Appendix B:
Conceptual Design (Task 1103 Deliverable)

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

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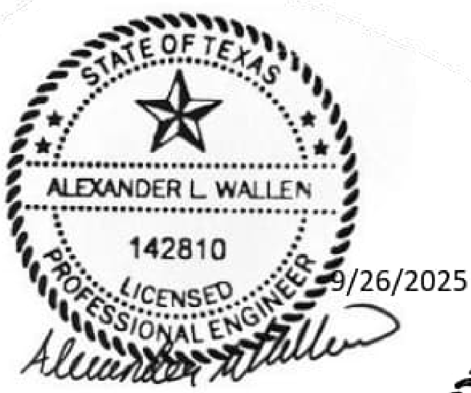

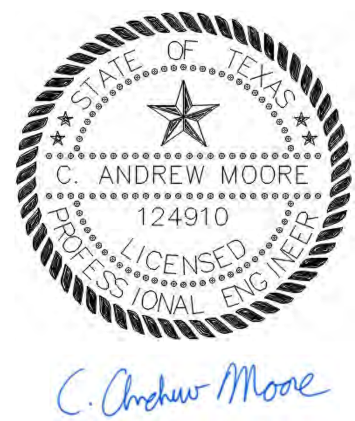

This Design Basis Memorandum for the Spring Creek Watershed Flood Control Dams Project, dated February 6, 2025, was prepared for Halff Associates (Consultant) and the San Jacinto River Authority (Client) to evaluate the feasibility of constructing two detention basins on Walnut Creek and Birch Creek. 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.

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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.

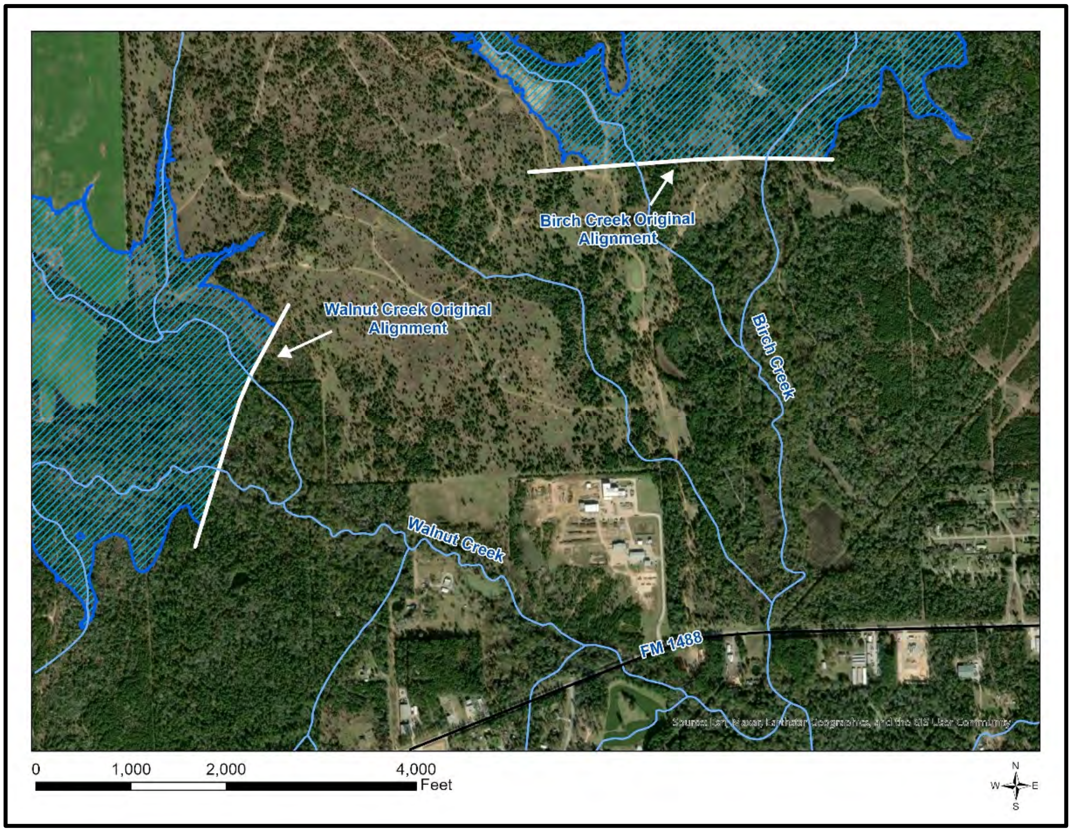

Figure 1-1 Project Overview Showing Walnut Creek and Birch Creek Dam Alignments

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.

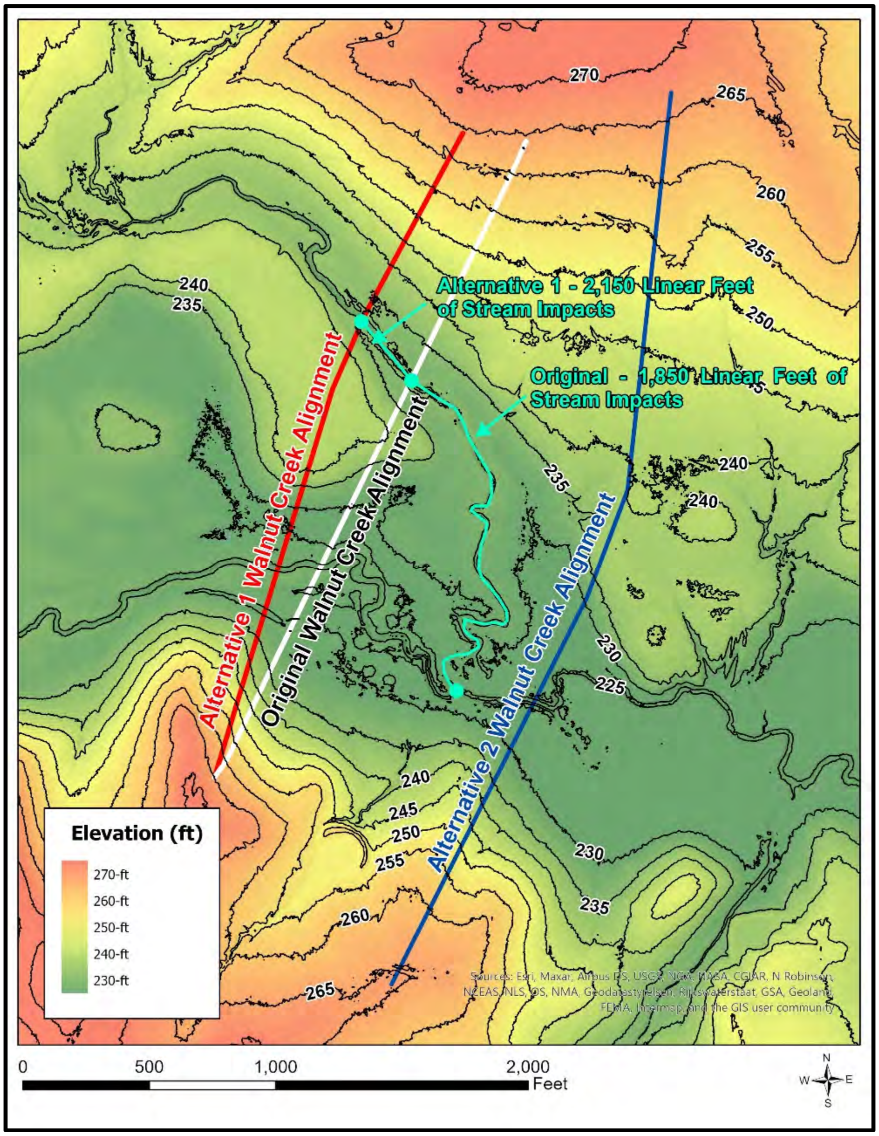

Figure 3-1 Walnut Creek Alignment Alternatives

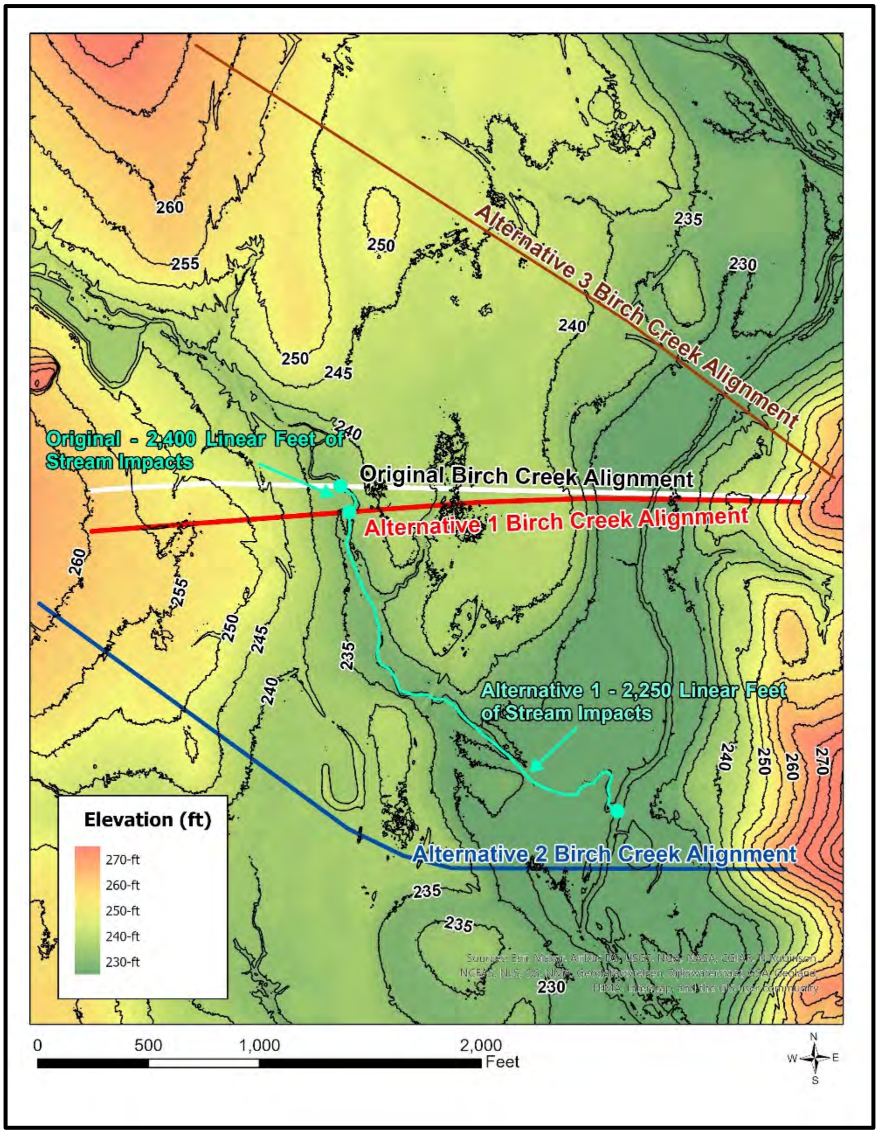

Figure 3-2 Birch Creek Alignment Alternatives

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

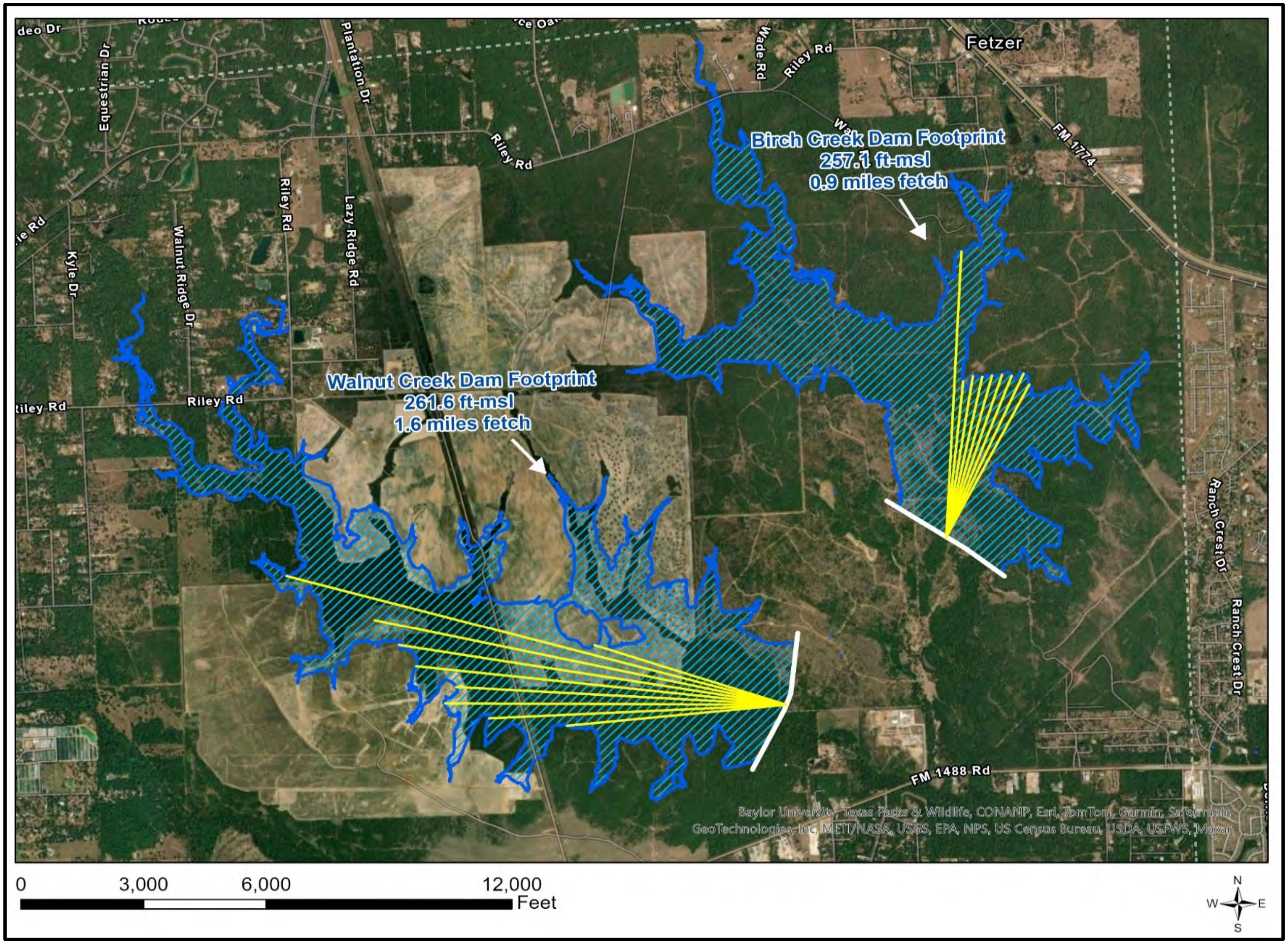

Figure 3-3 Design Flood WSEs Footprints

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.

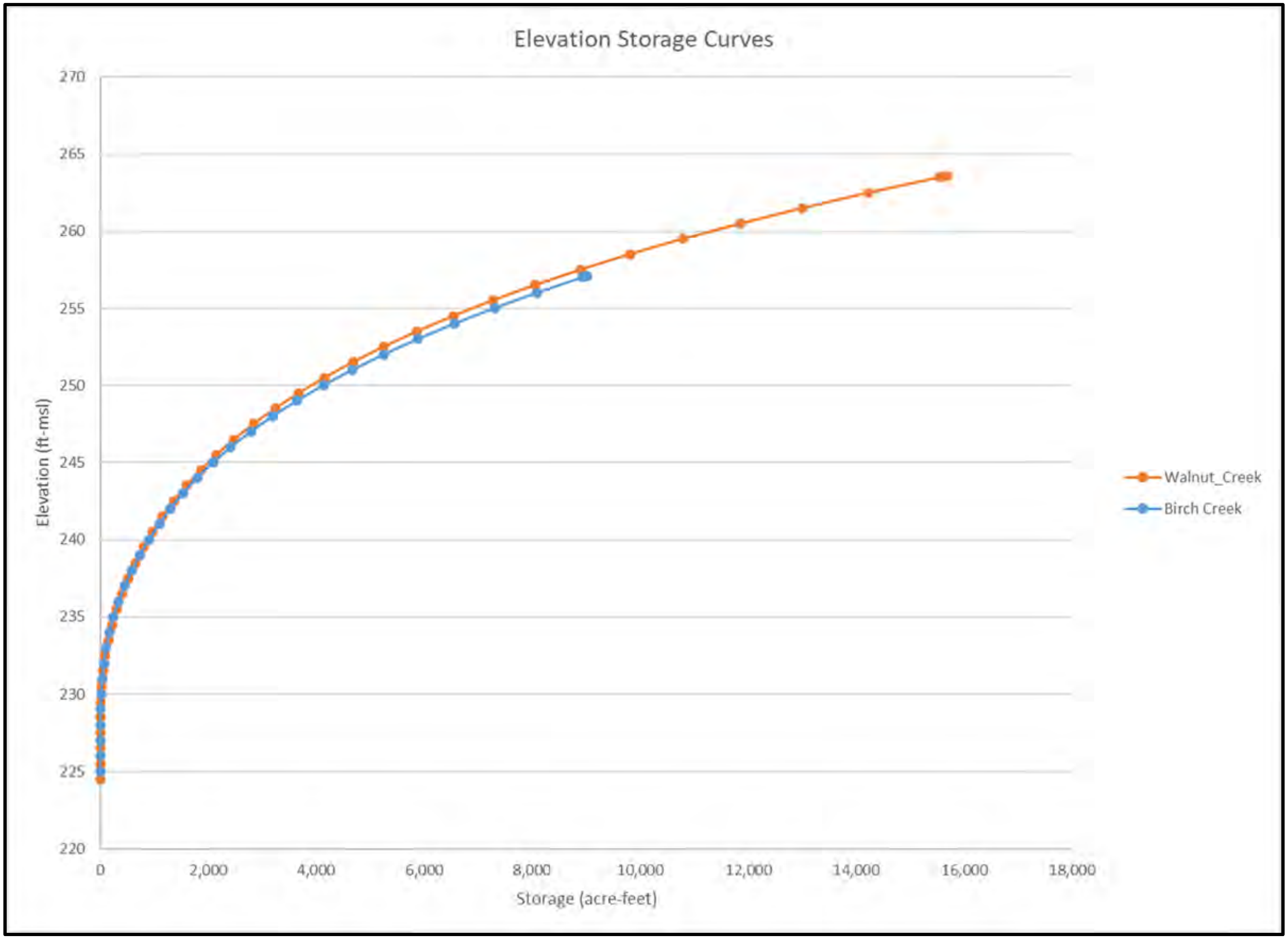

Figure 3-4 Elevation-Storage Curves

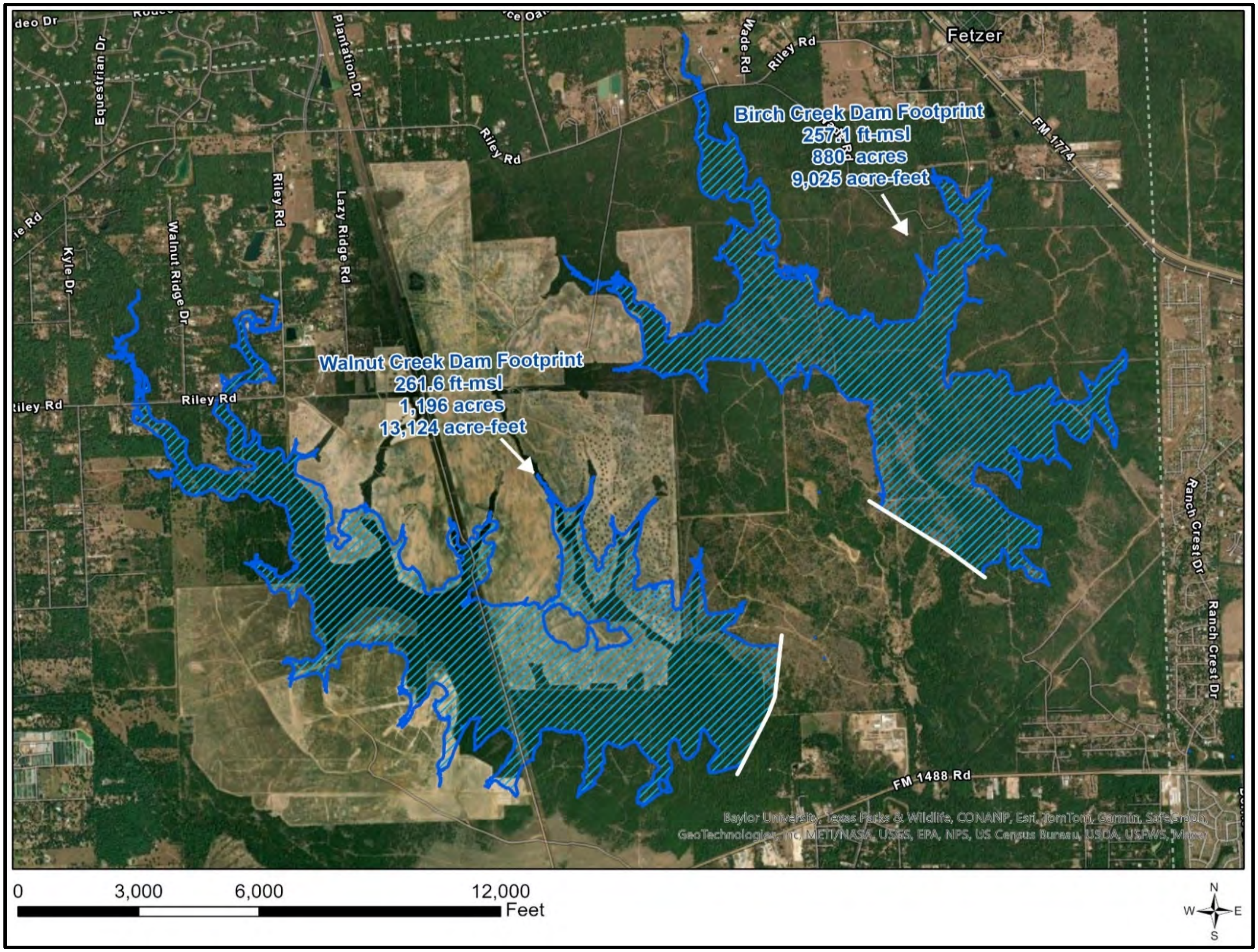

Figure 3-5 **Design Flood WSEs Footprints**

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].

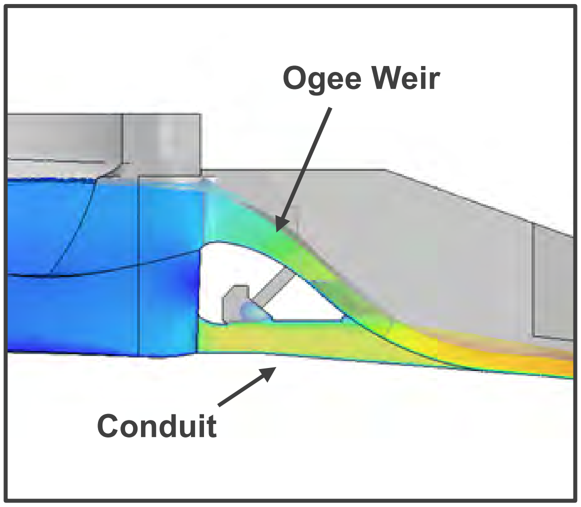

Figure 3-6 General Spillway and Conduit Configuration

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

Description	Walnut Creek		Birch Creek		Totals		Units
	Initial	Optimized	Initial	Optimized	Initial	Optimized	
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.

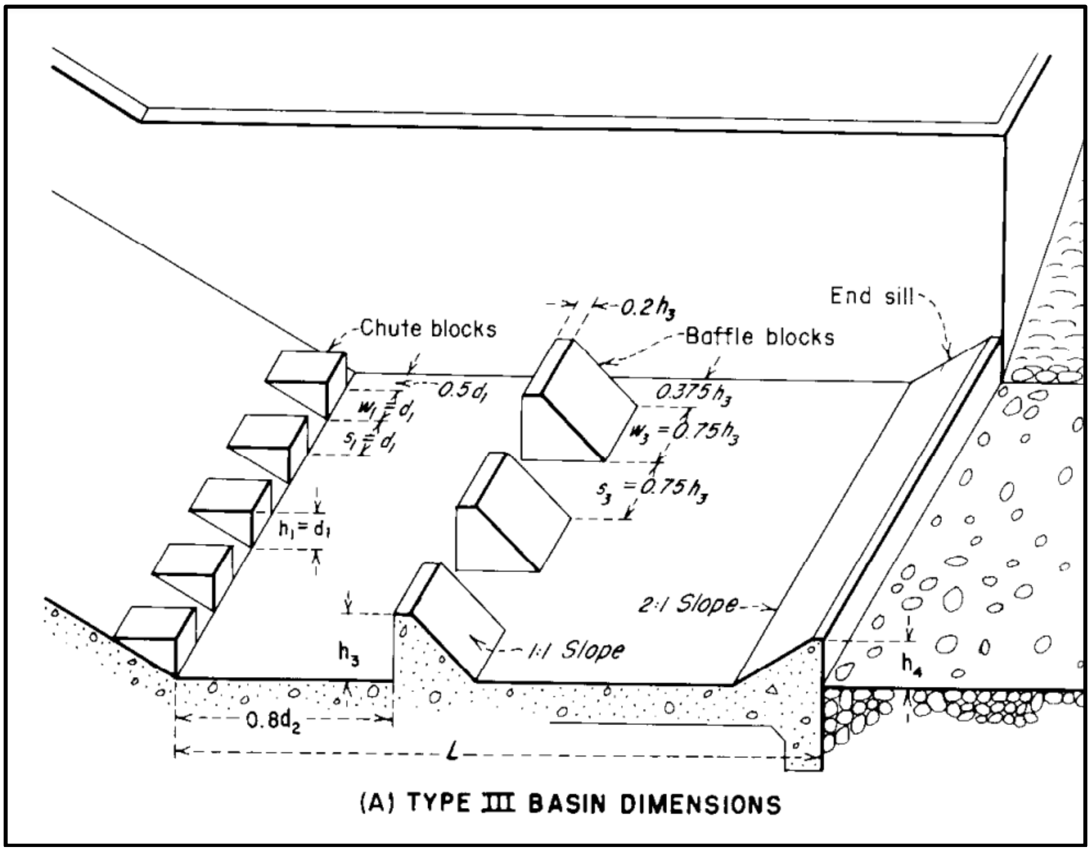

Figure 3-7 General Energy Dissipation Basin Configuration from [7]

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.

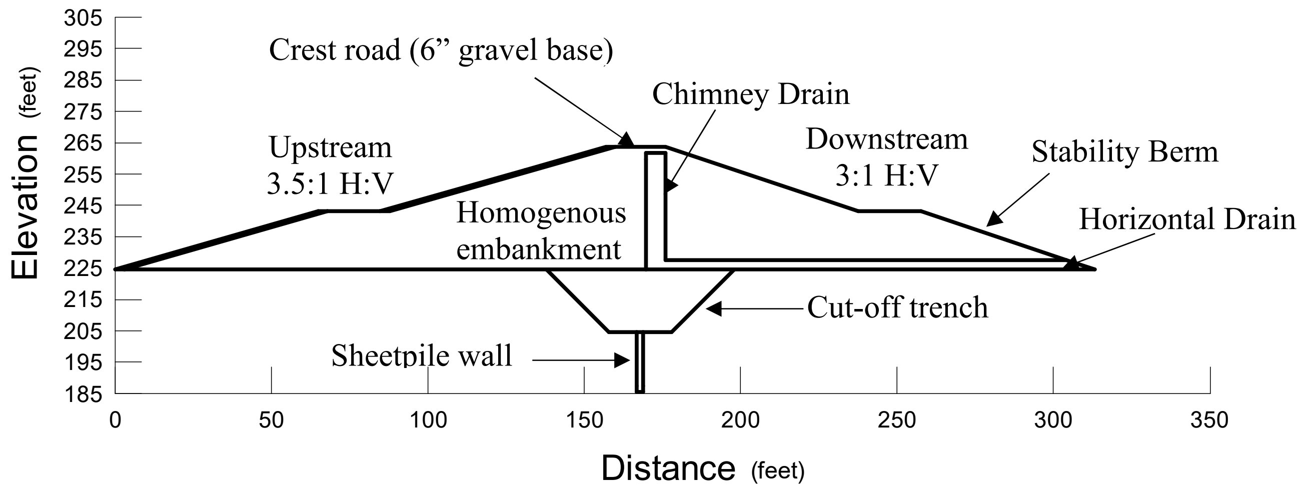

Figure 3-8 Cross Section of Alternative 1 Embankment

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.

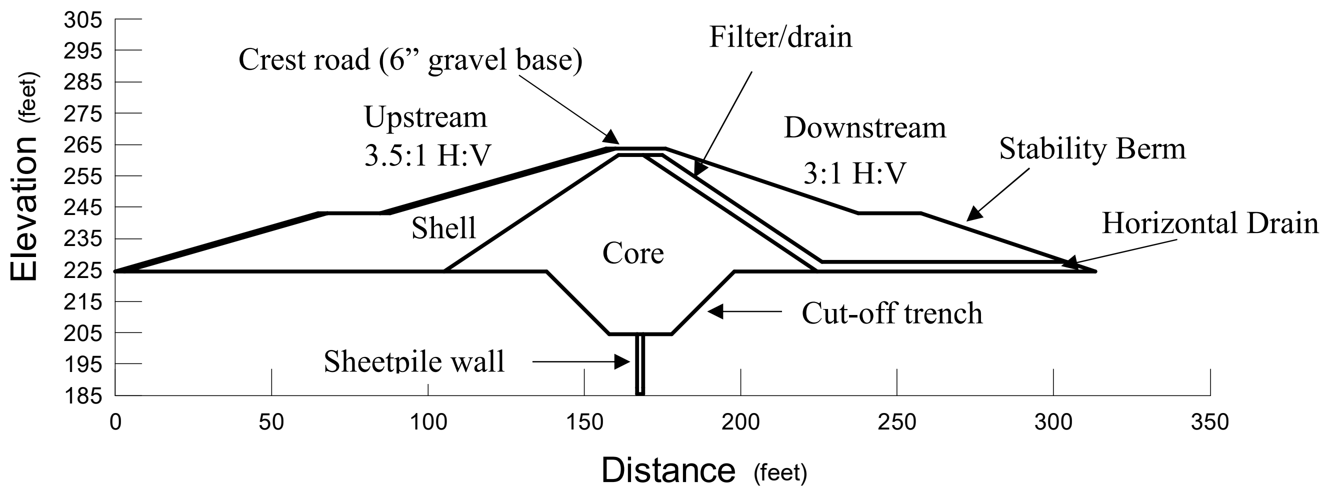

Figure 3-9 Cross Section of Alternative 2 Embankment

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.

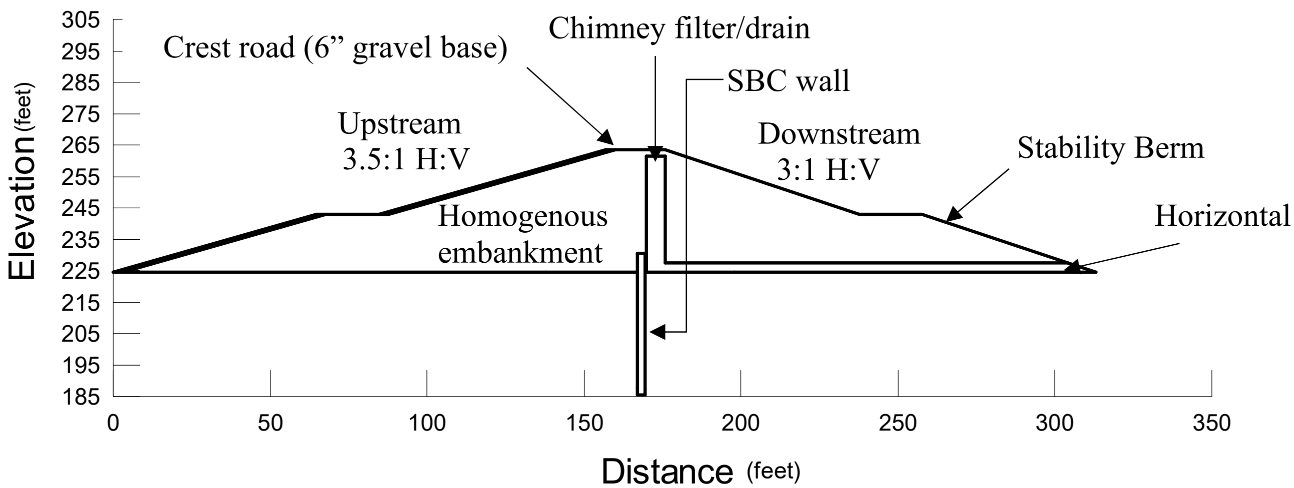

Figure 3-10 Cross Section of Alternative 3 Embankment

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.

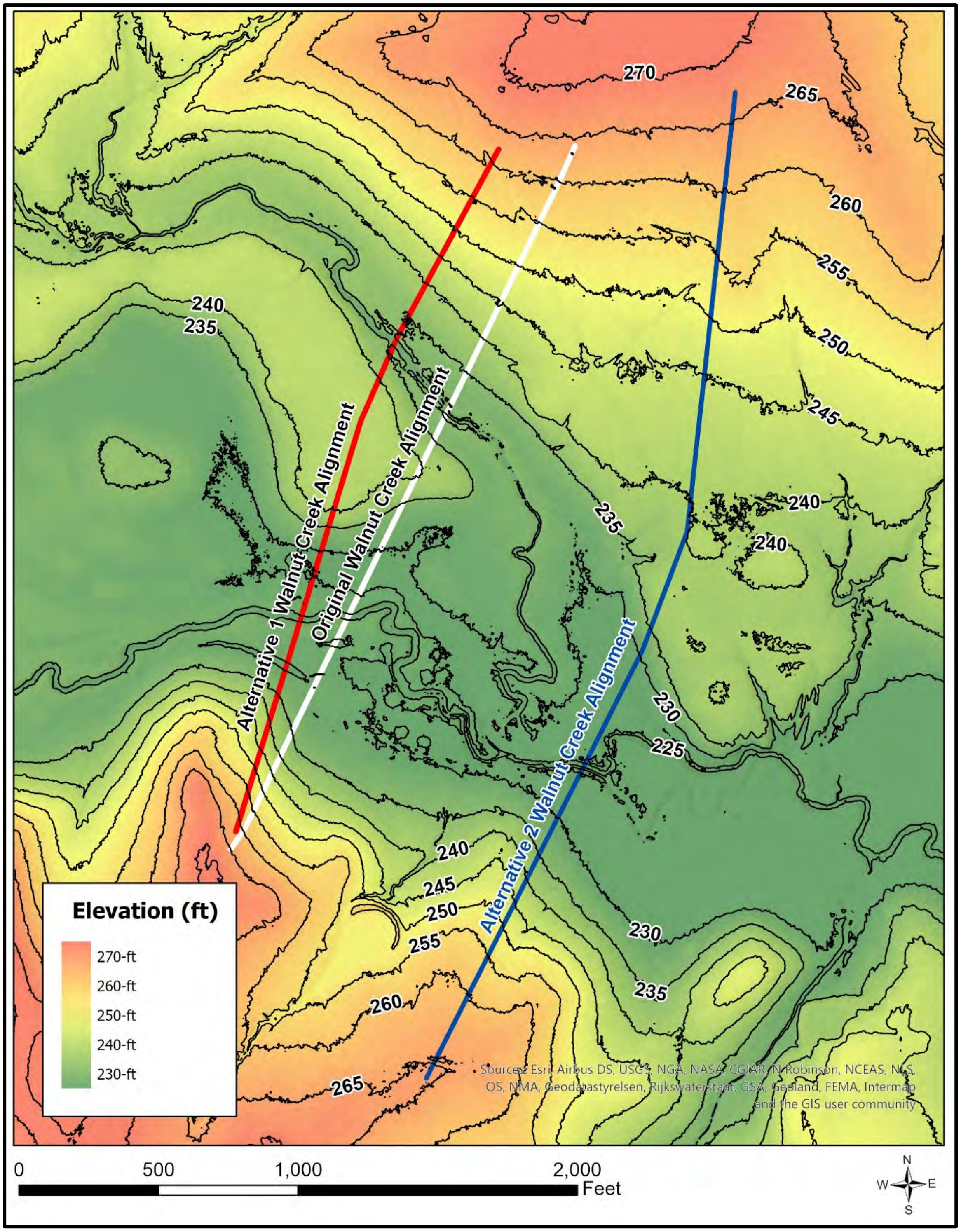

Figure 4-1 Walnut Creek Detention Basin Existing Site Terrain

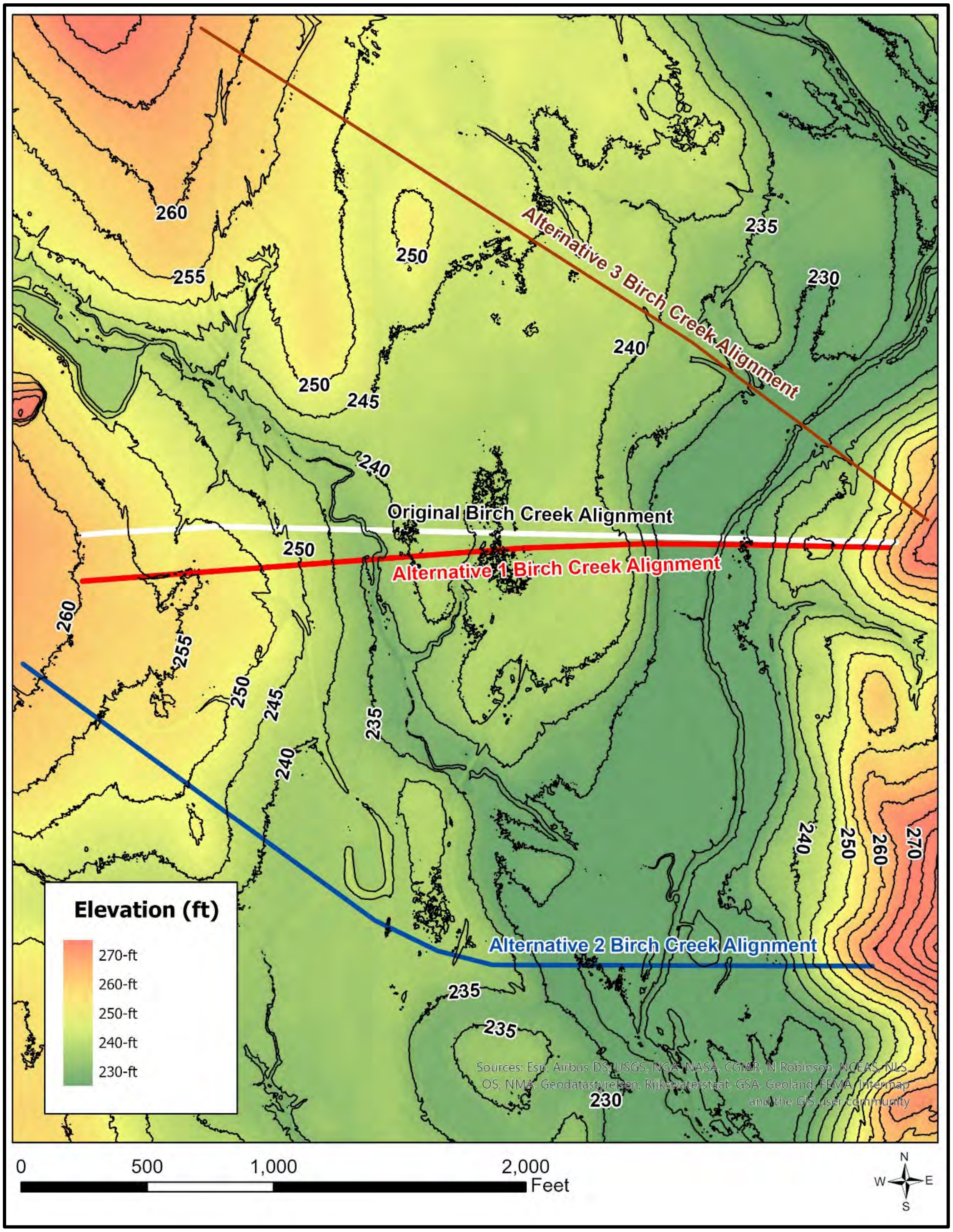

Figure 4-2 Birch Creek Detention Basin Existing Site Terrain

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.

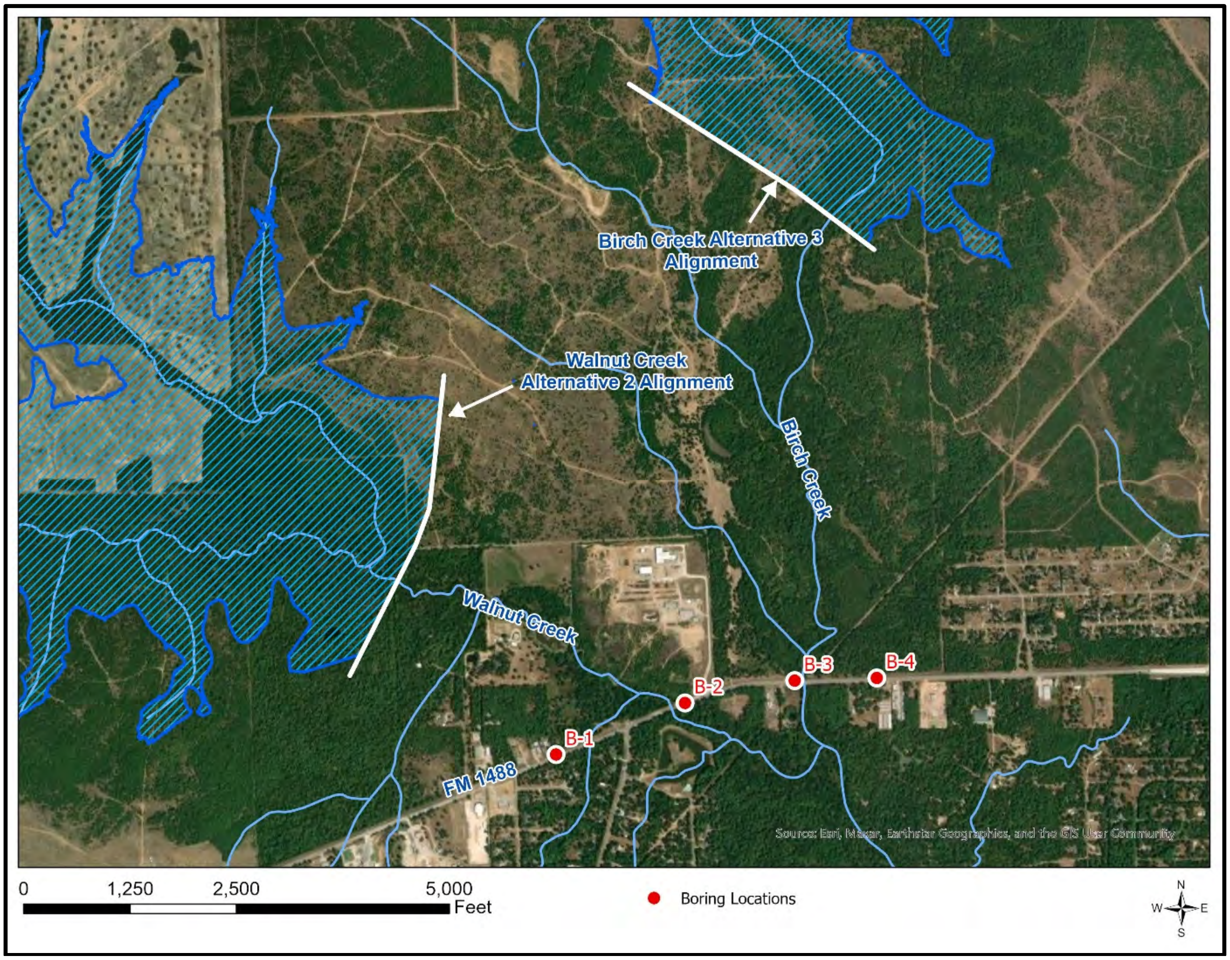

Figure 4-3 Approximate Borings Locations (from Aviles 2024)

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	4.0	46
Alternative 2		28
Alternative 3		50
Birch Creek		
Alternative 1	4.0	25
Alternative 2		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.

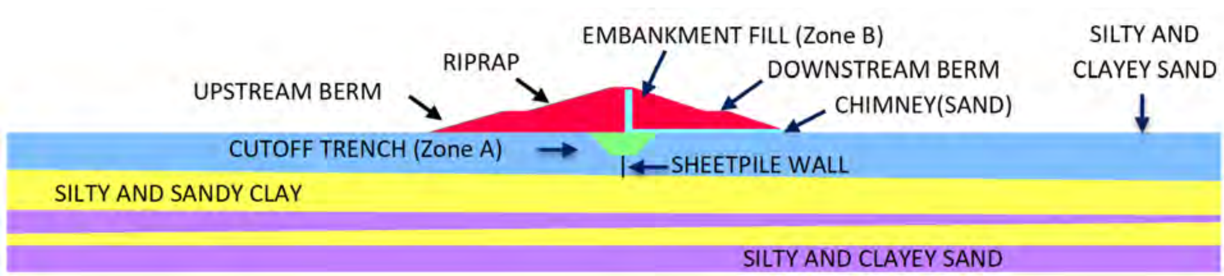

Figure 7-1 Typical Geometry and Zonation for Alternative 1— Walnut

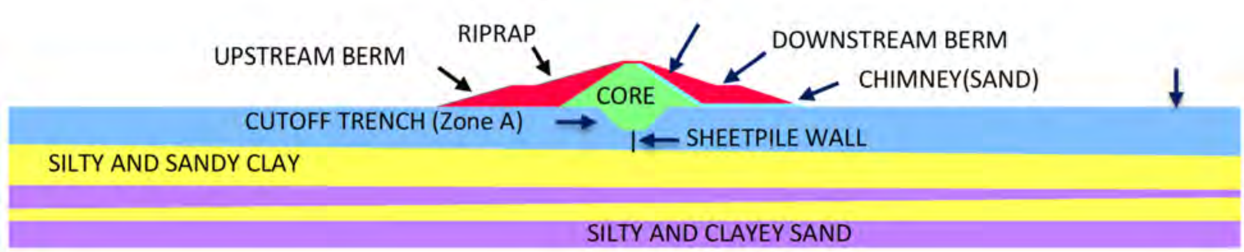

Figure 7-2 Typical Geometry and Zonation for Alternative 2— Walnut

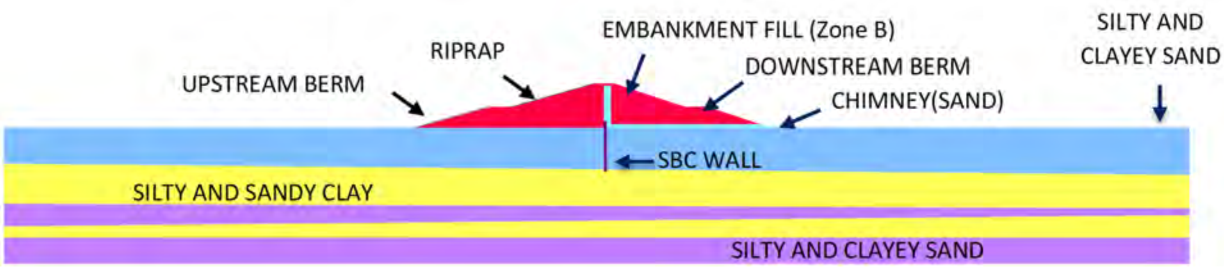

Figure 7-3 Typical Geometry and Zonation for Alternative 3— Walnut

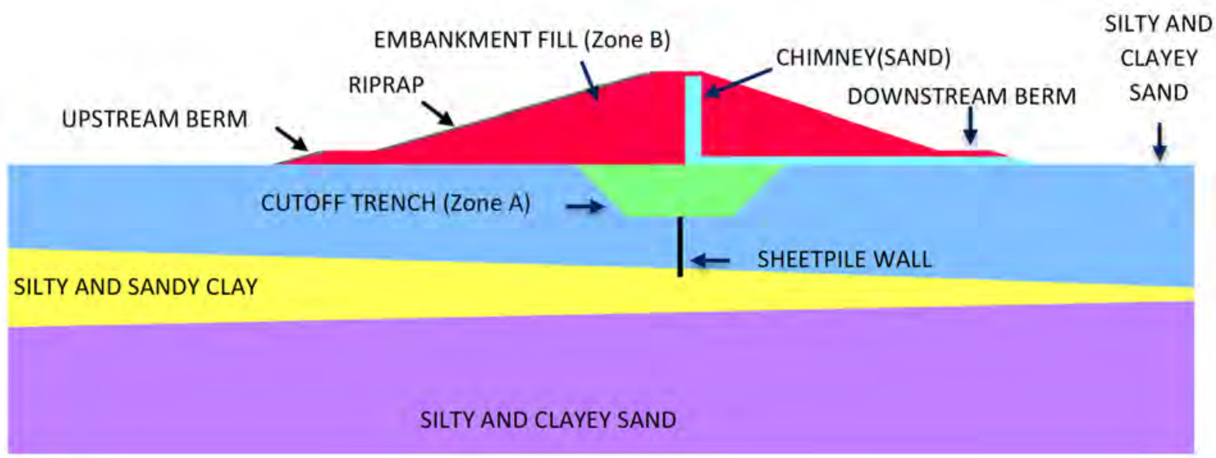

Figure 7-4 Typical Geometry and Zonation for Alternative 1— Birch

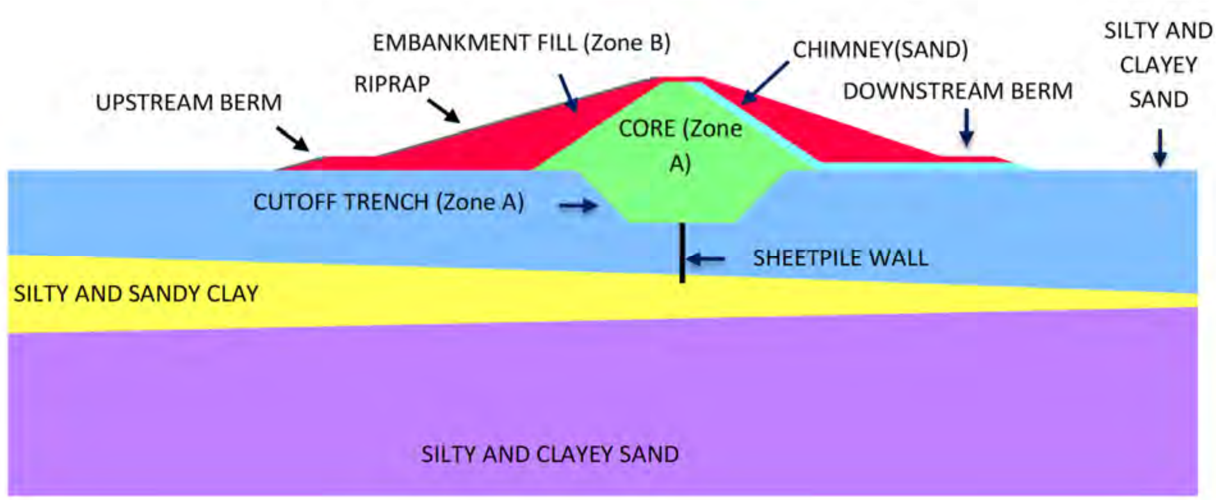

Figure 7-5 Typical Geometry and Zonation for Alternative 2— Birch

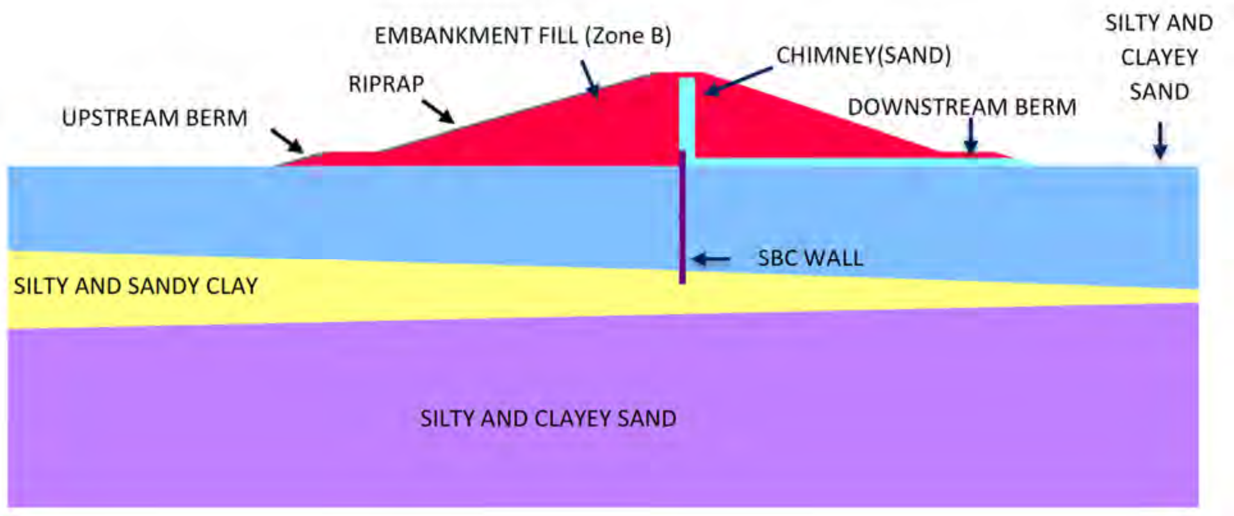

Figure 7-6 Typical Geometry and Zonation for Alternative 3— Birch

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

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Groundwater Conditions	• Alternating layers of sandy and clayey strata from soil borings present a potential for artesian conditions. The potential for artesian conditions and site-specific groundwater conditions must be evaluated through site-specific geotechnical investigation(s), including groundwater monitoring, to inform groundwater control considerations and recommendations required by the TCEQ (Section 4.4) [3]. • Based on findings from the 2024 borings, the shallowest groundwater depth encountered was 5 feet bgs. Saturated foundation conditions are anticipated based on location of Project on watercourse. Dewatering may be required for the Project foundation if groundwater has the potential to pond, pipe, or disturb foundation soils.	Dewatering of the cut-off trench excavation using a dewatering system to remove groundwater may be required. A dewatering plan following applicable environmental regulations is anticipated to be required.	Dewatering of the cut-off trench excavation using a dewatering system to remove groundwater may be required. A dewatering plan following applicable environmental regulations is anticipated to be required.	No specific considerations
Care for Water				
Creek Flow	• Embankment alignment across Walnut and Birch creeks may require diversion of water or creek flow during construction. A plan for care and diversion of water (including sedimentation and pollution control—SWP3 provisions) will be required. • Evaluation of site-specific conditions are required to develop cost-effective and efficient water diversion plans. • It is anticipated that the Project will be constructed under dry conditions to minimize the potential for flood events during construction.	No specific considerations	No specific considerations	No specific considerations

Construction Risk	All Alternatives	Alternative 1	Alternative 2	Alternative 3
Design Considerations				
Dam and Appurtenances	• Embankment slopes, materials (e.g., shell, fill, core, blankets, filters, drains, slope protection), must be evaluated during advanced design (TCEQ Section 6.1 [3]) based on site-specific survey and geotechnical investigations. • Spillway alternatives and other dam appurtenances must be evaluated during advanced design (TCEQ Chapter 7 [3]) based on site-specific survey and geotechnical investigations.	No specific considerations	No specific considerations	No specific considerations
Stability	• Updated stability analyses of the foundation, upstream and downstream slopes will be required during advanced design (TCEQ guidelines Section 4.4 [3]) when site-specific information become available. • Adverse soil conditions (e.g., dispersive, expansive, compressible, soluble material), ground subsidence related to groundwater pumping, and other factors affecting dam stability will be incorporated in stability analyses advanced design when site-specific information become available.	No specific considerations	No specific considerations	No specific considerations
Seismic Stability	• An unnamed southwest-northeast oriented fault approximately 10 miles long crosses the Project area approximately 2 miles north of the northern end of the proposed lake extents (Han, 2013), and seismic stability analyses for natural seismicity may be required (TCEQ guidelines Section 4.4 [3]). • It is recommended that TCEQ is engaged during design advancement to determine if seismic analyses will be required.	No specific considerations	No specific considerations	No specific considerations
Seepage	• An updated seepage analysis will be required during advanced design (TCEQ guidelines Section 4.4 [3]) when site-specific information become available.	No specific considerations	No specific considerations	No specific considerations
Deformation	• Deformation or settlement analysis will be required during advanced design (TCEQ guidelines Section 4.4 [3]) when site-specific information become available.	No specific considerations	No specific considerations	No specific considerations

8.2 Service life

Historically, it has been demonstrated that embankments can have service lives of over 100 years. Proper design, construction, and operation and maintenance practices will extend the service life of an embankment.

8.3 Construction materials

Estimated net volume of the embankment for Walnut Creek Detention Basin and Birch Creek Detention Basin is approximately 238,000 cubic yards and 133,600 cubic yards respectively. Anticipated main dam fill should consist of 20 to 40 percent fines (passing the #200 sieve). This fill should be moisture conditioned and compacted to a specified maximum dry density. Whenever possible, excavated material may be re-used/ repurposed for the main dam fill. Selected materials for embankment fill of the three alternative embankment geometries assume that there exists enough in-situ borrow. Otherwise, main dam fill materials will be imported for selected zones of the embankment where in-situ borrow is lacking based on excavation depth and groundwater constraints. The maximum excavation depths for in-situ borrow sources may be dictated by the groundwater depths. It is assumed some or all vertical chimney drains, horizontal blanket drain, and rock riprap materials will be imported from external borrow sources.

Alternative 1 consists of a homogenous embankment fill and a cutoff trench. The homogenous fill will be constructed from the silty sand and clayey sand soil type (hereafter referred to as Zone B) or materials with similar index properties capable of maintaining slope and foundation stability, and with acceptable permeability. The cutoff trench will be constructed from silty clay and sandy clay type (hereafter referred to as Zone A) or materials with similar or better index properties. Zone A will consist of relatively low permeability materials capable of minimizing seepage to reduce exit gradients that may result from high under-seepage flow. It is assumed that all embankment homogenous fill materials for Alternative 1 will be sourced on-site and the cutoff trench backfill material will be sourced from outside borrow sources.

The cut-off trench backfill material and impervious clay core zone for Alternative 2 will be constructed from Zone A or materials with similar or better index properties. It is assumed that all of the low permeable zones embankment fill (Zone A) for Alternative 2 will be sourced from external borrow sources. The shell zones for Alternative 2 will be constructed from Zone B and it is assumed that these soils will be sourced on-site.

The homogenous earthen fill for Alternative 3 will be constructed from Zone B or materials with similar or better index properties, and the SBC wall will be constructed from imported materials using specialized construction methods. It is assumed that all Zone B materials for the homogenous zone of Alternative 3 will be sourced on-site. A summary of construction materials for the three embankment alternatives is presented in Table 8-2.

Table 8-2. Construction Material for Embankment Zonation

Zonation	Fill Type		
	Alternative 1	**Alternative 2**	**Alternative 3**
Shell/Homogenous[1]	Zone B	Zone B	Zone B
Core[2]	—	Zone A	—
Cutoff trench[2]	Zone A	Zone A	—

[1] Zone B— assumed to comprise onsite borrow sources

[2] Zone A— assumed to comprise offsite borrow sources

8.4 Site civil design

8.4.1 Access road design

Access roads will be required for construction, and operation and maintenance following construction. Access roads will be designed along the crest of the Project embankment.

Access roads will be designed in accordance with the Texas Department of Transportation Roadway Design Manual [22], consistent with the State of Texas requirements. The access roads are considered low volume roads and will not be accessible to the public.

All access roads will be geometrically designed to accommodate the following:

- Passenger car
- Single unit truck
- Single unit truck (three axle)
- Car trailer
- Road grader
- Loader
- Intermediate semi-trailer

8.4.2 Clearing and grubbing

Clearing and grubbing of the land at the Project sites will be required for construction of the new facilities, for access road construction and for construction staging. These areas will be further defined during design advancement.

8.4.3 Stormwater

Permanent stormwater provisions will be incorporated as required to prevent site erosion. Features may include curbs, gutters, concrete drainage ditches, or storm drain inlets. Energy dissipation devices will be provided as required to slow down flow velocities.

8.4.4 Temporary facilities

Temporary facilities described in this section include those required during the construction of the Project.

8.4.5 Construction trailers and support facilities

Temporary support facilities required during construction include equipment trailers, temporary storage for equipment maintenance operations, fuel storage, and other facilities required to construct the Project. The Contractor will be allowed to utilize those portions of the site that are designated to be disturbed as required to locate these facilities.

8.4.6 Site utilities

Utilities required for the Project sites during construction and post completion include electrical, communications, sewer, and potable water. Prior to construction, existing utilities at the site, if any, will be confirmed to evaluate if the Contractor will be required to facilitate the installation of any new utilities or the connection to existing utilities. Utilities to be left in place permanently will be evaluated during design advancement.

8.4.7 Commissioning

The initial filling of the Project will be completed by re-diverting creek flow from the construction phase diversion channel to the embankment outlet culverts after construction of the Project. Filling is not anticipated to be completed in stages due to the primary function of the Project as dry detention basins with conduits.

9 Operations and maintenance considerations

It is anticipated that an Operation, Maintenance, and Surveillance Manual and the Emergency Management Plan will be developed for the Project, as required by existing regulations (refer to Section 2).

10 Recommended embankment option

Three individual alternatives for flood mitigation under the Spring Creek Watershed Flood Control Dams conceptual design task have been discussed in this report. Table 10-1 presents a summary of each alternative and its relative pros and cons for constructability, permitting, operation and maintenance, and an anticipated cost of construction based on experience. The estimated construction cost for all three alternatives was performed by Halff Associates and was not available at the time of this DBM.

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 basins, a zoned embankment with an impervious core (Alternative 2) may not be economical or critical to the safe operation of the dam given that long-term seepage conditions are not expected to be established in the dam due to the relatively short flood impoundment durations. Potential seepage losses are not of primary concern for the function of the Project and high exit gradients resulting from high under seepage are not anticipated when a foundation seepage barrier with sufficient imperviousness and depth is installed, hence the installation of a specialized impervious barrier in the case of Alternative 3 may not be economical or warranted for the safe operation of the Project.

Due to these limitations for Alternatives 2 and 3, Black & Veatch recommends Alternative 1 as presented in Section 3.3.2 and Section 7. Alternative 1 would allow for the potential use of on-site borrow sources for the construction of high-volume zones of the dam. Modification to the foundation seepage barrier presented in Section 7 for Alternative 1 (as illustrated in Figure 7-1) may be explored for an advanced design to reduce construction cost while maintaining a sufficient design and safe operation of the dam. The recommended alternative would not only improve construction cost and potentially represent the lowest construction cost amongst other alternatives considered in this DBM, but also reduce construction complexities and time.

Table 10-1 Summary of Alternatives

Alternative	Pros	Cons	Estimated Construction Cost
1— Homogenous embankment with cutoff trench	• Allows for potential use of onsite borrow sources for entire dam construction except for filtered drainage zone and riprap. • Reduced environmental impact from external embankment fill borrow sources. • Reduced construction complexities by use of conventional construction techniques and homogenous embankment. • Potential reduction in construction time.	• No dam through-seepage barrier.	Refer to cost estimate by Halff Associates.
2— Zoned embankment with impervious core and cutoff trench	• Allows for potential use of onsite borrow sources for dam shell construction. • Dam through-seepage barrier. • Less construction complexities compared to Alternative 3 by use of conventional construction techniques.	• Increased cost from potential clay fill import from external borrow sources. • Increased construction complexities compared to Alternative 1. • Potential increase in construction time compared to Alternative 1. • Increased environmental impact from external embankment fill borrow sources.	Refer to cost estimate by Halff Associates.
3— Homogenous embankment with soil-bentonite cutoff wall	• Allows for potential use of onsite borrow sources for entire dam construction except for SBC wall, filtered drainage zone and riprap. • Reduced environmental impact from external embankment fill borrow sources. • Potential reduction in foundation excavation footprint and cost compared to Alternatives 1 and 2.	• No dam through-seepage barrier. • Increased construction complexities by use of specialized construction techniques. • Potential increase in construction time compared to Alternative 1. • Potential increased construction cost by use of specialized construction techniques.	Refer to cost estimate by Halff Associates.

11 Future work

11.1 Next steps

The following items are anticipated to be completed in order to move the Spring Creek Watershed Flood Control Dams project from conceptual design to preliminary and detailed design, and construction level:

- Spillway Sizing and Location, and Freeboard Evaluation
- Geologic and Geotechnical Understanding (site-specific subsurface exploration)
- Borrow Evaluation and Embankment Zoning Plan
- Site Material Parameters
- Settlement Analysis
- Seismic Site Evaluation
- Seepage Analysis
- Stability Analysis
- Foundation Seepage Control
- Filter Compatibility and Internal Stability
- Embankment Slope Protection
- Flood Rim and Upper Reach Considerations
- Diversion Plan
- Conduit Plan
- Permanent Instrumentation
- First Fill and Long-Term Monitoring
- Operation and Maintenance Manual

12 References

1. Texas Water Code (TWC) Chapter 11— Water Rights, current as of October 18, 2024.
2. Texas Administrative Code (TAC) Title 30 Part 1 Chapter 299— Dams and Reservoirs, current as of October 18, 2024.
3. Texas Commission on Environmental Quality (2009). Design and Construction Guidelines for Dams in Texas, RG-473.
4. Texas Commission on Environmental Quality (2007). Hydrologic and Hydraulic Guidelines for Dams in Texas, GI-364.
5. U.S. Army Corps of Engineers EM 1110-2-1902— Slope Stability, 2003.
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13. U.S. Department of Interior Bureau of Reclamation, Design Standards No. 13 Chapter 8: Seepage, January 2014.
14. U.S. Department of Interior Bureau of Reclamation, Design Standards No. 13 Chapter 9: Static Deformation Analysis, November 2011.
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16. U.S. Department of Interior Bureau of Reclamation, Design Standards No. 13 Chapter 12: Foundation and Earth Materials Investigation, July 2012.
17. U.S. Department of Interior Bureau of Reclamation, Design Standards No. 13 Chapter 11: Instrumentation and Monitoring, March 2014.

18. U.S. Department of Interior Bureau of Reclamation, Design Standards No. 13 Chapter 10: Embankment Construction, May 2012.

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21. U.S Department of Interior Bureau of Reclamation, Characteristics of Dispersive and Problem Clay Soils, October 1991.

22. Texas Department of Transportation, Roadway Design Manual, November 2024.

23. Strategic Mapping Program (StratMap). Upper Coast Lidar, 2018-03-22.

Appendix B-1 Design standards, guidelines, and criteria

This appendix contains description of guidelines and/or standards relevant to the various analyses or activities anticipated for the Project design. The sections contained in the appendix provide design criteria and general implementation guidelines for specific elements of the Project.

Embankment Design

Guidelines and standards for embankment design are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 2 Embankment Design [8]. Project considerations for the embankment design are summarized in Table A-1.

It is anticipated that the Project alternative embankments will be designed as either a homogenous or a zoned earthfill embankment, composed primarily of compacted, relatively impervious fill (refer to Section 3.3). Internal drainage and slope protection are described in subsequent sections. The geometry of the conceptual embankment design presented in this DBM based on the stability analyses is presented in Section 7, and it is anticipated that additional refinements to the geometry will be made during design advancement.

Table A-1 Summary of Embankment Design Guidelines and Project Considerations

Chapter/Section No.	Chapter/Section Title	Project Considerations
Design and Construction Guidelines for Dams in Texas TCEQ [3]		
Chapter 4.2	Foundation Examination and Treatment — • Permeable foundation • Saturated foundation • Weak foundation	• It is anticipated that the foundation of the Project embankments near the centerline of the watercourse will be saturated silty and clayey sands, and drier conditions of similar soil type is anticipated along the mild slopes and beyond based on assumption from the 2024 field investigations findings. Note that the borings performed were situated about 1 mile from the sites. • Low density silt and sandy foundations may be subject to strength loss during earthquake loading; however, the risk for seismic activities is low for the Project sites. • There is potential for deformation or even shear failure and erosion resulting from dispersive silty sand soils. Crumb tests based on the ASTM D6572 test standard have been performed to determine the dispersive grade of foundation soils. • At a minimum, a cutoff trench must be excavated along the long axis of the dam foundation in overburden material (e.g., soil, weak rock) if competent rock is not encountered. 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).

Chapter/Section No.	Chapter/Section Title	Project Considerations
		• A partial cutoff trench or wall to a depth necessary to satisfactorily limit seepage may be explored during advanced design (see Section 7). • Filtered drainage system will be required to provide a free flow of seepage and to prevent internal erosion. • A staged construction or increased embankment width with flatter slopes may be required as mitigation to sliding potential from saturated foundation.
Chapter 4.3	The Analysis of Available Materials	• Borrow investigation(s) will be required to identify suitable embankment and filter/drain materials during design advancement. • Findings from the 2024 field investigations and testing program have been assumed for the conceptual design in this DBM.
Chapter 4.4	Geotechnical Report Requirements — • Test borings • Laboratory testing and analyses • Seepage analysis • Stability analyses • Seismic stability analyses	• Field investigations comprising four Standard Penetration test borings and laboratory testing on sampled soils were performed about 1 mile off the Project sites. See Aviles (2024) [20] for field exploration and test findings. Site specific field exploration and testing program will be required for advanced design. • It is anticipated that the slope stability for the embankments presented in this DBM will be updated during design advancement to incorporate new information (e.g., additional field/laboratory data, earthquake ground motions) and additional cross sections based on site-specific investigations. • It is anticipated that seepage analysis will be updated during design advancement to incorporate new information to advance filter and drain design and to evaluate the need for additional seepage mitigation measures based on site-specific investigations. • Static deformation analysis (settlement, cracking) will be required during design advancement. • Seismic stability analysis may be required during design advancement.
Chapter 6.1	The Basic Components of Embankment Dams— • Homogeneous embankment dams • Zoned embankment dams • Soil filter and drainage system designs	• It is anticipated that filtered drainage system will be incorporated in both homogenous and zoned embankment alternatives. • It is anticipated that stability berms extending the lengths of the upstream and downstream slopes will be incorporated in the dam design. • It is anticipated that embankment slope surface will be protected using rock riprap on the upstream slope and vegetation (short grass cover, free from any trees, large bushes, etc.) on the downstream slope. • It is anticipated that surface drainage of the crest will be provided by sloping the crest at a 2-percent slope to drain

Chapter/Section No.	Chapter/Section Title	Project Considerations
	Surface protection on embankment slopes and crest	towards the upstream slope unless environmental considerations dictate other requirements. • It is anticipated that additional camber may be required (typically 1 to 2 percent of the embankment height), depending on the compressibility of foundation materials. • It is anticipated that aggregate will be placed on the embankment crest to provide surface protection of the crest and function as an inspection road. • Delineation of the crest along the inspection road, by posts or other markers, may be required for safety. • The top of the chimney filter will be designed to extend to or above the maximum reservoir water level corresponding to the PDF. • Sufficient cover will be designed over the chimney filter to protect it from freezing.

Protective Filters

Guidelines and standards for protective filters are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 5 Protective Filters [9]. The Design and Construction Guidelines for Dams in Texas TCEQ [3] notes that filter (sand, gravel, or crushed rock) criteria must be developed based on gradation tests and filter criteria standards. Filter criteria standards are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 5 Protective Filters [9]. Granular filter design criteria from the USBR are summarized in Table A-2.

Table A-2. Granular Filter Design Criteria from the USBR Design Standard No. 13 Embankment Dams: Chapter 5 Protective Filters [9]

Base Soil Category	Percent Finer than No. 200 sieve (0.075 mm) (after regrading where applicable)[1]	Filtering Criteria
(1) Fine silts and clays	> 85	The maximum $D_{15}F$ should be ≤ 9 x $D_{85}B$, but not less than 0.2 mm, unless the soils are dispersive. Dispersive soils require a maximum $D_{15}F$ that is ≤ 6.5 x $D_{85}B$ size, but not less than 0.2 mm.
(2) Silts, clays, silty sands, and clayey sands	40 – 85	The maximum $D_{15}F$ should be ≤ 0.7 mm unless soil is dispersive, in which case the maximum $D_{15}F$ should be < 0.5 mm.

Base Soil Category	Percent Finer than No. 200 sieve (0.075 mm) (after regrading where applicable)[1]	Filtering Criteria
(3) Silty and clayey sands and gravels	15 – 39	A. For nondispersive soils, the maximum $D_{15}F$ should be: $\leq \left[\frac{40-A}{25}\right] [(4\, D_{85}\, B) - 0.7mm] + 0.7mm$ where: A = Percent passing No. 200 sieve. When 4 x D85B is less than 0.7 mm, use 0.7 mm B. For dispersive soils, use 0.5 mm.
(4) Sands and gravels	< 15	The maximum $D_{15}F$ should be ≤ 4 x $D_{85}B$ of base soil after regrading.

[1]mm = millimeter

A chimney drain, filter blanket, and toe drain are included in the conceptual design for the embankment (refer to Section 3.3). The chimney drain and filter blanket may be one or two-stage, depending on filter compatibility requirements and embankment materials. Seepage will be conveyed through the chimney drain and filter blanket to a toe drain embedded pipe collection system and discharged into a surface ditch.

Borrow investigation(s) will be required to evaluate filter criteria and compatibility during design advancement (refer to Site Investigation section below).

Foundation Preparation

Guidelines and standards for foundation preparation are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 3 Foundation Surface Treatment [10].

Foundation preparation is anticipated for the Project embankments where saturated soft soil is present in the foundation. For the embankment foundation including abutments and in the creek bed, it is anticipated that the foundation soil will be prepared by excavation, proof rolling or treated based on determined geological conditions for embankment construction. The need for a cutoff trench or other seepage barrier will be evaluated based on the selected embankment alternative.

Slope Protection

Guidelines and standards for slope protection are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 7 Riprap Slope Protection [12]. The Design and Construction Guidelines for Dams in Texas TCEQ [3] note that the upstream slopes should have adequate protection against erosion and breaching from waves, and the downstream slopes should have adequate protection against erosion from runoff, seepage, traffic, and burrowing animals.

The conceptual design of the Project embankments includes riprap protection on the upstream slope and topsoil and vegetation protection on the downstream slope. It is anticipated that riprap on the upstream slope may require a two-stage sand or filter cloth and gravel filter to meet filter compatibility requirements. Excavated material from the Project embankments foundation may be suitable for reuse as topsoil on the downstream slope. Borrow investigation(s) will be required to establish suitable slope protection materials and filter compatibility requirements during design advancement (refer to Site Investigation section below).

Slope Stability Analysis

Guidelines and standards for slope stability analysis are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3], USBR Design Standard No. 13 Embankment Dams: Chapter 9 Static Deformation Analysis [14], and USACE EM 1110-2-1902 – Slope Stability [5].

Consistent with the Design and Construction Guidelines for Dams in Texas TCEQ [3], a standards-based approach with target factors of safety (FoS) as acceptance criteria is used for slope stability analysis. A limit equilibrium analysis is considered sufficient to evaluate slope stability under normal operating conditions, as described in the USACE EM 1110-2-1902 – Slope Stability [5]. Industry standard FoS for various loading conditions, the selected target FoS, and target FoS justifications are summarized in Table A-3.

End of construction, long term, flood, and rapid drawdown loading conditions are evaluated for the Project embankments within the scope of this DBM (Section 6 and 0).

Table A-3. Acceptance Criteria (Factors of Safety) for Slope Stability Analysis

Loading Condition	TCEQ Min. FoS	USBR Min. FoS	Design Basis Shear Strength Parameters	Design Basis FoS	Justification
End of Construction	1.25	1.3 – 1.4[1]	Undrained	1.3	Consistent with minimum FoS from published guidelines; undrained shear strength parameters are the design basis for the analysis
Long Term (Normal 100-year Flood)	1.5	1.5	Drained	1.5	Consistent with minimum FoS from published guidelines
Peak Design Flood	—	1.2 – 1.3[2]	Drained	1.2 – 1.3	Consistent with minimum FoS from published guidelines; the Project is a flood control detention dam with outlet works and is expected to drain flood storage quickly
Full or Partial Rapid Drawdown	1.2	1.2 – 1.3[3]	Drained Undrained	1.2 – 1.3	Consistent with published guidelines; frequent drawdown is considered for the Project[3]

[1]USBR notes that a minimum FoS of 1.3 is adequate for analysis using effective shear strength parameters with field monitoring during construction or for analysis using undrained shear strength parameters. A minimum FoS of 1.4 should be used for effective shear strength parameters and if pore pressures are not monitored during construction.

[2]USBR notes that a FoS of 1.2 is adequate for short flood pool durations and steady-state seepage conditions. A FoS approaching 1.2 is adequate considering the relatively short flood durations that is expected for the dry detention dams. Long-term seepage phreatic surface under normal reservoir level is not anticipated to be established considering that the dams are not intended to impound water for long durations.

[3]USBR notes that a FoS of 1.3 is adequate for drawdown below the normal operating pool; a FoS of 1.3 is adequate for drawdown from maximum flood pool to dry creek channel grade.

Seepage Analysis

Guidelines and standards for seepage analysis are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3], USBR Design Standard No. 13 Embankment Dams: Chapter 8 Seepage [13], and USACE EM 1110-2-1901– Seepage Analysis and Control for Dams [19]. The Design and Construction Guidelines for Dams in Texas TCEQ [3] note that for high- and significant-hazard dams that will permanently impound water, seepage exit gradients should be within acceptable limits for the embankment and foundation materials. The purpose of the Project as flood control may not impose significant limitations on the allowable seepage, however the potential occurrence of dispersive foundation soils may require adequate seepage control measures. The selected seepage control measure will be evaluated based on the selected embankment alternative. Seepage analysis is evaluated for the Project embankments within the scope of this DBM (Section 5 and 0).

Industry standard FoS for exit gradients, the selected target FoS, and target FoS justifications are summarized in Table A-4.

Table A-4. Acceptance Criteria (Factors of Safety) for Exit Gradient

Type of Facility	TCEQ Min. FoS	USBR Min. FoS	USACE Min. FoS	Design Basis FoS	Justification
New Dam	—	4.0[1]	1.5 - 15[2]	4.0	Consistent with minimum FoS from published guidelines.

[1]USBR notes that a minimum FoS of 4.0 is adequate for high exit gradients in a cohesionless soil when designing either a new dam or remedial repairs at an existing dam to rectify a high exit gradient situation.

[2]USACE notes that a FoS of 1.5 - 15 is adequate for escape gradient depending on knowledge of soil and possible seepage conditions. USACE also notes that generally, factors of safety in the range of 4-5 (Harr 1962, 1977) or 2.5-3 (Cedergren 1977) have been proposed.

Site Investigation

Guidelines and standards for site investigations, including borrow investigations, are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 12 Foundation and Earth Materials Investigation [16].

A field and laboratory testing program will be required to evaluate potential borrow sources and suitability of potential borrow materials for the Project. Imported materials may be required if suitable borrow quantities or materials are not identified.

One field exploration and laboratory testing program has been completed to evaluate foundation conditions 1 mile away from the Project vicinity, documented in the Aviles 2024 Spring Creek Watershed Flood Control Engineering Feasibility Study Report [20]. Project site-specific field exploration and laboratory testing program(s) will be required during design advancement.

Instrumentation and Monitoring

Guidelines and standards for instrumentation and monitoring are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 11 Instrumentation and Monitoring [17]. Instrumentation and monitoring are required for various activities during the project life cycle of a dam, including the following:

- Original design
- Original construction
- Modification
- First reservoir filling
- Long-term performance monitoring
- Response to adverse or anomalous performance
- Decommissioning

Project considerations for instrumentation and monitoring of the Project are summarized in Table A-5. These considerations are primarily intended to encompass long-term performance monitoring for the Project; however, water pressure and deformation monitoring will also be required for design, construction, and first embankment flooding. Strategic instrumentation and monitoring planning may allow for instruments used in design, construction, and first embankment flooding to be converted for long-term performance monitoring. Instrumentation and monitoring in response to adverse or anomalous performance would be developed on an as-needed basis if indicated.

Given the primary function of the Project as dry detention creek, the need, type, and quantity of instrumentation for the Project would be developed during design advancement taking into account what critical elements of the Project require monitoring.

Table A-5 Summary of Instrumentation and Monitoring Guidelines and Project Considerations

Monitoring Type[1]	Project Purpose	Project Considerations
Seepage	• Long-term performance monitoring	• It is anticipated that seepage through the dam will be minimal, if any, based on the assumption that long-term phreatic surface may not be established in the lifetime of the dam considering the relatively short duration of impoundment after flood. • Installation of weirs or flow measuring devices to measure through-dam seepage may not be required.
Water Pressure	• Design • Construction • First reservoir filling • Long-term performance monitoring	• It is anticipated the dams will remain dry than wet for longer durations. Hence, it is anticipated that manual nested vibrating wire piezometers will be installed at large intervals for the Project. • The nested piezometers will be installed at 1500 feet spacing along the embankment. At each location, one piezometer will be installed within the foundation to monitor groundwater pressures; installation of a second piezometer near the embankment toe to monitor through-seepage pore pressures may not be required.

Monitoring Type[1]	Project Purpose	Project Considerations
Deformation	• Design • Construction • First reservoir filling • Long-term performance monitoring	• It is anticipated that in-place inclinometers and horizontal settlement arrays with ADAS will not be installed for the Project. • Survey monuments may be installed on the crest at 1000 feet spacing, or in place of that field survey measurements may be conducted at regular time intervals to monitor vertical settlements.

[1]Refer to USBR Design Standard No. 13 Embankment Dams: Chapter 11 Instrumentation and Monitoring [17].

Construction

Guidelines and standards for embankment construction are described in the Design and Construction Guidelines for Dams in Texas TCEQ [3] and USBR Design Standard No. 13 Embankment Dams: Chapter 10 Embankment Construction [18] and guidelines for construction performance monitoring are described in USBR Design Standard No. 13 Embankment Dams: Chapter 11 Instrumentation and Monitoring [17]. Project considerations for construction of the Project are summarized in Table A-6. Additional construction considerations are described in Section 8.

Table A-6 Summary of Construction Guidelines and Project Considerations

Chapter No.	Chapter Title	Project Considerations
USBR Design Standard No. 13 Embankment Dams: Chapter 10 Embankment Construction [18]		
10.3	Foundation Treatment	• It is anticipated that soft soils in the foundation will be excavated or treated using foundation improvement methods before placement of compacted fill.
10.4	Dewatering and Unwatering	• The Project is located in a creek with wet surface conditions and possibly shallow groundwater; it is anticipated that creek flow diversion, dewatering and unwatering systems will be required during construction.
10.5	Borrow Areas and Quarries	• Borrow materials are required for construction of the Project; plans and/or specifications must be developed for excavation, hauling, handling, and separating equipment, borrow area operation, stockpiling, and borrow area treatment (remediation).
10.6	Embankment Construction	• Specifications for fill requirements, including materials, compaction, and equipment, must be developed; it is anticipated that pervious and impervious fill will be required for the Project. • Scheduling and sequencing of construction must be developed. • Stability of temporary and permanent slopes during construction must be anticipated and evaluated.

Appendix B-2 Aviles Engineering Corp. geotechnical report