DRAFT Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

SJRA
SAN JACINTO RIVER AUTHORITY

Flood Infrastructure Fund Category 1

Project ID 21-0016

Prepared for:

Texas Water Development Board

Prepared by:

Halff

C. Andrew Moore, P.E., CFM

Sam Hinojosa, P.E., CFM

Levi Hein, P.E., CFM

Richard Howard, P.W.S.

Cynthia Rodriguez, EIT

Brandon Huggett, EIT, CFM

Black & Veatch

Alexander Wallen, P.E.

Prince Turkson, PhD, P.E

Wilber Wang, PE

Shou Ting Hou, PE

Aviles Engineering

Shou Ting Hu, PE

Wilber L. Wang

Acknowledgements

The Woodlands Municipal Utility District No. 1
Montgomery County Municipal Utility District No. 7
Montgomery County Municipal Utility District No. 46
Montgomery County Municipal Utility District No. 60
Harris-Montgomery Counties Municipal Utility District No. 386
Harris County Flood Control District
City of Humble
San Jacinto River Authority

Table of Contents

List of Figures

List of Tables

List of Appendices

1 Executive summary

1.1 Overview

As part of the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP) completed in 2020, two regional detention basins were recommended to be constructed along Birch Creek and Walnut Creek to reduce the potential for flood risk throughout the Spring Creek watershed. The master plan recommended completing feasibility studies for both projects to further investigate the potential for funding and constructing the basins as well as optimizing the design.

The Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study was sponsored and funded by the San Jacinto River Authority (SJRA), Harris County Flood Control District (HCFCD), the City of Humble, and MUDs within the Woodlands, with partial funding from the Texas Water Development Board Flood Infrastructure Fund (FIF) as a Category 1 study. The purpose of the study was to perform a conceptual level design analysis of detention basins for each of the two identified project sites, including identifying benefits and costs associated with individual and joint project implementation. This analysis allows regional stakeholders to determine the most feasible project(s) for future implementation.

The study area includes Waller County, Montgomery County, Harris County, the City of Pinehurst, the City of Tomball, the City of Houston, and the City of Humble. All are participants in the National Flood Insurance Program (NFIP) and are currently enforcing floodplain management standards at least equivalent to NFIP minimum standards. The study extents and modeled streams are shown in Figure 1-1.

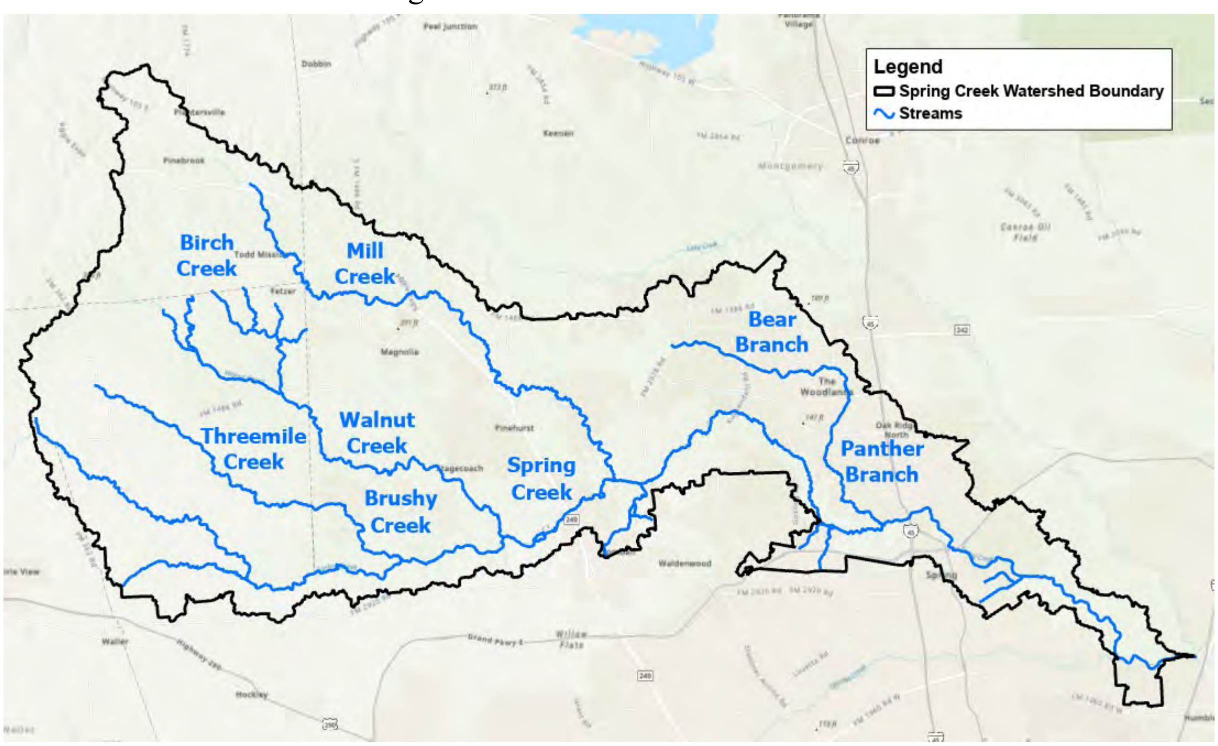


Figure 1-1 Spring Creek Watershed

The two detention basins will store flood waters during storm events by constructing embankments across the floodplains for each creek and restricting flow through specified outlets. The design of the embankments considered multiple alignments to manage the required fill, environmental permitting for crossing streams and potential wetlands, geotechnical investigation of nearby soils, embankment design options, spillway options to meet high and low flow requirements, required freeboard, and other dam safety permitting specifications.

A desktop environmental investigation was conducted to determine the necessary steps for permitting the detention basins and potential cost for mitigating any conflicts. The result of this investigation modified the recommended dam alignment to minimize potential stream mitigation and reduce the required permitting.

HEC-HMS and HEC-RAS models were used to determine the extents of flooding within the watershed as well as the benefits of the proposed detention basins. The analysis used the latest HCFCD models for the watershed as a basis and were modified as necessary within the Walnut and Birch Creek watersheds to reflect existing conditions. The analysis showed that there are currently over 800 residential and commercial structures susceptible to flooding within the Atlas 14 1% ACE (Annual Chance Exceedance) event and over 9,000 within the Atlas 14 0.2% ACE floodplain. This indicates that structure flooding is generally infrequent along Spring Creek; however, when large storm events occur, there is the potential for widespread damages.

Costs for each recommended project were tabulated accounting for land acquisition, construction, engineering, utility relocation, environmental permitting, and operations and maintenance of the facilities.

A benefit cost analysis was conducted using the FEMA BCA Toolkit to determine the flood mitigation benefits of each project separately as well as if combined into one application. The analysis included both the standard (buildings, contents, and displacement) and social benefits to calculate a total benefit of each project.

1.2 Recommendations

The recommended dams required for the detention basins included earthen embankments with 3.5:1 H:V upstream and 3:1 H:V downstream side slopes and maintenance access along the top of the dam. The design includes a large ogee spillway for extreme events and a cast in place box outfall for the more frequent storm events. All land within the limits of the probable maximum flood is recommended to be acquired either in fee or easement. As the conceptual design shows, the projects are implementable, permittable, and constructable as outlined in TWDB requirements. The opinion of probable construction cost for each basin is summarized in Table 1-1.

Table 1-1 Opinion of Probable Construction Costs

	Walnut Creek	**Birch Creek**	**Birch+Walnut**
Construction	$82,884,938	$64,043,650	$146,928,588
Engineering[1]	$12,432,740	$9,606,547	$22,039,287
Land Acquisition[2]	$95,463,459	$30,812,821	$126,276,280
Environmental	$2,290,500	$875,700	$3,166,200
Utilities	$0	$0	$0
Total	**$193,071,637**	**$105,338,718**	**$298,410,355**

[1] Engineering including geotechnical, survey, design, and construction management is assumed to be 15% of the total construction cost.
[2] The average cost of full acquisition and easements only was used for the total cost estimate; this is further explained in Section 6.2.

The hydraulic analysis showed that the proposed detention basins at Walnut Creek and Birch Creek will reduce flood risks in the Spring Creek watershed. The basins mitigate downstream flooding, benefiting numerous residential and non-residential structures. These projects produce no negative impact beyond the project extents in accordance with TWDB project criteria. Table 1-2 summarizes the benefits for each recommended project in accordance with TWDB grant requirements.

Table 1-2 Recommended Project Flood Risk Benefit

Mitigation Measurement	Walnut	Birch	Birch &Walnut
Structures with reduced 1% ACE flood risk. [1]	738	802	629
Structures removed from 1% ACE flood risk.	225	160	335
Structures with reduced 0.2% ACE flood risk. [2]	9,032	9,207	8,762
Structures removed from 0.2% ACE flood risk.	484	303	795
Residential structures removed from 1% ACE flood risk.	122	103	192
Population removed from 1% ACE flood risk.	458	336	655
Critical facilities removed from 1% ACE flood risk (#).	1	1	1
Farm & ranch land removed from 1% ACE (acres)	4.82	3.87	7.16
Pre-Project Level-of-Service	10% ACE	10% ACE	10% ACE
Post-Project Level-of-Service	10% ACE	10% ACE	10% ACE
Cost/ Structure removed.	$272,315	$227,513	$264,080
Percent Nature-based Solution	0%	0%	0%
Negative Impact	No	No	No
Negative Impact Mitigation	-	-	-
Social Vulnerability Index (SVI)	0.42	0.42	0.42
Water Supply Benefit (Y/N)	No	No	No
Traffic Count for Low Water Crossings	0	0	0
Low water crossings removed from 1% ACE flood risk	0	0	0
Reduction in road closure occurrences in 1% ACE	0	0	0
Length of roads removed from 1% ACE (mi).	0	0	0
Estimated reduction in fatalities	0	0	0
Estimated reduction in injuries	0	0	0

[1] 1% ACE = 100-year event
[2] 0.2% ACE = 500-year event

The economic feasibility of the project was also assessed by performing a benefit-cost analysis (BCA). The results demonstrated that both detention basins have a favorable benefit-cost ratio, indicating that the economic benefits of flood risk reduction outweigh the costs of construction and maintenance. The costs and benefits for each project are summarized in Table 1-3.

Table 1-3 Benefit Cost Ratios

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

The analysis shows that the individual projects both have the potential for benefit cost ratios greater than 1.0 meaning that the projects have the potential to be cost effective. This also indicates that specific federal funding sources may be available for funding portions of the total construction cost.

The combined project benefit cost is less than 1.0 due to a significant cost increase for two detention basins and the relatively small increase in social benefits (the projects still benefit the same population). This indicates that while both projects would provide downstream flood relief and a combination of projects provides the most relief, when seeking federal funding, separate applications should be submitted.

1.3 Next steps

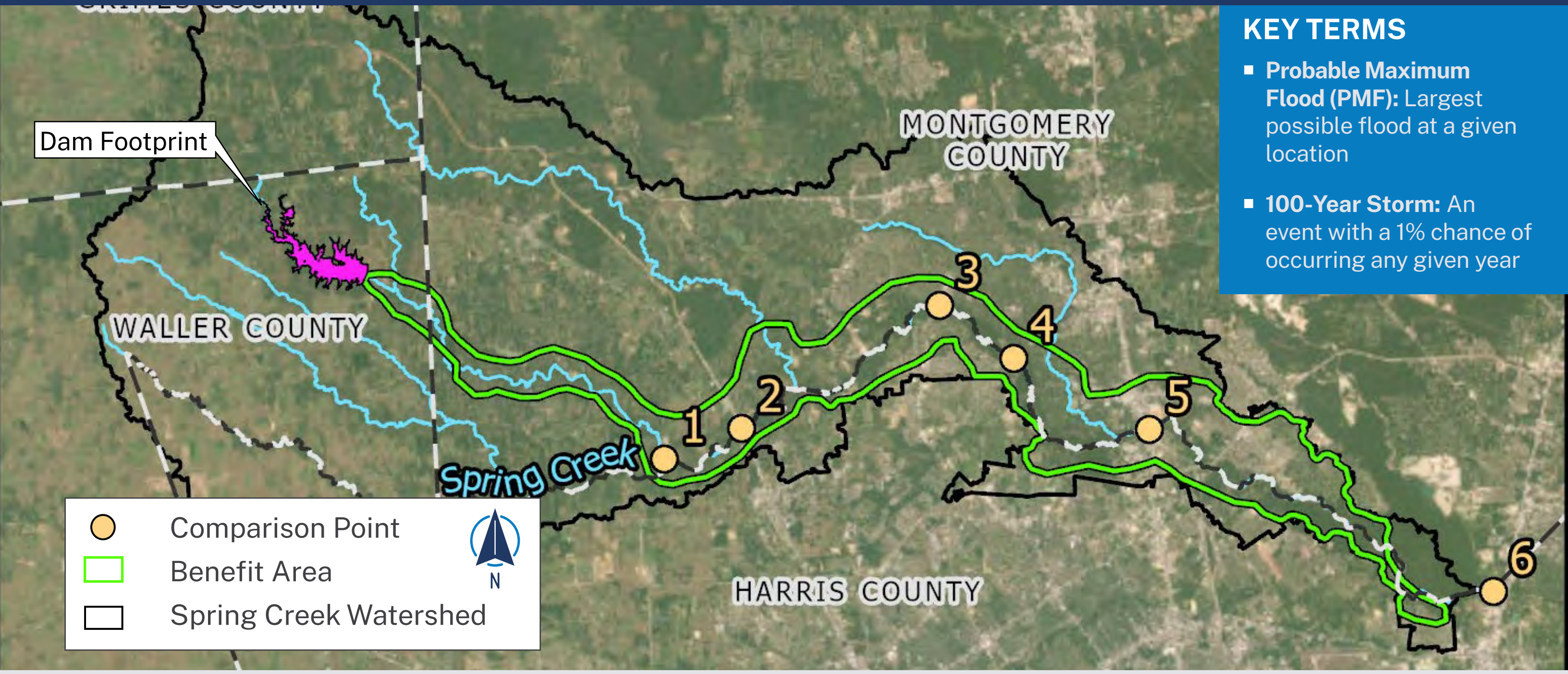
Based on these findings, it is recommended to advance the Walnut Creek and Birch Creek detention basins to the detailed design phase, which will involve more precise engineering analyses, coordination with landowners, acquisition of property, permitting, and the development of construction plans. Efforts should be made to secure funding from various sources, including federal, state, and local agencies, with potential funding opportunities such as FEMA's Hazard Mitigation Grant Program and the Texas Water Development Board's Flood Infrastructure Fund. In securing funding and completing the next phases of the design process, the entities within the area need to identify the potential owner for these projects to construct, maintain, and manage the facilities. This entity would need the jurisdiction to purchase land within the area as well as the ability and experience in maintaining and managing flood control dam facilities.

HARRIS COUNTY FLOOD CONTROL DISTRICT | CITY OF HUMBLE | Woodlands Water | SJRA SAN JACINTO RIVER AUTHORITY

Walnut Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Walnut Creek



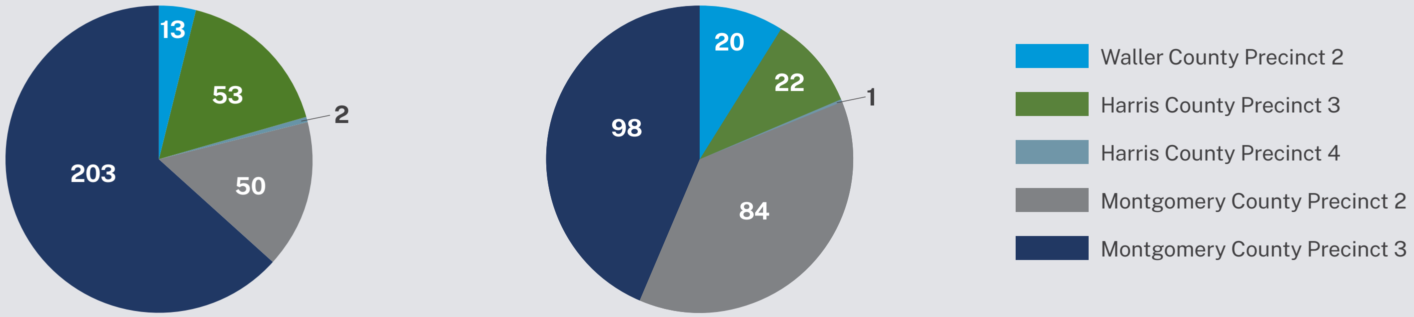
KEY TERMS

- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year

ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood **Hurricane Harvey**

Structures Anticipated to No Longer Flood **100-Year Storm**



ADDITIONAL BENEFITS

- Reduced flooding for 9,032 structures in 500-Year event
- Removed 484 structures from flooding in 500-Year

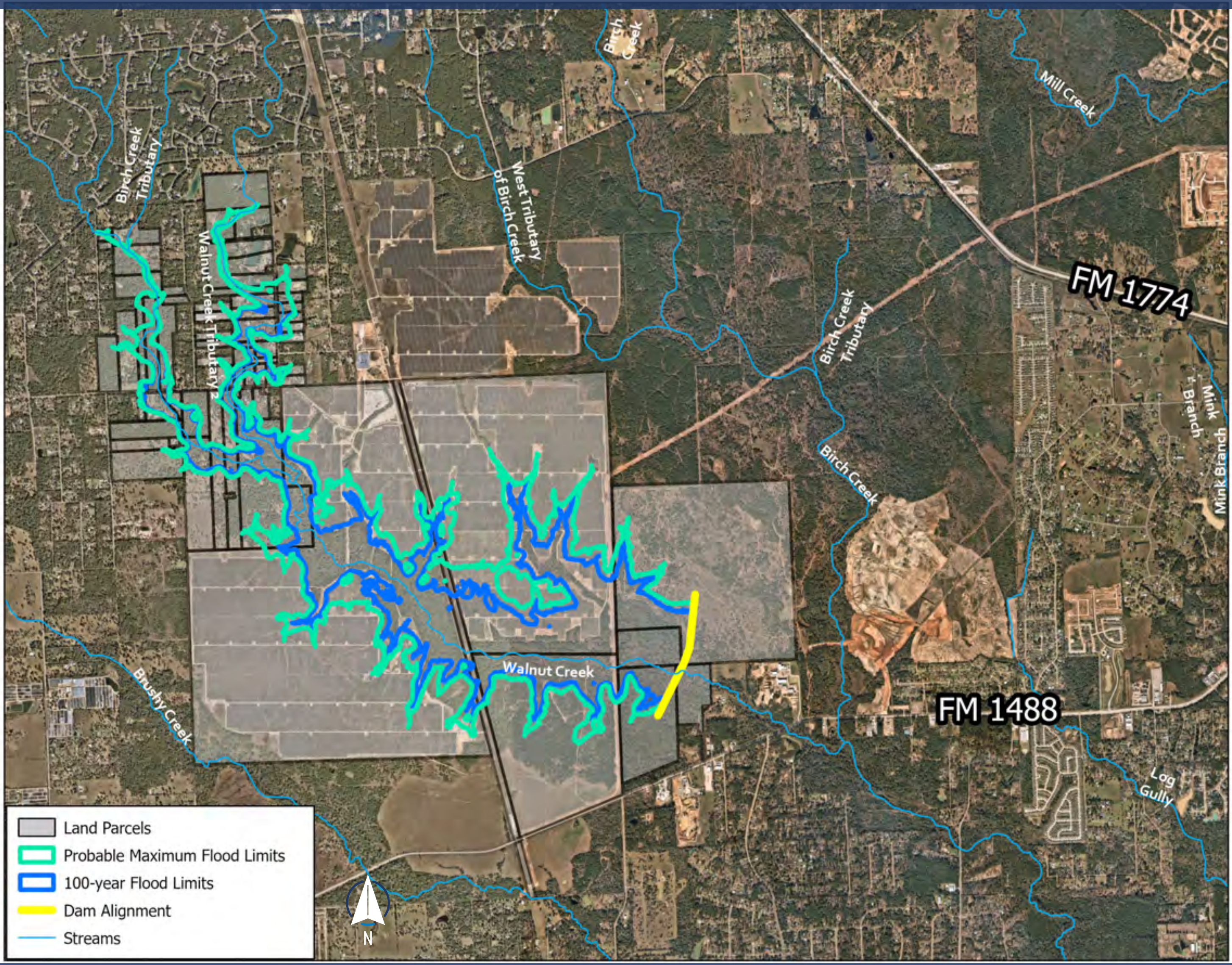
ESTIMATED COSTS

Design Cost	$12M
Environmental Cost	$2M
Construction Cost	$83M
Land Cost	$95M
TOTAL COSTS	**$193M**
TOTAL BENEFITS	**$202M**

PROJECT BENEFIT-COST RATIO: 1.05

Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-2.80
2	SH 249	-0.77
3	Kuykendahl	-0.54
4	Gosling	-0.50
5	I-45	-0.38
6	West Fork Confluences	-0.22



PROJECT DETAILS

- Type: Dry dam detention facility
- 100-year volume provided: 7,300 acre-feet
- Maximum height: 39.1 feet
- Dam Length: 3,373 feet
- Maximum inundation area: 1,370 acre
- 100-year inundation area: 940 acre
- Spillway Elevation: 254.7 feet
- Top of Dam Elevation: 263.6 feet

CHALLENGES

- Current solar farm overlaps portions of the proposed facility
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

NEXT STEPS

- **Coordinate with the solar farm for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

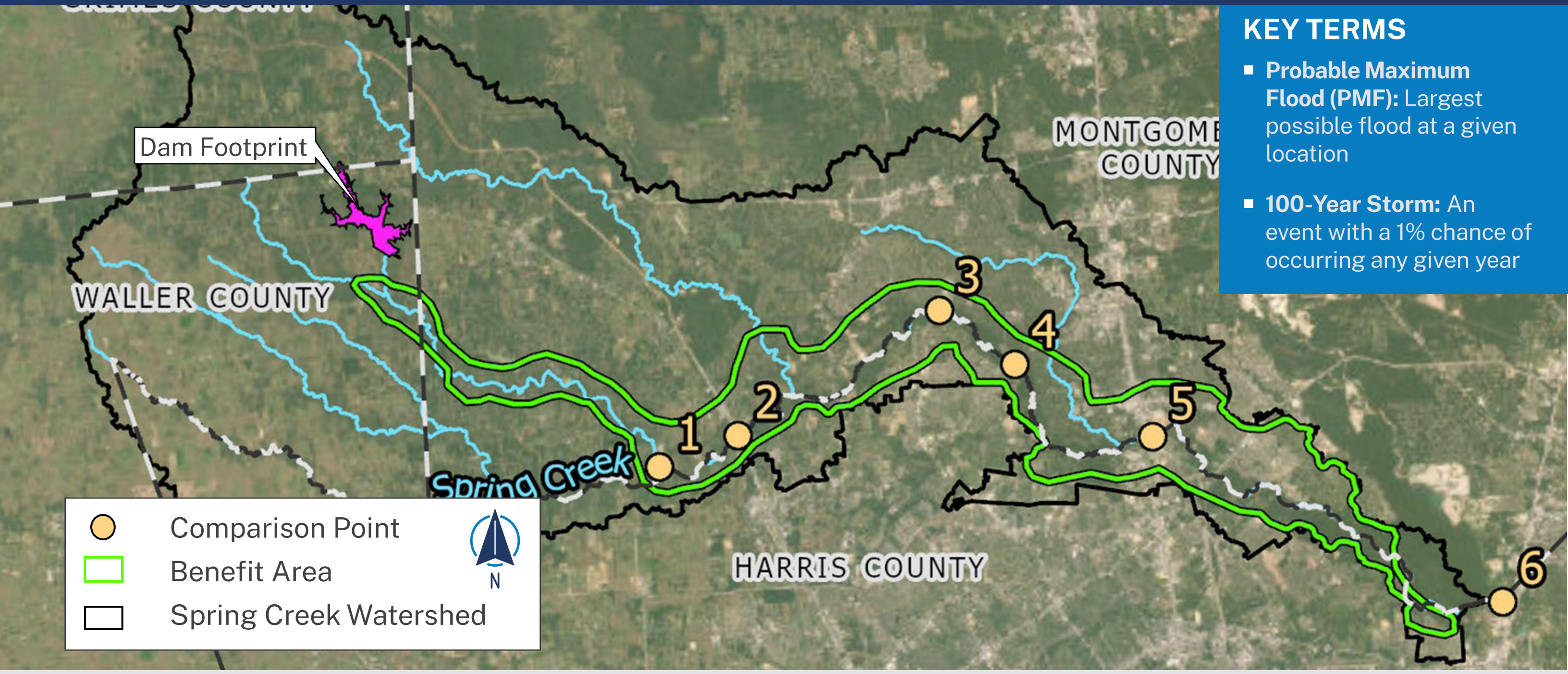
Birch Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Birch Creek

KEY TERMS

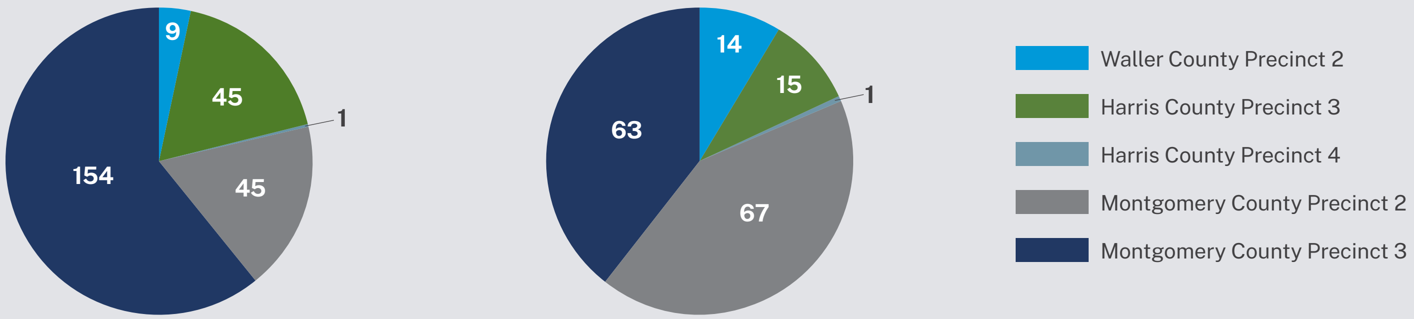
- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year



ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood **Hurricane Harvey**

Structures Anticipated to No Longer Flood **100-Year Storm**



ADDITIONAL BENEFITS

- Reduced flooding for 9,207 structures in 500-Year event
- Removed 303 structures from flooding in 500-Year

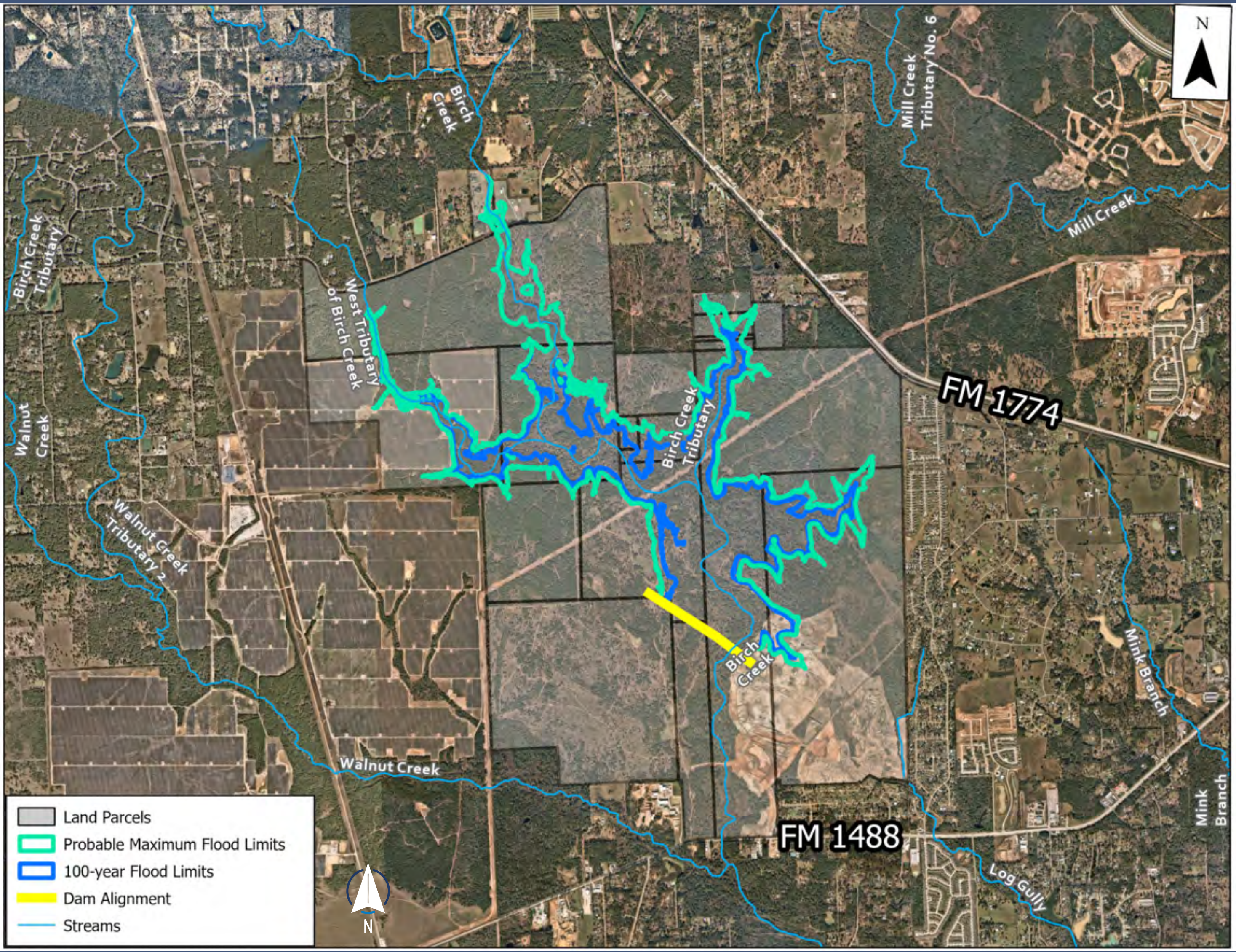
ESTIMATED COSTS

Design Cost	$10M
Environmental Cost	$1M
Construction Cost	$64M
Land Cost	$31M
TOTAL COSTS	**$105M**
TOTAL BENEFITS	**$185M**

PROJECT BENEFIT-COST RATIO: 1.76

Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-1.99
2	SH 249	-0.54
3	Kuykendahl	-0.36
4	Gosling	-0.33
5	I-45	-0.23
6	West Fork Confluences	-0.14



PROJECT DETAILS

- Type: Dry dam detention facility
- 100-year volume provided: 4,800 acre-feet
- Maximum height: 35.4 feet
- Dam Length: 3,168 feet
- Maximum inundation area: 920 acre
- 100-year inundation area: 690 acre
- Spillway Elevation: 251.2 feet
- Top of Dam Elevation: 259.1 feet

CHALLENGES

- Future Woodhaven Development overlaps portions of the proposed facility
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

NEXT STEPS

- **Coordinate with developers for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

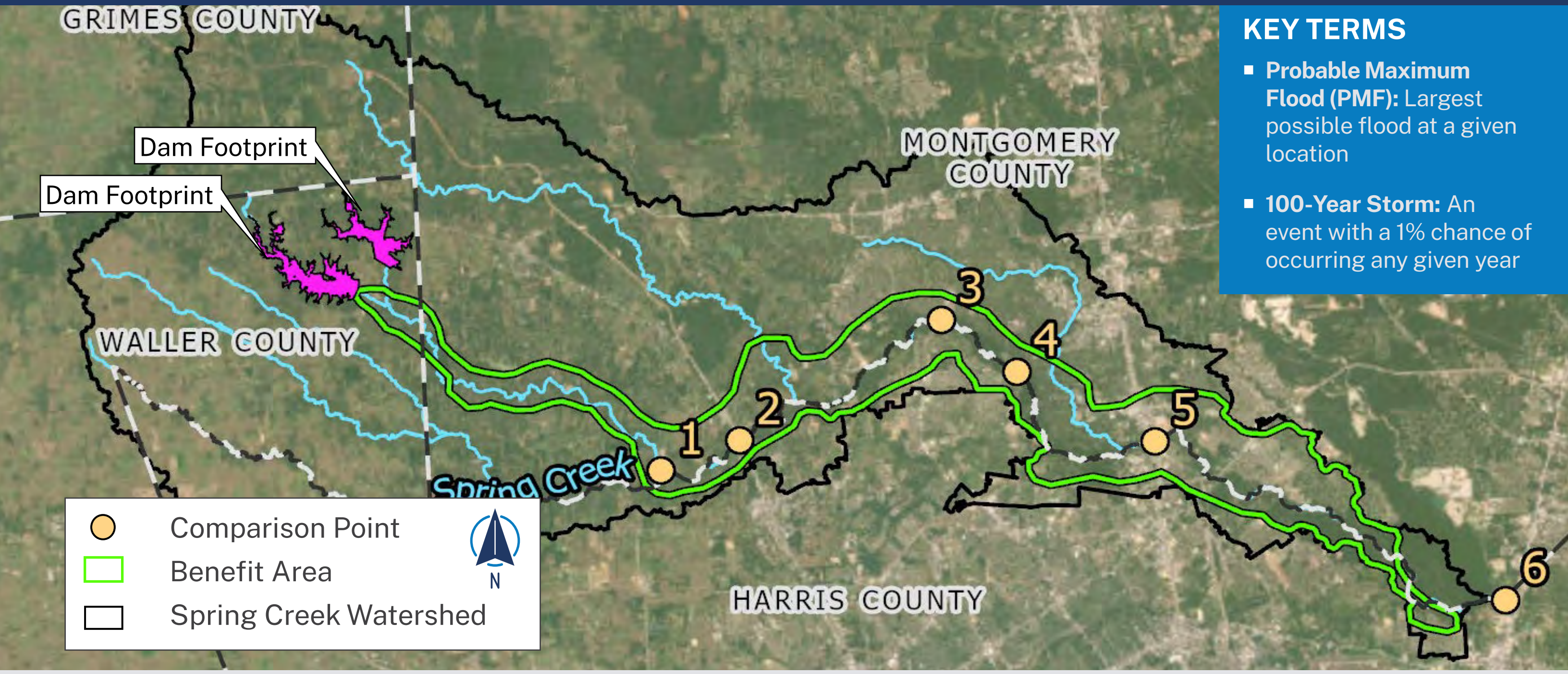
Walnut Creek & Birch Creek Detention

https://springcreekstudy.com/

A proposed dry bottom dam facility located on Walnut and Birch Creek

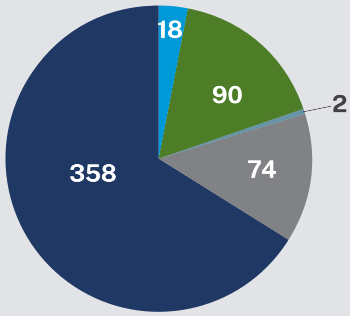
KEY TERMS

- **Probable Maximum Flood (PMF):** Largest possible flood at a given location
- **100-Year Storm:** An event with a 1% chance of occurring any given year

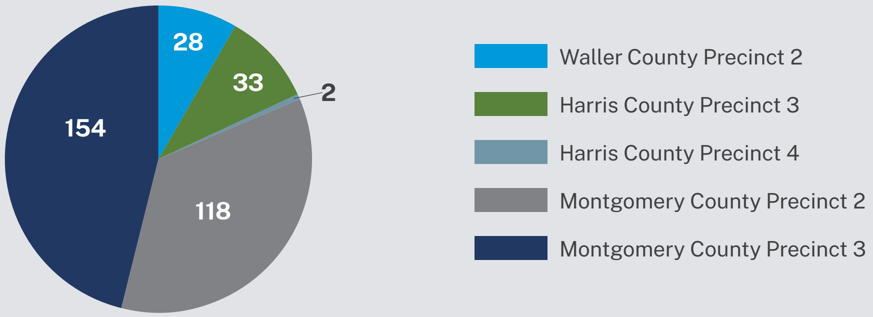


ESTIMATED BENEFITS

Structures Anticipated to No Longer Flood
Hurricane Harvey



Structures Anticipated to No Longer Flood
100-Year Storm



ADDITIONAL BENEFITS

- Reduced flooding for 8,762 structures in 500-Year event
- Removed 795 structures from flooding in 500-Year

ESTIMATED COSTS

Design Cost $22M
Environmental Cost $3M
Construction Cost $147M
Land Cost $126M

TOTAL COSTS $298M
TOTAL BENEFITS $212M

PROJECT BENEFIT-COST RATIO: 0.71

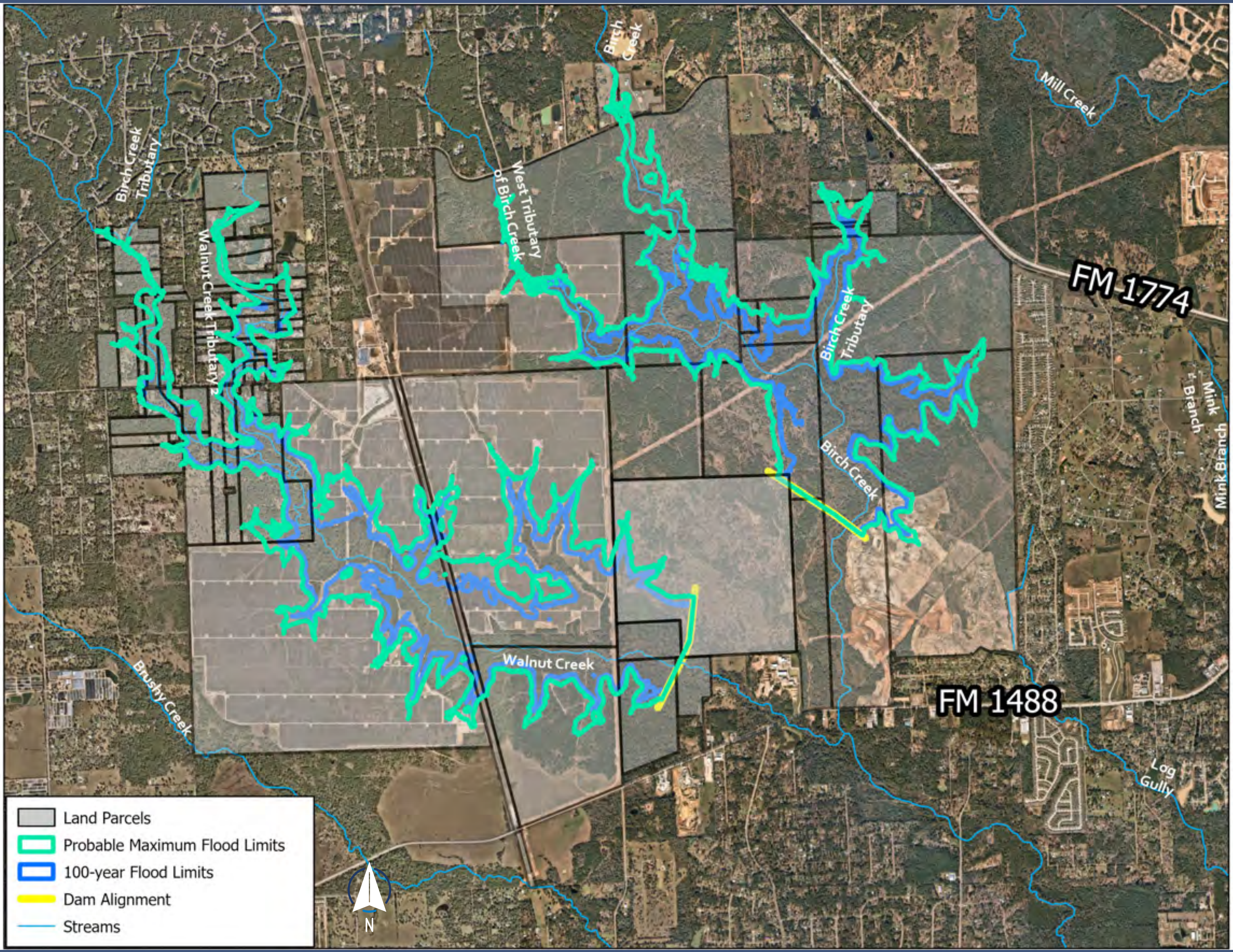
Reduction in Flood Elevations After Project Construction

Comparison Point	Location	100-YR (ft)
1	On Walnut Creek	-3.64
2	SH 249	-1.2
3	Kuykendahl	-0.88
4	Gosling	-0.82
5	I-45	-0.67
6	West Fork Confluences	-0.36

HARRIS COUNTY FLOOD CONTROL DISTRICT

Woodlands Water

SJRA SAN JACINTO RIVER AUTHORITY



PROJECT DETAILS (BIRCH / WALNUT)

- Type: Dry dam detention facility
- 100-year volume provided: 12,100 acre-feet
- Maximum height: 35.4 feet / 39.1 feet
- Dam Length: 3,168 feet / 3,373 feet
- Maximum inundation area: 920 acre / 1,370 acre
- 100-year inundation area: 690 acre / 940 acre
- Spillway Elevation: 251.2 feet / 254.7 feet
- Top of Dam Elevation: 259.1 feet / 263.6 feet

CHALLENGES

- Future Woodhaven Development and solar farm overlaps portions of the proposed facilities
- USACE coordination required due to minor environmental stream and wetland impacts
- Private land owners within project footprint

POTENTIAL PARTNERS

- Montgomery Co.
- MUDs
- SJRA
- The Woodlands
- HCFCD
- TWDB
- GLO
- FEMA
- USACE
- Future Flood Control District
- Waller County

NEXT STEPS

- **Coordinate with developers and the solar farm for potential shared project**
- **Identify potential dam owner and operator**
- **Identify funding partners**
- **Seek funding for land acquisition, design and construction**
- **Acquire land using local and other funding sources**
- **Final engineering and design of proposed facility**
- **Construction and operation of dam facility**

2 Introduction and background

Spring Creek serves as the boundary between the rapidly urbanizing counties of Montgomery, Harris, and Waller, and has a history of widespread flooding in large storm events caused by heavy rainfall and high flows within the watershed. Regional organizations act on behalf of the public to develop strategies to implement effective flood mitigation projects.

In 2020, the Harris County Flood Control District (HCFCD), Montgomery County, City of Houston, and San Jacinto River Authority (SJRA) initiated the San Jacinto Regional Watershed Master Drainage Plan (SJRWMDP). This plan was the first comprehensive regional study of the upper watershed. The primary objectives of this study were to identify existing flood risks within the upper San Jacinto River basin, including Lake Houston, and evaluate flood risk reduction alternatives on a regional scale. The study identified 25 flood mitigation projects along major streams and recommended 16 for future implementation based on their cost-effectiveness, benefits, and feasibility. The recommended projects are shown in Figure 2-1.

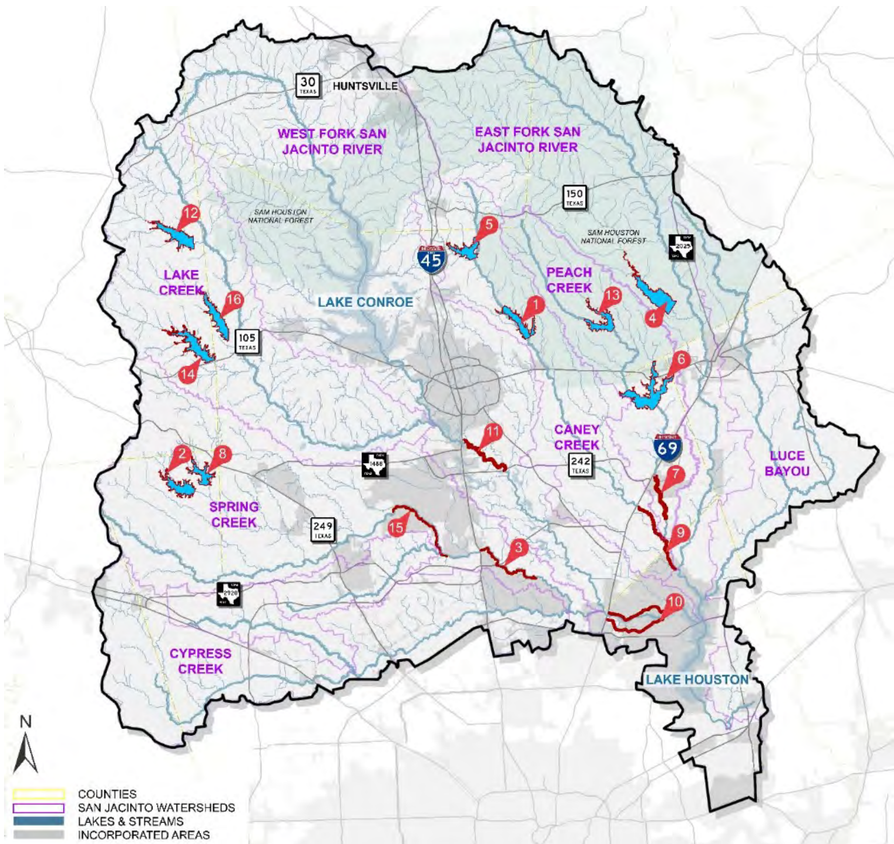


Figure 2-1 San Jacinto River Watershed Recommended Project Locations

A sub-task of the master plan involved identifying locations for regional detention within the Spring Creek watershed, leading to the recommendations for regional detention basins on Walnut and Birch Creeks. These proposed projects aim to reduce flooding along Spring Creek and provide mitigation volume for recommended future conveyance improvement projects. The recommendations for the Spring Creek watershed are shown in Figure 2-2.

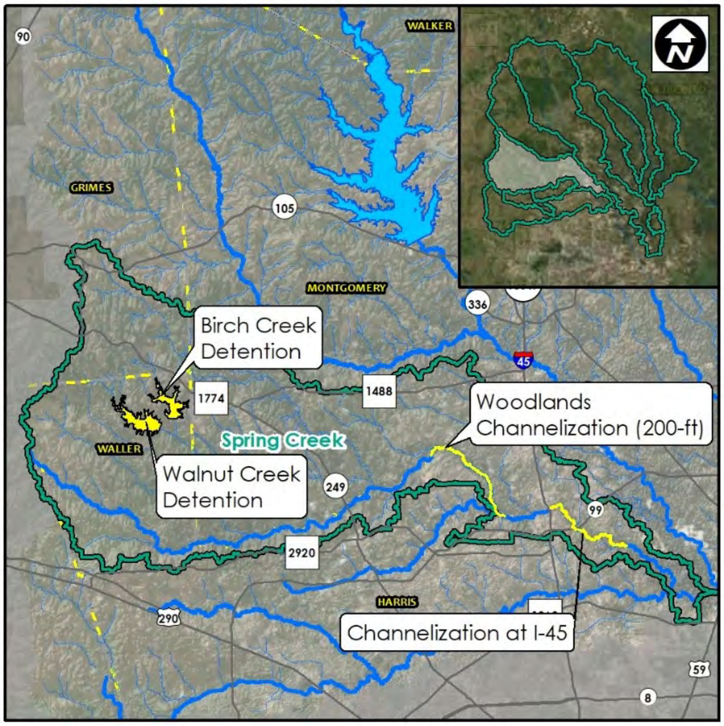


Figure 2-2 Spring Creek Watershed Recommended Project Locations (SJRWMDP)

The proposed Walnut Creek and Birch Creek detention basins were prioritized for implementation within the master drainage plan due to their substantial benefits and apparent land availability. Stakeholders within the watershed championed these projects, advancing them to the next phase of conceptual engineering by applying for and receiving a grant from the Texas Water Development Board (TWDB). This phase of study is intended to provide additional detail on the project extents, dam configuration, as well as the benefits and cost of each project.

2.1 Key stakeholders

This conceptual engineering feasibility study is funded by a grant from the Flood Infrastructure Fund (FIF), administered by the TWDB, as authorized by the 86th Texas Legislature and approved by Texas voters through a constitutional amendment in November 2019. The local partners associated with this study included:

- Harris County Flood Control District
- City of Humble
- The Woodlands Municipal Utility District No. 1
- Montgomery County Municipal Utility District No. 7
- Montgomery County Municipal Utility District No. 46
- Montgomery County Municipal Utility District No. 60
- Harris-Montgomery Counties Municipal Utility District No. 386

The San Jacinto River Authority managed and provided in-kind services towards the project. Other entities in the region within the benefit area for the projects include Montgomery County, Waller County, Harris County, City of Tomball, and the Woodlands Township. Coordination with these entities will likely be needed in future project phases for full project implementation.

2.2 Study area

Spring Creek forms a boundary between Harris County, Montgomery County, and Waller County and serves over 300 square miles of drainage area before merging with the West Fork San Jacinto River just upstream of Lake Houston. The creek retains a natural state, featuring a meandering low flow channel along with an expansive and densely vegetated floodplain and ranges between 203 and 37 feet in elevation. Spring Creek also acts as the outfall for both the Willow Creek and Cypress Creek watersheds prior to its confluence with the West Fork. Most of the drainage area lies within Montgomery County and includes four major tributaries: Threemile Creek, Walnut Creek, Mill Creek, and Panther Branch.

Figure 2-3 Spring Creek channel downstream of I-45

The watershed has experienced rapid development due to the northward expansion of the Houston metropolitan area in recent decades. The eastern portion of the watershed, primarily encompassing areas within Spring and The Woodlands, is predominantly developed. The Woodlands spans most of the Panther Branch watershed and consists mainly of residential properties. Key features include Lake Woodlands and Bear Branch Reservoir, which serve as regional detention for the township. The Magnolia area within the Mill Creek watershed is undergoing significant growth, along with the City of Tomball and its surrounding areas, which directly drain to Spring Creek. Development within the Walnut Creek, Birch Creek, and Threemile Creek watersheds remains relatively sparse but is expanding rapidly under considerable growth pressure in Waller County. Several large lot subdivisions exist along Riley Road, Joseph Road, and FM 1488.

The watershed has a documented history of flooding in recent decades, including the severe 1994 flood that recorded the highest elevation within the creek, Hurricane Harvey resulting in over 28 inches of rainfall within the watershed, and consecutive years of flooding during the Memorial Day 2015 and Tax Day 2016 events.

Figure 2-4 Spring Creek at I-45 During Hurricane Harvey

Comprehensive modeling for this study encompassed the entire watershed, including the major tributaries of Threemile Creek, Walnut Creek, Birch Creek, Mill Creek, and Panther Creek. This study was conducted within the boundary of HUC 10-1204010202. The entire study extents are illustrated in Exhibit 1 and Figure 2-5 below.

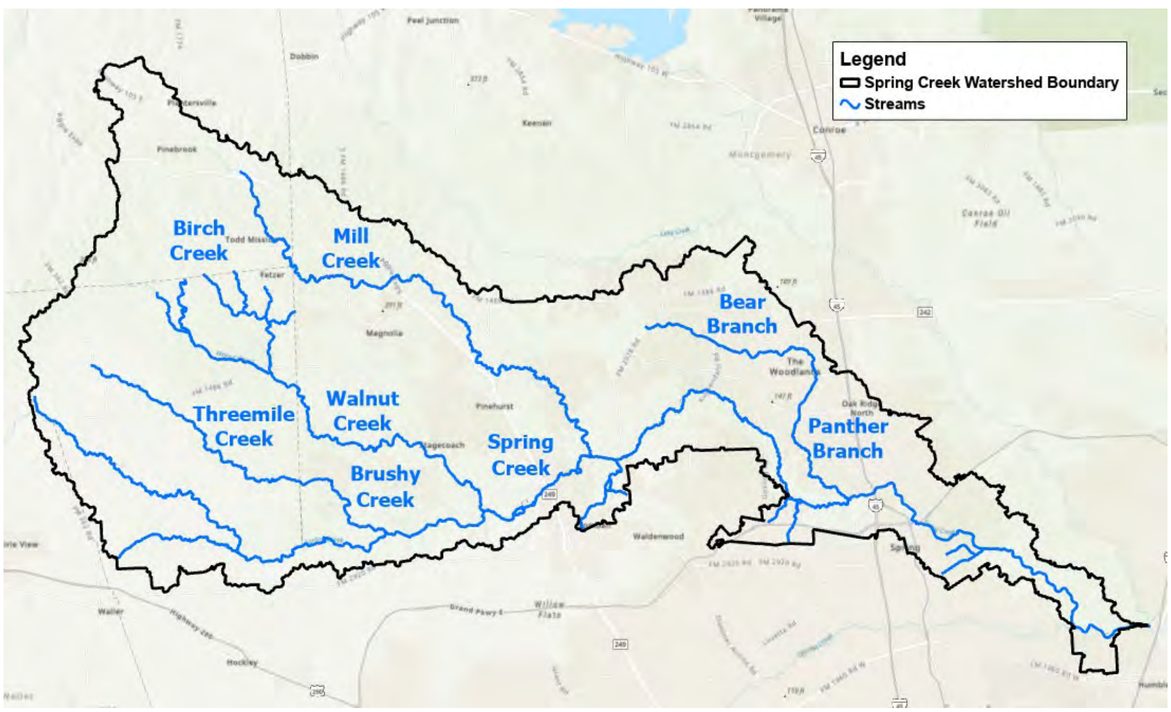


Figure 2-5: Spring Creek Watershed Overview

2.2.1 *Proposed Walnut Creek detention basin*

The Walnut Creek watershed consists of approximately 75 square miles within both Waller and Montgomery Counties before flowing into Spring Creek just upstream of SH 249. The proposed detention basin will impound floodwaters on Walnut Creek by constructing a dam located 0.6 miles upstream of FM 1488. The maximum area inundated by the detention basin from the SJRWMDP was proposed to be approximately 1,490 acres and benefited over 9,000 structures.

During the study, a large solar farm was constructed onsite that covers a portion of the proposed basin. Other land use within the basin footprint includes undeveloped land as well as rural and large residential lots. A location map for the proposed detention basin is included in Figure 2-6.

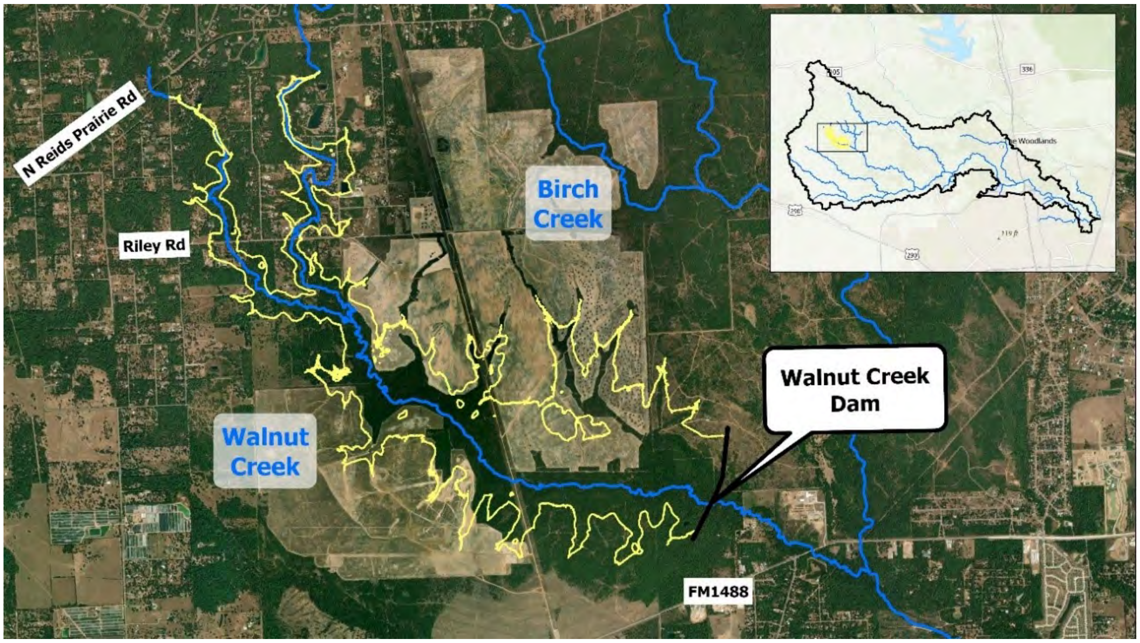


Figure 2-6: Location of Proposed Walnut Creek Detention Basin

2.2.2 Proposed Birch Creek detention basin

The Birch Creek watershed consists of approximately 15 square miles within both Waller and Grimes Counties before flowing into Walnut Creek just downstream of FM 1488. The detention basin will impound floodwaters on Birch Creek by constructing a dam located 1.2 miles upstream of FM 1488. The maximum area inundated by the detention basin from the SJRWMDP was proposed to be approximately 1,060 acres and benefited over 9,000 structures. Most of the land within the basin footprint is undeveloped or rural lots. Residential development has begun construction in portions of the study area. A location map for the proposed detention basin is included in Figure 2-7.

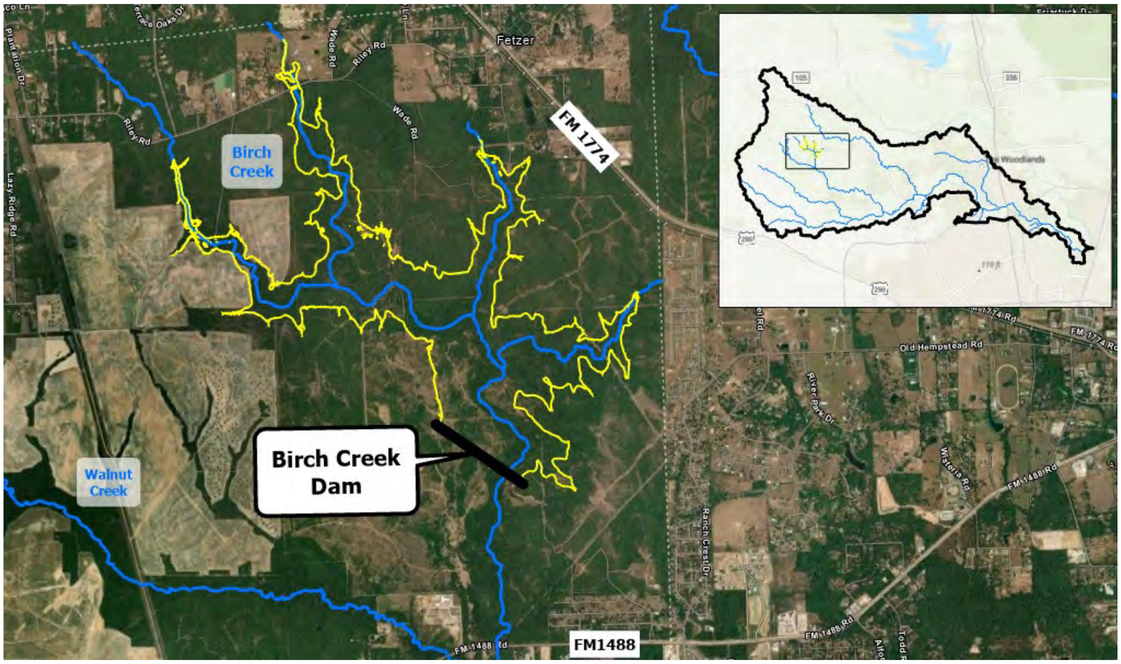


Figure 2-7: Location of Birch Creek Dam

2.3 Study goals

The objective of this study was to further assess the feasibility for each of the two sites as potential detention basins. It also aims to further identify benefits and costs to determine the most feasible and economical projects for future implementation. Specific tasks include the following:

- Performing environmental due diligence to assess any potential environmental issues with the proposed sites and adjust the recommended locations as necessary. Environmental investigations included desktop wetlands assessment, cultural resources survey, pre-application meeting with the USACE, and development of environmental mitigation costs.
- Performing a geotechnical analysis along the FM1488 right of way to obtain information regarding soil properties for the conceptual design of the dam embankment. This area was chosen due to the proximity to the sites as well as accessibility since the sites were on private land.
- Assessing the conceptual design of the dams required for the detention basins. Conceptual design included the assessment of the dam features including the alignment, embankment type, spillway configuration, and total storage.
- Developing an opinion of probable project costs for each detention basin including the embankment, spillway, land, environmental, and utility costs. Cost will also include operations and maintenance as well as financing over a 30-year period.
- Conducting a hydraulic analysis for the two detention basins to quantify the flow and water surface elevation benefits for the basins.
- Conducting a benefit cost analysis for the project utilizing the total construction and financing cost as well as all potential benefits utilizing the latest FEMA BCA toolkit.
- Conducting three public engagement meetings to present the project scope, initial layout of the proposed projects, and a final summary meeting of the findings of the project.

3 Project coordination and outreach

Coordination occurred throughout the project to engage the project stakeholders as well as receive feedback from both impacted and benefited residents. These took place in the form of workshops, project coordination, and public meetings.

3.1 Project coordination meetings

Around 15 coordination meetings occurred with the primary project partners to discuss project status and provide/gather input on the goals and product of the study. Several project workshops were held that included discussion of the updates to the hydrologic and hydraulic analysis, dam design recommendations, and potential project hurdles such as coordination with large landowners within the proposed basin footprint.

3.2 Website

Coordination with the public was performed throughout the feasibility study through an active website describing the project scope, status, and schedule as well as public meetings held during different phases of the project.

The project website (springcreekstudy.com) keeps the public informed of the overall project scope, the project schedule, initial and final findings, and study recommendations. It also provided an avenue for the public to provide input on the study and submit questions or comments. The website was updated as changes to the schedule and project status occurred.

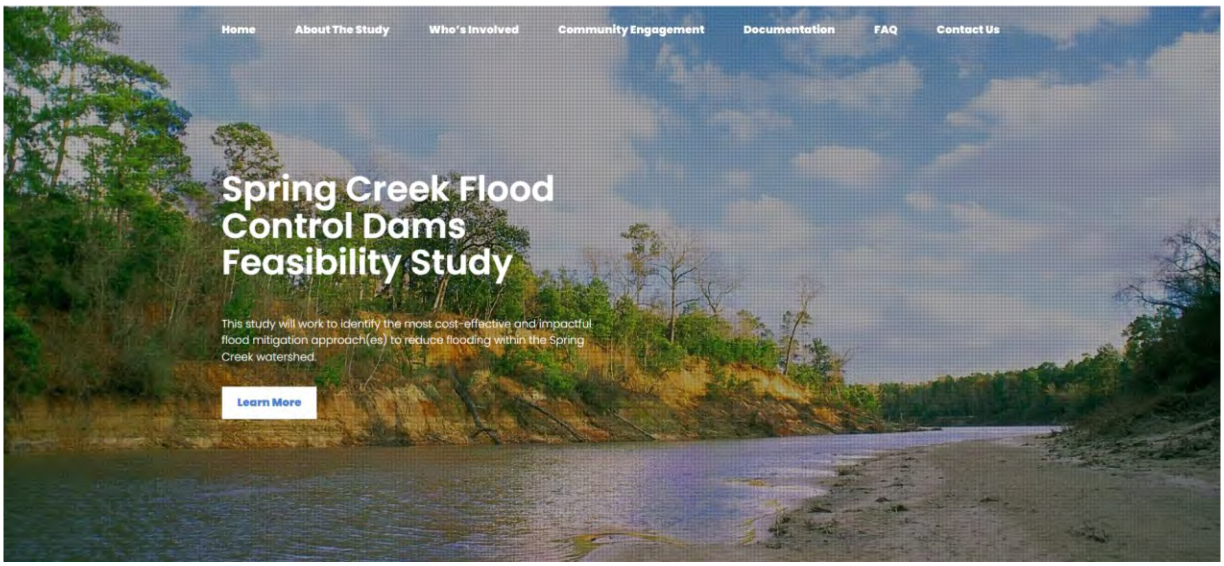


Figure 3-1 Project Website

3.3 Public meetings

The first public meeting was held on April 7, 2022, in Waller County. The meeting provided an overview of the project goals, scope of work, and background on the recommended detention basin layouts. Meeting attendees consisted primarily of local landowners that would be impacted by the project. General public comments pertained to the extents of the project in relation to the landowner's property and the need for the proposed detention basins within Waller County.

Figure 3-2 Public Meeting in Waller County (April 7, 2022)

The second public meeting was held on May 2, 2023 in The Woodlands. The meeting provided an update to the project regarding the optimization of the basin footprints, cost, and downstream benefits. The meeting was attended by landowners from the downstream areas on Spring Creek that would benefit from the project and local landowners that would be impacted by the project. Public comments included a mix of support for the facilities due to the downstream benefits and concern for the extents of the project in relation to the landowner's property. Some upstream owners were concerned about the use of their property for the detention basins.

Figure 3-3 Public Meeting in the Woodlands (May 2, 2023)

A third round of public meetings were held in April 2025. The meetings presented the findings and recommendations of the feasibility study with meetings in Waller County and The Woodlands. Attendees included both upstream and downstream residents which expressed interest in the timing of the projects, next steps, and information regarding the proposed detention basins. Exhibits were provided to residents that showed the structures that would benefit from the projects, a conceptual layout of the dam structures, and detailed figures of the inundation limits.

Public comments are included in Appendix E.

3.4 Landowner coordination

The proposed basin footprints would require acquisition of large tracts of land within Waller County. Early in the study, the SJRA reached out to the existing landowners to discuss the potential for coordination for use of the property. Conversations were held with large property holders to gage interest in providing support for the proposed projects.

4 Conceptual design

The basin configurations as proposed in the master planning effort were adjusted to account for potential soil conditions, iterations of the spillway and outlet structure, alignment of the embankment, and potential configuration of the embankment section. These considerations provided additional detail for a revised cost estimate and included conceptual schematics of the proposed dams. The full conceptual design analysis is included as Appendix B.

4.1 Alignment options

Dam alignments for the proposed dams were evaluated and optimized considering (1) the amount of soil borrow/fill required, (2) impacts to detention basin maximum storage, and (3) environmental permitting implications. The recommended alignments minimize the stream impacts outside the project site, tie into the surrounding topography, and maintain downstream flood benefits. The Walnut and Birch Creek alignment options are shown in Figure 4-1. Alternative 2 alignment was recommended for Walnut Creek as this alignment minimized the environmental stream impacts while maintaining the upstream volume. Alternative 3 for Birch Creek was recommended due to the reduction in fill material as well as the minimization of environmental stream impacts.

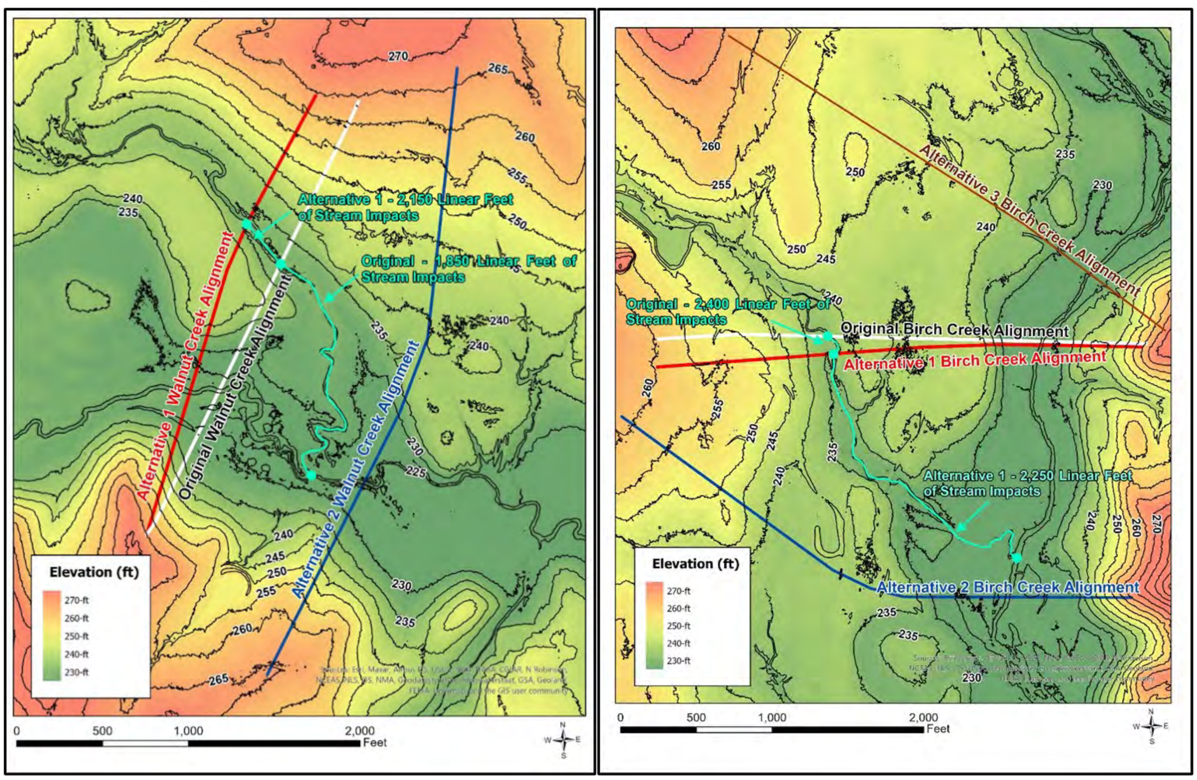


Figure 4-1 Walnut Creek (left) and Birch Creek (right) Dam Alignment Options

4.2 Hazard classification and freeboard

Based on the lidar data, the maximum capacities including all volume to the top of dam of the proposed Walnut and Birch Creek Dams are approximately 13,000 acre-feet and 9,000 acre-feet, respectively. This classifies the dams as intermediate sized dams per 30 Texas Administrative

Code (TAC) §299.13. The design flood for proposed high-hazard intermediate sized dams is interpolated from 75% to 100% of the PMF based on the maximum capacity of the dam. Assuming high-hazard classifications, 30 TAC §299.14 indicates design flood events of 83% and 80% of the Probable Maximum Flood (PMF) for the proposed Walnut and Birch Creek Dams, respectively. For simplicity, subsequent spillway design calculations assumed design flood events of 83% of the PMF for both dams.

Wave run-up heights were calculated for the proposed dams. The proposed dams will experience wave heights up to 1.5 feet with water surface elevations near the maximum water surface. As such, a 2-foot freeboard is sufficient for the proposed dams.

4.3 Spillway design

The spillway design objectives for both dams included the following:

- The spillway configuration should have appropriate freeboard during its design flood.
- Both dams should target volumes during the 1% ACE flood event to reduce discharges in Spring Creek.
- The auxiliary spillway crest elevation should be set at the peak 1% ACE flood level.
- The associated energy dissipation basin should be sized appropriately.

The proposed spillway configuration consists of a concrete structure positioned at the centerline of the stream. The concrete structure includes an ogee crested weir with a crest elevation at the 1% ACE elevation, with a single rectangular concrete conduit along the streambed. The combined concrete structure allows the ogee spillway and conduit to share a common energy dissipation basin. The conduit for each dam would detain the 1% ACE event prior to engaging the ogee weir, with the ogee weir functioning as the auxiliary spillway. Although a sharp crested weir was considered, it is less hydraulically efficient than the ogee crested weir and requires more weir length to pass the design flood. Additionally, a large single conduit (rather than multiple small conduits) was recommended to mitigate potential debris obstruction. Debris can pass more freely through the larger single conduit compared to multiple smaller conduits. An example of the ogee spillway and conduit structure configuration is shown in Figure 4-2.

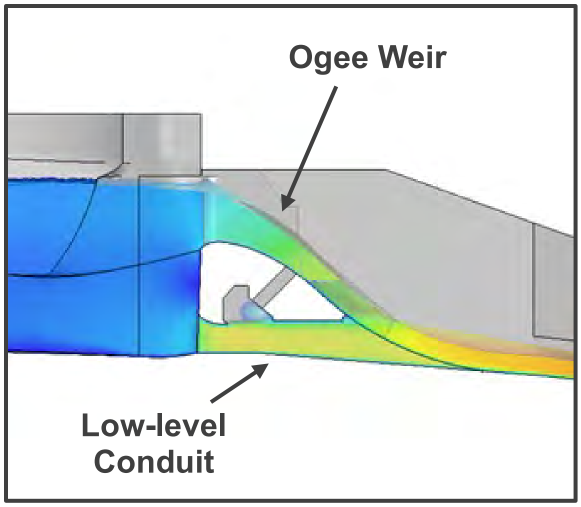


Figure 4-2 General Spillway and Conduit Configuration

The auxiliary spillway and conduit configurations at both dams were initially sized using HEC-HMS, Version 4.12 and then later confirmed as part of the overall hydrologic and hydraulic analysis. Design iterations were conducted to optimize the total required spillway length for both dams, thereby reducing the total project cost estimate. The recommended design parameters are shown in Table 4-1.

Table 4-1 Recommended Dam Hydraulic Design Configuration

Description	Walnut Creek	Birch Creek	Units
Top of Dam	263.6	259.1	ft
Peak 100 Year WSE (Water Surface Elevation)	254.7	251.2	ft-msl[1]
Peak 100 Year Discharge	2,700	2,300	cfs
PMF WSE	261.6	257.1	ft-msl
Opening Invert (also streambed)	224.5	223.7	ft-msl
Opening Size	6-ft by 17-ft	6-ft by 16-ft	Rise (ft) x Span (ft)
Ogee Spillway Control Elevation	254.7	251.2	ft-msl
Ogee Spillway Length	175	175	ft
Energy Dissipation Basin Lengths	45	35	ft

[1] Mean sea level

The energy dissipation basin configurations at both dams were designed in adherence with the Bureau of Reclamation Design of Small Dams guidance. The hydrologic and hydraulic conditions at both dams allow for the adoption of the Type III basin, shown in Figure 4-3. The Type III basin uses chute blocks, impact baffle blocks, and an end sill to shorten the jump length and dissipate the high-velocity flow within a shortened basin length. Shortening the hydraulic jump length means that flow transitions from supercritical to subcritical flow over a shorter longitudinal distance, in effect allowing for a shorter and smaller concrete energy dissipation basin. The basin relies on dissipation of energy by the impact blocks and on turbulence of the jump for its effectiveness. The Type III basin is recommended to shorten the jump length and, consequently, the footprint of the energy dissipation basin, thereby reducing the total project cost estimate.

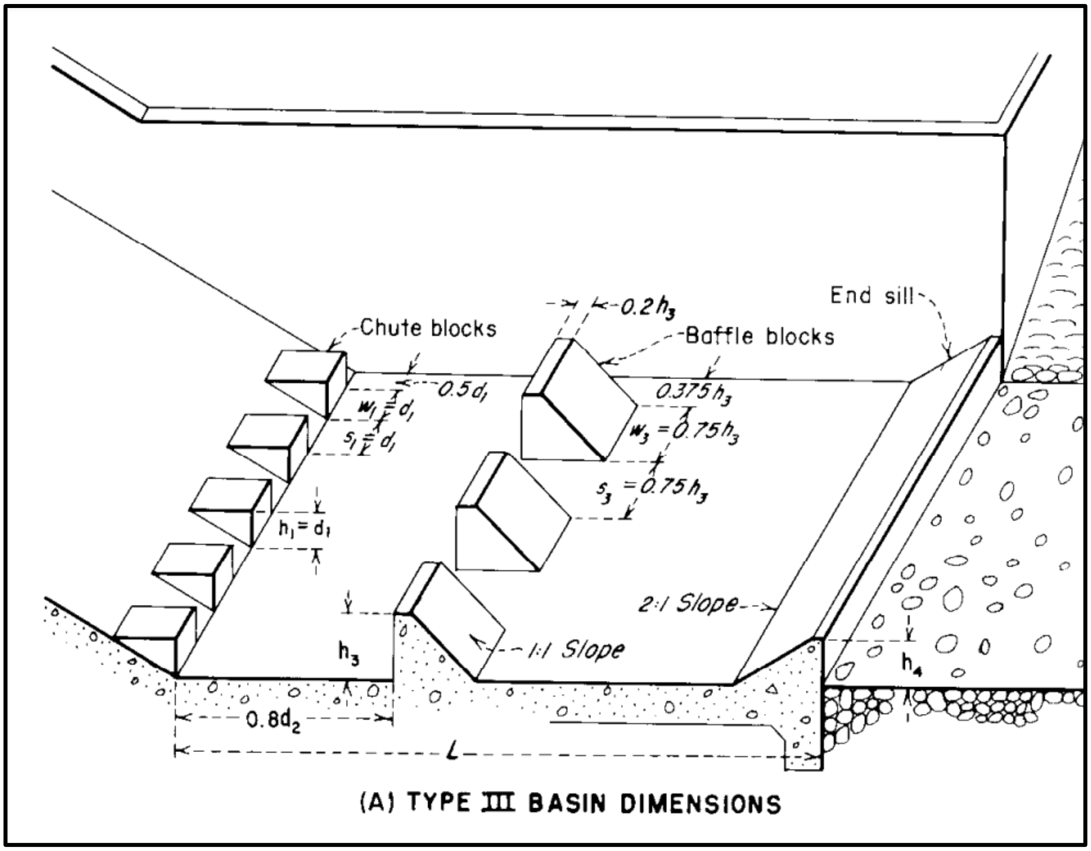


Figure 4-3 General Energy Dissipation Basin Configuration

Notably, five assumptions were used in the spillway design. They should be considered within future calculations and recommendations:

- Item 1: The analysis assumes fixed tailwater levels at the peak 100-year event during the 100-year routing event and at the peak 500-year event during the PMF event, rather than a discharge-tailwater curve. Future hydrologic analysis should be conducted to develop detailed flow-tailwater rating curves, which could reduce the sizes of the conduits required at both dams.
- Item 2: A constant ogee weir coefficient of 3.94 is used for all heads.
- Item 3: Current assumptions are conservative, using the 500-year event tailwater level for the energy dissipation basin calculations.
- Item 4: Erosion protection calculations downstream of the energy dissipation basin were not conducted.
- Item 5: Hydrologic and hydraulic calculations are needed to size a potential pilot channel upstream and downstream of the concrete opening.

The assumptions lean conservative for the purpose of this conceptual analysis. As such, future design calculations may reduce spillway sizes and/or shorten energy dissipation basin lengths. Recommended future calculations include rock riprap erosion protection calculations downstream of the energy dissipation basin, pilot channel sizing, and more detailed hydraulic modeling of the spillway configuration.

4.4 Geotechnical investigation

To support the design of the dams, field exploration and laboratory testing was performed. As the sites were inaccessible at the time of exploration, four standard penetration test borings were performed in a publicly accessible area approximately 1 mile downstream of the project site along FM 1488. Based on this investigation, it was found that the subsurface soils comprised of silty sands (SM), sandy lean clays (CL), clayey sands (SC), poorly graded sand with silt (SP-SM), sandy fat clay (CH), silty clay with sand (CL-ML), and silty clayey sand (SC-SM). Additional soil parameters, including total unit weight, soil permeability, undrained strength, drained strength, and soil dispersity, were obtained to support the embankment design. Generally, the soils are of medium plasticity and indicate a potential for dispersive behavior. The soils have relatively low permeability between 10^{-10} and 10^{-9} ft/s and are generally acceptable as fill material of 20% to 40% fines. Since physical access to the sites was not allowed, the borings were not taken in the project site vicinity.

4.5 Embankment design

Three embankment geometry concepts were considered for the project sites and have been analyzed for seepage and stability. The differences between each concept were based on type of seepage control and embankment internal zonation. The external configuration of the dam is the same for all three alternative options.

The general configurations of the dams are as follows. The upstream and downstream side slopes are 3.5:1 H:V and 3:1 H:V, respectively. A 3-foot-thick riprap layer was considered for the upstream face wave protection, and the downstream slope will be vegetated with grass. Both slope faces were considered to have 20 foot wide top-of-bench stability berms. The berms are flat areas along the embankment slopes that improve stability and reduce erosion. A gravel vehicular road, which will be located on the crest of the embankment and may include a vehicular turnaround on the crest , is anticipated to be used for dam operations, inspections, and maintenance.

The following are key features considered for the three alternative embankments, based on analyses completed to date:

- Upstream and downstream berms are included for all three alternative embankments for structural stability and to accommodate anticipated frequent drawdown on upstream slope face.
- Filter and drainage system is included in all three alternative embankments for erosion control based on the assumption that on-site borrow sources may exhibit potential for dispersion.
- Foundation seepage barriers are included in all three alternatives for embankment under-seepage control based on the assumption that pervious foundation materials will be encountered.
- An impervious core is included in Alternative 2 for seepage control based on the assumption that pervious on-situ borrow sources may be used as embankment shell fills.

The following three embankments were considered:

- Alternative 1 embankment geometry concept consists of a homogenous material of an acceptable permeability, a cutoff trench and sheet pile wall, and a chimney filter and blanket drain.
- Alternative 2 embankment geometry adds an impervious clay core with a filter aligned on the downstream face of the core. The foundation treatment against excessive seepage is similar to those of Alternative 1.
- Alternative 3 embankment geometry is similar to Alternative 1, but with a soil-bentonite cutoff wall foundation seepage barrier in place of the cutoff trench and sheet pile wall.

A schematic of the recommended Alternative 1 embankment configuration is presented as Figure 4-4. The other configurations are provided in Appendix B.

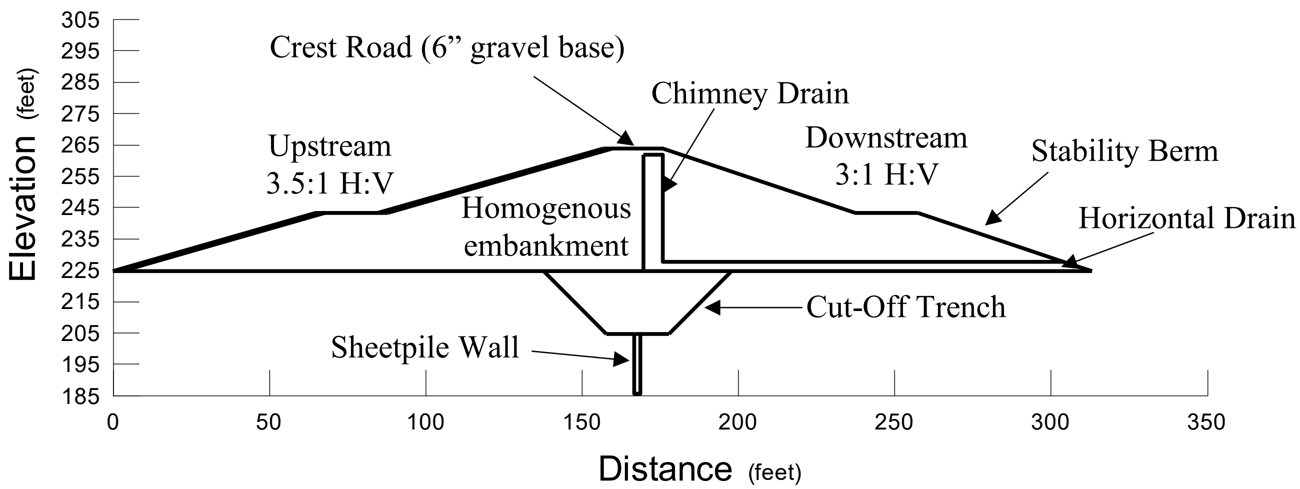


Figure 4-4 Alternative 1 Embankment Configuration

A summary of the design values for the alternative embankment sections, based on the seepage and slope stability analyses, is presented as Table 4-2. Plans and profiles of the sections are presented in Appendix B. It is anticipated that the embankment alternative selected for advanced design will be further developed during design advancement based on site-specific geotechnical investigations to incorporate settlement and other required analyses for the embankment sections.

Table 4-2 Key Embankment Features

Description	Walnut Creek	Birch Creek	Units
Feature	Walnut Creek Embankment Section Design Value	Birch Creek Embankment Section Design Value	
Length	3,373	3,168	feet
Maximum Height	39.1	35.4	feet
Design Crest Width	16	16	feet
Design Crest Elevation[1]	263.6	259.1	feet
Typical Upstream Slope	3.5H:1V	3.5H:1V	—
Typical Downstream Slope	3H:1V	3H:1V	—

[1]Elevation does not include allowance for settlement; settlement will be evaluated during design advancement and added to the design crest elevation. The US Bureau of Reclamation recommends 1% of maximum embankment height for preliminary camber design to account for potential settlement of the embankment fill.

Static deformation analysis (settlement, cracking) will be performed during the detailed design phase. The anticipated quantities of required import fill for Alternative 2 and specialized construction for Alternative 3 may present increased construction cost and permitting issues and construction complexities for the project. Due to the primary function of the project as dry detention dams, a zoned embankment with an impervious core (Alternative 2) may not be economical or critical to the safe operation of the dam.

Based on the preliminary site information and evaluation, Alternative 1, which consists of a homogenous material of an acceptable permeability, a cutoff trench and sheet pile wall, and a chimney filter and blanket drain, was recommended to be best suited among the three alternatives presented.

5 Environmental due diligence

A desktop assessment was conducted to identify environmental considerations for the next design phase. These include delineating potential waters of the U.S. (WOTUS), assessing threatened and endangered species (T&E), evaluating aquatic resources, and reviewing cultural resources. The full environmental findings and recommendations are included as Appendix A.

5.1 Waters of the United States

Halff conducted a desktop wetland assessment to identify the presence, location, and extent of potential waters of the U.S. within the project area and any associated potential environmental permitting requirements. According to the U.S. Army Corps of Engineers (USACE), waters of the U.S. include territorial seas, tidal waters, traditional navigable waters, interstate waters, and the adjacent, contributing, or impoundments of these waterbodies (e.g., rivers, creeks, streams, lakes, reservoirs). Special aquatic sites associated with these waterbodies are also considered waters of the U.S. and include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes.

Wetlands are typically the most common special aquatic resources present and are defined by the USACE as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (40 Code of Federal Regulations [CFR] 230.3(t)). Based on this definition, for an area to be considered a wetland it must possess the following three parameters under normal circumstances: 1) a predominance of plants adapted to live in water or saturated soils (i.e., hydrophytic vegetation), 2) soil characteristics of frequent saturation (i.e., hydric soils), and 3) the presence of hydrology showing evidence of regular flooding or ponding (i.e., wetland hydrology).

These cannot be accurately assessed without field work; however, publicly available data may provide a reasonable estimate of aquatic resources. Halff reviewed historic aerial photography (Google Earth 2024), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) data (USFWS 2024), U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) data (USGS 2024), USGS topographic quadrangles (USGS 2023), and the most recent Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) data (FEMA 2019). The project area is defined by the parcels containing the sub-watersheds of Birch Creek and Walnut Creek, focusing primarily on the areas that may be inundated during flood events.

5.1.1 Walnut Creek

NWI wetlands intersecting the proposed Walnut Creek dam alignment include two PFO1A (temporarily flooded forested wetlands), one PFO1C (seasonally flooded forested wetland), and one PSS1C (seasonally flooded scrub-shrub wetlands) in addition to two streams (Walnut Creek and an unnamed tributary) identified in the NHD. The current dam alignment has a maximum length of 3,373 feet and would require placement of fill over approximately 12.0 acres (including 3.5 acres of wetlands), excluding access roads, laydown areas, or other appurtenances. In addition to the direct construction impacts, the planned flood detention reservoir on Walnut Creek may potentially cause temporary flooding of approximately 49.3 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. Flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404 of the Clean Water Act (Section 404). Furthermore, any additional flooded areas upstream are unlikely to be inundated or saturated for a hydroperiod sufficient to result in creating additional jurisdictional aquatic features. Areas downstream of the dam may experience reduced hydrologic input, which may cause reduced aquatic functions.

According to the NHD and NWI, the proposed dam alignment will potentially impact an approximately 295-foot stream segment of Walnut Creek. Collectively, the Walnut Creek dam watershed includes approximately 15,296 linear feet of streams within the 0.2% ACE floodplain upstream of the proposed dam. Assuming that the project would not lead to permanent inundation, the stream reaches upstream of the dam would not be impacted.

5.1.2 Birch Creek

Potentially impacted NWI wetlands associated with the proposed dam alignment on Birch Creek include one PFO1A and one PFO1C. The current dam alignment has a maximum length of 3,168 feet and would require placement of fill over approximately 8.7 acres (including 0.9 acre of wetlands), excluding access roads, laydown areas, or other appurtenances. The planned flood detention basin on Birch Creek may potentially cause temporary flooding of approximately 50.7 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. As with Walnut Creek, flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404. Furthermore, any additional flooded areas upstream are unlikely to be inundated or saturated for a hydroperiod sufficient to result in creating additional jurisdictional aquatic features. As with the Walnut Creek dam, areas downstream of the dam may experience reduced hydrologic input, which may cause reduced aquatic functions.

The NHD and NWI identify Birch Creek as the lone waterbody that would be directly impacted by the dam's 267-foot crossing of the stream reach. Collectively, the Birch Creek detention basin watershed includes approximately 12,764 linear feet of streams within 0.2% ACE floodplain upstream of the proposed dam. Assuming that the project would not lead to permanent inundation, the stream reaches upstream of the dam would not be impacted.

5.2 Protected Species Assessment

Halff conducted a desktop assessment of federally and state protected species (i.e., threatened and endangered species, migratory birds, and bald and golden eagle) for the proposed project to determine which protected species are associated with the potential work areas and identify what permitting tasks may be required for the project. Halff drew data from the following resources:

- Mussels of Texas Project Database
- National Hydrography Dataset (NHD)
- National Wetland Inventory (NWI)
- TPWD Ecological Mapping Systems of Texas (EMST) and Rare, Threatened, and Endangered Species of Texas (RTEST) list
- USFWS IPaC and Environmental Conservation Online System (ECOS)
- United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Web Soil Survey

- U.S. Geological Survey (USGS) Texas Geologic Database

Habitat conditions within the study area were characterized using the Texas Geologic Map Database, Web Soil Survey, and EMST. The IPaC provides information on federally managed resources to streamline the environmental review process by generating an official species list based on the location in which the project occurs. The official species list identifies federally listed threatened and endangered species, proposed to be listed species, candidate species, and designated critical habitat that may occur within the boundary of the study area and/or may be affected by the project. This information is used to evaluate suitable habitat within the study area and potential environmental impacts that may result from the proposed project. Additionally, the RTEST by County generates information regarding potential occurrence of federally and state protected species and Species of Greatest Conservation Need (SGCN) on a county level.

The above resources identify listed species whose known ranges could extend into the study area, provide requisite habitat descriptions, and identify if USFWS-designated critical habitat exists within the vicinity. Potential for the proposed project to affect species listed by the USFWS under the ESA was evaluated by publicly available data compared to the study area's habitat conditions and project plans.

Based on our desktop assessment of the study area, publicly available data, and suitable habitat descriptions, USFWS identifies five species that are listed as threatened, endangered, proposed to be listed, or candidate species that may occur within the study area. TPWD's RTEST provides a more liberal species assessment that includes the potential for eleven federally protected species in addition to nineteen state listed species. In addition, several migratory birds were identified within the project area.

5.3 Permitting tasks

To determine permitting needs, formal field services including wetland delineation, threatened and endangered species assessment, aquatic resource functional assessment, cultural resource assessment, and environmental site assessment are necessary in future design phases. Wetland delineation will quantify aquatic features and identify what USACE permits are necessary. Assuming that impacts to aquatic resources are not negligible, the aquatic resource assessments calculate functional values for stream and wetland impacts requiring compensatory mitigation under the USACE permit. Functional assessments are calculated based on the aquatic resource's pre- and post-construction conditions to determine the degree to which ecological functions will be degraded by the project. The threatened and endangered species assessment will evaluate potential impacts to protected species and identify methods for mitigating take to the species. The cultural resource assessments will review historic properties and coordinate those findings with the appropriate state and federal agencies. Finally, environmental site assessments will ensure the project does not result in CERCLA liabilities that lead to ongoing concerns for the properties.

Each of these permitting tasks is integral to ensuring the project's compliance with federal, state, and local environmental regulations. Detailed field assessments provide the necessary data to inform the permitting process, ensuring that environmental impacts are accurately quantified and appropriately mitigated. These reports also facilitate communication with regulatory agencies and stakeholders.

5.4 Federal permitting

Based on preliminary discussions with USACE Galveston District staff, the project's scope and potential impacts to waters of the U.S. will require a CWA Section 404 permit and an Environmental Assessment (EA). The EA is a National Environmental Policy Act (NEPA) document that examines the purpose, need, and environmental outcomes of the project to determine whether a full Environmental Impact Statement (EIS) is necessary. The EA will provide a comprehensive analysis of the proposed project, exploring various alternatives and their potential environmental impacts. This process ensures that all feasible mitigation measures are considered and that stakeholders are informed about the project's environmental footprint with the goal of balancing development needs and environmental stewardship.

Approval of an EA would generally be expected to have an approximately 12 to 18-month timeline. Therefore, an EA might extend the typical timeline of a general Section 404 permit by up to 6 months. If a nationwide Section 404 permit is appropriate for the project, the EA might extend the federal permitting process at 6 to 12 months beyond what is typical. Both of these anticipated timelines are initiated at USACE receiving an administratively complete permit application that includes all necessary support documents.

Considering that there are no plans to acquire additional water rights or perform basin excavation, coordination between USACE and Texas agencies (i.e., TCEQ, TPWD) will likely be the extent of state environmental permitting.

Overall, the environmental due diligence process is designed to identify, assess, and mitigate potential environmental impacts of the project. This ensures compliance with regulatory requirements while protecting valuable natural resources.

6 Probable project cost

The project cost analysis included developing Class 4 Opinion of Probable Construction Cost (OPCC) estimates for the detention basins, estimating land costs, screening utilities, and assuming relocation or demolition of infrastructure and buildings. The task also included estimating environmental mitigation costs, annual operations, maintenance, and financing costs over 30 years, plus an additional 20 years without financing. The full cost analysis is included as Appendix C.

6.1 Construction cost

The cost estimate totals for both the Walnut Creek and Birch Creek detention basins are summarized in Table 6-1 and Table 6-2 to include all labor, materials and equipment reflecting the current scope of work as defined by the received documents detailed in Basis of Estimate Section of the Cost Analysis Appendix. The estimates reflect the preliminary nature of the projects, and costs have been derived using a unit cost estimating approach. The cost estimates include a contingency markup based on unknown project site conditions.

Table 6-1 Walnut Creek Construction Cost Estimate Summary (cost rounded)

Description	Cost Estimate
Mobilization	$4,465,200
Demolition and Temporary Measures	$3,419,000
Embankment	$29,333,850
Outlet	$10,970,775
Site Stabilization	$12,091,130
Construction Cost Subtotal	$60,279,955
Total Construction Cost[1]	**$82,884,938**

Table 6-2 Birch Creek Construction Cost Estimate Summary (cost rounded)

Description	Cost Estimate
Mobilization	$3,450,200
Demolition and Temporary Measures	$3,169,500
Embankment	$20,934,950
Outlet	$8,600,450
Site Stabilization	$10,422,100
Construction Cost Subtotal	$46,577,200
Total Construction Cost[1]	**$64,043,650**

[1]Includes 35% contingency and 2.5% for bond and insurance

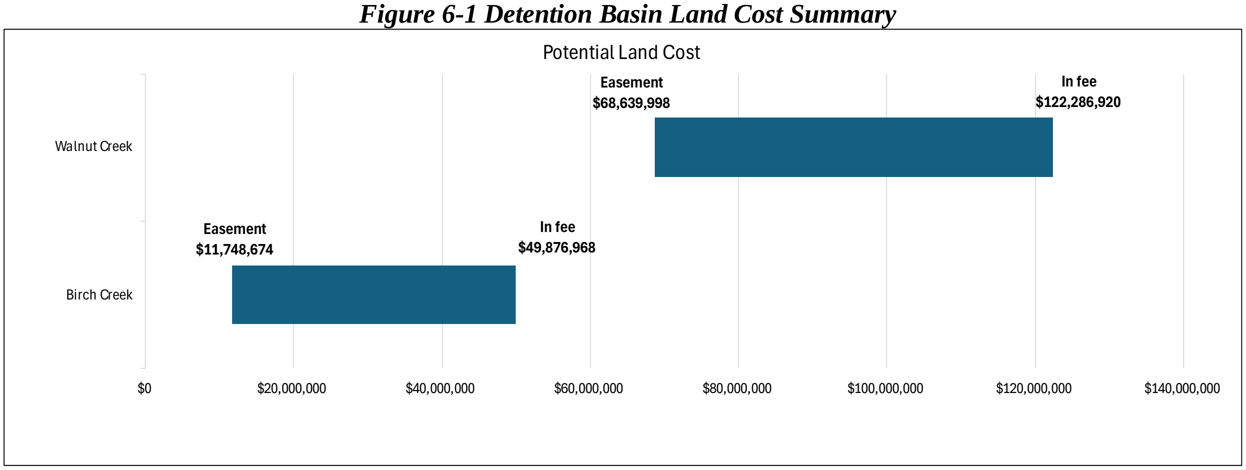
6.2 Land cost

The estimation of land costs for the proposed detention basins on Birch and Walnut Creek involves several key considerations, including land acquisition, purchase types, existing land use, roadway access, and future land use. These factors contribute to the overall costs, which have been evaluated to ensure accurate budgeting for the projects.

For the Walnut Creek detention basin the land acquisition extends up to 1,370 acres, impacting 72 tracts, some of the land may include relocating or retrofitting 880 acres of solar panels costing up to $50 million in addition to land purchases for additional land and relocation of the solar panels. For the Birch Creek detention basin the land acquisition extends up to 920 acres, impacting 19 tracts.

Potential costs for each project will vary depending on individual negotiations with property owners and whether the acquisition will be in fee or as an easement. The range of potential land costs are summarized in Figure 6-1 below.

Figure 6-1 Detention Basin Land Cost Summary



6.3 Utility conflicts and relocations cost

The site review confirmed no utility conflicts with the proposed project, based on the best available data, including the Texas Railroad Commission web viewer. Two large natural gas pipelines cross the site but do not conflict with the proposed alignments. Gas line relocation costs are not included in the construction cost estimate, but if needed, it would be about $3 million per mile per line. Minor overhead utility adjustments may be required at the construction entrance, with costs included in the mobilization estimate. No other utility conflicts were identified, though further coordination with utility providers may be needed during final design and construction.

6.4 Environmental mitigation cost

The Walnut Creek project involves constructing an approximately 3,373-foot-long dam with an approximately 12.0-acre footprint, using fill material from two nearby upland borrow pits. Additionally, it involves construction of approximately 6,160 feet of road improvements and an 17.2-acre temporary construction area. Similarly, the Birch Creek project features an approximately 3,168-foot-long dam with an approximately 8.7-acre footprint, using fill from a 53-acre borrow pit, and includes 7,410 feet of road improvements and the same temporary construction area as that proposed for the Walnut Creek project.

Direct aquatic impacts for the Walnut Creek dam project include 3.5 acres of wetlands and 295 feet of streams. Likewise, the Birch Creek dam project's impacts include 0.9 acre of wetlands and 267 feet of streams. Projected aquatic resource mitigation costs for Walnut Creek may be as much as $2,290,500 for wetlands and streams. Similarly, projected aquatic resource mitigation costs for Birch Creek may be as much $875,700 for wetlands and streams. Considering that there are abundant credits in the area, these estimates are based on primary service area prices. However, should there be insufficient credits at the time of construction, the costs of compensatory aquatic mitigation may increase by 50% or more.

6.5 Total project cost

The total cost to construct each detention basin is influenced by land and easement acquisitions, utility relocations, and environmental requirements. The primary cost driver is the lack of site-specific geotechnical information, which affects assumptions about subsurface conditions, seepage control design, foundation design, and groundwater levels. Annual maintenance costs for dry detention basins are estimated to be approximately 2-5% of the initial construction cost. For this cost analysis, maintenance was assumed to be approximately 3.4%. This percentage accounts for routine activities such as inspections, vegetation management, and minor repairs. Non-routine maintenance, like sediment removal or significant structural repairs, will incur additional costs and should be budgeted for separately.

The total costs for each dam are shown in Table 6-3.

Table 6-3 Detention Basin Total Cost

	Walnut Creek	Birch Creek
Construction	$82,884,938	$64,043,650
Engineering[1]	$12,432,740	$9,606,547
Land Acquisition[2]	$95,463,459	$30,812,821
Environmental	$2,290,500	$875,700
Utilities	$0	$0
Total	**$193,071,637**	**$105,338,718**
Annual Maintenance	$2,800,000	$2,100,000

[1] Engineering including geotechnical, survey, design, and construction management is assumed to be 15% of the total construction cost
[2] The 50% mark of the land cost range was used for the total cost estimate

The purpose of this lifecycle cost estimate is to assess the full financial commitment associated with the two projects, including both construction and long-term maintenance costs. The analysis calculates total annual costs over a 50-year project life, which includes 30 years of O&M plus debt service followed by 20 years of continued operations and maintenance. Each project is evaluated independently with its own financing structure and O&M obligations. The results provide a clear, long-range financial outlook to support decision-making and resource planning.

Each project is assumed to be financed independently using a 30-year term loan at a fixed interest rate of 4.00%, which aligns with recent rates available to public entities (e.g., AA-rated municipal bonds). Level debt service is assumed, meaning the same payment is made each year, simplifying long-term financial planning. This structure assumes no refinancing, variable rates, or early payoff. All cost figures are presented in 2025 dollars, with no inflation applied. The debt service amounts are calculated using a standard amortization formula, annual payments over the loan period.

Table 6-4 Project Financing

	Walnut Creek	**Birch Creek**
Construction	**$193,071,637**	**$105,338,718**
Annual Maintenance	$2,800,000	$2,100,000
Debt Service Factor	0.05783	0.05783
Annual Debt Service	$11,165,000	$6,092,000
30-Year Debt Service Total	$334,950,000	$182,760,000
50-Year Operations & Maintenance Total	$140,000,000	$105,000,000
50-Year Lifecycle Cost	**$474,950,000**	**$287,760,000**

7 Hydrology and hydraulics

A hydrologic and hydraulic analysis was performed to size the two detention basins, identify the inundation limits upstream of the dams, and determine the downstream benefits. Hydrology was conducted using HEC-HMS version 4.8 and hydraulics using HEC-RAS version 5.0.7. Details of the hydrology and hydraulic analysis are included in Appendix D.

7.1 Modeling background

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. This 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 (2015), and Tax Day (2016).
- HEC-HMS (v4.3) model for the Spring Creek Watershed including simulations for both the frequency and historical storm events

7.2 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.

The major update to the hydrology was that drainage areas were subdivided for additional detail near the proposed project sites. The following parameters were revised and recalculated for the subdivided drainage areas.

- Hydrologic losses were calculated using the Green & Ampt method, with adjustments for vegetation using the Canopy Loss Method.
- Impervious cover values were updated based on land use types and recalculated for the subdivided drainage areas.
- The Clark Unit Hydrograph Method was used for hydrograph transformation, with updated time of concentration (Tc) and storage coefficient (R) values.

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.

7.3 Hydraulics

The HCFCD HEC-RAS model consisted of a 1D/2D representation of the entire watershed. The Spring Creek mainstem was modeled with 1D cross sections for the main channel and 2D zones for the floodplain. Tributaries north of Spring Creek were modeled using 1D cross sections. Tributaries south of Spring Creek, within Harris County, were modeled using combined 1D/2D sections. The HCFCD HEC-RAS model was updated on Birch Creek and Walnut Creek to assess existing conditions and prepare for proposed projects. The following updates were made to the HEC-RAS model:

- The 1D cross sections on the upstream end of Walnut Creek were replaced with a 2D area upstream of FM 1488 to better account for proposed detention basins.
- Hydrographs for drainage areas within the 2D area were added as internal boundary conditions.
- Breaklines were added to outline stream centerlines within the 2D area to match flow patterns.
- Cross sections were extended along Walnut Creek downstream of FM 1488 and cross sections were added on Walnut Creek from FM 1488 to the confluence with Birch Creek.
- An additional structure was added to include the FM 1488 crossing on Walnut Creek.
- 1D/2D Connections were placed at the downstream end of the 2D area to connect with storage areas upstream of Walnut and Birch Creek.

The revised existing conditions model was simulated for two historical storm events and results were compared to ensure the model would provide reasonable results when compared to observed conditions. Table 7-1 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 7-1 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 7-2 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 7-2 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 calibration as well as the observed conditions. These results showed that with the changes to the model, it remained calibrated and appropriate for the hydraulic analysis.

7.4 Existing conditions results

The models were simulated for the Atlas 14 10% ACE (Annual Chance Exceedance), 2% ACE, 1% ACE, and 0.2% ACE, also known as the 10-year, 50-year, 100-year, and 500-year, events to determine discharges and water surface elevations throughout the watershed. Spring Creek serves as the major conveyance for the main northern tributaries from Waller and Montgomery Counties as well as the minor tributaries in Harris County. Being a mostly natural stream watershed, it can take three to four days for the creek to rise and fall following a large rain event. Peak flows for the 1% ACE event range between 16,000 cfs upstream of Threemile Creek to just over 70,000 cfs at the confluence with Cypress Creek. Point flows in the creek increase at the junction of each major tributary in-between. However, following the confluence of Mill Creek, the peak flows do not increase as drastically due to the timing of the large watershed. This confirms that upstream detention would be more effective than downstream detention in reducing overall flows in the creek. Figure 7-1 shows how the flows combine throughout the watershed and the 1% ACE peak discharges at key locations in the creek.

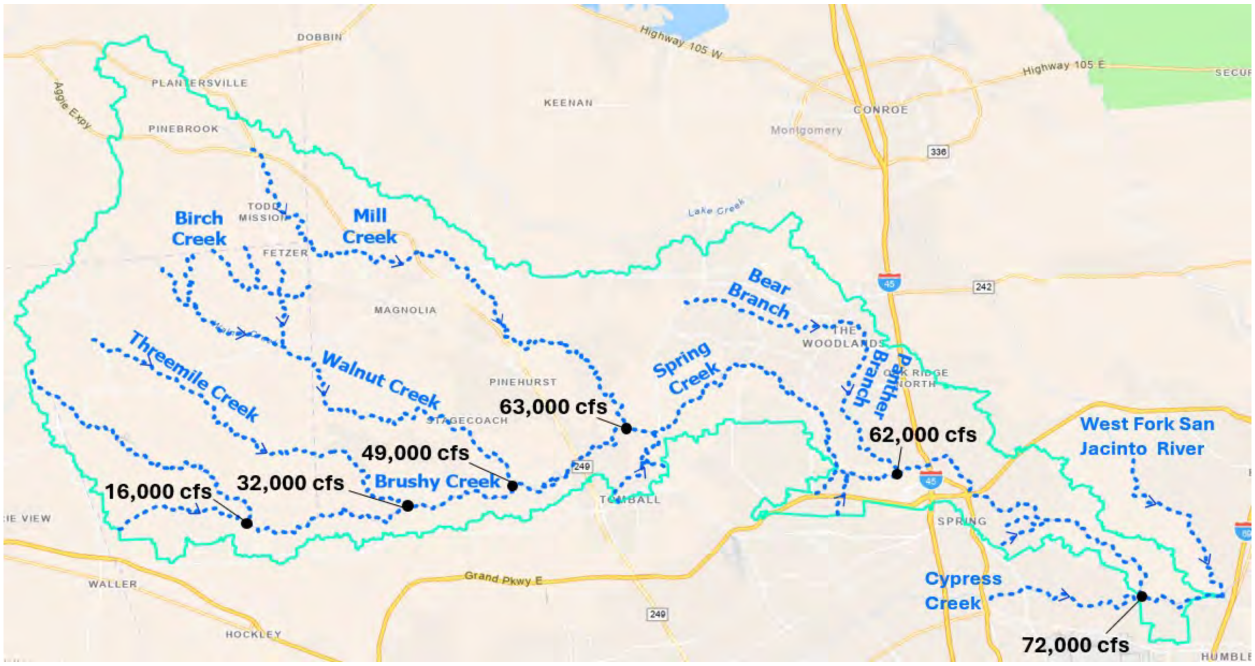


Figure 7-1 1% ACE Discharges within Spring Creek

The FEMA effective model is the current standard in the Spring Creek watershed. Discharges for the 1% ACE event were compared between the effective model, HCFCD model, and the revised model developed for the purpose of this study. In general, the revised model discharges are higher than the effective due to the application of Atlas 14 rainfall in the watershed but match well with the HCFCD discharges.

Table 7-3 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

Water surface elevations for the 1% ACE event were compared between the effective, 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 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.

Table 7-4 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

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 structure flooding until it reaches the 2% ACE event. This indicates that structure flooding in Spring Creek is infrequent; however, when large storm events occur, there is the potential for widespread damages.

Table 7-5 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 mostly 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 are located within 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.

A heat map of the areas with a high concentration of flood damages is shown in Figure 7-2.

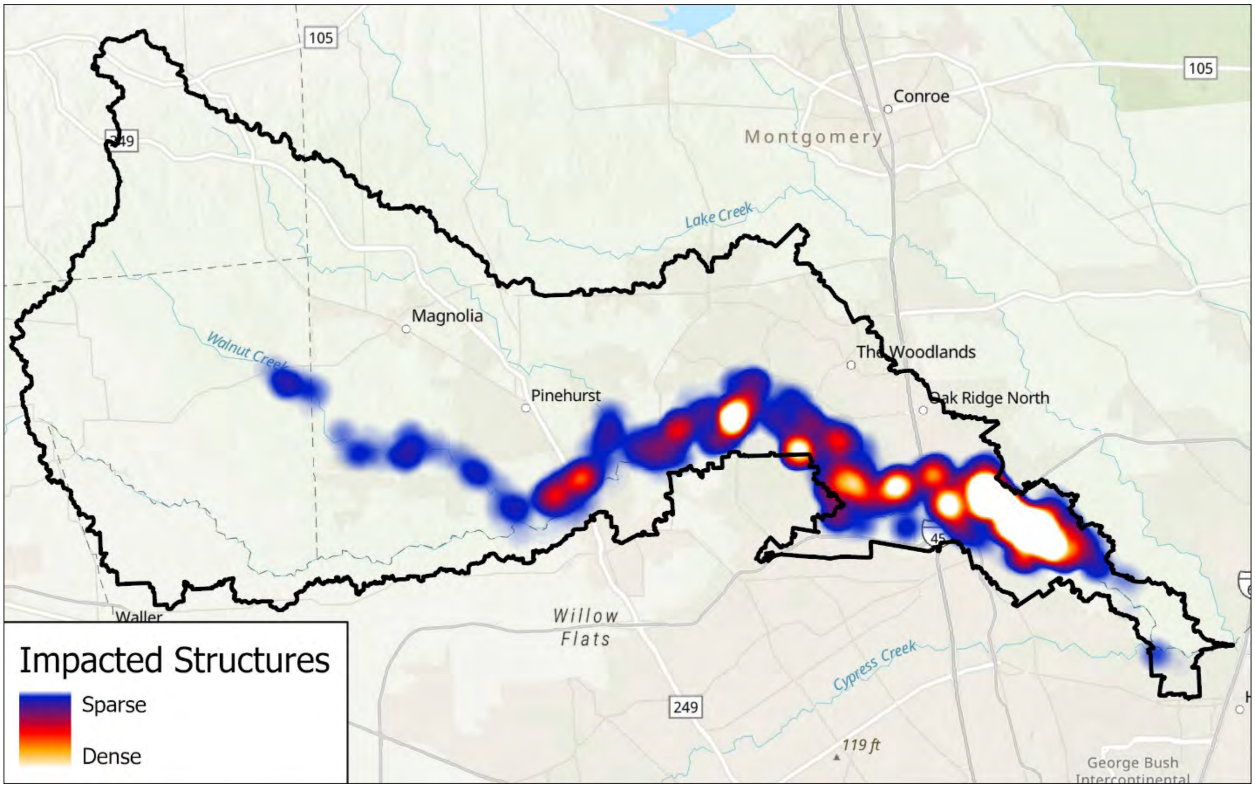


Figure 7-2 Impacted Structures Heat Map

The number of structures flooded for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events for each county are in Table 7-6.

Table 7-6 Potentially Flooded Structures by County

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

7.5 Proposed projects

The detention basins were modeled using 2D connections along the proposed project alignments, and as ogee weirs with culvert openings for outlets. 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 initial simulations showed that the detention facilities as proposed in the SJRWMDP needed to be optimized to reduce costs and optimize 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. These iterations showed that an optimal 1% ACE storage volume for Walnut Creek was approximately 6,500 acre-feet and 4,500 acre-feet for Birch Creek. The basins were resized accordingly by reducing the top of dam elevation and alignment. The resulting configuration of the optimized dry detention basins is shown in Table 7-7.

Table 7-7 Detention Basin Parameters

	Walnut Creek Detention Basin	Birch Creek Detention Basin
Spillway Elevation	254.7 ft	251.2 ft
Spillway Length	175 ft	175 ft
Top of Dam	263.6 ft	259.1 ft
Max Dam Height	39.1 ft	35.4 ft
1% ACE Inundation Area	940 ac	690 ac
1% ACE Storage Capacity	7,300 ac-ft	4,800 ac-ft
Opening Size	6’ x 17’ RCB	6’ x 16’ RCB

The dams were evaluated independently and in combination for both frequency storms and historical storm events. Tables provided in Appendix D show the reduction in flow and water surface elevations with the proposed detention basins in place. The detention basins reduce the number of impacted structures for the 10% ACE, 2% ACE, 1% ACE, and 0.2% ACE events. Table 7-8 show the number of benefited structures for each individual detention basin as well as the combined project scenario.

Table 7-8 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 facilities were also modeled with historical rainfall to assess potential benefits if they had been operational during events like Hurricane Harvey (2017), Memorial Day (2015), and Tax Day (2016). Table 7-9 show the potential benefited structures for the historical storm events.

Table 7-9 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

In addition to the benefits shown in the tables above, the hydraulic analysis also showed that both detention basins produce no negative impacts to water surface elevations outside of the project footprint in accordance with the TWDB project criteria.

8 Benefit cost analysis

A benefit-cost analysis was performed using the FEMA BCA toolkit for each detention basin individually as well as a combined scenario. The benefit cost analysis evaluates flood damage benefits for structures within the floodplain of Spring Creek and was performed using standard FEMA practices.

8.1 Cost

The maximum cost for each project was used in the benefit cost analysis to determine the "worst case" scenario for the benefit cost ratio. Project cost for the individual as well as combined dams are summarized in Table 8-1.

Table 8-1 Project Costs Per Dam Alternative

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

8.2 Benefits

Information from the hydraulic models including discharges and water surface elevations for existing conditions as well as with the proposed projects were extracted to perform the analysis. In addition, base data such as residential and non-residential structure footprints, location, terrain, and structure square footage were used within the analysis. The analysis was conducted using the FEMA BCA toolkit with the following assumptions:

- Period of Analysis: 50-years
- Interest Rates: 3.1 % discount rate
- Affected Structures: Identified all structures within the 500-year floodplain and assigned finished floor elevations by adding 1 foot to the base terrain data at the centroid of the structure. Affected structures were assigned flood depths for each of the modeled frequency events under existing conditions and each of the proposed alternatives.
- Damage Curves: Depth-damage curves were assigned based on either non-residential or residential structures using the USACE standard curves within the BCA toolkit.
- Structure size: Structure sizes were obtained from the relative county appraisal district information. Usable living space values were selected as the building size to exclude garages and other non-insurable structures.
- Replacement values: The FEMA standard $100 per square foot multiplied by the structure size was used for the building replacement value.

- Contents: Structure contents were assumed using the standard FEMA values per unit cost associated with the building type.
- Displacement: Values represent the additional cost incurred when people are forced to relocate temporarily due to damage from a hazard. Residential displacement values account for the housing and meal costs from displacement and were based on the FY 2025 per diem rates provided by the U.S. General Services Administration. Non-Residential displacement values account for the rental and transportation costs for a structure's loss of function and were based on standard values by building type within the toolkit.
- Social Benefits: Values include the non-market benefits not captured in direct financial costs, but they reflect the broader public good. Social benefits were included within the benefit calculation as allowed by FEMA including mental stress and anxiety. All residential structures were assumed to have an average of 3 residents including 1 working resident based on the average information provided by the U.S. Census Bureau.

8.3 Benefit cost ratio

A benefit-cost analysis was performed for each detention basin and a combination of both using the water surface elevation results described in Section 7.4 in comparison to the damages calculated under existing conditions. The benefit value derived for each alternative was used along with the engineering opinion of probable project cost to generate the final benefit-cost ratio for each project, as shown in Table 8-2 through 8-4.

Table 8-2 Walnut Creek Detention Basin Benefit Cost Analysis

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**

Table 8-3 Birch Creek Detention Basin Benefit Cost Analysis

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**

Table 8-4 Walnut Creek and Birch Creek Detention Basins Benefit Cost Analysis

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**

The analysis shows that the individual projects both have the potential for benefit cost ratios greater than 1.0 meaning that the projects have the potential to be cost effective. This also indicates that specific federal funding sources may be available for funding portions of the total construction cost.

The combined project benefit cost is less than 1.0 due to a significant cost increase for two detention basins and the relatively small increase in social benefits (the projects still benefit the same population). This indicates that while both projects would provide downstream flood relief and a combination of projects provides the most relief, when seeking federal funding, separate applications should be submitted. As shown in the tables above, separate projects would both have positive benefit cost ratios by maximizing the application of social benefits.

9 Potential funding opportunities

Due to the size of the projects, funding for the detention basins will require a combination of multiple funding sources from both local entities and 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 by agency.

9.1 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.

9.1.1 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

9.1.2 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

9.2 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 this 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.

9.2.1 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

9.2.2 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

9.3 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.

9.3.1 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

9.4 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) request or earmark—for a particular project in their district or state. If approved, the request may be 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.

9.5 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 San Jacinto Regional Flood 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.

9.5.1 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

9.6 Local funding

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

9.6.1 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.

9.6.2 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 is not a legal use of impact fees. 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.

9.6.3 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.

10 Conclusion and recommendations

The Spring Creek Watershed Flood Control Dams Feasibility Study has provided a comprehensive analysis of the potential benefits and feasibility of implementing two regional detention basins within the watershed. Funded partially by the Texas Water Development Board's Flood Infrastructure Fund (FIF), the study focused on the Walnut Creek and Birch Creek detention basins.

The study concluded that the proposed detention basins at Walnut Creek and Birch Creek are expected to effectively reduce flood risks in the Spring Creek watershed. These basins would mitigate downstream flooding, benefiting numerous residential and non-residential structures. Additionally, the study included extensive environmental due diligence, identifying potential impacts on wetlands, threatened and endangered species, and cultural resources. Mitigation measures have been proposed to address these impacts. The economic feasibility of the project was also assessed, with a benefit-cost analysis demonstrating that both detention basins have a favorable benefit-cost ratio individually, indicating that the economic benefits of flood risk reduction outweigh the costs of construction and maintenance. Furthermore, the study involved significant coordination with key stakeholders, including local counties and municipalities, utility districts, and the public, with public meetings and workshops held to gather input and address concerns.

Based on these findings, it is recommended to advance the Walnut Creek and Birch Creek detention basins to the detailed design phase, which will involve more precise engineering and geotechnical analyses, coordination with landowners for purchase of property as well as the development of construction plans. One of the important next steps includes identifying a project sponsor within the region that will continue to move the projects forward. Efforts should be made to secure funding from various sources, including federal, state, and local agencies, with potential funding opportunities such as FEMA's Hazard Mitigation Grant Program and the Texas Water Development Board's Flood Infrastructure Fund. It is also essential to implement the proposed environmental mitigation measures to address potential impacts on wetlands, species, and cultural resources, including obtaining necessary permits and coordinating with regulatory agencies. Finally, maintaining ongoing communication with stakeholders, including local communities and landowners, is crucial to ensure their concerns are addressed and to foster support for the project.

Appendix A1:

Waters of the United States Desktop Report for Spring Creek Dam Feasibility Study

Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

Waters of the United States Desktop Report for Spring Creek Dam Feasibility Study

Flood Infrastructure Fund Category 1

Project ID 21-0016

Prepared for:

Texas Water Development Board

Prepared by:

Halff

Richard Howard, P.W.S.

Table of Contents

List of Tables

List of Appendices

1 Introduction

At the request of the San Jacinto River Authority, Halff conducted a desktop assessment of potential waters of the U.S. for the Spring Creek Dam Feasibility Study (proposed project). The proposed project includes potential construction alternatives for detention basins within the Spring Creek watershed to reduce flooding in the watershed downstream to the confluence of the San Jacinto River (**Figure 1, Appendix A1-1**). The project area contains two potential dam alignments within the sub-watersheds of Walnut Creek and Birch Creek. The dam alignment within the Walnut Creek sub-watershed is situated approximately 800 feet northwest of the intersection of Farm-to-market (FM) 1488 and Woodway Drive. The dam alignment within the Birch Creek sub-watershed is situated between FM 1488, Ranch Crest Drive, and FM 1774. Both potential projects are in the Spring Creek watershed as defined by U.S. Geological Survey (USGS) hydrologic unit code (HUC) 12040102. Halff conducted this desktop assessment to determine the presence, location, and extent of potential waters of the U.S. within the project area and any associated potential environmental permitting requirements.

According to the U.S. Army Corps of Engineers (USACE), waters of the U.S. include territorial seas, tidal waters, traditional navigable waters, interstate waters, and the adjacent, contributing, or impoundments of these waterbodies (e.g., rivers, creeks, streams, lakes, reservoirs). Special aquatic sites associated with these waterbodies are also considered waters of the U.S. and include sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs, and riffle and pool complexes.

Wetlands are typically the most common special aquatic resource present and are defined by the USACE as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (40 Code of Federal Regulations [CFR] 230.3(t)). Based on this definition, for an area to be considered a wetland it must possess the following three parameters under normal circumstances: 1) a predominance of plants adapted to live in water or saturated soils (i.e., hydrophytic vegetation), 2) soil characteristics of frequent saturation (i.e., hydric soils), and 3) the presence of hydrology showing evidence of regular flooding or ponding (i.e., wetland hydrology).

2 Methods

Halff conducted a resource review using publicly available background information to help identify the portions of the project area most likely to contain wetlands and/or waterbodies. Resources reviewed included historic aerial photography (Google Earth 2024), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) data (USFWS 2024), U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) data (USGS 2024), USGS topographic quadrangles (USGS 2023), and the most recently available Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) data (FEMA 2019). The project area is defined by the parcels containing the sub-watersheds of Birch Creek and Walnut Creek.

3 Results

3.1 Resource review

Historic topographic maps and aerial imagery show Walnut Creek and Birch Creek with riparian forest surrounded by agriculture and undeveloped lands. From 1995 to the present, the project area became increasingly impacted by human development, including clearing of the surrounding riparian forest and commercial and residential developments.

The most recent USGS topographic map (2023), the project area consists of forests with some urban residential and commercial areas south of the area. Furthermore, the Magnolia West, Texas 7.5-minute topographic quadrangles (**Figure 1, Appendix A1-1**) depicts several wetlands along Walnut Creek and Birch Creek. FEMA FIRM Number 48473C0100E indicates that a substantial portion of the area is located within the floodway, 100-year floodplain and 500-year floodplain (FEMA 2009) (**Figure 1, Appendix A1-1**). Halff also evaluated historic topographic maps and aerial images (**Figures 2a through 2d, Appendix A1-1**), as well as LiDAR data (**Figure 3, Appendix A1-1**) to identify areas that are more likely to contain waterbodies or wetlands. The NWI indicates that the project area includes 42 wetland features, four ponds, and 19 riverine features (USFWS 2023; **Figure 4, Appendix A1-1**). The NHD identifies 35 waterbodies within the assessed area, most of which are consistent with the NWI features (USGS 2024).

3.2 Wetlands

Halff identified 65 NWI features within the project area, four of which intersect the proposed alignment of the Walnut Creek detention basin dam and two of which intersect the alignment of the Birch Creek detention basin dam (**Figure 4, Appendix A1-1**). Table 3-1 summarizes details pertaining to the NWI wetlands within each sub-watershed.

Table 3-1 NWI Wetland Types within Walnut Creek and Birch Creek Sub-watersheds

NWI Wetlands Type	Walnut Creek	Birch Creek
Freshwater Pond	3	1
Freshwater Emergent Wetland	3	9
Riverine	9	10
Freshwater Forested/Shrub Wetland	10	20
Total	**25**	**40**

3.2.1 Vegetation communities

From an aerial view, the project area appears to be forested with riparian vegetation along the creeks. Forested and herbaceous uplands dominate the rest of the project area. A field survey would be needed to further determine the vegetation communities within the project area.

3.2.2 Soils

According to the NRCS Soil Survey for Waller County, Texas, there are eight major soil map units present within the project area (**Figure 5, Appendix A1-1**). Table 3-2 and Table 3-3 provide details pertaining to the soil map units associated with the Walnut Creek and Birch Creek sub-watersheds, respectively.

Table 3-2 Soil Map Units within Walnut Creek Sub-watershed

Soil Symbol	Soil Map Unit	Acres	Percent	Hydric Soil
AnC	Annona fine sandy loam, 1 to 5 percent slopes	31.7	2.3%	No
CoC	Conroe loamy fine sand, 1 to 5 percent slopes	114.1	8.2%	No
CpC	Conroe soils, graded, 1 to 5 percent slopes	16.9	1.2%	No
DeC	Depcor loamy fine sand, 1 to 5 percent slopes	722.5	52.2%	No
HatA	Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded	131.1	9.5%	Yes
LdC	Landman loamy fine sand, 1 to 5 percent slopes	28.6	2.1%	No
LIE	Landman-Larue complex, 3 to 12 percent slopes	322.2	23.3%	No
SpB	Splendora fine sandy loam, 0 to 2 percent slopes	16.3	1.2%	No

Table 3-3 Soil Map Units within Birch Creek Sub-watershed

Soil Symbol	Soil Map Unit	Acres	Percent	Hydric Soil
CoC	Conroe loamy fine sand, 1 to 5 percent slopes	165.6	12.1%	No
CpC	Conroe soils, graded, 1 to 5 percent slopes	9.3	0.8%	No
DeC	Depcor loamy fine sand, 1 to 5 percent slopes	385.3	28.2%	No
HatA	Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded	233.5	17.1%	Yes
LdC	Landman loamy fine sand, 1 to 5 percent slopes	340.2	24.9%	No
LIE	Landman-Larue complex, 3 to 12 percent slopes	190.7	14.0%	No
SpB	Splendora fine sandy loam, 0 to 2 percent slopes	39.8	2.9%	No

HatA contains 35% of Pluck hydric component and 25% of Kian hydric component, occurs in dips, is poorly drained, and, therefore, is classified as a hydric soil (NRCS 2024). SpB contains 7% of Waller hydric component, occurs on flatwoods, is somewhat poorly drained, but is largely classified as non-hydric (NRCS 2024). See **Appendix A1-2** for a brief description of each NRCS soil map unit presented within the project area.

Although an NRCS hydric listing alone is generally insufficient to determine if soils within an area are hydric, it does indicate that suitable soil properties or conditions exist that promote the formation of hydric soil conditions. As a result, the portions of the project area depicted as containing hydric soil map units may be subjected to greater scrutiny with respect to the presence of hydric soil indicators.

3.2.3 Walnut Creek

The NWI wetlands that intersect with the dam alignment on Walnut Creek include two PFO1A (temporarily flooded forested wetlands), one PFO1C (seasonally flooded forested wetland), and one PSS1C (seasonally flooded scrub-shrub wetlands). The current dam alignment has a maximum length of 3,373 feet and would require placement of fill over approximately 12.0 acres, including 3.5 acres of wetlands. See **Figure 6a, Appendix A1-1** for the potential impacts to Walnut Creek and its adjacent wetlands.

In addition to the direct construction impacts, the planned flood detention reservoir on Walnut Creek may potentially cause temporary flooding of approximately 49.3 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. Flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404 of the Clean Water Act (Section 404). Areas downstream of the dam will not be flooded but may experience reduced hydrologic input. See **Figure 6c, Appendix A1-1** for the potential flooding impacts.

3.2.4 Birch Creek

The NWI wetlands that intersect with the dam alignment on Birch Creek include one PFO1A and one PFO1C. The current dam alignment has a maximum length of 3,168 feet and would require placement of fill over approximately 8.7 acres, including 0.9 acre of wetlands. See **Figure 6b, Appendix A1-1** for the potential impacts to Birch Creek and its adjacent wetlands.

In addition to the direct construction impacts, the planned flood detention reservoir on Birch Creek may potentially cause temporary flooding of approximately 50.7 acres of NWI wetlands within the 500-year flood plain upstream of the dam alignment. Flooding these NWI wetlands may increase their hydroperiod but would likely not be considered a loss of these resources under Section 404. Areas downstream will not be flooded but may be reduced due to the lack of hydrology input. See **Figure 6c, Appendix A1-1** for the potential flooding impacts.

3.3 Waterbodies

Based on the USGS topographic maps (**Figure 2b, Appendix A1-1**), Halff identified two named streams (Walnut Creek and Birch Creek) and several tributaries within the project area. According to the NHD and NWI, the proposed alignment for the Walnut Creek detention basin dam may impact Walnut Creek (**Figure 6a, Appendix A1-1**). Collectively, the Walnut Creek detention basin watershed includes approximately 15,296 linear feet of streams within 500-year floodplain upstream of the proposed detention basin.

Similarly, the NHD and NWI identify Birch Creek as the lone waterbody that would be directly impacted by the Birch Creek detention basin's construction (**Figure 6b, Appendix A1-1**). Collectively, the Birch Creek detention basin watershed includes approximately 12,764 linear feet of streams within 500-year floodplain upstream of the proposed detention basin.

The confluence of Birch Creek and Walnut Creek is approximately 800 feet south of the project area and flows into Spring Creek at approximately 10 miles southeast of the project area. In total, Halff identified 35 NHD features within the project area. Table 3-4 summarizes the NHD features associated with each sub-watershed.

Table 3-4 NHD Feature Types within Walnut Creek and Birch Creek Sub-watersheds

NHD Feature Type	Walnut Creek	Birch Creek
Intermittent Stream	14	8
Perennial Stream	6	7
Total	20	15

4 Conclusion

Halff performed a desktop assessment of the proposed Spring Creek Dam Feasibility Study in April 2024. The assessment identified two watersheds (Walnut Creek and Birch Creek), containing approximately 15,296 linear stream feet and 12,764 linear stream feet within 500-year floodplain upstream of the proposed detention basin, respectively. Based on a review of current and historical aerial imagery and topographic maps, Walnut Creek and Birch Creek have been present in the project area since before 1964. Walnut Creek and Birch Creek converge and flow into Spring Creek, which flows directly into West Fork San Jacinto River, a traditional navigable water. Therefore, in Halff's professional opinion, Walnut Creek and Birch Creek would likely be considered jurisdictional under the current USACE pre-2015 regulatory regime and the findings of the *Sackett v. EPA* decision.

The dam alignments may directly impact a total of 3.54 acres of wetlands adjacent to (bearing a direct surface connection with) Walnut Creek and a total of 0.85 acre of wetlands adjacent to Birch Creek. Due to their proximity to Walnut Creek and Birch Creek and their tributaries, these wetlands would likely be considered jurisdictional under Section 404 following USACE's pre-2015 regulatory regime and the findings of the *Sackett v. EPA* decision.

The proposed dam alignments have the potential to impact Walnut Creek and Birch Creek and the adjacent wetlands. To demonstrate avoidance of potentially jurisdictional aquatic resources, USACE will require the consideration of alternative locations that may decrease potential impacts. The impoundment of Walnut Creek and Birch Creek may flood the wetlands located upstream of the dam alignments and potentially sever hydrology for downstream wetlands. Impacts to wetlands and streams may require the purchase of mitigation credits. Available mitigation banks for wetland credits include Mill Creek, Spellbottom, and Tarkington Bayou. Available mitigation banks for stream credits include Houston-Conroe, Katy Prairie Stream, and Tarkington Bayou.

Depending on construction plans, relevant Section 404 permits for these projects may include Nationwide Permits (NWP) 43 (Stormwater Management Facilities) or an Individual Permit (IP); however, the extent of potential wetlands affected by the project would likely trigger an IP. Permitting of the projects under IPs would likely take approximately 18 months after complete permit applications are submitted to USACE. Complete permit applications will require delineations of aquatic features, threatened and endangered species assessments, cultural resource assessments, project plans, and mitigation plans as part of the permit packages. Additionally, preliminary discussions with USACE Galveston District indicate that they may require an environmental assessment (EA) as part of the approval process. The EA may add to the permitting timeline; however, the specifics of this will be determined with USACE.

The results and conclusions contained within this report represent the professional opinion of Halff and are not a verification or jurisdictional determination of waters of the U.S. Only the USACE is authorized to verify the boundaries and jurisdictional determination of waters of the U.S. The information provided in this report may be used to support a request for jurisdictional determination from the USACE, if needed for Clean Water Act Section 404 permitting compliance. Field delineations are required to identify the type and extent of potentially jurisdictional features in the project areas.

5 Literature cited

Federal Emergency Management Agency (FEMA). 2009. Flood Insurance Rate Map (FIRM): Waller County, Texas and Incorporated Areas. Map Number 48473C0100E. Effective Date: February 18, 2009.

Google Inc. 2024. U.S. Department of State Geographer Image Landsat. Available at: https://www.google.com/earth/. Accessed April 2024.

National Resource Conservation Service (NRCS). 2024. Web Soil Survey. United States Department of Agriculture. Available at: http://websoilsurvey.nrcs.usda.gov/. Accessed April 2024.

Palmer, W.C. 1965. Meteorological drought. Research Paper No. 45. Washington D.C.: U.S. Weather Bureau, NOAA Library and Information Services Division. Available at: https://www.ncdc.noaa.gov/temp-and-precip/drought/docs/palmer.pdf. Accessed April 2024.

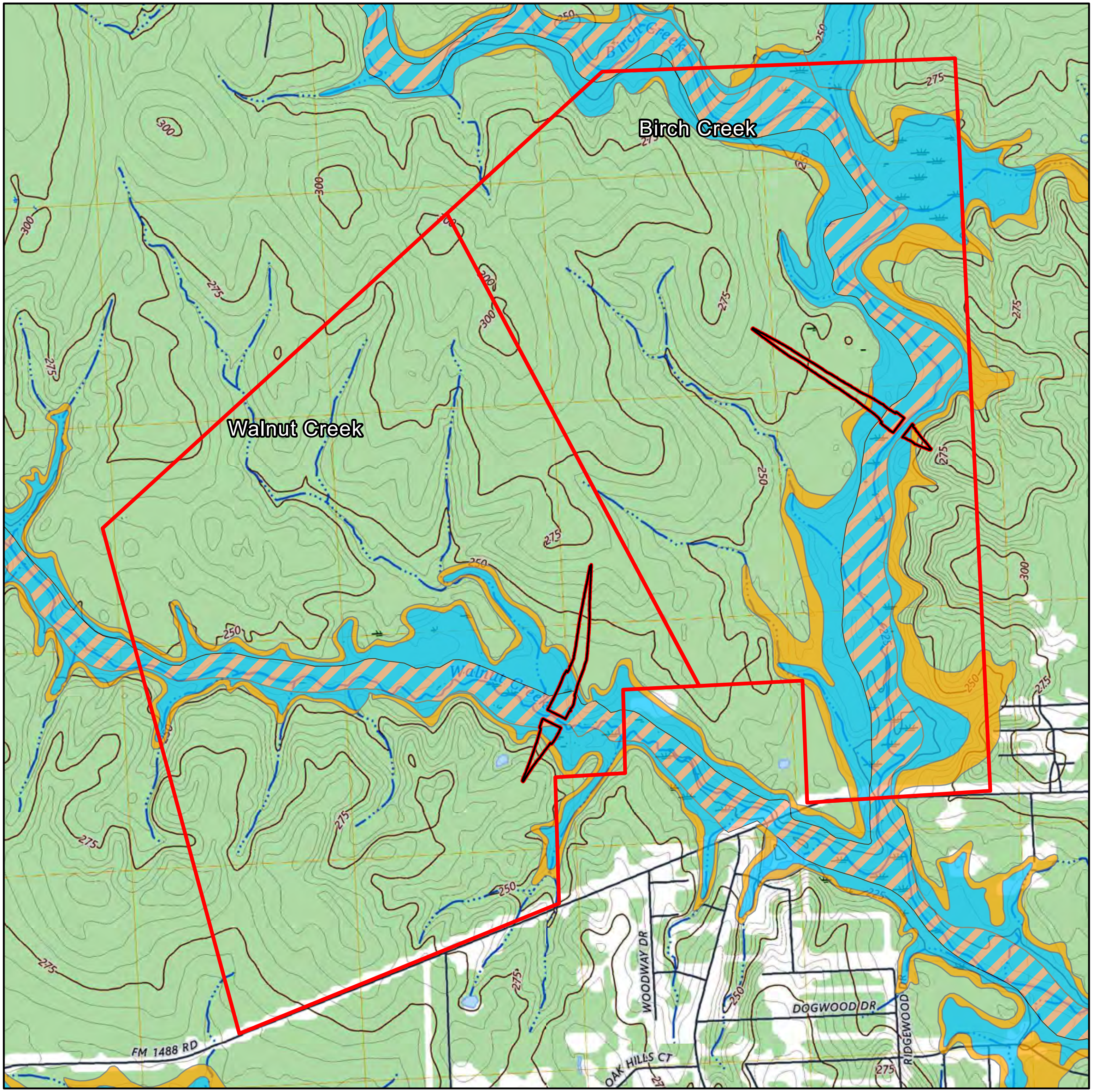
U.S. Fish and Wildlife Service (USFWS). 2023. National Wetland Inventory (NWI). Available at: https://www.fws.gov/wetlands. Accessed April 2024.

U.S. Geological Survey (USGS). 2023. Magnolia West, TX 7.5-minute Quadrangle Map 1:24,000. United States Department of Interior, Washington D.C.

2024. National Hydrography Dataset (NHD). Available at: https://www.usgs.gov/core-science-systems/npg/national-hydrography. Accessed April 2024.

Appendix A1-1:

Maps



0 1,000 2,000 4,000
Feet

Legend

- Study Area
- Dam Alignments

Flood Zone Type

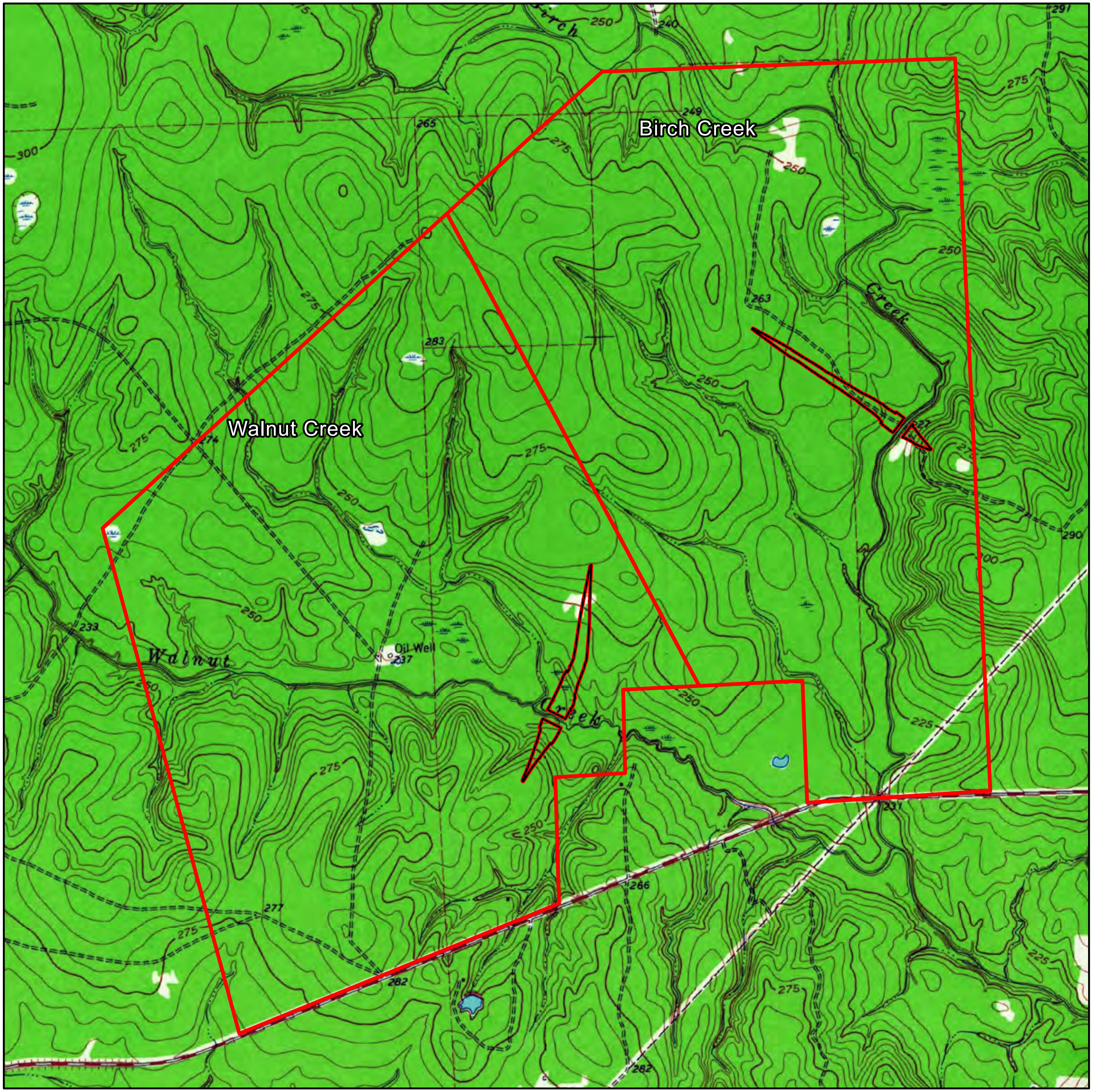
- Floodway
- 1% Annual Change Flood Hazard
- 0.2% Annual Change Flood Hazard

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. USGS topoView: "Magnolia West, Texas" 7.5 minute quadrangle, 2023

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 1
USGS Topographic and FEMA NFHL Map

halff



0 1,000 2,000 4,000
Feet

Legend

Study Area

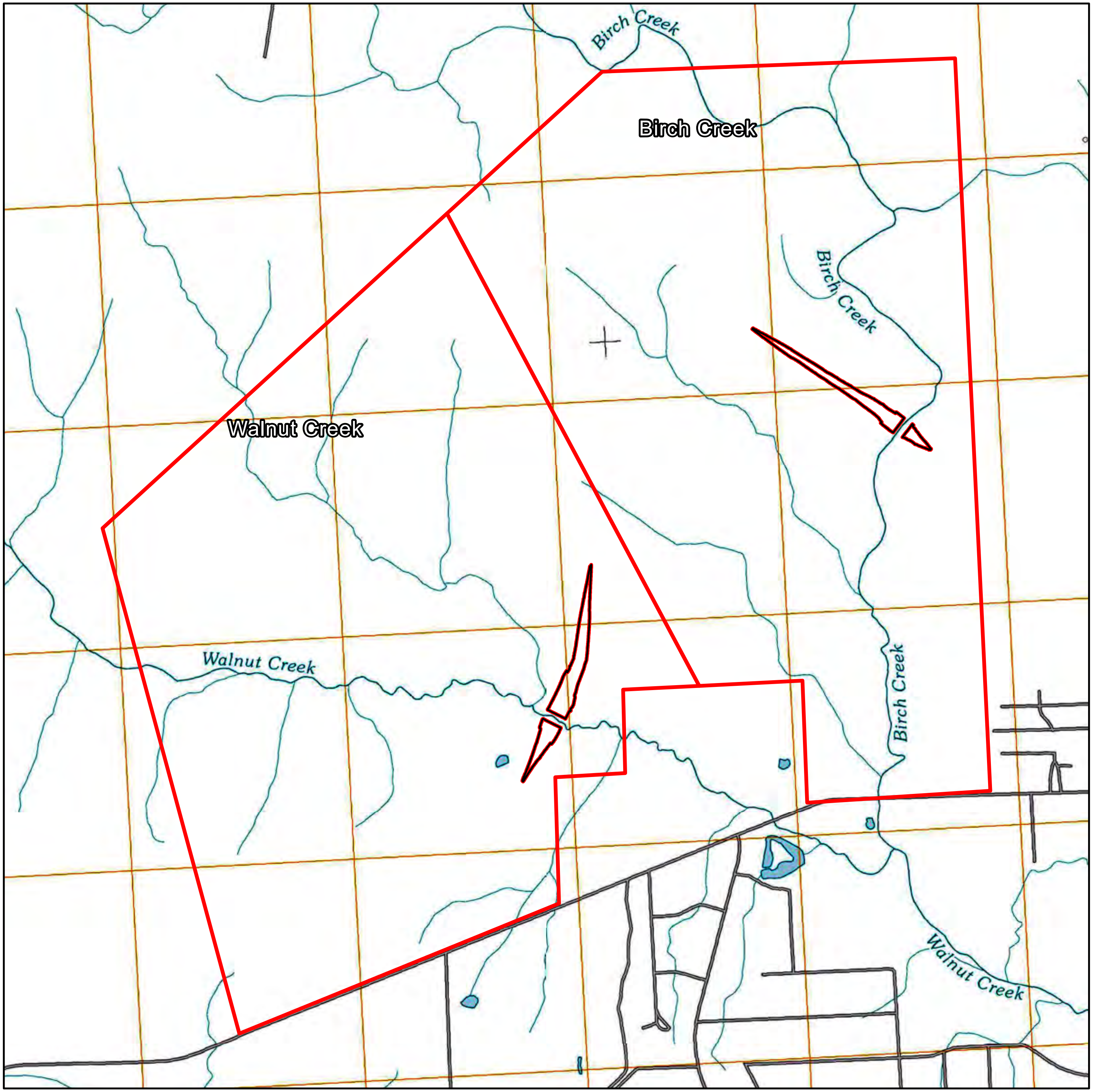
Dam Alignments

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. USGS topoView: "Magnolia West, Texas" 7.5 minute quadrangle, 1962

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 2a
1962 USGS Topographic Map

halff



Legend

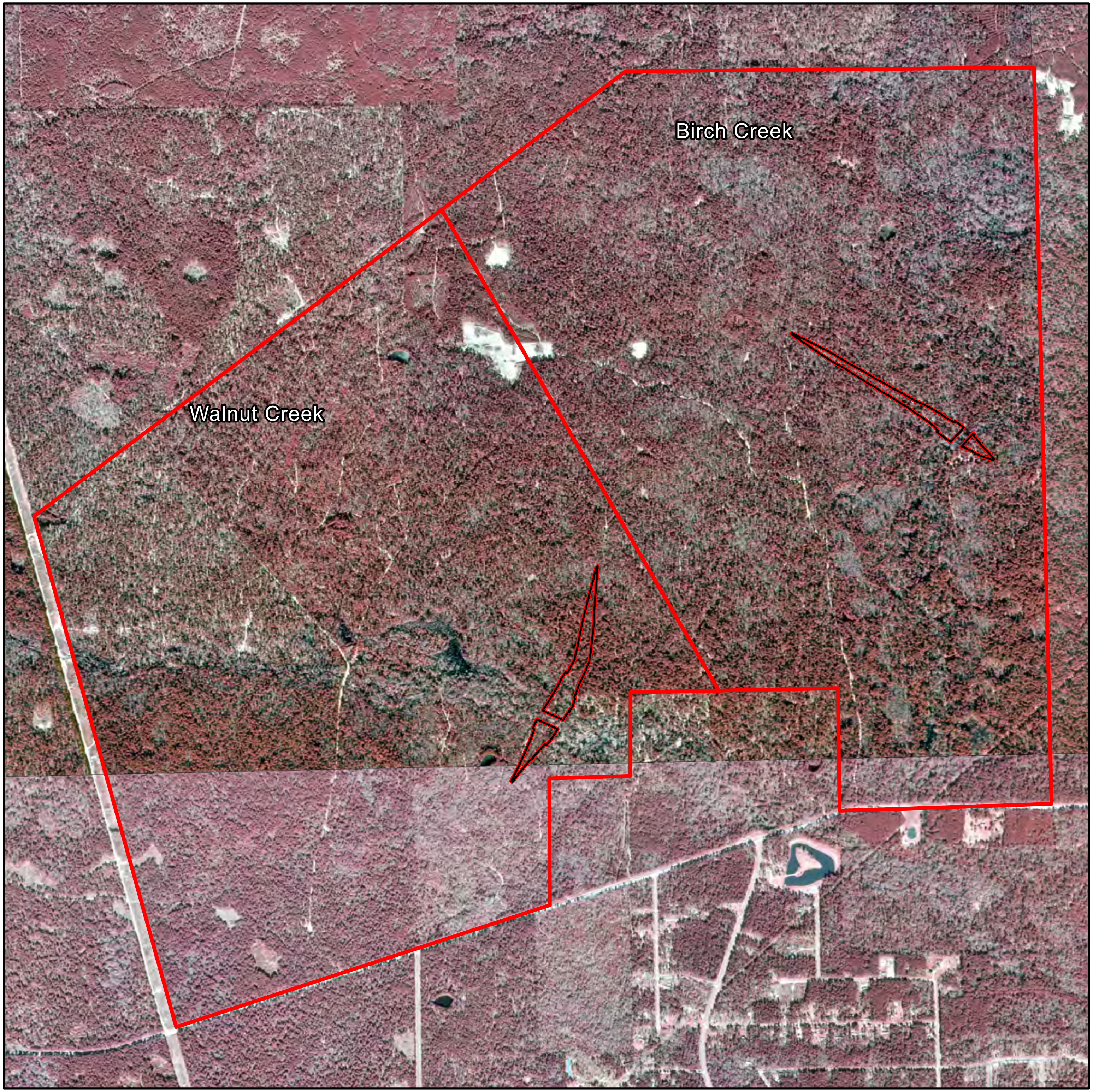
- Study Area
- Dam Alignments

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. USGS topoView: "Magnolia West, Texas" 7.5 minute quadrangle, 2010

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 2b
2010 USGS Topographic Map

halff



Legend

Study Area

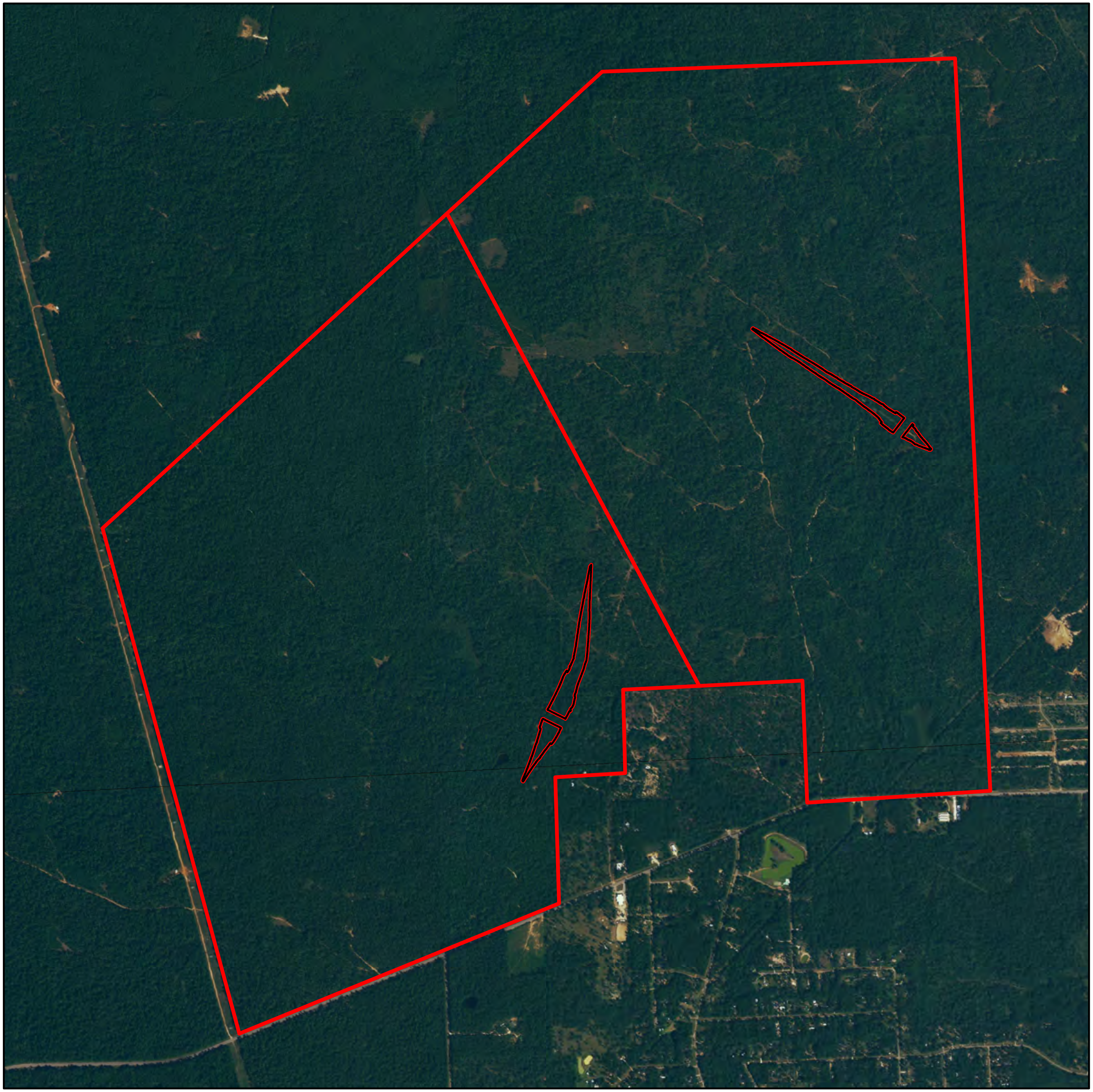
Dam Alignments

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. TNRIS Aerial Imagery - Magnolia West | NE, NW, SE, SW 1995

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 2c
1995 Aerial Map

halff



Legend

Study Area

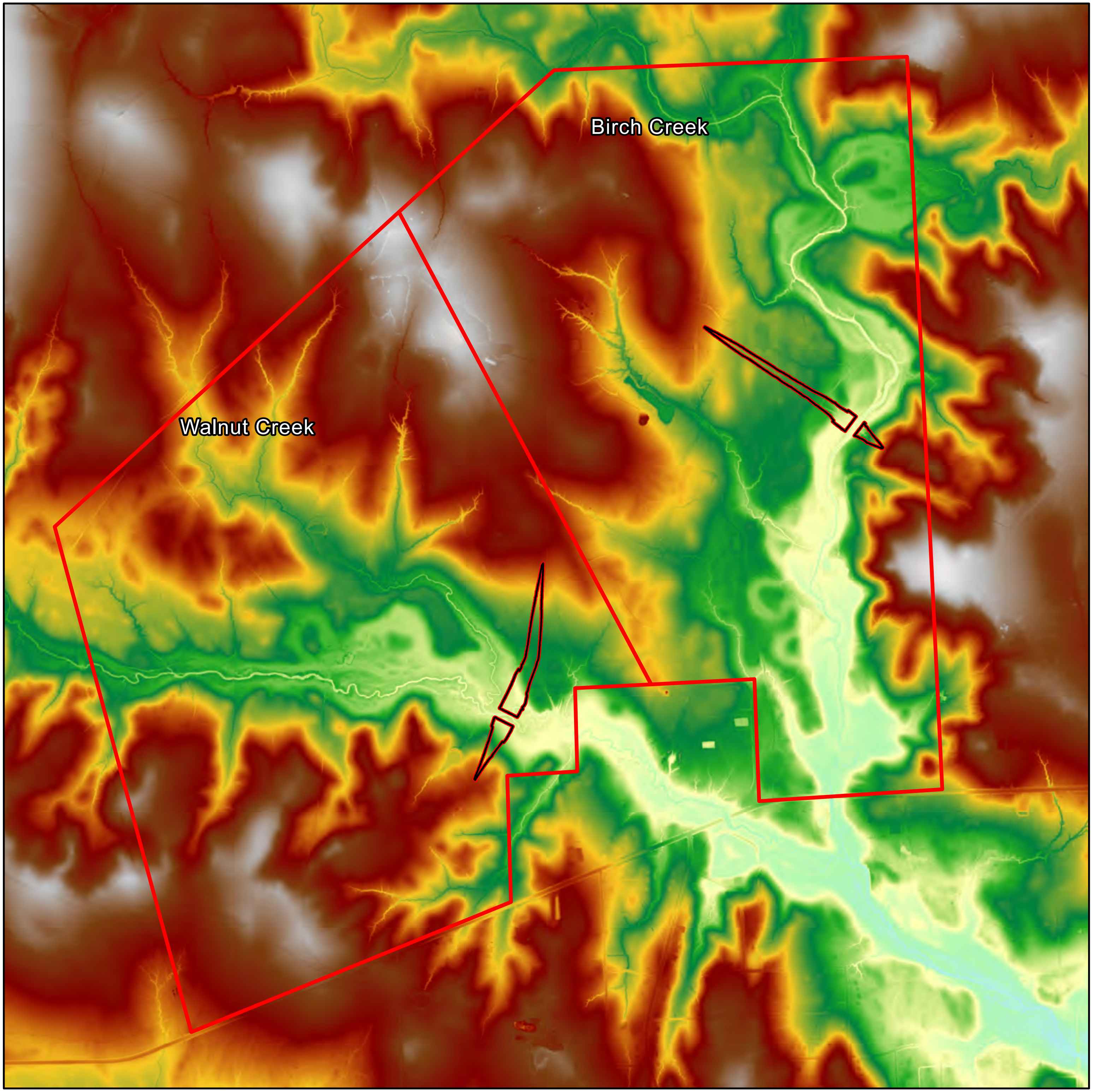
Dam Alignments

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. TNRIS Aerial Imagery - Magnolia West | NE, NW, SE, SW 2005

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 2d
2005 Aerial Map

halff



0 1,000 2,000 4,000
Feet

Legend

Study Area

Dam Alignments

Value (Feet)

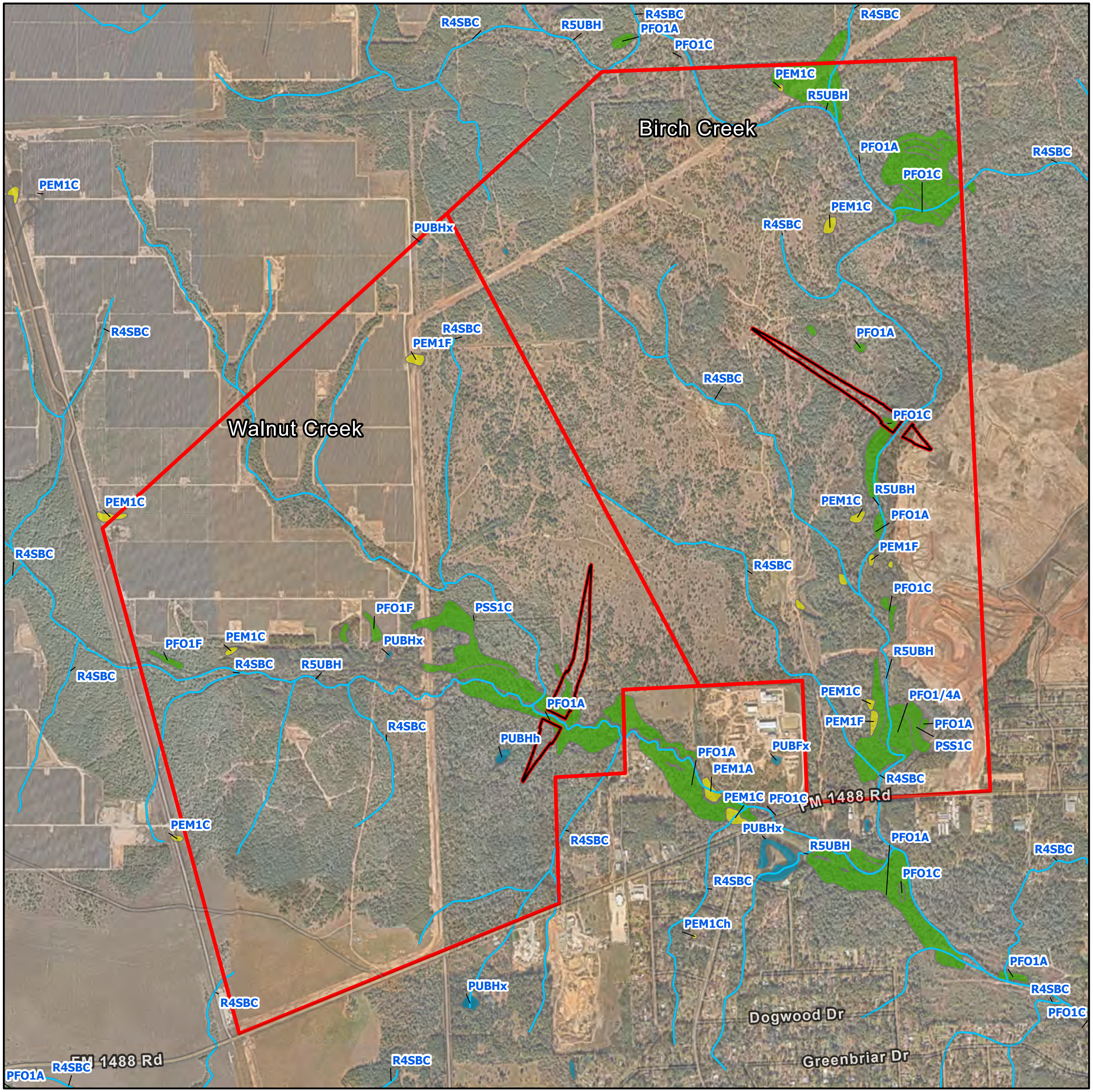
320.285

202.431

Notes:
1. Map Center: 95.8341°W 30.19998°N
2. TXGIO - Upper Coast Lidar, 2018

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 3
LiDAR Map



Legend

- Study Area
- Dam Alignments

NHD Feature Type

- Stream/River

NWI Feature Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

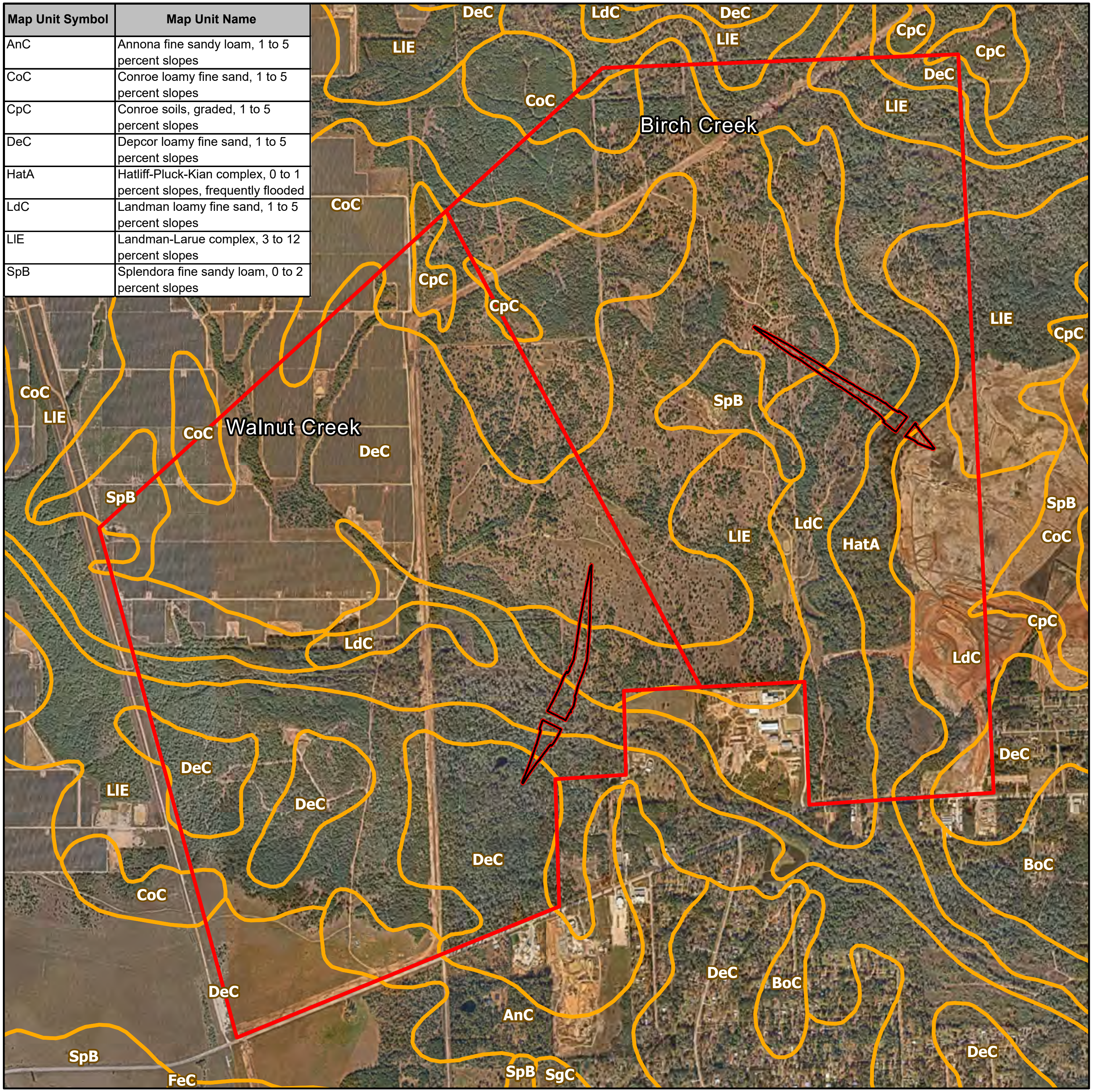
Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Hybrid Reference Layer: Baylor University, Texas Parks & Wildlife, CONANP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS
Nearmap WMS Server: 2023
3. USFWS National Wetlands Inventory
4. USGS National Hydrography Dataset

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 4
NWI and NHD Map

halff

Map Unit Symbol	Map Unit Name
AnC	Annona fine sandy loam, 1 to 5 percent slopes
CoC	Conroe loamy fine sand, 1 to 5 percent slopes
CpC	Conroe soils, graded, 1 to 5 percent slopes
DeC	Depcor loamy fine sand, 1 to 5 percent slopes
HatA	Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded
LdC	Landman loamy fine sand, 1 to 5 percent slopes
LlE	Landman-Larue complex, 3 to 12 percent slopes
SpB	Splendora fine sandy loam, 0 to 2 percent slopes



0 1,000 2,000 4,000
Feet

Legend

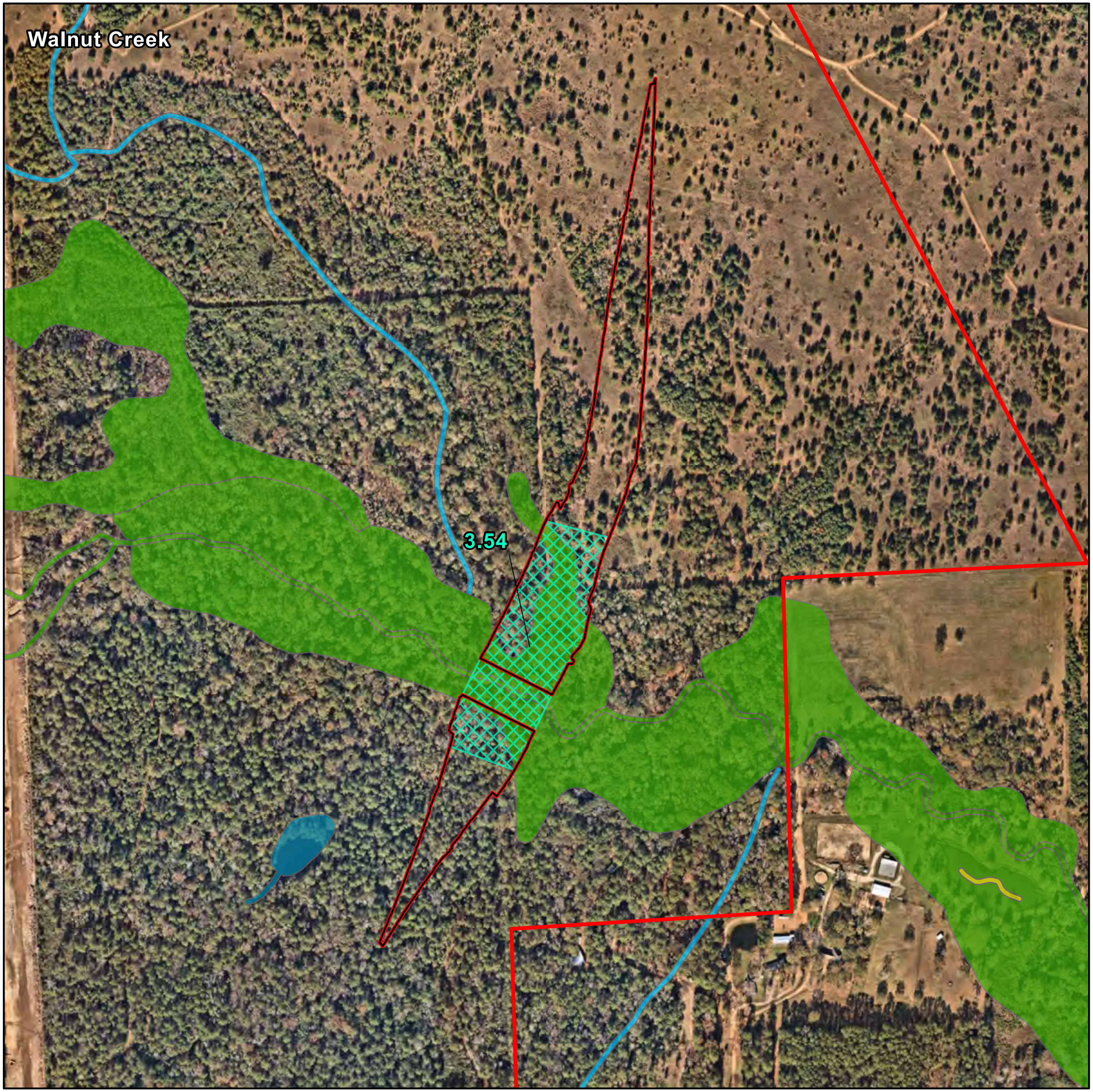
- Study Area
- SSURGO Soil Unit

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2023
3. USDA NRCS Web Soil Survey

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 5
Soil Map

halff



Legend

- Study Area
- Dam Alignments
- Potential Impacts (Dam)

NWI Feature Type

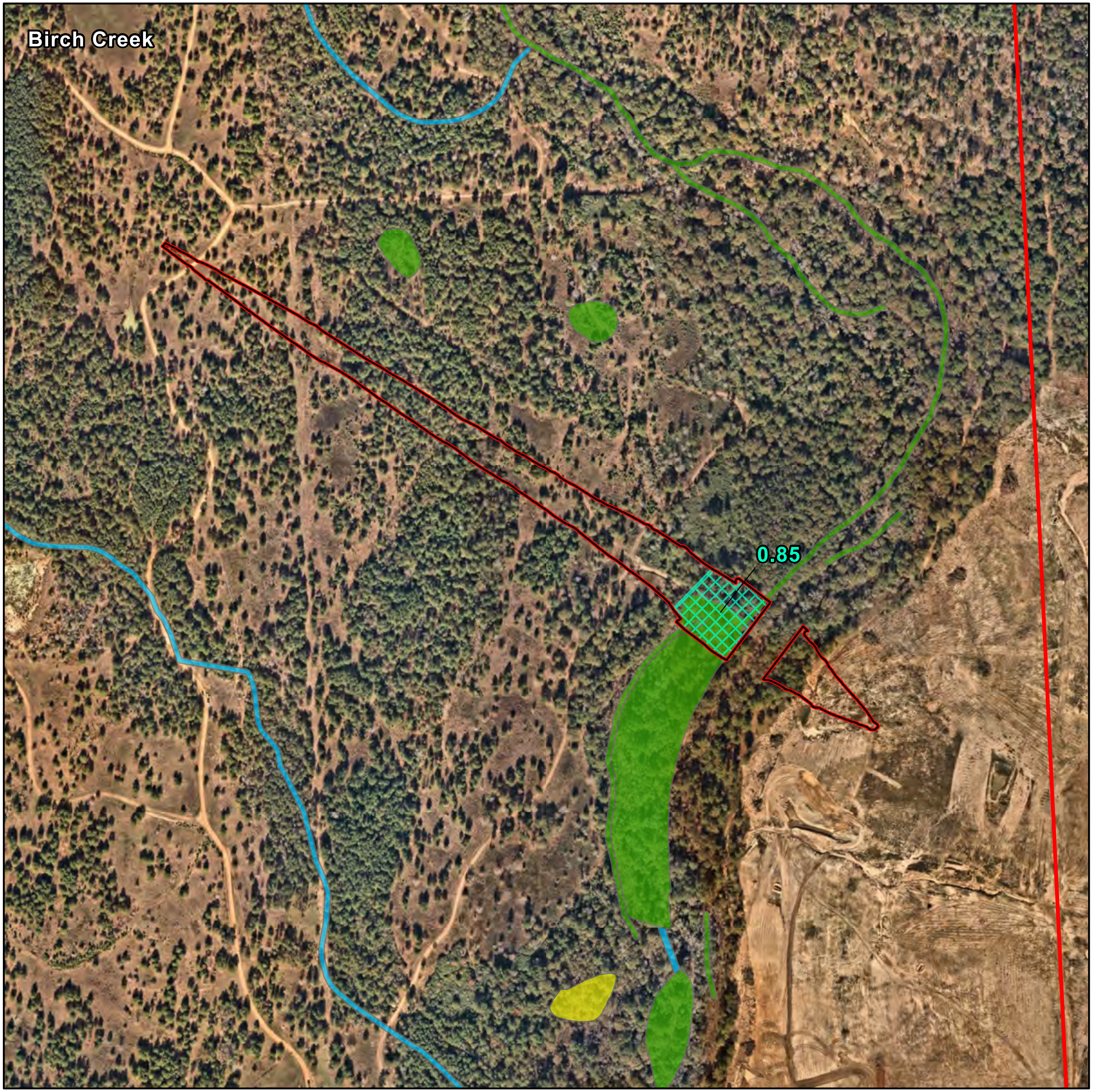
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

Notes:
1. Map Center: 95.83569°W 30.19458°N
2. Nearmap WMS Server: 2023
3. USFWS National Wetlands Inventory

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 6a
Potential Impacts Map

halff



Legend

- Study Area
- Dam Alignments
- Potential Impacts (Dam)

NWI Feature Type

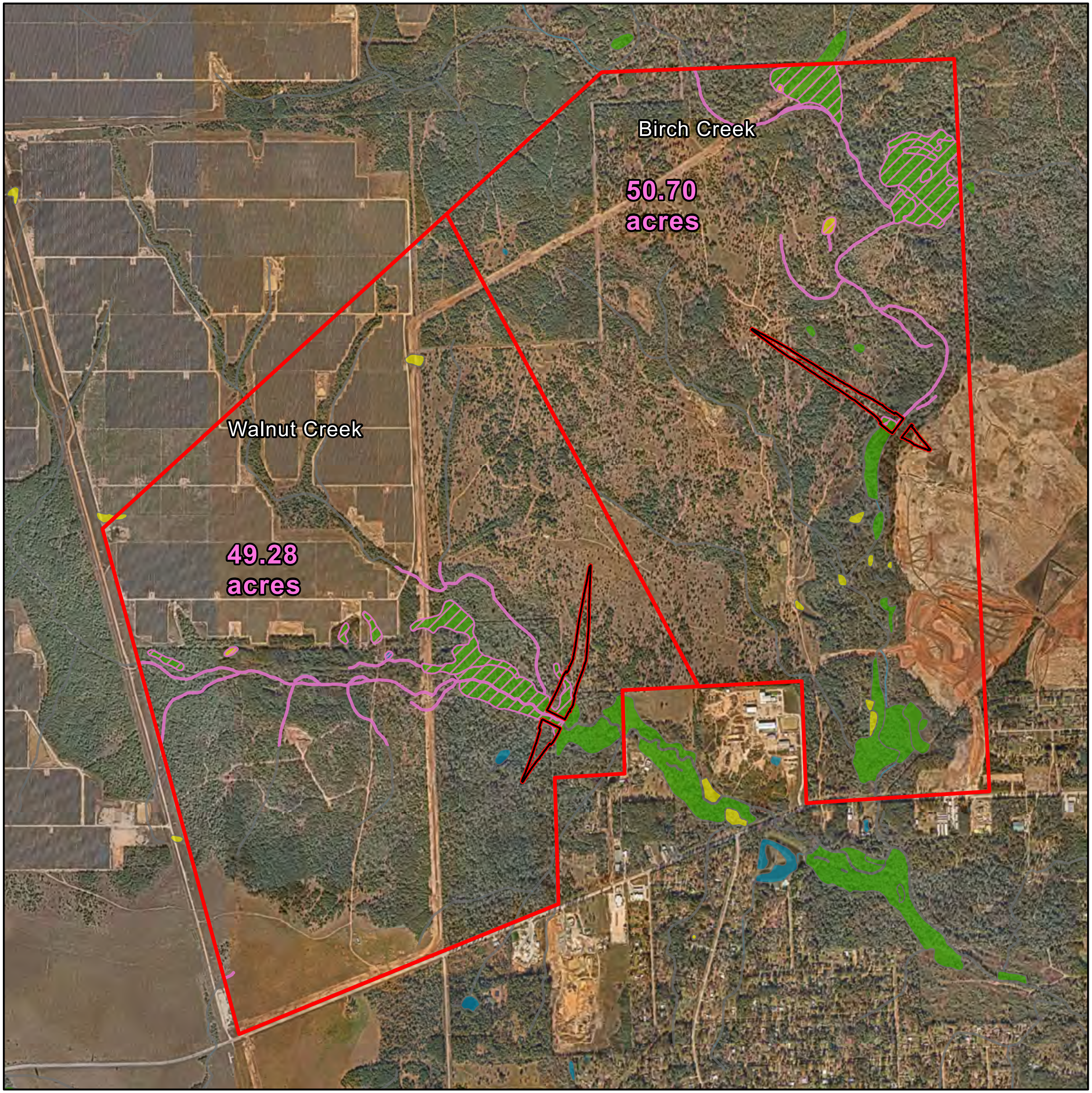
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

Notes:
1. Map Center: 95.82208°W 30.20552°N
2. Nearmap WMS Server: 2025
3. USFWS National Wetlands Inventory

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 6b
Potential Impacts Map

halff



Legend

- Study Area
- Dam Alignments
- Potential Flooding

NWI Feature Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2025
3. USFWS National Wetlands Inventory

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
WOTUS Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 6c
Potential Impacts Map

halff

Appendix A1-2:
NRCS Soil Map Unit Descriptions

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Austin and Waller Counties, Texas

April 18, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

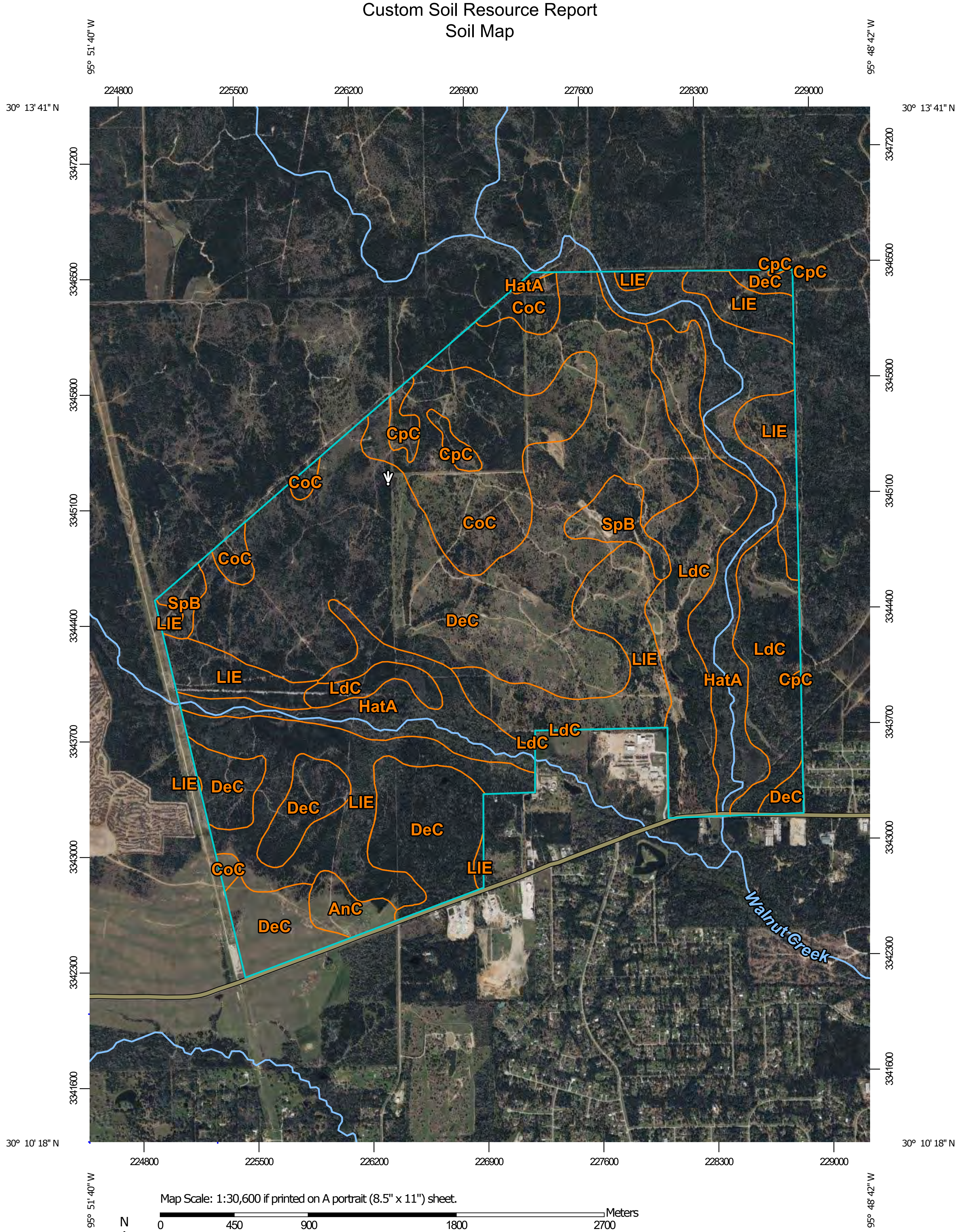
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:30,600 if printed on A portrait (8.5" x 11") sheet.

Meters: 0 450 900 1800 2700

Feet: 0 1000 2000 4000 6000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Austin and Waller Counties, Texas
Survey Area Data: Version 21, Sep 5, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 26, 2023—Mar 4, 2023

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AnC	Annona fine sandy loam, 1 to 5 percent slopes	31.7	1.2%
CoC	Conroe loamy fine sand, 1 to 5 percent slopes	279.6	10.2%
CpC	Conroe soils, graded, 1 to 5 percent slopes	26.1	1.0%
DeC	Depcor loamy fine sand, 1 to 5 percent slopes	1,107.8	40.3%
HatA	Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded	364.6	13.3%
LdC	Landman loamy fine sand, 1 to 5 percent slopes	368.8	13.4%
LlE	Landman-Larue complex, 3 to 12 percent slopes	512.9	18.7%
SpB	Splendora fine sandy loam, 0 to 2 percent slopes	56.1	2.0%
Totals for Area of Interest		**2,747.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Austin and Waller Counties, Texas

AnC—Annona fine sandy loam, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: 30d1j
Elevation: 200 to 500 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 64 to 68 degrees F
Frost-free period: 217 to 280 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Annona and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Annona

Setting

Landform: Interfluves
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Clayey residuum weathered from sandstone and shale

Typical profile

A - 0 to 10 inches: fine sandy loam
Bt - 10 to 18 inches: clay
Btss - 18 to 80 inches: clay

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: F133BY013TX - Terrace
Hydric soil rating: No

Minor Components

Kullit

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F133BY005TX - Loamy Upland
Hydric soil rating: No

Sacul

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

CoC—Conroe loamy fine sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: 30drv
Elevation: 240 to 420 feet
Mean annual precipitation: 42 to 43 inches
Mean annual air temperature: 67 to 68 degrees F
Frost-free period: 263 to 273 days
Farmland classification: Not prime farmland

Map Unit Composition

Conroe and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Conroe

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy and clayey fluviomarine deposits

Typical profile

A - 0 to 6 inches: loamy fine sand
E - 6 to 22 inches: gravelly loamy fine sand

Bt - 22 to 25 inches: sandy clay
Btv - 25 to 70 inches: clay
BCv - 70 to 80 inches: sandy clay

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: 23 to 43 inches to plinthite
Drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.1 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum: 0.7
Available water supply, 0 to 60 inches: Very low (about 2.1 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

Minor Components

Depcor

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY007TX - Southern Sandy Loam Upland
Hydric soil rating: No

Boy

Percent of map unit: 4 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY009TX - Southern Deep Sandy Upland
Hydric soil rating: No

Segno

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY005TX - Loamy Upland
Hydric soil rating: No

Splendora

Percent of map unit: 2 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

Fetzer

Percent of map unit: 1 percent
Landform: Interfluves
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

CpC—Conroe soils, graded, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: djzz
Elevation: 50 to 500 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 260 to 285 days
Farmland classification: Not prime farmland

Map Unit Composition

Conroe and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Conroe

Setting

Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Clayey residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 3 inches: gravelly loamy fine sand
H2 - 3 to 65 inches: sandy clay

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Moderately well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

Minor Components

Fetzer

Percent of map unit: 5 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

Depcor

Percent of map unit: 5 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY007TX - Southern Sandy Loam Upland
Hydric soil rating: No

Waller

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F152BY007TX - Poorly Drained Loamy Upland
Hydric soil rating: Yes

DeC—Depcor loamy fine sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: 30cqq
Elevation: 200 to 470 feet
Mean annual precipitation: 40 to 48 inches
Mean annual air temperature: 57 to 77 degrees F

Frost-free period: 260 to 272 days
Farmland classification: Not prime farmland

Map Unit Composition

Depcor and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Depcor

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Loamy residuum weathered from sandstone and shale

Typical profile

A/E - 0 to 22 inches: loamy fine sand
Btv1 - 22 to 72 inches: sandy clay loam
Btv2 - 72 to 76 inches: sandy clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 6.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F133BY007TX - Southern Sandy Loam Upland
Hydric soil rating: No

Minor Components

Conroe

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

Boy

Percent of map unit: 5 percent
Landform: Interfluves

Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F152BY006TX - Well Drained Loamy Upland
Hydric soil rating: No

Splendora

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F152BY005TX - Seasonally Wet Loamy Upland
Hydric soil rating: No

Fetzer

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

HatA—Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 1vykn
Elevation: 20 to 150 feet
Mean annual precipitation: 48 to 62 inches
Mean annual air temperature: 67 to 68 degrees F
Frost-free period: 240 to 300 days
Farmland classification: Not prime farmland

Map Unit Composition

Hatliff and similar soils: 38 percent
Pluck and similar soils: 35 percent
Kian and similar soils: 24 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hatliff

Setting

Landform: Flood plains
Landform position (three-dimensional): Rise
Microfeatures of landform position: Bars

Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Holocene age clayey alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 12 inches: loam
Bw1 - 12 to 38 inches: fine sandy loam
Bw2 - 38 to 62 inches: fine sandy loam
Bg - 62 to 80 inches: fine sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 44 to 64 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.3 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): 5w
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: A
Ecological site: F152BY012TX - Well Drained Bottomland
Hydric soil rating: No

Description of Pluck

Setting

Landform: Flood plains
Landform position (three-dimensional): Dip
Microfeatures of landform position: Channels
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Loamy alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 6 inches: fine sandy loam
Bg1 - 6 to 34 inches: loam
Bg2 - 34 to 60 inches: loam
Bg3 - 60 to 80 inches: loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 3 to 6 inches

Frequency of flooding: Frequent
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.5 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): 5w
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F152BY013TX - Poorly Drained Loamy Bottomland
Hydric soil rating: Yes

Description of Kian

Setting

Landform: Flood plains
Landform position (three-dimensional): Dip
Microfeatures of landform position: Channels
Down-slope shape: Linear
Across-slope shape: Concave, linear
Parent material: Loamy alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 5 inches: fine sandy loam
Bw - 5 to 26 inches: fine sandy loam
Bg1 - 26 to 55 inches: fine sandy loam
Bg2 - 55 to 80 inches: loamy fine sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 3 to 10 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.5 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water supply, 0 to 60 inches: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): 8e
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: D
Ecological site: F152BY013TX - Poorly Drained Loamy Bottomland
Hydric soil rating: Yes

Minor Components

Simelake

Percent of map unit: 2 percent
Landform: Flats
Landform position (three-dimensional): Talf

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F152BY014TX - Poorly Drained Clayey Bottomland
Hydric soil rating: Yes

Cowmarsh

Percent of map unit: 1 percent
Landform: Oxbows
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: F152BY011TX - Swamp
Hydric soil rating: Yes

LdC—Landman loamy fine sand, 1 to 5 percent slopes

Map Unit Setting

National map unit symbol: dk10
Elevation: 170 to 350 feet
Mean annual precipitation: 42 to 52 inches
Mean annual air temperature: 66 to 70 degrees F
Frost-free period: 240 to 285 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Landman and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Landman

Setting

Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loamy residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 65 inches: loamy fine sand
H2 - 65 to 80 inches: sandy clay loam

Properties and qualities

Slope: 1 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)

Depth to water table: About 48 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F133BY013TX - Terrace
Hydric soil rating: No

Minor Components

Depcor

Percent of map unit: 3 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY007TX - Southern Sandy Loam Upland
Hydric soil rating: No

Conroe

Percent of map unit: 3 percent
Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

Boy

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F152BY006TX - Well Drained Loamy Upland
Hydric soil rating: No

Fetzer

Percent of map unit: 3 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

Larue

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY006TX - Northern Sandy Loam Upland
Hydric soil rating: No

LIE—Landman-Larue complex, 3 to 12 percent slopes

Map Unit Setting

National map unit symbol: dk11
Elevation: 350 to 650 feet
Mean annual precipitation: 40 to 46 inches
Mean annual air temperature: 64 to 70 degrees F
Frost-free period: 230 to 285 days
Farmland classification: Not prime farmland

Map Unit Composition

Larue and similar soils: 40 percent
Landman, affr >30, and similar soils: 30 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Larue

Setting

Landform: Interfluves
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Loamy residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 28 inches: loamy fine sand
H2 - 28 to 72 inches: sandy clay loam
H3 - 72 to 76 inches: sandy clay loam

Properties and qualities

Slope: 3 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 6.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F133BY006TX - Northern Sandy Loam Upland
Hydric soil rating: No

Description of Landman, Affr >30

Setting

Landform: Interfluves
Parent material: Loamy residuum weathered from sandstone and shale

Typical profile

H1 - 0 to 62 inches: loamy fine sand
H2 - 62 to 80 inches: sandy clay loam

Properties and qualities

Slope: 3 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 48 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F133BY013TX - Terrace
Hydric soil rating: No

Minor Components

Conroe

Percent of map unit: 10 percent
Landform: Interfluves
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: F133BY003TX - Loamy Over Clayey Upland
Hydric soil rating: No

Depcor

Percent of map unit: 10 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F133BY007TX - Southern Sandy Loam Upland
Hydric soil rating: No

Fetzer

Percent of map unit: 5 percent
Landform: Interfluves
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: F133BY002TX - Seasonally Wet Upland
Hydric soil rating: No

Boy

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F152BY006TX - Well Drained Loamy Upland
Hydric soil rating: No

SpB—Splendora fine sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: f763
Elevation: 80 to 400 feet
Mean annual precipitation: 48 to 58 inches
Mean annual air temperature: 67 to 68 degrees F
Frost-free period: 240 to 300 days
Farmland classification: Not prime farmland

Map Unit Composition

Splendora and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Splendora

Setting

Landform: Flatwoods
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Early pleistocene age loamy fluviomarine deposits derived from igneous, metamorphic and sedimentary rock

Typical profile

A - 0 to 6 inches: fine sandy loam
E - 6 to 15 inches: fine sandy loam
Bt/E - 15 to 28 inches: loam
Bt - 28 to 70 inches: loam
Btg - 70 to 80 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 10 to 32 inches
Frequency of flooding: None

Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.2 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: D
Ecological site: F152BY005TX - Seasonally Wet Loamy Upland
Hydric soil rating: No

Minor Components

Waller

Percent of map unit: 7 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F152BY007TX - Poorly Drained Loamy Upland
Hydric soil rating: Yes

Segno

Percent of map unit: 3 percent
Landform: Interfluves
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: F152BY006TX - Well Drained Loamy Upland
Hydric soil rating: No

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Appendix A2:
Protected Species Desktop Assessment Report for the Spring Creek Dam Feasibility Study

Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

SJRA
SAN JACINTO RIVER AUTHORITY

Protected Species Desktop Assessment Report for the Spring Creek Dam Feasibility Study

Flood Infrastructure Fund Category 1

Project ID 21-0016

Prepared for:

Texas Water Development Board

Prepared by:

Halff

Richard Howard, P.W.S.

Table of Contents

List of Tables

List of Appendices

1 Introduction

At the request of the San Jacinto River Authority, Halff Associates (Halff) conducted a desktop assessment of federally and state protected species (threatened and endangered species, migratory birds, and bald and golden eagle) for the Spring Creek Dam Feasibility Study (proposed project). The proposed project includes construction alternatives for detention basins within the Spring Creek watershed near Magnolia, Texas (project area) to reduce flooding in The Woodlands and other areas downstream to the confluence of the San Jacinto River (**Figure 1, Appendix A2-1**). The project area contains two potential dam alignments within the sub-watersheds of Walnut Creek and Birch Creek. The dam alignment within the Walnut Creek sub-watershed is situated between Farm-to-market (FM) 1488 and Riley Road. The dam alignment within the Birch Creek sub-watershed is situated between FM 1488, Ranch Crest Drive, and FM 1774. Both potential projects are in the Spring watershed as defined by U.S. Geological Survey (USGS) hydrologic unit code (HUC) 12040102. Halff conducted this desktop assessment to determine what, if any, protected species are associated with the potential work areas and identify what permitting tasks may be required for the project.

2 Background information

2.1 Endangered Species Act

U.S. Fish and Wildlife Service (USFWS) has authority under the Endangered Species Act (ESA) to list and monitor the status of species whose populations are considered imperiled. USFWS regulations implementing the ESA are codified and regularly updated in 50 Code of Federal Regulations Part 17. The federal process identifies potential candidates based on the species' biological vulnerability. The vulnerability decision is based upon many factors affecting the species within its range and is linked to the best scientific data available to the USFWS at the time. Species listed as threatened or endangered by the USFWS are provided full protection under the ESA including a prohibition of indirect take such as destruction of known critical habitat (i.e., areas formally designated by USFWS in the Federal Register).

USFWS proposes one of three recommended determinations of effect on federally listed endangered and threatened species, species proposed to be listed, and their habitat: "no effect," "may affect, not likely to adversely affect," or "may affect, likely to adversely affect." These three possible determinations are described below.

1. No effect – A "no effect" determination means that there are absolutely no effects from the proposed action, positive or negative, to listed species. A "no effect" determination does not include effects that are insignificant (small in size), discountable (extremely unlikely to occur), or beneficial.
2. May affect, not likely to adversely affect – A "may affect, not likely to adversely affect" determination may be reached for a proposed action where all effects are beneficial, insignificant, or discountable. Beneficial effects have contemporaneous positive effects without any adverse effects to the species or habitat. Insignificant effects relate to the size of the effects and should not reach the scale where take occurs. Discountable effects are those that are extremely unlikely to occur. This conclusion is usually reached through the informal consultation process, and written concurrence from the USFWS exempts the proposed action from formal consultation. The federal action agency's written request for USFWS concurrence should accompany the biological assessment/biological evaluation.
3. May affect, likely to adversely affect – A "may affect, likely to adversely affect" determination means that all adverse effects cannot be avoided. A combination of beneficial and adverse effects is still "likely to adversely affect" even if the net effect is neutral or positive. Section 7 of the ESA requires that the federal action agency request initiation of formal consultation with the USFWS when a "may affect, likely to adversely affect" determination is made. A written request for formal consultation should accompany the biological assessment/biological evaluation. Formal consultation results in the USFWS issuing a biological opinion as to whether the action, as proposed, will jeopardize the continued existence of any listed species.

These effects determinations are based on the potential for the species or their habitat to occur and the planned construction activities within the project area. Because the project's construction activities are undefined, this report is limited to the potential to occur.

2.2 Texas Parks and Wildlife Code

The 1973 Texas endangered species legislation and subsequent amendments have established a state regulatory program for the management and protection of endangered species (i.e., species in danger of extinction) and threatened species (i.e., likely to become endangered within the foreseeable future). Chapters 67 and 68 of the Texas Parks and Wildlife Code authorize the TPWD to formulate lists of threatened and endangered fish and wildlife species and to regulate the taking or possession of the species. Under this statutory authority, the TPWD regulates the taking, possession, transport, export, processing, selling or offering for sale, or shipping of threatened or endangered species of fish and wildlife.

2.3 Migratory Bird Treaty Act

Passed in 1918, Migratory Bird Treaty Act (MBTA) utilizes treaties between the United States, Canada, Mexico, and Russia to protect migratory bird species populations. Under federal regulation, the MBTA makes it unlawful to pursue, hunt, take, capture, kill, possess, sell, purchase, barter, import, export, or transport any migratory bird, or any part, nest, or egg of any such bird without a USFWS-issued permit.

2.4 Bald and Golden Eagle Act

Enacted in 1940, the Bald and Golden Eagle Protection Act (BGEPA) has since undergone various amendments and ultimately aids in the federal protection and management of bald eagles and golden eagles. The BGEPA prohibits the take, possession, sale, purchase, barter, offer to sell, purchase or barter, transport, export, or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit.

3 Methods

Halff completed a desktop review of the study area utilizing information and data from the following resources:

- Mussels of Texas Project Database
- National Hydrography Dataset (NHD)
- National Wetland Inventory (NWI)
- TPWD Ecological Mapping Systems of Texas (EMST) and Rare, Threatened, and Endangered Species of Texas (RTEST) list
- USFWS IPaC and Environmental Conservation Online System (ECOS)
- United States Department of Agriculture (USDA) National Resource Conservation Service (NRCS) Web Soil Survey
- U.S. Geological Survey (USGS) Texas Geologic Database.

Habitat conditions within the study area were characterized using USGS Texas Geologic Map Database, NRCS Web Soil Survey, and EMST. The USFWS IPaC is an online tool that provides information on federally managed resources to streamline the environmental review process. Through the USFWS IPaC, a local USFWS office can generate an official species list based on the location in which the project occurs. The official species list identifies federally listed threatened and endangered species, proposed to be listed species, candidate species, and designated critical habitat that may occur within the boundary of the study area and/or may be affected by the project. Under Section 7 of the ESA, this information is used to evaluate suitable habitat within the study area and potential environmental impacts that may result from the proposed project.

The TPWD RTEST by County is an online tool that generates information regarding potential occurrence of federally- and state-protected species and Species of Greatest Conservation Need (SGCN) on a county level. Species designated as a SGCN are generally those that are declining or rare and in need of attention to recover or to prevent the need to list under state or federal regulation. Species designated as SGCN do not have regulatory protection and will not be discussed further. Historically, the TPWD county species lists have been overly inclusive when compared to USFWS lists and may list species known to be extirpated from the area. Furthermore, TPWD only regulates intentional direct harms to the state listed species. The TPWD RTEST species list for Waller County, which was last updated on September 1, 2023, was used to evaluate potential impacts to protected species based on the presence of suitable habitat within the study area for each state listed species.

The above resources identify listed species whose known ranges could extend into the study area, provide requisite habitat descriptions, and identify if USFWS-designated critical habitat exists within the vicinity. Potential for the proposed project to affect species listed by the USFWS under the ESA was evaluated by comparing USFWS's IPaC, TPWD's RTEST species lists, TPWD TXNDD data, and the study area's habitat conditions.

4 Habitat assessment

4.1 Terrestrial habitats

4.1.1 Ecoregion

According to the Level III Ecoregions created by the Environmental Protection Agency, the study area is located within the South Central Plains ecoregion near its intersection with Texas Blackland Prairie and East Central Texas Plains (**Figure 2, Appendix A2-1**). The South Central Plains ecoregion constitutes much of the east Texas piney woods on the western edge of the southern coniferous forest belt. Although the ecoregion historically consisted of a mix of pine and hardwood forests, loblolly and shortleaf pine plantations now dominate much of the region. Soils throughout the ecoregion are generally acidic sands and sandy loams. Croplands are generally sparse throughout the region, with roughly two-thirds of the region dominated by forests and woodland. Lumber, pulpwood, oil, and gas production are major economic activities in the ecoregion.

Furthermore, the study area is within the Southern Tertiary Uplands Level IV Ecoregion. Mesic sites are dominated by mixed hardwood pine forests with a variety of species components. Although, some sandstone outcrops have distinctive barrens or glades, seeps in sand hills support acid bog species, similar to those found in the Flatwoods. The region is relatively hilly and dissected with soils that are generally better drained over the more permeable sediments. Today, the region is more pine forest than the oak-pine and pastureland cover with large parts of the region consisting of National Forests.

4.1.2 Geology

The only geologic unit within the study area is the Willis Formation (Qwc) (**Figure 3, Appendix A2-1**). Major constituents within Qwc consist of clay, silt, sand, and siliceous gravel of granule to pebble size, including some petrified wood, with coarser sands in younger rocks. The soils are noncalcareous and cemented by iron oxide locally. Iron oxide concretions are abundant throughout, especially in the western portions. Scarps (bluffs) may form on the landward portions of this formation. This geologic unit dates to the Pleistocene.

4.1.3 Soils

Eight soil units occur within the study area (**Figure 4, Appendix A2-1**). Characteristics of each soil unit are summarized in Table 4-1.

Table 4-1 Summary of Soil Units

Map Unit Name (Symbol)	Hydric Soil Map Unit	Hydric Component Characteristics			Acreage	Percent of Study Area
		Unit Name (Percent)	Landform	Hydric Criteria		
Annona fine sandy loam, 1 to 5 percent slopes (AnC)	No	NA	NA	NA	31.7	1.2
Conroe loamy fine sand, 1 to 5 percent slopes (CoC)	No	NA	NA	NA	279.6	10.2
Conroe soils, graded, 1 to 5 percent slopes Yes (CpC)	Yes	Waller (5%)	Flats	2	26.1	1.0
Depcor loamy fine sand, 1 to 5 percent slopes (DeC)	No	NA	NA	NA	1,107.8	40.3
Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA)	Yes	Pluck (35%) Kian (24%) Simelake (2%) Cowmarsh (1%)	Flood plains Flood plains Flats Oxbows	2 2 4 2, 3, 4	364.6	13.3
Landman loamy fine sand, 1 to 5 percent slopes (LdC)	No	NA	NA	NA	368.8	13.4
Landman-Larue complex, 3-12 percent slopes (LIE)	No	NA	NA	NA	512.9	18.7
Splendora fine sandy loam, 0 to 2 percent slopes (PsB)	No	NA	NA	NA	56.1	2.0

Source: USDA NRCS Web Soil Survey

4.1.4 Vegetation

The TPWD EMST database is a 398 class, ten-meter spatial resolution land classification map for Texas. According to the EMST data, the study area contains nine vegetation types (**Figure 5, Appendix A2-1**). The most common vegetation types within the study area are all various subclasses of Pineywoods, which collectively make up approximately 98% (approximately 2,689 acres) of the study area. The EMST classifications indicate that the communities are generally dominated by loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), post oak (*Q. stellata*), sugarberry (*Celtis laevigata*), American elm (*Ulmus americana*), cedar elm (*U. crassifolia*), and green ash (*Fraxinus pennsylvanica*). Where these are absent, herbaceous communities are dominated by Bermudagrass (*Cynodon dactylon*), bahia grass (*Paspalum notatum*), and perennial ryegrass (*Lolium perenne*). Table 4-2 summarizes all EMST vegetation types associated with the study area.

Table 4-2 Predominant Vegetation Communities within the Project Area

EMST Vegetation Types – Common Name	Dominant Plant Species	Acreage	Percent of Study Area
Pine Plantation > 3 Meters Tall	*Pinus taeda*, *Pinus echinata*, *Liquidambar styraciflua*, *Quercus nigra*, *Nyssa sylvatica*, *Quercus falcata*, *Quercus stellata*, and *Quercus alba*	57.31	2.09
Pineywoods: Disturbance or Tame Grasslands	Non-native grasses (*Cynodon dactylon*, *Paspalum notatum*, *Lolium perenne*, *Schedonorus phoenix*, *Bromus catharticus*) and native grasses (e.g., *Andropogon virginicus*, *Schizachyrium scoparium*)	1.22	0.04
Pineywoods: Pine-Hardwood Forest or Plantation	*Pinus taeda* with co-dominant hardwood species	645.82	23.50
Pineywoods: Pine Forest or Plantation	*Pinus taeda* and other pines	782.43	28.48
Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest	*Liquidambar styraciflua*, *Quercus nigra*, *Celtis laevigata*, *Ulmus crassifolia*, and *Fraxinus pennsylvanica*.	266.07	9.68
Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest	*Pinus taeda*, *Pinus elliottii*, and/or *Juniperus virginiana* with mixed deciduous species sharing in the canopy	34.75	1.26
Pineywoods: Southern Mesic Pine-Hardwood Forest	*Fagus grandifolia*, *Magnolia grandiflora*, *Pinus taeda*, and *Pinus echinata*	0.29	0.01
Pineywoods: Upland Hardwood Forest	A wide variety of hardwoods (*Quercus* sp., *Liquidambar styraciflua*, *Ulmus* sp., often including *Pinus taeda*	958.06	34.87
Urban Low Intensity	Built up lands with little, if any, vegetation	1.80	0.07

4.2 Aquatic habitats

Based on the USGS topographic maps, Halff identified two named streams (Walnut Creek and Birch Creek) and several tributaries within the project area. The NHD and NWI databases were reviewed to identify potential aquatic resources within the study area (**Figure 6, Appendix A2-1**). Based on the NWI, Halff identified 65 NWI features totaling approximately 155 acres within the project area, three of which intersect the proposed alignment of the Walnut Creek detention basin and two of which intersect the alignment of the Birch Creek detention basin. The potentially impacted wetlands measure 3.54 and 0.85 acres for the Walnut Creek detention basin and Birch Creek detention basin, respectively. The proposed alignment for the Walnut Creek detention basin dam may impact Walnut Creek and the proposed alignment for the Birch Creek detention basin dam may impact Birch Creek. Collectively, the project area includes approximately 28,060 linear feet of stream channel (15,296 associated with the Walnut Creek detention basin and 12,764 associated with the Birch Creek detention basin) within 500-year floodplain upstream of the proposed detention basin. Halff identified 35 NHD features within the project area.

5 Results

5.1 Federally listed species

On January 17, 2024, Halff received an official species list (**Appendix A2-2**) from the Texas Coastal Ecological Services Field Office, which identified five species that are listed as threatened, endangered, proposed to be listed, or candidate species that may occur within the study area. A table summarizing the federally listed species, suitable habitat descriptions, and effect determinations is included in **Appendix A2-3**. It is important to note that the occurrence data provided in the official species list are not based on field assessments. Field surveys and project plans will be required to make formal assessments of the effects the project may have to threatened and endangered species.

5.2 State listed species

The TXNDD database does not identify any known occurrence of threatened or endangered species within one mile of the project area. **Figure 7, Appendix A2-1** illustrates this and the nearest recorded protected species: Heller's marbleseed (*Onosmodium helleri*) and eastern box turtle (*Terrapene carolina carolina*).

Halff acquired a list of rare, threatened, and endangered species whose geographic range may include the project area. Review of the TPWD RTEST indicated a total of eleven federally protected species and nineteen state listed species in Waller County that are listed as threatened or endangered by TPWD. A table summarizing the state listed species, suitable habitat descriptions, and impact determinations is included in **Appendix A2-3**.

5.3 Migratory birds

The IPaC report (**Appendix A2-2**) indicates that the project area may support five species protected statutorily under the Migratory Bird Treaty Act. Specifically, these include the American kestrel (*Falco sparverius paulus*), bald eagle (*Haliaeetus leucocephalus*), brown-headed nuthatch (*Sitta pusilla*), Kentucky warbler (*Oporornis formosus*), and red-headed woodpecker (*Melanerpes erythrocephalus*). Field surveys and project plans will be required to make formal assessments of the effects the project may have to these species.

5.4 Bald and golden eagles

In Texas, preferred bald eagle winter nesting habitat is located along or within one to two miles of large bodies of water, such as coasts, bays, lakes, swamps, or marshes. This species typically nests in tall trees and cliffs. Field surveys and project plans will be required to make formal assessments of the effects the project may have to bald eagles.

The golden eagle is typically found in open to semi-open areas composed of native vegetation. This raptor is known to avoid developed areas including agricultural fields as well as heavily forested areas. The golden eagle usually nests in mountains, cliffs, and bluffs from January to September. They have also been known to nest in tall trees, on the ground, or in human-made structures like electric towers and windmills. These habitats are absent from the project area. The study area lacks suitable golden eagle nesting sites, such as mountains, cliffs, bluffs, and tall trees, and is surrounded by agricultural disturbances and development.

Due to the lack of suitable habitat, it is unlikely that the bald or golden eagle would occur within the study area; however, field surveys and project plans will be required to make formal assessments of the effects the project may have to these species.

6 Conclusion

Based on our desktop assessment of the study area, publicly available data, and suitable habitat descriptions, USFWS identifies five species that are listed as threatened, endangered, proposed to be listed, or candidate species that may occur within the study area. TPWD's RTEST provides a more liberal species assessment that includes the potential for eleven federally protected species in addition to nineteen state listed species. In addition, several migratory birds were identified for the project area.

Because the project is conceptual at this point, this assessment provides a preliminary planning tool to aid in identifying potential threatened and endangered species constraints for the project. Depending on project location, design, configuration, and operation, impacts to these species may be reduced or eliminated entirely. Therefore, Halff recommends recommencing these assessments during the formal design process to reduce impacts to species that may be present.

The assessments in **Appendix A2-3** are based on occurrence probability at the time of this report. Depending on when project construction commences, the species lists may alter substantially due to listings and de-listings by TPWD and USFWS. Field surveys and design specifics would need to be evaluated fully to produce a species assessment suitable for permit coordination with USACE and/or USFWS. Coordination with TPWD would only be required if the project will intentionally lead to the death of state listed species.

7 References

Cornell Lab of Ornithology. 2024. "eBird." *eBird*. The Cornell Lab. https://ebird.org/home.

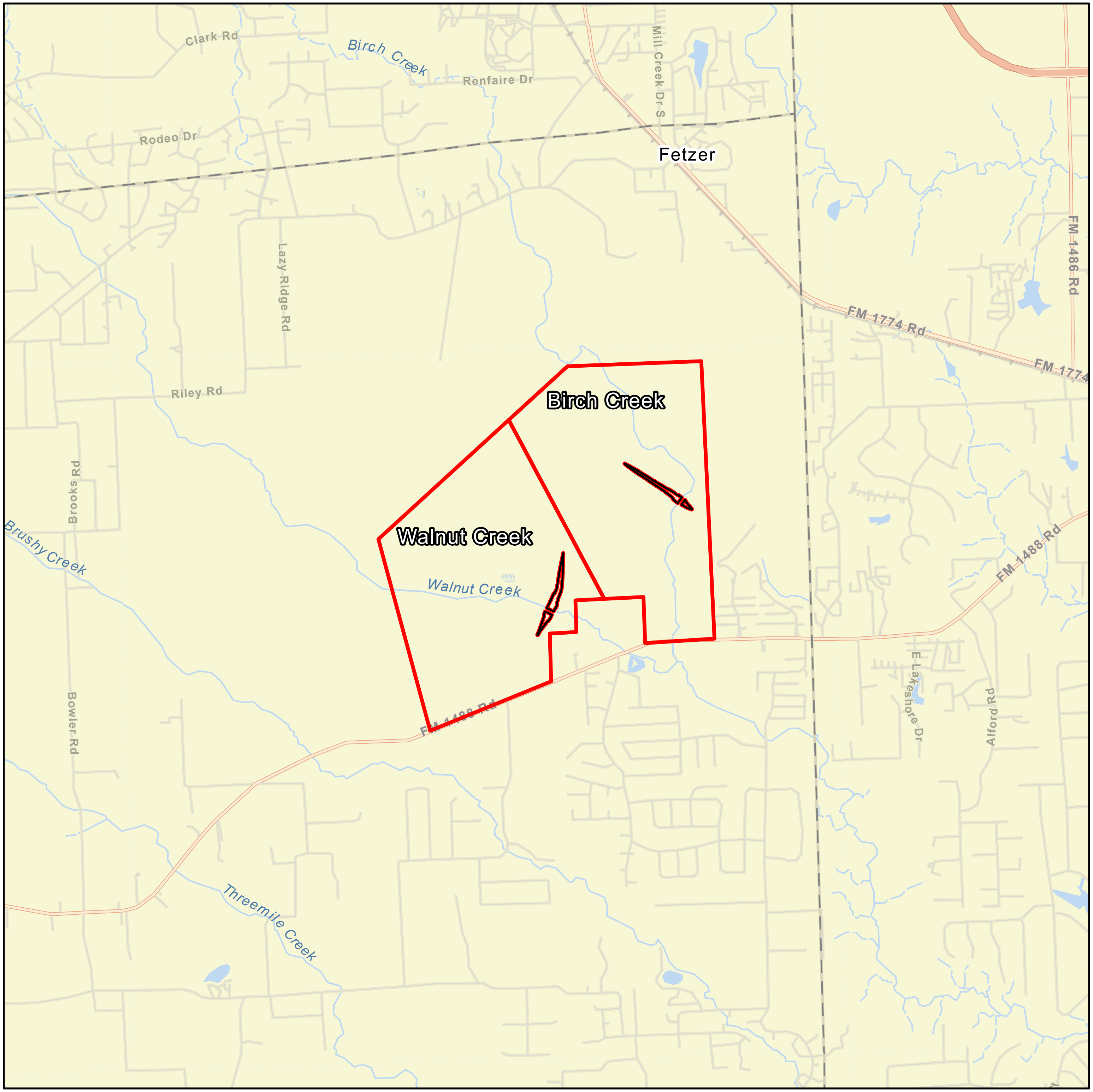
Stoeser, D. B., Shock, N., Green, G. N., Dumonceaux, G. M., & Heran W. D. 2005. "Geologic Map Database of Texas." *U.S. Geological Survey*, ds170, no. 170. doi:10.3133/ds170.

TPWD. 2014. Ecological Mapping Systems of Texas. Descriptions of Systems, Mapping Subsystems, and Vegetation Types for Texas. Accessed May 2024.

TPWD. 2024. Texas Natural Diversity Database. Element Occurrence data export. Wildlife Diversity Program of Texas Parks & Wildlife Department. May 2024.

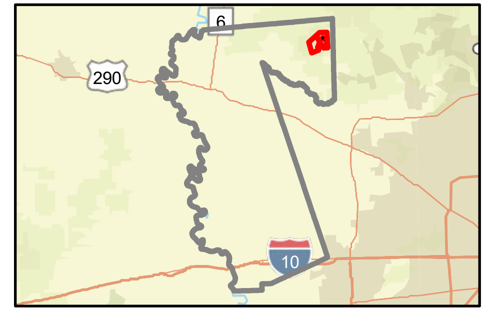
USFWS. 2024. USFWS Official Species List. Houston, TX: Texas Coastal Ecological Services Field Office. October 12, 2023.

Appendix A2-1:
Figures



0 0.5 1 2

Miles



Legend

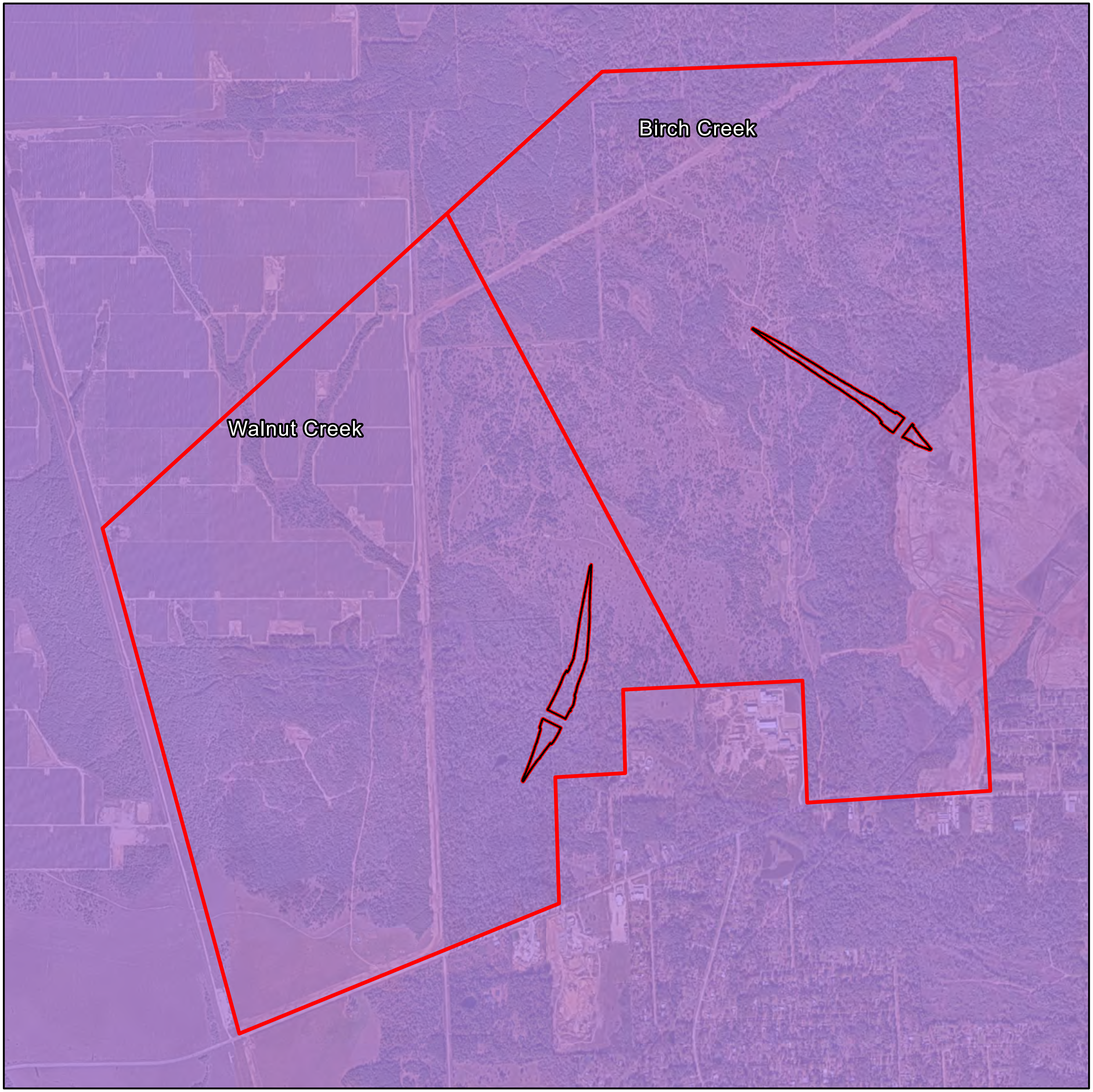
- Study Area
- Dam Alignments

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Service Layer Credits: World Street Map: Texas Parks & Wildlife, CONANP, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS
World Street Map: Baylor University, Texas Parks & Wildlife, CONANP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, USDA, USFWS

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/29/2024 AVO: 42682

Figure 1
Location Map

halff



N

0 1,000 2,000 4,000
Feet

Legend

Study Area

Dam Alignments

Ecoregion

South Central Plains

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2025
3. EPA Level III Ecoregions

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/29/2024 AVO: 42682

Figure 2
Ecoregion Map

halff

Legend

- Study Area
- Dam Alignments

Geologic Unit

- Pow: Willis Formation

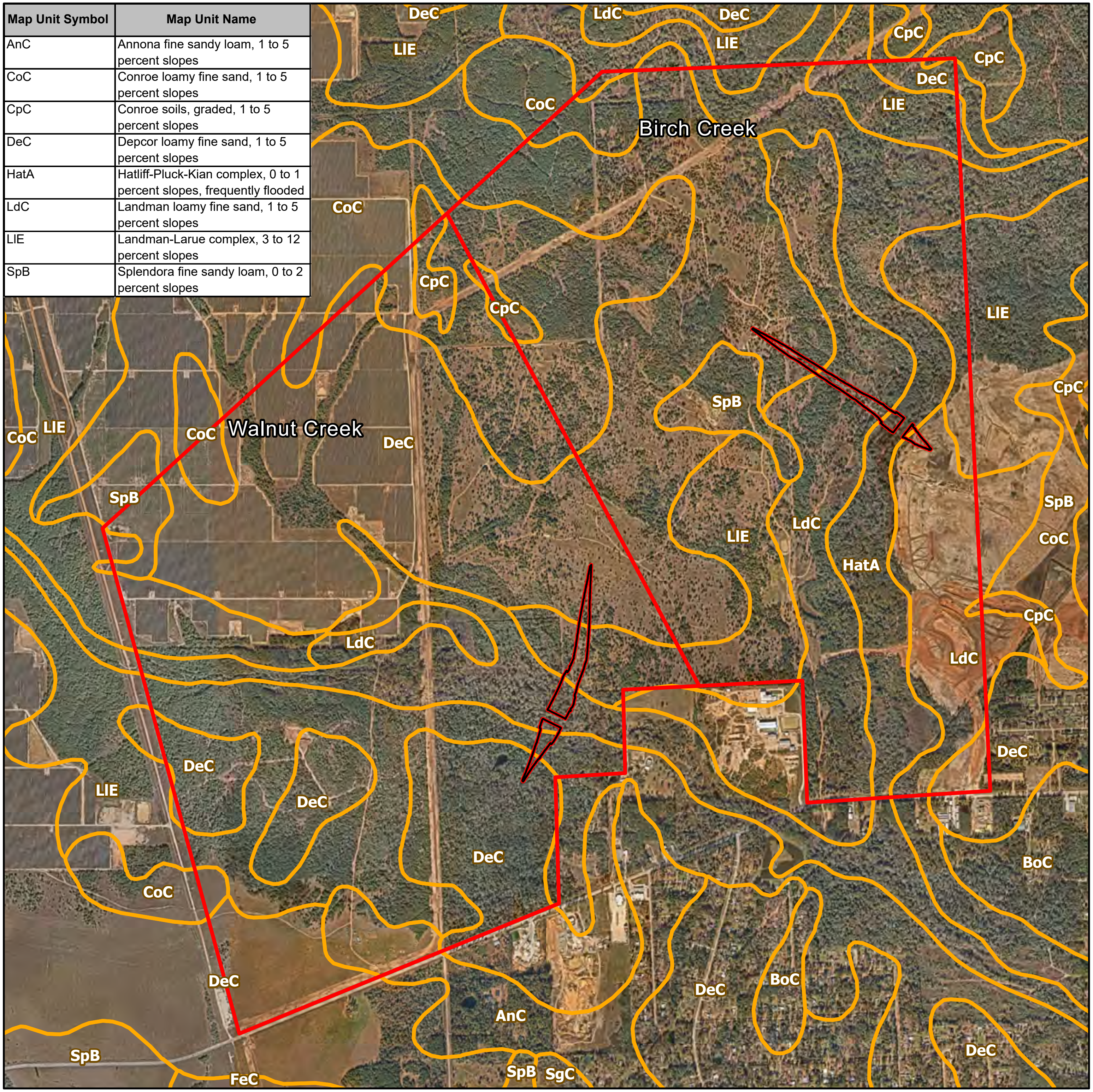
Notes:
1. Map Center: 95.8341°W 30.19998°N
2. Nearmap WMS Server: 20253.
3. USGS Geologic Formations Database

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 3
Geology Map

halff

Map Unit Symbol	Map Unit Name
AnC	Annona fine sandy loam, 1 to 5 percent slopes
CoC	Conroe loamy fine sand, 1 to 5 percent slopes
CpC	Conroe soils, graded, 1 to 5 percent slopes
DeC	Depcor loamy fine sand, 1 to 5 percent slopes
HatA	Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded
LdC	Landman loamy fine sand, 1 to 5 percent slopes
LlE	Landman-Larue complex, 3 to 12 percent slopes
SpB	Splendora fine sandy loam, 0 to 2 percent slopes



Legend

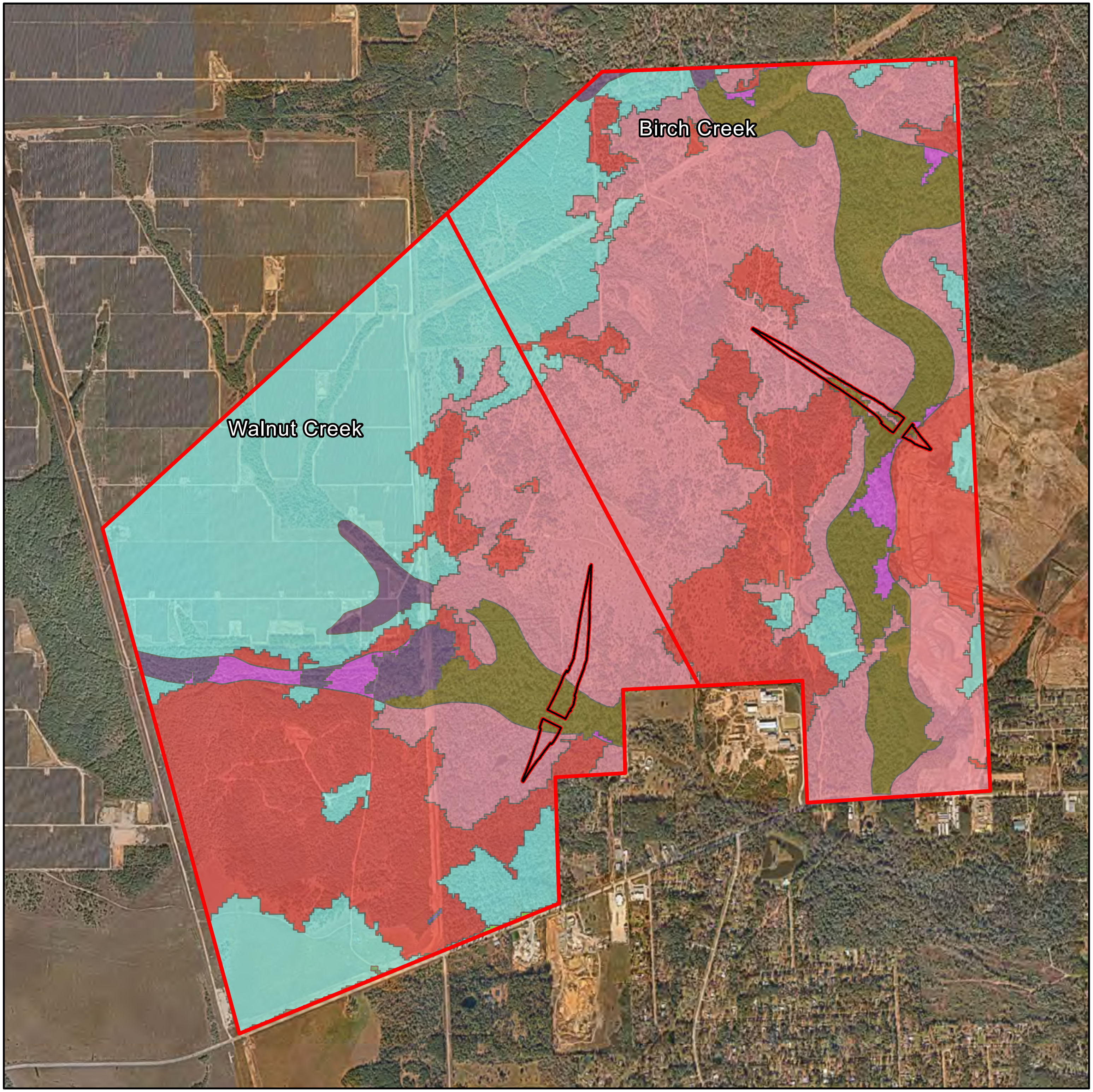
- Study Area
- Dam Alignments
- SSURGO Soil Unit

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2025
3. USDA NRCS Web Soil Survey

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 4
Soil Map

halff



Legend

- Study Area
- Dam Alignments

EMST Type

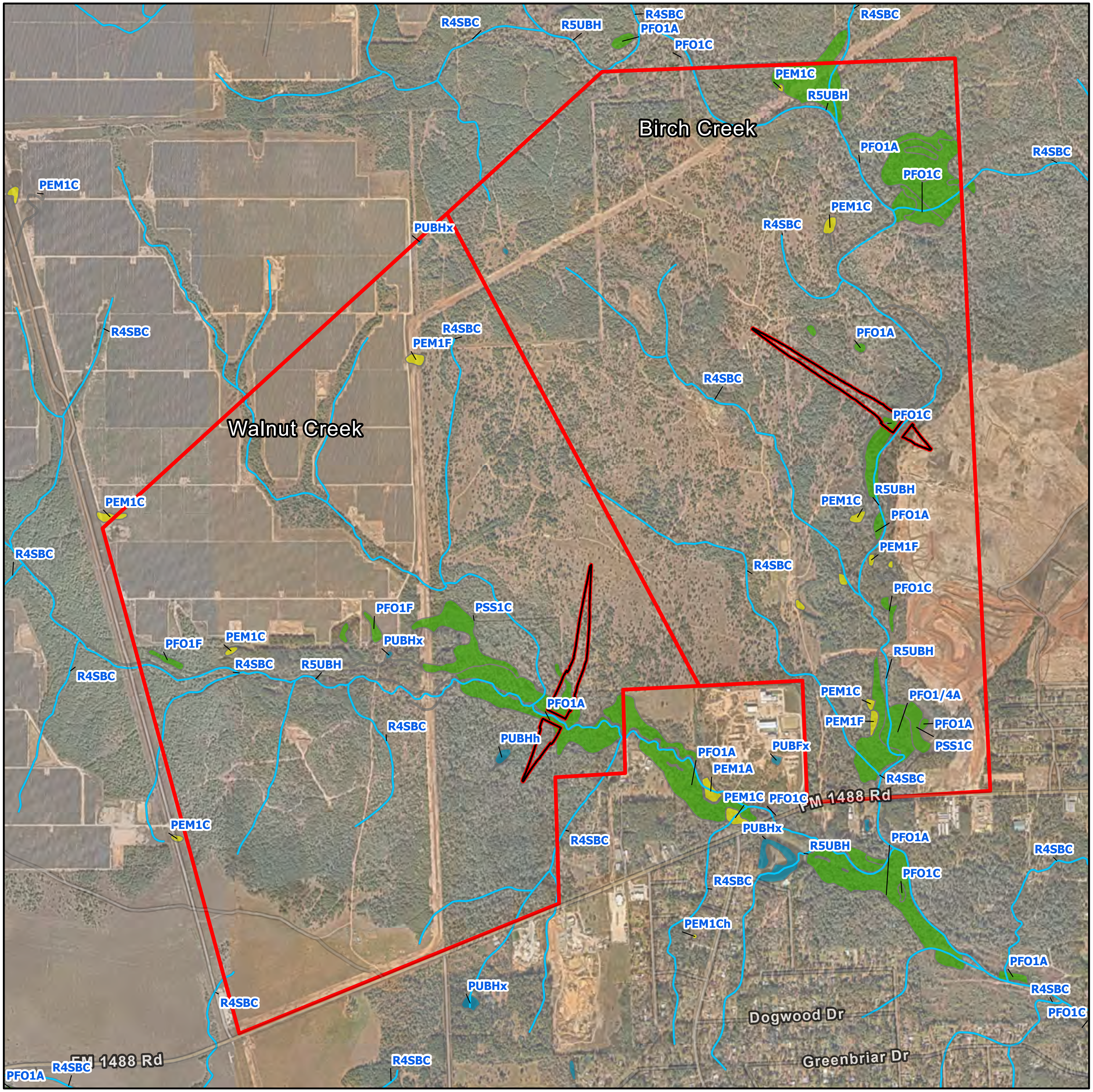
- Pine Plantation > 3 meters tall
- Pineywoods: Disturbance or Tame Grassland
- Pineywoods: Pine - Hardwood Forest or Plantation
- Pineywoods: Pine Forest or Plantation
- Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest
- Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest
- Pineywoods: Southern Mesic Pine - Hardwood Forest
- Pineywoods: Upland Hardwood Forest
- Urban Low Intensity

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2025
3. TPWD Ecological Mapping Systems

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 5
EMST Map

halff



0 1,000 2,000 4,000
Feet

Legend

Study Area

Dam Alignments

NHD Feature Type

Stream/River

NWI Feature Type

Freshwater Emergent Wetland

Freshwater Forested/Shrub Wetland

Freshwater Pond

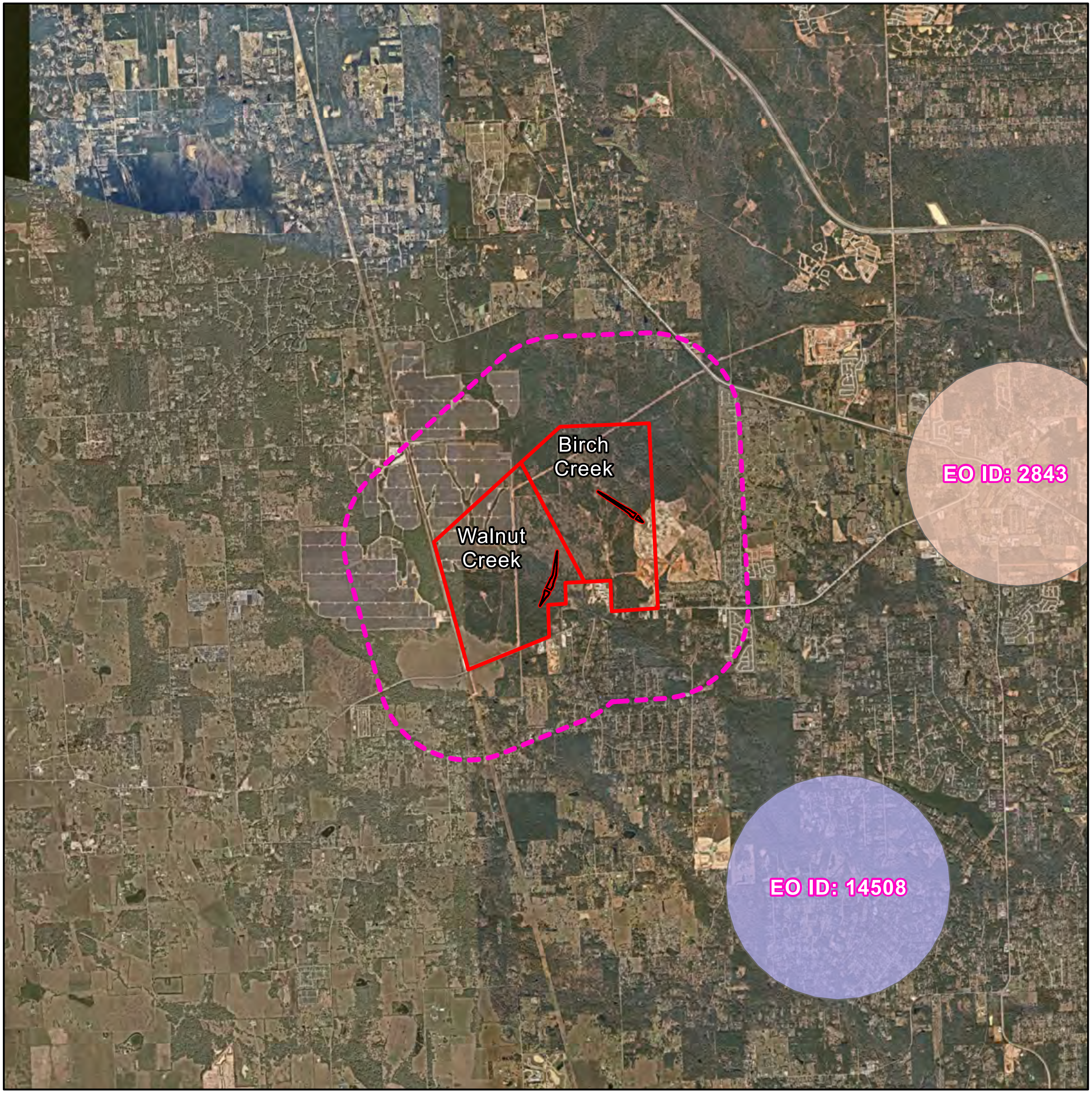
Riverine

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Hybrid Reference Layer: Baylor University, Texas Parks & Wildlife, CONANP, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, USFWS
Nearmap WMS Server: 2024
3. USFWS National Wetlands Inventory
4. USGS National Hydrography Dataset

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 6
NWI and NHD Map

halff



0 0.75 1.5 3
Miles

Legend

- Study Area
- Dam Alignments
- 1-Mile Buffer

Species Common Name

- Heller's marbleseed
- eastern box turtle

Notes:
1. Map Center: 95.83634°W 30.2001°N
2. Nearmap WMS Server: 2025
3. TPWD Texas Natural Diversity Database

Spring Creek Dam Feasibility Study
Magnolia, Waller County, Texas
T&E Desktop Assessment
Date: 5/1/2025 AVO: 42682

Figure 7
TXNDD Map

halff

Appendix A2-2:
USFWS IPaC Report

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Texas Coastal & Central Plains Eso
17629 El Camino Real, Suite 211
Houston, TX 77058-3051
Phone: (281) 286-8282 Fax: (281) 488-5882

In Reply Refer To: January 17, 2024
Project Code: 2024-0037289
Project Name: Spring Creek Detention Dam

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The U.S. Fish and Wildlife Service (Service) field offices in Clear Lake, Corpus Christi, and Alamo, Texas, have combined administratively to form the Texas Coastal Ecological Services Field Office. All project related correspondence should be sent to the field office address listed below responsible for the county in which your project occurs:

Project Leader; U.S. Fish and Wildlife Service; 17629 El Camino Real Ste. 211; Houston, Texas 77058
Angelina, *Austin*, *Brazoria*, *Brazos*, *Chambers, Colorado, Fayette, Fort Bend, Freestone, Galveston, Grimes, Hardin, Harris, Houston, Jasper, Jefferson, Leon, Liberty, Limestone, Madison, Matagorda, Montgomery, Newton, Orange, Polk, Robertson, Sabine, San Augustine, San Jacinto, Trinity, Tyler, Walker, Waller, and Wharton.*

Assistant Field Supervisor, U.S. Fish and Wildlife Service; 4444 Corona Drive, Ste 215; Corpus Christi, Texas 78411
Aransas, Atascosa, Bee, Brooks, Calhoun, De Witt, Dimmit, Duval, Frio, Goliad, Gonzales, Hidalgo, Jackson, Jim Hogg, Jim Wells, Karnes, Kenedy, Kleberg, La Salle, Lavaca, Live Oak, Maverick, McMullen, Nueces, Refugio, San Patricio, Victoria, and Wilson.

U.S. Fish and Wildlife Service; Santa Ana National Wildlife Refuge; Attn: Texas Ecological Services Sub-Office; 3325 Green Jay Road, Alamo, Texas 78516
Cameron, Hidalgo, Starr, Webb, Willacy, and Zapata.

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the Service under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2) (c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at: http://www.fws.gov/media/endangered-species-consultation-handbook.

Non-Federal entities may consult under Sections 9 and 10 of the Act. Section 9 and Federal regulations prohibit the take of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined (50 CFR § 17.3) to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined (50 CFR § 17.3) as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Should the proposed project have the potential to take listed species, the Service recommends that the applicant develop a Habitat Conservation Plan and obtain a section 10(a)(1)(B) permit. The Habitat Conservation Planning Handbook is available at: https://www.fws.gov/library/collections/habitat-conservation-planning-handbook.

Migratory Birds:
In addition to responsibilities to protect threatened and endangered species under the Act, there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts visit: https://www.fws.gov/program/migratory-birds.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable National Environmental Policy Act (NEPA) documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures see https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- Bald & Golden Eagles
- Migratory Birds
- Wetlands

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Texas Coastal & Central Plains Eso
17629 El Camino Real, Suite 211
Houston, TX 77058-3051
(281) 286-8282

PROJECT SUMMARY

Project Code: 2024-0037289
Project Name: Spring Creek Detention Dam
Project Type: Dam - New Construction
Project Description: Potential dams to retard floodwater in an effort to reduce downstream flooding.
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@30.20916005,-95.83076731626113,14z

Counties: Waller County, Texas

ENDANGERED SPECIES ACT SPECIES

There is a total of 5 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 2 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

---

1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Tricolored Bat *Perimyotis subflavus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10515	Proposed Endangered

BIRDS

NAME	STATUS
Piping Plover *Charadrius melodus* Population: [Atlantic Coast and Northern Great Plains populations] - Wherever found, except those areas where listed as endangered. There is **final** critical habitat for this species. Your location does not overlap the critical habitat. This species only needs to be considered under the following conditions: ▪ Wind related projects within migratory route. Species profile: https://ecos.fws.gov/ecp/species/6039	Threatened
Rufa Red Knot *Calidris canutus rufa* There is **proposed** critical habitat for this species. This species only needs to be considered under the following conditions: ▪ Wind related projects within migratory route. Species profile: https://ecos.fws.gov/ecp/species/1864	Threatened

REPTILES

NAME	STATUS
Alligator Snapping Turtle *Macrochelys temminckii* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/4658	Proposed Threatened

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

BALD & GOLDEN EAGLES

Bald and golden eagles are protected under the Bald and Golden Eagle Protection Act[1] and the Migratory Bird Treaty Act[2].

Any person or organization who plans or conducts activities that may result in impacts to bald or golden eagles, or their habitats[3], should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

---

1. The Bald and Golden Eagle Protection Act of 1940.
2. The Migratory Birds Treaty Act of 1918.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

There are bald and/or golden eagles in your project area.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Sep 1 to Jul 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

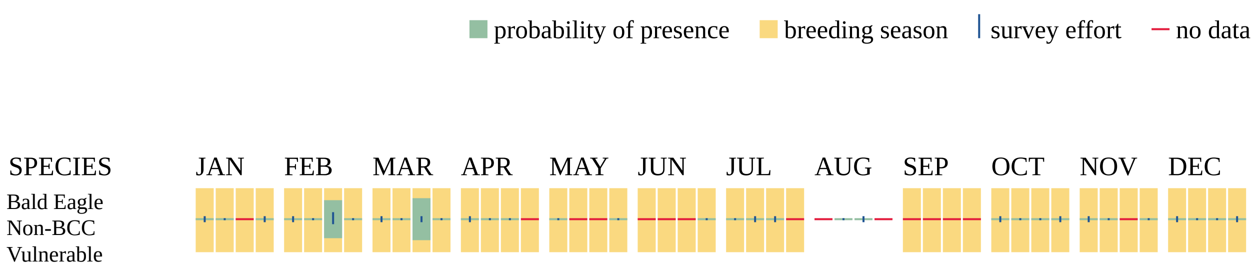
Probability of Presence (■)

Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (■)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds

- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

MIGRATORY BIRDS

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats[3] should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

---

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
American Kestrel *Falco sparverius paulus* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9587	Breeds Apr 1 to Aug 31
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Sep 1 to Jul 31
Brown-headed Nuthatch *Sitta pusilla* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9427	Breeds Mar 1 to Jul 15
Kentucky Warbler *Oporornis formosus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9443	Breeds Apr 20 to Aug 20

NAME	BREEDING SEASON
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9398	Breeds May 10 to Sep 10

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

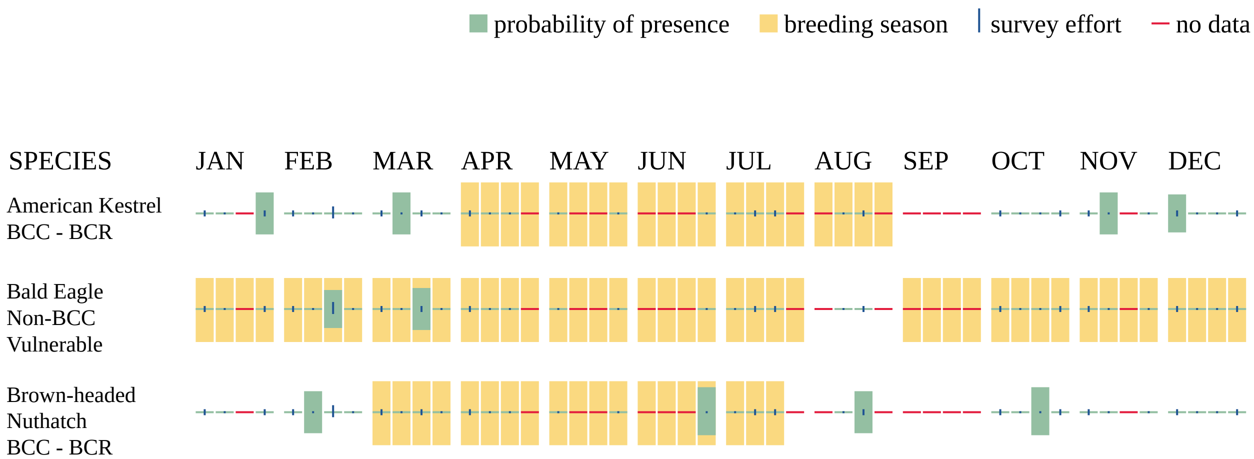
Probability of Presence (■)

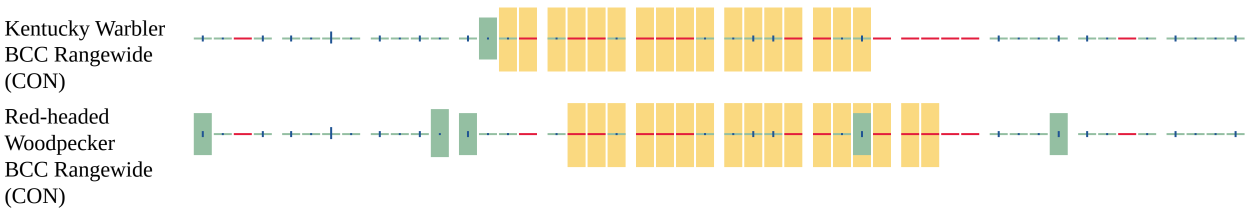
Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (■)
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.





Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

WETLANDS

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

FRESHWATER FORESTED/SHRUB WETLAND

- PFO1C
- PSS1C
- PFO1/4A
- PFO1F
- PFO1A

FRESHWATER POND

- PUBHx
- PUBHh

FRESHWATER EMERGENT WETLAND

- PEM1F
- PEM1C

RIVERINE

- R5UBH
- R4SBC

IPAC USER CONTACT INFORMATION

Agency: Private Entity
Name: Rick Howard
Address: 14800 Saint Mary's Lane Ste 160
Address Line 2: Houston, TX 77079
City: Houston
State: TX
Zip: 72830
Email rhoward@halff.com
Phone: 7135882453

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Army Corps of Engineers

Appendix A2-3:

Threatened and Endangered Species Assessment

Species	Status (Federal/State)	Suitable Habitat	Probability of Occurrence
Plants			
Navasota ladies' tresses (*Spiranthes parksii*)	E / E	Openings in post oak woodlands in sandy loams along upland drainages or intermittent streams, often in areas with suitable hydrologic factors, such as a perched water table associated with the underlying claypan; flowering populations fluctuate widely from year to year. Individual plants may not flower every year. Flowering is between late October and December.	Unlikely to occur. This species is typically found in deep, sandy soils that are well drained. The riparian corridors associated with the project area provide little, if any, habitat of value.
Insects			
Monarch butterfly (*Danaus plexippus*)	C / --	Species consists of migratory and non-migratory populations that feed on the nectar of a wide range of wildflowers. Eggs are typically laid on any of a number of species of milkweeds with larvae feeding on the leaves and stems of these plants until pupating. Currently considered a candidate for listing as a protected species due to population declines.	May occur. Milkweeds are common throughout southeast Texas but are relatively rare in densely forested areas.
Mollusks			
Brazos heelsplitter (*Potamilus streckersoni*)	-- / T	Reported from streams (but not far into the headwaters), large rivers, and some reservoirs. In riverine systems it often occurs in nearshore habitats (banks and backwater pools) but occasionally in main channel habitats such as riffles. Typically found in standing to slow-flowing water in soft substrates consisting of silt, mud, or sand but occasionally in moderate flows with gravel and cobble substrates.	Does not occur. The Mussels of Texas database indicates that this species is absent from the San Jacinto River watershed.
Texas fawnsfoot (*Truncilla macrodon*)	PT / T	Occurs in large rivers but may also be found in medium-sized streams. Is found in protected near shore areas (banks and backwaters) but also riffles and point bar habitats with low to moderate water velocities. Typically occurs in substrates of mud, sandy mud, gravel, and cobble. Considered intolerant of reservoirs.	Unlikely to occur. This species is known to occur within the San Jacinto River watershed; however, the streams in the project area appear to be insufficient to support the species.
Fishes			
Western creek chubsucker (*Erimyzon claviformis*)	-- / T	Eastern Texas streams from the Red River to the San Jacinto drainage. Habitat includes silt-, sand-, and gravel-bottomed pools of clear headwaters, creeks, and small rivers; often near vegetation; occasionally in lakes. Spawning occurs in river mouths or pools, riffles, lake outlets, or upstream creeks. Prefers headwaters, but seldom occurs in springs.	Unlikely to occur. This species is known to occur within the San Jacinto River watershed; however, the streams in the project area appear to be insufficient to support the species.
Paddlefish (*Polyodon spathula*)	-- / T	Species occurred in every major river drainage from the Trinity Basin eastward, but its numbers and range had been substantially reduced by the 1950s; recently reintroduced into Big Cypress drainage upstream of Caddo Lake. Prefers large, free-flowing rivers but will frequent impoundments with access to spawning sites.	Does not occur. The species is not known to be in the San Jacinto watershed. Furthermore, the streams in the project area appear to be too small to support the species.
Amphibians			
Houston toad (*Anaxyrus houstonensis*)	E / E	Primary terrestrial habitat is forests with deep sandy soils. Juveniles and adults are presumed to move through areas of less suitable soils using riparian corridors. Aquatic habitats can include any water body from a tire rut to a large lake.	Unlikely to occur. Although the soil types that are associated with the species are present, there are no records of occurrence in Waller County.

Reptiles			
Alligator snapping turtle (*Macrochelys temminckii*)	PT / T	Perennial water bodies; rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near running water; sometimes enters brackish coastal waters. Females emerge to lay eggs close to the water's edge.	May occur. The species is documented in many streams associated with southeast Texas. Deep water areas in the streams may support populations.
Texas horned lizard (*Phrynosoma cornutum*)	-- / T	Open habitats with sparse vegetation, including grass, prairie, cactus, scattered brush, or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive. Occurs to 6,000 feet, but largely limited below the pinyon-juniper zone on mountains in the Big Bend area.	Unlikely to occur. The species is not typically associated with riparian corridors.
Birds			
White-tailed hawk (*Buteo albicaudatus*)	-- / T	Near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral. Breeds between March and May.	May occur; however, unlikely to be harmed by the project.
Rufa red knot (*Calidris canutus rufa*)	T / T	Primarily seacoasts on tidal flats and beaches, herbaceous wetland, and Tidal flat/shore. Bolivar Flats in Galveston County, sandy beaches Mustang Island, few on outer coastal and barrier beaches, tidal mudflats, and salt marshes.	May occur; however, unlikely to be harmed by the project.
Piping plover (*Charadrius melodus*)	T / T	Beaches, sandflats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Based on the November 30, 1992, Section 6 Job No. 9.1, algal flats appear to be the highest quality habitat. Sand flats often appear to be preferred over algal flats when both are available, but sand flats along the Texas coast are often only available during very low tides and are often completely. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes.	Unlikely to occur. Necessary migratory habitat is not present. Therefore, unlikely to be harmed by the project.
Red-cockaded woodpecker (*Dryobates borealis*)	E / E	Nests in cavities in older (60+ years) pine trees. Forages in younger (30+ years) pines. Species prefers longleaf, shortleaf, and loblolly pines.	Unlikely to occur. Species is generally associated with old-growth forests, which appear to be absent from the project area.
Swallow-tailed kite (*Elanoides forficatus*)	-- / T	Typical habitat includes lowland forested regions especially swampy areas ranging to open woodland, marshes, along rivers, lakes, and ponds. Nests high in tall trees in clearing or on forest woodland edges, usually using pine, cypress, or various deciduous trees.	May occur; however, unlikely to be harmed by the project.
Whooping crane (*Grus americana*)	E / E	Habitat includes small ponds, marshes, and flooded grain fields for both roosting and foraging during migration. Potential migrant via plains throughout most of Texas. Winters in coastal marshes of Aransas, Calhoun, and Refugio counties.	May occur; however, unlikely to be harmed by the project.
Black rail (*Laterallus jamaicensis*)	T / T	Habitat includes salt, brackish, and freshwater marshes, pond borders, wet meadows, and grassy swamps. Nests in or along marsh edges, sometimes on damp ground, but usually on mat of previous years dead grasses. Nests are usually hidden in marsh grass or at base of *Salicornia*.	May occur; however, unlikely to be harmed by the project.
Wood stork (*Mycteria americana*)	-- / T	Prefers to nest in large tracts of baldcypress (*Taxodium distichum*) or red mangrove (*Rhizophora mangle*). Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including	Unlikely to occur. Preferred habitat is absent.

		salt-water. Typically roosts communally in tall snags, sometimes in association with other wading birds. Breeds in Mexico but traverses the Gulf in search of mud flats and other wetlands. No breeding records in Texas since 1960.	
White-faced ibis (*Plegadis chihi*)	-- / T	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats. Currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.	Unlikely to occur. Preferred habitat is absent.
Mammals			
Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)	-- / T	Historically, lowland pine and hardwood forests with large hollow trees. Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures	May occur. Project specifics would be needed to determine impact.
Tricolored bat (*Perimyotis subflavus*)	PE / --	The once common species is wide ranging across portions of southern Canada, eastern and central United States, Mexico, and Central America. During the winter, tricolored bats are found in caves and mines, although in the southern United States, where caves are sparse, tricolored bats are often found roosting in road-associated culverts. During the spring, summer and fall, tricolored bats are found in forested habitats where they roost in trees, primarily among leaves. White-nose syndrome has led to 90 to 100% declines in tricolored bat winter colony abundance at sites impacted by the disease.	May occur. Project specifics would be needed to determine impact.
Louisiana black bear (*Ursus americanus luteolus*)	-- / T	Bottomland hardwoods, floodplain forests, upland hardwoods with mixed pine, and marsh. Possible as transient. Generally associated with bottomland hardwoods and large tracts of inaccessible forested areas.	Does not occur. Core habitat required the species are absent from the project area.

Appendix B:
Conceptual Design Appendix

Spring Creek Watershed Flood Control Dams Conceptual Engineering Feasibility Study

Conceptual Design Appendix

Flood Infrastructure Fund Category 1

Project ID 21-0016

Prepared for:

Texas Water Development Board

Prepared by:

Black & Veatch

Alexander Wallen, P.E.

Prince Turkson, PhD, P.E.

Wilber Wang, PE

Shou Ting Hou, PE

This Design Basis Memorandum for the Spring Creek Watershed Flood Control Dams Project, dated February 6, 2025, was prepared for Halff Associates (Consultant) and the San Jacinto River Authority (Client) to evaluate the feasibility of constructing two detention basins on Walnut Creek and Birch Creek. The hydrologic and hydraulic, geotechnical, and other engineering analyses summarized in the report are preliminary and were intended to be indicative for evaluation of engineering alternatives for embankment geometries and appurtenances. The analyses summarized in the report should explicitly not be used for other than this stipulated purpose or to make engineering decisions for projects outside the scope of the Spring Creek Watershed Flood Control Dams Project. Use of data and information contained in this report is the direct responsibility of the user and no warranty of use is implied by the San Jacinto River Authority, or their consultants engaged with the Spring Creek Watershed Flood Control Dams Project. The documents are intended only for the use of the recipients for the specific purpose for which they have been provided and should not be transmitted to any third party, copied or re-used for any other purpose without the express written consent of San Jacinto River Authority, Halff Associates, and Black & Veatch Corporation.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Purpose

The purpose of this Design Basis Memorandum (DBM) is to provide the design basis for the proposed Spring Creek Watershed Detention Basins, which includes Walnut Creek Detention Basin and Birch Creek Detention Basin. The proposed Walnut Creek and Birch Creek Detention Basin will provide detention during flood events to mitigate downstream flooding, particularly during the 100-year event. This design basis is developed from standard practices, guidelines, and preliminary analyses performed to select adequate conduit and spillway sizing, and to evaluate the global stability of the dams against seepage and slope stability failure.

1.2 Scope

Black & Veatch Corporation (Engineer), acting as a Subcontractor to Halff Associates is to provide the full scope of engineering services pertaining to the Spring Creek Dam Feasibility Project. Specific efforts involve project management, conceptual design of proposed detention basins and development of reports for conceptual design effort.

The DBM describes the performance of a comprehensive review of alternative configurations in delivery of a preferred alternative through various analyses and evaluations in this DBM. The Black & Veatch team evaluated physical constraints, including flow conditions through hydrologic and hydraulic (H&H) models, foundation criteria from geotechnical explorations and testing, and embankment fill material selection through soil testing. H&H analyses were conducted to examine the challenges associated with various configurations of the conduit structure and spillway.

The DBM also documents the conceptual geotechnical design of Walnut Creek Detention Basin and Birch Creek Detention Basin (hereafter referenced as "the Project") including seepage and stability assessments under anticipated loading conditions. Specific conceptual engineering design studies performed in this DBM for this Project include subsurface investigation, dam alignment studies and hydrologic modeling, opinion of probable construction cost (by Halff Associates), embankment concept alternatives, and selection of preliminary embankment configuration(s).

This report presents various sections of the DBM and a brief description for each is presented below:

- **Section 2 — Regulatory Requirements and Permitting** lists and briefly describes regulatory and permitting requirements applicable to the Project.
- **Section 3 — Design Basis** highlights design basis including references, design criteria, codes, standards, and guidelines for the Project. This section also provides the anticipated operating flood pool depths for the embankment design based on hydrologic and hydraulic (H&H) flood routing analysis. Section **3** also provides dam alignment and hydrological considerations, and hydraulic analysis for the proposed alignment. Results from hydraulic calculations used for the selection of flow discharge elements are

presented, and conceptual embankment geometries and zonation based on existing conditions are described.

- **Section 4 — Summary of Subsurface Explorations, Geotechnical Parameters, and Suitability of On-site Material** provides a general background of the regional geology and field exploration findings, and summarizes the soil testing program for the Project. This section also provides a general background of the field exploration materials and their suitability for the Project based on the assumption that in-situ materials can readily be used as embankment fill materials. Section **4** summarizes selected material properties and strength values for the preliminary analyses.
- **Section** 5 — **Results of Seepage Analysis** section provides a list of assumptions and data used in the development of the seepage models. Results from steady-state seepage analysis are used to evaluate flow rates and exit gradients at critical sections of the embankment models.
- **Section** 6 — **Results of Slope Stability Analysis** section provides a list of assumptions and data used in the development of the stability models. Results from limit-equilibrium slope stability for different loading cases are presented.
- **Section** 7 — **Conceptual Design of the Walnut Creek and Birch Creek Detention Basins** provides the selected design values for the conceptual embankment geometries based on results from hydrologic and hydraulic, seepage and stability analyses.
- **Section** 8 — **Construction Considerations** section discusses constructability considerations which are identified at the conceptual design phase for consideration in an advanced design.
- **Section** 9 — **Operations and Maintenance Considerations** stipulates anticipated operations and maintenance considerations based on regulatory requirements.
- **Section** 10 — **Recommended Embankment Option** provides a summary of key criteria for the selection of a recommended embankment concept.
- **Section** 11 — **Future Work/Next Steps** provides a summary of recommended future work necessary for an advanced design effort.
- The references used for this study are listed in **Section** 12 — **References**.
- **Key Attachments** included as **Appendices** in this report are summaries of referenced geotechnical report and various calculations. Also included are various figures from hydrologic and hydraulic, seepage and stability analyses.

The Project features included within the scope of this DBM are summarized in Table 1-1.

Table 1-1. Project Feature and Analyses Included in the DBM Scope

Project Feature	Analyses
Embankment Configuration	2-Dimensional Finite Element Seepage Analysis; Limit Equilibrium Slope Stability Analysis
Spillway Control Structure and Energy Dissipation Basin	Hydraulic design of the spillway and energy dissipation measures.
Conduit Structure	HEC-HMS 4.12 Hydraulic Routing Analysis

1.3 Project background

As part of the San Jacinto Watershed Master Drainage Plan (SJMDP) prepared for the Harris County Flood Control District (HCFCD), San Jacinto River Authority (SJRA), City of Houston, and Harris County, the study team implemented a sub-task funded by several Municipal Utility Districts (MUDs) within The Woodlands area including The Woodlands Municipal Utility District No. 1, Montgomery County Municipal Utility District No. 7, Montgomery County Municipal Utility District No. 46, Montgomery County Municipal Utility District No. 60, and Harris-Montgomery Counties Municipal Utility District No. 386. This sub-task focused on the identification and assessment of alternative detention basins within the Spring Creek watershed to reduce flooding in the Woodlands area as well as downstream to the confluence with the San Jacinto River. Following extensive H&H studies by Halff Associates, two flood control sites were identified for further study, Walnut Creek Detention Basin and Birch Creek Detention Basin. The proposed detention basins are expected to lower peak flow rates and peak water surface elevations to benefit structures along Walnut Creek, Birch Creek, and Spring Creek, but are also expected to provide some ancillary benefits at the downstream reaches of Willow Creek (a tributary of Spring Creek) and the West Fork of the San Jacinto River. Figure 1-1 presents the preliminary Walnut Creek and Birch Creek dam alignments.

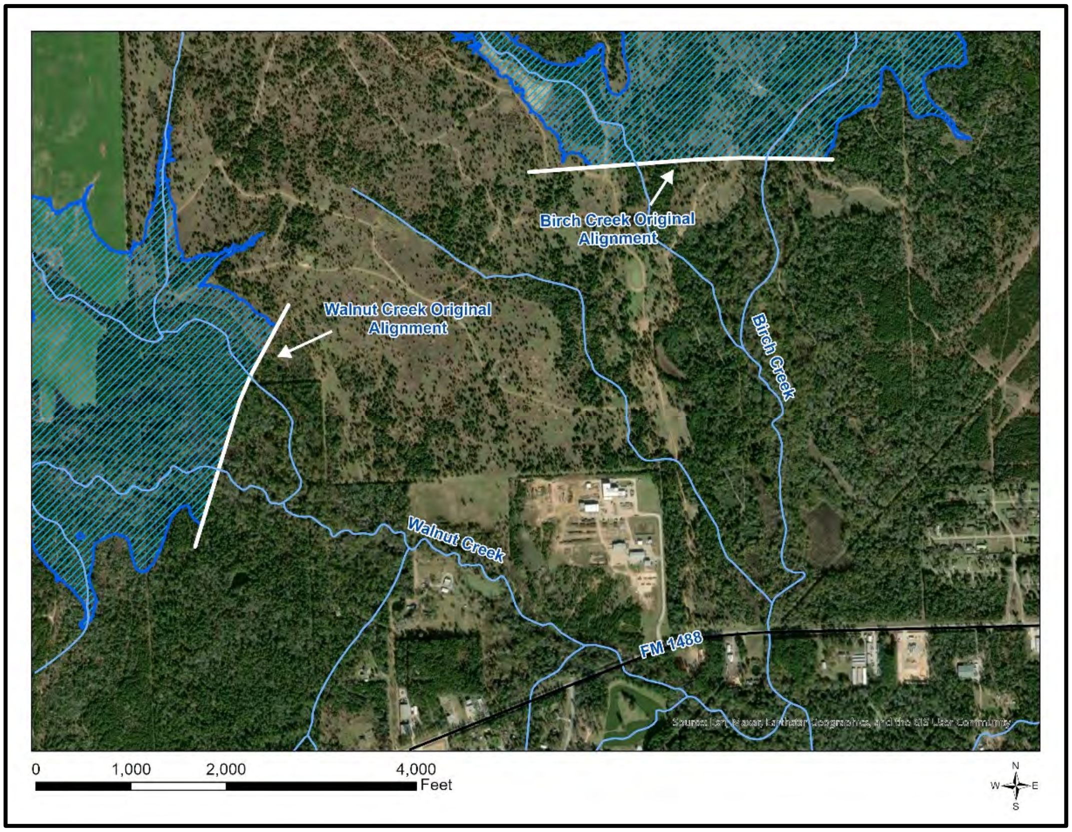


Figure 1-1 Project Overview Showing Walnut Creek and Birch Creek Dam Alignments

2 Regulatory requirements and permitting

This section highlights the regulatory requirements that are anticipated to be applicable to the Project. Implementation of published regulations is subject to the discretion of the administering regulatory agencies. Black & Veatch recommends that the Project Owner(s) initiates coordination with regulators early in the project life cycle to confirm project requirements and establish a plan and timeline for regulatory submissions that will be required during the Project life cycle.

The following regulatory requirements and guidelines have also been used by Black & Veatch to measure quantitatively and qualitatively considered alternatives based on their degree of success in meeting the identified stakeholder needs.

2.1 Dam safety regulation

The Project is subject to the dam safety regulatory requirements established by the State of Texas and administered by Texas Commission on Environmental Quality (TCEQ). Project features regulated by these requirements and within the DBM scope include the Walnut Creek Detention Basin and Birch Creek Detention Basin. The regulatory framework encompasses the following publications:

- Texas Water Code (TWC) Chapter 11, current as of October 18, 2024 [1]
- Texas Administrative Code (TAC) Title 30 Part 1 Chapter 299, "Dams and Reservoirs", current as of October 18, 2024 [2]

Table 2-1 highlights the anticipated regulatory requirements and submittals to advance the Project as defined in this DBM.

Table 2-1. Summary of Applicable Regulatory Requirements from the TAC Title 30, Part 1, Chapter 299 [2]

Subchapter or Rule	Regulatory Requirement	Project Considerations
Subchapter A — General Provisions		
299.3	Information required for new dam	It is anticipated than an authorization application which includes information sheet for the new dam will be required to undertake construction of the Project.
299.3	Design report	A design report of the construction for the proposed Project is required to be submitted to the regulator and authorizing agency.
299.3	Hydrologic and hydraulic report	A hydrologic and hydraulic (H&H) report which includes H&H analyses and evaluation summary is required to be submitted to the regulator and authorizing agency. A breach analyses report may be required if applicable.
299.3	Geotechnical report	Geotechnical report supporting the design and construction of the Project is required to be submitted to the regulator and authorizing agency.
299.3	Information required for EIA	If EIA is required[1], additional information will be required for submittal with the authorization application
299.7	Information required for other authorizations	It is anticipated that information related to operation and maintenance of the Project will be required from the Project Owner(s)
Subchapter B — Design and Evaluation of Dams		
299.11	Hydrologic and hydraulic analysis	Evaluation of the hydrologic and hydraulic adequacy of the Project and spillways using the criteria in the most current version, at the time of the evaluation, of the regulator's Hydrologic and Hydraulic Guidelines for Dams in Texas
299.12	Classification of dams	A classification based on dam size and downstream hazard must be conducted and presented to TCEQ for review for the Project prior to obtaining an authorization or submitting an EIA; an accepted consequence classification must be approved by the regulator
299.13	Size classification criteria	A size classification must be proposed for the Project prior to obtaining an authorization or submitting an EIA; an accepted consequence classification must be approved by the regulator
299.14	Hazard classification	A hazard consequence classification must be conducted and presented to TCEQ for review for the Project prior to obtaining an authorization or submitting an EIA; an accepted consequence classification must be approved by the regulator
299.15	Hydrologic and hydraulic criteria for dams	Minimum hydrologic criteria for proposed Project must be evaluated as part of regulatory requirements

Subchapter or Rule	Regulatory Requirement	Project Considerations
299.16	Site investigation is required	Site investigation is required to provide details of geology, subsurface conditions, and construction material characteristics. It is anticipated that borrow investigation(s) will be required to support the design of the Project.
299.16	Seepage analysis	Seepage analysis will be required to support the design of a proposed Project. Preliminary analyses are included with this DBM
299.16	Stability analyses	Stability analyses of embankments, spillways, retaining walls, and inlet/outlet structures as outlined in the most current version, at the time of the analysis, of the agency's Design and Construction Guidelines for Dams in Texas will be required. Preliminary analyses are included with this DBM
299.16	Dam design requirements	A standards-based approach is applied to design of the Project in this DBM; a performance-based approach with quantifiable performance objectives may be considered during design advancement
299.16	Target stability criteria and selected factors of safety must be justified	It is anticipated that Section 6 of this DBM fulfills this requirement for preliminary analyses and design; additional justification may be required during design advancement
Subchapter C — Construction Requirements		
299.22	Pre-construction requirements	A schedule of construction activities, construction plans and specifications are required to be submitted to the regulator and authorizing agency.
299.22	Storm water pollution prevention plan	A Storm Water Pollution Prevention Plan (SWPP) and a Notice of Intent (NOI) for coverage under the State of Texas Construction General Permit (TXR150000) is required by the regulator
299.22	Construction	Any deviations from the designs, plans, and specifications are required to be communicated in writing to the regulator; additional information and/or authorization may be required by the regulator
299.22	Construction quality control plan	A construction quality control plan is required to be submitted to the regulator and authorizing agency.
299.22a	Construction quality assurance plan	A construction quality assurance plan is required to be submitted to the regulator and authorizing agency.
299.22	Instrumentation and monitoring plan	A report on proposed instrumentation and monitoring plan for the proposed Project may be required by regulator and authorizing agency if applicable.
Subchapter D — Operation and Maintenance of Dams		
299.43	Operation and maintenance	It is anticipated that an operation, maintenance, and surveillance manual as described in Guidelines for Operation and Maintenance of Dams in Texas will be required by the regulator

Subchapter or Rule	Regulatory Requirement	Project Considerations
Subchapter F — Emergency Management		
299.61	Emergency action plans	An emergency action plan for addressing possible emergencies will be required for the Project by the regulator and authorizing agency.
299.62	Security of dams	It is anticipated that a security plan will be required for the Project by the regulator

[1]Refer to Section 2.2 for additional information.

[2]The authorizing agency, TCEQ, will require a closure plan as part of submittals for the Project authorization.

2.1.1 Application and authorization

Authorizations are issued by Texas Commission on Environmental Quality (TCEQ). It is anticipated that an authorization will be required to undertake the Project as defined in this DBM. Requirements for the authorization application are described in Subchapter C of the Texas Administrative Code Title 30, Part 1, Chapter 299 [2]. The authorization application requires detailed project information, including a final design report, final construction drawings and specifications, and construction planning details, among other requirements. Document submission requirements are described in Chapter 2 (Parts 2.1 and 2.2) of the Design and Construction Guidelines for Dams in Texas (version RG-473) [3].

If it is determined that an Environmental Impact Assessment (EIA) is required (refer to Section 2.2), information required for EIA to be submitted with the authorization application is described in Chapter 5 of the Design and Construction Guidelines for Dams in Texas [3].

2.1.2 Design and evaluation of dams

Subchapter B Rule 299.14 of the TAC [2] describes the size classification of dams based on the larger of the height of the dam or the maximum storage capacity. Subchapter B Rule 299.14 of the TAC [2] also describes the hazard classification criteria for proposing a consequence classification for a new dam. The proposed Project is classified as intermediate by size and as high hazard by consequences in the event of failure or malfunction of the dam.

Subchapter B of the TAC [2] provides prescriptive technical standards and procedures that encompass design and construction of a new dam. It is anticipated that a standards-based approach will be applied to design of the Project, pursuant to Subchapter B Rule 299.15 and Rule 299.16 of the TAC [2]. The design basis for the standards-based approach is based on industry guidelines and standards as defined in Section 3.4.

2.1.3 Construction requirements

Subchapter C of the TAC [2] describes the requirements for development of construction plans and specifications for a new dam, and the requirements for the approval of same. Prescribed pre-construction requirements along with construction requirements for the Project will be required for regulatory approval.

2.1.4 Operation and maintenance of dams

Subchapter D of the TAC [2] describes the Project owner’s responsibility for operating and maintaining the dams and appurtenant structures in a safe manner. It is anticipated that an operation and maintenance (O&M) plan for the Project will be required. The O&M plan may use the most current version, at the time of the plan development, of the agency's Guidelines for Operation and Maintenance of Dams in Texas.

2.1.5 Emergency management

Subchapter F of the TAC [2] describes the requirements for developing an emergency management plan for a new dam. It is anticipated that a new emergency management plan as well as a safety action plan will be required for the Project.

2.2 Environmental and permitting requirements

A federal environmental assessment and/or State of Texas EIA may be required for the Project. It should be conservatively assumed that both assessments will be required for schedule and cost estimation. An environmental permitting plan may be developed to provide a framework for the execution of the necessary steps to evaluate the environmental permits and approvals required to advance the Project.

3 Design basis

Applicable project design values, project references, design criteria, codes, standards, guidelines, and key assumptions are included in the design basis.

3.1 Alignment alternatives

In addition to the original alignment, other dam alignments for Walnut and Birch Creek were evaluated, considering (1) the amount of soil borrow/fill required, (2) impacts to reservoir maximum storage, and (3) environmental permitting implications. All the alignments tie into the surrounding topography and maintain downstream flood benefits. The alignment alternatives comparative evaluation did not include any subsurface investigations in the vicinity of the proposed alignments. The alignment alternatives for Walnut and Birch Creek are shown below in Figure 3-1 and Figure 3-2. Notably, some of the alignments would potentially have stream impacts outside of the project site shown in the figures.

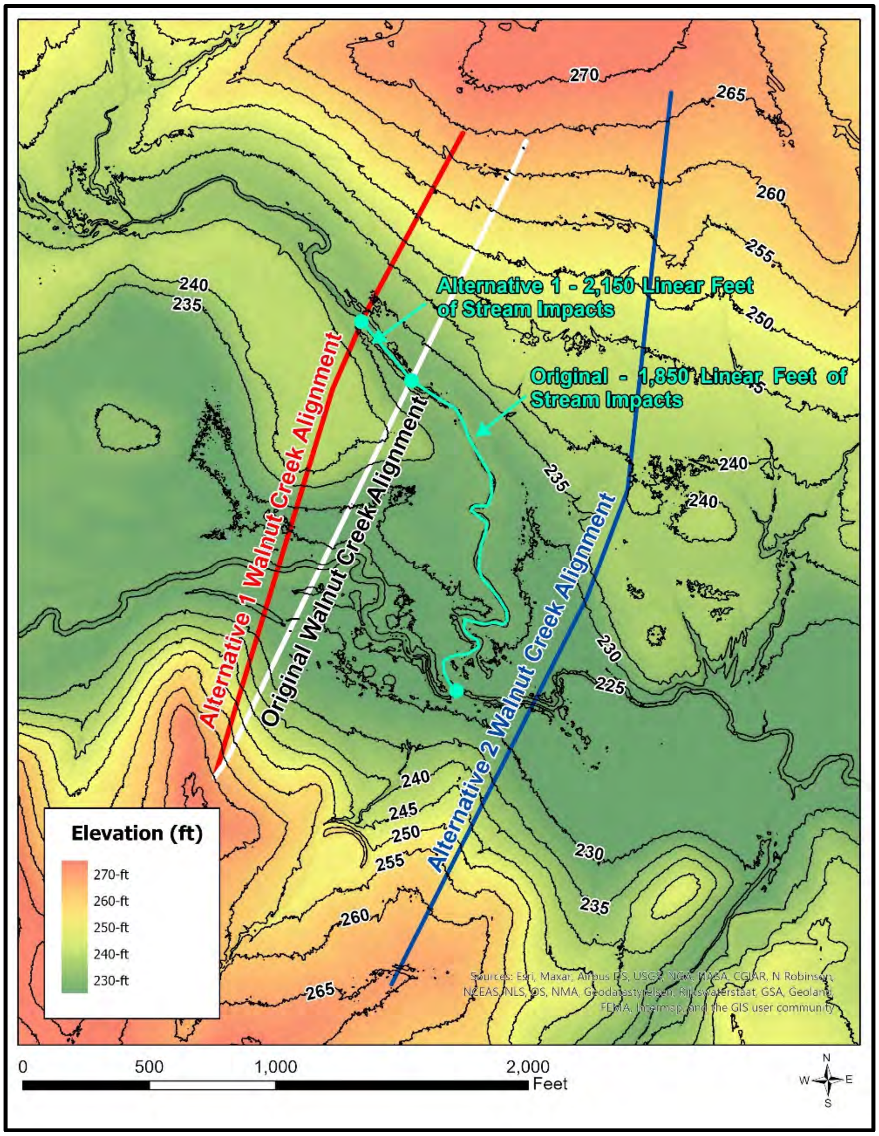


Figure 3-1 Walnut Creek Alignment Alternatives

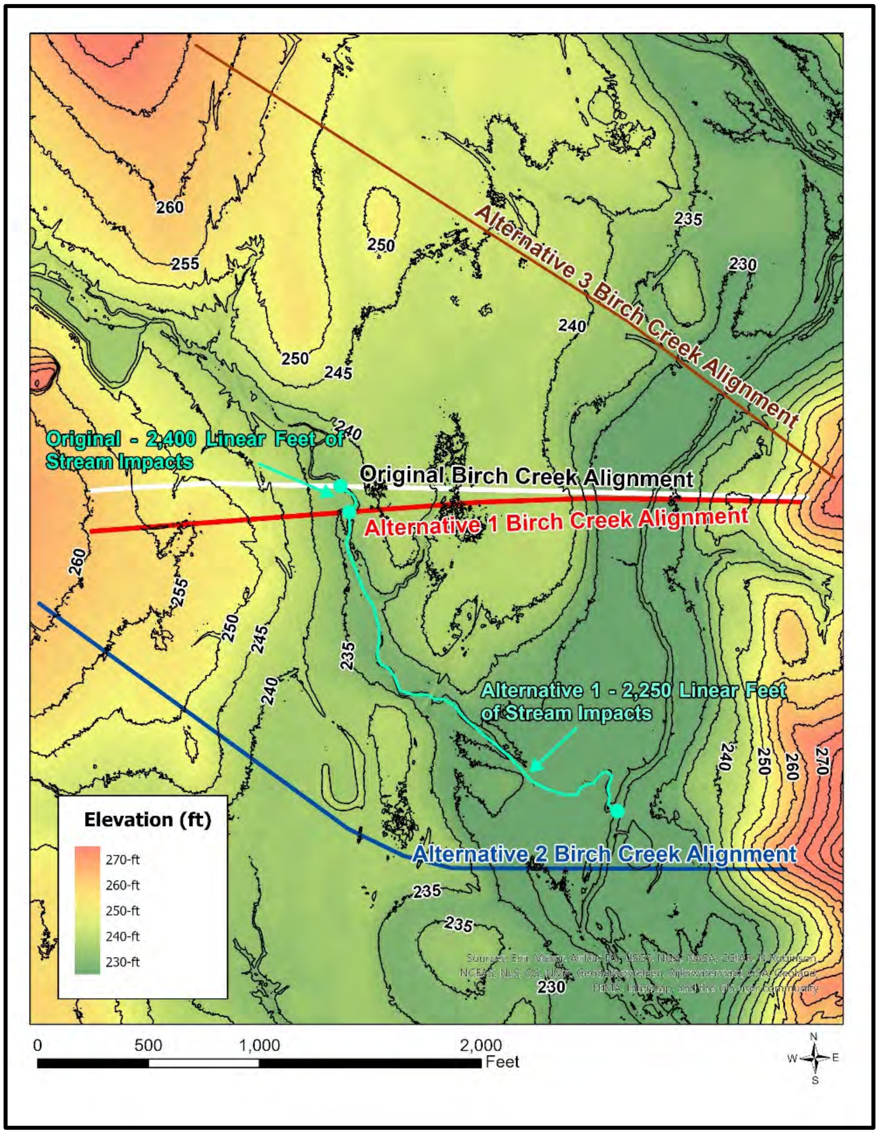


Figure 3-2 Birch Creek Alignment Alternatives

Tabular comparisons of embankment borrow, maximum storage capacity, and linear feet of environmental stream impacts for the Walnut and Birch Creek alternatives are shown in Table 3-1 and Table 3-2 respectively. Note that the comparisons assumed 3.5 H: 1V upstream and downstream slopes, whereas subsequent sections in the report utilized 3.5 H: 1V along the upstream slope and 3 H: 1 V on the downstream slope. **Walnut Creek's alternative 2 alignment is the recommended alternative.** Although the embankment borrow was marginally increased by 4%, the maximum storage capacity increased by 12% and there were no environmental linear stream impacts outside the project site. **Birch Creek's alternative 3 alignment is the recommended alternative.** Although the maximum storage capacity was reduced by 11%, the embankment borrow was reduced by 11%, and there were no environmental linear stream impacts outside the project site. The subsequent hydraulic and geotechnical calculations use the Walnut Creek Alternative 2 and Birch Creek Alternative 3 alignments. Note that the spillway and conduit sizing are based on the original alignments' inflow design hydrograph. It is anticipated that the various alignment alternatives will not appreciably impact the design inflow hydrograph.

Table 3-1 Walnut Creek Alignment Alternatives

Description	Walnut Creek		
	Original	A1	A2
Embankment Borrow (yd^3)	262,000	232,000 (-12%)	273,650 (+4%)
Maximum Storage Capacity (acre-ft)	11,650	11,450 (-2%)	13,150 (+12%)
Linear Stream Impacts outside Project Site (ft)	1,850	2,150	None

Table 3-2 Birch Creek Alignment Alternatives

Description	Birch Creek			
	Original	A1	A2	A3
Embankment borrow (yd^3)	183,000	176,100 (-4%)	268,000 (+52%)	162,700 (-11%)
Maximum Storage Capacity (acre-ft)	10,200	10,300 (+1%)	12,250 (+20%)	9,050 (-11%)
Linear Stream Impacts outside Project Site (ft)	1,850	2,150	None	None

3.2 Hydrologic and hydraulic criteria

3.2.1 Background

The proposed Walnut Creek Detention Basin and Birch Creek Detention Basin will provide detention during significant flood events to mitigate downstream flooding. The proposed dams will function as normally-dry detention dams. The purpose of this analysis is to evaluate and develop potential conduit and auxiliary spillway configurations for high-level cost-estimates. The spillway design objectives for both dams include the following:

1. Both dams should detain approximately 12,000 acre-feet total during the 100-year flood event. A Halff Associates hydraulic analysis iteratively determined that 12,000 acre-feet of detention during the 100-year flood maximizes downstream flood benefits.
2. The auxiliary spillway crest elevation should be set at the peak 100-year flood level.
3. The spillway configuration should have appropriate freeboard during its design flood. A preliminary Halff Associates analysis indicated that the proposed Walnut and Birch Creek top of dam elevations should be set at 263.6 ft-msl and 259.1 ft-msl respectively.
4. The associated energy dissipation basin should be sized appropriately.

A simplified version of the dam configurations was developed using USACE HEC-HMS Version 4.12 by Halff Associates to support this analysis. The simplified model is a proxy to the full HEC-RAS model to allow for design iterations. The model included preliminary conduit sizing, auxiliary spillway sizing, and 500-year tailwater information. The subject initial information was used as a starting point for the subsequent hydrologic and hydraulic calculations.

3.2.2 Hazard classification

The Walnut Creek and Birch Creek maximum capacities of 13,124 acre-feet and 9,025 acre-feet (See Section 3.2.4) are classified as intermediate sized dams per 30 Texas Administrative Code (TAC) §299.13. The design flood for proposed high-hazard intermediate sized dams is interpolated from 75% to 100% of the PMF based on the maximum capacity of the dam. Assuming high-hazard classifications, 30 TAC §299.14 indicates design flood events of 83% and 80% of the Probable Maximum Flood (PMF) for the proposed Walnut and Birch Creek Detention Basins respectively. For simplicity, subsequent hydraulic calculations assume design flood events of 83% of the PMF for both dams.

3.2.3 Freeboard

Wave run-up heights were calculated in adherence with the guidelines indicated in the Bureau of Reclamation standards [11] and TCEQ Dam Safety Guidelines [4]. The approach includes calculating an appropriate amount of normal and minimum freeboard to protect the embankment dam from overtopping due to wind-generated waves and reservoir setup. Reservoir setup is caused by the shearing effect of the wind that tends to tilt the reservoir higher in the direction of the wind. The minimum freeboard, normal freeboard, and checks were conducted in adherence with the guidelines.

The 10% exceedance wind speed utilized for the Maximum Reservoir Water Surface (MRWS) cases was derived from a US Department of Energy (USDOE) Wind Energy Study [6], in adherence with the guidelines indicated in the Bureau of Reclamation standards [11]. The inputs and outputs for the series of calculations are provided for the following cases: MRWS, 2-ft below the MRWS, and 4-ft below the MRWS. Because the reservoir will be normally dry, the Normal Reservoir Water Surface (NRWS) with 2% wave and the NRWS with 0.4% Wave are not applicable. The inputs and outputs are provided in Table 3-3 through Table 3-6, with the fetch lines shown in Figure 3-3. Notably, the average fetch lengths were conservatively calculated with reservoir water surface elevations at the design flood water surface elevations. Based on the subject calculations, the dams experience wave heights up to 1.5-ft with water surface elevations near the MRWS. As such, a 2-ft freeboard is sufficient for the proposed dams.

Table 3-3 Walnut Creek Freeboard Calculations Inputs

Description	MRWS	2-ft Below MRWS	4-ft below MRWS	Units
Design Wind Speed	9	10	11	m/s
Average Fetch	8,413	8,413	8,413	ft
Embankment Slope	3.5	3.5	3.5	x H: 1 V
A Parameter	1.6	1.6	1.6	N/A
C Parameter	0	0	0	N/A
Reduction Factors	1	1	1	N/A
Average Depth of Water	20.0	18.0	16.0	Ft

Table 3-4 Walnut Creek Freeboard Calculations Outputs

Description	MRWS	2-ft Below MRWS	4-ft below MRWS	Units
Fetch	1.6	1.6	1.6	Miles
Design Wind Speed	20.1	22.4	24.6	mph
Significant Wave Height	0.7	0.8	0.9	ft
Wave Period	1.56	1.62	1.68	sec
tan (alpha)	0.29	0.29	0.29	radians
Surf Similarity Factor (Xi)	1.21	1.18	1.16	N/A
2-percent exceedance runup	1.43	1.57	1.72	ft
Wind Setup	0.02	0.03	0.04	ft
Total Wave Height	1.45	1.61	1.76	ft

Table 3-5 Birch Creek Freeboard Calculations Inputs

Description	MRWS	2-ft Below MRWS	4-ft below MRWS	Units
Design Wind Speed	9	10	11	m/s
Average Fetch	4,693	4,693	4,693	ft
Embankment Slope	3.5	3.5	3.5	x H: 1 V
A Parameter	1.6	1.6	1.6	N/A
C Parameter	0	0	0	N/A
Reduction Factors	1	1	1	N/A
Average Depth of Water	16.5	14.5	12.5	Ft

Table 3-6 Birch Creek Freeboard Calculations Outputs

Description	MRWS	2-ft Below MRWS	4-ft below MRWS	Units
Fetch	0.9	0.9	0.9	Miles
Design Wind Speed	20.1	22.4	24.6	mph
Significant Wave Height	0.6	0.6	0.7	ft
Wave Period	1.29	1.34	1.39	sec
tan (alpha)	0.29	0.29	0.29	radians
Surf Similarity Factor (Xi)	1.15	1.13	1.11	N/A
2-percent exceedance runup	1.02	1.12	1.22	ft
Wind Setup	0.02	0.02	0.03	ft
Total Wave Height	1.03	1.14	1.26	Ft

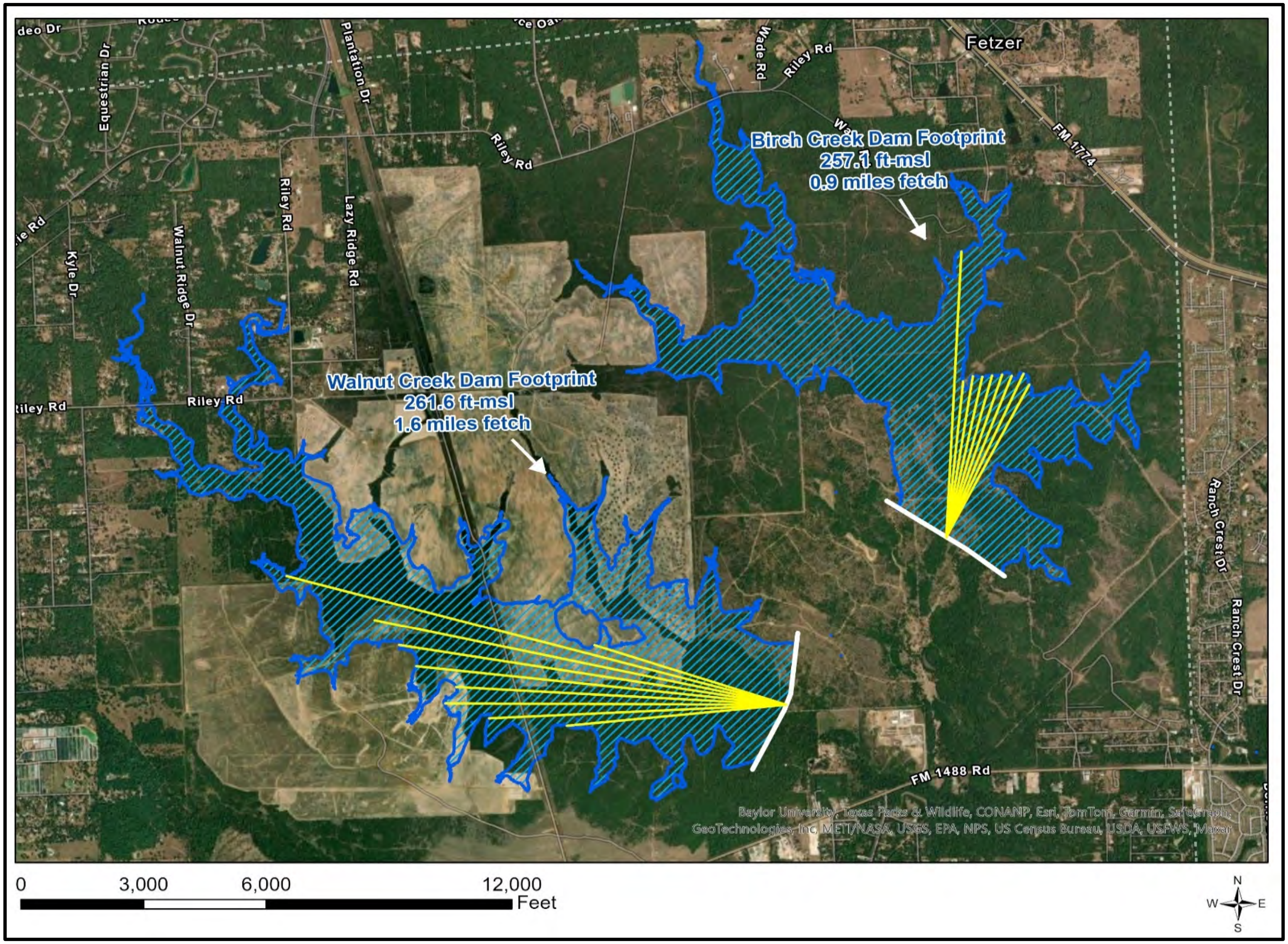


Figure 3-3 Design Flood WSEs Footprints

3.2.4 Elevation-storage curves

The reservoir elevation-storage curves were updated appropriately based on best-available 2018 Upper Coast lidar data [23]. The curves extend to the reservoir peak water surface elevations during their design floods (261.6 ft-msl for Walnut Creek and 257.1 ft-msl for Birch Creek), considering 2-ft of freeboard described in Section 3.2.2. The tabular elevation-area-storage data is shown in Appendix B-8. The elevation-storage data and reservoir footprints are shown in Figure 3-4 and Figure 3-5.

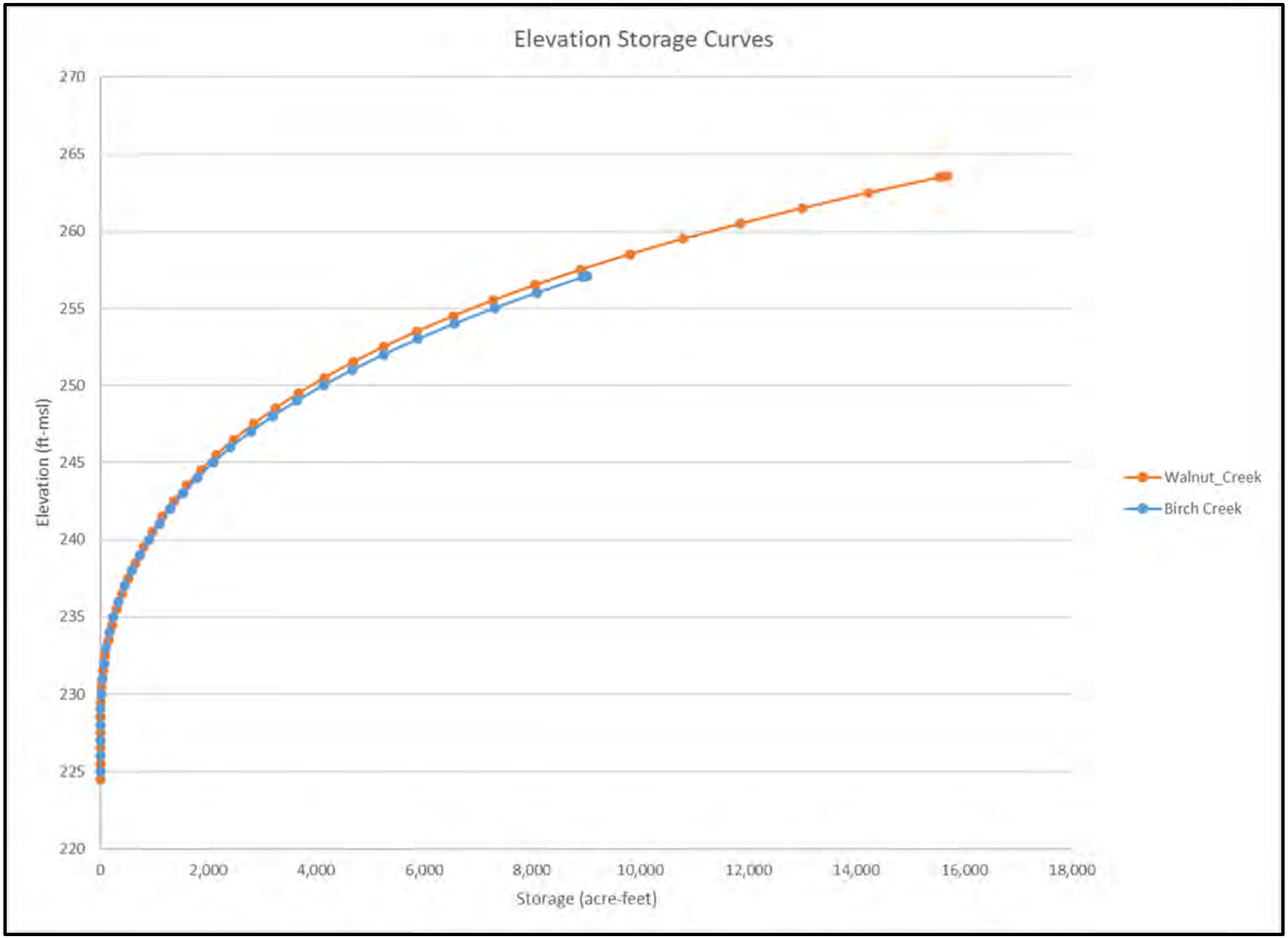


Figure 3-4 Elevation-Storage Curves

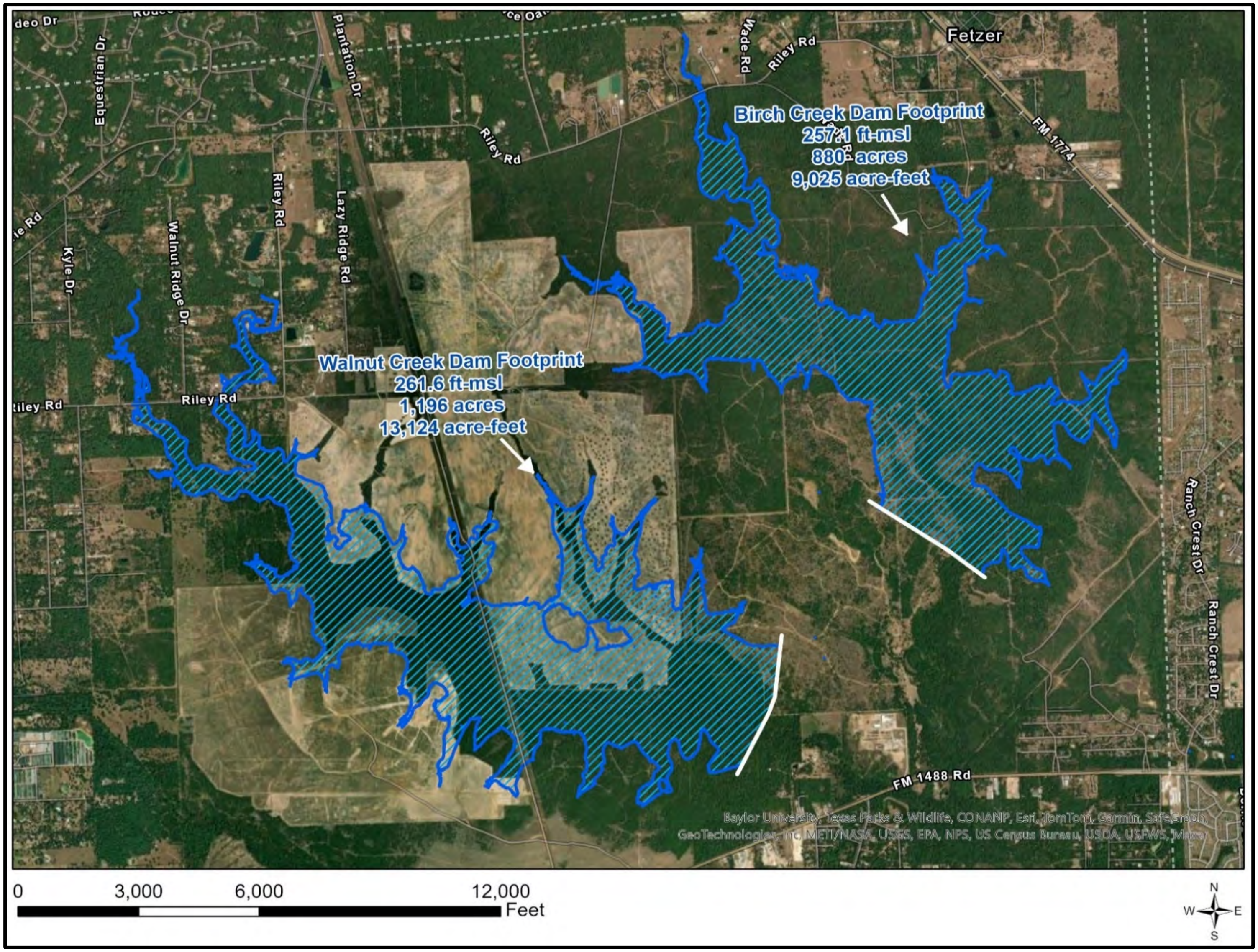


Figure 3-5 Design Flood WSEs Footprints

3.2.5 Auxiliary spillway and conduit structure

The proposed spillway configuration consists of a concrete structure positioned at the centerline of the stream. The concrete structure consists of an ogee crested weir with a crest elevation at the 100-year flood event elevation, with a single rectangular concrete conduit along the streambed. A profile of the general conceptual configuration is shown in Figure 3-6, with additional details provided in the associated sheets. The shape of the ogee was calculated in adherence with the Bureau of Reclamation Design of Small Dams guidance [7].

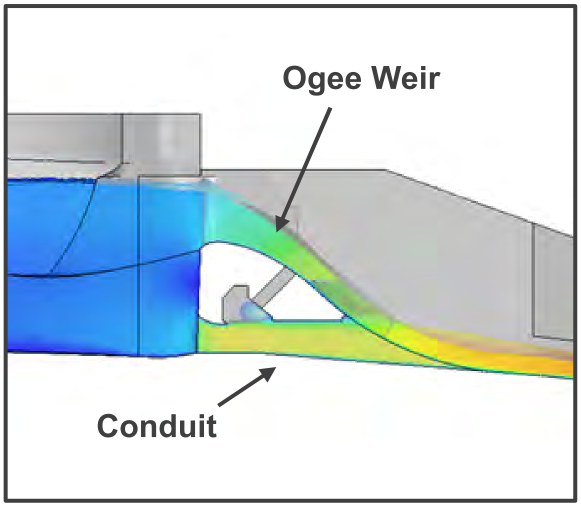


Figure 3-6 General Spillway and Conduit Configuration

The proposed spillway configuration includes a combined concrete structure that incorporates an ogee spillway and conduit that share a common energy dissipation basin. A single larger conduit (rather than multiple smaller conduits) is recommended to mitigate potential debris obstruction. Debris can pass more freely through the larger single conduit compared to multiple smaller conduits. The conduit for each dam would detain the 100-year flood event prior to engaging to the ogee weir. The ogee weir will function as the auxiliary spillway. Although a sharp crested weir was considered, it is less hydraulically efficient than the ogee crested weir requiring more weir length to pass the design flood.

3.2.6 Auxiliary spillway and conduit sizing

The spillway and conduit configurations at both dams were sized using HEC-HMS version 4.12, building on the hydrologic model provided by Halff Associates. The spillway configurations are designed according to the objectives described in Section 3.2.1. Additionally, the following analysis was conducted to reduce the total required spillway length for both dams, thereby reducing the total project cost estimate.

The initial conduit and auxiliary spillway configuration had a lower spillway design head at Walnut creek (5.4-ft) and a higher spillway design head at Birch Creek (7.1-ft). Spillway design head is defined as the head of water over the proposed spillway crest elevation during the design flood (83% of the PMF). However, because Walnut Creek has a larger peak design flood flow (~21,900-cfs) than Birch Creek's peak design flood flow (~15,700-cfs), it made sense to optimize the spillway configurations by increasing the design head at Walnut Creek and lowering the design head at Birch Creek. This was achieved by increasing the conduit discharge at Walnut Creek and decreasing the conduit discharge at Birch Creek. Consequently, the optimized configuration lowered the Walnut Creek spillway crest elevation (from 256.2 to 254.7 ft-msl) and raised the Birch Creek spillway crest elevation (from 250.0 to 251.2 ft-msl). The subject optimization reduced the total required spillway length for both dams from 455-ft to 350-ft, as shown in Table 3-7.

Table 3-7 Spillway and Conduit Sizing

	Walnut Creek		Birch Creek		Totals		
Description	**Initial**	**Optimized**	**Initial**	**Optimized**	**Initial**	**Optimized**	**Units**
100-year WSE	256.2	254.7	250.0	251.2	N/A	N/A	ft-msl
PMF WSE	261.6	261.6	257.1	257.1	N/A	N/A	ft-msl
Spillway Head Differential	5.4	6.9	7.1	5.9	N/A	N/A	ft
100-year Detention	7,800	6,700	4,100	4,800	11,900	11,500	ac-ft
100-year Peak Discharge	1,800	2,700	3,100	2,300	4,900	5,000	cfs
X-ft wide by 6-ft culvert	11	17	22	16	33	33	ft
Ogee Spillway Width	350	175	105	175	455	350	ft

Based on the above calculations, the recommended dam hydraulic design parameters are shown in Table 3-8, with additional details provided in the associated sheets. The subject parameters were used in the embankment geometry analysis, including the seepage and embankment stability calculations.

Table 3-8 Recommended Dam Hydraulic Design Configuration

Description	Walnut Creek	Birch Creek	Units
Top of Dam (ft-msl)	263.6	259.1	ft-msl
Peak 100-year WSE	254.7	251.2	ft-msl
Peak 100-year Discharge	2,700	2,300	cfs
PMF WSE	261.6	257.1	ft-msl
Opening Invert (also streambed)	224.5	223.7	ft-msl
Opening Size	6-ft by 17-ft	6-ft by 16-ft	Rise (ft) x Span (ft)
Ogee Spillway Control Elevation	254.7	251.2	ft-msl
Ogee Spillway Length	175	175	ft

The recommended configuration confirmed that using an ogee crested weir coefficient of 3.94 was appropriate based on Bureau of Reclamation Design of Small Dams guidance [7]. The height of the upstream faces (P) for Walnut Creek and Birch Creek are 30.2-ft and 27.5-ft respectively. Design heads (H_o) for Walnut Creek and Birch Creek are 6.9-ft and 5.9-ft respectively. $\frac{P}{H_o}$ values exceed 3.0, which correspond to an ogee weir discharge coefficient of 3.94.

3.2.7 Energy dissipation basin sizing

The energy dissipation basin configuration was designed in adherence with the Bureau of Reclamation Design of Small Dams guidance [7] for the type III basin. The type III basin uses chute blocks, impact baffle blocks and an end sill to shorten the jump length and to dissipate the high-velocity flow within the shortened basin length. Shortening the hydraulic jump length means that flow transitions from supercritical to subcritical flow over a shorter longitudinal distance, in effect allowing for a shorter and smaller concrete energy dissipation basin. The basin relies on dissipation of energy by the impact blocks and on turbulence of the jump for its effectiveness. Incoming velocities do not exceed 60 feet per second (ft/s), allowing for the adoption of the type III basin shown in Figure 3-7.

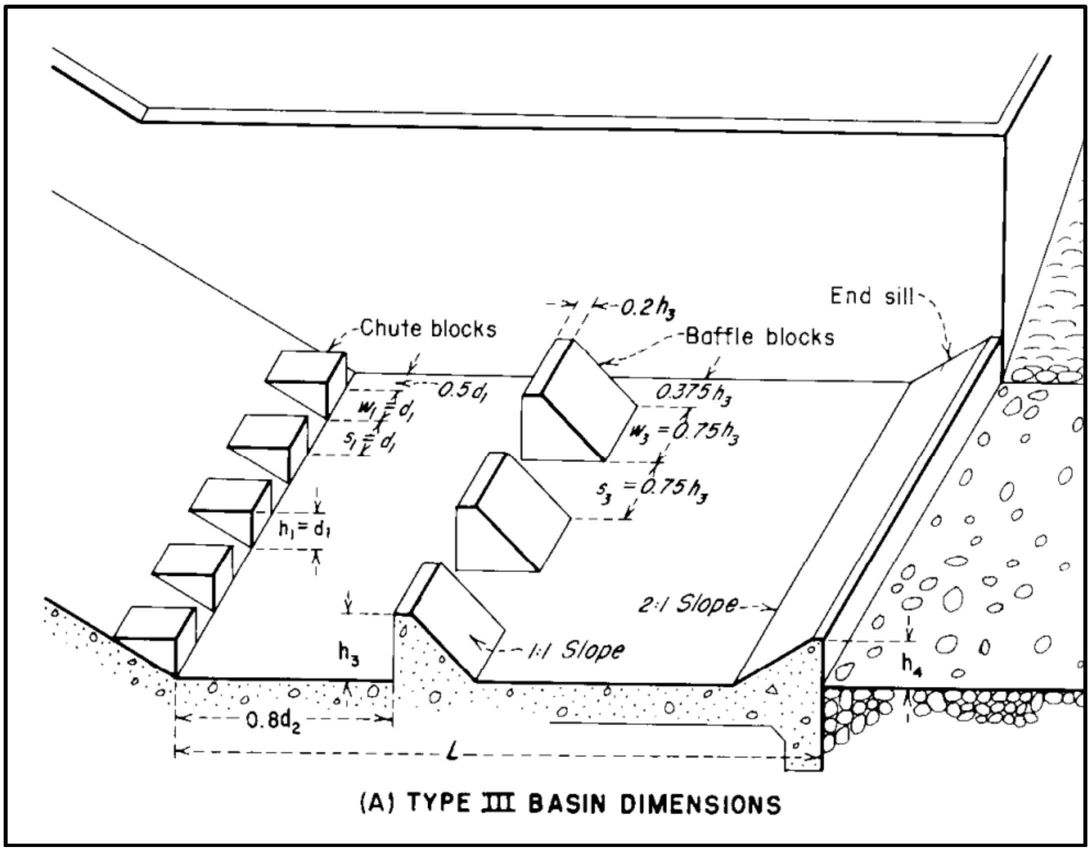


Figure 3-7 General Energy Dissipation Basin Configuration from [7]

The inputs and outputs of the calculation are provided in Table 3-9. Walnut Creek and Birch Creek require energy dissipation basin lengths (L) of 42-ft and 34-ft respectively. The associated sheets round up the energy dissipation basin lengths to 45-ft and 35-ft respectively. Notably, the Walnut Creek required apron elevation is approximately 4-ft below the streambed, indicating that a depressed energy dissipation basin is required. Birch Creek would not require a depressed energy dissipation basin. It should be noted that the energy dissipation basin tailwater level was conservatively assumed to be at the 500-year event for both dams because the design flood tailwater level was not determined as part of this study. As such, future calculations may raise the required maximum apron elevations and potentially remove the need for a depressed energy dissipation basin at Walnut Creek.

Table 3-9 Energy Dissipation Basin Calculations

Description	Walnut Creek	Birch Creek	Units
Discharge	15,720	12,660	cfs
Discharge per Foot	90	72	cfs
500-year Tailwater Level	236.8	238.6	ft-msl
Reservoir Level	261.6	257.1	ft-msl
Reservoir Level minus Tailwater	24.8	18.5	ft
Conjugate Depth (d_2)	16.0	13.5	ft
Required Maximum Apron Elevation	**220.8**	**225.1**	**ft-msl**
Streambed*	224.5	223.7	ft-msl
Upstream Depth of Flow at Basin Floor Level (d_1)	1.79	1.64	ft
Froude Number (F_1)	6.6	6.1	N/A
Basin Length (L)	**42**	**34**	**ft**
Baffle Block Height (h_3)	**3.0**	**2.5**	**ft**
End Sill (h_4)	**2.3**	**2.1**	**ft**

*Provided for reference

3.2.8 Assumptions and recommended future hydrologic and hydraulic calculations

Item 1:

The current analysis assumes fixed tailwater levels at the peak 100-year event during the 100-year routing event and at the peak 500-year event during the PMF event, rather than a discharge-tailwater curve. Future hydrologic analysis should be conducted to develop detailed flow-tailwater rating curves, which could reduce the sizes of the conduits required at both dams.

Item 2:

The current analysis assumes a constant ogee weir coefficient of 3.94 for all heads over the ogee weirs at both dams. Future analyses should develop a more detailed rating curve, considering discharge coefficients for other than the design head, which would marginally reduce the ogee weir flow conveyance.

Item 3:

Future hydrologic analyses should determine design flood tailwater levels to determine whether tailwater levels may impact the ogee weir discharge coefficient. Based on the available information, it is anticipated that tailwater levels would likely not reduce ogee weir discharges; however, the subject analysis should be conducted.

Furthermore, the energy dissipation basin tailwater level was conservatively assumed to be at the 500-year event for both dams because the design flood tailwater level was not determined. As such, the conjugate depth and basin length was conservatively calculated in this analysis. Future calculations using appropriate design flood tailwater levels will likely reduce the energy dissipation basin lengths and raise the required apron elevations at both dams.

Item 4:

Rock riprap erosion protection calculations downstream of the energy dissipation basin were not conducted as part of this analysis. The appropriate riprap gradation, extents, filter layer, and geotextile calculations should be conducted to mitigate potential scour. Modeling of pre and post conditions downstream of the dams should be conducted to determine downstream velocity changes and whether additional erosion and scour countermeasures need to be implemented.

Item 5:

Hydrologic and hydraulic calculations should be conducted to size a potential pilot channel upstream and downstream of the concrete opening. Because a combined pilot channel, conduit, and ogee structure deviates from the well-studied energy dissipation basin geometry [7], more detailed hydraulic calculations (including computational fluid dynamics (CFD) modeling) should be considered to confirm the effectiveness of the energy dissipation basin.

3.3 Conceptual embankment options for Walnut Creek and Birch Detention Basins

3.3.1 Embankment configuration alternatives

Three embankment geometry concepts are considered for the Project sites and have been analyzed for seepage and stability. A summary of the dam characteristics for the two sites is presented in Table 3-10. The proposed embankment geometry concepts considered different embankment foundation treatment methods and/or embankment seepage control for evaluation.

Table 3-10 Dam Characteristics at Walnut Creek and Birch Creek

Item	Walnut Creek	Birch Creek
Streambed elevation[1] (feet)	224.5	223.7
Crest elevation (feet)	263.6	259.1
Maximum dam height (feet)	39.1	35.4
Crest width (feet)	16	
[1]Streambed elevation along the dam centerline.		

The geometry of the embankment slopes is same for all three alternative geometries. A gravel vehicular road, which will be located on the crest of the embankment and may include a vehicular turnaround on the crest or access bridge is anticipated to be used for dam operations, inspections, and maintenance. The access bridge could span the spillway and allow for additional access. The differences between each concept are based on type of seepage control and embankment internal zonation.

3.3.2 Alternative 1 — Cut-off trench seepage barrier

Alternative 1 embankment is assumed to be constructed using a homogenous material of an acceptable permeability. The upstream and downstream side slopes are 3.5:1 H:V and 3:1 H:V, respectively.

A 3-foot-thick riprap layer is considered for the upstream face wave protection and the downstream slope will be vegetated with grass. Both slope faces are considered to have a 20-foot wide top-of-bench stability berms. The berms are flat areas along the embankment slopes that improve stability and reduce erosion. Additionally, a 6 feet wide vertical chimney filter and drain used to prevent the movement of clay particles and the development of internal seepage conduits is located along the central portion of dam and directed towards the downstream side of the dam. The chimney drain and the blanket drain comprise the internal drainage system, which limits pore pressure development in the embankment. The chimney filter and drain will drain into a near horizontal blanket drain system that will convey seepage to a toe drain with embedded pipe collection system. Collected seepage will be discharged into a surface ditch.

This embankment configuration consists of a compacted low permeability cutoff trench along its alignment as well as a sheet pile wall anchored into the impervious strata beneath the cut-off trench to reduce or minimize seepage immediately underneath the embankment. A cross-section of the embankment considered for Alternative 1 is presented in Figure 3-8 below and a summary of the characteristics are presented in Table 3-11.

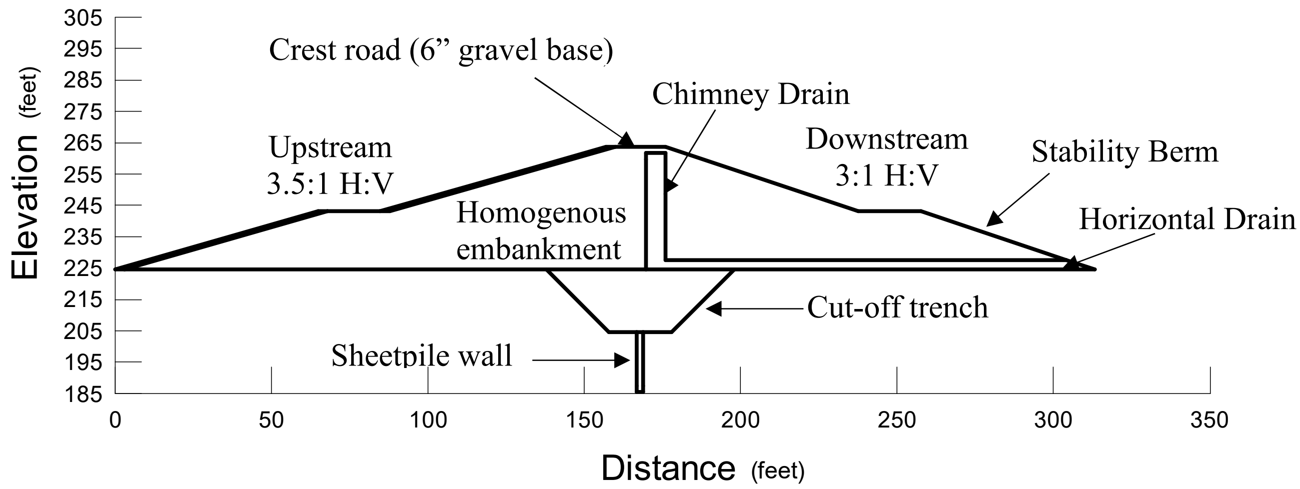


Figure 3-8 Cross Section of Alternative 1 Embankment

Table 3-11 Alternative 1 Geometry Characteristics

Item	Embankment[1]	Chimney Drain and Filter	Horizontal Drain
Top elevation (feet)	263.6 and 259.1	2 feet below dam crest	3 feet above grade
Crest width (feet)	16	6	—
Upstream slope	3.5:1 H:V	Vertical	—
Downstream slope	3:1 H:V	Vertical	Horizontal
[1]Crest elevation for Walnut Creek Detention Basin and Birch Creek Detention Basin respectively.			

3.3.3 Alternative 2 — Cut-off trench and impervious core seepage barrier

Alternative 2 is assumed to comprise of a zoned clay core embankment which is retained by upstream and downstream shells of compacted soil. The embankment foundation configuration consists of an excavated cut-off trench along its alignment which will be backfilled with compacted low permeability clay to reduce or minimize seepage immediately underneath the embankment. The cutoff trench is followed by a sheet pile wall anchored into the impervious strata beneath the cut-off trench. Similar to Alternative 1, a 6-foot-wide filter and drain is located on the downstream face of the core. The filter and drain will drain into a near horizontal blanket drain system that will convey seepage to a toe drain with embedded pipe collection system. Collected seepage will be discharged into a surface ditch. A cross-section of the embankment is shown on Figure 3-9.

The upstream and downstream side slopes are 3.5:1 H:V and 3:1 H:V respectively. A 3-foot-thick riprap layer is placed on the upstream face for wave protection, and the downstream slope will be vegetated with grass. Both side slope faces have a 20-foot wide top-of-bench stability berms. The berms are flat areas along the embankment slopes that improve stability and reduce erosion. The width of core is 8 feet at the top and 2 feet below the dam crest. The impervious core upstream and downstream slope face is 1.5:1 H:V. The downstream filter and drain are aligned with the respective slope face of the core at a slope of 1.5:1 H:V.

A summary of geometry characteristics of Alternative 2 is presented in Table 3-12.

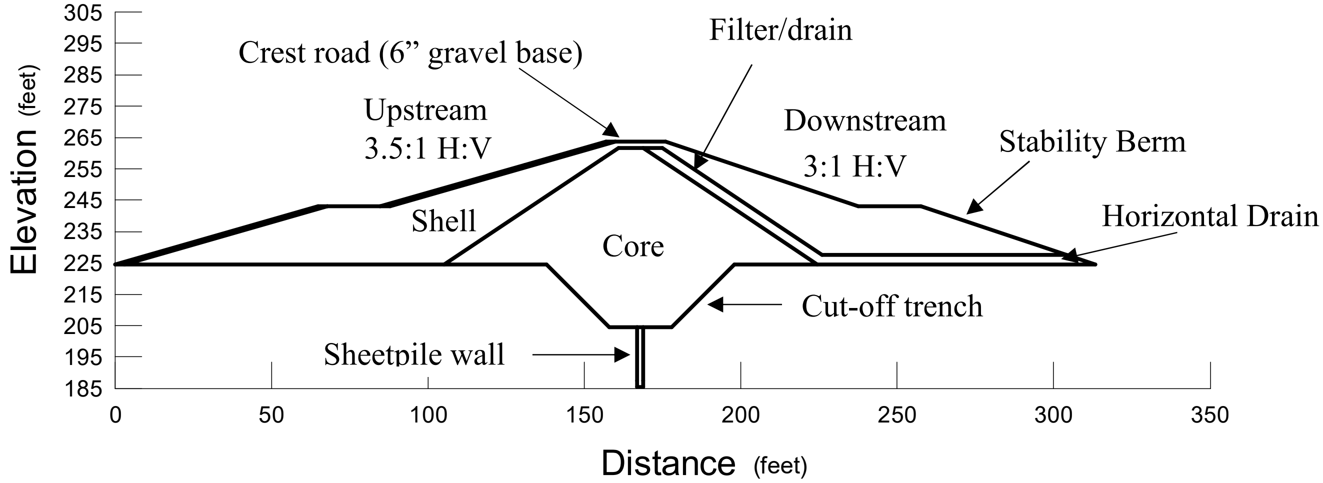


Figure 3-9 Cross Section of Alternative 2 Embankment

Table 3-12 Alternative 2 Geometry Characteristics

Item	Shell[1]	Core	Filter and Drain	Cut-off
Top elevation (feet)	263.6 and 259.1	2 feet below dam crest	2 feet below dam crest	Foundation
Crest width (feet)	16	8	6	—
Base width (feet)	—	—	—	20
Upstream slope	3.5:1 H:V	1.5:1 H:V	Aligned with core	1:1 H:V
Downstream slope	3:1 H:V	1.5:1 H:V	1.5:1 H:V	1:1 H:V

[1]Crest elevation for Walnut Creek Detention Basin and Birch Creek Detention Basin, respectively.

3.3.4 Alternative 3 — Soil-bentonite cutoff seepage barrier

Alternative 3 is assumed to be a homogenous embankment with a 2.5-foot-wide soil-bentonite cutoff (SBC) wall installed along the centerline of the embankment. The SBC wall is assumed to be installed at least 6 feet above foundation level. The SBC is anticipated to be anchored into the impervious strata beneath the foundation to reduce or minimize seepage immediately underneath the embankment.

A 3-foot-thick blanket drain which extends the full length of the downstream slope and connected to a 6-foot-wide vertical chimney filter and drain is assumed. The filter and drain will convey seepage to an embedded pipe collection system. Collected seepage will be discharged into a surface ditch. The cross-section of embankment is shown on Figure 3-10.

Similar to Alternatives 1 and 2, the upstream slope is maintained at 3.5:1 H:V, and the downstream slope is 3:1 H:V. A 3-foot thick riprap layer will be placed on the upstream face for wave protection, and the downstream slope will be vegetated with grass. Both slope faces will have a 20-foot wide stability berms. The berms are flat areas along the embankment slopes that improve stability and reduce erosion. A summary of geometry characteristics of Alternative 3 is presented in Table 3-13.

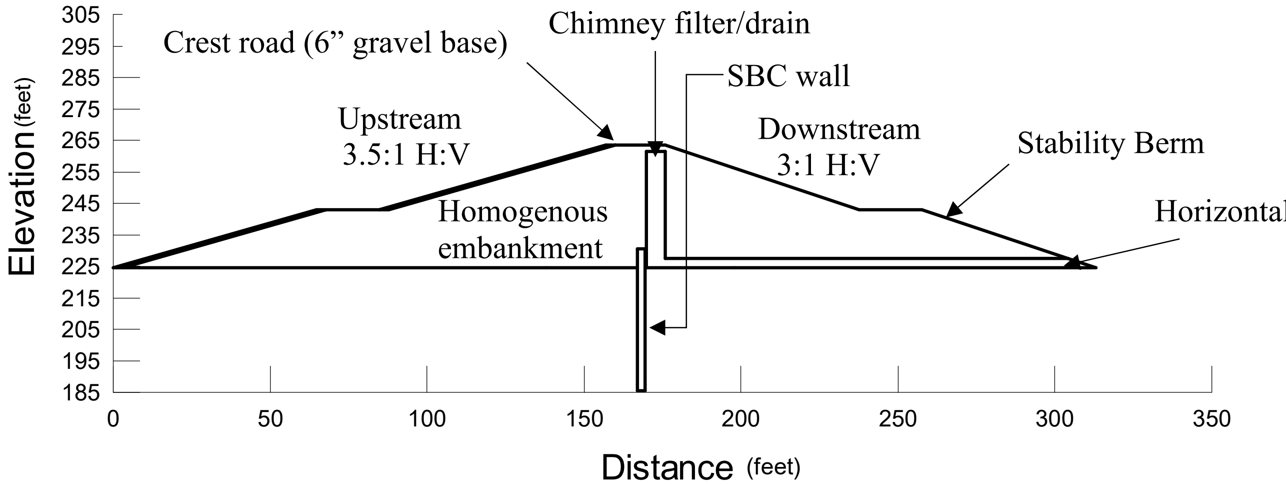


Figure 3-10 Cross Section of Alternative 3 Embankment

Table 3-13 Alternative 3 Geometry Characteristics

Item	Embankment	SBC Wall
Top elevation (feet)	263.6 and 259.1	6 feet above foundation level
Crest width (feet)	16	2.5
Upstream slope	3.5:1 H:V	Vertical
Downstream slope	3:1 H:V	Vertical
[1]Crest elevation for Walnut Creek Detention Basin and Birch Creek Detention Basin respectively.		

3.3.5 Summary

Three different embankments with various configurations were evaluated for this preliminary study. A summary of the three conceptual geometries evaluated is presented in Table 3-14. Considerations for modifications to the foundation treatment methods proposed for the three alternatives with the potential to reduce construction cost are provided in Section 7.

Table 3-14 Summary of Conceptual Geometry Characteristics

Item	Alternative 1	Alternative 2	Alternative 3
Seepage barrier	Cut-off trench with sheet pile wall	Cut-off trench with sheet pile wall, Impervious core	Soil-bentonite cutoff
Filter	Central portion of dam	Downstream of core	Central portion of dam
Upstream slope	3.5:1 H:V	3.5:1 H:V	3.5:1 H:V
Downstream slope	3:1 H:V	3:1 H:V	3:1 H:V
Stability Berm	Upstream and Downstream	Upstream and Downstream	Upstream and Downstream

3.4 Dams

3.4.1 Standards of practice

Published design criteria, standards, and guidelines included in the design basis for the Project are summarized in Table 3-15 and description of the relevant analysis or activity is provided in Appendix B-1. The standards and/or guidelines referenced for each analysis or activity are intended to encompass future work anticipated during design advancement.

In addition to information provided by the TCEQ Design and Construction Guidelines for Dams in Texas [3], the U.S. Bureau of Reclamation (USBR) Design Standard No. 13 is selected as the design basis for several analyses and activities associated with the Project. USBR design standards are written to apply to both new design/construction and design/construction of modifications to existing infrastructure. The U.S. Army Corps of Engineers (USACE) Engineering Manual (EM) 1110-2-1902 – Slope Stability [5] is included in the design basis for the rapid drawdown loading condition.

The TCEQ Design and Construction Guidelines for Dams in Texas [3] is the governing guidelines document. Guidelines from USBR and USACE will be used to supplement this document when guidance or design criteria are not available or are not specific.

3.4.2 *Assumptions*

The following are key assumptions to the design basis approach for the Project:

- Preliminary design borings and laboratory testing conducted by Aviles (2024) are considered for the dam site conditions. However, these borings are situated about 1 mile from the Project sites and are assumed to be analogous to hydrogeologic and geological conditions at the Project sites. A project site-specific field exploration and soil testing program will be required for future design advancement.
- Suitable borrow materials for the embankments are assumed to be available on-site or nearby in limited quantities based on the preliminary offsite field exploration. If suitable borrow material is not available or is cost prohibitive, other alternatives may be evaluated during design advancement (Section 8.3).

Table 3-15. Published Design Criteria, Standards, and Guidelines for Dams

Analysis or Activity	Design Standard and/or Guidelines
Consequence Classification	Texas Administrative Code (TAC) Title 30 Part 1 Chapter 299 [2]
Flood Hazard	Texas Administrative Code (TAC) Title 30 Part 1 Chapter 299 [2]
Seismic Hazard[1]	Design and Construction Guidelines for Dams in Texas TCEQ [3]
Embankment Design	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 2 Embankment Design [8]
Protective Filters	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 5 Protective Filters [6]
Foundation Preparation	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 3 Foundation Surface Treatment [10]
Freeboard	TCEQ (2007). Hydrologic and Hydraulic Guidelines for Dams in Texas, GI-364 [4] USDOE Wind Energy Study Volume 7 [6] StratMap. Upper Coast Lidar, 2018-03-22 [23]
Stilling Basin	USBR, Design of Small Dams, 3rd Edition, 1987 [7]
Spillway and Conduit Structure	TCEQ (2007). Hydrologic and Hydraulic Guidelines for Dams in Texas, GI-364 [4] USBR, Design of Small Dams, 3rd Edition, 1987 [7]
Slope Protection	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 7 Riprap Slope Protection [12]
Seepage Analysis	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 8 Seepage [13]

Analysis or Activity	Design Standard and/or Guidelines
Static Deformation Analysis[2]	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 9 Static Deformation Analysis [14]
Slope Stability Analysis	Texas Administrative Code (TAC) Title 30 Part 1 Chapter 299 [2] Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 9 Static Deformation Analysis [14] USACE EM 1110-2-1902 – Slope Stability [5]
Seismic Analysis	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 13 Seismic Analysis and Design [15]
Site Investigation	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 12 Foundation and Earth Materials Investigation [16]
Instrumentation and Monitoring	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 11 Instrumentation and Monitoring [17]
Construction	Design and Construction Guidelines for Dams in Texas TCEQ [3] USBR Design Standard No. 13 Embankment Dams: Chapter 10 Embankment Construction [18]

[1]The risk of seismic hazard is assumed to be low for the Project areas and has not been evaluated in this DBM. The potential for seismic activities in the Project areas should be evaluated during future design advancement.

[2]Includes evaluation of settlement and cracking. Static deformation has not been evaluated in this DBM. The potential for settlement and cracking should be evaluated during future design advancement.

4 Summary of subsurface explorations, geotechnical parameters, and suitability of on-site material

4.1 Site conditions

This section presents a summary of the 2024 field exploration and laboratory testing program performed by Aviles Engineering Corp. The following description of site conditions (Table 4-1) is derived from the field exploration report by Aviles Engineering Corp. (2024) [21] in conjunction with review of the site aerial maps obtained from Google Earth.

Table 4-1. Site Conditions

Item	Description
Site Information	The Project is located on Walnut Creek and Birch Creek about 1 mile off the FM 1488 road, in Waller County, Texas.
Existing Improvements	Access to the Project sites was not available at the time the work was performed. However, The Carlton Speed Oil and Gas field is reported to be located near the northern end of the lake that will result from the proposed Birch Creek Detention Basin.
Current Ground Cover	From Google Earth maps, the Project area at both sites is predominantly covered with heavy vegetation including scattered trees and bushes with light brush and weeds present.
Existing Topography	The general existing site topography around the proposed dam alignments include two separate tributaries, which drain to confluences approximately 1,500-ft downstream. Both sites include localized high areas along the midpoint of the dam alignments, with elevations approximately 10 to 15 feet higher than the adjacent streambeds. Elevations use the North American Vertical Datum of 1988 (NAVD 88). General existing site terrain of the two sites relative to the embankment alignment is shown in Figure 4-1 and Figure 4-2.

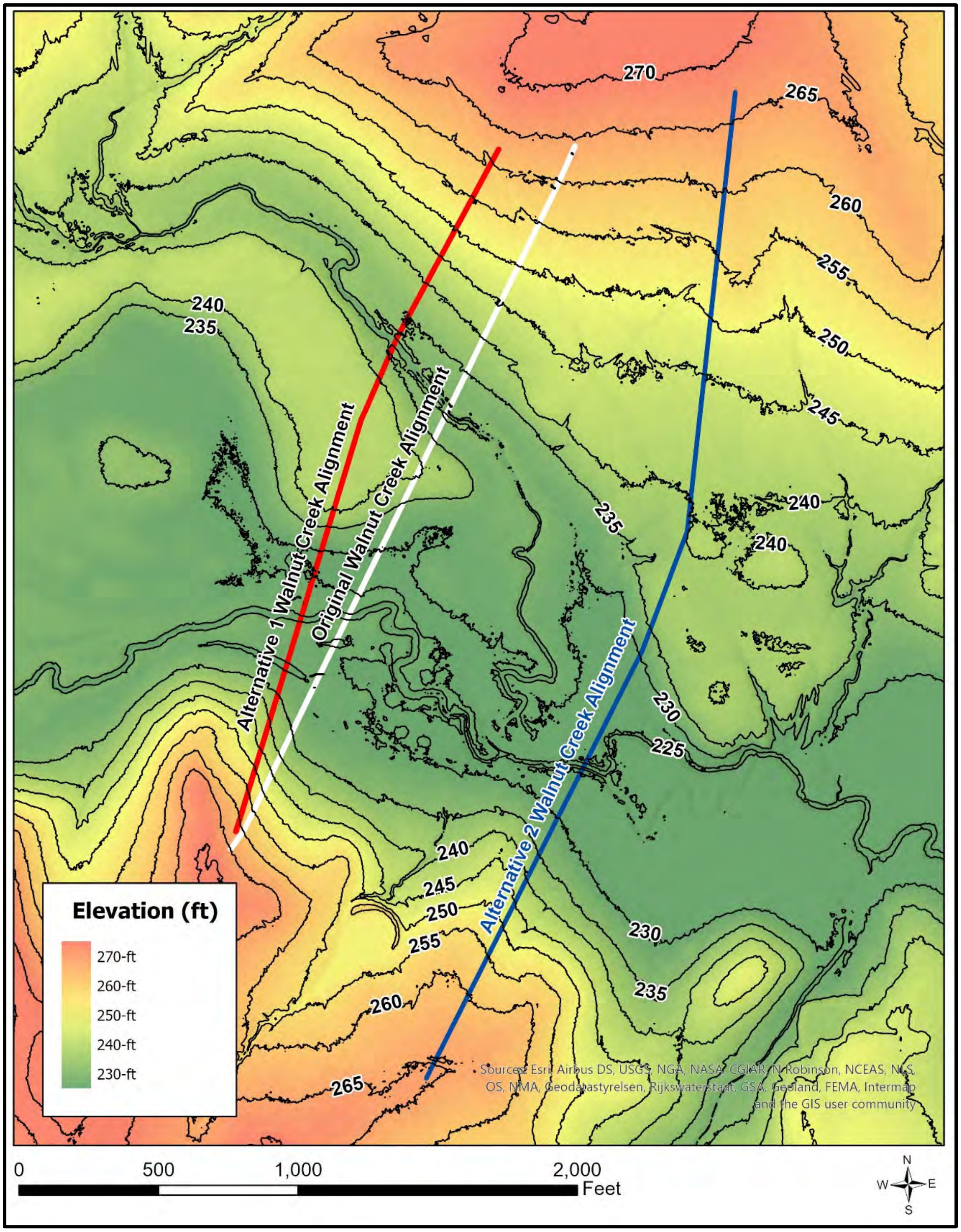


Figure 4-1 Walnut Creek Detention Basin Existing Site Terrain

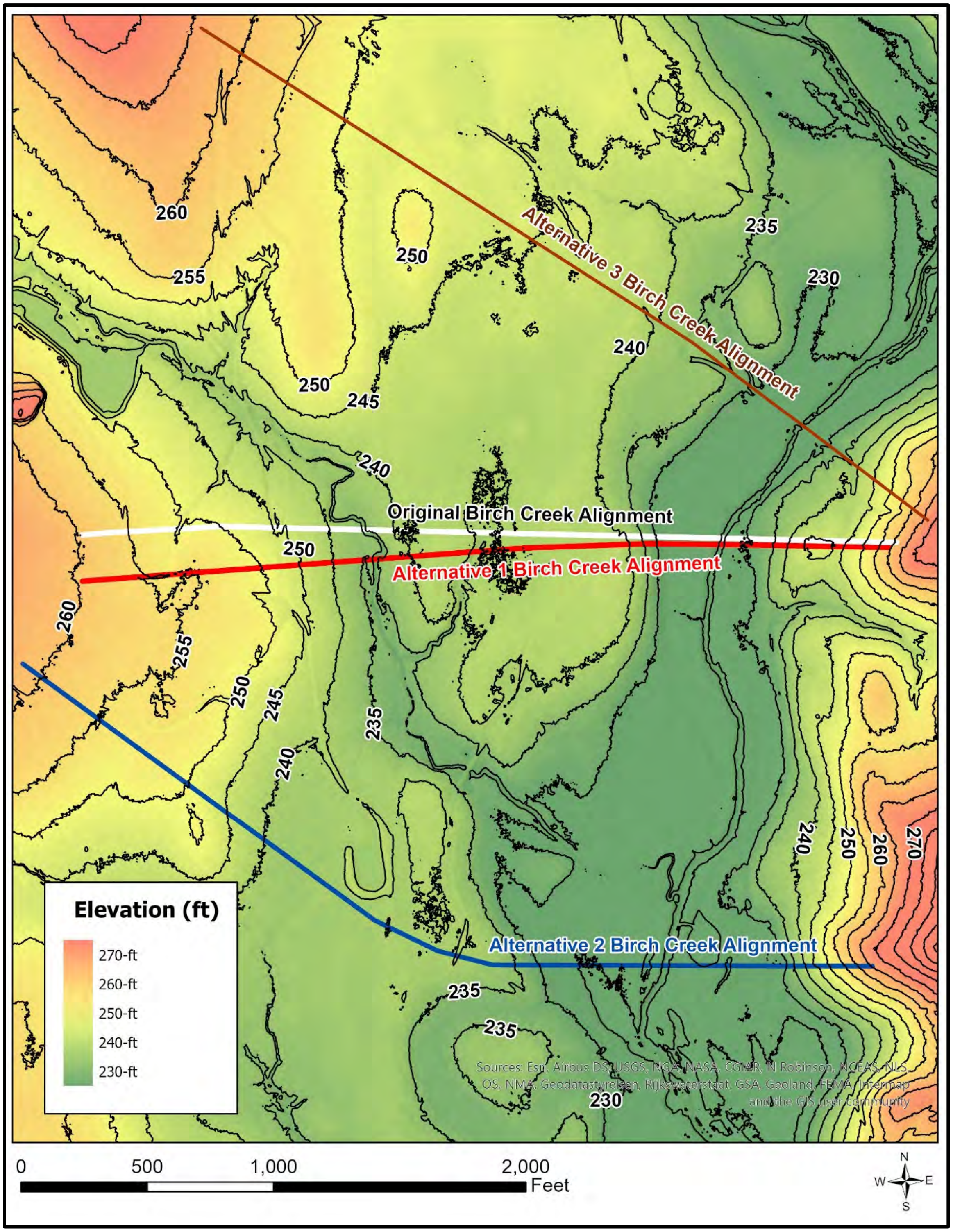


Figure 4-2 Birch Creek Detention Basin Existing Site Terrain

4.2 Site geology

The geologic setting of the Project area lies within Willis Formation which is a mixture of clay, silt, fine to very coarse sand and gravel. These Quaternary deposits are from the Pleistocene era and are predominant in southeastern Texas and southern Louisiana. The thickness of the formation is approximately 100 feet. A portion of the lake resulting from the proposed Walnut Creek Detention Basin appears to also be located in the Lissie Formation. This formation is approximately 200 feet thick and is composed of clay, silt, sand, and very minor to minor amounts of gravel.

4.3 Subsurface exploration

Aviles Engineering Corp. conducted field exploration to investigate the subsurface conditions near the vicinity of the project area during the dates of February 9, 2024, and February 19, 2024. Due to restricted access to the Project sites at the time of the field exploration, these borings were drilled along FM 1488 road which is located approximately one mile south to the Project site. A total of four Standard Penetration Test (SPT) borings (labeled B-1 through B-4) with termination depths ranging from 90 to 120 feet below ground surface (bgs) were drilled. Borings B-1 and B-2 were drilled approximately 4,500 feet southeast of Walnut Creek Detention Basin. Borings B-3 and B-4 were drilled approximately 5,100 feet south of Birch Creek Detention Basin. The as drilled boring locations are shown on Figure 4-3. A summary of the boring data is provided in Table 4-2. These SPT borings were performed using the dry auger and wet rotary drilling methods and the soil samples were tested at the Aviles Engineering Corp. laboratory. A geotechnical data and interpretation report was developed based on the field exploration and laboratory testing program by Aviles Engineering Corp. and is provided in Appendix B-2.

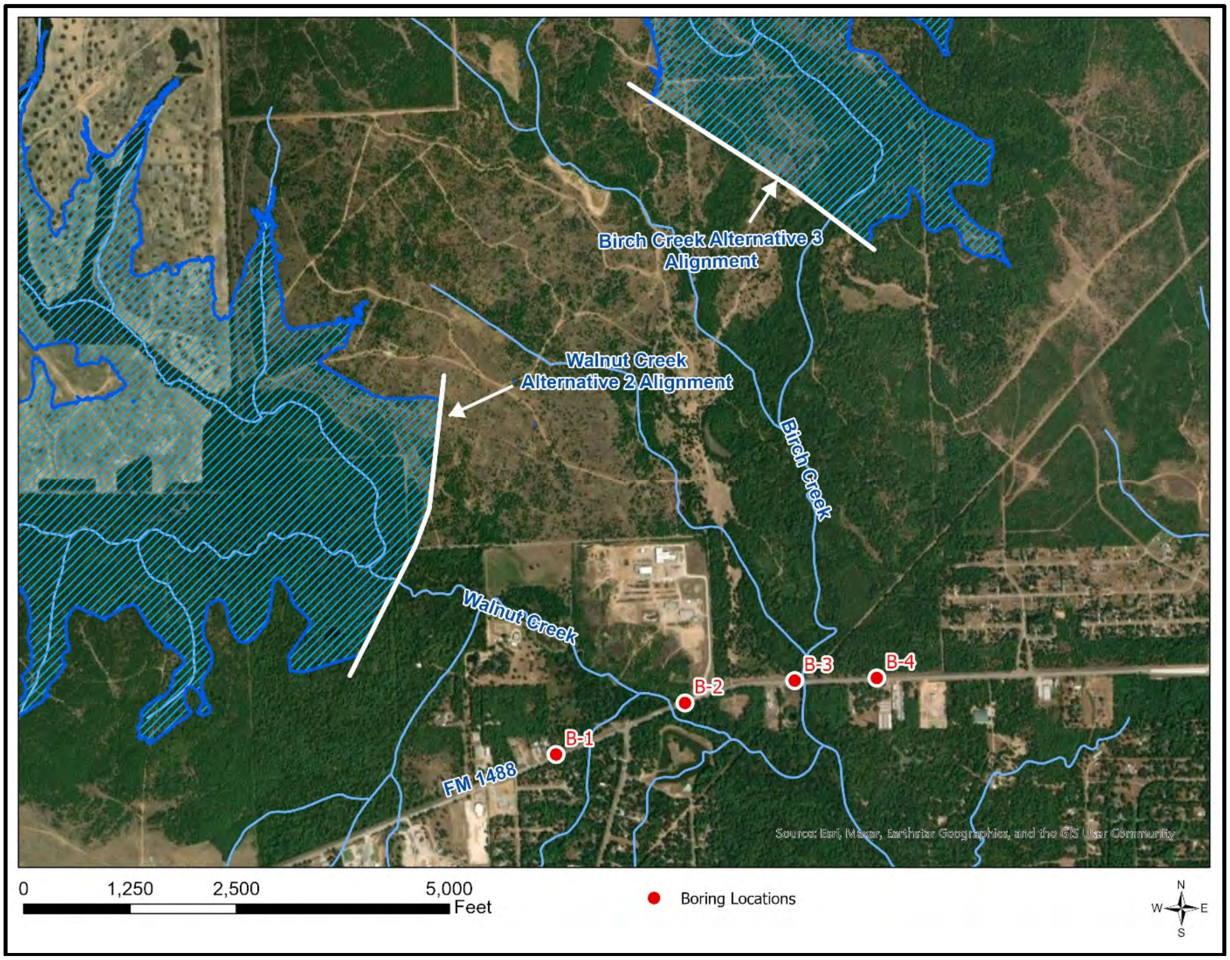


Figure 4-3 Approximate Borings Locations (from Aviles 2024)

Table 4-2 Boring Location

Boring ID	Latitude	Longitude	Elevation[1] (feet)	Total Depth (feet)
B-1	30°11'14.68"N	95°49'49.60"W	250	90
B-2	30°11'20.29"N	95°49'32.18"W	224	120
B-3	30°11'22.52"N	95°49'17.42"W	223	120
B-4	30°11'22.57"N	95°49'6.42"W	248	90
[1]Approximate elevations from Google Earth obtained on 4/8/2024				

4.4 Subsurface conditions and soil properties

Generally, the subsurface soils from borings comprised silty sands (SM), sandy lean clays (CL), clayey sands (SC), poorly graded sand with silt (SP-SM), sandy fat clay (CH), silty clay with sand (CL-ML) and silty clayey sand (SC-SM). The design subsurface and groundwater conditions encountered from the field exploration and laboratory testing program to determine soil parameters is presented in a Material Calculation Package as Appendix B-3.

4.5 Selected soil parameters

Soil engineering properties for embankment design are mainly defined based on the results of field and laboratory testing of undisturbed foundation and laboratory-compacted specimens. Calculations to estimate and select design parameters is included as 0. Relevant design parameters for this conceptual design are summarized as Table 4-3 to Table 4-8.

Table 4-3 Total Unit Weight for Foundation

Stratum	Total Unit Weight (pcf)
Walnut	
Silty Sand and Clayey Sand	125
Silty Clay and Sandy Clay	125
Silty Sand and Clayey Sand	130
Silty Clay and Sandy Clay	125
Silty Sand and Clayey Sand	130
Birch	
Silty Sand and Clayey Sand	125
Silty Clay and Sandy Clay	123
Silty Sand and Clayey Sand	130

Table 4-4 Total Unit Weight for Embankment Fill Materials

Material Type	Total Unit Weight (pcf)
Embankment Fill (Zone A)[1]	125
Embankment Fill (Zone B)[2]	130
SBC	90
Filter	120
Riprap	124

[1]Embankment Fill (Zone A) is impervious fill with properties analogous to silty clay and sandy clay (see Appendix B-3).

[2]Embankment Fill (Zone B) is structural fill with properties analogous to silty sand and clayey sand (see Appendix B-3).

Table 4-5 Design Soil Permeability

Material Type	Soil Permeability, k_s ft/s (cm/s)
Silty Sand and Clayey Sand	3×10^{-9}, (1×10^{-7})
Silty Clay and Sandy Clay	3×10^{-10}, (1×10^{-8})
Embankment Fill (Zone A)	3×10^{-10}, (1×10^{-8})
Embankment Fill (Zone B)	3×10^{-9}, (1×10^{-7})
SBC	3×10^{-9}, (10^{-7})
Filter	3×10^{-5}, (0.001)
Riprap	1, (30.48)

Table 4-6 Soil Undrained Strength Parameters

Material Type	Dam	Undrained Strength (psf)
Embankment Fill (Zone A)	Both	720
Embankment Fill (Zone B)		1000
SBC		No strength
Filter		NA
Riprap		NA
Foundation- silty and sandy clays		722
Foundation- silty and clayey sands	Walnut	1030
	Birch	1000

NA— Not Applicable

Table 4-7 Soil Drained Strength Parameters

Material Type	Drained Strength Parameters	
	Cohesion, c' (kPa)	Friction Angle, φ' (deg)
Embankment Fill (Zone A)	0	21
Embankment Fill (Zone B)	0	31
SBC	No strength	
Filter	0	36
Riprap	0	40
Foundation- silty and sandy clays	0	21
Foundation- silty and clayey sands	0	31

Table 4-8 Soil R-Envelope Strength Parameters

Material Type	Drained Strength Parameters	
	Cohesion, cR (kPa)	Friction Angle, φR (deg)
Embankment Fill (Zone A)	240	14.6
Embankment Fill (Zone B)	210	23.6
SBC	No strength	
Filter	NA	
Riprap		
Foundation- silty and sandy clays	240	14.6
Foundation- silty and clayey sands	210	23.6

4.6 Dispersive soils

The dispersive properties of on-site materials evaluated in Appendix B-2 and Appendix B-3 indicate a potential for dispersive behavior of the on-site materials. Challenges and risk associated with the use of dispersive clay soils have been highlighted in the Design and Construction Guidelines for Dams in Texas by TCEQ [3] and Bureau of Reclamation Report No. R-91-09 [21]. Engineering considerations and measures by TCEQ and Bureau of Reclamation include provision of adequate filter, compaction and water content control during construction, and lime-stabilization for slope protection where other means such as gravel with the necessary filter layers are not economically feasible.

5 Results of seepage analyses

This section presents the summary results of the seepage analyses completed to evaluate the behavior of seepage within the embankment and its foundation soils. Calculation package detailing these analyses, including assumptions, selected parameters and critical seepage sections is included in Appendix B-4. Considering that the proposed dams are intended for use as detention basins, long-term reservoir losses deemed acceptable was of secondary importance to the seepage analysis. The seepage analysis includes verification that exit gradients are acceptable based on the acceptance criteria provided in Appendix B-1 of the DBM.

A summary of Factor of Safety (FoS) to check against soil movement because of the exit gradient, and predicted embankment through-seepage discharges for the alternative geometries is included as Table 5-1 and Table 5-2 respectively. The results show acceptable FoS against exit gradient.

The seepage analyses provide an understanding of the quality of potential on-site embankment fill materials. Results from the seepage model also provide guidance for advanced design field explorations and laboratory testing, selection and design of seepage control barrier and seepage collection systems.

Table 5-1 Summary of Seepage Analyses Factor of Safety Against Exit Gradient

Dam	Target FoS[1]	Calculated FoS[2]
Walnut Creek		
Alternative 1		46
Alternative 2	4.0	28
Alternative 3		50
Birch Creek		
Alternative 1		25
Alternative 2	4.0	26
Alternative 3		28

[1]Refer to Appendix B-1 Table A-4

[2]Refer to Appendix B-4.

Table 5-2 Summary of Seepage Analyses Discharge

Dam	Discharge (ft^3/day/ft)[1]	
	Combined Flow Through Dam and Foundation	**Flow Through Filter**
	Walnut Creek	
Alternative 1	0.006	0.005
Alternative 2	0.002	0.001
Alternative 3	0.005	0.005
	Birch Creek	
Alternative 1	0.006	0.004
Alternative 2	0.003	0.001
Alternative 3	0.006	0.005

[1]Refer to Appendix B-4.

6 Results of slope stability analysis

This section presents the summary results of the static slope stability analyses completed to evaluate the Project alternative embankments. Calculation package detailing these analyses, including assumptions, selected parameters and critical slip surfaces are included in Appendix B-5.

A summary of the slope stability analysis results for the Project is included as Table 6-1. The calculated factors of safety exceed the minimum factors of safety recommended by TCEQ and are considered to be acceptable for this level of effort. The TCEQ minimum factors of safety are provided in Appendix B-5. Comparison of the factors of safety to design criteria provided in Appendix B-1 shows that the proposed alternative embankment geometries are acceptable.

Table 6-1 Summary of Slope Stability Analysis Results for the Project

Loading Condition	Target FoS[1]	Calculated FoS[2]		
		Alt. 1	Alt. 2	Alt. 3
Walnut Creek				
End of Construction (Upstream)	1.3	1.5	1.7	1.4
End of Construction (Downstream)	1.3	1.5	1.7	1.3
Long Term (Normal 100-year Flood)	1.5	1.8	1.9	1.8
Peak Design Flood	1.2–1.3	1.9	1.8	1.8
Rapid Drawdown from Normal 100-year Flood (Drawdown to existing grade)	1.3—1.5	1.3	1.3	1.3
Rapid Drawdown from Peak Design Flood (Drawdown to existing grade)	1.3—1.5	1.3	1.2 (Note 2)	1.3
Birch Creek				
End of Construction (Upstream)	1.3	1.6	1.8	1.5
End of Construction (Downstream)	1.3	1.6	1.3	1.4
Long Term (Normal 100-year Flood)	1.5	1.8	1.6	1.8
Peak Design Flood	1.2–1.3	1.8	1.6	1.8
Rapid Drawdown from Normal 100-year Flood (Drawdown to existing grade)	1.3—1.5	1.3	1.3	1.3
Rapid Drawdown from Peak Design Flood (Drawdown to existing grade)	1.3—1.5	1.2 (Note 2)	1.2 (Note 2)	1.2 (Note 2)

[1]Refer to Appendix B-1 Table A-3.

[2]FoS= 1.2 is acceptable based on considerations and recommendations provided in Appendix B-5. Refer to Appendix B-5.

7 Conceptual design of the Walnut Creek and Birch Creek Detention Basins

This section presents the conceptual design of the Project, based on the results presented in Section 5 and Section 6, and the calculation packages included in Appendix B-4 and Appendix B-5. The following are key features considered for the three alternative embankments, based on the analyses completed to date:

- Upstream and downstream berms are included for all three alternative embankments for structural stability and to accommodate anticipated frequent drawdown on upstream slope face.
- Filtered drainage system is included in all three alternative embankments for erosion control based on the assumption that on-site borrow sources may exhibit potential for dispersion.
- Foundation seepage barrier is included in all three alternatives for embankment under-seepage control based on the assumption that pervious foundation materials will be encountered.
- Impervious core is included in Alternative 2 for seepage control based on the assumption that pervious on-situ borrow sources will be used as embankment shell fills.

A summary of the design values for the alternative embankment sections based on the seepage and slope stability analyses completed in this DBM is summarized in Table 7-1. Plans and profiles of the sections are presented as Appendix B-6. It is anticipated that the embankment alternative selected for advanced design will be further developed during design advancement to incorporate settlement and other required analyses for the embankment sections. Cross-sections of the alternative embankments showing the calculated geometries, based on seepage and slope stability analyses are include as Figure 7-1 to Figure 7-3 for Walnut, and Figure 7-4 to Figure 7-6 for Birch.

Table 7-1 Project Embankment Design Values

Feature	Embankment Section Design Value	Unit
Walnut Creek		
Length	3,373	feet
Maximum Height	39.1	feet
Design Crest Width	16	feet
Design Crest Elevation[1]	263.6	feet
Typical Upstream Slope	3.5H:1V	—
Typical Downstream Slope	3H:1V	—
Birch Creek		
Length	3,168	feet
Maximum Height	35.4	feet
Design Crest Width	16	feet
Design Crest Elevation[1]	259.1	feet
Typical Upstream Slope	3.5H:1V	—
Typical Downstream Slope	3H:1V	—

[1]Elevation does not include allowance for settlement; settlement will be evaluated during design advancement and added to the Design Crest Elevation. The US Bureau of Reclamation recommends 1% of maximum embankment height for preliminary camber design to account for potential settlement of the embankment fill.

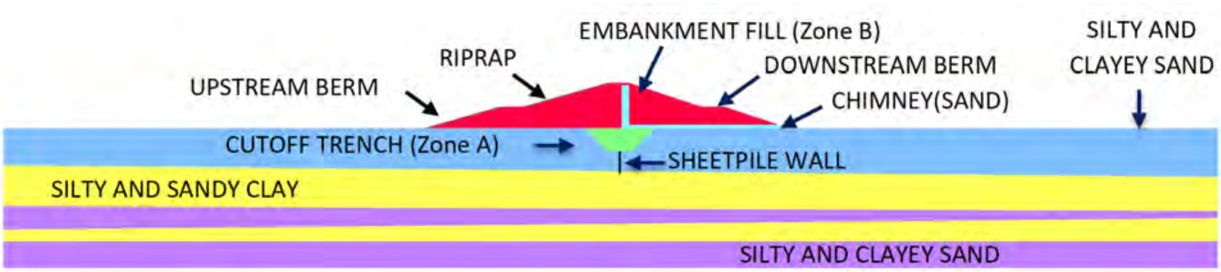


Figure 7-1 Typical Geometry and Zonation for Alternative 1— Walnut

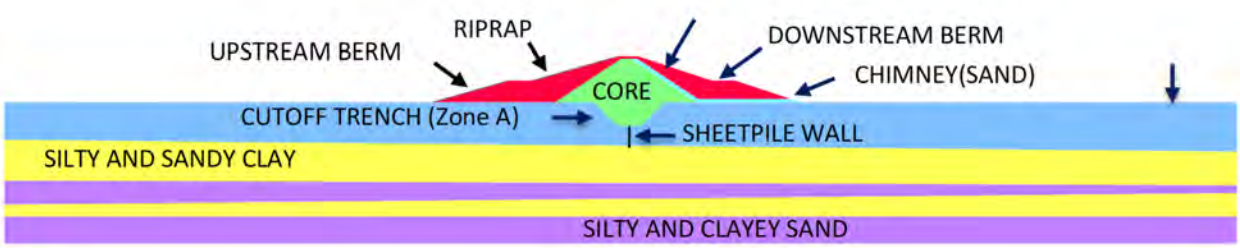


Figure 7-2 Typical Geometry and Zonation for Alternative 2— Walnut

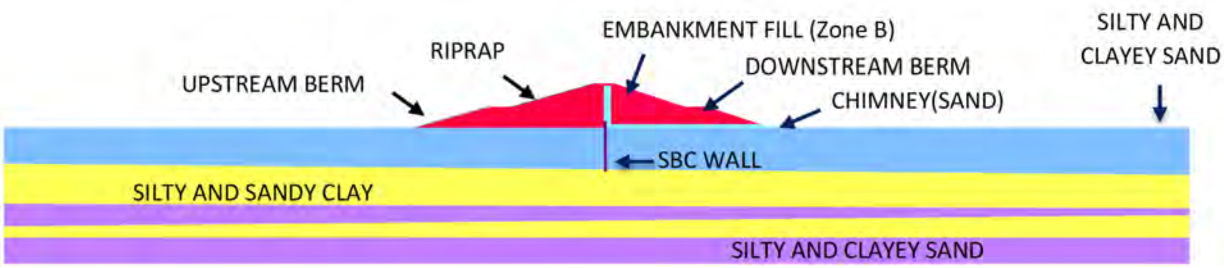


Figure 7-3 Typical Geometry and Zonation for Alternative 3— Walnut

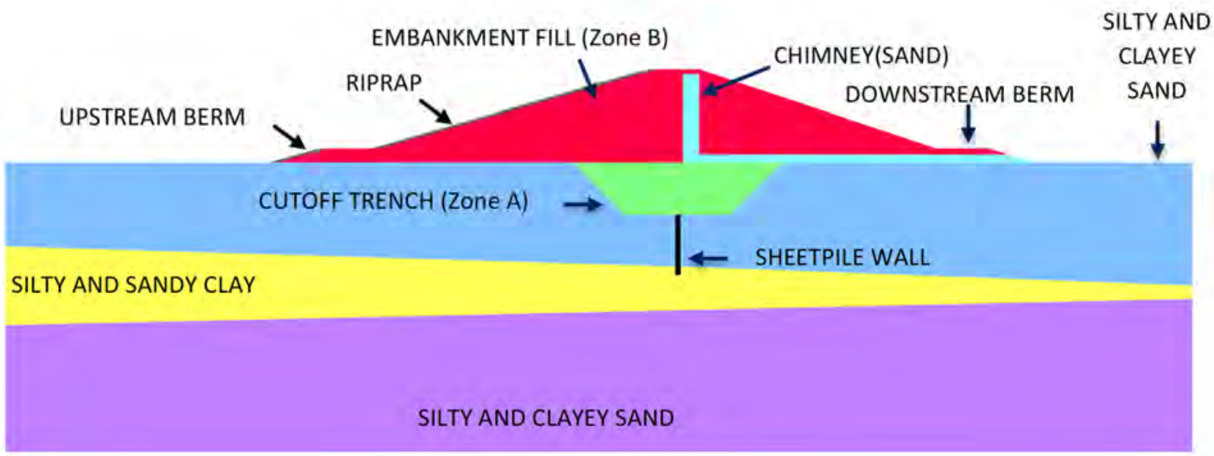


Figure 7-4 Typical Geometry and Zonation for Alternative 1— Birch

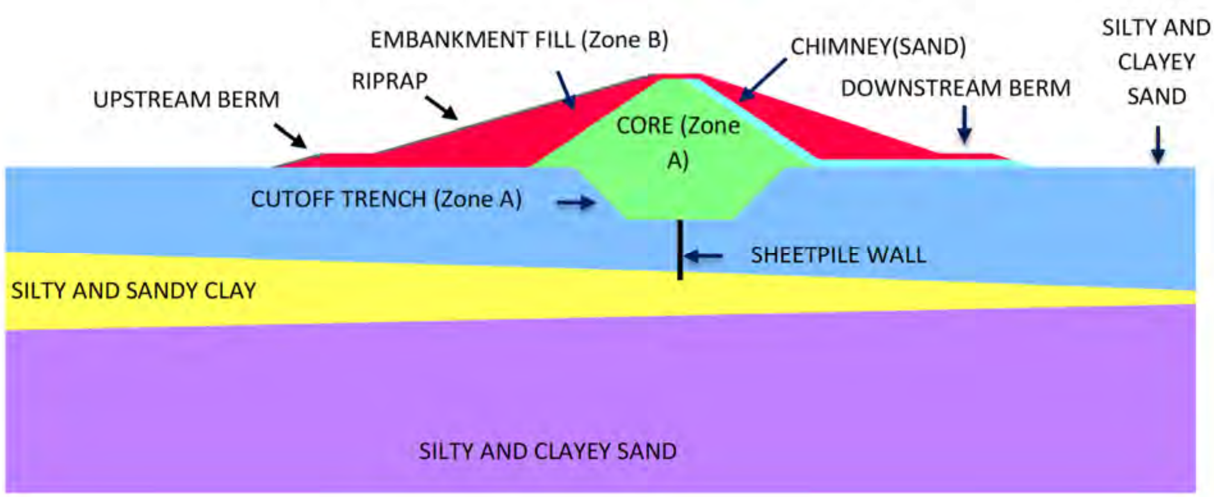


Figure 7-5 Typical Geometry and Zonation for Alternative 2— Birch

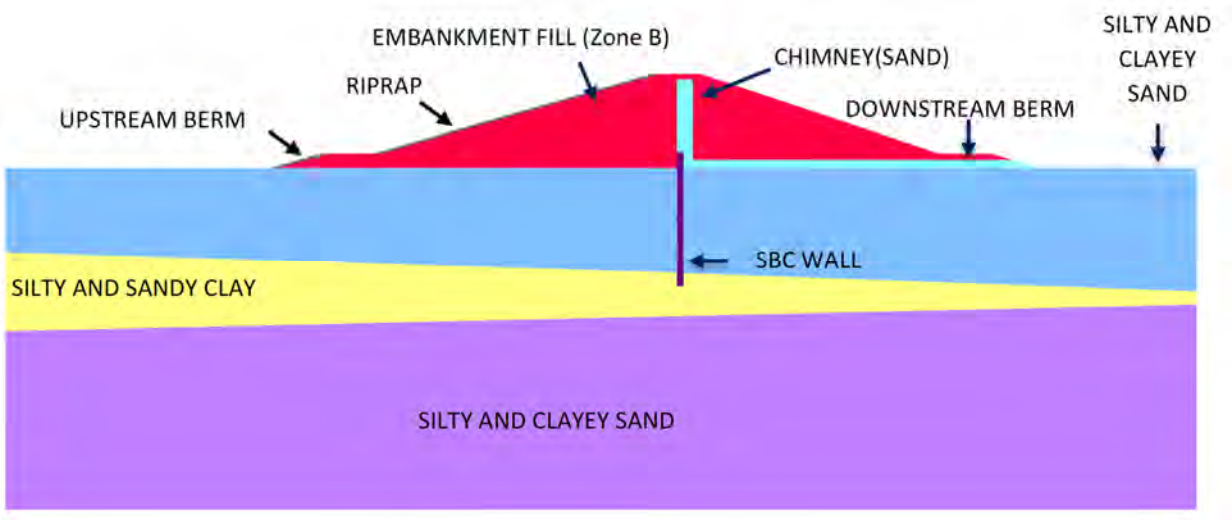


Figure 7-6 Typical Geometry and Zonation for Alternative 3— Birch

The primary function of the Project as detention basins presents a potential for modification of the selected embankment foundation treatment options for the alternative geometries for the following reasons:

- The primary function of the Project is to impound flood water for a relatively short duration (days or weeks) to reduce flow discharges to minimize the potential for flooding downstream of the Project. Hence seepage losses are not of primary concern for the function of the Project.
- Embankment under-seepage can cause foundation soil erosion resulting from piping. Minimizing the under-seepage exit gradients to acceptable values based on TCEQ recommendations and Reclamation factor of safety criterion may be sufficient for embankment stability.

The following embankment foundation treatment modifications presented in Table 7-2 are provided for consideration during advanced design. The purpose of these modifications is to explore cost-saving alternatives for foundation treatment and improve the financial value of the Project, and at the same time ensuring minimum regulatory requirements are achieved. Illustration of these modifications is presented in Appendix B-7.

Table 7-2 Foundation Treatment Modifications

Foundation Treatment	Considerations		
	Alternative 1	**Alternative 2**	**Alternative 3**
Cutoff trench with sheet pile wall	• Modification 1—Implement a partial cutoff trench which will be terminated in the silty and clayey sand stratum at a depth necessary to satisfactorily limit seepage and high exit gradients, excluding a sheet pile wall. • Modification 2—Implement a partial sheet pile wall which will be terminated in the silty and clayey sand stratum at a depth necessary to satisfactorily limit seepage and high exit gradients. • Site-specific geotechnical exploration will be required to evaluate proposed modifications.	• Modification 1—Implement a partial cutoff trench which will be terminated in the silty and clayey sand stratum, at a depth necessary to satisfactorily limit seepage and high exit gradients, excluding a sheet pile wall. • Modification 2—Implement a partial sheet pile wall which will be terminated in the silty and clayey sand stratum at a depth necessary to satisfactorily limit seepage and high exit gradients. • Site-specific geotechnical exploration will be required to evaluate proposed modifications.	No specific consideration
Soil-bentonite cutoff wall	No specific consideration	No specific consideration	• Install a partial soil-bentonite cutoff wall which will be terminated in the silty and clayey sand stratum at a depth necessary to satisfactorily limit seepage and high exit gradients. • Site-specific geotechnical exploration will be required to evaluate proposed modifications.

8 Construction considerations

8.1 Project embankment constructability

The following constructability considerations have been identified from the conceptual design of the Project. Construction risks and considerations and/or recommendations for these risks are presented as Table 8-1.

Table 8-1 Construction Risks and Considerations

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Borrow Material Suitability				
Available material	• Silty and clayey sand, and clayey soils may be available on site that may be suitable for embankment borrow material (e.g., core, fill, drain/filter material). • A riprap source may not be locally available; other alternatives will have to be considered for embankment slope protection (e.g., vegetation, soil cement, roller compacted concrete (RCC), geotextiles) (TCEQ guidelines Section 6.1 [3]). • Adverse soil (e.g., dispersive soils based on 2024 lab testing) may not be suitable as borrow material or may require special improvements to be used as borrow material based TCEQ recommendations. • Sufficient granular borrow is likely unavailable on-site for relatively pervious design elements such as drains and filters. It is anticipated that hauling of granular borrow to the site or in limited volumes from select on-site areas will be required (e.g., from riverbeds, imported). Access road design must consider these hauling requirements. • Site-specific geotechnical investigation(s) and laboratory testing are required to evaluate on-site materials suitability as a borrow.	• Clay soils available on site may be present at depths below estimated groundwater level based on findings from soil borings and may require extensive dewatering program to utilize on-site borrow sources for clay. • It is anticipated that hauling of clay borrow to the site or in limited volumes from select on-site areas will be required. Access road design must consider these hauling requirements.	• Clay soils available on site may be present at depths below estimated groundwater level based on findings from soil borings and may require extensive dewatering program to utilize on-site borrow sources for clay. • It is anticipated that hauling of clay borrow to the site or in limited volumes from select on-site areas will be required. Access road design must consider these hauling requirements.	No specific considerations

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Foundation Suitability				
Depth to competent rock	Review of borings stratigraphy from field exploration suggests it is unlikely competent rock will be encountered in the Project foundations.	• The cutoff trench must have adequate contact with a suitable impervious subsurface stratum, the suitability and depth of which must be evaluated through site-specific geotechnical investigation(s). • Based on findings from field exploration, a suitable impervious stratum may be relatively deep, hence a partial cutoff trench or partial cutoff wall (e.g., slurry trench, concrete, secant pile, sheet pile) may be a more economical alternative considering the primary function of the Project.	• The cutoff trench must have adequate contact with a suitable impervious subsurface stratum, the suitability and depth of which must be evaluated through site-specific geotechnical investigation(s). • Based on findings from field exploration, a suitable impervious stratum may be relatively deep, hence a partial cutoff trench or partial cutoff wall (e.g., slurry trench, concrete, secant pile, sheet pile) may be a more economical alternative considering the primary function of the Project.	• The soil-bentonite wall must fully penetrate pervious strata and key into suitable impervious subsurface stratum, the suitability and depth of which must be evaluated through site-specific geotechnical investigation(s). • Based on findings from field exploration, a suitable impervious stratum may be relatively deep, hence a partially penetrating SBC wall may be a more economical alternative. considering the primary function of the Project.
Nonuniform strata	Field exploration logs indicate variable layering of material in the foundations. This variability encompasses material type (e.g., sand, clay, silt) and degree of lithification/strength (e.g., unconsolidated deposits). Multiple foundation treatment options may need to be evaluated to address nonuniform conditions in the foundation.	No specific considerations	No specific considerations	No specific considerations

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Nonuniform strata	• There is the potential for weak and permeable layers (e.g., clay, sand, silt) within the Project foundation based on findings from field exploration; TCEQ guidelines (Section 4.2) [3] outline potential treatment options if these materials are encountered in the foundation (e.g., removal of problematic material, filtered drainage systems, installation of cutoff trench/wall, covering permeable foundation material with impervious material). • Site-specific geotechnical investigation(s) are required to evaluate foundation conditions and recommended foundation treatment(s).	No specific considerations	No specific considerations	No specific considerations
Dispersive soil	• There is the potential for dispersive soil (i.e., clay) in the Project foundations based on findings from laboratory testing. Site-specific sampling and lab testing are required to identify and characterize dispersive soil. • Dispersive soil within the dam foundation would require removal, additional provisions for adequate drainage (e.g., upstream/downstream filters), or soil stabilization to mitigate piping risk. • TCEQ guidelines recommend avoiding highly dispersive soils altogether within a dam foundation (Section 4.2) [3]. • TCEQ and USBR guidelines provide engineering considerations for using dispersive soils in dams. Engineering considerations include provision of adequate filter, compaction and water content control during construction, and lime-stabilization for slope protection where other means such as gravel with the necessary filter layers are not economically feasible.	No specific considerations	No specific considerations	No specific considerations

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Compressible Soil	• There is the potential for compressible soil (i.e., clay, silt, organic material) in the foundations. Site-specific sampling and lab testing are required to identify and characterize compressible soil. • If compressible soil in the foundation is thick or underlain by a permeable layer, compressible soil can be treated by pre-wetting during construction to mitigate post-construction settlement (TCEQ guidelines Section 4.2 [3]) • Soft soils may be encountered in the foundation footprint across the creek and may require treatment prior to embankment construction. If hauling and off-site disposal of unsuitable material is required, definition of areas for placement and drainage prior to removal may be required. A disposal plan following applicable environmental regulations is anticipated to be required.	No specific considerations	No specific considerations	No specific considerations
Soluble Material	• No testing was performed to determine the potential presence of soluble material. The TCEQ recommends evaluation of special improvements for soluble material (e.g., gypsum, calcite) (Section 4.2) [3] • Site-specific geotechnical investigation(s) are required to evaluate the presence of, type and extent of soluble material, the results of which would inform special improvements alternatives.	No specific considerations	No specific considerations	No specific considerations
Liquefiable Soil	• Predominantly sandy soils may be present on site based on findings from soil borings. Risk of liquefaction is low based on records of seismic activity and soil consistency from SPT results; however, it is standard practice to remove potentially liquefiable soil within an embankment dam foundation. • Site-specific geotechnical investigation(s) are required to identify and characterize potentially liquefiable soil.	No specific considerations	No specific considerations	No specific considerations