Appendix D:
Hydrologic and Hydraulics Benefit Cost Analysis (Task 1105 Deliverable)

Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

Hydrology & Hydraulics BCR Appendix

Flood Infrastructure Fund Category 1

Project ID 21-0016

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1 Introduction and background

A hydrologic and hydraulic analysis provided the basis for sizing the two detention basins on each of the creeks, identifying the inundation limits upstream of the detention basins, and determining the downstream benefits. Hydrology was conducted using HEC-HMS version 4.8 and hydraulics using HEC-RAS version 5.0.7. Following the sizing of the structures and completion of the analysis, benefits were calculated based on the FEMA Benefit Cost Analysis (BCA) guidelines and tool.

1.1 Scope of work

The scope of work for hydrologic, hydraulic, and benefit cost analysis included the following:

- Development of hydrologic and hydraulic models for the Birch Creek, Walnut Creek, and Spring Creek watersheds to determine flood storage and hydraulic benefits provided by the proposed detention basins.
- Simulation of the models for two historical storm events to confirm calibration with observed conditions.
- Development of a structural database from publicly available information for structures potentially benefitting from the projects.
- Quantification of benefits from the projects both individually and in combination.
- Determination of the benefit cost ratio for the projects using the FEMA BCA toolkit over a 50-year period.

1.2 San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP)

The San Jacinto River Regional Watershed Master Drainage Plan (SJRWMDP) was a comprehensive regional study led by the Harris County Flood Control District (HCFCD), Montgomery County, City of Houston (City), and the San Jacinto River Authority (SJRA). The study was completed in December 2020. The study goals were to identify existing flood risk within the San Jacinto River basin upstream of the Lake Houston dam and evaluate flood risk reduction alternatives on a regional basis. The study included development of hydrologic and hydraulic models for the major streams of the upper San Jacinto River watershed including Spring Creek.

Recommendations from the study for the Spring Creek watershed included two detention facilities on the Walnut Creek and Birch Creek tributaries. These recommended projects targeted flood reduction along Spring Creek as well as future mitigation for conveyance improvement projects in the watershed. The Walnut Creek and Birch Creek detention basin projects are further explored in the current analysis.

1.2.1 Walnut Creek detention basin

The proposed inline detention basin is located on Walnut Creek, a tributary to Spring Creek, approximately 0.6 miles north of the FM 1488 crossing and 5.5 miles west of Magnolia, Texas. The detention basin is in the upper half of the Spring Creek watershed and captures flow from a drainage area of approximately 21 square miles. The location of the proposed detention basins is shown in Figure 1-1.

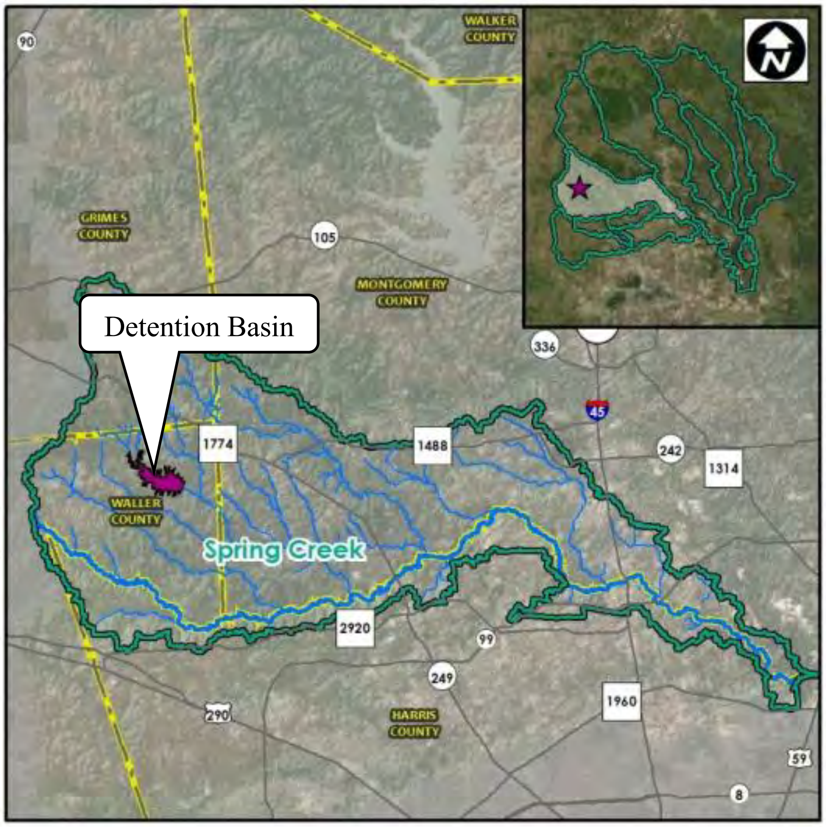

Figure 1-1 Walnut Creek Detention Basin Location (from SJRWMDP)

The proposed project includes a dry detention basin that reduces flows within the watershed. The control structure is a 46-foot-high earth dam with a concrete cap with a primary outfall consisting of 2 – 4’ x 4’ reinforced concrete boxes and a secondary ogee spillway approximately 200 feet in length. The impoundment requires approximately 0.7 million cubic yards of embankment. At the 1% ACE (Annual Chance Exceedance) water surface elevation the detention basin encompasses an area of 1,218 acres and detains over 12,000 acre-feet of storage.

1.2.2 Birch Creek detention basin

The proposed inline detention basin is located on Birch Creek, a tributary to Spring Creek, approximately 1 mile north of the FM 1488 crossing and 3.5 miles west of Magnolia, Texas. The detention basin is in the upper half of the Spring Creek watershed and captures flow from a drainage area of approximately 13 square miles. The location of the proposed detention basins is shown in Figure 1-2.

Figure 1-2 Birch Creek Detention Basin Location (from SJRWMDP)

The proposed project includes a dry detention basin that reduces flow within the watershed. The control structure is a 35-foot- high earth dam with a concrete cap with a primary outfall consisting of 2 – 4' x 3' reinforced concrete boxes and a secondary ogee spillway approximately 200 feet in length. The impoundment will require approximately 0.46 million cubic yards of embankment. At the 1% ACE water surface elevation the detention basin encompasses an area of 873 acres and detains over 7,700 acre-feet.

2 Data collection

Various data sources were acquired, reviewed, and adjusted as part of the hydrologic and hydraulic analysis. Data types included terrain, gages, historical rainfall, previous studies, and modeling.

2.1 HCFCD modeling

The Modeling Assessment & Awareness Project (MAAPnext), led by the Harris County Flood Control District (HCFCD) in partnership with FEMA, involved the development of new modeling and updated floodplain mapping for Harris County's 22 major watersheds, including the Spring Creek watershed. The effort incorporated most current terrain and rainfall data and utilized new hydrologic and hydraulic modeling methodologies to better depict flood risk in the region. The feasibility study leveraged the following HCFCD models and supporting documentation:

- HEC-RAS (v5.0.7) model for the Spring Creek Watershed including simulations for both the frequency and historical storm events including Hurricane Harvey (2017), Memorial Day (2016), and Tax Day (2016).
- HEC-HMS (v4.3) model for the Spring Creek Watershed including simulations for both the frequency and historical storm events

2.2 Terrain

The terrain developed as part of the HCFCD mapping effort was used as the basis for the analysis. The terrain was developed in 2018 by the Texas Strategic Mapping (StratMap) Program on the North American Vertical Datum of 1988 (NAVD88), Geoid 12B (cell size is 3 feet x 3 feet). The terrain also incorporated channel bathymetry for the Spring Creek channel from Kuykendahl Road to the confluence with the West Fork San Jacinto River developed under MAAPnext.

2.3 Structural database

A structural database was developed and used for the calculation of damages for the benefit cost analysis. The database included building footprints, finished floor elevations, square footage, and building type.

- Building footprints were provided by the Texas Water Development Board (TWDB) and screened to include structures within 1,000 feet of the 500-year floodplain. Structures smaller than 500 square feet were assumed to be sheds or other non-habitable structures and were removed from the database.
- Finished floor elevations were tabulated for each structure based on the underlying terrain elevations. Each structure's finished floor elevation was estimated to be one foot above the terrain elevation at the centroid of the structure.
- Square footage was obtained from the residing structure's county appraisal district (Waller, Montgomery, or Harris).
- Building types were set based on the TWDB information including either residential, industrial, or commercial.

3 Hydrology

The HEC-HMS models prepared by the HCFCD were used as the basis to develop runoff hydrographs for the watershed. These models were updated as needed to incorporate the proposed projects. Updates included changes to the drainage basins within the vicinity of the proposed projects as well as parameters associated with the basin changes. HEC-HMS v4.8 was used for the analysis.

3.1 Rainfall data

Rainfall data for the frequency storm events was obtained from HCFCD Rainfall Depths and Intensities White Paper for Harris County Hydrologic Region No. 1, which encompasses the Spring Creek watershed. Table 3-1 below provides the Atlas 14 rainfall depth, duration, and frequency data used.

Table 3-1 Atlas 14 Rainfall Depths

Duration	10 % AEP[1]	2 % AEP	1% AEP	0.2 % AEP
Min	0.81	1.07	1.19	1.49
15 Min	1.62	2.13	2.36	2.95
1 Hour	3.07	4.06	4.51	5.87
2 Hour	4.03	5.67	6.49	9.04
3 Hour	4.66	6.84	7.99	11.50
6 Hour	5.79	8.94	10.70	15.90
12 Hour	6.95	11.10	13.40	20.10
1 Day	8.22	13.40	16.30	24.20

[1] Annual Exceedance Probability

3.2 Hydrology updates

Drainage areas were obtained from the HCFCD model and verified with the topography and land use. Areas near the proposed project sites were subdivided and adjusted to include additional detail upstream of the proposed detention basins. Exhibit 2 shows the drainage areas from the prior study and drainage areas for the updated analysis. The HCFCD drainage area and updated drainage area sizes are shown in Table 3-2.

Table 3-2 Drainage Area Sizes

HCFCD Drainage Areas	Area (ac)	Updated Drainage Areas	Area (ac)
J501_06	1,888.95	J501_06	1,118.23
		J501_06_02	770.72
J503_04	2,041.67	J503_04_01	888.95
		J503_04_02	1,152.72
J503_05	2,216.47	J503_05_01	894.15
		J503_05_02	489.72
		J503_05_03	847.44

The hydrologic losses, impervious cover, and transform methodology were updated for the subdivided drainage areas. The methods from the HCFCD study were used to determine these parameters.

3.2.1 Hydrologic losses

Rainfall losses were calculated using the Green & Ampt method for all drainage areas. The Green & Ampt methodology requires suction and hydraulic conductivity values, which are based on soil type. The Canopy Loss Method was used in conjunction with Green and Ampt to account for losses due to vegetation. The values used in the HEC-HMS model are based on the HCFCD study and presented below in Table 3-3.

Table 3-3 Hydrologic Loss Parameters

Predominate Soil	Hydrologic soil group	Initial Canopy (in)	Max. Canopy (in)	Crop Coefficient	Initial Moisture Content	Saturated Content	Suction (in)	Conductivity (in/h)
Sandy Loam	B	0.0	0.5	1.0	0.059	0.46	2.286	0.181

3.2.2 Impervious cover

Impervious cover values were assigned based on the underlying land use type and the values from the HCFCD study as presented in Table 3-4.

Table 3-4 HCFCD Typical Impervious Cover Values

Land Use	Description	Percent Impervious
Undeveloped	Unimproved, natural, or agricultural	0%
Residential – Rural Lots	≥ 5-acre ranch or farm	5%
Residential – Large Lots	> 1/2 acre new residential with storm sewers or roadside ditches with adequate capacity, OR > 1/4 acre older neighborhoods with limited capacity roadside ditches	25%
Residential – Small Lots	≤ 1/4 acre	40%
School	School with non-paved areas	40%
Developed Green Areas	Parks or golf courses	15%
Light Industrial/Commercial	Office, parks, nurseries, airports, warehouses, or manufacturing with non-paved areas	65%
High Density	Commercial, business, industrial, or apartments	85%
Isolated Transportation	Highway or major thoroughfare corridors	80%
Water	Detention basins, lake, and channels	100%

Impervious cover values were recalculated for the subdivided drainage areas using the same GIS-based impervious cover layer developed in the HCFCD study. Table 3-5 shows the original and recalculated impervious cover values for the updated drainage areas.

Table 3-5 Calculated Impervious Cover

Original Subbasins	Original Impervious	Updated Subbasins	Updated Impervious
J501_06	6.35%	J501_06	2.58%
		J501_06_02	11.82%
J503_04	4.85%	J503_04_01	7.66%
		J503_04_02	2.68%
J503_05	10.75%	J503_05_01	14.59%
		J503_05_02	4.83%
		J503_05_03	10.50%

3.2.3 Transform method

The Clark Unit Hydrograph Method was used for the hydrograph transform method and uses both a time of concentration factor (Tc) and a storage coefficient (R). The Tc and R values for the updated drainage areas were computed from the Basin Development Factor (BDF) method in the HCFCD study. Table 3-6 shows the original and recalculated Tc and R values for the updated drainage areas.

Table 3-6 Calculated Tc and R Values

Original Subbasins	Original TC	Original R	Updated Subbasins	Updated TC	Updated R
J501_06	2.03	5.40	J501_06	1.52	4.16
			J501_06_02	1.18	3.20
J503_04	1.82	4.85	J503_04_01	1.14	3.10
			J503_04_02	1.45	3.96
J503_05	2.14	5.68	J503_05_01	1.02	2.79
			J503_05_02	1.07	3.02
			J503_05_03	1.28	3.53

3.3 HEC-HMS results

The HEC-HMS model was simulated for the frequency and historical storm events to develop the peak flows and hydrographs for the updated drainage areas. The results for the original and updated peak discharges for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events are shown in Table 3-7. The peak discharges remained unchanged for drainage areas that were not subdivided.

Table 3-7 HEC-HMS Peak Discharge

Original Subbasins	Peak Discharge (cfs)				Updated Subbasins	Peak Discharge (cfs)			
	10%	2%	1%	0.2%		10%	2%	1%	0.2%
J501_06	1,092	1,816	2,222	3,433	J501_06	792	1,292	1,568	2,388
					J501_06_02	688	1,090	1,303	1,942
J503_04	1,305	2,136	2,598	3,984	J503_04_01	802	1,274	1,525	2,271
					J503_04_02	849	1,382	1,670	2,540
J503_05	1,266	2,092	2,550	3,933	J503_05_01	897	1,395	1,655	2,439
					J503_05_02	450	710	850	1,267
					J503_05_03	298	494	601	1,088

4 Existing hydraulic model

The HEC-RAS models prepared by the HCFCD were used as a basis for the hydraulic analysis and updated as needed to reflect changes in the topography and land use as well as re-configured for the analysis of the two projects.

4.1 HCFCD model

The HCFCD HEC-RAS model consisted of a 1D/2D model of the entire watershed. The Spring Creek main stem was modeled with 1D cross sections for flows within the main channel and 2D zones for the floodplain. Northern tributaries in the model included Panther Branch, Mill Creek, Walnut Creek, Birch Creek, and Threemile Creek all of which were modeled using 1D cross sections. Southern tributaries included several HCFCD channels noted as J109, M101, J121, J131, J157, J158, J231 which were modeled using combined 1D/2D sections. The layout of the 1D/2D hydraulic model for the Spring Creek watershed is shown in Figure 4-1.

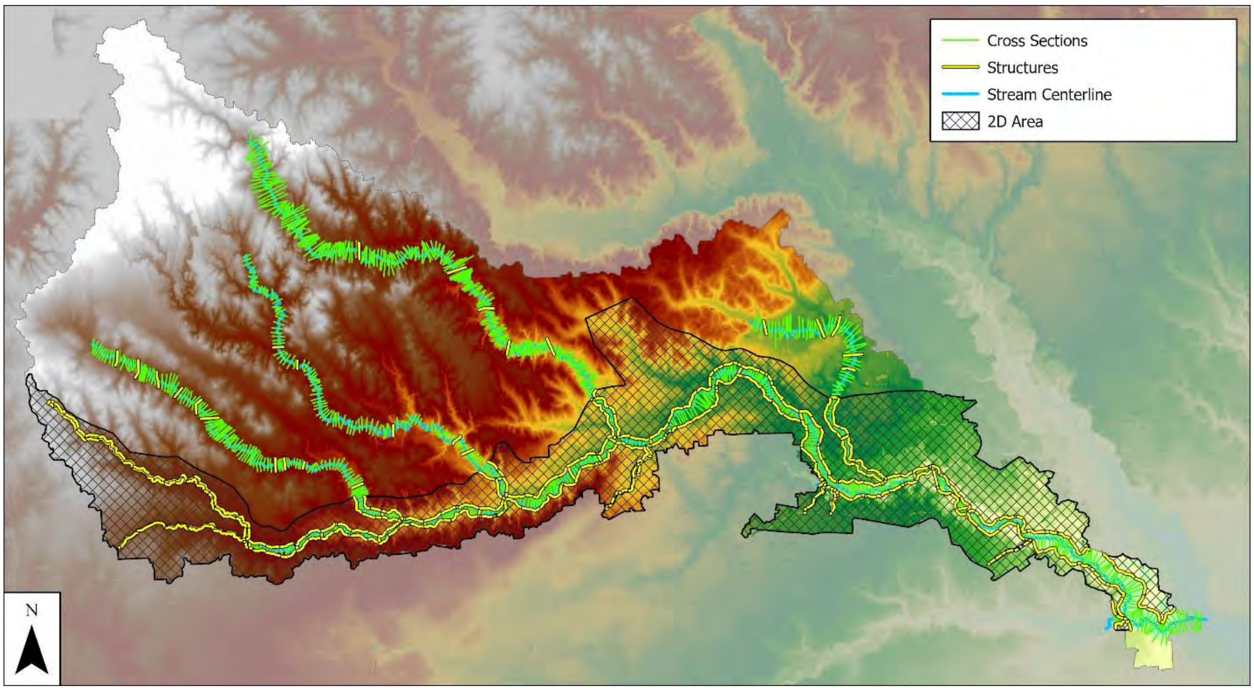

Figure 4-1 1D/2D Spring Creek Hydraulic Model Layout

4.2 Model adjustments

Since the HEC-RAS model was recently developed and calibrated, updates to the model were focused on Birch Creek and Walnut Creek to both accurately assess the existing conditions of the creeks as well as prepare for modeling the proposed projects. The layout of the revised 1D/2D hydraulic model for the Spring Creek watershed is shown in Exhibit 3.

4.2.1 2D area

The HCFCD HEC-RAS model consisted of 1D cross sections along Walnut Creek that extended into Birch Creek upstream of FM 1488. The cross sections upstream of FM 1488 were removed and replaced with a 2D area that covered the upstream portion of Walnut Creek and Birch Creek. A 2D area was used instead of 1D cross sections so that the alignment of the projects could be relocated as necessary and to best account for the footprint of the proposed projects. The 2D area boundary, shown in Figure 4-2, was delineated based on the upstream drainage area boundaries for Birch Creek and Walnut Creek.

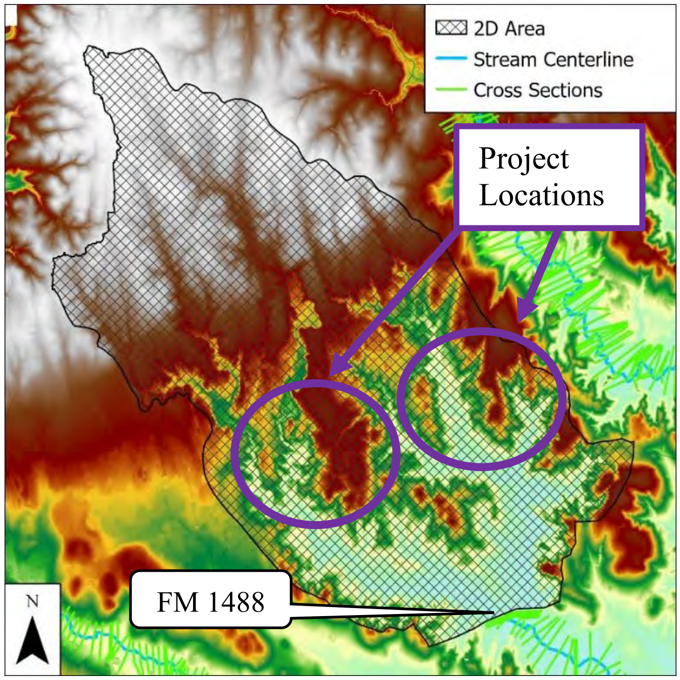

Figure 4-2 Walnut and Birch Creek 2D Area

4.2.2 Internal boundary conditions

The hydrographs for the drainage areas within the 2D area were added as internal boundary conditions. On the upstream end of the 2D area the boundary conditions were placed perpendicularly to the stream to simulate the upstream cross section of the stream. The boundary conditions for the drainage areas along the stream were placed following the stream centerline. The internal boundary conditions within the 2D area are shown in Figure 4-3.

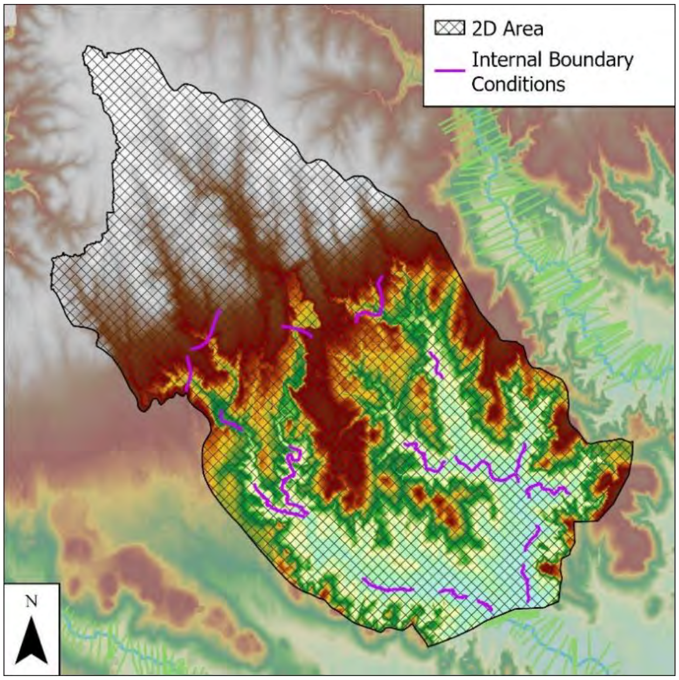

Figure 4-3 2D Area Internal Boundary Conditions

4.2.3 Breaklines

Breaklines were added to outline the centerlines of streams located within the 2D area. The breaklines oriented the cell alignments to best match the flow patterns for each creek. Figure 4-4 shows the breaklines that were added to the 2D area.

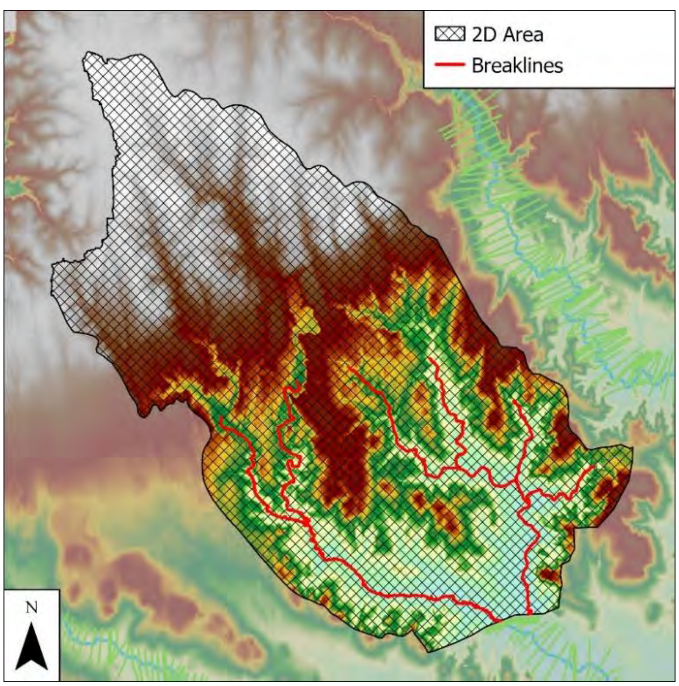

Figure 4-4 2D Area Breaklines

4.2.4 Cross sections adjustments

Cross sections along Walnut Creek downstream of FM 1488 were extended to contain the entire 0.2% ACE extents. Cross section elevations were obtained from the terrain data and roughness values corresponded to the existing land use values used within the HCFCD study. The adjusted cross sections are shown in Figure 4-5 below.

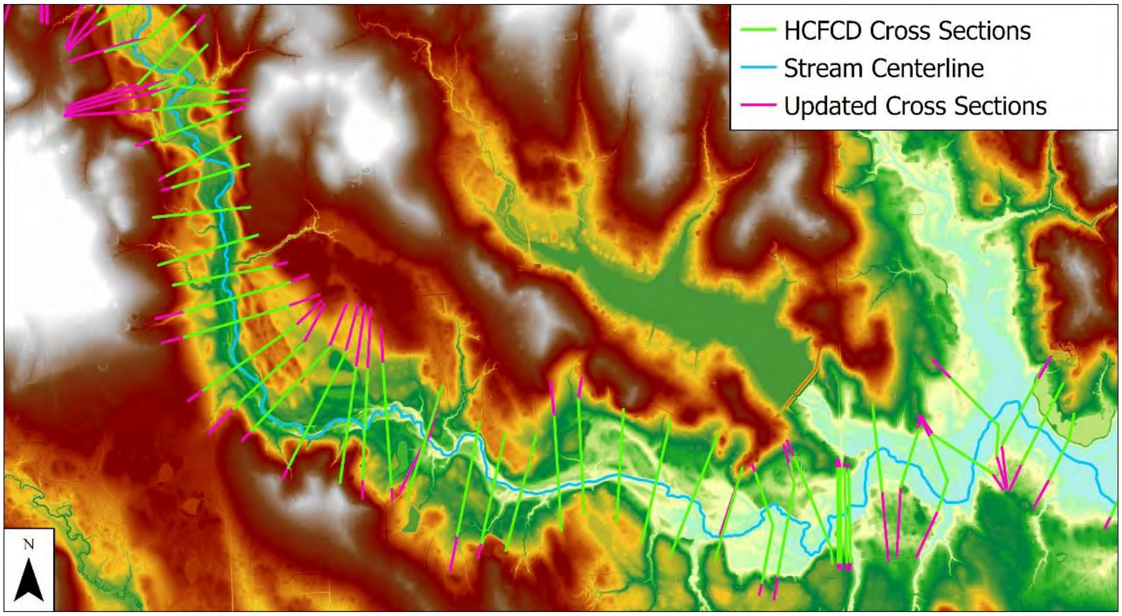

Figure 4-5 Walnut Creek Adjusted Cross Sections

Cross sections were also added along Walnut Creek from FM 1488 to the confluence with Birch Creek. The cross sections along Birch Creek Upstream of FM 1488 were removed and replaced with a 2D area. Cross section elevations were obtained from the terrain data and roughness values corresponded to the existing land use values used within the previous study. The cross sections that were added and adjusted on Walnut Creek are shown in Figure 4-6.

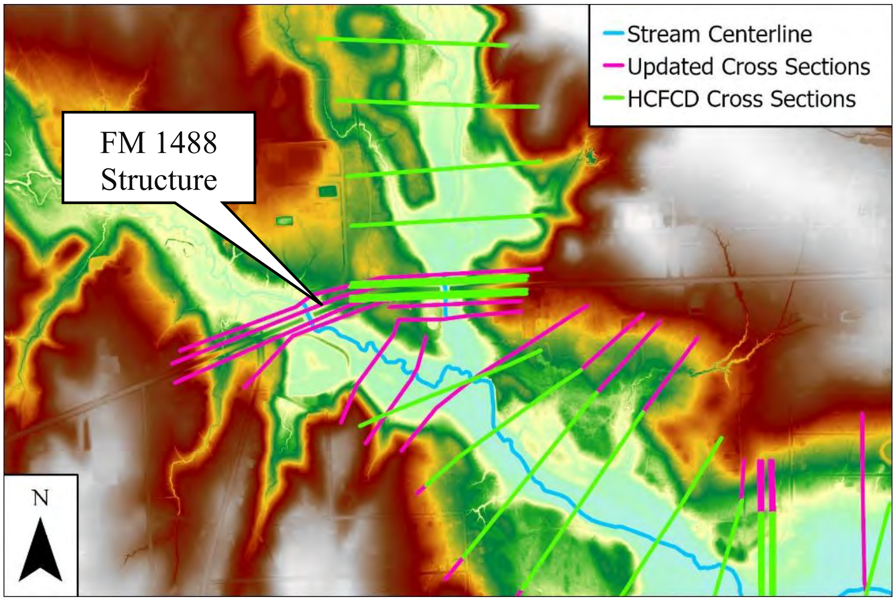

Figure 4-6 Walnut Creek Additional Cross Sections

4.2.5 Additional structure

The HCFCD HEC-RAS model included the FM 1488 crossing on Birch Creek, but not along Walnut Creek. The FM 1488 crossing along Walnut Creek was included from field survey provided by Waller County. Figure 4-7 shows the additional crossing location on FM 1488.

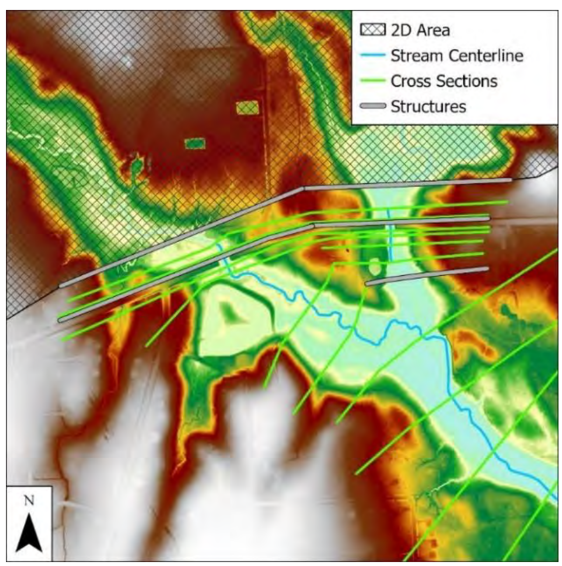

Figure 4-7 Walnut Creek Additional Structure

4.2.6 1D/2D connections

At the downstream end of the 2D area, two 2D connections were placed along Walnut Creek and Birch Creek. The 2D connections connected the 2D area and storage areas located on the upstream end of Walnut Creek and Birch Creek. This allowed for flow to go from the 2D area to the 1D sections of Walnut and Birch Creek. The two 2D connections and storage areas are shown in Figure 4-8.

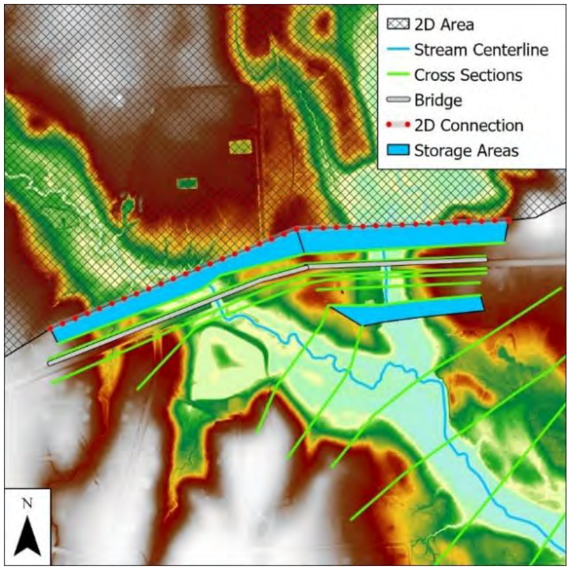

Figure 4-8 1D/2D Connections on Walnut and Birch Creek

5 Calibration

The existing conditions model was simulated for two historical storm events that were previously calibrated in the HCFCD study, and results were compared to ensure the model would provide reasonable results when compared to observed conditions. Table 5-1 below shows the Harvey (2017) observed water surface elevations, as well as discharge and water surface elevations for the HCFCD model and the revised existing conditions model.

Table 5-1 Harvey (2017) WSE and Discharge Comparisons

	SH 249	FM2978	Kuykendahl	I-45
HCFCD Discharge	55,315	80,021	80,522	97,444
Revised Discharge	53,774	75,857	76,638	95,019
HCFCD WSEL	165.61	154.19	141.00	111.19
Revised WSEL	165.37	153.76	140.79	111.81
Observed WSEL	165.08	153.74	140.62	111.40

Table 5-2 below shows the Memorial Day (2016) observed water surface elevations, as well as discharge and water surface elevations for the HCFCD model and the revised existing conditions model.

Table 5-2 Memorial Day (2016) WSE and Discharge Comparisons

	SH 249	FM2978	Kuykendahl	I-45
HCFCD Discharge	45,954	65,310	63,959	67,631
Revised Discharge	46,839	63,941	62,511	66,918
HCFCD WSEL	164.68	152.96	138.39	108.14
Revised WSEL	164.12	152.37	138.61	108.61
Observed WSEL	164.66	152.90	139.19	108.25

The revised existing conditions model has similar results to the previous HCFCD calibration as well as the observed conditions. These results showed that with the changes to the model, it remained calibrated and appropriate for the benefit analysis.

6 Existing conditions results

The calibrated models were simulated for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events to determine discharges and water surface elevations throughout the watershed.

6.1 Spring Creek watershed summary

The Spring Creek watershed has over 392 square miles of drainage area that consists of flows from Grimes, Waller, Montgomery, and Harris Counties. Most of the runoff reaches the creek through the four major northern tributaries: Threemile Creek, Walnut Creek, Mill Creek, and Panther Branch. Peak flows for the 1% ACE in Spring Creek are over 70,000 cfs at the confluence with the West Fork, making it one of the higher flow watersheds within the San Jacinto River basin. Figure 6-1 shows how the flows combine throughout the watershed and the 1% ACE peak discharges at key locations in the creek.

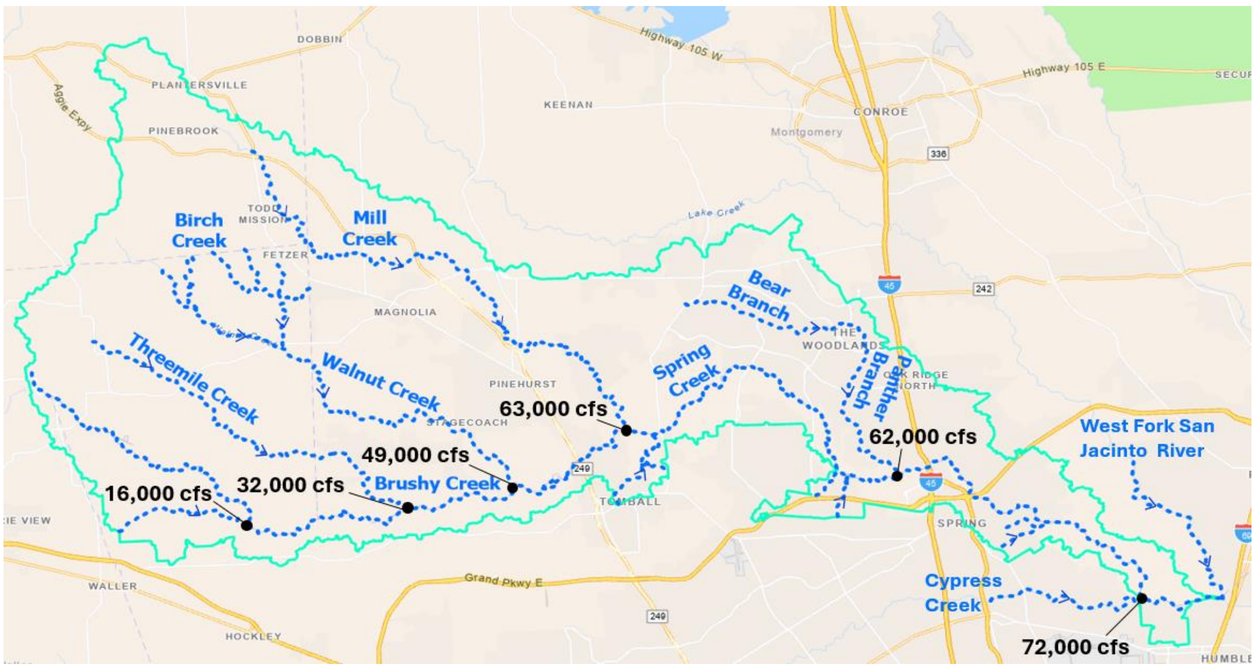

Figure 6-1 1% ACE (100-year) Flows Throughout Spring Creek

6.2 Discharge comparisons

Discharges for the 1% ACE event were compared between the effective FEMA model, HCFCD model, and the revised model used for the study to identify major changes. In general, the revised model discharges are higher than the effective FEMA model due to the application of Atlas 14 rainfall in the watershed but match well with the HCFCD discharges. The increases in discharges from the effective modeling indicate that flood risk may be higher than those shown on current FEMA maps (which are based on pre-Atlas 14 rainfall values).

Table 6-1 1% ACE (100-year) Existing Conditions Discharge Comparisons

	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
Effective Discharge	-	44,311	44,311	54,138	49,790	57,889	76,749
HCFCD Discharge	23,646	53,004	49,458	60,143	56,818	63,757	70,074
Revised Discharge	18,334	48,330	46,808	58,220	56,087	60,814	69,337

6.3 Water surface elevation comparisons

Water surface elevations for the 1% ACE event were compared between the effective FEMA model, HCFCD model and the revised model used for the study to identify major changes. In general, the revised model elevations are higher than the effective FEMA model due to the application of Atlas 14 rainfall in the watershed. The increases in elevation show that the watershed has more potential for flood risk than that shown on current FEMA maps (which are based on pre-Atlas 14 rainfall values).

Table 6-2 1% ACE (100-year) Existing Conditions WSE Comparisons

	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
Effective WSEL	-	168.75	161.87	136.99	126.00	107.24	67.10
HCFCD WSEL	187.54	170.46	164.53	138.76	127.81	111.26	71.42
Revised WSEL	186.95	170.06	164.09	138.44	127.52	111.07	71.29

6.4 Structure flooding summary

The resulting water surface elevations from the revised model were compared to assumed building finished floor elevations to identify the number of structures potentially flooded in each storm event. Spring Creek has a wide and deep floodplain and in general does not experience significant structural flooding until it reaches the 2% ACE event. This indicates that structural flooding is infrequent; however, when large storm events occur, there is the potential for widespread damages.

Exhibit 4 shows the structures that are potentially flooded for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events. The number of potentially flooded structures in Spring Creek for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events are in Table 6-3.

Table 6-3 Potentially Flooded Structures

Event	Potentially Flooded Structures
10% ACE	42
2% ACE	292
1% ACE	848
0.2% ACE	9,603

While damages occur throughout the floodplain of Spring Creek, concentrations of flood damages tend to occur in the following areas:

- Walnut Creek – There are nearly a hundred structures within the Walnut Creek floodplain that are most single-family residential housing in rural subdivisions. Most structures are older homes likely built prior to floodplain regulations and are subject to frequent flooding due to the creek.
- SH 249 – In this location there are low lying older neighborhoods that are susceptible to flooding in the 50-year event, as well as a large amount of commercial and industrial facilities that are inundated in the larger events. Most structures here reside in Montgomery County.
- FM 2978 – There are multiple residential structures and commercial/industrial facilities in Montgomery County that are susceptible to flooding in the larger events. This includes communities on Dobbin-Huffsmith Road and sections of the Northgrove neighborhood.
- Kuykendahl road – This area is mostly residential structures in Harris County that are susceptible to flooding in the 500-year event including the Creekside and Timmarron Lakes neighborhoods of The Woodlands.
- Between Gosling Rd and I-45 – There are multiple residential structures and a few commercial/industrial sites in Montgomery County that are susceptible to flooding in the larger events. Notable neighborhoods include Grogan's Point, Timber Lakes, and the commercial districts near Rayford Road.
- Grand Parkway – There are many residential structures around Grand Parkway in Montgomery County that are susceptible to flooding in the 500-year event including the Forest Village, Spring Trails, Fox Run, and Benders Landing neighborhoods.

The number of potentially flooded structures in Spring Creek for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events for each county are in Table 6-4.

Table 6-4 Potentially Flooded Structures

Event	Waller	Montgomery	Harris
10% ACE	4	30	8
2% ACE	17	251	24
1% ACE	32	743	73
0.2% ACE	60	7,575	1,968

7 Proposed projects

As recommended in the San Jacinto Regional Watershed Master Drainage Plan, two projects are proposed within the Walnut Creek watershed to provide flood mitigation along Spring Creek. One project is proposed on Walnut Creek upstream of FM 1488. The second project is proposed along the Birch Creek tributary also upstream of FM 1488.

7.1 Modeling approach

The proposed projects are located within the 2D area on the upstream end of Walnut Creek. The detention basins were modeled by adding 2D connections along the proposed project alignments. The 2D connections are shown in Figure 7-1.

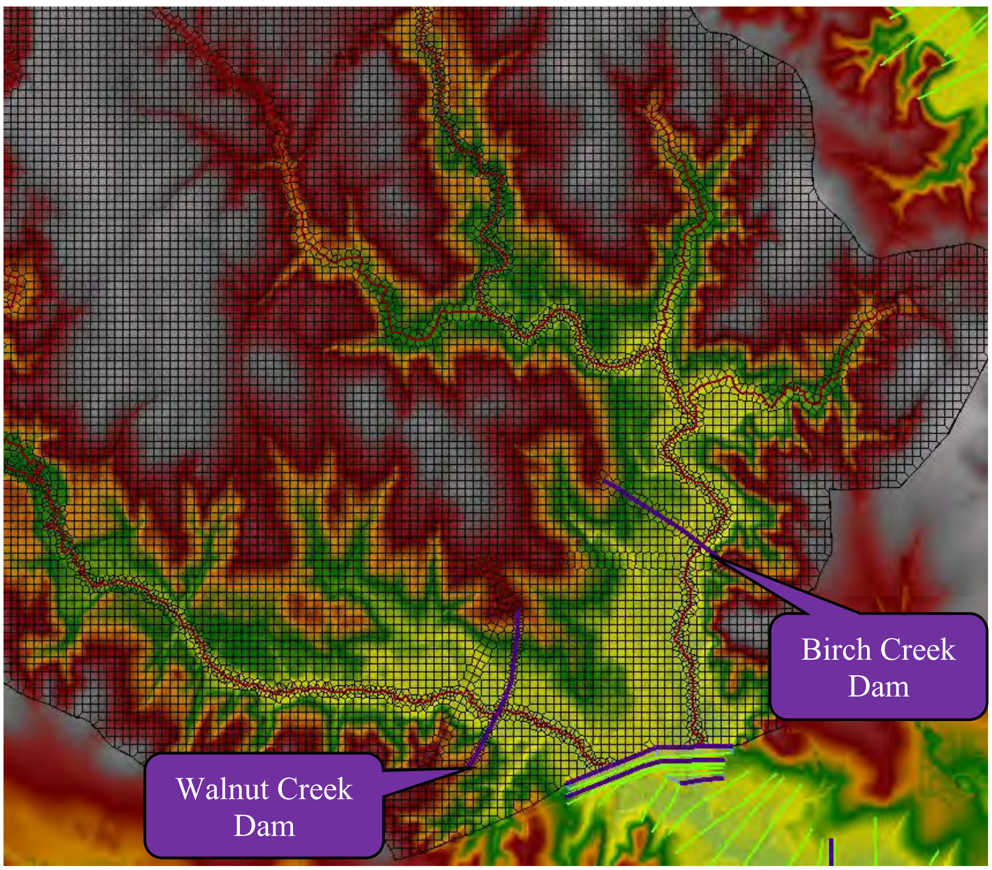

Figure 7-1 2D Connections Modeling Proposed Detention Basins

The 2D connections were modeled as ogee weirs and the weir elevations matched the top of dam and spillway elevations. The project outlets were modeled as large culvert openings at the flowline of the streams. A cross section view of the 2D connections for the proposed Walnut and Birch Creek projects are shown in Figure 7-2 and Figure 7-3.

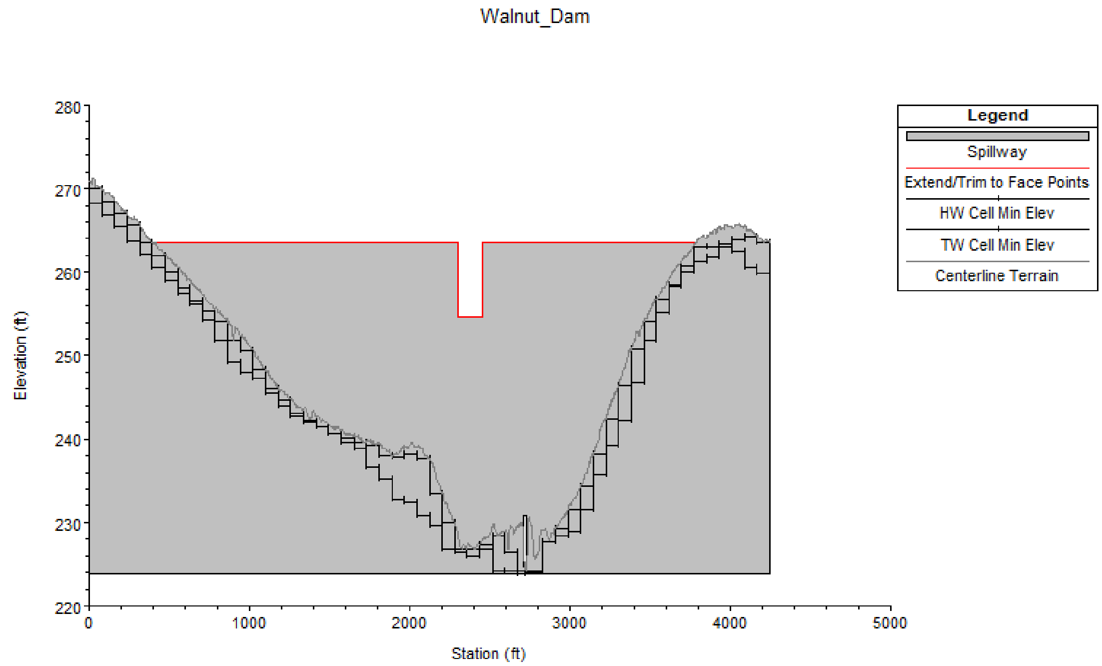

Figure 7-2 Walnut Dam Cross Section View of Dam 2D Connection

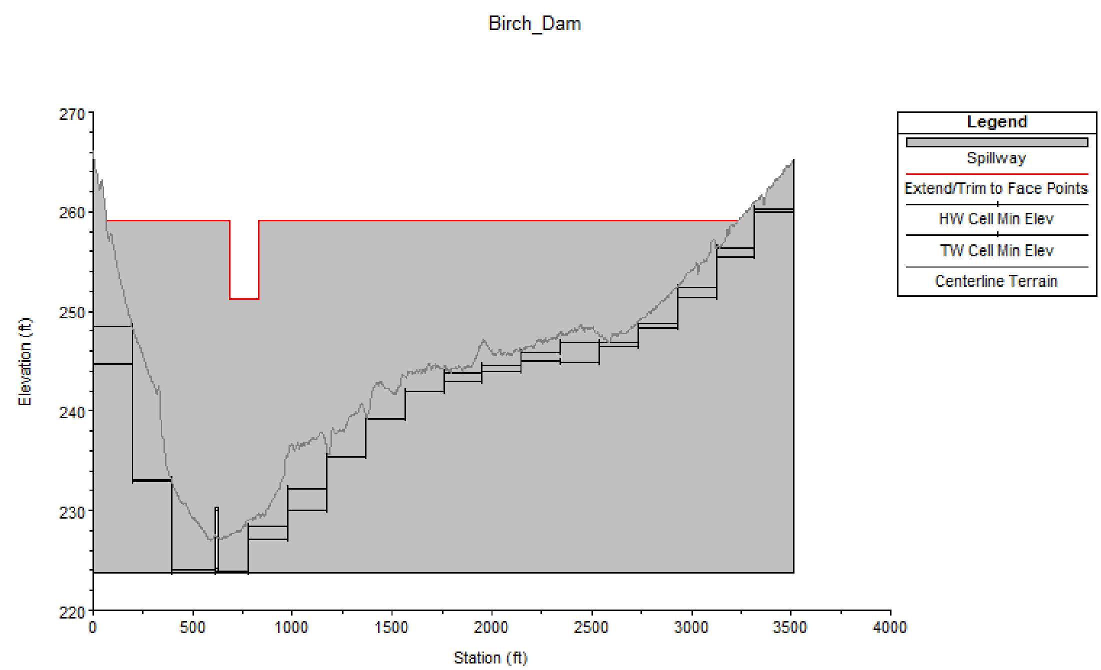

Figure 7-3 Birch Dam Cross Section View of Dam 2D Connection

7.2 Optimization

The detention basin elevations and footprints as presented in the SJRWMDP were initially simulated within the revised models to identify the design and benefits of the features. The models showed that the project areas were not completely full during large events and the size of the detention footprint could be reduced while providing similar benefits.

An optimization analysis was performed to determine the optimal volume within both the Birch and Walnut Creek detention basins that would minimize cost while still providing benefits along Spring Creek. Several different volume iterations for each dam were simulated and resulting water surface elevations compared at Kuykendahl Road. The Birch Creek comparisons are shown in Figure 7-4.

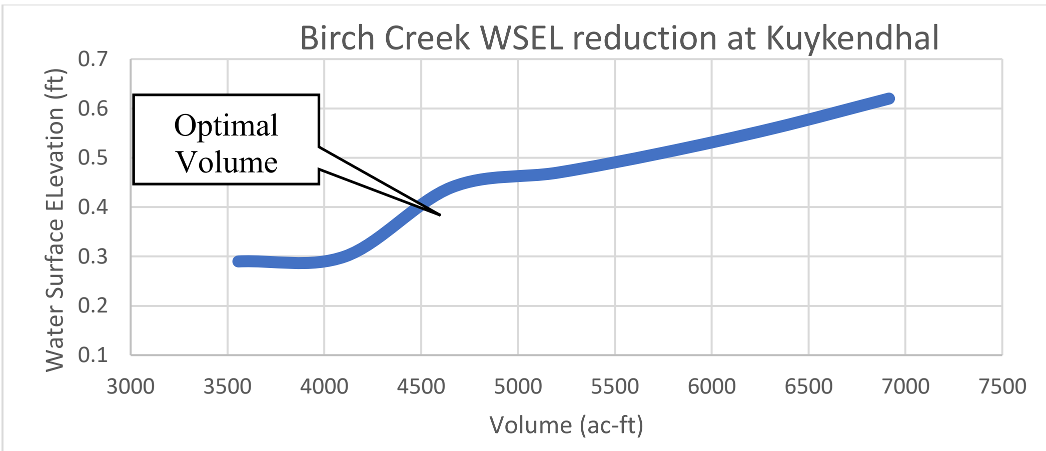

Figure 7-4 Birch Creek Volume Vs WSE Reduction Comparison

The optimization for Birch Creek showed that a detention volume of approximately 4,700 acre-feet would provide an optimized solution where the water surface elevation reductions are maximized while the volume is minimized. This volume became the new target volume for the project area behind the dam.

The Walnut Creek comparisons are shown in Figure 7-5. The optimization for Walnut Creek showed that a detention volume of approximately 6,600 acre-feet would provide an optimized solution where the water surface elevation reductions are maximized while the volume is minimized. This volume became the new target volume for the project area behind the dam.

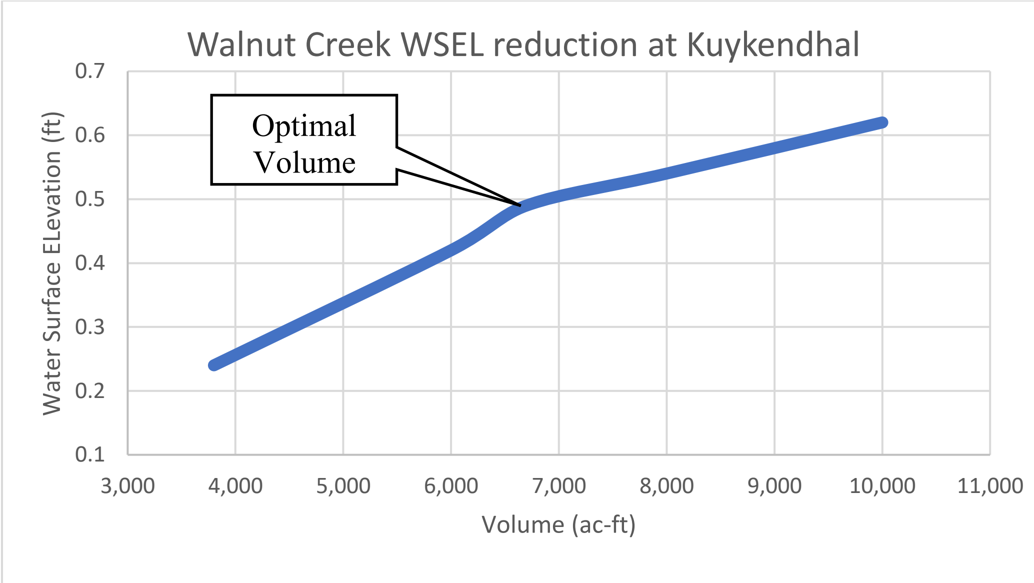

Figure 7-5 Walnut Creek Volume Vs WSE Reduction Comparison

7.3 Walnut Creek detention basin

7.3.1 Description

The detention basin will be a dry detention basin that passes low flows and everyday rain events to match existing conditions and detains water during larger storm events. Table 7-1 shows a variety of parameters detailing the size of the detention basin.

Table 7-1 Walnut Creek Detention Basin Parameters

	Dam Design Configuration
Spillway Elevation	254.7 ft
Spillway Length	175 ft
Top of Dam	263.6 ft
Max Dam Height	39.1 ft
1% ACE Inundation Area	940 ac
1% ACE Storage Capacity	7,300 ac-ft
Opening Size	6’ x 17’ RCB

7.3.2 Hydraulic results

The proposed Walnut Creek detention basin reduces the flow and water surface elevations throughout Spring Creek. Table 7-2 and Table 7-3 show the reduction in flow and water surface elevations between the proposed conditions and revised existing conditions for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events, respectively.

Table 7-2 Walnut Creek Flow Difference

Flow Difference (cfs)							
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-1,452	-334	-773	-450	-431	-223	0
2% ACE	-4,047	-903	-2,837	-1,954	-1,690	-1,582	-1,200
1% ACE	-6,381	-1,214	-3,397	-2,724	-3,409	-3,319	-1,296
0.2% ACE	-9,874	-1,956	-2,719	-1,982	-2,201	-1,324	-708

Table 7-3 Walnut Creek Water Surface Elevation Difference

Water Surface Elevation Difference (ft)							
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-1.15	-0.30	-0.29	-0.14	-0.12	-0.08	0.00
2% ACE	-2.1	-0.59	-0.58	-0.41	-0.37	-0.34	-0.25
1% ACE	-2.8	-0.75	-0.77	-0.54	-0.50	-0.38	-0.22
0.2% ACE	-3.03	-0.78	-0.71	-0.56	-0.41	-0.09	-0.15

7.4 Birch Creek detention basin

7.4.1 Description

The detention basin will be a dry detention basin that passes low flows and everyday rain events to match existing conditions and detains water during larger storm events. Table 7-4 shows a variety of parameters detailing the size of the dam.

Table 7-4 Birch Creek Detention Basins Parameters

	Dam Design Configuration
Spillway Elevation	251.2 ft
Spillway Length	175 ft
Top of Dam	259.1 ft
Max Dam Height	35.4 ft
1% ACE Inundation Area	690 ac
1% ACE Storage Capacity	4,800 ac-ft
Opening Size	6' x 16' RCB

7.4.2 Hydraulic results

The proposed Birch Creek detention basin reduces the flow and water surface elevations throughout Spring Creek. Table 7-5 and Table 7-6 show the reduction in flow and water surface elevations between the proposed conditions and revised existing conditions for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events, respectively.

Table 7-5 Birch Creek Flow Difference

	Flow Difference (cfs)						
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-979	-272	-678	-449	-417	-294	-1
2% ACE	-2,587	-639	-1,860	-1,230	-1,012	-850	-556
1% ACE	-4,399	-868	-2,349	-1,901	-1,988	-2,562	-811
0.2% ACE	-6,235	-1,384	-1,896	-1,263	-1,438	-826	-428

Table 7-6 Birch Creek Water Surface Elevation Difference

Water Surface Elevation Difference (ft)							
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-0.79	-0.26	-0.26	-0.14	-0.12	-0.11	0.00
2% ACE	-1.36	-0.40	-0.38	-0.25	-0.22	-0.18	-0.11
1% ACE	-1.99	-0.52	-0.54	-0.36	-0.33	-0.23	-0.14
0.2% ACE	-1.87	-0.54	-0.49	-0.37	-0.26	-0.06	-0.09

7.5 Combined detention basin hydraulic results

The proposed Birch Creek and Walnut Creek detention basins together reduce the flow and water surface elevations throughout Spring Creek. Table 7-7 and Table 7-8 show the reduction in flow and water surface elevations between the proposed conditions and revised existing conditions for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events, respectively.

Table 7-7 Combined Detention Basins Flow Difference

Flow Difference (cfs)							
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-2,309	-597	-1,467	-888	-821	-489	0
2% ACE	-7,601	-1,514	-4,699	-3,189	-2,726	-2,379	-1,775
1% ACE	-10,626	-1,917	-5,441	-4,614	-5,137	-4,689	-2,134
0.2% ACE	-17,676	-3,190	-4,596	-3,442	-3,792	-2,683	-1,191

Table 7-8 Combined Detention Basins Water Surface Elevation Difference

Water Surface Elevation Difference (ft)							
	On Walnut Creek	Walnut Creek Confluence	SH 249	Kuykendahl	Gosling	I-45	West Fork Confluence
10% ACE	-1.96	-0.57	-0.56	-0.29	-0.25	-0.18	0.00
2% ACE	-2.90	-1.00	-1.00	-0.68	-0.61	-0.53	-0.37
1% ACE	-3.64	-1.18	-1.20	-0.88	-0.82	-0.67	-0.36
0.2% ACE	-4.47	-1.31	-1.20	-0.93	-0.70	-0.15	-0.26

8 Structure benefit analysis

Using the structure database as well as the hydraulic model results, an analysis of benefits was conducted to determine the number and frequency of structures that would benefit from the detention basins. The detention basins were evaluated both independently and in a combined scenario to understand the benefits for both the frequency storms as well as the historical storm events.

8.1 Frequency storms

The proposed Birch Creek and Walnut Creek detention basins reduce the number of structures impacted throughout Spring Creek for each of the modeled frequency events. Table 8-1 show the benefited structures for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events with the Birch Creek detention basin, Walnut Creek detention basin, and combined detention basin scenarios.

Table 8-1 Benefited Structures

	Birch		**Walnut**		**Birch + Walnut**	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
10% ACE	37	2	36	5	30	11
2% ACE	252	48	230	70	199	101
1% ACE	802	160	738	225	629	335
0.2% ACE	9,207	303	9,032	484	8,762	795

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

The results show the detention basins have widespread benefit in reducing water surface elevations for all storm events due to the large detention volume provided. Over 9,000 structures show some type of benefit from each detention basin, including several hundred showing removal from the 1% ACE floodplain.

8.2 Historical storms

The proposed Birch Creek and Walnut Creek facilities were modeled with historical rainfall to determine the potential structural benefit if the facilities had been in operation prior to the events. Table 8-2 show the potential benefited structures for Hurricane Harvey (2017), Memorial Day (2016), and Tax Day (2016) with the Birch Creek detention basin, Walnut Creek detention basin, and combined detention basin scenarios.

Table 8-2 Potential Structural Benefits for Historical Storms

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
Harvey	3,749	254	5,081	321	5,351	542
Memorial Day	1,230	160	1,234	233	1,237	359
Tax Day	241	14	235	13	286	93

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

Table 8-3 shows the potential benefited structures for Hurricane Harvey (2017) within each county precinct.

Table 8-3 Potential Structural Benefits for Hurricane Harvey (2017) by Precinct

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
Harris County Precinct 3	662	45	701	53	701	90
Harris County Precinct 4	11	1	11	2	11	2
Montgomery County Precinct 2	423	45	423	50	432	74
Montgomery County Precinct 3	2,631	154	3,924	203	4,185	358
Waller County Precinct 2	22	9	22	13	22	18

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

Table 8-4 show the potential benefited structures for Memorial Day (2016) within each county precinct.

Table 8-4 Potential Structural Benefits for Memorial Day (2016) by Precinct

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
Harris County Precinct 3	120	19	120	23	120	33
Harris County Precinct 4	8	0	8	1	8	1
Montgomery County Precinct 2	361	41	361	64	361	95
Montgomery County Precinct 3	712	85	716	126	719	206
Waller County Precinct 2	29	15	29	19	29	24

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

Table 8-5 show the potential benefited structures for Tax Day (2016) within each county precinct.

Table 8-5 Potential Structural Benefits for Tax Day (2016) by Precinct

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
Harris County Precinct 3	18	6	18	6	18	7
Harris County Precinct 4	3	0	3	0	5	2
Montgomery County Precinct 2	126	0	123	0	151	47
Montgomery County Precinct 3	85	8	84	7	97	26
Waller County Precinct 2	9	0	7	0	15	11

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

9 Benefit cost analysis

For each of the evaluated detention basin alternatives described in Section 7, benefit-cost analyses (BCA) were performed to evaluate flood damage benefits for structures within the watershed of Spring Creek. The analyses were performed in March 2025 utilizing the FEMA BCA Toolkit version 6.0 (build 20250108.0114) to evaluate cost-effectiveness, adhering to the then-current FEMA Benefit Cost Analysis practices. Base data was gathered and analyzed based on the methodologies described in Section 2.2.

9.1 Methodology

Information from the hydraulic models including water surface elevations for both existing conditions and each of the proposed detention basin alternatives were extracted to perform the analysis. In addition, base data such as residential and non-residential building footprints, building type and use, location, terrain, and building square footage were used within the analysis.

9.1.1 Period of analysis

The period of analysis was based on 50 years, which is the typical benefit period for dam projects which are in service for several decades. The costs over the 50-year period account for estimated environmental mitigation, property acquisition, and capital costs. Project cost for the individual as well as combined detention basins are summarized in Table 9-1.

Table 9-1 Project Costs Per Detention Basin Alternative

Project	Cost
Birch Creek	$105 M
Walnut Creek	$193 M
Combined	$298 M

9.1.2 Interest rates and price levels

All economic damages, benefits, and costs for drainage improvement projects use base fiscal year (FY) 2024. Future damages, benefits, and costs use the FEMA-default discount rate of 3.1 percent over the 50-year period of analysis.

9.1.3 Affected structures

Following the completed analysis of the existing condition results, the structures showing inundation based on the estimated finished floor elevations and the modeled inundation areas were inventoried into affected structures. This inventory captured all residential and non-residential buildings within 1,000 feet of the Spring Creek 0.2% ACE floodplain. Structures under 500 square feet were removed from this analysis. The finished floor elevations were determined by the elevation of the Lidar data at the centroid of the structure with an additional 1 foot. Affected structures were assigned flood depths for each of the modeled frequency events under existing conditions and each of the proposed alternatives.

9.1.4 *Depth-damage functions*

Depth-damage functions (DDF) are used to link the hydraulic data inputs, structure value, content value, and flood elevations to determine the monetary value of flood damages. These functions identify the percentage of the total damage value that correspond to the severity of flooding. Functions for damages to residential property structures and contents were obtained from the USACE EGM 04-01. Functions for non-residential properties are specific to building type and use; therefore, this study used the FEMA toolkit's default DDF by building type. Table 9-2 presents the Generic USACE depth-damage functions used for all residential structures in this study.

Table 9-2 USACE Residential Generic Depth-Damage Function

Flood Depth (ft.)	One Story, No basement Mean of Damages		Two or More Stories, No basement Mean of Damages	
	Structure	Contents	Structure	Contents
-2	0%	0%	0%	0%
-1	2.5%	2.4%	3.0%	1.0%
0	13.4%	8.1%	9.3%	5.0%
1	23.3%	13.3%	15.2%	8.7%
2	32.1%	17.9%	20.9%	12.2%
3	40.1%	22.0%	26.3%	15.5%
4	47.1%	25.7%	31.4%	18.5%
5	53.2%	28.8%	36.2%	21.3%
6	58.6%	31.5%	40.7%	23.9%
7	63.2%	33.8%	44.9%	26.3%
8	67.2%	35.7%	48.8%	28.4%
9	70.5%	37.2%	52.4%	30.3%
10	73.2%	38.4%	55.7%	32.0%
11	75.4%	39.2%	58.7%	33.4%
12	77.2%	39.7%	61.4%	34.7%
13	78.5%	40.0%	63.8%	35.6%
14	79.5%	40.0%	65.9%	36.4%
15	80.2%	40.0%	67.7%	36.9%
16	80.7%	40.0%	69.2%	37.2%

9.1.5 *Building size*

The building size is defined as the entire finished and livable space with disregard to unfinished basements, porches, attached garages, and other outside areas. For non-residential structures, the building size is equivalent to the first-floor area as it is assumed that only the first-floor area will sustain damages to the building and contents in a flood event. The first-floor area is a parameter to avoid inputting the full building square footage for a multi-story building.

The building sizes are sourced from the County Appraisal District databases for Harris, Montgomery, and Waller Counties.

9.1.6 Building replacement value and costs

The Building Replacement Value (BRV) is defined as the cost per square foot to replace an affected structure with a functionally equivalent building. This value is not the equivalent of the current market or assessed value of the structure. The BRV considers only the current cost of labor and the replacement materials. The FEMA default BRV of $100 per square foot was used in this analysis.

The total building replacement cost is found from the product of the BRV and the building size. The building replacement cost and the structure data are applied to a DDF as shown in Table 9-2 to calculate the expected annual losses (damages) in relation to the water surface elevations (depth) modeled at a given structure.

9.1.7 Content value

Content values for all residential and non-residential structures were calculated using the FEMA default method as a percentage of the BRV.

- For residential structures, the default method considers the contents to be equivalent to 100% of the building replacement costs mentioned in the BRV section. This total content value, which does not include permanent utilities such as plumbing and electrical systems, is applied to the contents section of a DDF as shown in Table 9-2.
- For non-residential structures, the content values are determined by the product of the first-floor area, the BRV, and an economic percentage value multiplier based on the building type and use. It was undetermined if the buildings were pre-engineered; therefore, all non-residential buildings were considered engineered buildings for a conservative approach. Table 9-3 displays the FEMA BCA Toolkit's default economic values by non-residential building type and use.

Table 9-3 Contents – Economic Percentage Values

Building Use	Value Multiplier (Engineered Building)	Value Multiplier (Pre-engineered Building)
Apartment	10%	12%
Clothing, Retail	29%	36%
Industrial Light	38%	47%
Office One-Story	12%	14%
Service Station	66%	83%
Warehouse, Non-Refrigerated	36%	43%

9.1.8 Additional benefits

A major component in determining benefits for flood mitigation projects is based on the effects of depth reduction and evaluated monetary damages, described in the previous sections. Additional benefits may be incorporated into the overall benefits including the effects the project may have on services and residents.

Displacement

An additional part of the standard benefits calculation includes the residential and non-residential displacement costs after a flood event. Residential displacement losses represent the cost to residents caused by being out of their home after a storm event causes damage to the structure. The cost of residential displacement was calculated using the method and the recommended values in the FEMA BCA Toolkit. These costs account for temporary lodging for each displaced household and increased meal costs associated with eating out of the home for each displaced resident. The unit costs are sourced from the U.S. General Services Administration's (GSA) "FY 2025 per diem rates for Texas."[1]

Expected annual benefits depend on the number of displaced residents per the depth of flooding at the structures. The total benefits associated with the avoidance of residential displacement costs are summarized in Table 9-4. The meal cost per person on a daily basis is found by the difference of the U.S. GSA's unit costs of meals per day per capita and the daily meal cost of eating at home per person.

For this study, the population per household was not accounted for from the appraisal districts. The U.S. Census Bureau's "QuickFacts for Texas" states the average persons per households is 2.7; therefore, the number of residents per structure was rounded to 3 persons per household for the BCA input requirement.[2]

Table 9-4 Residential Displacement Unit Cost

County	Meals per Day per Capita	Cost of Eating at Home per Day	Meal Cost per Person per Day	Hotel per Day per Family, up to 5 People
Waller (standard rate)	$68	$10	$58	$110
Harris and Montgomery	$80	$10	$70	$128

Nonresidential displacement losses represent the rental costs and one-time costs that an owner would experience for loss of function. Rental costs consider that the non-residential structure will rent the same amount of space required for the damaged building use. One-time costs consider the costs required to transport relevant items to the alternate rental locations and other pertinent costs due to displacement.

The rental costs and the one-time costs are determined by the building type and building use, and the FEMA default values are summarized in Table 9-5

[1] U.S. General Services Administration FY 2025 per diem rates for Texas

[2] U.S. Census Bureau QuickFacts Texas Table

Table 9-5 Non-Residential Displacement Unit Cost

Label	Occupancy Class	Rental Cost per sq.ft. per day	One-time Cost per sq.ft.
COM3	Personal and Repair Services	$ 1.83	$ 1.28
COM4	Professional/Technical/Business	$ 1.83	$ 1.28
IND2	Light	$ 0.37	$ 1.28
AGR1	Agriculture	$ 0.91	$ 0.91
GOV1	General Services	$ 1.37	$ 1.28

Social benefits

Flooding can be a mental stress and added anxiety to residents experiencing natural disasters. Social benefits are based on FEMA BCA standard values which include $2,443 for treatment of mental stress and anxiety for each resident of a home benefitted by the project and $8,736 for the loss of production for full-time workers impacted by the flooding.

To standardize the social benefits, the same assumption for number of residents from the displacement section was made. For number of working residents, the U.S. Census Bureau provides Texas's total employment and the total households to provide an average of 1 working resident per household[1]. With the FEMA standard values and the assumptions made for residents and working residents, the social benefits applied is equal to $16,065 per benefitted residential structure.

9.2 Walnut Creek results

A benefit-cost analysis was performed for the Walnut Creek Detention Basin Alternative using the water surface elevation results described in Section 7.3 with the parameters described in Section 9.1. The benefit value derived for this alternative was used along with the engineering opinion of probable project cost to generate the final benefit-cost ratio for the Walnut Creek Detention Basin, as shown in Table 9-6.

Table 9-6 Walnut Creek Detention Basin BCA Results

Building Type	Benefits		Total
	Standard	Social	
Residential	$42,899,652	$141,420,195	$184,319,847
Non-Residential	$17,467,588	$0	$17,467,588
		Total Mitigation Benefits	**$201,787,435**
		Total Project Cost	**$193,071,637**
		Project BCR	**1.05**

Using the total mitigation benefits and the associated project cost, the Walnut Creek Detention Basin has a benefit cost ratio (BCR) of 1.05.

[1] U.S. Census Bureau QuickFacts Texas Table

9.3 Birch Creek results

A benefit-cost analysis was performed for the Birch Creek Detention Basin Alternative using the results described in Section 7.4 with the parameters described in Section 9.1. The benefit value derived for this alternative was used along with the engineering opinion of probable project cost to generate the final benefit-cost ratio for the Birch Creek Detention Basin, as shown in Table 9-7.

Table 9-7 Birch Creek Detention Basin BCA Results

Building Type	Benefits		Total
	Standard	Social	
Residential	$33,369,403	$141,163,155	$174,532,558
Non-Residential	$10,814,136	$0	$10,814,136
		Total Mitigation Benefits	**$185,346,694**
		Total Project Cost	**$105,338,718**
		Project BCR	**1.76**

Using the total mitigation benefits and the associated project cost, the Birch Creek Detention Basin has a benefit cost ratio of 1.76.

9.4 Combined Detention Basin results

A benefit-cost analysis was performed for the Combined Detention Basins Alternative using the results described in Section 7.5 with the parameters described in Section 9.1. The benefit value derived for this alternative was used along with the engineering opinion of probable project cost to generate the final benefit-cost ratio for the Combined Detention Basins Alternatives, as shown in Table 9-8.

Table 9-8 Birch-Walnut Creek Detention Basins BCA Results

Building Type	Benefits		Total
	Standard	Social	
Residential	$49,527,304	$141,709,365	$191,236,669
Non-Residential	$20,504,771	$0	$20,504,771
		Total Mitigation Benefits	**$211,741,440**
		Total Project Cost	**$298,410,355**
		Project BCR	**0.71**

Using the total mitigation benefits and the associated project cost if constructed together, the Combined Birch Creek and Walnut Creek Detention Basins have a benefit cost ratio of 0.71. The lower BCR in comparison to the BCRs of the independent detention basins is attributed to the significant cost increase of a project for two detention basins and due to the nature of social benefits being attributed to the number of affected structures rather than the changes in depth-to-damage. For the combined case, social benefits are still only counted per the structures benefiting so remain the same as if only one basin was being constructed.

As of June 2025, FEMA has updated the Benefit Cost Analysis Toolkit to reflect new discount rates (3.1% rather than 7%) and the removal of social benefits. This indicates that how FEMA is calculating these features has changed and may evolve in the coming months and years as this project progresses into the next phase. This study calculated the Benefit Cost Ratio based on FEMA policy as of March 2025. While social benefits significantly contributed to the overall benefits for these two projects, these benefits are not being considered by FEMA at this time. However, this doesn't mean they are invalid—these benefits may be reintroduced or redefined in future FEMA policy updates. The TWDB and USACE are also exploring how other economic and social factors can be incorporated into the benefits of a flood mitigation project.

10 Potential funding opportunities

Due to the size of the projects, funding for the detention basins will likely require a combination of multiple funding sources from both the local entities as well as partnerships with the state and federal governments. Each funding source may have specific requirements for meeting the source and stipulations as to the types of projects or parts of projects that it can fund. Below is a summary of current potential funding sources separated out by potential agency.

10.1 Federal Emergency Management Agency (FEMA)

Assuming both projects retain a benefit cost ratio greater than 1.0 in subsequent detailed design efforts, FEMA funding can be a source for project design and construction. FEMA has a variety of funding opportunities with eligible activities that range from Hazard Mitigation Planning to conveyance and detention improvements to flood warning system enhancements. The entity that applies must have an adopted Hazard Mitigation Plan.

10.1.1 Flood Mitigation Assistance (FMA)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $25 million
- Cost Share: 75% FEMA, 25% local
- Frequency: Annually
- Administrator: Texas Water Development Board
- Restrictions: BCR > 1.0

10.1.2 Hazard Mitigation Grant Program (HMGP)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $25 million
- Cost Share: 75% FEMA, 25% local
- Frequency: After federally-declared disaster
- Administrator: Texas Division of Emergency Management
- Restrictions: BCR > 1.0

10.2 US Housing and Urban Development Funding (HUD/GLO)

The HUD Community Development Block Grants (CDBG) provide opportunities for communities following a major disaster. HUD funding is administered through the General Land Office (GLO) for Texas and can also be filtered through the local council of governments (Houston-Galveston Area Council [HGAC] for our region). HUD funding generally does not have a BCR requirement but may have a low-moderate income emphasis for the applying entity. Funding opportunities may have different thresholds of percent Low-Moderate Income (LMI) benefitting from the project.

10.2.1 Community Development Block Grant – Disaster Relief (CDBG-DR)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: Varies
- Cost Share: 100% HUD
- Frequency: After federally-declared disaster
- Administrator: General Land Office
- Restrictions: Large emphasis on LMI communities

10.2.2 Community Development Block Grant – Mitigation (CDBG-MIT)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: Varies
- Cost Share: 100% HUD
- Frequency: After federally-declared disaster
- Administrator: General Land Office
- Restrictions: Large emphasis on LMI communities

10.3 Natural Resource Conservation Service (NRCS)

NRCS's natural resources conservation programs help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters. NRCS funds have been used locally for conservation efforts or repair of damaged infrastructure. The funding requires projects to be completed relatively quickly.

10.3.1 Watershed and Flood Prevent Operations (WFPO)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $5 million (unless otherwise approved by Congress)
- Cost Share: Varies
- Frequency: Annually
- Administrator: NRCS (US Department of Agriculture)
- Restrictions: Benefit area must include 20% agriculture

10.4 Congressional Allocation

Congress can directly allocate funding for a drainage infrastructure project through the annual appropriations process or by authorizing specific funding in legislation. This typically involves a member of Congress submitting a request—often in the form of a Community Project Funding (CPF) or earmark—for a particular project in their district or state. If approved, the request is included in one of the appropriations bills passed by Congress and signed into law by the President. Alternatively, Congress can include funding for such projects in larger infrastructure or disaster relief bills, directing federal agencies such as the Army Corps of Engineers or the Environmental Protection Agency to administer the funds. This process ensures that federal dollars are designated for targeted improvements, like stormwater management systems or flood mitigation infrastructure, that address local needs and protect communities. Projects funded with direct allocation may have to follow the rules of the funding agency such as that USACE funding cannot be used for land acquisition.

10.5 Texas Water Development Board (TWDB)

The TWDB has several sources of funding available for flood mitigation projects and has recently increased awareness of these projects and programs through the regional flood planning initiative. These two projects were included in the latest amendment of the plan which will make them eligible for state funding. Some of these funding sources are relatively new and standard requirements may be subject to change.

10.5.1 Flood Infrastructure Fund (FIF)

- Project Type: Planning, Engineering, Design, Construction
- Maximum Funding: $19 million (current cycle)
- Cost Share: 30%-75%, low interest loans
- Frequency: Bi-annually
- Administrator: TWDB
- Restrictions: Subject to state legislature funding the program

10.6 Local funding

Local funds will need to be raised for the local share required in most state and federal sources as well as for the long-term operations and maintenance of the basins.

10.6.1 Bonds

Bond funding can be used for flood protection and management projects. Bonds typically provide project specific financing that requires proposed improvements to be ready for design and construction and meet the priorities set by the funder. Although repayment terms can offer low or no interest financing, these sources do require full repayment.

10.6.2 Fees and ad valorem taxes

A development impact mitigation fee is a tax that is imposed as a precondition for the privilege of developing land. Since the proposed projects address existing conditions and are not meant for mitigating developing land, imposing a fee on new development to address pre-existing flooding conditions may be difficult to implement. Ad valorem taxes are based on the value of a transaction of a property. Sales taxes or property taxes are ad valorem taxes that could be considered for funding the projects.

10.6.3 Public private partnerships

While there is not an identified stream of funding available for private investment, it may be considered as an option if the opportunity is presented. The detention basins will provide ample space for recreational activities outside of storm events and dual use of the basins should be explored. The watershed also includes several different industrial and commercial developments that were significantly damaged in recent flood events and whose owners may be looking for opportunities to reduce flood risk in the area.

11 Recommendations and next steps

The hydrologic and hydraulic analyses show that the Walnut Creek and Birch Creek Detention Basins both individually, as well as combined, would provide a widespread benefit to the Spring Creek watershed. By detaining flows within each tributary, the detention basins reduce the overall flow in Walnut Creek and Spring Creek. The structural analysis showed that the reductions in both flow and water surface elevation translate to reductions in flooding throughout the watershed for both the frequency as well as historical storm events.

Table 11-1 Benefitted Structures

	Birch		Walnut		Birch + Walnut	
	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]	Reduced[1]	Removed[2]
10% ACE	37	2	36	5	30	11
2% ACE	252	48	230	70	199	101
1% ACE	802	160	738	225	629	335
0.2% ACE	9,207	303	9,032	484	8,762	795

[1] Structures that are still in the inundation area but the depth of flooding at the structure was reduced
[2] Structures that would no longer flood

The benefit cost analysis shows that both detention basins have a positive benefit cost ratio when analyzed individually and below a 1.0 benefit cost when analyzed together due to the application of social benefits. Applications for these projects should keep these projects as separate in order to maximize the benefit cost ratio.

Table 11-2 Final Benefit Cost Ratio

	Cost	Benefit	BCR
Birch Creek	$105,338,718	$185,346,694	1.76
Walnut Creek	$193,071,637	$201,787,435	1.05
Combined	$298,410,355	$211,741,440	0.71

Several funding sources are available for project funding, and construction as well as operations and maintenance will likely require a combination of federal, state, and local funding sources. The project owner should begin funding discussions with local, state, and federal agencies to determine the most probable source and begin funding applications.