 to its confluence with the San Marcos River, shown in Figure 10. The increased capacity of Bypass Creek will receive additional overflow from the Blanco River into the improved channel while avoiding heavily populated areas. The conceptual diversion consisted of a 125-foot wide by 20-feet deep channel, with sloping sides. Further, this alternative requires lowering the topography between the Blanco River and Bypass Creek upstream of County Road 160 to divert more flow into Bypass Creek. Channel improvements will also require the crossing structures to be removed and reconstructed to span the improved channel. The Blanco Garden Berm is part of this alternative.

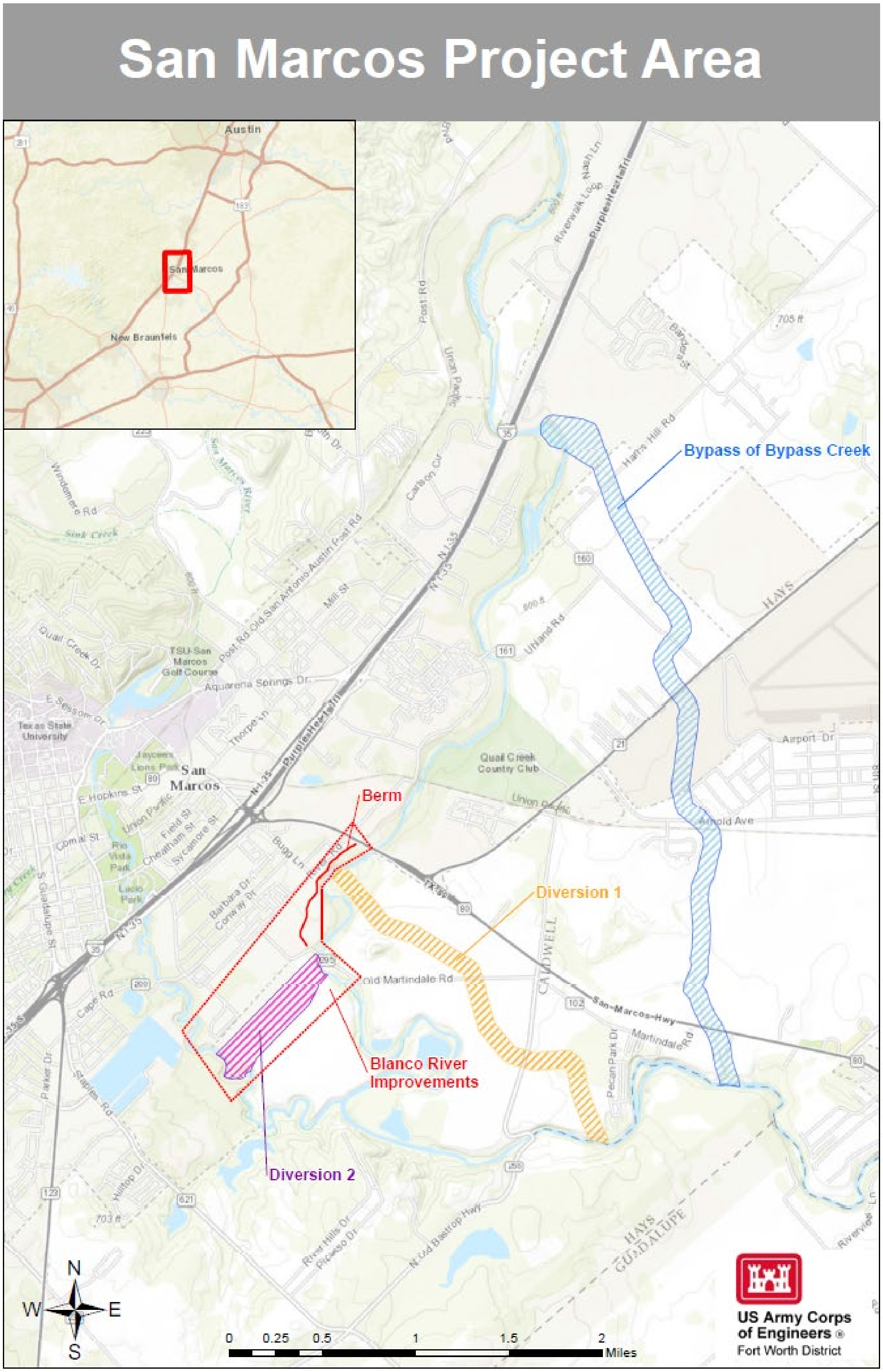

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Figure 10: San Marcos Alternatives

3.2.3 Bypass of Bypass Creek

Bypass Creek would be channelized from the Blanco River overflow near IH-35 and rerouting the channel to the confluence with the San Marcos River, shown in Figure 10. The increased capacity of Bypass Creek and its bypass will receive additional overflow from the Blanco River into the improved channel while avoiding heavily populated areas. This alternative reroutes Bypass Creek between Airport Highway and Highway 80 creating a shorter channel with less crossings, development, and constraints. Two conceptual channel options were investigated: 1) 125-foot, 20-feet deep channel and 2) 200-ft, 20-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires lowering the topography between the Blanco River and Bypass Creek and construction of bridges. The Blanco Garden Berm is part of this alternative.

3.2.4 San Marcos Diversion 1

Water downstream of the Highway 89 Bridge would be diverted from the Blanco River to the San Marcos River downstream of the Old Bastrop Highway, shown in Figure 10. This alternative efficiently transfers flow to the San Marcos River allowing for water surface elevation reductions along the Blanco River downstream of the Highway 80. The conceptual diversion consisted of a 125-foot, 20-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires each of the roadway crossings to be constructed as bridges that span the channel.

3.2.5 San Marcos Diversion 2B

Water near Old Martindale Road would be diverted from the Blanco River to the San Marcos River between Cape Street and Scrutchin Lake, shown in Figure 10. This alternative efficiently transfers flow to the San Marcos River allowing for water surface elevation reductions along the Blanco River downstream of the Highway 80. This diversion is primarily located on the City of San Marcos property in between the Blanco and San Marcos Rivers. The conceptual diversion consisted of a 300-foot, 10-feet deep channel. Similar to channelization of Bypass Creek, this alternative also requires each of the roadway crossings to be constructed as bridges that span the channel.

3.2.6 Blanco County Upstream Detention

This alternative is a detention on the Blanco River upstream of the San Marcos confluence near where Chimney Valley Road crosses the Blanco River, shown in Figure 11. The detention height was evaluated at 60, 65, and 73 feet, and 1972, 2139, and 2457 feet long respectively. The upstream and downstream side slopes would be 2H:1V, with a 30 foot wide top crest. A trapezoidal outlet will be constructed having a 20 foot flat bottom width at the existing channel flowline, with 1:1 side slopes extending to the crest of the dam.

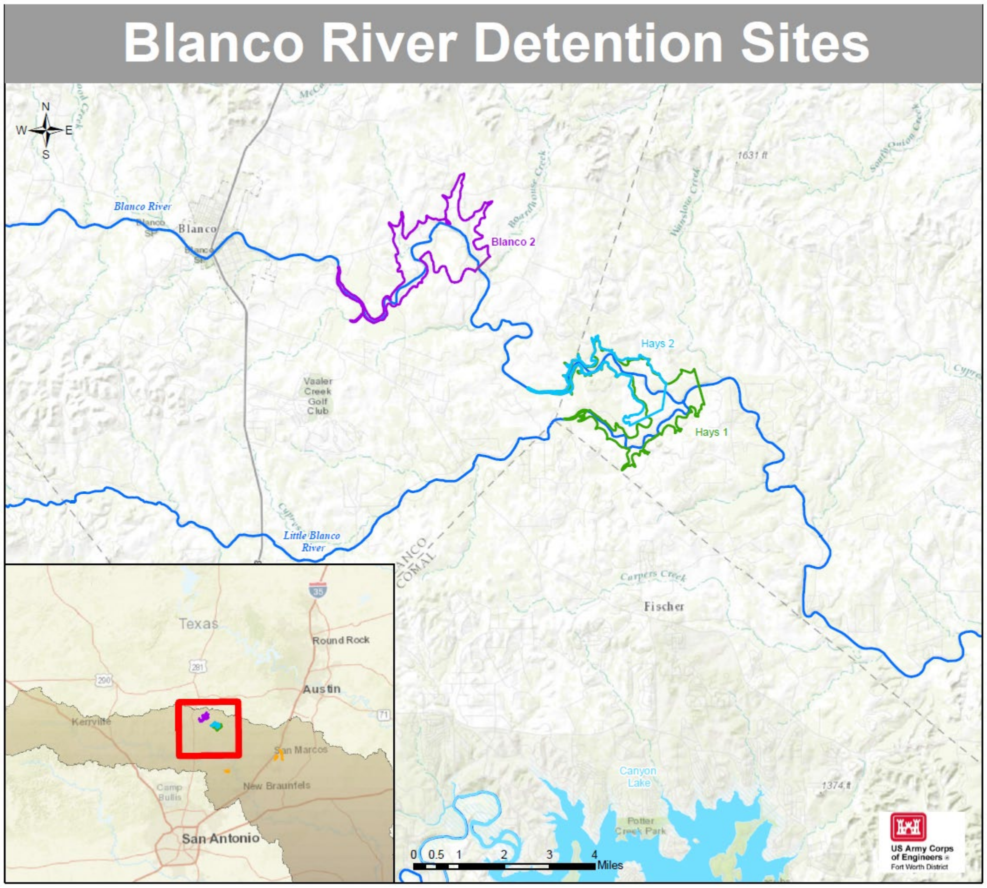

Figure 11: Blanco River Detention Sites

3.2.7 Hays County Detention

This alternative is a dentition on the Blanco River near the Hays, Comal, and Blanco County line, shown in Figure 11. The detention height was evaluated at 110 feet and approximately 4090 feet long. The upstream and downstream slide slopes would be 2H:1V, with a 30 foot wide top crest. A trapezoidal outlet will be constructed having a 20 foot flat bottom width at the existing channel flowline, with 1:1 side slopes extending to the crest of the dam.

3.2.8 Bear Creek Detention

This alternative is a detention on Bear Creek upstream of the Guadalupe River confluence near Farm to Market Road 2722, shown in Figure 12. The detention height was evaluated at 75 feet and 680 feet long. The upstream and downstream slide slopes would be 2H:1V, with a 30 foot wide top crest. A 10 foot by 12 foot principal spillway culvert 300 feet in length will be constructed matching the existing channel flowline for low flows.

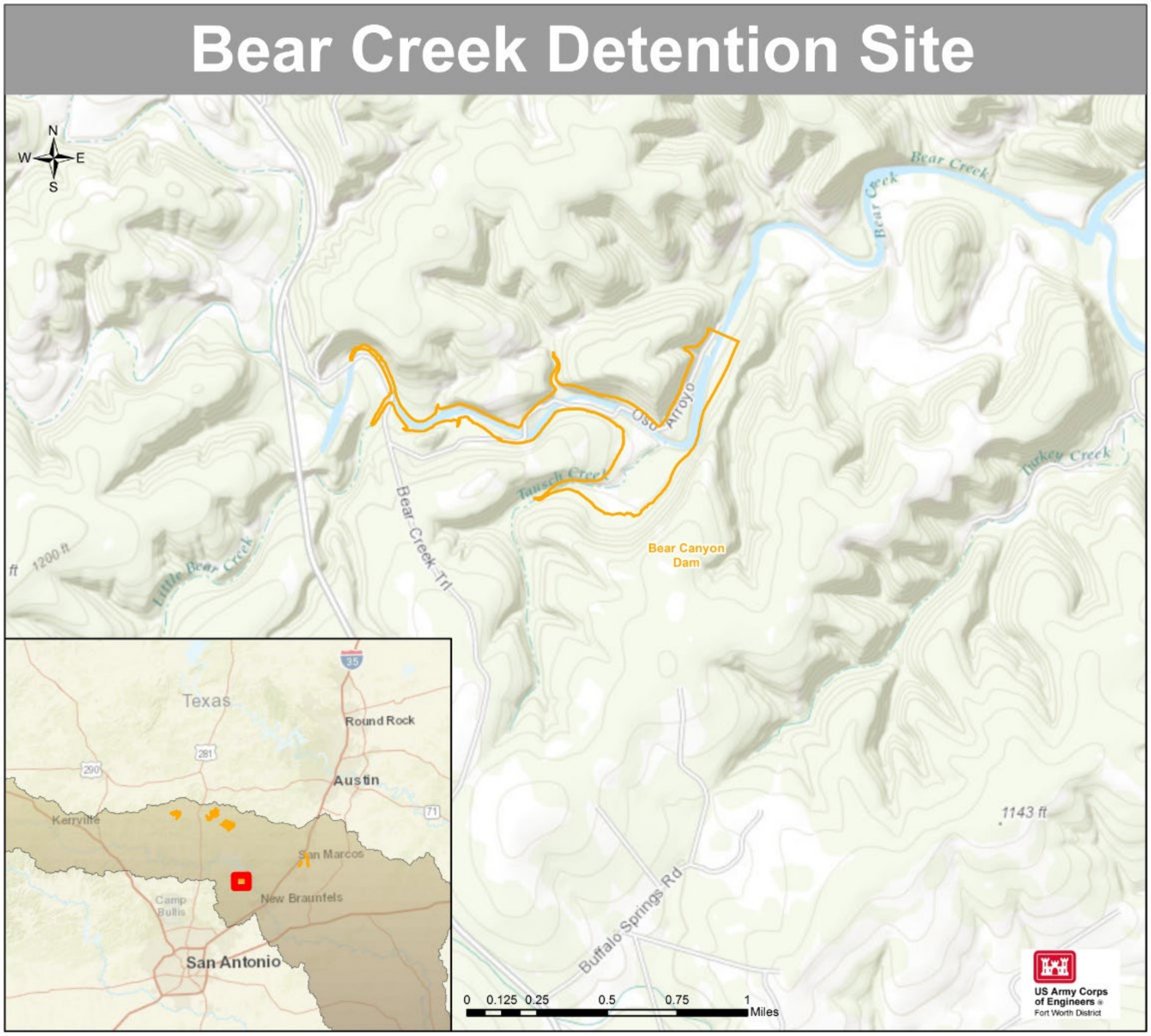

Figure 12: Bear Creek Detention Site

3.3 Alternative Screening

3.3.1 San Marcos Alternatives

The San Marcos alternatives consist of the two diversions, Blanco Garden Berm, and the bypass creek alternatives. The Blanco Garden Berm Alternative is currently being implemented by the non-federal sponsor outside of this project. Therefore, the benefits associated are part of the future without project condition. The San Marcos Diversion and Bypass Creek work were evaluated with the berm in order to provide a complete flood risk management solution to the city of San Marcos. These alternatives were not justified; however, when separated the berm was economically justified.

	Future Without	Bypass Channel	Blanco Garden Berm
Total first cost	$0	52,503	9,412
Annualized	$0	1,998	358
O&M	$0	300	300
Total Annual Cost	$0	2,298	658
Total Annual Benefits	$0	1,967	840
Net Benefits	$0	-331	182

The berm was justified as a standalone alternative but when combined with the diversions, the diversions would not be justified without the berm. The benefits gained by the berm cannot be included in the benefit cost calculations for the diversions since it is being implemented locally and considered part of the future without project condition, neither diversion alignment would be economically justified and have been removed from further consideration.

3.3.2 Hays and Blanco County Detention Alternatives

A benefit analysis was done using the Flood Damage Assessment (FDA) model developed by the Hydraulic Engineering Center (HEC). Details on the how the analysis was performed is found in Appendix B. The costs were annualized with an interest rate of 2.875% over the 50 year study period.

	Future Without	Hays	Blanco 73	Blanco 65	Blanco 60	Bear Creek
Total first cost	0	70,252	85,062	70,390	62,084	21,774
Annualized	0	2,666	3,228	2,671	2,356	829
O&M	0	300	300	300	300	300
Total Annual Cost	0	$2,966	$3,528	$2,971	$2,656	1,129
Total Annual Benefits	0	$1,224	$3,528	$1,205	$1,030	1,620
Net Benefits	0	-$1,742	-$2,201	-$1,766	-$1,626	483

The alternatives were not economically justified were removed from further consideration.

3.4 Risk Analysis of Bear Creek Detention Alternative

After determining that Bear Creek was the only economically justified alternative, additional analysis was done. That analysis revealed that the location of the Bear Creek Detention had a high likelihood of that it is sitting on karst terrane, which is limestone with contiguous cavities. Avoiding seepage caused failures from the cavities require additional foundation work. This would be done in the form of grouting and cutoff walls. The dam would be roller compacted concrete (RCC) to ensure that overtopping does not cause failure. A newly constructed earthen dam with on top would have increased voids beneath the RCC layer. These updates in the design increased the costs of the Bear Creek detention, but would have been required for all the detention structures evaluated. The new costs for Bear Creek are shown below.

Alternative	Average Annual Benefits	Average Annual Costs	Net Benefits	BCR
Bear Creek Detention	1,620	2,799	-1,179	0.58

4.0 Conclusion

After completing all the needed analysis and risk management there was no economically viable plan. Therefore the no action plan was selected.