Memorandum

To: **The Planning Commission**

From: **Niall Connolly**

Date: **February 13, 2026**

Re: **Erosion Hazard Permit for the River Park Expansion Project**

Introduction

The River Park expansion project is discussed in detail in the Design Development Review (DDR) staff report. Most of the river park is within one of the erosion hazard zones (high and moderate risk), and therefore so are some of the proposed improvements. Section 10-13E of the Town Code sets out the Town's regulations for the Erosion Hazard Zone.

Figure 1. Aerial view of the River Park, showing the high and moderate erosion hazard zones in red and yellow respectively

An erosion hazard permit is required for any "land disturbance" within the erosion hazard zone. The definition of land disturbance is provided in 10-13E-5, and includes "earthwork such as filling, grading, excavation or contouring land". By this definition, an erosion hazard permit is required in this case.

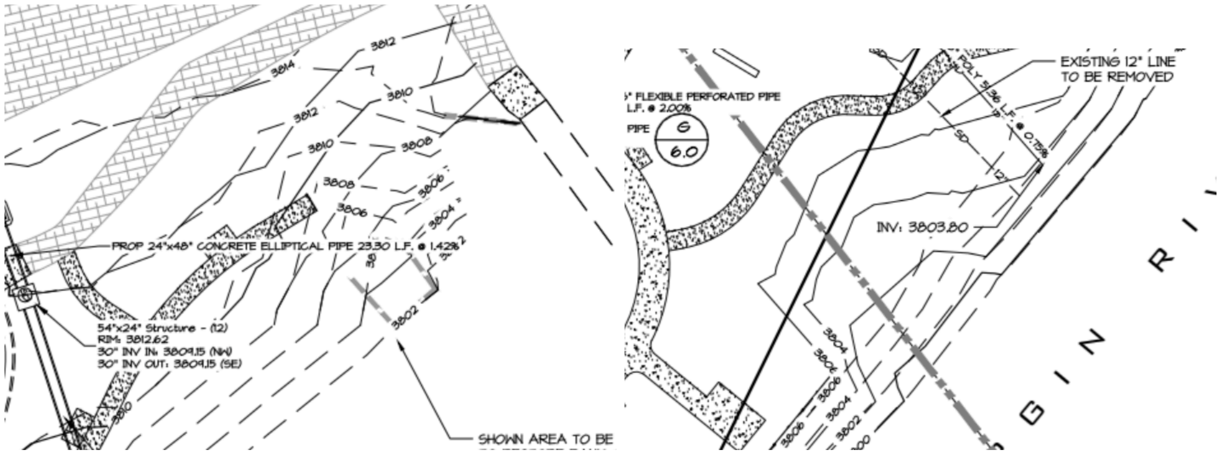

Figure 2. Examples of the proposed re-grading (existing contours are shown in broken lines and proposed contours are shown in solid lines)

Erosion Hazard Study

An erosion hazard study, prepared by Rosenberg Engineers, has been submitted with the application. The erosion hazard study includes an assessment of more significant development at the park than is actually proposed at this time. The improvements listed in the study include new restrooms, a river viewing platform, and pavilion. These improvements are *not* proposed for the park at this time.

The erosion study finds that the proposed improvements (including the presently proposed improvements as well as the potential future phase improvements) will not result in an increase in the base flood elevation, or result in an increased risk of erosion on, or off site. The study discusses the potential risk of erosion to a new restroom building, and explores two options for addressing this risk. Firstly, a traditional erosion protection solution involving a section of riprap along the river bank. The second option is to simply deepen the building footings to a depth of 5' below the finished floor elevation. The study recommends the second option, because it would involve significantly less disturbance to the park and its riparian zone. In any event, a new restroom building is not proposed, and therefore no such erosion mitigation is needed in conjunction with the presently proposed improvements. If a new restroom building is proposed in the future the recommended erosion hazard mitigation would need to be implemented.

No erosion protection improvements are proposed as part of the river park expansion project as presently proposed.

Floodplain Development Permit

For the Commission's information - a separate floodplain development permit is required for this project. An application has been submitted for this permit. These permits are staff reviewed, and Planning Commission approval is not part of that process.

Planning Commission Action
The Planning Commission should review the proposed Erosion Hazard Permit application to determine if it complies with the applicable standards in the Town Ordinance. Staff recommends the Commission specifically consider the following:

- Does the proposal meet the standards for Erosion Hazard Permits, as set out in Section 10-13E of the Town Code?

Sample Motion Language
The Planning Commission may refer to the following sample language when making a motion on the application:

The Planning Commission approves/ denies the proposed Erosion Hazard Permit, associated with the expansion of the George A Barker River Park, as discussed at the Commission meeting on February 18th, 2026. The motion is based on the following findings:

[LIST FINDINGS]

EROSION HAZARD ASSESSMENT

Springdale River Park Expansion
Springdale, Utah

Prepared For:

Assist Inc. Community Design Center
218 East 500 South
Salt Lake City, UT 84111
(801) 355-7085

Rosenberg Associates
Project No: 6650-24-005
January 16, 2026

PROFESSIONAL ENGINEER
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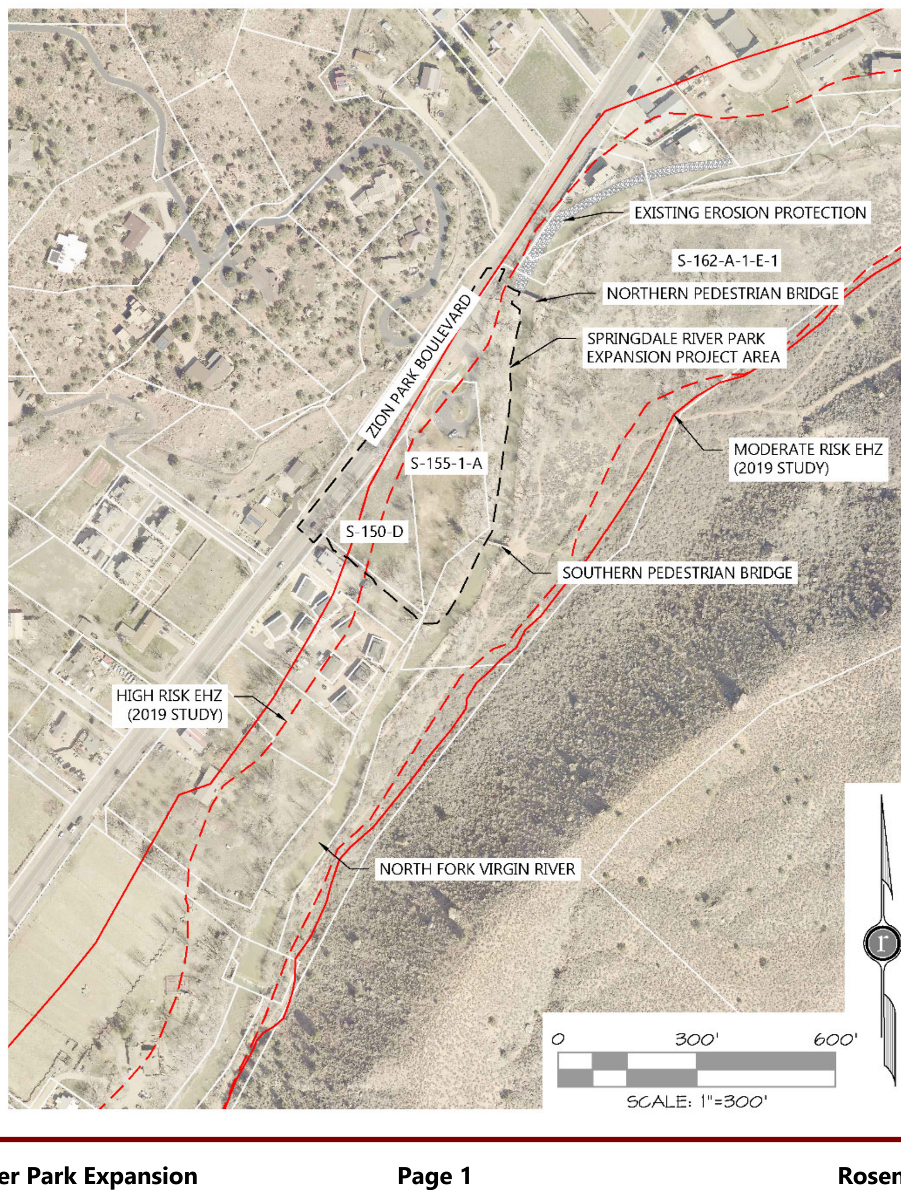
ROSENBERG ASSOCIATES™
CIVIL ENGINEERS LAND SURVEYORS

1.0 INTRODUCTION

1.1 PROJECT OVERVIEW & LOCATION

The expansion of George Barker River Park is proposed along the right (west) overbank of the North Fork of the Virgin River within Parcels S-155-1-A, S-150-D and S-162-A-1-E-1. The expanded river park encompasses a 4.2 acre area in Springdale, UT, located within Section 32, Township 41 South, Range 10 West, Salt Lake Base and Meridian. The proposed river park expansion includes the installation of a new restroom facility, covered pavilion area, river viewing platform, parking lot improvements, utility improvements, a nature-based play area, walking paths, detention basins, and other public amenities. The project area is bounded by Zion Park Boulevard to the northwest, the North Fork of the Virgin River to the southeast, and private land owned by others to the south and north. A copy of the proposed site plan is included in the Appendix. Refer to *Figure 1 – Vicinity Map.*

Figure 1 – Vicinity Map



The Erosion Hazard Zone (EHZ) consists of areas adjacent to the river channel likely to suffer flood related damage by a typical series of flood events over a 60 year period, plus the erosion caused by a single 100 year flood event. The EHZ also includes areas prone to natural channel movement due to geomorphic processes such as meander migration or channel avulsion. It is important to recognize an EHZ is not a "no build" zone, but it serves notice to landowners of the inherent risk that should be addressed through engineering design, insurance, appropriate land uses or avoidance. The Town of Springdale requires an Erosion Hazard Assessment be completed as part of any proposed development or building permits issued on properties impacted by the established Erosion Hazard Zone (EHZ).

Based on the Springdale River Park Expansion Site Plan, the proposed park improvements are partially located within the HREHZ (High Risk Erosion Hazard Zone), and MREHZ (Moderate Risk Erosion Hazard Zone) as defined by the *Draft Erosion Hazard Delineation* (Reference 1). The purpose of this document is to assess the erosion hazard risks associated with the North Fork of the Virgin River adjacent to the proposed development, present recommendations to mitigate the risk of lateral erosion damage to proposed structures and ensure proposed improvements associated with the project do not increase the risk of erosion to adjacent properties.

2.0 SITE INVESTIGATION

2.1 SITE CONDITIONS

The study reach of the North Fork of the Virgin River begins at a major bend, just upstream of the pedestrian bridge north of George Barker River Park and extends downstream approximately 1,300 feet. Rock rip-rap erosion protection was recently installed along the right (west) overbank of the river along the upstream portion of the study reach, as part of the Zion Park Boulevard Erosion Protection Project. During installation of this erosion protection, mature cottonwoods were left undisturbed along the active floodplain/low terrace boundary, and willow pole plantings were placed at the toe of the rip-rap. The slope of the installed erosion protection varies from a 2:1 to a 1.5:1 slope. Recontouring took place along the left (east) overbank, with willows installed along the overbank zone. This erosion protection ties into the right (west) abutment of the pedestrian bridge just north of the river park. The low flow channel of the river through this portion of the study reach consists of a wide, sandy bed with occasional cobbles and boulders.

Adjacent to the proposed improvements, the low flow channel consists of a wide, sandy bed, with a higher proportion of cobbles and boulders when compared to the upstream section. Along the right (west) overbank, the steep active floodplain is moderately vegetated with mature cottonwoods, coyote willows, and mule fat, with a general lack of vegetation in areas where social trails have been established. A few of the cottonwoods along the water's edge have been undercut due to past high flow events, leaving the roots exposed. A small vertical cutbank has formed adjacent to one of the picnic areas within the park, likely due to foot traffic, which either prevented vegetation from establishing, or negatively affected existing vegetation. The low terrace has been previously mass graded to varying extents to accommodate the river park. Mature trees installed as part of the landscaping for the park are present, with a general lack of shrubs in the understory. Along the left (east) overbank, the steep active floodplain is also moderately vegetated with mature cottonwoods, coyote willows, and mule fat. The mature cottonwoods and numerous large boulders keyed into the bank along both sides of the river have provided resistance to erosion and are likely partially responsible for preventing large scale vertical cutbanks from forming previously. A pedestrian bridge with concrete abutments is located near the downstream end of the study reach, which provides additional stability to the location of the main channel.

Figure 2 – November 11, 2024. Image of George Barker Springdale River Park, looking south from the edge of the parking lot. The North Fork of the Virgin River is located behind the mature cottonwoods on the left side of the image. These cottonwoods provide some erosion protection for the park. The proposed improvements are partially located within the HREHZ and MREHZ.

Figure 3 – November 11, 2024. Looking upstream from the downstream edge of the park along the right (west) low terrace. The proposed improved restroom facility and covered pavilion are to be located near the current restroom (red building on the left side of the image).

Figure 4 – November 11, 2024. Image of the undeveloped area south of the existing river park, where the expansion is proposed to take place. The low terrace is vegetated with a few mature cottonwoods and herbaceous vegetation in the understory.

Figure 5 – November 11, 2024. Looking downstream from the pedestrian bridge north of the river park. Recent disturbance from the erosion protection installed along the right (west) overbank is visible in the front of the image. The moderately vegetated, steep and narrow floodplains are visible on either side of the river through this portion of the study reach.

Figure 6 – November 11, 2024. Looking upstream along the right (west) overbank of the North Fork of the Virgin River adjacent to the existing river park. Work associated with the proposed park expansion will not disturb the overbank area, allowing the existing vegetation to continue to provide some erosion protection.

Figure 7 – November 11, 2024. Looking downstream along the right (west) overbank of the North Fork of the Virgin River. The lack of vegetation in the understory within some section of the active floodplain can likely be attributed to erosion occurring during high flow events and foot traffic from park visitors.

Figure 8 – November 11, 2024. Small (1-2’) vertical cutbank located along the right (west) overbank of the North Fork of the Virgin River, approximately 50 feet upstream of the southern pedestrian bridge.

Figure 8 – November 11, 2024. Looking downstream from the southern pedestrian bridge. The active floodplain along both overbanks is well vegetated with cottonwoods in varying life stages, coyote willows, mule fat, and herbaceous vegetation.

2.3 GEOLOGY AND SOILS INFORMATION

The NRCS has classified soils within most of the project area as NaC – Naplene silt loam, 2 to 6 percent slopes (Reference 2). The NaC soil unit is a relatively loose, silty loam associated with alluvial fans and valleys. These soils generally have a minimum distance to lithic bedrock of 80". These soil units within the project area have a high potential for erosion and scour damage due to their composition and location.

An investigation of the regional and local geology of the study reach was performed using geologic mapping data obtained from the Utah Geologic Survey (UGS) database. The geology of the stream bed and banks can greatly influence the erosivity of the floodplain, in turn affecting the lateral erosion distances expected during a flood. The spatial extent of the geologic units within the river systems can provide information of where the river has been in the past. The proposed project area is located within the Qath and Qafc geologic units, which are described as follows in the Geologic Map of the St. George and East Part of the Clover Mountains (Reference 3).

Qat: Old river and stream alluvium (Holocene to middle Pleistocene): Stratified, moderately to well-sorted alluvial gravel, sand, silt, and minor clay that forms level to gently sloping terraces above modern drainages; locally divisible into six or more distinct terrace levels based on elevation above modern drainages, but undivided here due to map scale; deposited in stream channel and floodplain environments and may include colluvium and alluvial fans too small to map separately; commonly forms a sand-and-gravel veneer 10 to 30 feet (3–9 m) thick over an eroded bedrock surface.

Qafy: Younger fan alluvium (Holocene) – Poorly to moderately sorted, non-stratified, subangular to subrounded, boulder to clay-size sediment deposited at the mouths of streams and washes; clast composition ranges widely and reflects rock types exposed in upstream drainage basins; forms both active depositional surfaces (Qaf1 equivalent) and low-level inactive surfaces incised by small streams (Qaf2 equivalent) undivided here; deposited principally as debris flows and debris floods, but colluvium locally constitutes a significant part of the deposits; small, isolated alluvial fans are typically less than a few tens of feet thick, but large, coalesced fans, as in the New Harmony basin, are probably as much as 200 feet (60 m) thick.

The fine-grained alluvial material of units Qat and Qafy is associated with modern, active channel processes and is highly erosive. The USGS map material description is consistent with the finding in the NRCS soil survey and the site investigation.

2.4 EFFECTIVE FLOODPLAIN INFORMATION

A majority the project area is located within Zone AE, defined as areas inside the 1% annual chance floodplain according to FEMA Flood Insurance Rate Map (FIRM), panel 49053C 0895G, dated April 2, 2009 (Reference 4). A portion of the project area, including the proposed restroom facility and covered pavilion are located within Zone X, defined as areas outside the 1% annual chance floodplain. A FIRMette of panel 0895G and a floodplain exhibit with the project area boundary are included in the Appendix.

2.5 FLOODPLAIN ANALYSIS

To determine the impacts of placing fill within the project area as part of the proposed improvements, a HEC-RAS hydraulic model was prepared based on existing and proposed conditions and compared with the regulatory model of the North Fork of the Virgin River along the study reach. The existing conditions hydraulic model was prepared with geometric data derived from 2017 Washinton County LiDAR topography, 2024 field survey data, and 2009 Washington County FIS (Reference 5) regulatory flow information. The proposed conditions hydraulic model was developed by adjusting the elevations along the right (west) overbank based on proposed site improvements. Table 1 below provides a comparison between effective, existing, and proposed water surface elevations.

Table 1 ***100 Year Water Surface Elevations***				
Station	***Effective 100 Year Water Surface Elevation***	***Existing 100 Year Water Surface Elevation***	***Proposed 100 Year Water Surface Elevation***	***Difference (Proposed – Existing)***
7+600.735 (FEMA Q)	3816.05'	3816.10'	3816.10'	0.00'
7+402.373 (FEMA P)	3815.16'	3815.43'	3815.43'	0.00'
7+296.517	3812.32'	3814.09'	3814.09'	0.00'
7+276.270 (FEMA O)	3811.69'	3811.08'	3811.06'	-0.02'
7+146.536 (FEMA N)	3811.44'	3810.71'	3810.67'	-0.04'
6+886.104 (FEMA M)	3809.31'	3809.25'	3809.14'	-0.11'
6+752.393	3809.02'	3808.88'	3808.69'	-0.19'
6+735.798 (FEMA L)	3808.97'	3808.00'	3807.98'	-0.02'
6+535.399 (FEMA K)	3807.34'	3806.83'	3806.83'	0.00'

As shown in Table 1 above, the proposed improvements do not change the 100-year water surface elevations more than one foot within the property limits, meeting the requirements of Ordinance 2020-04. Based on the hydraulic analysis, the proposed improvements do not impact water surface elevations at properties adjacent to the project area. See the Floodplain Exhibit, the Proposed Erosion Protection Exhibit, and the hydraulic calculations included in the Appendix for additional information.

3.0 RIVER MEANDER & SCOUR ANALYSIS

3.1 HISTORICAL AERIAL PHOTO ANALYSIS

Historic aerial photos from 1973 to 2024 of the study reach were reviewed to establish the location of the North Fork of the Virgin River active channel and determine meander patterns and trends over the extended recent time period, including the impacts of the significant flood events in 2005 and 2010. The results of the analysis indicate that throughout most of the reach, the location of the active channel has remained relatively stable throughout the study period. The lack of lateral movement of the North Fork of the Virgin River is likely due to the presence of mature cottonwoods alone the water's edge, the active floodplain, and active floodplain/ low terrace transition zone. The presence of the two pedestrian bridges also likely plays a role in stabilizing this reach of the river.

3.2 SCOUR ANALYSIS

Scour depths were calculated based on the Virgin River 100-year flood event. 100-year flood water surface elevations, flow depths, and flow velocities were based on the proposed conditions HEC-RAS model of the study reach.

Total estimated scour depth along the study reach was based on the Clark County Regional Flood Control District Hydrologic Criteria and Drainage Design Manual, which uses a sum of long term degradation, bend scour, and (1/2) anti-dune scour (Reference 5). Table 3 lists the individual components and total scour value calculated along the channel.

Table 3 - Total Scour Depths

½ Anti-Dune Scour	0.68 ft
Bend Scour	0.36 ft
Long Term Degradation	1.00 ft
Total Scour	***2.04 ft***

3.3 ANALYSIS OF EROSION HAZARD RISK

The proposed improvements are partially located within the HREHZ, and are along a relatively straight, stable reach of the North Fork of the Virgin River. The existing erosion protection along the right (west) overbank, upstream of the northern pedestrian bridge, provides lateral stability to this section of river, and will limit channel migration to the west. The two pedestrian bridges also contribute to the lateral stability of the river through the proposed project area. The mature cottonwoods located within the active floodplain and terrace along the right (west) overbank provide natural stabilization, limiting lateral migration of the channel and minimizing the effect of scour. Although there is evidence of some scour by the exposed root structure of several of the larger cottonwoods, many of the trees remain healthy and stable. The presence of the roots structure has likely prevented the formation of vertical cutbanks adjacent to the site. However, if the trend of erosion continues, it can be assumed that the cottonwoods along the toe of the bank will continue to be undercut and likely will collapse into the river, removing bank protection and potentially increasing the risk of lateral erosion.

The proposed improvements are intended to closely match existing grades, and outside of the installation of the restroom building, no significant alterations to the site are anticipated. Care was taken to ensure that no fill was placed within the floodway as a result of site grading. As the proposed improvements will result in minor impacts to the existing developed conditions of the site, the intended use of the area matches the current use, the existing right (west) overbank has remained stable for over 60 years and no disturbance will occur below the top of the bank, erosion protection is recommended to specifically protect the restroom building from the high velocity flows expected during a 100-year flood event.

The sole use of bioengineering techniques was considered for the proposed erosion protection improvements but was deemed to be insufficient due to the erosion protection improvements specifically addressing the restroom building. As riparian species need access to water year-round, plants used for bioengineering would be unable to establish within the low terrace. As the erosion protection improvements are to be located within the high terrace, no specific bioengineering improvements are considered feasible for this site.

A calculation of required rock rip-rap size for the study reach based on tractive stress was used along with the scour depth listed above to determine the quantity of rock necessary to protect the restroom building. A rock rip-rap section consisting of 24" D50 (median particle size) rock, 4 feet thick, extending from a height 1 foot above the base flood elevation to a depth 2.04 feet below the flowline on a 1.5:1 slope would require 4.0 cubic yards of rock per linear foot. In lieu of placing rock rip-rap erosion protection, the building footings for the restroom can be extended 5' below the proposed finished floor elevation to provide adequate erosion protection.

Based on the Engineer's experience working in this reach of the North Fork of the Virgin River, it is assumed that the project is susceptible to potential damage caused by major flooding and scour. It is the opinion of the Engineer that extension of the building footings is required to adequately protect the restroom facility, and the temporary river viewing platform should be designed to break away from its foundation during high water events.

4.0 RECOMMENDATIONS

4.1 PROPOSED IMPROVEMENTS

Extending the building footings 5' below the finished floor elevation is recommended to protect the restroom facility from potential scour resulting from future flood events. The finished floor elevation (FFE) of the restroom building should be one foot above the 100 year water surface elevation. The proposed river viewing platform is to be considered temporary and be designed to break away during major floor events. See the Proposed Erosion Protection Plans in the Appendix for additional information.

All applicable provisions of the Uniform Building Code must be adhered to while constructing the proposed improvements and any associated site grading activities. Any public utilities or facilities constructed with the proposed development should be located and constructed to minimize the risk of flood and erosion damage.

4.2 DO NOT DISTURB THE STREAM BANKS & RIPARIAN ZONE

No disturbance should be allowed within the regulatory floodplain, North Fork of the Virgin River wet stream, or the riparian zone without the necessary regulatory permits. Significant biological conditions are anticipated to be part of the regulatory permits issued by the Corps of Engineers or the State Engineers Office as part of any proposed disturbance within the jurisdictional areas. The existing North Fork Virgin River riparian zones should remain undisturbed during the construction process except for the permitted activities. In addition, any disturbed areas within the riparian corridor should be re-vegetated with native Coyote Willow, Gooding Willow or Fremont Cottonwood plantings as appropriate. All proposed grading should adhere to the recommendations of the *Virgin River Management Plan* (Reference 7) as it relates to grading, surface drainage and surface roughness. A Grading Permit and a Floodplain Development

Permit is required by the Town of Springdale prior to construction of erosion protection improvements.

4.3 IMPACTS TO STREAM STABILITY AND ADJACENT PROPERTIES

As shown in Table 1 and the Floodplain Exhibit included in the Appendix, 100 year water surface elevations within adjacent properties will not increase above the effective water surface elevations as a result of the proposed improvements. No changes or impacts to the regulatory floodway shall occur with this project. As designed, construction of the proposed improvements should not impact the Waters of the U.S., riparian vegetation, or federally protected endangered species. No impacts to stream stability or sediment transport patterns are anticipated with the project.

4.4 PROVIDE FOR PERPETUAL ACCESS & MAINTENANCE

Perpetual maintenance of the proposed erosion protection improvements and access to the area between the restroom building and SR-9 and the parking lot is required. Routine inspection of the improvements and access should be completed at least annually and immediately following any major flood event in the river. Maintenance of the proposed erosion protection and access will be the responsibility of the property owner. Any required repair of the improvements or access shall be completed in a timely manner as per the direction of a professional engineer or his assignee.

4.5 PROPERTY OWNERS SHALL ACKNOWLEDGE RISKS

It should be acknowledged by any current or future property owners that flood events larger than the 100 year flood can and do occur. Areas adjacent to the North Fork of the Virgin River are susceptible to flooding and erosion damage beyond the design events analyzed in this report. Development plans should consider the risk of erosion, sedimentation, and flood damage from large flood events during the design of structural foundation systems, utilities, pavements, and site drainage. Approval of future building permit approvals for the property should be conditioned upon acknowledgement by property owners of the potential risks of flood and erosion damage at this location.

5.0 ENGINEER’S OPINION OF RISK

The findings and recommendations presented in this document are based on a review of existing technical studies concerning the flooding and erosion hazard risks at this location on the North Fork of the Virgin River; a site investigation to determine existing conditions; evaluation of other erosion protection counter measures already in place; engineering analysis and past professional experience working in the area. It is the professional engineering opinion of Rosenberg Associates that if the recommendations presented in this document are implemented and maintained properly, then the risk of lateral bank erosion to the expanded Springdale River Park will be mitigated as required by the Town of Springdale code. No adverse effects to properties upstream, downstream, or across the river are anticipated with the proposed project.

REFERENCES

1. Draft Erosion Hazard Delineation, Rosenberg Associates, January, 2020.

2. Custom Soil Resource Report for Washington County Area, Utah, Natural Resources Conservation Service, January 18, 2024.

3. Geologic Map of the St. George and East Part of the Clover Mountains 30′ x 60′ Quadrangles, Washington and Iron Counties, Utah, Utah Geologic Survey, 2010.

4. Washington County Flood Insurance Study, Federal Emergency Management Agency, April 2, 2009.

5. Hydrologic Criteria and Drainage Design Manual, Clark County Regional Flood Control District, 1999.

6. Bank Stabilization Design Guidelines, U.S. Department of the Interior, 2015.

7. Virgin River Management Plan, Town of Springdale, 2019.

APPENDIX

Custom Soil Resource Report for Washington County Area, Utah – NRCS
FIRMette Washington County FIS, Panel 49053C 0895G
Floodplain Exhibit – North Fork Virgin River, Rosenberg Associates, 2026
Site Plan – Springdale River Park Expansion
Proposed Erosion Protection Plans, Rosenberg Associates, 2026

Hydraulic Model Data
Total Scour Calculations

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for
Washington County Area, Utah

February 26, 2025

Preface

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

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

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

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

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

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

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

Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

Soil Map

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

Soil Map

Map Scale: 1:1,660 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 20, 40, 80, 120

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Washington County Area, Utah
Survey Area Data: Version 18, Aug 28, 2024

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

Date(s) aerial images were photographed: Sep 8, 2022—Sep 29, 2022

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
FA	Fluvaquents and torrifluvents, sandy	2.1	26.0%
NaC	Naplene silt loam, 2 to 6 percent slopes	4.3	53.9%
W	Water	1.6	20.0%
Totals for Area of Interest		**7.9**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Washington County Area, Utah

FA—Fluvaquents and torrifluvents, sandy

Map Unit Setting

National map unit symbol: j8dt
Elevation: 2,500 to 3,000 feet
Mean annual precipitation: 8 to 11 inches
Mean annual air temperature: 57 to 67 degrees F
Frost-free period: 190 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Fluvaquents and similar soils: 55 percent
Torrifluvents and similar soils: 35 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fluvaquents

Setting

Landform: Swales
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Sandy alluvium derived from limestone, sandstone, and shale

Typical profile

H1 - 0 to 5 inches: fine sand
H2 - 5 to 60 inches: stratified fine sand to silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: Frequent
Frequency of ponding: Rare
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7w
Hydrologic Soil Group: A/D
Ecological site: R035XY011UT - Loamy Bottom (Basin Big Sagebrush)
Hydric soil rating: Yes

Description of Torrifluvents

Setting

Landform: Flood plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from limestone, sandstone, and shale

Typical profile

H1 - 0 to 5 inches: loamy fine sand
H2 - 5 to 60 inches: stratified loamy fine sand to silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr)
Depth to water table: About 42 to 72 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 5.0
Available water supply, 0 to 60 inches: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7w
Hydrologic Soil Group: A
Ecological site: R035XY011UT - Loamy Bottom (Basin Big Sagebrush)
Other vegetative classification: Loamy Bottom (Basin Big Sagebrush) (035XY011UT)
Hydric soil rating: No

Minor Components

Riverwash

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tobler, silty clay loam

Percent of map unit: 3 percent

Tobler, fine sandy loam

Percent of map unit: 3 percent

NaC—Naplene silt loam, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: j8fz
Elevation: 3,600 to 5,300 feet
Mean annual precipitation: 14 to 15 inches
Mean annual air temperature: 44 to 52 degrees F
Frost-free period: 140 to 160 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Naplene and similar soils: 75 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Naplene

Setting

Landform: Alluvial fans, valleys
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium derived from igneous and sedimentary rock

Typical profile

H1 - 0 to 2 inches: silt loam
H2 - 2 to 7 inches: silt loam
H3 - 7 to 15 inches: silt loam
H4 - 15 to 22 inches: silty clay loam
H5 - 22 to 39 inches: silt loam
H6 - 39 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 10.8 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: C
Ecological site: R035XY306UT - Upland Loam (Basin Big Sagebrush)
Hydric soil rating: No

Minor Components

Schmutz
Percent of map unit: 5 percent

Redbank
Percent of map unit: 5 percent

Mespun
Percent of map unit: 5 percent

Clovis
Percent of map unit: 5 percent

Chilton
Percent of map unit: 5 percent

W—Water

Map Unit Composition
Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Percentage of rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination. Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

References:

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

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

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Washington County Area, Utah														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*	*L-R-H*
FA—Fluvaquents and torrifluvents, sandy														
Fluvaquents	55	A/D	0-5	Fine sand	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	65-73-80	20-28-35	0-7 -14	NP
			5-60	Stratified fine sand to silt loam	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	65-73-80	20-28-35	15-20-25	NP-3 -5
Torrifluvents	35	A	0-5	Loamy fine sand	SM	A-4	0- 0- 0	0- 0- 0	100-100-100	100-100-100	75-83-90	35-43-50	0-7 -14	NP
			5-60	Stratified loamy fine sand to silt loam	SM	A-2-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	50-63-75	10-20-30	15-20-25	NP-3 -5
NaC—Naplene silt loam, 2 to 6 percent slopes														
Naplene	75	C	0-2	Silt loam	CL, CL-ML	A-6, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15
			2-7	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15
			7-15	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15
			15-22	Silty clay loam	CL	A-6	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	80-88-95	30-35-40	10-13-15
			22-39	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15
			39-60	Silt loam	CL-ML, CL	A-6, A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	85-93-100	65-78-90	25-30-35	5-10-15

References

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

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National Flood Hazard Layer FIRMette

FEMA

113°0'51"W 37°10'50"N

113°0'13"W 37°10'21"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/26/2025 at 10:08 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

LEGEND

PROJECT AREA

DATE: 2/26/2025
JOB NO.: 2824-24-002
DESIGNED BY: WJP
CHECKED BY: JWB
DWG: EHZ

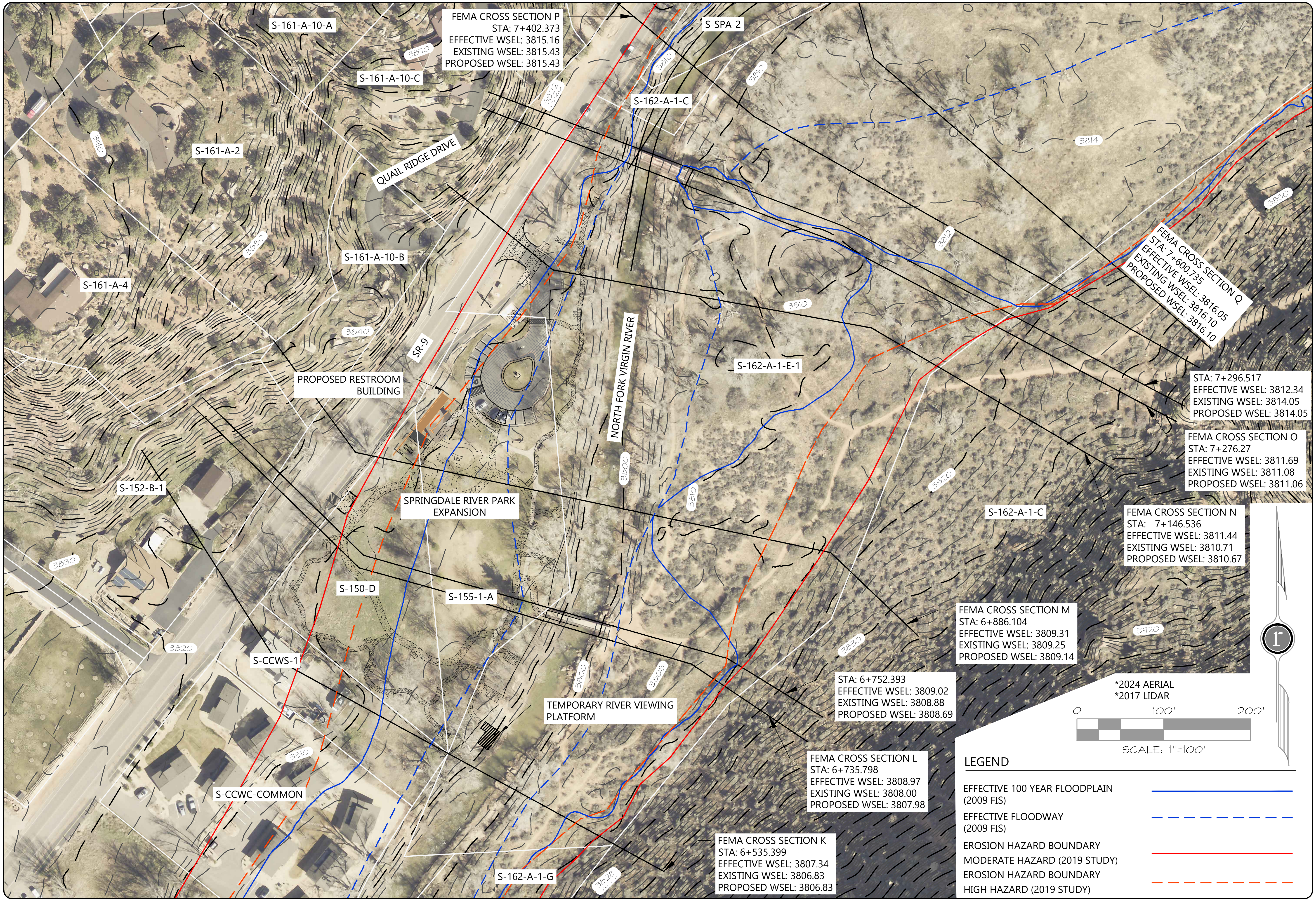
DATE REVISIONS

ROSENBERG ASSOCIATES
CIVIL ENGINEERS • LAND SURVEYORS

352 East Riverside Drive, Suite A-2
St. George, Utah 84790
Ph (435) 673-8586 Fx (435) 673-8397
www.racivil.com

FEMA FIRMETTE - 0895G
FOR
SPRINGDALE RIVER PARK EXPANSION
SPRINGDALE
UTAH

SHEET
1
1 OF 1 SHEETS



DATE:	2/20/2025
JOB NO.:	2848-24-002
DESIGNED BY:	WJP
CHECKED BY:	JWB
DWG:	EHZ

DATE

REVISIONS

ROSENBERG ASSOCIATES
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St. George, Utah 84790
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www.racivil.com

FLOODPLAIN EXHIBIT - NORTH FORK VIRGIN RIVER

FOR

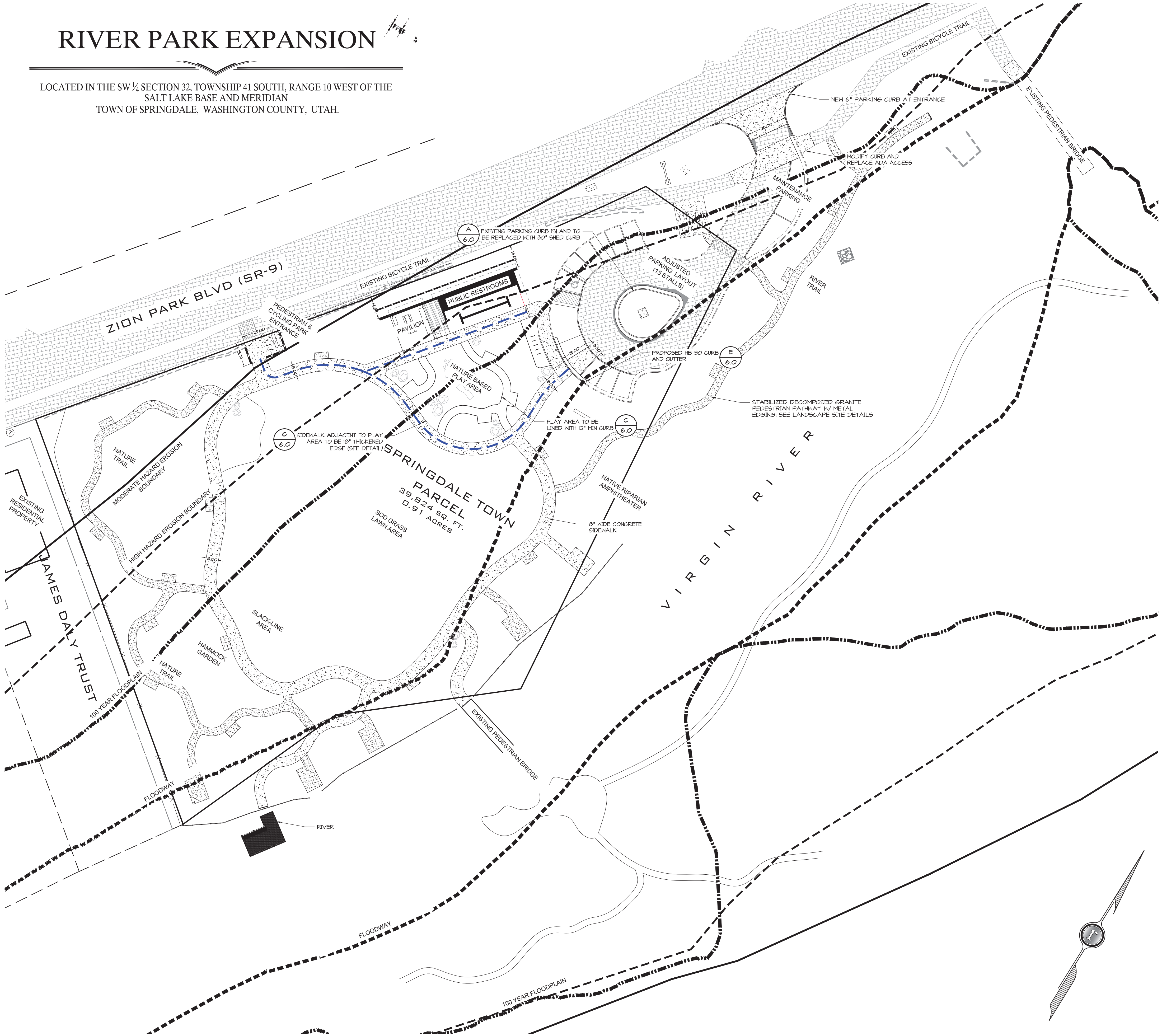
SPRINGDALE RIVER PARK EXPANSION

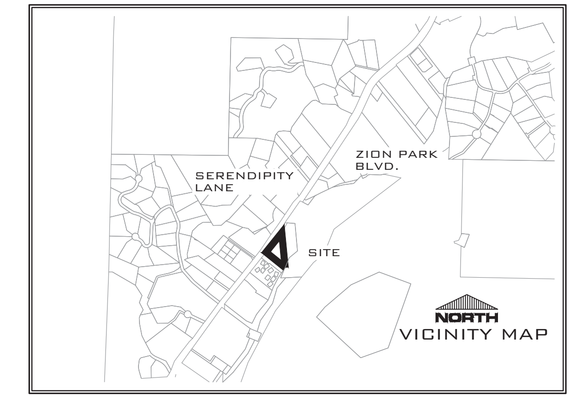
SPRINGDALE
UTAH

SHEET
1
1 OF 1 SHEETS

RIVER PARK EXPANSION

LOCATED IN THE SW ¼ SECTION 32, TOWNSHIP 41 SOUTH, RANGE 10 WEST OF THE
SALT LAKE BASE AND MERIDIAN
TOWN OF SPRINGDALE, WASHINGTON COUNTY, UTAH.





SITE NOTES

"ALL AREAS OUTSIDE OF THE GRADING LIMITS WILL BE FENCED OR TAPED OFF DURING CONSTRUCTION TO PREVENT ACCIDENTAL OR INCIDENTAL DISTURBANCE OF THESE AREAS"

LEGEND

EXISTING	DESCRIPTION	PROPOSED
dashed line	TOP BACK CURB	solid line
grey dashed line	WALL	heavy dashed line
	ADA PATH	blue dashed line
hatched	ASPHALT PAVEMENT	grey fill
stippled	CONCRETE	stippled

0 30' 60'
SCALE: 1"=30'

Know what's below. Call before you dig.

NOTICE:
EXISTING UTILITIES ARE SHOWN ON PLANS FOR THE CONVENIENCE OF THE CONTRACTOR ONLY. THE CONTRACTOR IS RESPONSIBLE FOR THE LOCATION AND PROTECTION OF ALL UTILITIES. THE ENGINEER BEARS NO RESPONSIBILITY FOR UTILITIES NOT SHOWN OR SHOWN INCORRECTLY.

DATE:	1-10-25
JOB NO.:	#2848-24-002
DESIGNED BY:	ETY
CHECKED BY:	JWB
DWG:	CONST SET

DATE
REVISIONS

ROSENBERG ASSOCIATES
CIVIL ENGINEERS • LAND SURVEYORS
352 East Riverside Drive, Suite A-2
St. George, Utah 84790
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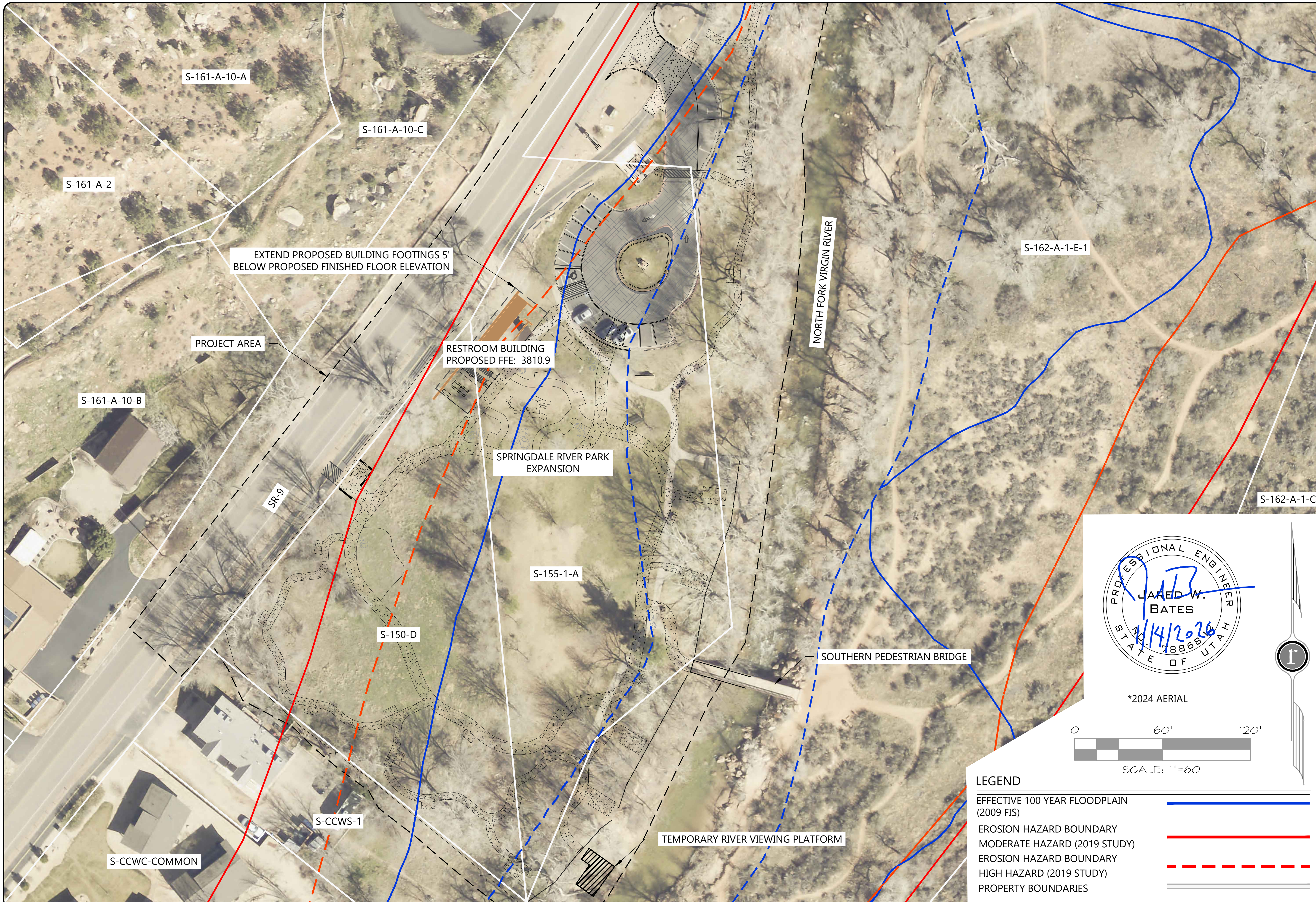
www.racivil.com

SITE PLAN
FOR
SPRINGDALE RIVER PARK EXPANSION
SPRINGDALE
UTAH

SHEET
3.0
3 OF 7 SHEETS



DATE:	2/26/2025
JOB NO.:	2824-24-002
DESIGNED BY:	WJP
CHECKED BY:	JWB
DWG:	EHZ

DATE
REVISIONS

ROSENBERG
ASSOCIATES
CIVIL ENGINEERS • LAND SURVEYORS

352 East Riverside Drive, Suite A-2
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www.racivil.com

EROSION PROTECTION PLAN - NORTH FORK VIRGIN RIVER

FOR

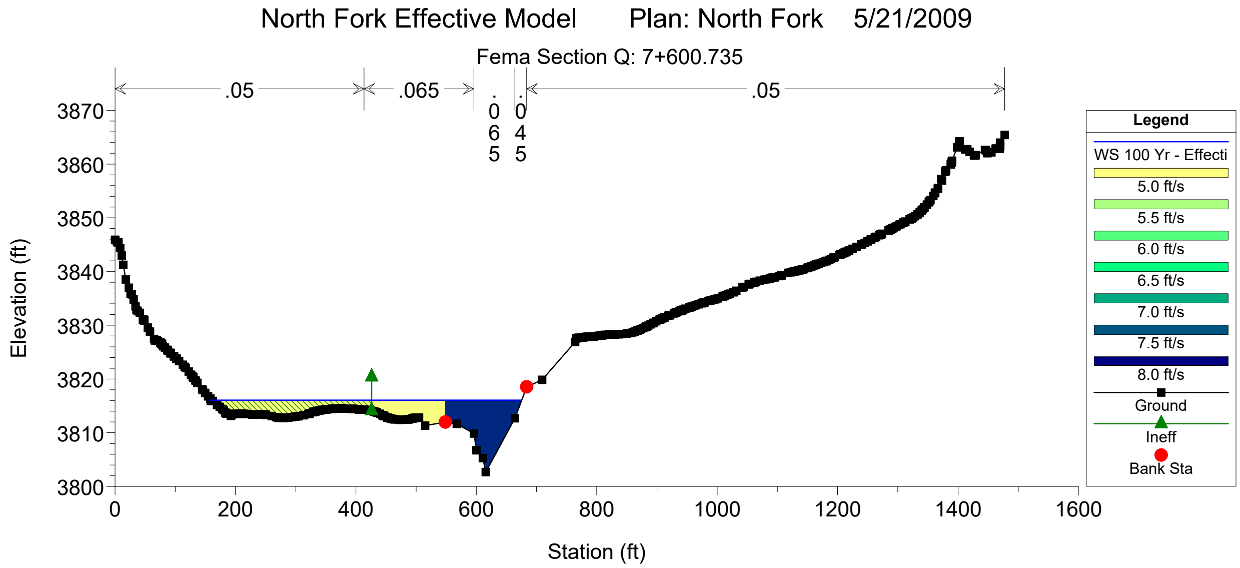
SPRINGDALE RIVER PARK EXPANSION

SPRINGDALE
UTAH

SHEET
PV
1 OF 1 SHEETS

HEC-RAS Model Results - Effective Conditions - North Fork Virgin River

FEMA Sta	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	Hydr Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)
Q	7+600.735	100 Yr	8830	3802.67	3816.05	3816.85	0.008924	7.76	1291.01	516.69	0.53	13.38	5.18
P	7+402.373	100 Yr	8830	3799.55	3815.16	3815.94	0.002976	7.39	1351.23	525.19	0.39	15.61	8.35
	7+296.517	100 Yr	8830	3797.7	3812.32	3815.17	0.01258	13.56	651.4	259.02	0.74	14.61	10.33
	7+286.394		Bridge										
O	7+276.270	100 Yr	8830	3797.41	3811.69	3814.73	0.01282	13.99	630.99	208.89	0.78	14.28	10.01
N	7+146.536		8830	3794.44	3811.44	3812.38	0.008043	7.84	1176.81	333.48	0.48	17	6.05
M	6+886.104	100 Yr	8830	3792.32	3809.31	3810.33	0.007704	8.24	1194.41	243.64	0.5	16.99	4.9
	6+752.393	100 Yr	8830	3789.42	3809.02	3809.61	0.002845	6.49	1801.01	390.6	0.3	19.6	4.61
	6+742.344		Bridge										
L	6+735.798	100 Yr	8830	3789.4	3808.97	3809.5	0.003161	6.13	1824.47	380.96	0.31	19.57	4.79
K	6+535.399	100 Yr	8830	3790.43	3807.34	3808.46	0.006261	8.87	1154.68	242.81	0.55	16.91	4.76


North Fork Effective Model Plan: North Fork 5/21/2009
Fema Section Q: 7+600.735
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Elevation (ft)
Station (ft)
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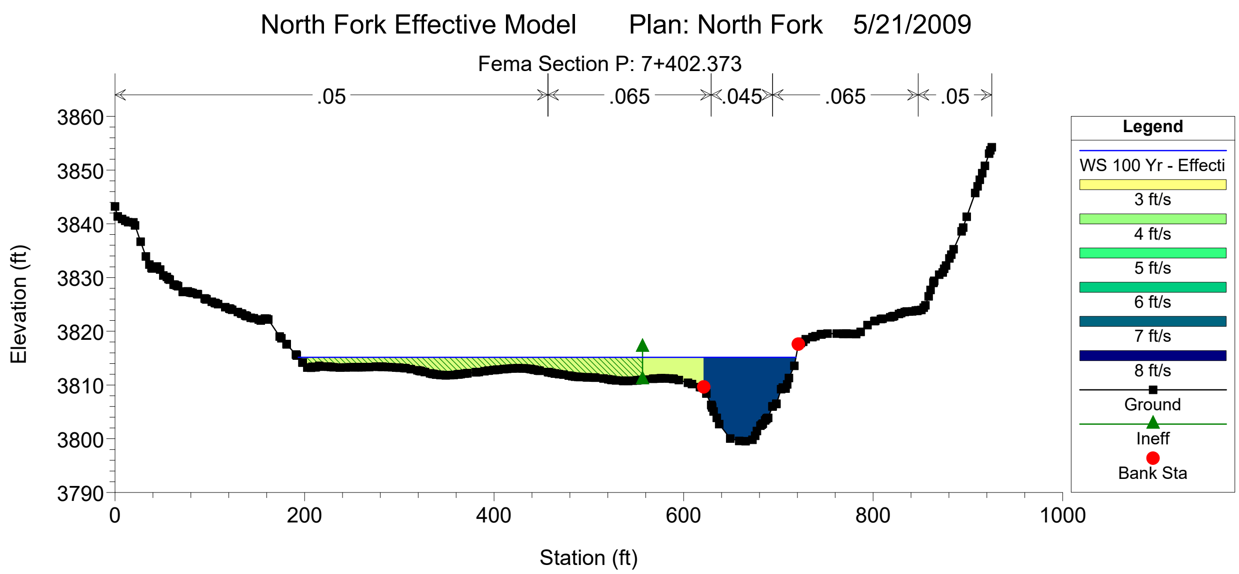
North Fork Effective Model Plan: North Fork 5/21/2009
Fema Section P: 7+402.373
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Elevation (ft)
Station (ft)
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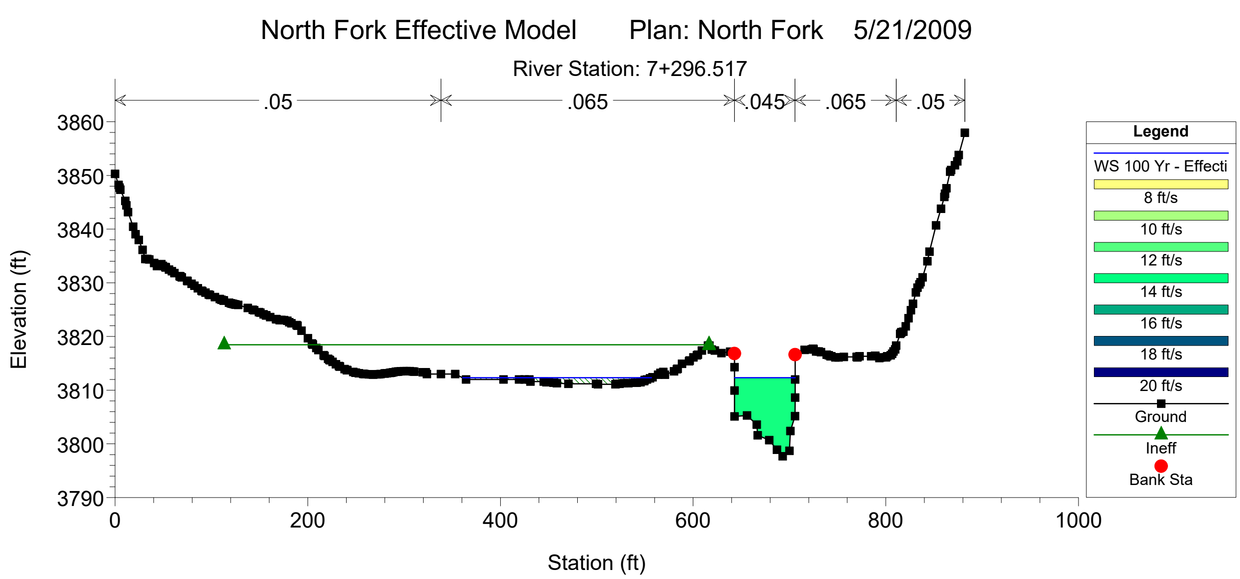
Bank Sta


North Fork Effective Model Plan: North Fork 5/21/2009
River Station: 7+296.517
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Elevation (ft)
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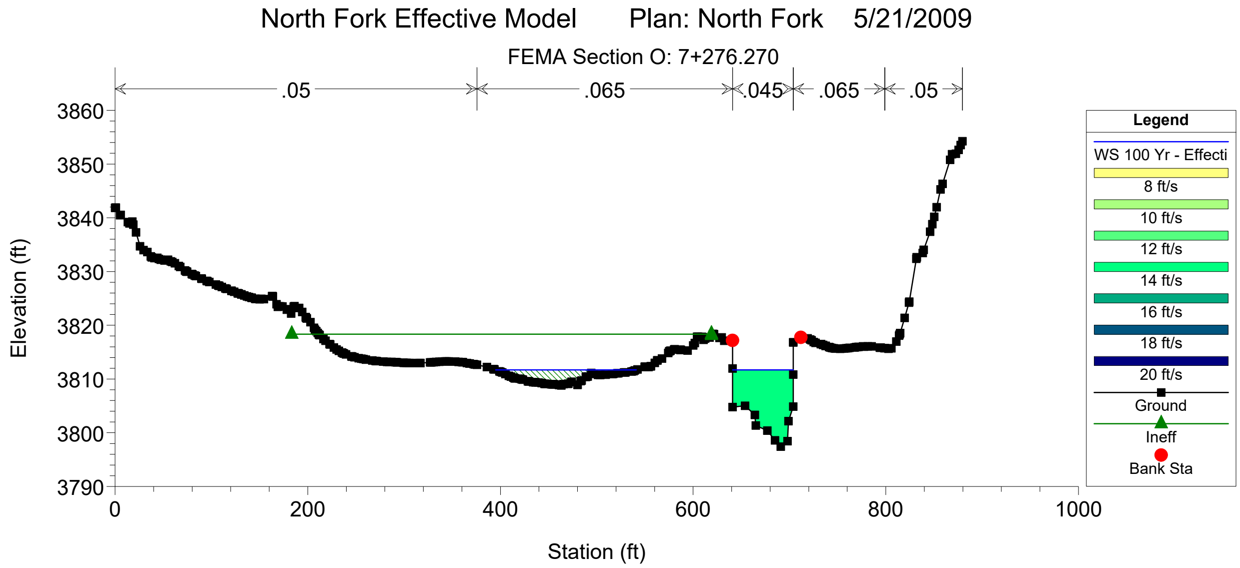
Bank Sta



North Fork Effective Model Plan: North Fork 5/21/2009
FEMA Section O: 7+276.270
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Elevation (ft)
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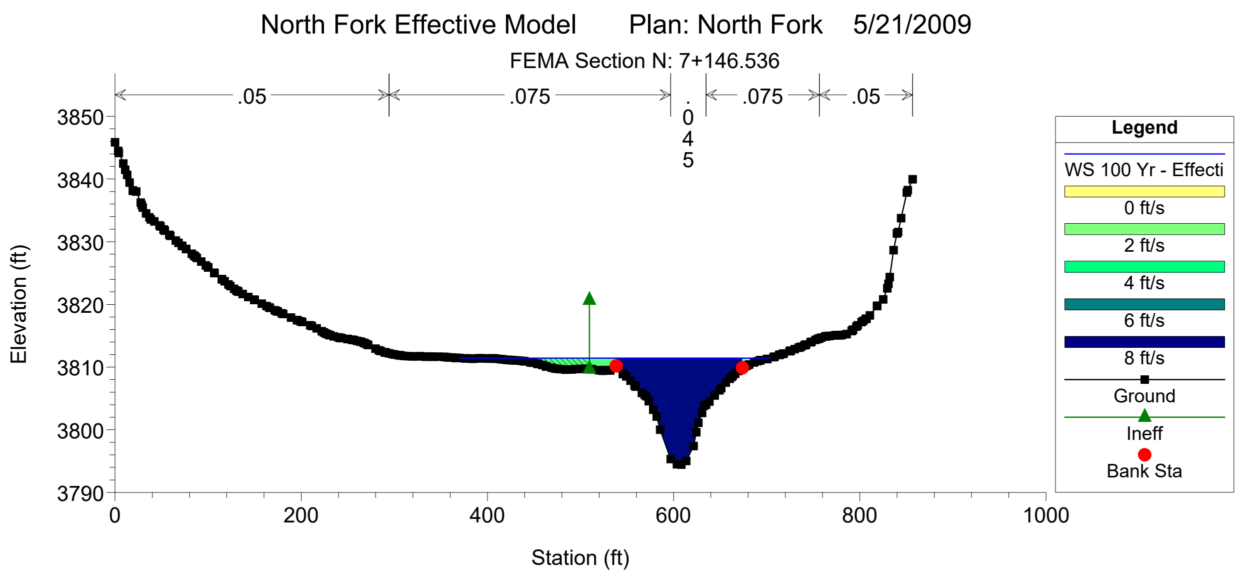

North Fork Effective Model Plan: North Fork 5/21/2009
FEMA Section N: 7+146.536
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Elevation (ft)
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Ground
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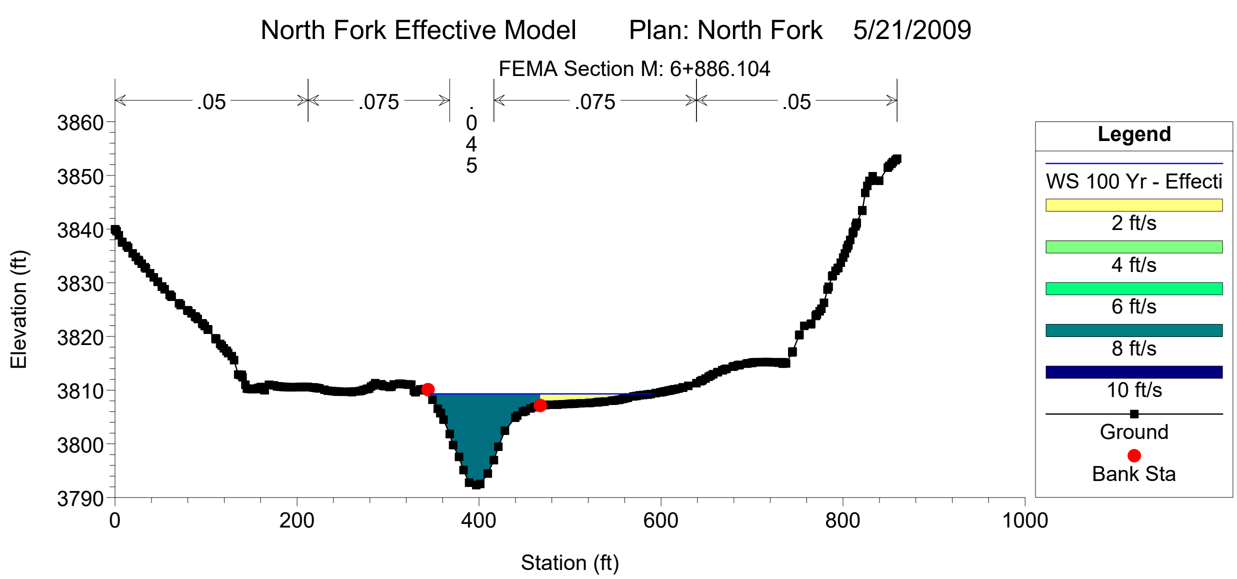
Bank Sta



North Fork Effective Model Plan: North Fork 5/21/2009
FEMA Section M: 6+886.104
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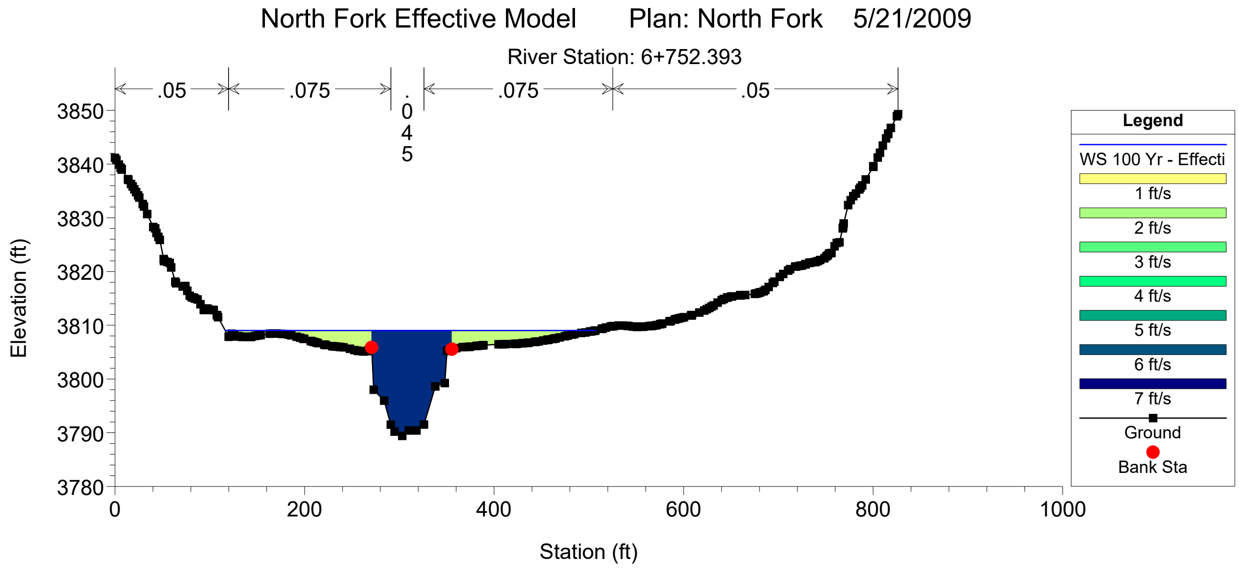
North Fork Effective Model Plan: North Fork 5/21/2009
River Station: 6+752.393
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Elevation (ft)
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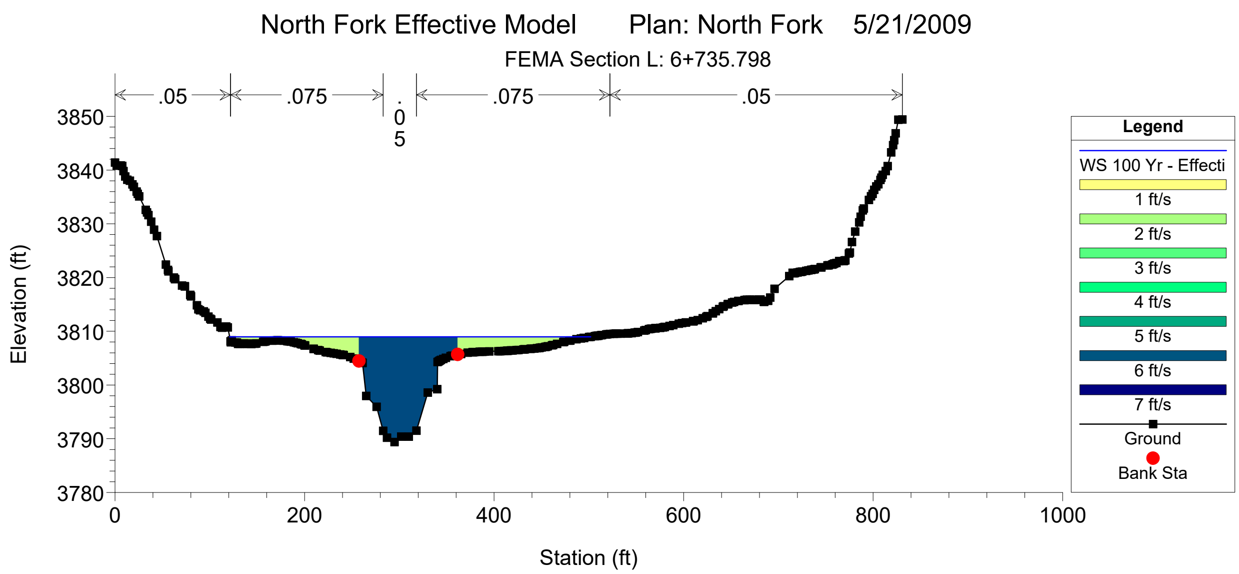
7 ft/s
Ground
Bank Sta


North Fork Effective Model Plan: North Fork 5/21/2009
FEMA Section L: 6+735.798
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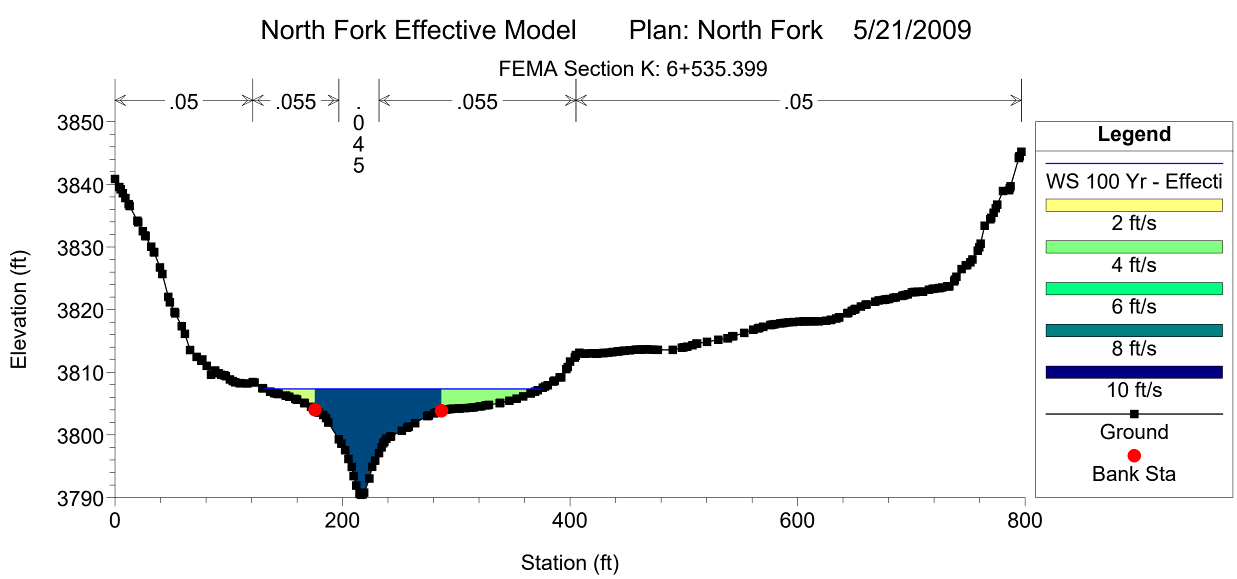
North Fork Effective Model Plan: North Fork 5/21/2009
FEMA Section K: 6+535.399
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Legend
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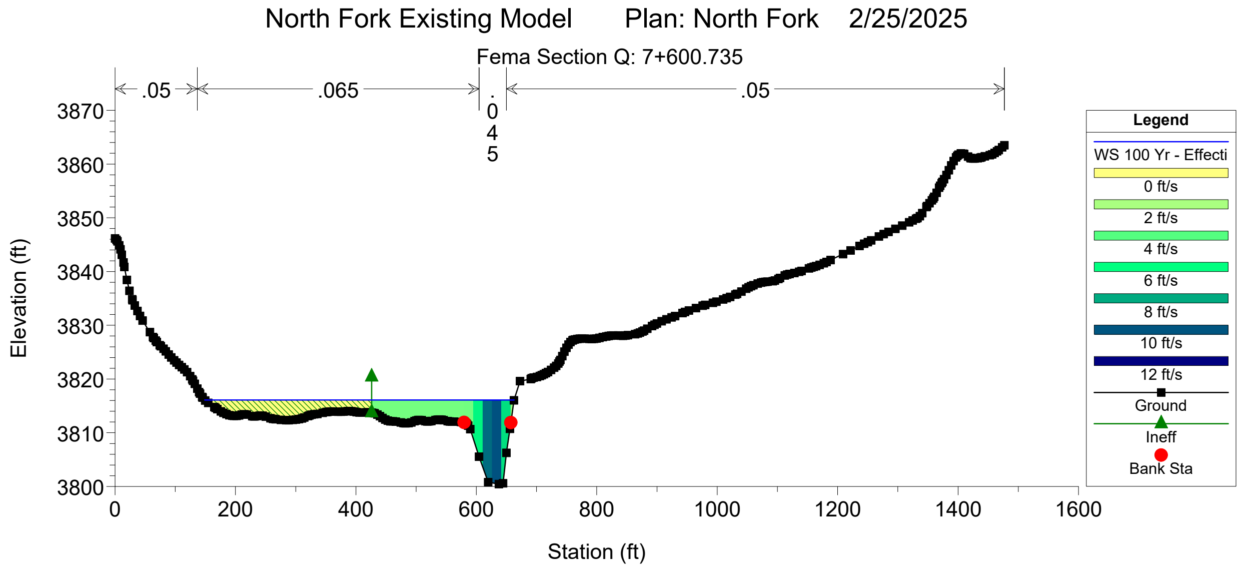
8 ft/s
10 ft/s
Ground
Bank Sta

HEC-RAS Model Results - Existing Conditions - North Fork Virgin River													
FEMA Sta	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	Hydr Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)
Q	7+600.735	100 Yr	8830	3800.44	3816.1	3816.9	0.003462	7.97	1460.64	513.81	0.42	15.66	6.17
P	7+402.373	100 Yr	8830	3800.37	3815.43	3816.22	0.003685	7.41	1313.74	535	0.41	15.06	7.98
	7+296.517	100 Yr	8830	3800.05	3814.09	3815.64	0.006588	9.98	888.84	455.62	0.56	14.04	9.25
	7+286.394		Bridge										
O	7+276.270	100 Yr	8830	3799.61	3811.08	3813.76	0.012091	13.12	673.2	216.44	0.82	11.48	7.98
N	7+146.536		8830	3798.79	3810.71	3812.11	0.005431	9.5	934.69	220.02	0.67	11.92	5.63
M	6+886.104	100 Yr	8830	3796.9	3809.25	3810.64	0.005824	9.81	1105.39	285.93	0.56	12.35	3.87
	6+752.393	100 Yr	8830	3794.61	3808.88	3809.95	0.003548	8.75	1393.71	392.08	0.52	14.27	3.55
	6+742.344		Bridge										
L	6+735.798	100 Yr	8830	3794.58	3808	3809.43	0.00856	9.98	1090.74	321.73	0.63	13.42	3.39
K	6+535.399	100 Yr	8830	3794.12	3806.83	3808.12	0.004673	9.32	1098.31	236.75	0.58	12.71	4.64


North Fork Existing Model Plan: North Fork 2/25/2025
Fema Section Q: 7+600.735
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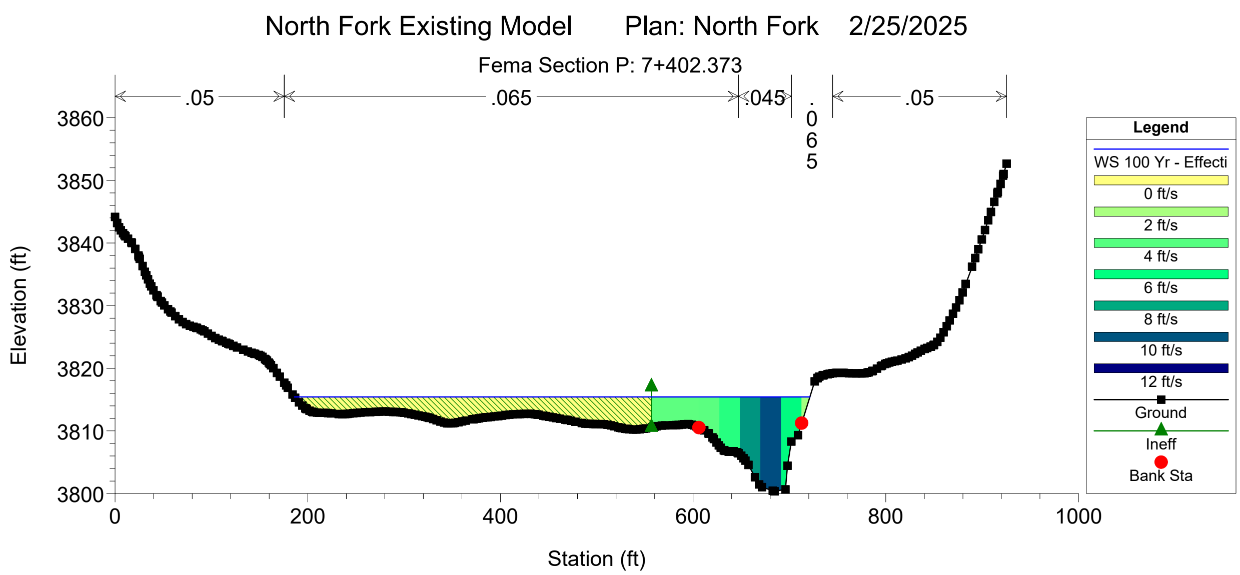
North Fork Existing Model Plan: North Fork 2/25/2025
Fema Section P: 7+402.373
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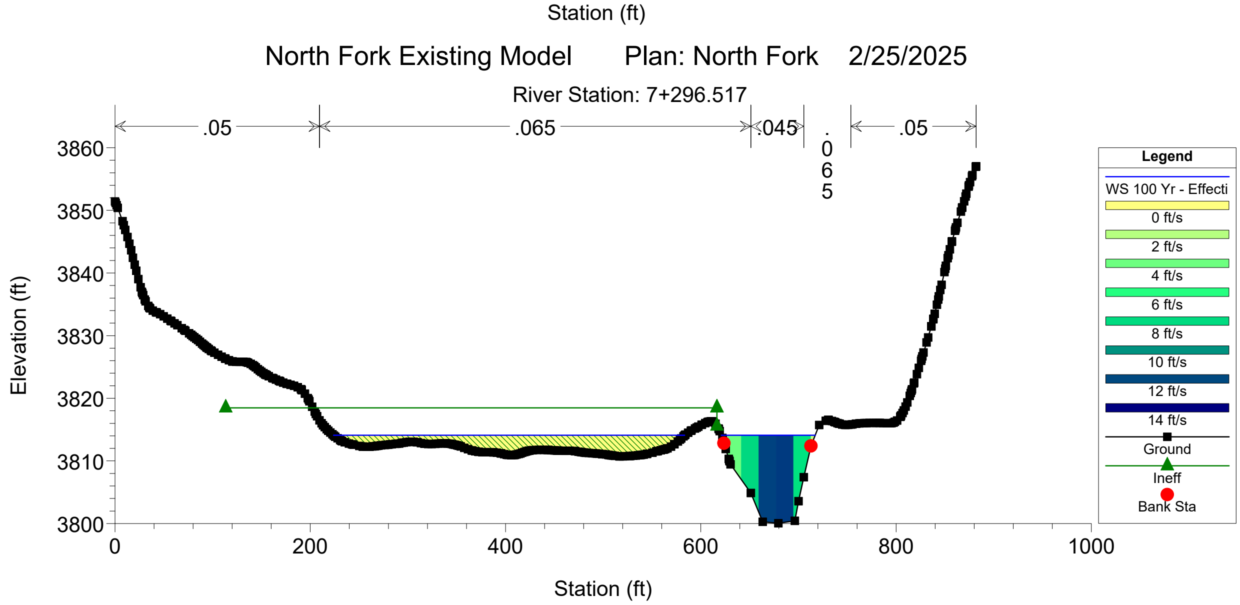
North Fork Existing Model Plan: North Fork 2/25/2025
River Station: 7+296.517
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Elevation (ft)
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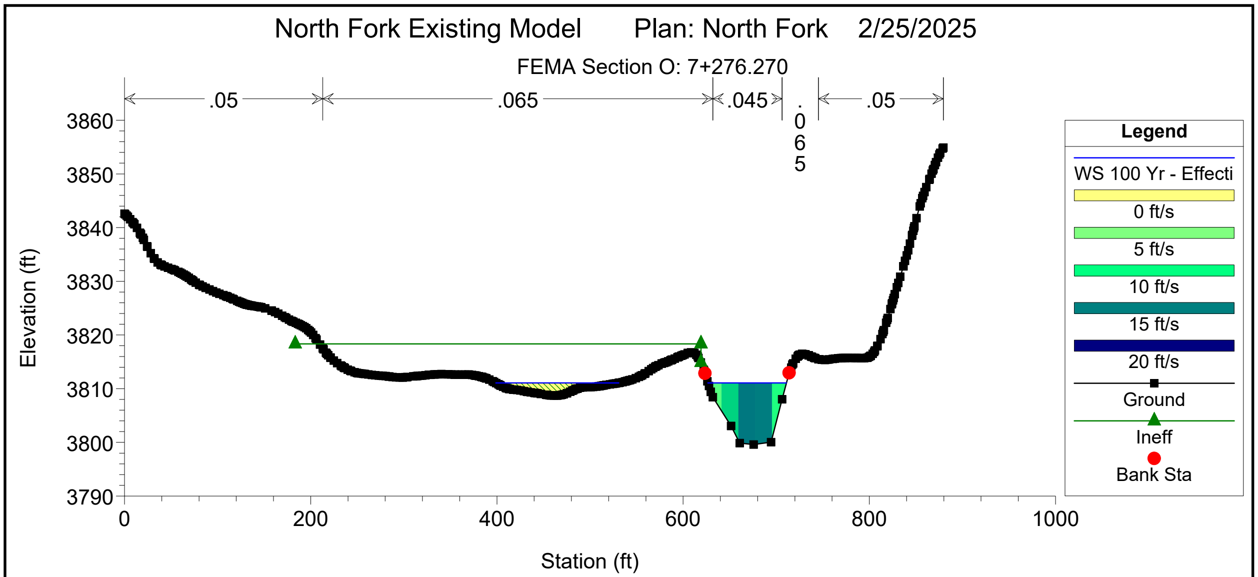
North Fork Existing Model Plan: North Fork 2/25/2025
FEMA Section O: 7+276.270
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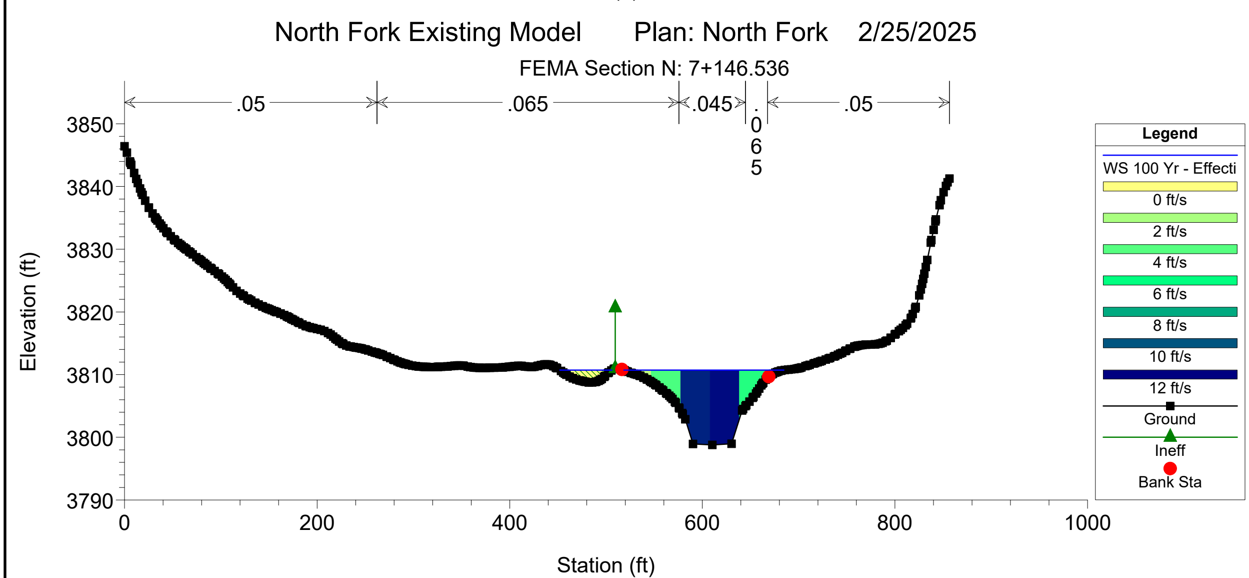
North Fork Existing Model Plan: North Fork 2/25/2025
FEMA Section N: 7+146.536
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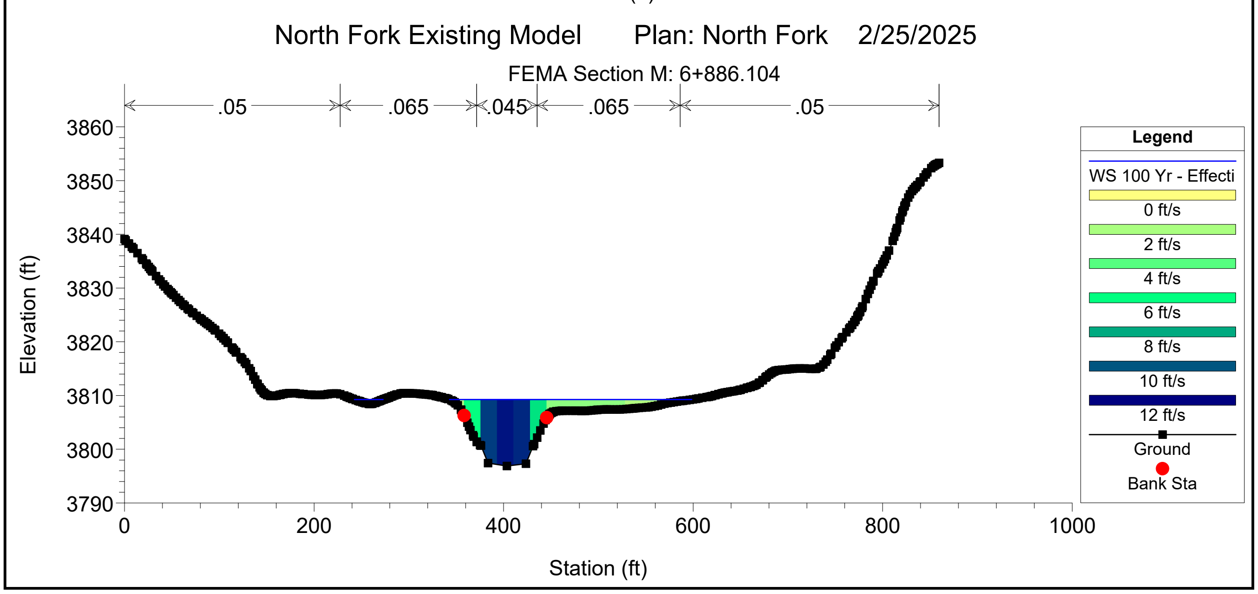
North Fork Existing Model Plan: North Fork 2/25/2025
FEMA Section M: 6+886.104
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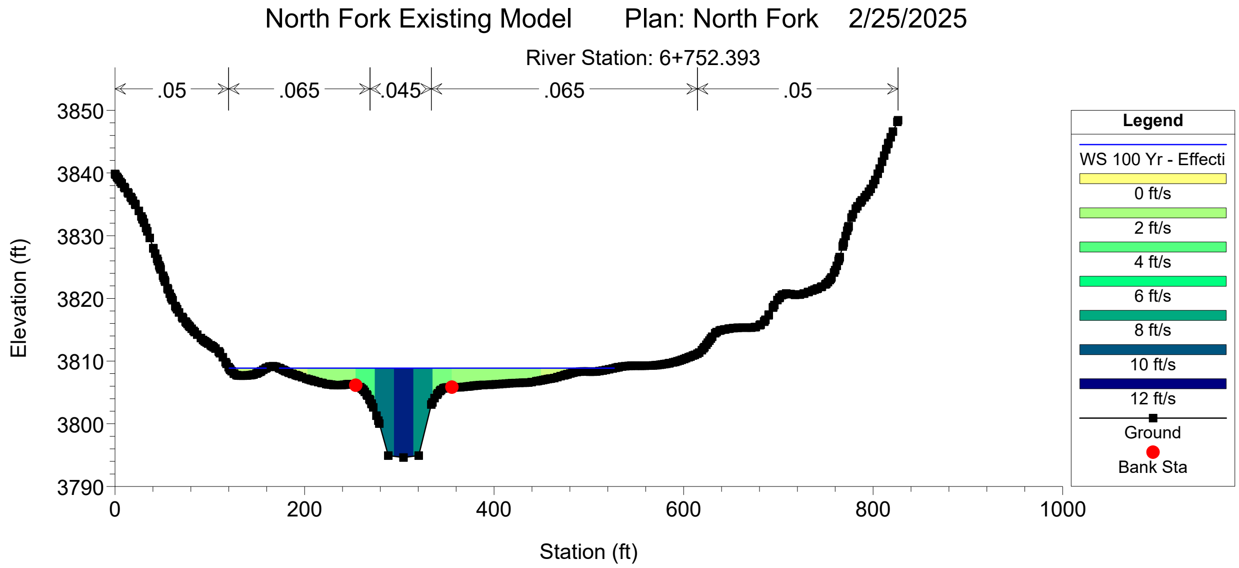
North Fork Existing Model Plan: North Fork 2/25/2025
River Station: 6+752.393
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Elevation (ft)
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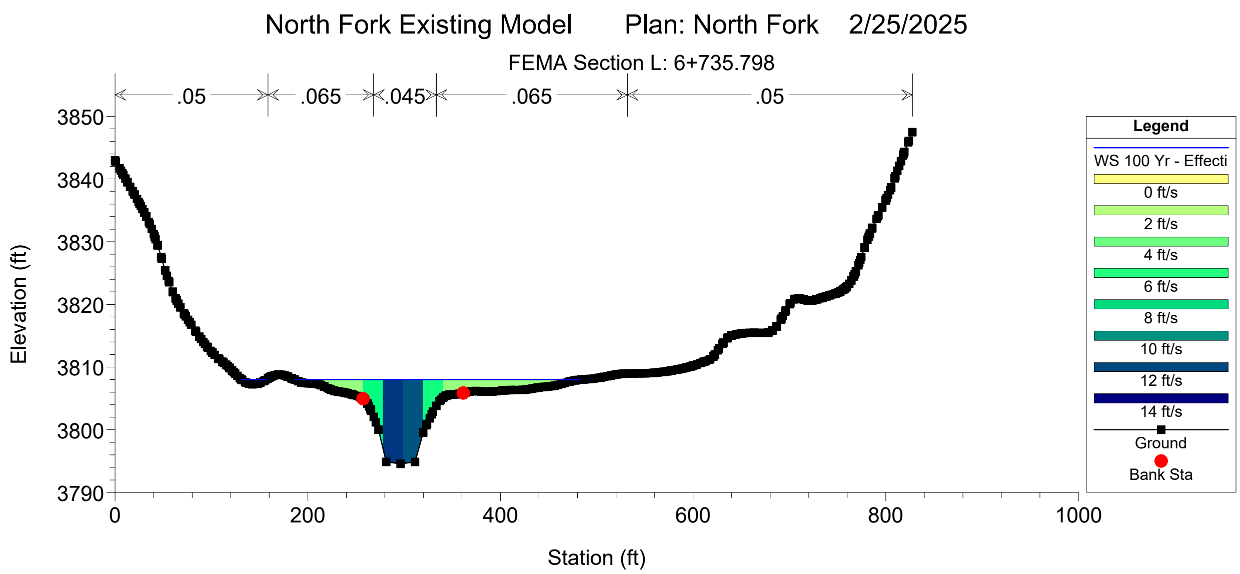
North Fork Existing Model Plan: North Fork 2/25/2025
FEMA Section L: 6+735.798
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Elevation (ft)
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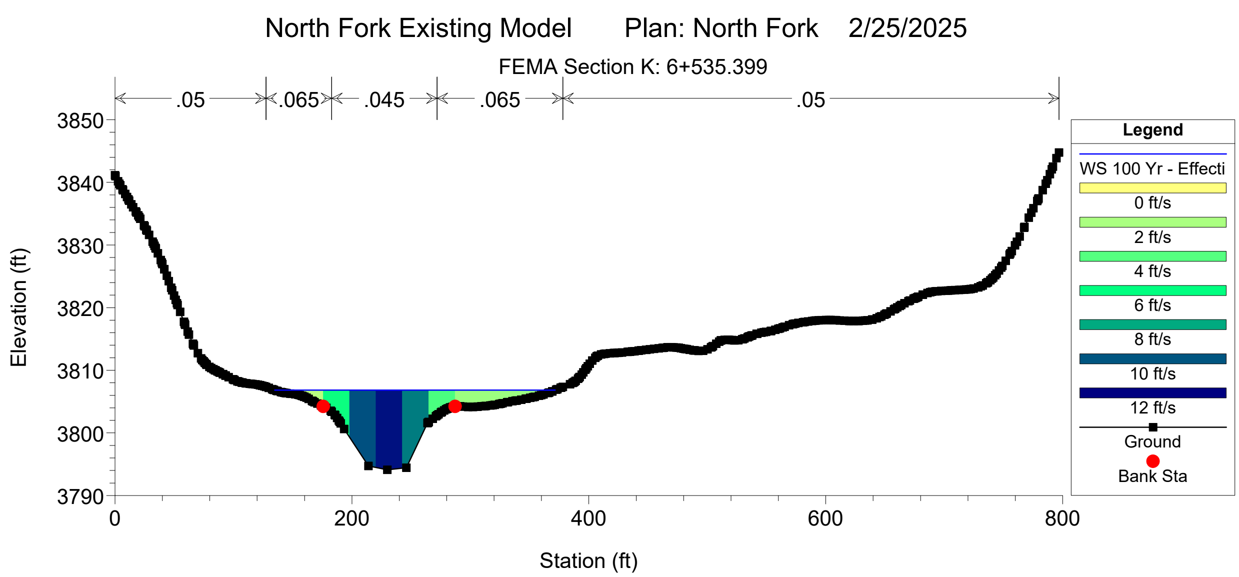
North Fork Existing Model Plan: North Fork 2/25/2025
FEMA Section K: 6+535.399
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Elevation (ft)
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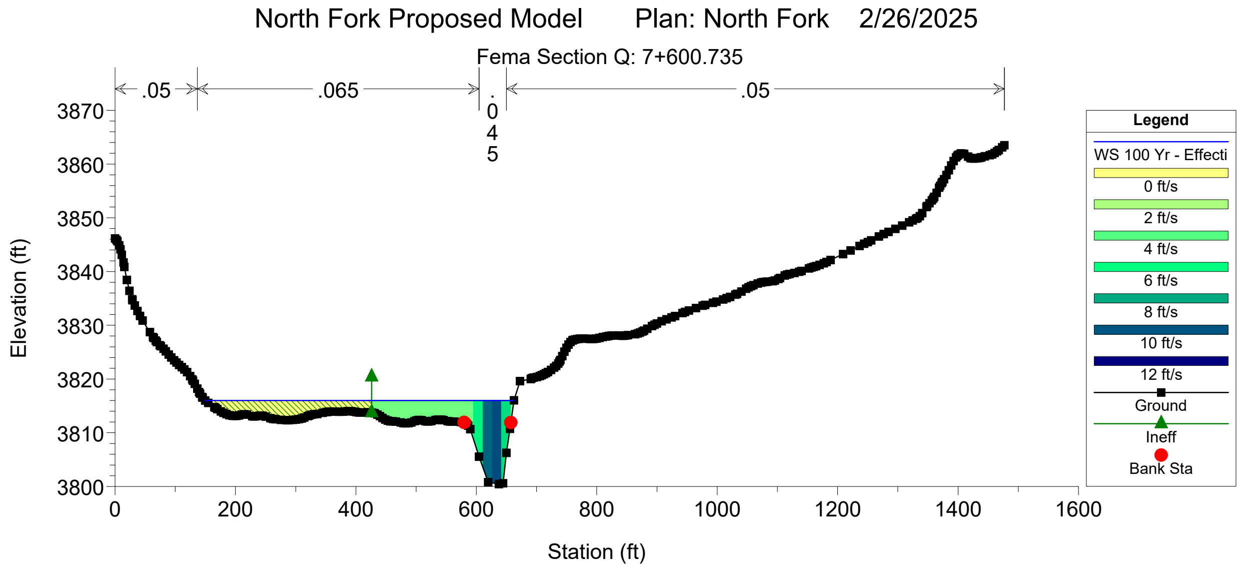
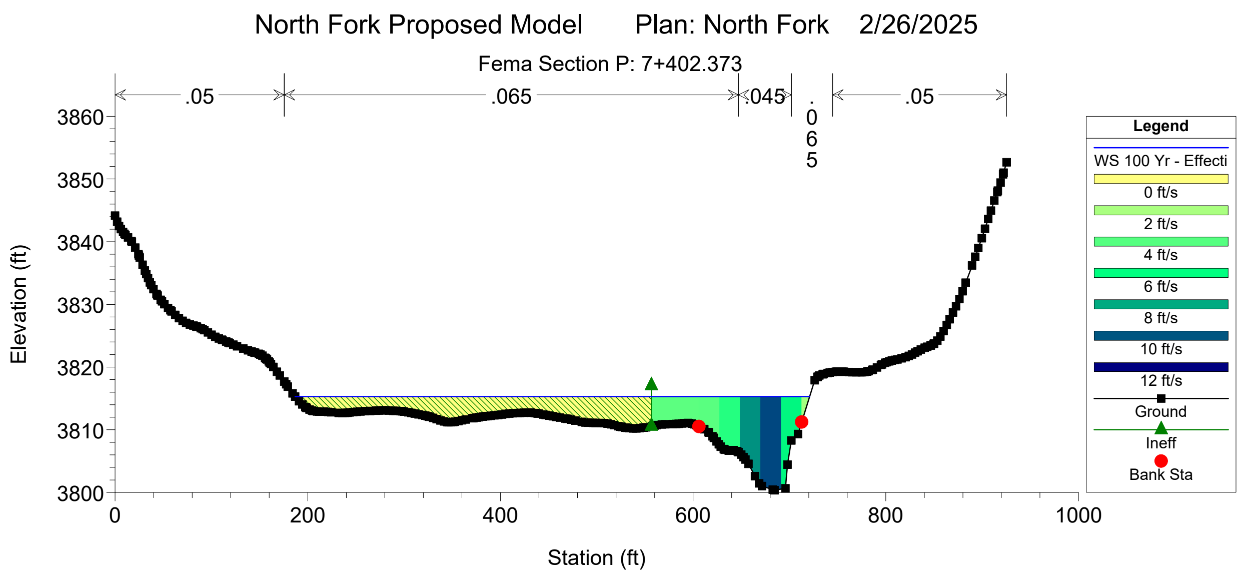
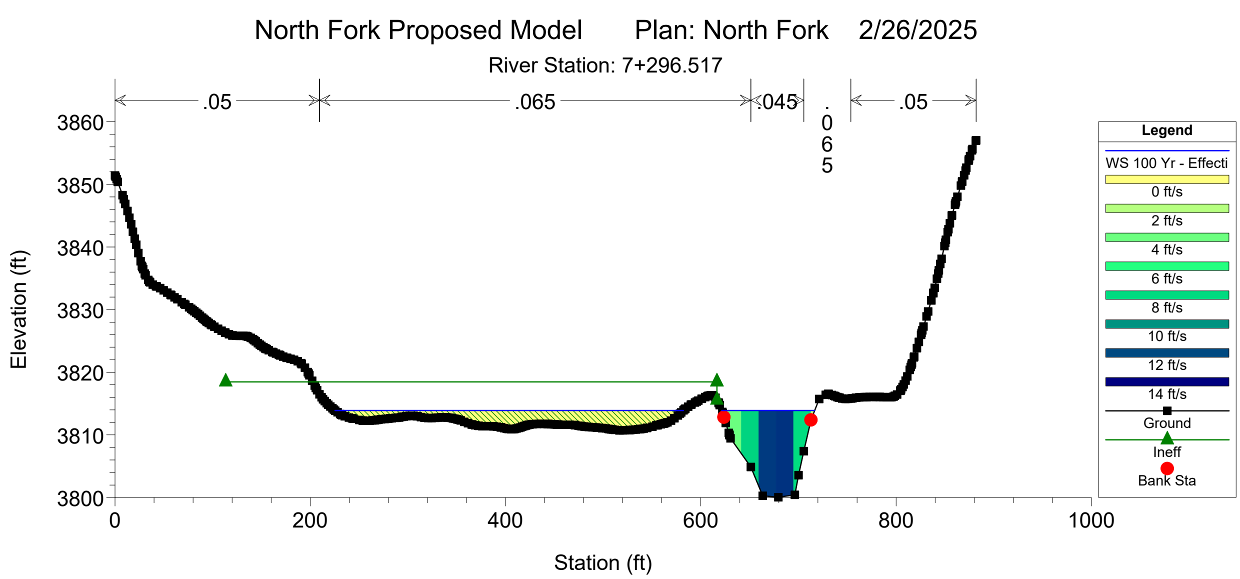
12 ft/s
Ground
Bank Sta

HEC-RAS Model Results - Proposed Conditions - North Fork Virgin River													
FEMA Sta	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	Hydr Dpth
			(cfs)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)
Q	7+600.735	100 Yr	8830	3800.44	3816.1	3816.9	0.003462	7.97	1460.64	513.81	0.42	15.66	6.17
P	7+402.373	100 Yr	8830	3800.37	3815.43	3816.22	0.003685	7.41	1313.74	535	0.41	15.06	7.98
	7+296.517	100 Yr	8830	3800.05	3814.09	3815.64	0.006588	9.98	888.84	455.62	0.56	14.04	9.25
	7+286.394		Bridge										
O	7+276.270	100 Yr	8830	3799.61	3811.06	3813.75	0.012183	13.16	671.22	215.39	0.82	11.45	7.96
N	7+146.536		8830	3798.79	3810.67	3812.09	0.005504	9.56	928.97	217.32	0.68	11.88	5.66
M	6+886.104	100 Yr	8830	3796.9	3809.14	3810.58	0.006091	9.96	1075.31	259.7	0.57	12.24	4.14
	6+752.393	100 Yr	8830	3794.61	3808.69	3809.86	0.003907	9.09	1314.05	385.26	0.55	14.08	3.41
	6+742.344		Bridge										
L	6+735.798	100 Yr	8830	3794.58	3807.98	3809.39	0.00816	9.88	1099.82	331.79	0.62	13.41	3.31
K	6+535.399	100 Yr	8830	3794.12	3806.83	3808.12	0.004673	9.32	1098.31	236.75	0.58	12.71	4.64


North Fork Proposed Model Plan: North Fork 2/26/2025
Fema Section Q: 7+600.735
.05
.065
.045
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta


North Fork Proposed Model Plan: North Fork 2/26/2025
Fema Section P: 7+402.373
.05
.065
.045
.065
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta


North Fork Proposed Model Plan: North Fork 2/26/2025
River Station: 7+296.517
.05
.065
.045
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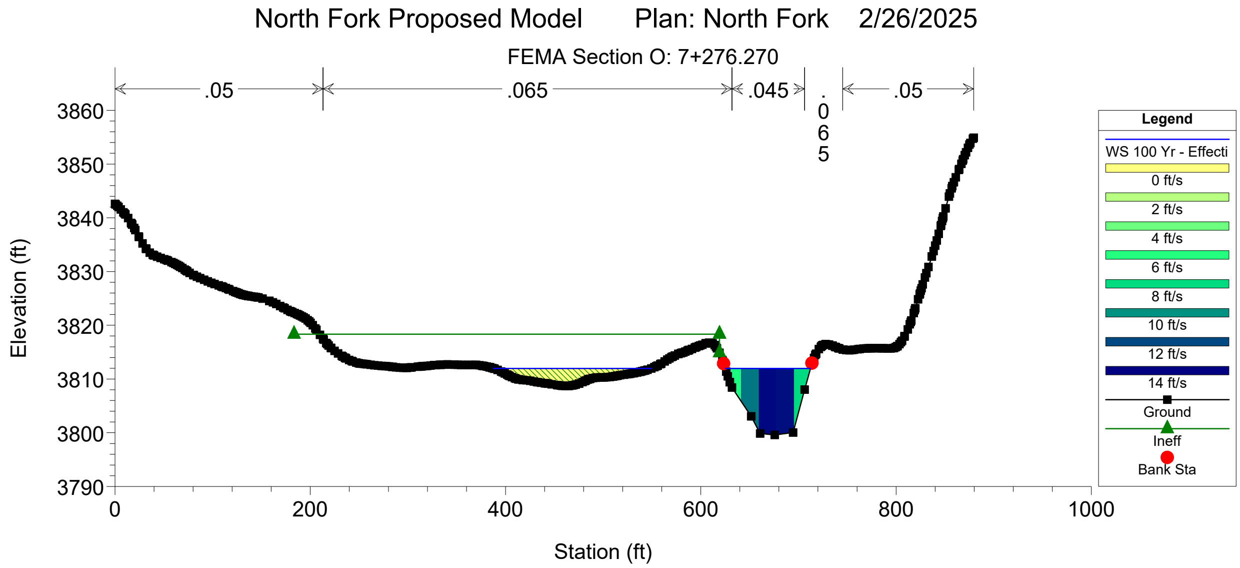
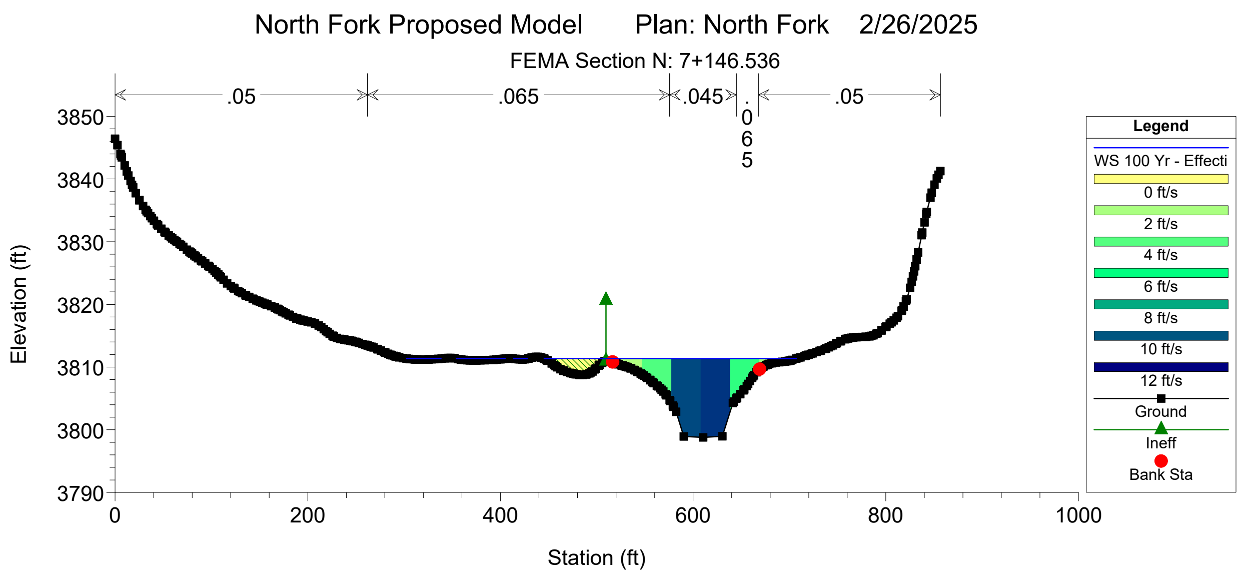
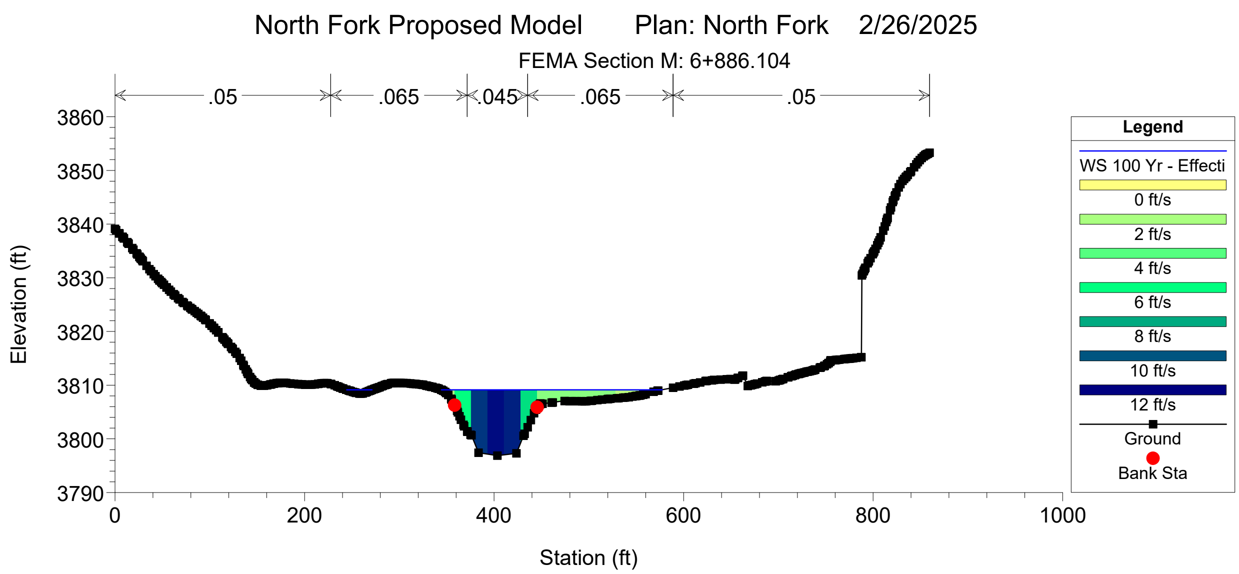
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta



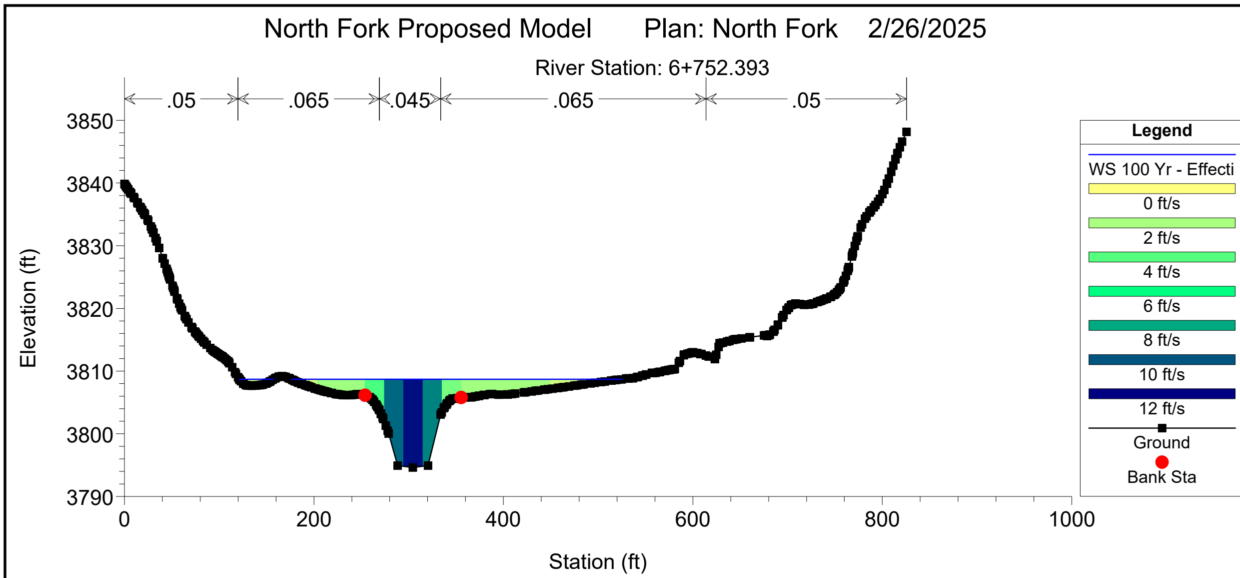
North Fork Proposed Model
Plan: North Fork
2/26/2025
FEMA Section O: 7+276.270
.05
.065
.045
.065
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Ineff
Bank Sta



North Fork Proposed Model
Plan: North Fork
2/26/2025
FEMA Section N: 7+146.536
.05
.065
.045
.065
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Ineff
Bank Sta



North Fork Proposed Model
Plan: North Fork
2/26/2025
FEMA Section M: 6+886.104
.05
.065
.045
.065
.05
Elevation (ft)
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


North Fork Proposed Model Plan: North Fork 2/26/2025
River Station: 6+752.393
.05
.065
.045
.065
.05
Elevation (ft)
3850
3840
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3810
3800
3790
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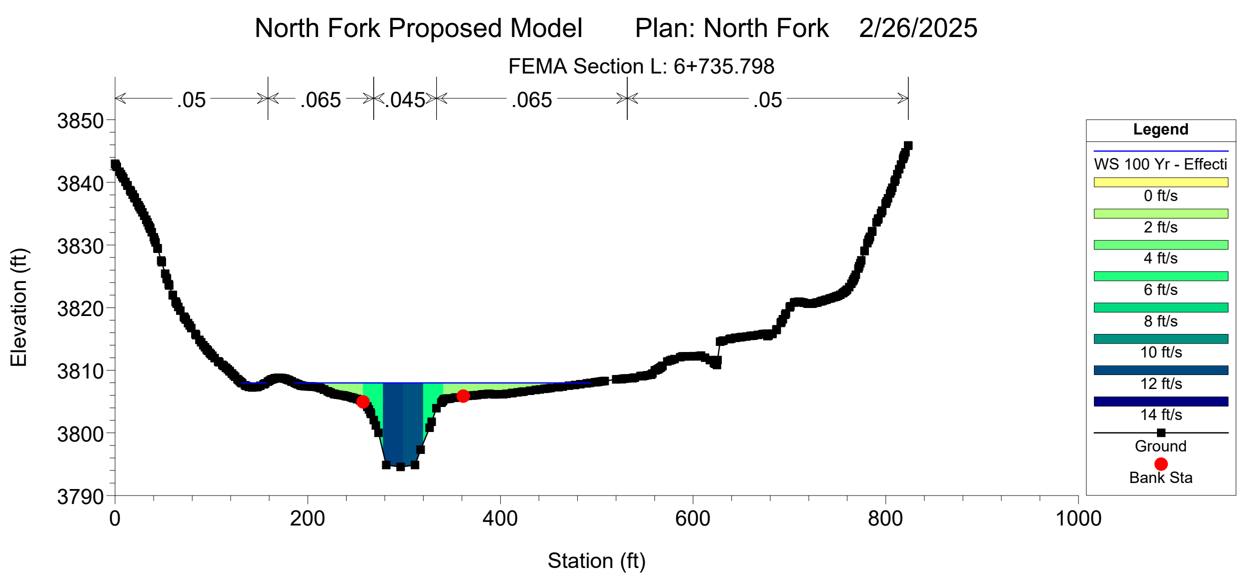
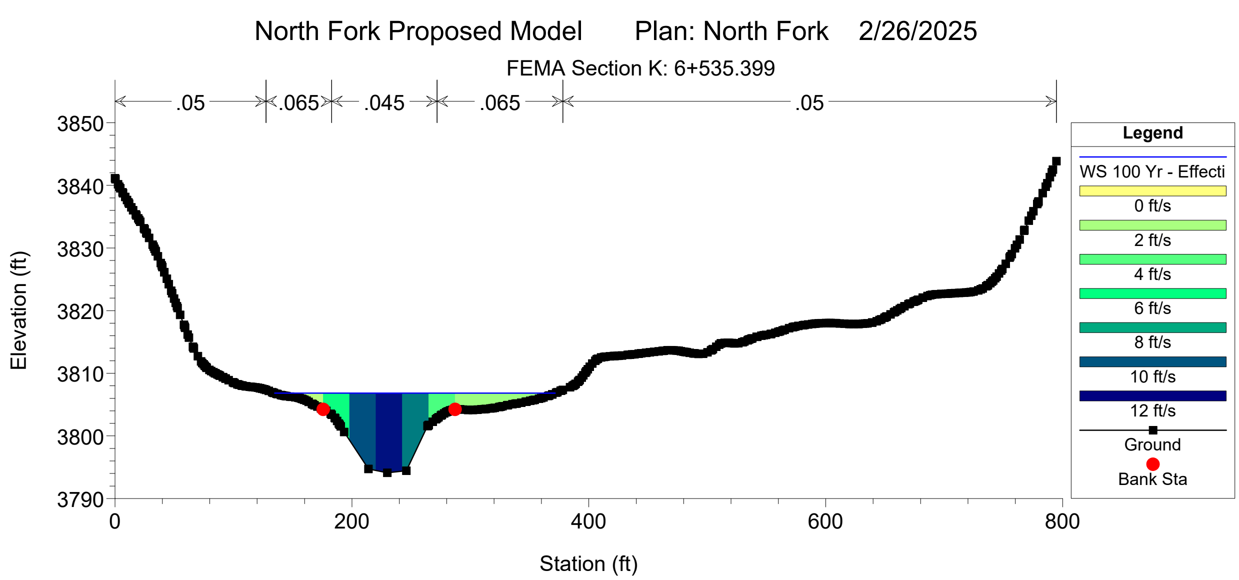
200
400
600
800
1000
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta


North Fork Proposed Model Plan: North Fork 2/26/2025
FEMA Section L: 6+735.798
.05
.065
.045
.065
.05
Elevation (ft)
3850
3840
3830
3820
3810
3800
3790
0
200
400
600
800
1000
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
14 ft/s
Ground
Bank Sta


North Fork Proposed Model Plan: North Fork 2/26/2025
FEMA Section K: 6+535.399
.05
.065
.045
.065
.05
Elevation (ft)
3850
3840
3830
3820
3810
3800
3790
0
200
400
600
800
Station (ft)
Legend
WS 100 Yr - Effecti
0 ft/s
2 ft/s
4 ft/s
6 ft/s
8 ft/s
10 ft/s
12 ft/s
Ground
Bank Sta

Project: Springdale River Park Expansion BY: WJP DATE: 2/25/2025

Subject: Long Term Degradation CHKD. BY: JWB DATE: 2/25/2025

Assumptions:

Long Term Degradation for this site was determined by estimating the elevation difference in the North Fork Virgin River flowline between 2009 (2009 Washington County Flood Insurance Study) and 2017 (2017 Washington County Lidar Topography). This method was chosen as accurate river topography was available and two 50 yr+/- storm events occurred during this time period. Table 3 shows the difference in flowline elevations at several locations within the study reach. As the 2009 elevation data is based on ground survey points and the 2017 LiDAR topography provides the water surface elevations along the river, the LiDAR elevations were reduced by 2'. The value of 2' was used based on recent ground surveys in similar areas close to the study reach and site visits. Based on these elevations, the North Fork Virgin River flowline experienced an elevation increase of 1.8' at Sta. 7+402.3 and an elevation increase of 3.7' at Sta. 6+535.3. Review of historical images (1960-present) indicate that the location of the central channel has remained stable throughout the course of the study period. No evidence of head cutting or significant bed degradation is present within the reach. Due to the net aggradation within the channel over an 8 year period in which significant storm events have occurred, the stability of the central channel within the study reach, and the Engineer's experience working within the reach, it can be assumed that long term degradation is unlikely to contribute significantly to channel scour. A long term degradation value of 1' was used as a conservative estimate.

Table 3 - North Fork Virgin River Flowline Elevations

River Station	2009 Flowline Elevation (ft)	2017 Flowline Elevation (ft)	8 Year Change (ft)
7+402.3	3799.5	3801.3	1.8
6+535.3	3790.4	3794.1	3.7

ROSENBERG ASSOCIATES
CIVIL ENGINEERS • LAND SURVEYORS

PROJECT NO. 2824-24-002

Project:	Springdale River Park Expansion	BY:	WJP	DATE:	2/25/2025
Subject:	Bend Scour	CHKD. BY:	JWB	DATE:	2/25/2025

Bend Scour: (Section 704.2.1.4 - Bend Scour
Clark County Hydraulic Criteria and Drainage Design Manual, 8/12/99)

Location:
North Fork Virgin River Sta. 7+402.373

Given:

Average velocity upstream from bend, V =	7.52	ft/s
Maximum depth upstream of bend, Y_{max} =	14.95	ft
Hydraulic depth in channel upstream of bend, Y_h =	7.88	ft
Energy slope upstream of bend, S_e =	0.003852	ft/ft
Angle of bend, α =	18	deg

*Determined by acute angle formed by intersection between projection of flowline and line tangent to outer bank of bend

Equation:

$$Z_{bs} = \left(\frac{0.0685 * Y_{max} * V^{0.8}}{Y_h^{0.4} * S_e^{0.5}} \right) \left(2.1 \left(\frac{\sin^2 \left(\frac{\alpha}{2} \right)}{\cos \alpha} \right)^{0.2} - 1 \right)$$

Bend Scour, Z_{bs} = **0.36 ft** ←

Project: Springdale River Park Expansion BY: WJP DATE: 2/25/2025

Subject: 100 YR Anti Dune Trough Scour CHKD. BY: JWB DATE 2/25/2025

Anti Dune Trough: (Section 704.2.1.3 - Anti Dune Trough Depth
Clark County Hydraulic Criteria and Drainiage Design Manual, 8/12/99)

Location:
North Fork Virgin River Sta. 6+886.104

Given:

100 YR	Average channel velocity, V =	9.96	ft/s
	Hydraulic depth, Y =	4.14	ft

Anti Dune Depth based on Velocity:

Equation:

$$Z_a = 0.0137 * V^2$$

Anti Dune Trough Depth, Z_a = **1.36 ft** ←

Anti Dune Trough Depth (max), Z_a = **2.07**

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CIVIL ENGINEERS • LAND SURVEYORS

PROJECT NO. 2824-24-002

Project:	Springdale River Park Expansion	BY:	WJP	DATE:	2/25/2025
Subject:	Rip-Rap Size	CHKD. BY:	JWB	DATE:	2/25/2025

Riprap Design for Channel Lining Based on Channel Velocity

Rip-Rap: (Section 704.2.1.3 - Clark County Hydraulic Criteria and Drainiage Design Manual, 8/12/99)

Location:
North Fork Virgin River Sta. 6+752.393

Given:

Mean Channel Velocity, V =	9.09	fps	
Longitudinal Channel Slope, S =	0.0023	ft/ft	
Specific Gravity of Riprap Lining, S_S =	2.50	minimum S_s = 2.50	

Smith and Murray Model Equation:

Equation:

$$V = 3(d_{50})^{0.5}(S_s-1)/S^{0.17}$$

Median Rock Size	d_{50} =	**0.52**	ft	*Equation 734*
		6	in	

Riprap Design for Channel Lining Based on Tractive Stress*

Maximum Channel Depth, Y_{max} =	14.08	ft	
Average Energy Slope, S_e =	0.003907	ft/ft	
Channel Stability Factor, F_s =	1.1	1.0 - 1.2	Straight or mildly curving reach
		1.2 - 1.4	Moderate bend curvature with minor impact from floating debris
		1.4 -1.6	Sharp bend with significant impact from floating debris and wave
		1.6 - 2.0	Rapidly varying flow with significant uncertainty in design
Channel Side Slopes =	1.50	H : 1V	2H : 1V max
Trial Average Rock Size, d_{50} =	18.00	in	insert a first trial, then adjust

Tractive Stress Equation $d_{50} = 14.2F_sY_{max}(S_e/K_1)$ *Equation 736*

Solving

Slope Angle with Horizontal, a =	0.5880	rad	
Angle of Repose, h =	0.7313	rad	
Bank Angle Modification Factor, K_1 =	0.55687		$= (1-(\sin^2 a/\sin^2 h))^{0.5}$ *Lane Equation*
Median Rock Size, d_{50} =	**1.54**	ft	
	<u>19</u>	in	←

The hydrodynamic force of water flowing in a channel is known as the tractive force. Flow-induced tractive force should not exceed the permissible or critical shearstress of the riprap. Theabove equation is a relationship to estimate d50 assuming a specific gravity of 2.50