

Montoyas Arroyo Reach Stabilization Plan, Broadmoor Blvd to NM Hwy 528

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**MONTOKAS ARROYO REACH STABILIZATION PLAN,
BROADMOOR BOULEVARD TO NEW MEXICO HIGHWAY 528**

SEPTEMBER 12, 2024

Prepared for:

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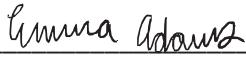
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EXECUTIVE SUMMARY

This document provides a reach stabilization plan (RSP) for the Arroyo de los Montoyas (Montoyas Arroyo) between Broadmoor Blvd and NM Hwy 528 (i.e., project reach). Although the Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) intends to use this document to evaluate existing and proposed drainage infrastructure improvements to address the goals and recommendations of this plan, SSCAFCA is not obligated to design or construct the recommended drainage improvements. Project reach alignments, corridors, drainage feature locations, treatments, and cost estimates are recommended only at a conceptual level and should be reviewed and revised based upon future project analysis, changed circumstances, or otherwise.

To develop this plan, Bohannon Huston, Inc. (BHI) and SSCAFCA conducted a field reconnaissance to evaluate the existing morphologic and geologic setting of the arroyo, note areas of recent erosion, characterize the channel bank materials, collect sediment samples, identify the location and condition of infrastructure, and collect representative field photographs to document the field observations. Using SSCAFCA's existing conditions (ExC), existing facilities hydrology, BHI established elemental runoff to the Montoyas Arroyo during the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events. All these events except the 500-year event were simulated in two-dimensional (2D) hydraulic modeling that was developed for this plan. The hydraulic model was prepared using HEC-RAS and incorporates all inflow tributary elements from HEC-HMS that were assigned as inflow boundary conditions in HEC-RAS. The project reach was broken up into nine (9) hydraulically similar subreaches, and the model results were used to prepare representative, cross-sectionally averaged subreach hydraulic parameters. The resulting hydraulic parameters and gradation information from the field sediment sampling were used as input to sediment transport analyses that informed calculation of equilibrium slopes and a lateral erosion envelope. Those analyses were used to evaluate the need for and locate proposed locations of grade control structures (GCSs) and bank protection (BP). Most proposed structures were located within existing SSCAFCA-owned rights-of-way (ROWs), but in some cases acquiring additional ROW would be required because the existing bank is already outside of SSCAFCA ROW. Conceptual-level cost estimates were developed for all proposed GCSs, BP, and channel grading. For all recommendations presented herein, value engineering and design refinement should be performed as part of the detailed design.

The estimated total cost of all proposed improvements is \$27,050,000. Four (4) GCSs are proposed. All GCSs, except for GCS 2, were limited to a 5-foot drop height. GCS 2 is located at the end of the Sportsplex dam culvert outlet apron. GCS 2 is proposed to have a 12 ft drop because the

existing erosion at the end of this structure as it exists now is already approximately 11.5 ft. The estimated cost to design and construct all proposed GCSs is \$3,250,000 (\$3,550,000 if the drop height is limited to 5 ft). This cost does not include the cost of channel grading between structures, construction of access roads, or seeding. Fourteen BP structures are recommended. Of these 14 structures, four (4) of them are outside SCAFCA ROW and thus require land acquisition. The estimated cost to design and construct all BP is \$22,200,000. This cost estimate does not include channel grading between structures, acquisition of ROW, access roads, or seeding. The estimated cost of repair/reconstruction of the failed spillway on Subreach 2 is absorbed by the GCS cost at that location, and the cost of the failed spillway on Subreach 8 is estimated to be \$745,000. This cost estimate does not include access roads.

This RSP is based on ExC hydrology because local municipality regulations require all new developments to restrict associated discharges to pre-development levels. Because the ExC hydrology does not consider future development and the associated shift to the hydrologic regime in areas not covered by these regulations, it is recommended that this RSP be updated to factor in developed conditions, existing facilities (DevEx) hydrology. BHI also recommends that this RSP be periodically updated to evaluate how future development and arroyo evolution impacts equilibrium slopes and lateral erosion potential in the project reach. Several actions may prompt an update. Some examples include (1) significant and observable changes to the channel bed, exposing local scour protection along the reach, (2) an update to SCAFCA's *Montoyas Watershed Management Plan* that results in substantial differences to flood flows, or (3) every 10 years.

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ACRONYMS/ABBREVIATIONS

Acronym/Abbreviation	Definition
2D	two-dimensional
BHI	Bohannon Huston, Inc.
Blvd	Boulevard
BP	bank protection
CAWB	Calabacillas Arroyo West Branch
cfs	cubic feet per second
cu ft	cubic feet
DEM	Digital Elevation Model
DevEx	developed conditions, existing facilities
ExC	existing conditions
fps	feet per second
ft	foot or feet
ft/ft	feet per foot
GCS	grade control structure
HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
Hwy	Highway
LC	Loma Colorado
LEE	Lateral Erosion Envelope
LiDAR	light detection and ranging
MEI	Mussetter Engineering, Inc.
MPM	Meyer-Peter Muller
MRCOG	Mid-Region Council of Governments
NMGRT	New Mexico Gross Receipts Tax
psf	pounds per square foot
RAS	River Analysis System
ROW	right-of-way
RSP	Reach Stabilization Plan
sq ft	square feet
SSCAFCA	Southern Sandoval County Arroyo Flood Control Authority
USACE	United States Army Corps of Engineers
WMP	Watershed Management Plan

I. INTRODUCTION

The Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) retained Bohannon Huston, Inc. (BHI) to prepare a Reach Stabilization Plan (RSP) of the Montoyas Arroyo between Broadmoor Blvd and NM Hwy 528 (project reach). This project reach extends approximately 2 miles. SSCAFCA's goal is to identify potential projects to address existing erosion issues throughout the reach, provide vertical stabilization, contain lateral erosion within their right-of-way (ROW) prior to further watershed development, and protect existing public infrastructure and private development.

To develop an RSP for this project area, BHI conducted a field reconnaissance (Section II), expanded SSCAFCA's existing hydrologic analysis model (Section III.A), developed hydraulic modeling (Section III.B), and performed sediment-transport analyses (Section III.C) that included equilibrium slope (Section III.C.4) and lateral erosion envelope (LEE) line calculations (Section III.C.5). These analyses informed recommendations of grade control structures (GCS) and bank protection (BP) along with estimated associated costs of these potential solutions (Section IV).

Although it is the intent of SSCAFCA to evaluate drainage infrastructure improvements to address the goals and recommendations of this plan, this plan does not obligate SSCAFCA in any way to design or construct the recommended drainage improvements. Drainage facility alignments, corridors, locations, treatments, and cost estimates are recommended herein at a conceptual level only and may be altered or revised based upon future project analysis, changed circumstances, or otherwise.

II. FIELD RECONNAISSANCE

A site visit was completed on February 6, 2024, by Stuart Trabant and Madeline Olivas (BHI) along with Andres Sanchez, Junko Nishida, and Jamie Vigil (SSCAFCA). The project team walked the project reach from approximately 700 ft upstream of the Broadmoor Blvd NE culverts to the outlet of the NM Hwy 528 culverts. The purpose of the site visit was to:

- Evaluate the morphologic and geologic setting of the arroyo, including location of geologic, geomorphic, and hydraulic controls.
- Note areas of local recent erosion and general areas of aggradation and degradation.
- Characterize the channel bank materials, noting locations with erosion-resistant features, such as Santa Fe (SF) formation or calcite-cemented sediments.
- Perform sediment sampling of the channel boundary materials for laboratory gradation analysis to determine the caliber of the existing bed and bank material.
- Assess upstream and tributary sediment supply to the reach, including sediment delivered by naturalistic stormwater drainage features.
- Identify the location and extent of existing erosion protection infrastructure including GCS and BP.
- Identify locations of utility features such as storm drain outfalls, sanitary sewer manholes, and stormwater collection/retention features within the arroyo corridor.
- Collect representative field photographs to document field observations.

Figure 1 shows the location of key observations collected during the site visit. Photos of key observations are listed in Section II.F. Photos are presented in order from upstream to downstream. Because Sections II.A through II.D are organized topically, photos are sometimes referenced out of order.

A. EXISTING GRADE CONTROL, BANK PROTECTION

Baselevel control (i.e., a fixed point in the arroyo bed profile that cannot erode vertically) in the reach above Sportsplex Dam is provided by the dam pool inlet structure, and the slope of this reach is relatively mild (1.05%). The reach has largely been kept natural, while the reach below Sportsplex Dam is narrower due to a steeper channel gradient and encroaching development. Therefore, this reach needs more grade control and BP. Lateral and vertical control is provided by the Broadmoor Blvd and NM Hwy 528 culverts at the up- and downstream ends of the project area, respectively. Within the project area, the inlet and outlet of Sportsplex Dam and the GCS at the



Loma Colorado outfall (LC GCS in **Figure 1**) provide additional vertical control. In addition to these lateral and vertical controls, there are some locations of BP throughout the study area that limit lateral migration locally:

- Upstream of the Sportsplex Dam, approximately 700 ft of the left (north) bank and 150 ft of the right (south) bank is protected with concrete. The main channel follows the left (north) bank, and a floodplain has developed on the right (south) bank side (**Figure 15**).
- Downstream of the Sportsplex Dam, adjacent to the Rio Rancho Sports Complex baseball fields, there is approximately 1,500 ft of shotcrete BP on the right (south) bank (**Figure 18**).
- Poured or dumped concrete along left (north) bank at ASK Academy has been undermined but functions as BP (**Figure 31**).
- BP along the right (south) bank upstream from the NM Hwy 528 culvert is varied, with cabled steel posts, basalt riprap, and riprap (**Figure 35** and **Figure 36**).
- Localized BP at the majority of the storm sewer outfalls and detention pond outlets (discussed below).

B. EXISTING INLET AND OUTFALL STRUCTURES

There are various outfalls that contribute flow to the Montoyas Arroyo discharging from ponds and surrounding developed area. Additional tributary flow locations are further discussed in Section III.B.1.c. Notable observations about inlet and outflow structures from the field reconnaissance include:

- Approximately 520 ft downstream of the Broadmoor Blvd culverts, the spillway for a detention pond outlet has been undermined on the right bank (**Figure 5**).
- The Sportsplex Dam inlet has experienced local scour that has undermined the left (north) side of this transverse structure (**Figure 10**).
- There are numerous failed and abandoned sewer lines and appurtenances along the right (south) bank downstream of the LC GCS that demonstrate channel widening and downcutting along this portion of the project reach (**Figure 21**, **Figure 22**, **Figure 23**, and **Figure 24**).
- Approximately 2,000 ft downstream of the LC GCS, near the downstream end of the Rio Rancho Sports Complex property, there is a failed spillway for a detention pond

that now discharges mostly clearwater flows from the subdivision. Erosion associated with the failed spillway is threatening structures at pond inlets (**Figure 28, Figure 29, and Figure 30**).

C. CHANNEL MORPHOLOGY, BANK CHARACTERISTICS, AND SEDIMENT SUPPLY

1. EROSION AREAS

Local scour was observed in various locations in the study area. Below is a list of field observations concerning areas of erosion and other key observations:

- Approximately 675 ft downstream of the Broadmoor Blvd culverts, poorly cemented Santa Fe Formation in the right (south) bank terrace has not prevented bank erosion but has slowed erosion rates (**Figure 6**).
- Concrete rubble protection around a manhole acts as a spur along the right (south) side of the arroyo, approximately 700 ft downstream of Broadmoor Blvd culverts (**Figure 9**).
- Substantial erosion and undermining of the wire-tied riprap below the Sportsplex Dam outlet apron and Loma Vista Blvd NE (**Figure 11**) has put the apron at risk.
- The eroding banks below Sportsplex Dam are a source of gravel to this arroyo (**Figure 13**).
- The channel incision below Sportsplex Dam has resulted in a baselevel lowering for culvert outlets along the right bank adjacent to the Rio Rancho Sports Complex, leaving the outlets in a perched condition (**Figure 14, Figure 15, Figure 16, and Figure 17**).
- Exposed manholes downstream of the LC GCS indicate the arroyo has widened significantly since construction of the storm sewer line (**Figure 24**).
- Concrete rubble riprap on the left (north) bank, approximately 1,600 ft downstream of the LC GCS, has slowed the rate of erosion but has not been an effective stabilization treatment, likely because the rubble was not toed down to a depth sufficient to protect against scour and long-term degradation (**Figure 25**). The presence of the concrete rubble has shifted the erosion to the right (south) bank, putting the detention pond adjacent to the right (south) bank at risk (**Figure 26**).
- Poured or dumped concrete along the left bank at ASK Academy has been undermined but continues to provide some degree of BP. The concrete-hardened left

(north) bank results in erosion of the right (south) bank due to the ongoing channel widening process (**Figure 31**, **Figure 33**, and **Figure 34**).

- The fan at the outlet of the left (north) bank detention pond outlet upstream from NM Hwy 528 deflects flow into the right (south) bank, resulting in erosion of unprotected areas (**Figure 37**).
- NM Hwy 528 reinforced concrete box culverts provide baselevel control for the upstream reach.

2. VERTICAL AND LATERAL HARD POINTS

Observed hard points are identified in **Figure 1**. In addition to the LC GCS, the box culverts at NM Hwy 528 and Broadmoor Blvd, as well as the inlet and outlet of Sportsplex Dam, provide baselevel control, fixing the vertical and horizontal location of the channel. Varied BP can be found throughout the arroyo fixing the horizontal location of the channel. These hard points are discussed in more detail above in Section II.A.

3. SEDIMENT SUPPLY

The upstream sediment supply is delivered from the upper reaches of the arroyo through the Broadmoor Blvd culverts. No incision was observed over the approximately 200 ft downstream from the culverts, suggesting the upstream-most portion of the project reach is currently in balance with the sediment supply (**Figure 4**). However, if stabilization measures are constructed in the reach upstream from Broadmoor Blvd and substantially reduce the sediment supply, some degradation in this area would be expected. Sediment delivered by the storm drains, detention ponds, and tributaries (discussed below) is primarily wash load and does not have a significant impact on bed material continuity.

D. TRIBUTARY ARROYOS

In 2021, a Watershed Park Management Plan (WMP) was produced and published by SSCAFCA. As part of this WMP, an HEC-HMS model was created (SSCAFCA, 2021). There are 17 distinct inflows modeled in the SSCAFCA HEC-HMS model (WMP HEC-HMS model) and the BHI Hydrologic Engineering Center River Analysis Software (HEC-RAS) model discussed in Section III.A and III.B, respectively. These contributing inflows range in nature from arroyos to surface flow from developed areas and pond outflows. The inflows and their reference photos (where available), from upstream to downstream, are listed below (**Table 1**).

Table 1. Tributary Flows

Tributary Name	Figure Reference	Description
C_008_Pond	Figure 5	Pond Overflow
Q_101_R2	Figure 7	Pipe Outflow
C_007_Pond	Figure 8	Pond Overflow
C_006_Pond	Not pictured	Pond Overflow
A_108	Not pictured	Neighborhood Drainage
Q_102_J	Not pictured	Culvert Outflow
C_017	Not pictured	Neighborhood Drainage
C_005	Not pictured	Neighborhood Drainage
C_004_R	Figure 14	Pipe Outflow
C_003_R	Figure 17	Pipe Outflow
C_018_R	Not pictured	Neighborhood Drainage
C_019_Pond	Figure 20	Pond Overflow
C_020	Figure 28	Neighborhood Drainage/Pipe Outflow
C_002_Pond	Figure 32	Pond Outflow/Overflow
A_109	Not pictured	Pipe Outflow
R_104_Pond	Figure 38	Pond Overflow
C_001_R	Not pictured	Hwy Drainage Channel

E. BED MATERIAL SEDIMENT SAMPLING

Four (4) bulk sediment samples were collected along the project reach to characterize the gradation of the bed material (**Figure 1; Figure 2**). Sample S1 (**Figure 3**) was collected from the channel bed in the expansion zone below the Broadmoor Blvd culverts and represents the bed material upstream from the Sportsplex Dam facility, with a median diameter (D50) of about 0.67 mm and includes about 26 percent gravel (based on the American Geophysical Union Sediment Classification System). Sample S2 (**Figure 12**) was collected downstream from the Sportsplex Dam outlet and is slightly coarser than Sample S1 (D50 = 0.73 mm; 28 percent gravel). Samples S3 and S4 (**Figure 16** and **Figure 27**, respectively), both of which are located below the Sportsplex Dam and are somewhat coarser than the upstream samples, have similar gradations with a D50 of about 0.9 mm and 40 percent gravel.

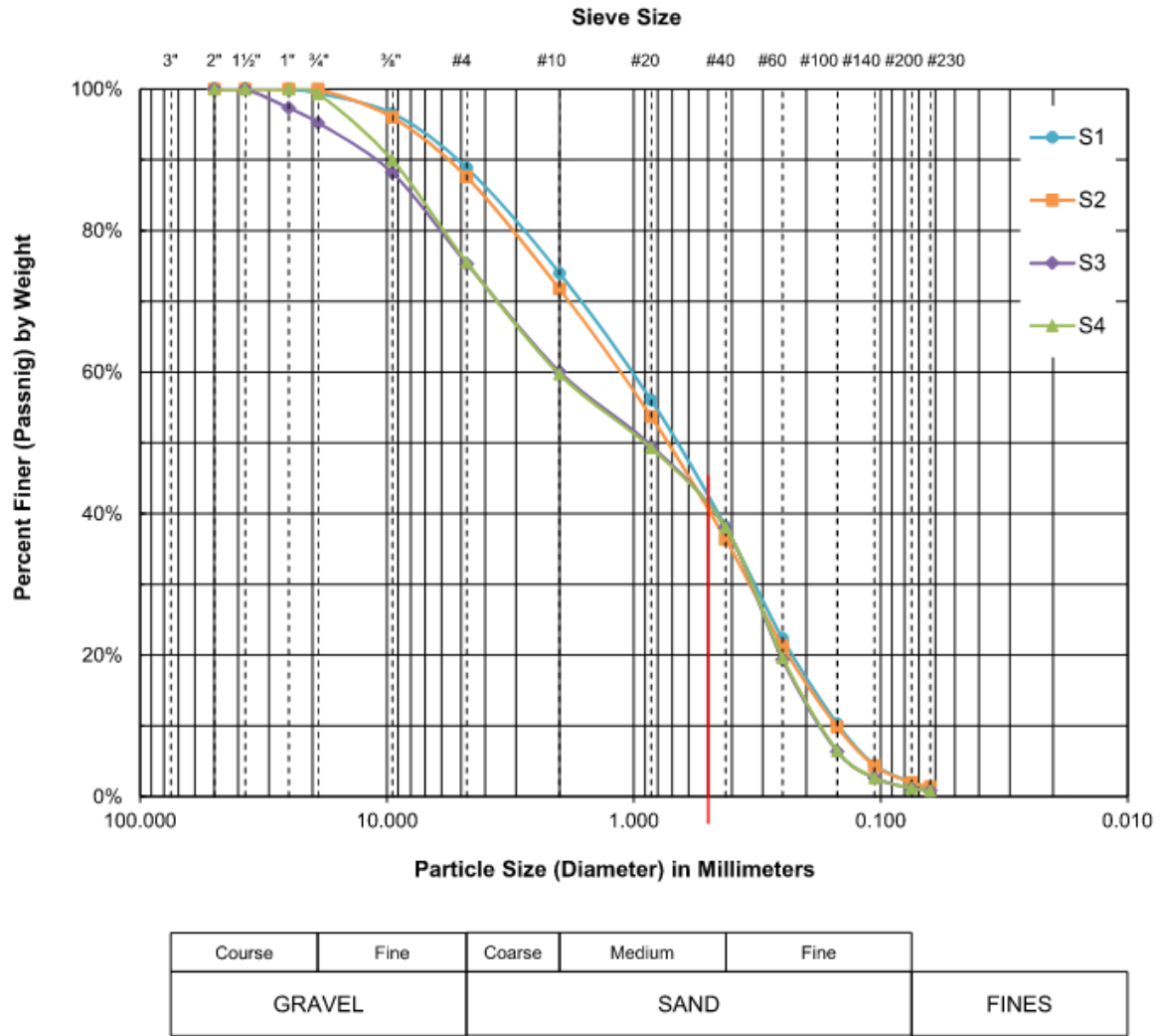


Figure 2. Gradation of Bed Material Samples

F. PHOTOS OF KEY FEATURES

The following photos (**Table 2**) represent key features that were identified during the Montoyas Arroyo site visit, their respective categories, locations, and descriptions. **Figure 1** shows the location of all key features discussed.

Table 2. Site Reconnaissance Key Features

Feature	Description	Photo(s)
Feature Category: Field Reconnaissance Name: Sediment sample 1 Location: 106°40'34.93" W 35°15'43.81" N	Sediment sample 1 collected on February 6th, 2024. This sediment sample was used in calculations for Subreaches 1, 2, 3, and 4. Subreach calculations are discussed further in Section III.C. Approximately 175 ft downstream of Broadmoor Blvd culverts.	 Figure 3. Collection Location of Sediment Sample 1
Feature Category: Erosion Areas Name: Right bank 200 ft downstream of Broadmoor Blvd culverts Location: 106°40'35.42" W 35°15'43.23" E	Deposition below Broadmoor Blvd This photo was taken approximately 200 ft downstream of the Broadmoor Blvd culverts.	 Figure 4. Deposition Along Right Bank Downstream of Broadmoor Blvd Culverts
Feature Category: Tributary; Inlet and Outfalls Name: C_008_Pond tributary and erosion Location: 106°40'33.17" W 35°15'40.07" E	Undermined rundown from the outfall of C_008 pond, approximately 520 ft downstream of Broadmoor Blvd culverts.	 Figure 5. Undermined Rundown From C_008_Pond

Feature Category: Erosion Areas Name: Poorly cemented Santa Fe Formation Location: 106°40'31.80" W 35°15'40.29" E	Eroding right bank terrace below Broadmoor Blvd, with poorly cemented Santa Fe formation that has not prevented erosion. Approximately 700 ft downstream of Broadmoor Blvd culverts.	 Figure 6. Eroding Right Bank With Poorly Cemented Santa Fe Formation
Feature Category: Tributary Name: Q_101_R2 tributary Location: 106°40'24.41" W 35°15'40.21" E	Q_101_R2 tributary channel lined with rock, protecting banks on outflow side of drainage RCP. On left bank approximately 1,050 ft downstream of Broadmoor Blvd culverts.	 Figure 7. Q_101_R2 Tributary
Feature Category: Tributary Name: C_007_Pond tributary Location: 106°40'23.69" W 35°15'37.12" E	C_007_Pond overflow and outflow on right bank approximately 1,200 ft downstream of Broadmoor Blvd culverts.	 Figure 8. C_007_Pond Tributary

Feature Category: Erosion Areas Name: Spur example Location: 106°40'21.36" W 35°15'36.98" E	Concrete rubble manhole protections approximately 1,500 ft downstream of Broadmoor Blvd culverts that acts as spur and directs flows away from the bank.	 Figure 9. Manhole Protection Acting as a Spur
Feature Category: Erosion Areas Name: Sportsplex Dam inflow erosion Location: 106°40'04.25" W 35°15'37.05" E	Scour and undermining of the left side of the Sportsplex inflow structure (the right side of the structure is currently intact).	 Figure 10. Sportsplex Inflow Scour on Left Side
Feature Category: Erosion Areas Name: Sportsplex Dam outflow erosion Location: 106°39'52.52" W 35°15'28.52" E	Substantial erosion and undermining of wire-tied riprap below Sportsplex Dam outlet apron and Loma Vista Blvd NE.	 Figure 11. Undermined Wire-tied Riprap Below Sportsplex Outlet Apron

Feature Category: Field Reconnaissance Name: Sediment sample 2 Location: 106°39'52.66" W 35°15'28.95" E	Sediment sample 2 collected on February 6th, 2024. This sediment sample was used in calculations for Subreach 5. Subreach calculations are discussed further in Section III.C. Approximately 150 ft downstream of the Sportsplex outfall.	
Figure 12. Collection Location of Sediment Sample 2		
Feature Category: Erosion Areas Name: Left eroding bank immediately downstream of Sportsplex outflow Location: 106°39'52.49" W 35°15'29.18" E	Eroding banks are a source of gravel. This bank was photographed approximately 150 ft downstream of the Sportsplex outflow structure.	
Figure 13. Photo of Bank Gravel		
Feature Category: Tributary; Erosion Areas Name: C_004_R tributary Location: 106°39'50.43" W 35°15'28.39" E	Tributary outflow has been undermined below wire-enclosed rocks. Tributary contributing flow from the right side of the arroyo, approximately 400 ft downstream of the Sportsplex Dam outflow.	
Figure 14. C_004_R Tributary		

Feature Category: Grade Control, BP Name: Right bank floodplain along BP at Sportsplex Location: 106°39'43.37" W 35°15'27.95" E	Photo taken in the arroyo approximately 950 ft downstream of the Sportsplex Dam outflow. Right BP is adjacent to the Sportsplex baseball fields.	 Figure 15. Looking Downstream to Right BP Near Sportsplex
Feature Category: Field Reconnaissance Name: Sediment Sample 3 Location: 106°39'40.13" W 35°15'27.96" E	Sediment sample 3 collected on February 6th, 2024. This sediment sample was used in calculations for Subreaches 6 and 7. Subreach calculations are discussed further in Section III.C. Approximately 1,200 ft downstream of Broadmoor Blvd culverts.	 Figure 16. Collection Location of Sediment Sample 3
Feature Category: Tributary; Erosion Areas Name: C_003_R tributary Location: 106°39'40.80" W 35°15'26.50" E	Tributary outflow from corrugated metal pipe, dropping onto riprap before eroding the bed and converging with the main flow. Photo taken approximately 1,300 ft downstream of the Sportsplex Dam outflow.	 Figure 17. C_003_R Tributary

Feature Category: Grade Control, BP Name: GCS at Sportsplex Location: 106°39'20.25" W 35°15'27.98" E	Stable GCS at grade in arroyo, adjacent to C_019_Pond inflow. Located in the arroyo at Loma Colorado storm drain outfall adjacent to the eastern edge of the Sportsplex. Abrasion has lowered elevation of right portion of sill by 3".	 Figure 18. View Upstream of Loma Colorado GCS Below Sportsplex
Feature Category: Grade Control, BP3 Name: Right side of GCS at Sportsplex Location: 106°39'19.18" W 35°15'27.12" E	Storm drain outfall below GCS located at the Loma Colorado storm sewer outfall adjacent to the eastern edge of the Sportsplex.	 Figure 19. Right Bank Storm Drain Outfall Below Loma Colorado GCS
Feature Category: Tributary Name: C_019_Pond tributary Location: 106°39'19.90" W 35°15'27.14" E	Left side of GCS located in the arroyo adjacent to the eastern edge of the Sportsplex C_019_Pond tributary is here.	 Figure 20. Loma Colorado Outfall and GCS Left Bank at C_019_Pond Tributary

Feature Category: Inlet and Outfall Name: Exposed, abandoned PVC Location: 106°39'18.50" W 35°15'26.38" E	Abandoned, exposed PVC piping at toe of arroyo right bank. This photo was taken approximately 140 ft downstream of the GCS, looking downstream.	 Figure 21. Exposed and Abandoned PVC Pipe
Feature Category: Inlet and Outfall Name: Exposed, abandoned CMP Location: 106°39'16.66" W 35°15'26.48" E	Abandoned, exposed CMP piping at toe of arroyo right bank. This photo was taken approximately 150 ft downstream of the LC GCS, looking downstream.	 Figure 22. Exposed and Abandoned CMP
Feature Category: Inlet and Outfall Name: Exposed, abandoned concrete Location: 106°39'15.52" W 35°15'27.50" E	Abandoned and failed manhole at toe of arroyo left bank. This photo was taken approximately 320 ft downstream of the LC GCS, looking south.	 Figure 23. Abandoned and Failed Manhole

Feature Category: Erosion Areas Name: Exposed manholes Location: 106°39'06.30" W 35°15'27.15" E	Exposed manholes along arroyo right bank. This exposure is evidence of channel widening over the last couple decades. Approximately 750 ft downstream of the GCS.	 Figure 24. Exposed Manholes from Channel Widening
Feature Category: Erosion Areas Name: Left bank rubble Location: 106°39'00.23" W 35°15'28.21" E	Concrete rubble riprap has proven largely ineffective along the arroyo left bank. Approximately 1,100 ft upstream of ASK Academy.	 Figure 25. Failed Concrete Rubble Riprap
Feature Category: Erosion Areas Name: Right bank erosion opposite to concrete rubble Location: 106°39'00.50" W 35°15'28.23" E	Eroding and sloughing the right arroyo bank opposite to concrete rubble on the left arroyo bank. Approximately 1,100 ft upstream of ASK Academy.	 Figure 26. Eroding Right Bank

Feature Category: Field Reconnaissance Name: Sediment sample 4 Location: 106°38'56.11" W 35°15'28.28" E	Sediment sample 4 collected on February 6th, 2024. This sediment sample was used in calculations for Subreaches 8 and 9. Subreach calculations are discussed further in Section III.C. Approximately 740 ft upstream of ASK Academy.	 Figure 27. Collection Location of Sediment Sample 4
Feature Category: Inlet and Outfall Name: Failing spillway near C_020 tributary Location: 106°38'56.19" W 35°15'28.11" E	Failed spillway being undermined by erosion near the C_020 tributary.	 Figure 28. C_020 Failed Spillway
Feature Category: Tributary Name: C_020 tributary Location: 106°38'56.33" W 35°15'28.70" E	The confluence of multiple sources of runoff, contributing to the C_020 tributary flows. Failed spillway (left) and eroding channel (right).	 Figure 29. C_020 Tributary

Feature Category: Inlet and Outfall Name: Incised channel at C_020 tributary Location: 106°38'57.40" W 35°15'30.02" E	Incising channel from the north contributing to C_020 tributary flows.	 Figure 30. C_020 Incised Channel
Feature Category: Erosion Areas Name: Left bank at ASK Academy Location: 106°38'55.30" W 35°15'28.50" E	Poured or dumped concrete along left bank approximately 675 ft upstream of ASK Academy has been undermined but offers BP.	 Figure 31. Concrete BP Along Left Bank
Feature Category: Tributary Name: C_002_Pond tributary Location: 106°38'51.22" W 35°15'27.74" E	Outfall structure, rundown, and erosion protection appear to be in good condition. Approximately 470 ft upstream of ASK Academy.	 Figure 32. C_002_Pond Tributary
Feature Category: Erosion Areas Name: Looking upstream near ASK Academy Location: 106°38'52.70" W 35°15'28.26" E	Undermined left, concrete BP (photo right), and vertical, eroding walls on the right bank (photo left). BP protects the left bank despite being undermined and causes more stress on the opposite bank.	 Figure 33. Looking Upstream by ASK Academy

Feature Category: Erosion Areas Name: Looking downstream at ASK Academy Location: 106°38'45.43" W 35°15'28.24" E	Reduced bank erosion in widened channel below ASK academy.	 Figure 34. Downstream at ASK Academy
Feature Category: Grade Control, BP Name: Upstream end of varied BP Location: 106°38'39.60" W 35°15'26.81" E	BP along the right bank upstream from the NM Hwy 528 culverts is varied, with cabled steel posts, basalt riprap and granite riprap. This is a photo of the upstream end. Approximately 650 ft upstream of NM Hwy 528 culverts.	 Figure 35. Varied BP (upstream)
Feature Category: Grade Control, BP Name: Downstream end of varied BP Location: 106°38'40.40" W 35°15'26.49" E	BP along the right bank upstream from the NM Hwy 528 Bridge is varied, with cabled steel posts, basalt riprap, granite riprap. This is a photo of the downstream end. Approximately 400 ft upstream of NM Hwy 528 culverts.	 Figure 36. Varied BP Along Right Bank (downstream)
Feature Category: Erosion Areas Name: Right bank across from R_104_Pond Location: 106°38'36.99" W 35°15'26.15" E	R_104_Pond outflow impacts the opposite right bank causing erosion and sloughing. Approximately 300 ft upstream of NM Hwy 528 culverts.	 Figure 37. Eroding Right Bank Across from R_104_Pond Outfall

Feature Category: Tributary Name: R_104_Pond tributary Location: 106°38'35.73" W 35°15'26.42" E	R_104_Pond tributary outflow structures on the arroyos left side. Approximately 300 ft upstream of the NM Hwy 528 culverts.	 Figure 38. R_104_Pond Tributary
Feature Category: Inlet and Outfall Name: Downstream channel of NM Hwy 528 Location: 106°38'27.98" W 35°15'24.84" E	Constructed riprap and concrete channel downstream of the NM Hwy 528 concrete box culverts.	 Figure 39. Downstream of NM Highway 528 Culverts

III. SUMMARY OF TECHNICAL ANALYSES

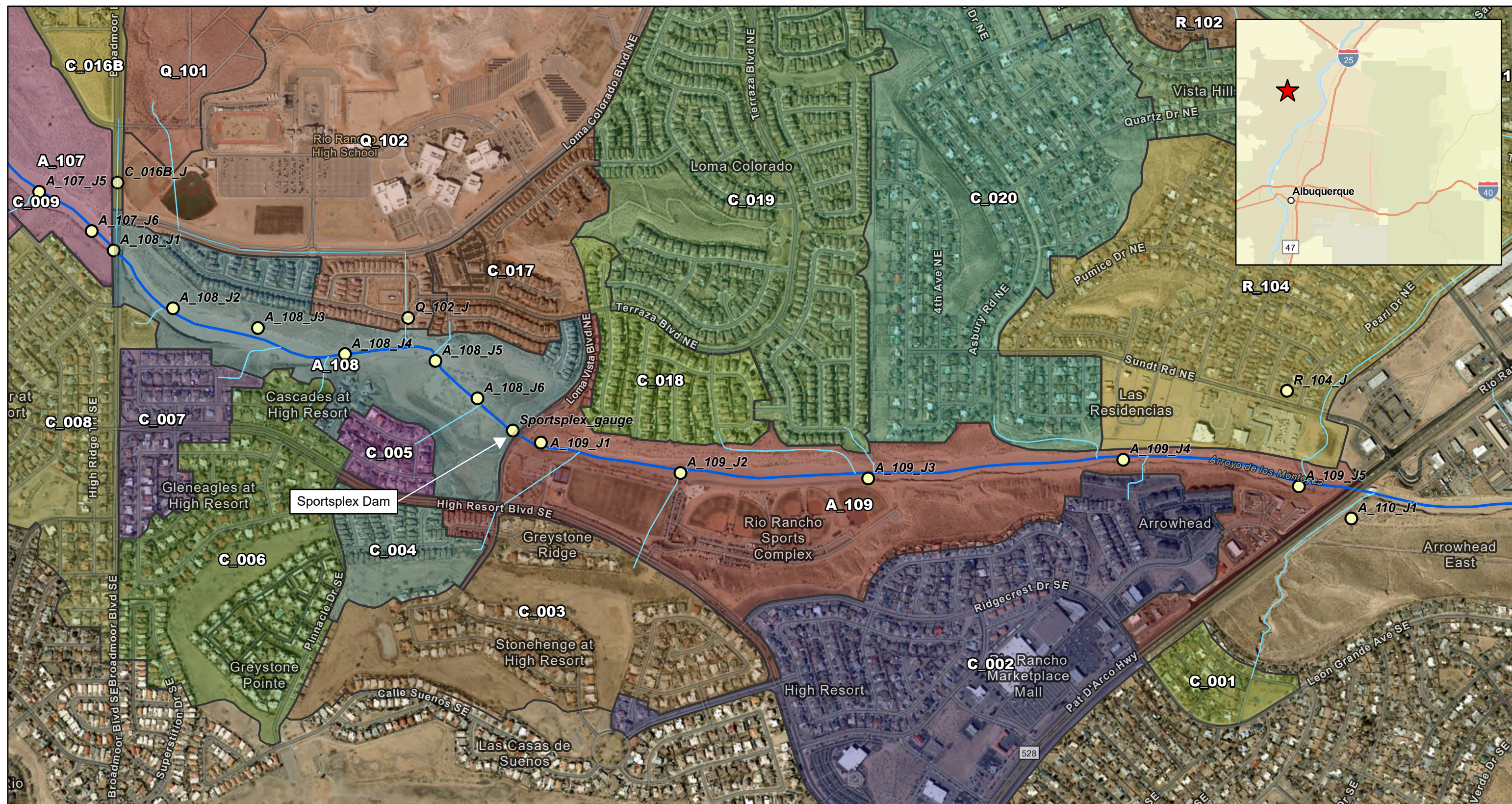
To develop recommendations for stabilizing the reach of Montoyas Arroyo from Broadmoor Blvd to NM Hwy 528, hydrology (Section III.A), hydraulics (Section III.B), and sedimentation and erosion (Section III.C) were analyzed.

A. HYDROLOGIC MODELING

SSCAFCA provided the existing conditions (ExC) WMP HEC-HMS model (version 4.2.1) to BHI, which represents existing conditions development and hydrologic parameters. The WMP HEC-HMS model set-up is displayed in **Figure 40**. This model contained the 100- and 500-year storm events. BHI added the 2-, 5-, 10-, 25-, 50-year storm events to the model for use in hydraulic modeling and, ultimately, sediment transport analysis. The ExC model incorporates an 18% sediment bulking factor. The ExC results were extracted and used as input to the hydraulic and sediment-transport analyses discussed below. Additional details about SSCAFCA's model development are available in the Montoyas WMP (SSCAFCA, 2021).

HEC-HMS element locations are marked in **Figure 40** and peak flows at key locations are presented in **Table 3** and **Table 4**. **Table 3** contains results from the simulations provided by SSCAFCA, with an 18% sediment bulking factor; **Table 4** presents results from the simulations without sediment bulking factors.

Hydraulic parameters of unbulked flows were required as clear-water input to the sediment-transport analysis. As such, all bulking factors were removed from the SSCAFCA HEC-HMS basin model for an additional set of simulations of all the aforementioned storm events. **Table 4** and **Figure 41** display results from the simulations created by BHI, removing all bulking factors in the model. The unbulked HEC-HMS peak flows were used in Sections III.B – III.C calculations. Tributaries throughout the reach do not provide significant flow in comparison to the overall hydrograph; therefore, junction hydrographs and peak flows are similar moving from upstream to downstream through the project reach. Because the hydrographs at all the HEC-HMS junctions were similar in shape throughout the project reach, only the hydrographs at the upstream element (A_108_J1) are presented in **Figure 41**. However, all inputs of flow or flow change locations were included in the hydraulic model and sediment-transport analysis. This accounts for the effects of storm drains in the ExC model that supply water but not sediment. The 500-year peak flow and hydrograph were not required in the sediment-transport analysis and are presented here for reference only.



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- Junction
- Reach
- Centerline
- Tributary

0 400 800 1,600 Feet
1 in. = 800 ft.



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Figure 40
HEC-HMS Basins and Junctions in the Project Reach

Table 3. HEC-HMS Simulated Bulk Peak Flows

Contributing Element	Receiving Junction	Peak Flow (cfs) by Recurrence Interval – 1.18 Bulking Factor						
		2-year	5-year	10-year	25-year	50-year	100-year	500-year
A_108_J1	A_108_J1	81	618	1,494	3,249	5,017	7,170	13,578
C_008_Pond	A_108_J2	3	8	30	65	101	145	244
C_007_Pond	A_108_J3	2	3	3	4	5	5	12
Q_101_R2	A_108_J3	1	4	8	15	22	30	59
C_006_Pond	A_108_J4	7	12	18	28	34	40	115
Q_102_J	A_108_J5	72	114	154	216	270	329	486
C_017	A_108_J5	15	23	31	43	53	64	94
A_108	A_108_J6	8	18	30	50	69	90	147
C_005	A_108_J6	4	7	9	14	17	21	31
C_004_R	A_109_J1	4	8	11	16	21	26	39
C_003_R	A_109_J2	9	24	39	66	88	111	173
C_018_R	A_109_J3	13	21	29	41	50	60	87
C_019_Pond	A_109_J3	52	85	115	143	163	242	497
C_020	A_109_J4	34	60	88	135	176	221	344
C_002_Pond	A_109_J4	35	50	61	73	110	152	290
A_109	A_109_J5	28	48	69	103	134	167	259
R_104_Pond	A_109_J5	82	169	257	389	495	610	941
C_001_R	A_110_J1	4	7	9	13	16	20	29

Table 4. HEC-HMS Simulated Unbulked Peak Flows

Contributing Element	Receiving Junction	Peak Flow (cfs) by Recurrence Interval – Unbulked						
		2-year	5-year	10-year	25-year	50-year	100-year	500-year
A_108_J1	A_108_J1	63	472	1,193	2,653	4,134	5,935	11,334
C_008_Pond	A_108_J2	2	3	20	50	83	119	203
C_007_Pond	A_108_J3	2	2	3	4	4	5	7
Q_101_R2	A_108_J3	1	3	7	13	19	26	45
C_006_Pond	A_108_J4	6	11	16	25	31	36	88
Q_102_J	A_108_J5	63	100	135	190	237	289	426
C_017	A_108_J5	13	21	28	39	48	58	84
A_108	A_108_J6	7	15	25	43	59	77	126
C_005	A_108_J6	3	6	8	12	15	19	28
C_004_R	A_109_J1	4	7	10	14	18	23	34
C_003_R	A_109_J2	7	20	33	56	77	97	152
C_018_R	A_109_J3	11	19	26	36	44	53	77
C_019_Pond	A_109_J3	46	76	102	131	151	170	381
C_020	A_109_J4	30	53	77	118	154	194	302
C_002_Pond	A_109_J4	32	46	56	69	90	123	251
A_109	A_109_J5	24	41	59	89	115	144	223
R_104_Pond	A_109_J5	63	141	214	334	435	537	828
C_001_R	A_110_J1	4	6	9	13	16	20	29

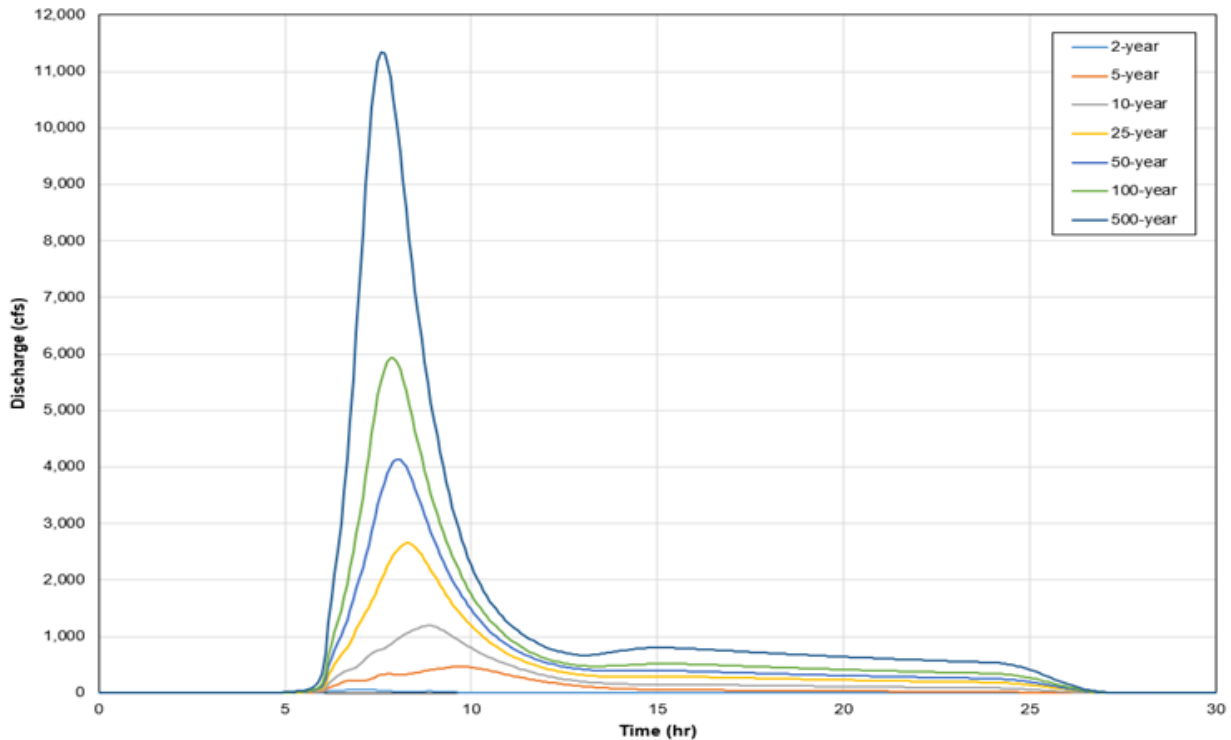


Figure 41. Unbulked Hydrographs Immediately Downstream of Broadmoor Blvd on Montoyas Arroyo

It should be noted that Subbasin A_108, in the current HEC-HMS model, includes recent areas of development with outfalls that discharge to the left (north) bank of the arroyo and should be modeled as separate subbasins in future revisions to the hydrologic modeling. Although these updates to the HEC-HMS model are not anticipated to significantly affect the overall results and recommendations presented herein, BHI recommends incorporating any updates to the hydrologic modeling into the next round of planning studies.

B. HYDRAULIC MODELING

A two-dimensional (2D) hydraulic model was developed for the Montoyas Arroyo reach from Broadmoor Blvd to 500 ft downstream of the NM Hwy 528 culverts to determine existing hydraulic parameters for input to the sediment-transport analysis and prepare flood inundation mapping for the storm events of interest (2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval floods). This model was prepared using U.S. Army Corps of Engineers (USACE) HEC-RAS version 6.4.1. The 2D hydraulic model was used to simulate flooding events using equations representing conservation of mass and momentum. These equations compute flow conditions such as depth, water surface elevation, velocity, and inundation extents over the specified event duration. Key model input is

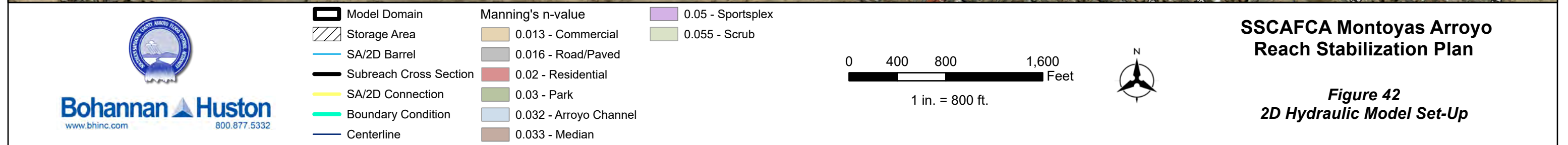
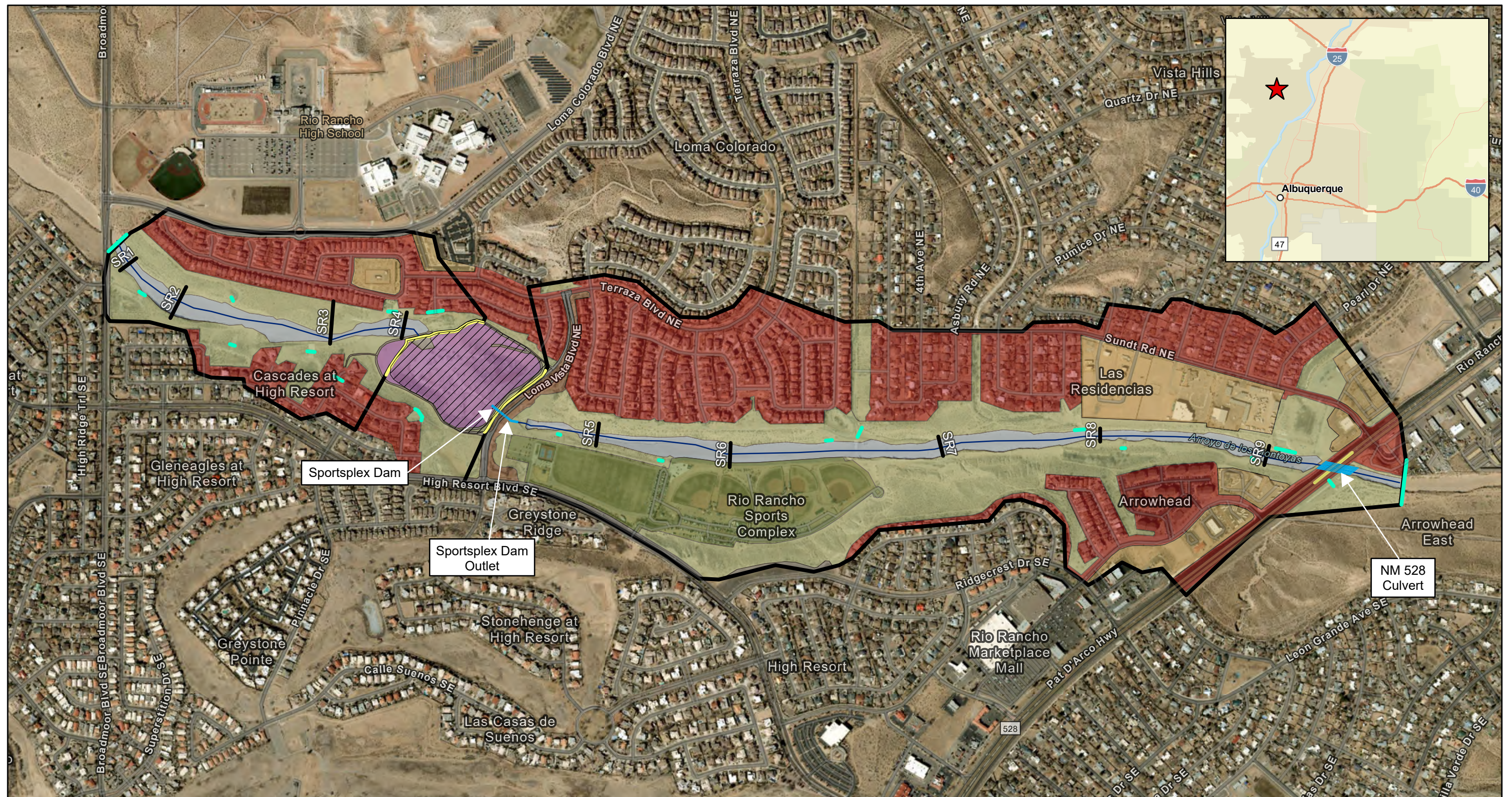
shown in **Figure 42**. To support sediment-transport analyses, the project reach was divided into nine (9) subreaches where the HEC-RAS results exhibited similar hydraulic conditions (**Table 5; Figure 43**).

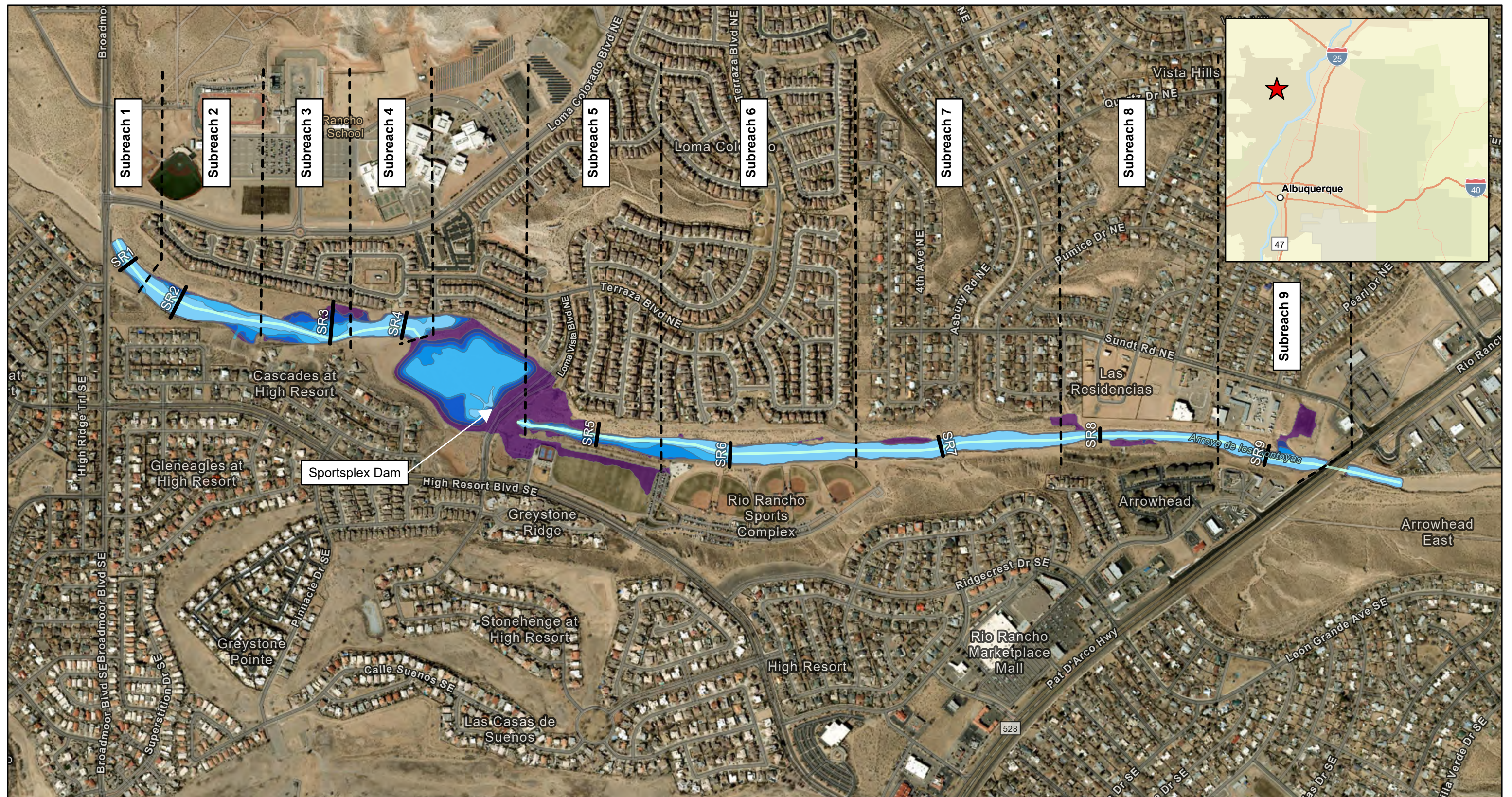
Topography for the ExC hydraulic models were developed from Mid-Region Council of Governments (MRCOG) light detection and ranging (LiDAR) mapping collected in 2018 (BHI, 2022). The 2018 MRCOG LiDAR mapping is understood to have errors of up to 1.7 ft. Considering the project reach spans a distance of over 2 miles, the relative error along the study area could be significant and have a substantial impact on the results of the analysis, the reach stabilization recommendations, and the associated costs. As such, correction to the mapping was required and involved field survey to collect 18 check points that were used to compare with the LiDAR mapping and determine required elevational corrections. The check points indicated that the elevation differences (survey elevation minus MRCOG elevation) ranged from +0.51 ft to -0.88 ft, with an average difference of -0.33 ft. As such, a corrected Digital Elevation Model (DEM) was generated by adjusting the MRCOG topography by -0.33 ft. The resulting vertical accuracy within a 95% confidence interval is +/- 0.59 ft.

For the proposed conditions analysis, the DEM was modified to reflect the proposed channel profile, representative of the calculated equilibrium slope, proposed location and height of GCSs, and the location, extent, and roughness of BP. **Appendix A** includes a detailed discussion on model development and presents model results. Predicted flood inundation mapping for the simulated storm events under existing conditions is presented in **Figure 43**.

Table 5. Reach Boundaries Used in Analyses

Subreach	Length (ft)	Upstream Station (ft)	Downstream Station (ft)	Existing Bed Slope	Notes
1	440	0	440	1.06%	Below Broadmoor Blvd
2	1,088	440	1,528	1.22%	-
3	893	1,528	2,421	1.02%	-
4	509	2,421	2,930	0.96%	Above Sportsplex Dam
5	1,092	4,206	5,298	0.60%	Below Sportsplex
6	1,724	5,298	7,022	1.34%	Adjacent to Sportsplex BP
7	1,710	7,022	8,732	1.43%	Below LC GCS
8	1,491	8,732	10,223	1.35%	-
9	777	10,223	11,001	1.38%	Above NM Hwy 528





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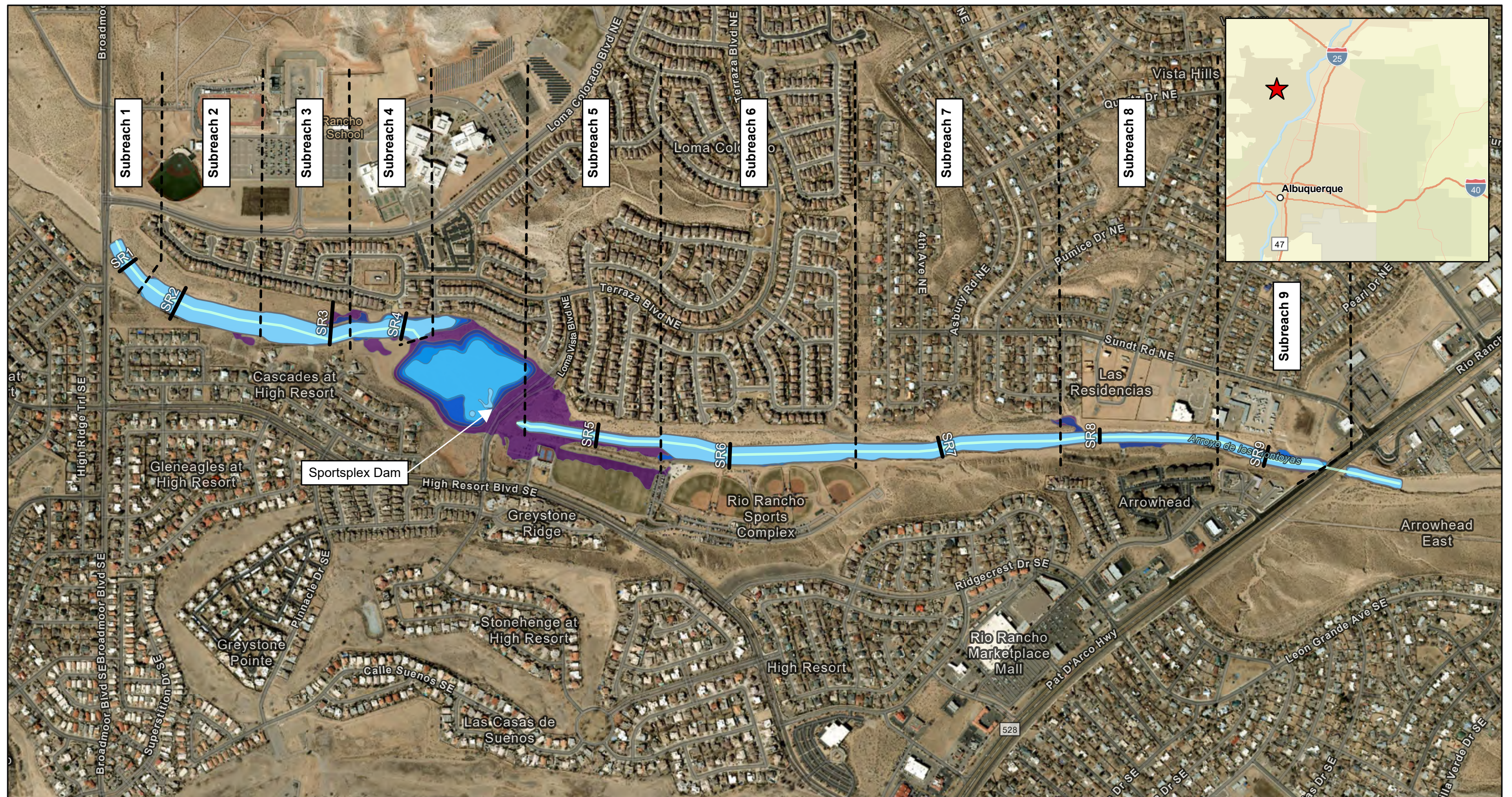
Figure 43
Predicted Flood Inundation Mapping
(Existing Conditions)

Proposed conditions modeling was also conducted. This modeling used a preliminary bank height of 10 ft., as this was the height needed to contain the 100-year arroyo depth. This modeling simulated flowrates calculated using the bulking factors calculated in this study and discussed in Section III.C. The results of the analysis were used to map predicted inundation in proposed conditions, illustrated in **Figure 44**. Additional details on model development are provided in **Appendix A**.

C. SEDIMENT TRANSPORT

Sediment transport analysis was conducted in a similar manner to that conducted for the previous Tetra Tech RSP (2024) for the Montoyas Arroyo Northern Blvd to Broadmoor Blvd. This process included breaking this study area into nine (9) subreaches based on hydraulic similitude, calculating representative hydraulic conditions within each subreach from the hydraulic model results, and then preparing applicable sediment-transport calculations for each subreach.

There are two components of total sediment load in an arroyo: wash load and bed material load. Wash load is comprised of silts and clays, is sourced from the watershed, and is transported in suspension so does not have significant physical interactions with the arroyo bed and banks. Wash load was estimated using the Modified Universal Soil Loss Equation. In general, bed material is largely made of coarse (sand and gravel) sediment and is derived from the erosion of channel boundary materials. Imbalances in the bed material transport capacity from one reach to the next can lead to aggradation or degradation. Bed material transport capacity rating curves were developed in the project reach using methods presented in the *SSCAFCA Erosion and Sediment Design Guide* (MEI, 2008) [*Design Guide*] to represent the quantity of bed material (i.e., sand and gravel) that is transported by the arroyo over a range of discharges.



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- | | |
|--|--|
| <ul style="list-style-type: none"> Subreach Extent Subreach Cross Section Centerline | <p>Inundation Boundary</p> <ul style="list-style-type: none"> PR2yr PR5yr PR10yr PR25yr PR50yr PR100yr |
|--|--|

0 400 800 1,600 Feet
1 in. = 800 ft.



SSACFCA Montoyas Arroyo Reach Stabilization Plan

Figure 44
Predicted Flood Inundation Mapping (Proposed Conditions)

The total mass of bed material transport associated with the 2-year through 100-year floods was calculated for each subreach (**Figure 45**) using the Meyer-Peter Muller (MPM)-Woo sediment-transport formula (MEI, 2008), which was in turn used to compute sediment-bulking factors. The sediment bulking factors calculated, using the 100-year sediment analysis, are listed in **Table 6**.

Table 6. Calculated Sediment Bulking Factors

Subreach	Bulking Factor
1	1.15
2	1.13
3	1.04
4	1.04
5	1.12
6	1.1
7	1.14
8	1.13
9	1.13

The long-term mean annual yields were calculated from the individual event yields and used to estimate equilibrium slopes by reach (**Appendix B**). Upstream from Sportsplex Dam, the equilibrium slopes are relatively flat (~0.9%) but only slightly flatter than the existing slopes. The equilibrium slope is most flat in Subreach 5, located immediately downstream from Sportsplex Dam, where the channel has already evolved in response to the reduced sediment supply from the dam. Steeper equilibrium slopes were calculated for the lower subreaches that have widened substantially and thus require less vertical adjustment to achieve balance with the upstream sediment supply. Once equilibrium slopes have been achieved, further systematic degradation or aggradation should cease under the existing hydrologic regime.

To prevent further erosion beyond the existing SSCAFCA ROW, stabilization measures will need to be constructed. Equilibrium slopes were used to assess the need for new GCSs and BP. Local scour analyses were performed to support the conceptual design of proposed GCSs and BP. Local scour estimates should be revised during future design efforts with revisions to the HEC-RAS model that reflect design-specific structure geometry and updated topography as well as any changes to the HEC-HMS simulated flows.

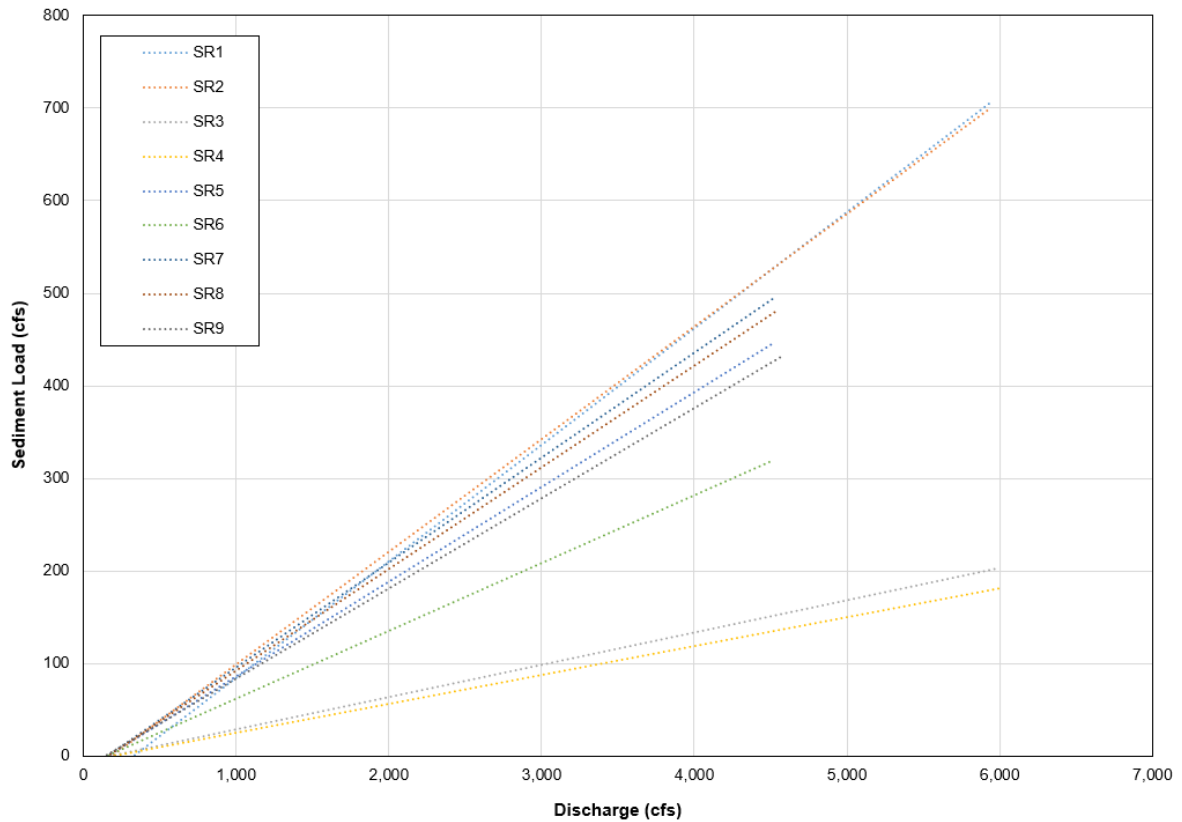


Figure 45. 100-year Bed Material Load Rating Curves for the 9 Subreaches

Because this RSP is based on ExC hydrology, the impact of increased flood flows associated with future development on channel evolution is not accounted for in the equilibrium slope and lateral erosion analyses. As such, BHI recommends that this reach stabilization plan be updated to evaluate the impacts of future development on equilibrium slopes and lateral erosion potential in the project reach prior to the design of any proposed improvements.

D. AREA FOR FUTURE DETAILED ANALYSIS

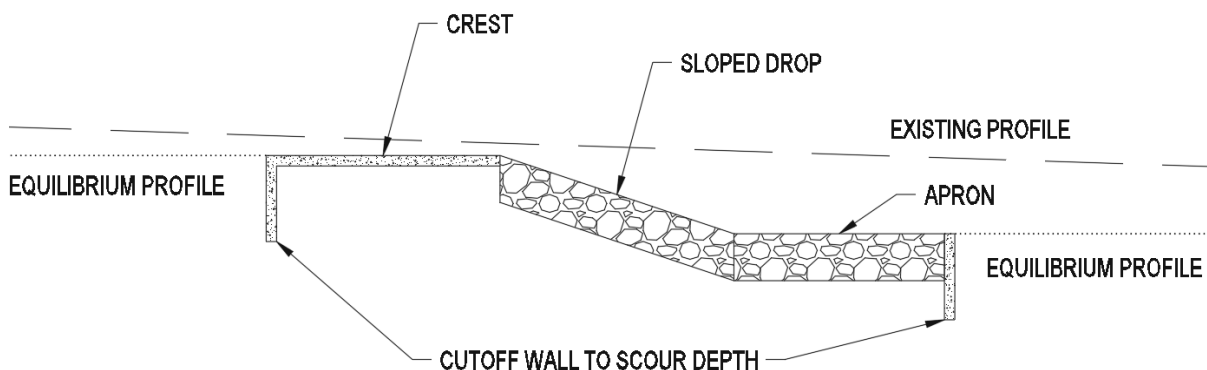
The hydraulic analysis in this plan was focused on arroyo-specific flow parameters related to reach stabilization. The results of this analysis indicate the potential for overtopping at Sportsplex Dam in the 100-year bulked events. Planning of future detention facilities within the Montoyas Arroyo watershed should include a more detailed analysis of potential impacts to Sportsplex Dam to ensure future arroyo improvements address capacity issues at Sportsplex, if any truly exist.

IV. DEVELOPMENT OF OPTIONS

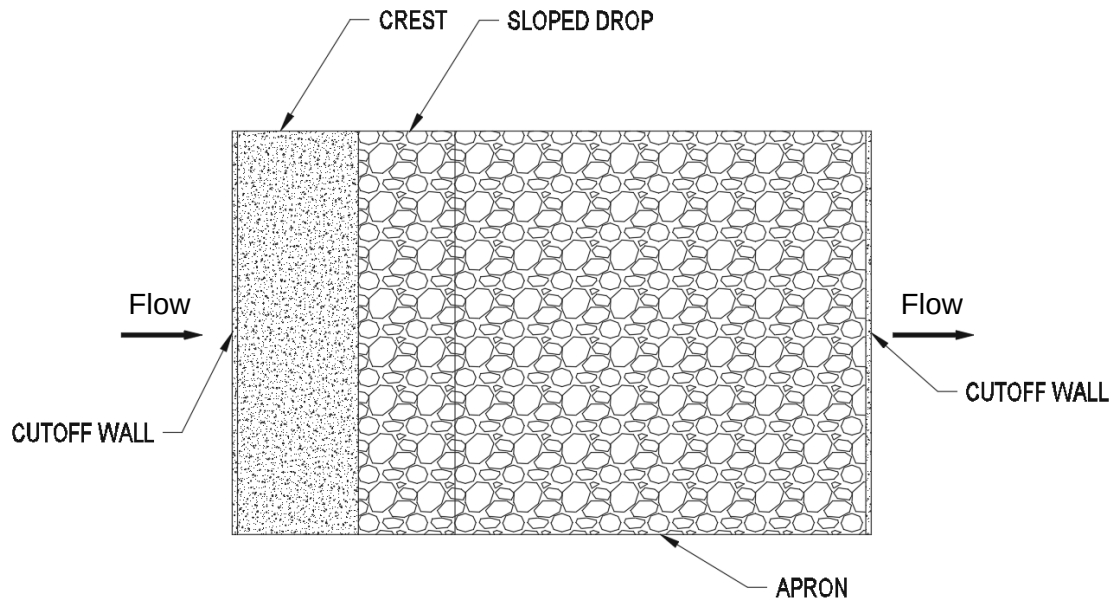
Using the equilibrium slopes, the need for GCSs was evaluated (Section IV.A). Four (4) new GCSs are recommended in the project reach, including one large drop structure below the Sportsplex Dam outlet apron. BP structures are proposed where lateral erosion potential extended beyond the existing SCAFCA ROW and/or threatened adjacent development (Section IV.B). The location and conceptual dimensions were developed for each proposed BP structure, including height above the equilibrium profile, length, and local scour protection depth. Conceptual-level cost estimates were developed for all proposed GCSs and BP structures by preparing quantity estimates and assigning unit costs based on the Calabacillas Arroyo West Branch (CAWB) GCS 11, Crossing, and Bank Protection (2022) bid tabs. This project was chosen because it is a recent, BHI-designed GCS/BP project that has comparable dimensions and materials to this RSP's potential solutions, and it has been bid on and constructed. Unit costs were adjusted to account for inflation using the most current RSMeans (2023 Albuquerque, NM) cost index. Value engineering and design refinement is recommended during future phases as new data are collected.

A. GRADE CONTROL OPTIONS

GCSs can be used to limit incision, incision-induced widening, and lateral erosion of the arroyo. **Figure 46** and **Figure 47**, respectively, present conceptual profile and plan views of a typical GCS. The need for GCSs was evaluated by projecting the calculated equilibrium slopes (**Table 7**) upstream from the existing hard points (the Sportsplex Dam inlet structure, the LC GCS, and the NM Hwy 528 culvert) (**Figure 48**).



**Figure 46. Conceptual Profile View of a Typical GCS
(not drawn to scale)**



**Figure 47. Conceptual Plan View of Typical GCS
(not drawn to scale)**

Table 7. Summary of Calculated Equilibrium Slopes

Subreach	Dominant Flow (cfs)	Mean Annual Bed Material Yield (cu ft)	Equilibrium Slope	Existing Slope
1	1,187	294,434	0.95%	1.06%
2	1,188	287,602	0.95%	1.22%
3	1,196	150,016	0.93%	1.02%
4	1,201	108,403	0.89%	0.96%
5	901	295,201	0.59%	0.60%
6	902	237,445	1.26%	1.34%
7	904	346,078	1.23%	1.43%
8	906	339,662	1.10%	1.35%
9	914	399,328	1.06%	1.38%

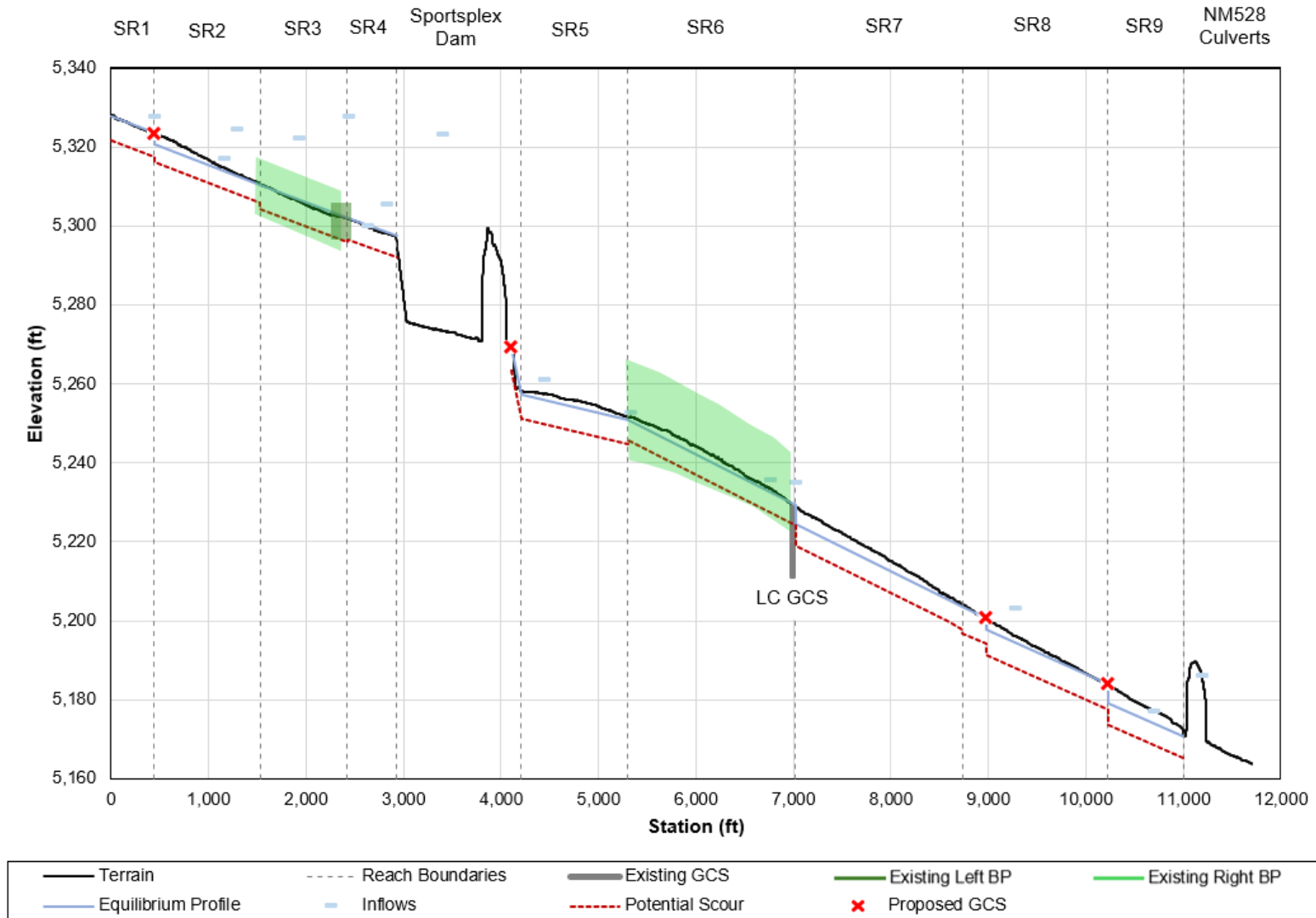


Figure 48. Existing and Equilibrium Longitudinal Profile

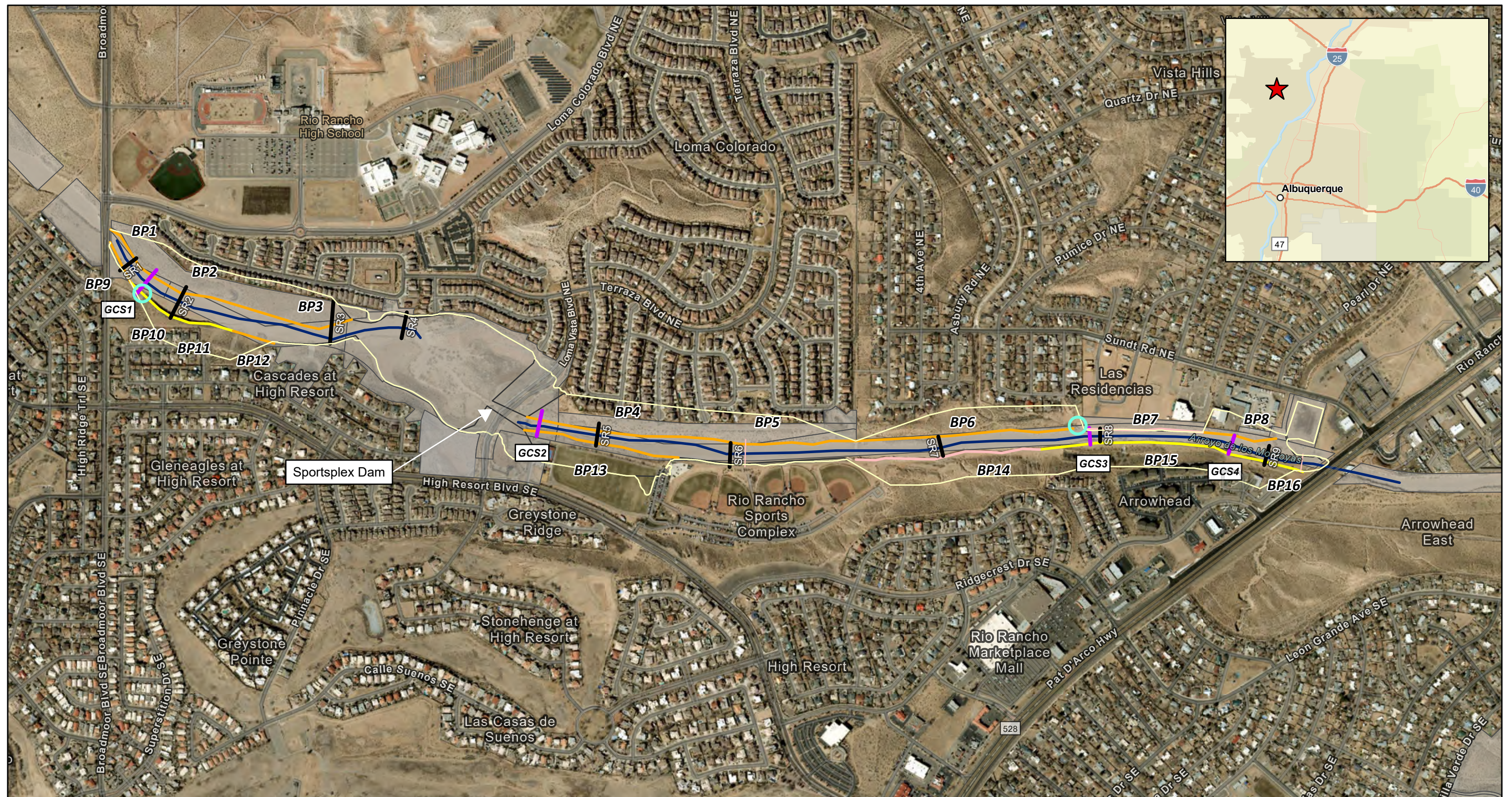
Four (4) new proposed GCSs and one (1) existing GCS are included in the proposed channel profile (**Figure 48**). GCSs are named by increasing numbers from upstream to downstream. GCS 2 has a significantly larger drop because there is currently an approximately 12-ft drop below the culvert apron structure at the outlet of Sportsplex Dam. The potential solutions plan-view layout is presented in **Figure 49**.

Because scour protection at the up- and downstream limits of the structures would need to be toed down to a depth that would be equal to the toe-down depth of the adjacent bank protection, scour depths were calculated using flow impinging on a wall (with a 5-degree angle), plus antidune scour to account for large flow scour, per the *Design Guide* (MEI, 2008) (**Table 8**). Flow along a wall scour was calculated with a 5-degree impingement because some bends experience a small amount of angle when water comes into contact with it. This 5-degree assumption is conservative for most subreaches. Hydraulic parameters were calculated for the 100-year unbulked HEC-RAS modeled simulations for proposed conditions, and these parameters were used as inputs in the scour calculations. The hydraulic parameters were based on unbulked flow rates because the bulking factors would be expected to reduce substantially under equilibrium slope conditions, and re-computation of the bulking factors for proposed conditions was beyond the scope of this study. Scour was calculated for the existing GCS and it was confirmed, using as-built record drawings, that with the calculated scour in addition to the lowering of the channel profile, the GCS is still buried deep enough to not be threatened. Scour calculations are discussed further in **Appendix B**.

Table 8. GCS Locations and Conceptual-level Dimensions

ID	Location	Crest River Station (ft)	GCS Width (ft)	Height (ft)	Local Scour Protection Depth (ft)
1	Between SR1 and 2	440	120	3	6
2	Upstream end of SR5	4,100	80	12	6
3	Upstream end of SR8	8,972	75	3	6.5
4	Between SR8 and SR9	10,223	95	5	6.5

The GCS cost estimate was developed by calculating quantities from the conceptual design and grading, then multiplying by a unit cost. Unit cost estimates were developed for all proposed GCSs and BP structures using unit costs based on the CAWB GCS 11, Crossing, and Bank Protection (2022) bid tabs. Unit costs were adjusted to account for inflation from 2022 using the most current RSMeans (2023 Albuquerque, NM) cost indices. The hard costs were marked up by 13% to account for general construction costs (mobilization, signage, staking, water redirection, traffic



control/barricading) based on the percentage of said costs on CAWB GCS 11, 15% for design and permitting (see **Table 24**), and 7.4375% for New Mexico Gross Receipts Tax (NMGRT). An additional contingency of 35% was added to account for the conceptual nature of the estimates. After accounting for construction costs, design, permitting, NMGRT, and contingency, the unit cost was estimated to be approximately \$141,000 per foot of drop height. Permitting includes processes such as Clean Water Act Section 404 permitting, a survey of Western Burrowing Owl habitat for U.S. Fish and Wildlife Endangered Species Act, and floodplain permitting. This nominal percentage for permitting should be revisited during design effort scoping. Supporting cost estimate details are provided in

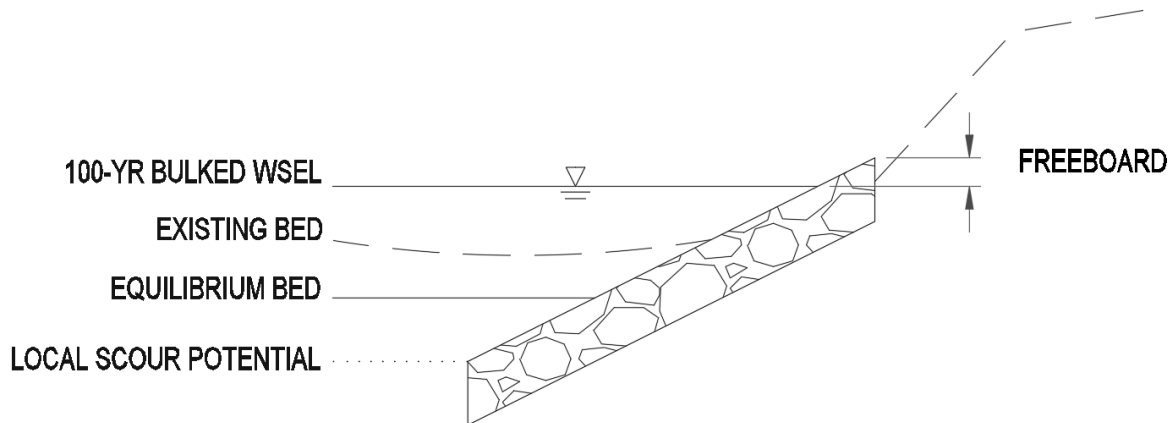
Appendix C. The total cost to design and construct all proposed GCSs is approximately \$3,250,000.

See **Appendix C** for more information on cost estimation. If, for safety reasons, the 12-ft drop height at GCS 2 is deemed to be unacceptably large and the structure was divided into two 6-ft-high drops, the total cost for all proposed GCSs would increase to about \$3,550,000.

B. BANK PROTECTION OPTIONS

Properties adjacent to the arroyo that are expected to be impacted by long term lateral erosion should be protected using BP. The lateral erosion envelope (LEE) was calculated using the methodology presented by the *Design Guide* (MEI, 2008). Where the LEE line was outside the SSACFCA ROW and/or intersecting adjacent developments signifying they were at risk from future degradation, BP is proposed (**Figure 49** and **Figure 50**). An additional two areas of bank erosion should be monitored. One of the areas is a reach of the right (south) bank downstream from the LC GCS that is currently eroding and unprotected, but does not appear to be a threat to infrastructure that has not already been abandoned. The other area recommended for monitoring is the non-engineered BP on the left (north) bank in the vicinity of the AKS Academy, where the treatments are currently mitigating bank erosion. Conceptual dimensions of BP are listed in **Table 9** and **Table 10**. These dimensions are based on bulked (factor of 1.18) 100-year arroyo depths and estimates of local scour, assuming 1.5 ft of freeboard. These bank protection depths were also verified to be adequate according to the freeboard equation in Section 4.3.1 of *Criteria Manual – Volume 2: Hydraulics* (SSACFCA, 2024), using the hydraulic depth and depth-averaged velocity from the hydraulic model results from simulations using bulked inflow hydrographs with calculated bulking factors as documented in **Appendix B**.

The prudent line (**Figure 49**) is developed by comparing LEE lines with the 100-year flood inundation mapping, making adjustments in cases where the inundation mapping extends beyond the LEE lines to encompass the combined risk of flooding and erosion.



**Figure 50. Conceptual Profile View of Typical BP
(not drawn to scale)**

Scour depths were calculated using flow impinging on a wall (with a 5-degree angle based on a conservative evaluation of the 2D model results), plus antidune scour to account for large flow scour. This calculations were done following the *Design Guide* methodology (MEI, 2008) (**Table 9** and **Table 10**). Hydraulic parameters were calculated for the 100-year unbulked HEC-RAS model run, and these parameters were used as inputs in the scour calculations. For the existing, engineered BP structures, scour was calculated in their subreach, and it was confirmed that with the calculated scour in addition to the lowering of the channel profile, the BP is still buried deep enough to not be threatened (see **Figure 48** for locations of analyzed BP). Scour calculations are discussed further in **Appendix B**.

Table 9. Left Bank Recommendations

ID	US River Station (ft)	DS River Station (ft)	Recommendation	Length (ft)	Height Above Proposed Channel Profile (ft)	Local Scour Protection Depth (ft)
BP1	0	440	Construct	440	6.5	6.0
BP2	440	1,528	Construct	1,088	6.0	4.5
BP3	1,528	2,331	Construct	802	7.5	6.0
BP4	4,100	5,269	Construct	1,169	9.0	6.0
BP5	5,269	6,993	Construct	1,724	6.0	5.0
BP6	6,993	8,703	Construct	1,710	7.0	5.5
BP7	8,925	9,925	Monitor	1,000	-	-
BP8	9,925	10,975	Construct	1,050	13.5	5.5

Table 10. Right Bank Recommendations

ID	US River Station (ft)	DS River Station (ft)	Recommendation	Length (ft)	Height Above Proposed Channel Profile (ft)	Local Scour Protection Depth (ft)
BP9	0	313	Construct	313	6.5	6.0
BP10	313	440	Acquire	128	6.5	6.0
BP11	440	1398	Acquire	958	6.0	4.5
BP12	1398	1529	Construct	130	6.0	4.5
BP13	4100	5269	Construct	1169	9.0	6.0
BP14	6897	8703	Monitor	1806	-	-
BP15	8703	9925	Acquire	1222	7.5	6.5
BP16	9925	10925	Acquire	1000	13.5	5.5

The BP cost estimate was developed by calculating quantities from conceptual design and grading, then multiplying by a unit cost. Unit cost estimates were developed for all proposed GCSs and BP structures using unit costs based on the CAWB GCS 11, Crossing, and Bank Protection (2022) bid tabs. Unit costs were adjusted to account for inflation from 2022 using the most current RSMeans (2023 Albuquerque, NM) cost indices. The hard costs were marked up by 13% to account for general construction costs (e.g., mobilization, signage, staking, water redirection, traffic control/barricading) based on the percentage of said costs on CAWB GCS 11, 15% for design and permitting (see **Table 24**), and 7.4375% for NMGR. An additional contingency of 35% was added to account for the conceptual nature of the estimates. After accounting for construction costs, design, permitting, NMGR, and contingency, the unit cost was estimated to be approximately \$1,715 per linear ft of BP. Supporting cost estimate details are provided in **Appendix C**. The total cost to design and construct all proposed BP is estimated to be approximately \$22,200,000. There are six (6) locations where monitoring or acquisition of land are recommended. No costs were estimated for acquisition of land. See **Appendix C** for more information on cost estimation.

C. REPAIR/RECONSTRUCT OPTIONS

Outfall detention ponds have two (2) spillways that are damaged and in need of repair. The spillway along the south bank of the arroyo that outfalls the detention pond on the east side of Broadmoor Blvd has been undermined at the toe of the spillway (**Figure 5**), so repair of the spillway toe is recommended. GCS 1 was strategically located at this spillway, with the crest located just downstream from the spillway, such that construction of the GCS would incorporate repair to the spillway. Thus, the cost for this repair is included in the cost of GCS 1. The spillway that outfalls the detention pond on the north bank at the upstream limit of Subreach 8 has failed (**Figure 28**). As such, reconstruction of this spillway is recommended. The cost for reconstructing the spillway is about \$745,000.

V. SUMMARY AND CONCLUSIONS

This reach stabilization plan was developed based on a field reconnaissance to evaluate existing geomorphic conditions and existing infrastructure (Section II), a 2D HEC-RAS model of the project reach (Section III.B and Appendix A) representing ExC flows, sediment transport analyses (Section III.C and Appendix B), including equilibrium slope and LEE, and recommendation of GCSs to limit future incision and BP to prevent lateral erosion from extending beyond the existing SSCAFCA ROW (Section IV). Conceptual-level cost estimates were developed for all proposed structures and improvements. For all recommendations presented herein, value engineering and design refinement should be performed as part of the design process.

Four (4) GCSs and 14 sections of BP are proposed. An additional two (2) areas of bank erosion are recommended to be monitored. One of the areas is a reach of the right (south) bank downstream from the LC GCS that is currently eroding and unprotected, but does not appear to be a threat to infrastructure that has not already been abandoned. The other area recommended for monitoring is the non-engineered BP on the left (north) bank in the vicinity of the AKS Academy, where the treatments are currently mitigating bank erosion. The estimated total cost to design and construct all proposed structures is \$22,200,000 for BP, \$3,250,000 for GCSs, and \$745,000 for repair and reconstruction of the failed spillway on Subreach 8.

This RSP is based on ExC hydrology because local municipality regulations require all new developments to restrict associated discharges to pre-development levels. Because the ExC hydrology does not consider future development and the associated shift to the hydrologic regime in areas not covered by these regulations, it is recommended that this RSP be updated to factor in developed conditions, DevEx hydrology to evaluate if changes in flow rates, and consequently sediment transport analyses, would necessitate changes to these recommendations. Events that could trigger an update to this document include but are not limited to:

- Significant and observable changes to the channel bed, exposing local scour protection along the reach,
- An update to the Montoyas WMP that results in substantial differences to flood flows from Northern Blvd to Broadmoor Blvd, or
- It has been 10 years since the previous update.

VI. REFERENCES

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VII. APPENDIX A: HYDRAULIC MODELING

The HEC-RAS version 6.4.1 (USACE, 2024) was used to simulate 2D hydrodynamic flow conditions of the Montoyas Arroyo along the length of the project reach in support of the sediment-transport analyses and prudent line development. The model extends from Broadmoor Blvd to about 500 ft downstream from NM Hwy 528. Hydraulics were analyzed for a range of flows up to the 100-year bulked peak flow based on the results of the hydrologic model (Section III.A). The required geometry files were created using RAS Mapper. This HEC-RAS model has been provided as a digital appendix (**Appendix D**).

A. INPUT PARAMETERS

Input to the model includes definition of the grid elements that make up the model mesh, topographic information, assigning up- and downstream boundary conditions (including boundary conditions representing tributary inflows), building in existing structures, definition of the hydraulic roughness, and specification of computational parameters.

1. MODEL GRID ELEMENTS

The initial grid point spacing was set to 25-ft before breaklines were enforced. Breaklines were enforced to increase model resolution in areas of hydraulic complexity, arrange elements to be perpendicular to expected flow, and ensure continuity. Breaklines with near spacing of 15-ft were added to define the tops and toes of the channel banks. Breaklines elsewhere were enforced with near spacing of 10-25 ft, and near repeats of 0-2, depending on the resolution required by the hydraulic complexity at specific locations.

2. TOPOGRAPHIC INFORMATION

The ExC hydraulic models were developed from MRCOG LiDAR mapping collected in 2018 (BHI, 2022). This LiDAR collection was done in state plane NM83-CF. This DEM was imported into HEC-RAS with a cell size of 2 ft x 2 ft. This DEM's ultimate vertical accuracy within a 95% confidence interval is +/- 0.59 ft. The proposed conditions modeling surface was comprised of the aforementioned surface and a superimposed design surface from Civil3D with a cell size of 2 ft x 2 ft. This is discussed further in Section III.B.

3. MODEL BOUNDARY CONDITIONS

Three (3) versions of the hydraulic model were created to account for varying hydrologic inputs. One version used the bulked HEC-HMS flow hydrographs (**Table 3**), one used the unbulked HEC-HMS hydrographs (**Table 4**) as inflow boundary conditions in the HEC-RAS model, and the last used the

calculated bulked flows derived from the bulking factors in **Table 6**. All models contain one (1) primary upstream inflow and 17 tributary inflows, inside the modeled domain. All inflow boundary conditions were drawn at the approximate location of the corresponding element in the WMP HEC-HMS model, and the energy gradients were calculated assuming parallel slope to the ground slope at the boundary condition location. A normal depth outflow boundary condition was defined at the downstream limit of the model domain, located approximately 500-ft downstream of the NM Hwy 528 culverts with an assigned energy gradient of 0.0128, parallel to the channel bed slope at this location.

4. STRUCTURES

Modeled structures include the Sportsplex Dam, the Sportsplex Dam outflow culverts, and the NM Hwy 528 culverts. The Sportsplex Dam was modeled as a storage area. The geometry used in the primary analysis, and in generating results for the figures presented in this report, used an elevation-storage curve derived from the DEM. This curve was truncated at approximately the top height of the dam listed in the as-built elevation-storage curve. A second geometry was created, at the request of SSCAFCA, using the as-built storage curve for the purpose of observing the difference in inundation and the impact of the existing sediment in the facility. These results are provided in the digital appendix, **Appendix D**. The Sportsplex Dam outflow culverts and NM Hwy 528 culverts dimensions and inverts were entered per the record drawings.

5. HYDRAULIC ROUGHNESS

Hydraulic roughness was accounted for by assigning spatially varied Manning's n-values. The spatial extents of roughness regions were delineated from aerial imagery from 2022. Determination of the Manning's n-values were based on observations during the field reconnaissance (primarily the boundary material and vegetation characteristics) and past experience with similar systems, as well as published values for similar roughness conditions (Barnes, 1967; Hicks and Mason, 1991; Arcement and Schneider, 1989; NMDOT, 2018; USACE [HEC-RAS online documentation](#)).

The Manning's n-values in the model domain vary between 0.013 and 0.055 (**Table 11**). The main channel bed was assigned an n-value of 0.032 to represent straight-channel conditions of minimal stones and weeds.

Table 11. Manning’s “n” Hydraulic Roughness Values

Category	Manning’s “n”	Source
Commercial	0.013	NMDOT Table 502-5 smooth asphalt
Road/Paved	0.016	NMDOT Table 502-5 rough asphalt
Residential (set as default)	0.020	HEC-RAS Hydraulic Reference Manual Table 3-1 A.2.a.1 (lower for concrete)
Park	0.030	HEC-RAS Hydraulic Reference Manual Table 3-1 A.2.a.1
Arroyo Channel	0.032	HEC-RAS Hydraulic Reference Manual Table 3-1 A.1.a-b
Median	0.033	NMDOT Table 502-3; HR6.0RM T3-1 A.2.a
Sportsplex Dam Pool	0.050	HEC-RAS Hydraulic Reference Manual Table 3-1 A.2.c.1
Scrub	0.055	HEC-RAS Hydraulic Reference Manual Table 3-1 A.2.c.1-3

6. COMPUTATIONAL PARAMETERS

The models were executed for all storm events using the Shallow Water Equations, Eulerian-Lagrangian Method (SWE-ELM) equation set with a varying computation interval of 0.25 – 4.00 seconds to satisfy a Courant Number between 0.5 and 1.0. The simulation window was set to a 48-hour duration to capture the entirety of the HEC-HMS output hydrographs. The mapping and hydrograph output intervals were set to 5 minutes, while the detailed output interval was set to 15 minutes.

B. SENSITIVITY RUNS

The Diffusion Wave and Saint-Venant (SWE-ELM) equation sets were tested. Although the results from simulations using both equation sets were similar along the majority of the reach, there were substantial water surface elevation differences at some key locations such as the Sportsplex Dam facility. As such, the SWE-ELM equation set was selected for use in this model because the full Saint-Venant equations include local and convective acceleration terms that produce more accurate results for “flashy” flood hydrographs, which are applicable to the simulated runoff events included in this analysis.

C. RESULTS

Results from the modeling were used to evaluate flood inundation boundaries and prepare the necessary input for the sediment-transport calculations. These sediment-transport calculations guided prudent line delineation and concept design.

1. FLOOD INUNDATION BOUNDARIES

Inundation mapping representing the maximum inundation extent was prepared for each of the simulated events based on existing conditions topography (**Figure 43**). The mapping indicates that the inundation extents are generally contained within the channel at flows up to the peak of the 50-year event. The inundation boundary for the 100-year event is also largely contained within the channel, but overbank floodplain flows are shown in some localized areas.

Results from the modeling indicate that Sportsplex Dam would be overtopped during the 100-year flood event simulations with and without sediment bulking. To determine the potential impact of sediment accumulation on flood storage, a version of the model was prepared that replaced the stage-storage curve based on ExC (which accounts for sediment accumulation that has occurred since construction of the dam) with the design stage-storage curve. Results from the model with the design stage-storage curve indicate that the unbulked 100-year event is attenuated in the dam pool without overtopping; thus, sediment accumulation is at least in part causing dam overtopping at the 100-year event. It should also be noted that the hydrology that was used in the design of the Sportsplex Dam has since been revised as part of the current WMP that is used in this study, and the resulting higher flow rates and volumes also have an impact on this storage assessment.

2. SUBREACH HYDRAULIC PARAMETERS

As discussed previously, the study area was broken down into nine (9) subreaches based on hydraulically similar parameters such as velocity, depth, width, and energy slope. **Figure 43** illustrates the extents of each subreach. Cross-sectionally averaged hydraulic parameters were calculated over the range of modeled flows at each representative subreach cross section. **Table 12** lists the hydraulic parameter averages for each subreach at the unbulked flowrate peak of each modeled storm event.

Table 12. Subreach Cross-sectionally Averaged Hydraulic Parameters

Subreach	Recurrence Interval (years)	Total Flow (cfs)	Chan. Hydraulic Depth (ft)	Chan. Velocity (fps)	Eff. Chan. Top Width (ft)	Energy Slope (ft/ft)	Bed Slope (ft/ft)
1	2	63	0.35	1.65	108	0.0178	0.0106
	5	472	0.96	4.19	117	0.0302	0.0106
	10	1,192	1.57	6.10	125	0.0342	0.0106
	25	2,652	2.46	8.25	131	0.0375	0.0106
	50	4,132	3.16	9.72	134	0.0402	0.0106
	100	5,933	3.87	11.09	138	0.0433	0.0106
2	2	65	0.24	1.96	137	0.0780	0.0122
	5	477	0.66	3.84	188	0.0591	0.0122
	10	1,195	1.06	5.57	202	0.0638	0.0122
	25	2,659	1.61	7.38	224	0.0631	0.0122
	50	4,139	2.15	8.38	230	0.0581	0.0122
	100	5,940	2.63	9.70	233	0.0624	0.0122
3	2	72	0.43	3.05	55	0.1391	0.0102
	5	481	0.78	4.28	145	0.0363	0.0102
	10	1,207	1.39	4.66	186	0.0168	0.0102
	25	2,678	1.71	5.77	271	0.0171	0.0102
	50	4,169	2.05	6.31	322	0.0170	0.0102
	100	5,981	2.74	6.46	337	0.0144	0.0102
4	2	103	0.50	1.62	127	0.0085	0.0096
	5	486	0.91	3.47	155	0.0166	0.0096
	10	1,216	1.53	4.86	164	0.0176	0.0096
	25	2,692	2.54	6.10	174	0.0165	0.0096
	50	4,187	3.36	6.79	183	0.0158	0.0096
	100	6,004	4.12	7.45	196	0.0162	0.0096
5	2	109	0.90	3.36	36	0.2092	0.0060
	5	467	1.70	5.41	51	0.1322	0.0060
	10	1,104	2.30	7.11	68	0.0989	0.0060
	25	2,443	3.05	9.13	88	0.0789	0.0060
	50	3,460	3.78	10.07	91	0.0683	0.0060
	100	4,505	4.44	10.90	93	0.0621	0.0060

Subreach	Recurrence Interval (years)	Total Flow (cfs)	Chan. Hydraulic Depth (ft)	Chan. Velocity (fps)	Eff. Chan. Top Width (ft)	Energy Slope (ft/ft)	Bed Slope (ft/ft)
6	2	109	0.90	3.36	36	0.2092	0.0060
	5	467	1.70	5.41	51	0.1322	0.0060
	10	1,104	2.30	7.11	68	0.0989	0.0060
	25	2,443	3.05	9.13	88	0.0789	0.0060
	50	3,460	3.78	10.07	91	0.0683	0.0060
	100	4,505	4.44	10.90	93	0.0621	0.0060
7	2	114	0.29	2.64	147	0.0417	0.0134
	5	473	0.69	4.48	153	0.0397	0.0134
	10	1,107	1.20	5.92	156	0.0352	0.0134
	25	2,447	1.98	7.77	159	0.0344	0.0134
	50	3,465	2.46	8.74	161	0.0346	0.0134
	100	4,510	2.90	9.55	162	0.0351	0.0134
8	2	156	0.36	3.05	141	0.0301	0.0143
	5	473	0.74	4.48	143	0.0285	0.0143
	10	1,114	1.26	6.13	145	0.0308	0.0143
	25	2,456	2.05	8.17	147	0.0351	0.0143
	50	3,477	2.55	9.26	147	0.0382	0.0143
	100	4,521	3.01	10.16	148	0.0409	0.0143
9	2	169	0.70	3.54	68	0.0366	0.0135
	5	476	1.28	5.31	70	0.0373	0.0135
	10	1,117	2.08	7.43	72	0.0397	0.0135
	25	2,463	3.33	9.86	75	0.0423	0.0135
	50	3,484	4.13	10.88	78	0.0415	0.0135
	100	4,532	4.79	11.73	81	0.0417	0.0135

VIII. APPENDIX B: SEDIMENT TRANSPORT AND SCOUR ANALYSES

The HEC-RAS model was used to simulate the flood hydraulics over a range of storm events under a hydrologic scenario representing existing development conditions and existing arroyo geometry (Section III.A). The resulting reach-averaged hydraulics (**Appendix A**) were used along with information from the bed material sampling to calculate bed material transport capacity and bulking factors. Based on differences in bed material transport capacity and mean annual bed material supply, a sediment continuity analysis was performed to address the current potential for aggradation and degradation by reach. The sediment transport capacities and estimated long-term bed material supplies to each reach were used to calculate equilibrium slopes for existing conditions. A lateral erosion analysis was performed to assess the potential for lateral erosion to migrate outside the existing SSCAFCA ROW. The resulting equilibrium slopes and LEE lines were used to locate and size GCS and BP. Local scour potential was calculated at each GCS and BP to support development of conceptual level dimensions and cost estimates (Section IV). The methods for calculating sedimentation and erosion potential follow those outlined in the *Design Guide* (MEI 2008).

A. SEDIMENT-TRANSPORT RATING CURVES

The sediment transport calculations require input describing the gradation of the bed material. As discussed previously, four (4) bulk sediment samples were collected during the field reconnaissance and submitted to the BHI laboratory for gradation analysis. **Table 13** identifies the sediment sample assigned to each subreach. Sample S1 represents the bed material upstream from the Sportsplex Dam facility and was used to characterize the bed material in Subreaches 1 through 4. Sample S2 was collected just downstream from the Sportsplex Dam outlet and is representative of Subreach 5. Compared to the upstream samples, Samples S3 and S4 are coarser with higher gravel content, representing the coarsening of the channel bed in the steeper downstream reaches. Sample S3 was used in Subreaches 6 and 7; Sample S4 was used in Subreaches 8 and 9.

Table 13. Subreach Sediment Sample Assignments

Subreach	Sediment Sample	Median Grain Size (mm)	Percent Gravel (> 2 mm)
1	1	0.67	26%
2			
3			
4			
5	2	0.73	28%
6	3	0.85	40%
7			
8	4	0.92	40%
9			

1. WASH LOAD TRANSPORT

Wash load is the portion of the total sediment load that is transported through alluvial systems in suspension without appreciable interaction with the bed or banks. This material is comprised of particle sizes in the silt and clay size fractions and does not directly influence erosion and sedimentation in the arroyo. However, increases in wash load can cause increases in the viscosity and density of the flow, which can increase the transport of bed material (i.e., sand and gravel). As such, wash load can have indirect impacts on channel dynamics and evolution.

Wash load yields were calculated using the Modified Unified Soil Loss Equation (MUSLE) (Williams 1972; Wischmeier and Smith 1978) based on the hydraulic modeling and *Design Guide* (MEI, 2008) recommended parameters. Calculated wash loads are listed in **Table 14**. These wash loads were one of the input parameters to the sediment transport capacity and bulking factor calculations.

Table 14. Summary of Computed Wash Load (ppm)

Subreach	2-year	5-year	10-year	25-year	50-year	100-year
1	118,818	112,747	129,000	148,220	160,844	171,263
2	111,039	112,176	128,470	147,765	160,403	170,840
3	107,106	111,566	128,357	147,639	160,335	170,785
4	110,544	108,861	126,990	146,597	159,370	169,892
5	111,278	106,649	120,836	139,625	145,318	148,152
6	111,079	106,464	120,466	139,279	144,980	147,855
7	119,385	104,618	119,428	138,463	144,410	147,291
8	119,612	103,773	118,976	138,138	143,980	146,914
9	122,566	101,971	117,927	137,316	143,303	146,310

2. BED MATERIAL AND TOTAL SEDIMENT-TRANSPORT CAPACITIES

Bed material load is the portion of the total load that is sourced from the bed and banks of the arroyo and is transported as either suspended load or bed load. Bed material load has a direct impact on channel dynamics and evolution because imbalances in the bed material transport capacity from one reach to the next can lead to aggradation or degradation. The bed material transport capacity was calculated with the MPM-Woo formula (Mussetter 2000; MEI 2008). MPM-Woo requires inputs of velocity and hydraulic depth that were derived from cross sectionally averaged hydraulic parameters (Sections III.C.1 and VII.A.3.b), bed material sediment gradation information from the sediment samples (Sections II.E and VII.B) and fine sediment concentration, from the MUSLE calculations (Sections III.C.2 and VII.B.1.a). Total sediment-transport capacities were calculated by summing the wash and bed material loads. Bulking factors were developed based on the ratio of total sediment volume to the anticipated total flow volume in each subreach. Computed sediment-transport capacities (including bed material load, wash load, and total load) along with the resulting bulking factors are listed in **Table 15** for each subreach by recurrence interval. Bulking factors for the 100-year event range from 1.08 to 1.15 and are consistent with values presented in the *Design Guide* (MEI, 2008). This range suggests that the use of a 1.18 bulking factor in the WMP HEC-HMS modeling is a reasonable but conservative estimate for predicting flood elevations and limits under the existing conditions hydrologic regime.

Table 15. Total Sediment-Transport Capacity

Subreach	Recurrence Interval (years)	Peak Flow (cfs)	Bed Material Load (cfs)	Wash Load (cfs)	Total Load Discharge (cfs)	Bulking Factor
1	2	63	0	0	0	1.00
1	5	472	9	9	18	1.02
1	10	1,192	54	54	109	1.04
1	25	2,652	233	233	466	1.08
1	50	4,132	514	514	1028	1.12
1	100	5,933	980	980	1961	1.15
2	2	65	0	0	1	1.00
2	5	477	9	9	19	1.02
2	10	1,195	57	57	113	1.05
2	25	2,659	234	234	468	1.09
2	50	4,139	437	437	875	1.10
2	100	5,940	877	877	1753	1.13

Subreach	Recurrence Interval (years)	Peak Flow (cfs)	Bed Material Load (cfs)	Wash Load (cfs)	Total Load Discharge (cfs)	Bulking Factor
3	2	72	1	1	2	1.01
3	5	481	12	12	24	1.04
3	10	1,207	23	23	46	1.03
3	25	2,678	91	91	182	1.03
3	50	4,169	165	165	330	1.04
3	100	5,981	195	195	390	1.04
4	2	103	0	0	0	1.00
4	5	486	5	5	10	1.01
4	10	1,216	25	25	50	1.02
4	25	2,692	77	77	153	1.03
4	50	4,187	134	134	267	1.04
4	100	6,004	221	221	441	1.04
5	2	109	1	1	2	1.00
5	5	467	10	10	20	1.03
5	10	1,104	49	49	98	1.05
5	25	2,443	207	207	414	1.08
5	50	3,460	340	340	680	1.11
5	100	4,505	504	504	1009	1.12
6	2	114	1	1	1	1.00
6	5	473	10	10	19	1.03
6	10	1,107	36	36	73	1.04
6	25	2,447	135	135	270	1.06
6	50	3,465	239	239	479	1.08
6	100	4,510	369	369	738	1.10
7	2	156	2	2	4	1.01
7	5	473	12	12	24	1.03
7	10	1,114	53	53	106	1.06
7	25	2,456	206	206	412	1.09
7	50	3,477	373	373	747	1.11
7	100	4,521	579	579	1159	1.14
8	2	169	1	1	3	1.01
8	5	476	11	11	21	1.03
8	10	1,117	55	55	111	1.05

Subreach	Recurrence Interval (years)	Peak Flow (cfs)	Bed Material Load (cfs)	Wash Load (cfs)	Total Load Discharge (cfs)	Bulking Factor
8	25	2,463	225	225	450	1.09
8	50	3,484	368	368	737	1.11
8	100	4,532	547	547	1094	1.13
9	2	214	6	6	11	1.02
9	5	484	16	16	33	1.05
9	10	1,132	62	62	124	1.07
9	25	2,488	197	197	393	1.09
9	50	3,515	327	327	653	1.11
9	100	4,568	489	489	977	1.13

B. SEDIMENT CONTINUITY ANALYSIS

The long-term mean annual bed material yield for each reach was calculated according to the *Design Guide* (MEI, 2008). In addition to the mean annual yield, yield from all recurrence interval events are presented in **Table 16**.

Table 16. Existing Conditions Bed Material Yields

Subreach	Bed Material Yield (cu ft)						
	2-year	5-year	10-year	25-year	50-year	100-year	Mean Annual
1	406	100,447	507,066	1,882,492	3,803,099	6,751,384	294,434
2	1,233	123,260	532,278	1,971,006	3,456,627	5,945,665	287,602
3	4,987	203,179	385,045	746,948	1,291,134	1,822,475	150,016
4	455	60,643	269,172	778,974	1,294,752	1,598,551	108,403
5	3,548	148,000	550,746	1,998,826	3,606,649	5,737,922	295,201
6	3,807	155,497	502,084	1,494,052	2,688,711	4,304,239	237,445
7	8,428	195,936	706,418	2,186,841	4,041,776	6,593,733	346,078
8	8,028	163,500	673,954	2,287,499	4,100,482	6,455,125	339,662
9	24,070	311,311	938,336	2,439,518	4,074,151	6,245,161	399,328

C. EQUILIBRIUM SLOPES

The equilibrium slope is an estimate of the slope to which the bed of the arroyo would adjust over the long term given a specific hydrologic regime and bed material supply conditions. Based on procedures presented in the *Design Guide* (MEI, 2008), the equilibrium slope represents a future condition wherein the bed material transport capacity of the arroyo is in balance with the upstream bed material supply, considering anticipated changes to arroyo geometry. The dominant discharge is required to estimate future changes to arroyo geometry and represents the peak discharge of the flood that would produce the calculated mean annual bed material yield. As such, the dominant discharge was calculated for each reach by interpolation of the mean annual bed material loads and bounding event-based loads (**Table 16**) and the associated event-based peak discharges. The dominant width is a function of the dominant discharge and approximates the width to which the arroyo would adjust if the channel width could freely adjust and existing sediment supply persisted for long enough; it was initially calculated using Equation 3.36 or Equation 3.47 from the *Design Guide* (MEI, 2008), as appropriate. Because the mean annual bed material sediment-transport capacity calculations are based on ExC hydrology, the calculated dominant width in some subreaches was less than the existing channel width. (The dominant width calculations are intended to provide a best-estimate of future channel geometry based on a long-term hydrologic and sediment regime, so the calculations may not accurately represent the existing channel geometry that has already responded to a relatively short-term hydrologic and sediment regime.) In these cases, the existing width of the arroyo was used as the dominant width. The resulting dominant width and dominant discharge values are presented for each subreach in **Table 17**.

Table 17. Dominant Width and Discharge

Subreach	Dominant Width (ft)	Existing Width (ft)	Dominant Discharge (cfs)
1	117 *	130	1,187
2	188 *	210	1,188
3	145	130	1,196
4	155 *	170	1,201
5	83	50	901
6	153 *	165	902
7	143 *	160	904
8	70 *	80	906
9	95	110	914

*Calculated dominant width was less than the existing channel width.

An equilibrium slope was initially computed for each subreach using Equation 3.30 from the *Design Guide* (MEI, 2008). To be consistent with the methods used to compute equilibrium slopes in the Northern Blvd to Broadmoor Blvd reach (Tetra Tech, 2024), the resulting initial estimates of the equilibrium slope were then refined based on the fundamental principles outlined in the *Design Guide* (MEI, 2008) to develop final estimates of the equilibrium slope. The refinements to the equilibrium slope calculations involved the following steps:

- An average annual hydrograph that preserved the shape of the individual flood hydrographs and produced the average annual sediment supply was estimated. Since the sediment supplies for the 5- and 10-year events bracket the average annual sediment supply, the ordinates of the average annual hydrograph were determined by interpolation between the hydrographs for these two storms.
- The initial equilibrium slope estimates from *Design Guide* (MEI, 2008) Equation 3.30 was then used to compute the transport capacity associated with the average annual hydrograph based on normal depth hydraulics and the MPM-Woo sediment-transport relationship. The normal depth hydraulics were based on a wide rectangular channel with the width equal to the dominant width for each subreach.
- The final equilibrium slope was then determined by adjusting the assumed slope until the computed transport capacity of each subreach was equal to the average annual sediment supply over the long-term. For Subreaches 1 through 4, located upstream from the Sportsplex Dam, the upstream sediment supply was computed using the sediment rating curves in the subreach upstream from Broadmoor Blvd (i.e., the transport capacity of Tetra Tech Subreach 4 in the Northern Blvd to Broadmoor Blvd RSP; Tetra Tech (2024)). For Subreaches 5 through 9, the sediment supply is controlled by the sediment-trapping effects of Sportsplex Dam. Because Subreach 5 has already flattened substantially in response to the reduced sediment supply, the sediment-transport capacity of this subreach was adopted as the sediment supply to the remaining downstream reaches.

The final, refined estimates for the equilibrium slope in each of the subreaches are presented in **Table 18**.

Table 18. Equilibrium Slope

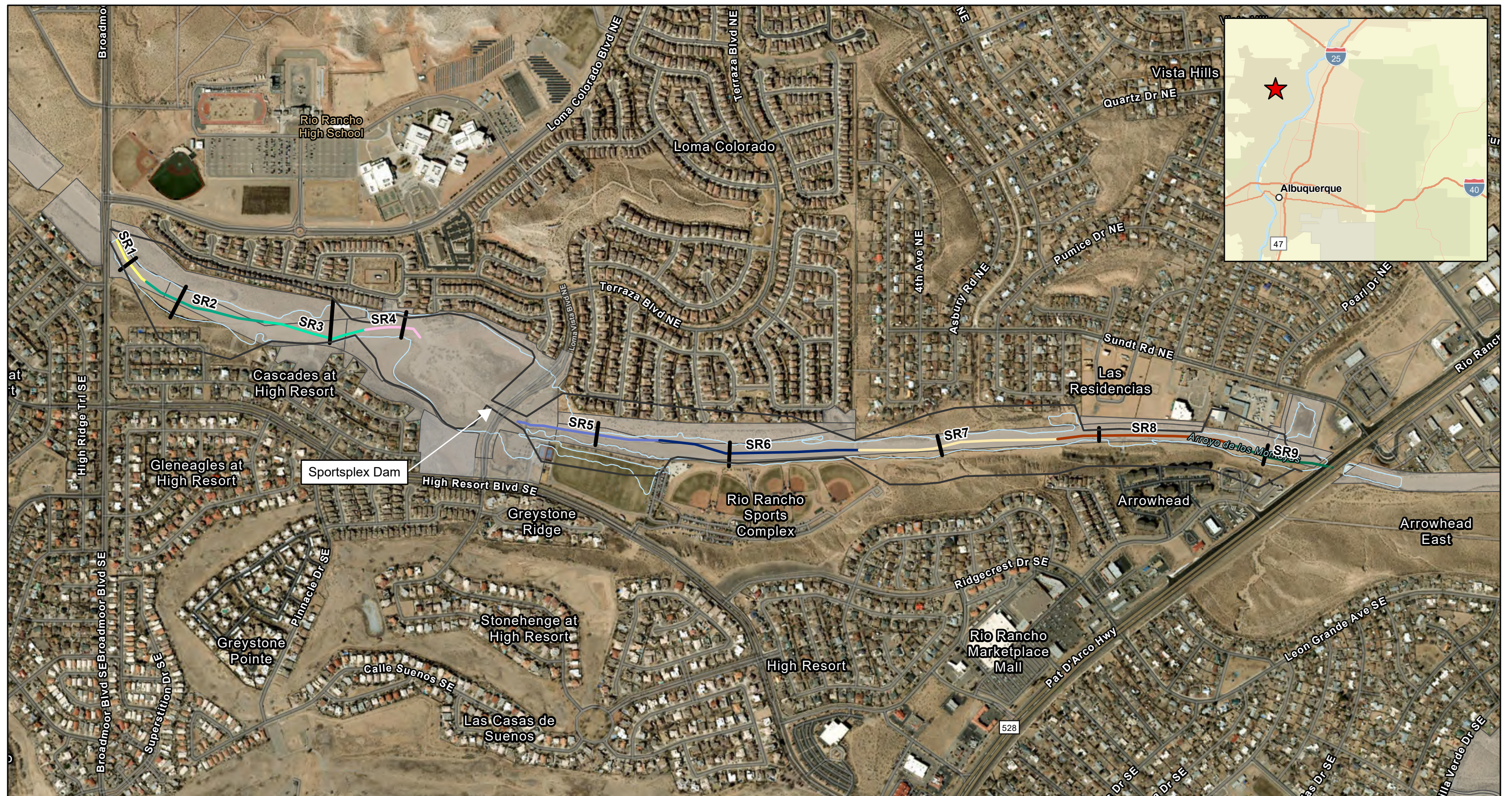
Reach	Equilibrium Slope	Existing Slope
1	0.95%	1.06%
2	0.95%	1.22%
3	0.93%	1.02%
4	0.89%	0.96%
5	0.59%	0.60%
6	1.26%	1.34%
7	1.23%	1.43%
8	1.10%	1.35%
9	1.06%	1.38%

D. LEE LINES

Lateral erosion risk was analyzed per subreach using LEE Line calculations as outlined in the *Design Guide* (MEI 2008). This methodology assumes supercritical flow in the arroyo, tending toward critical over time. The dominant widths and discharges as previously discussed along with the existing channel bed slope were used as the inputs to this calculation. Final erosion widths used to develop the LEE lines are shown in **Figure 51** are listed in **Table 19**. The channel alignment centerline was visually delineated along the centroid of the main channel flow-line, offset to these widths, then tied into known hard points to create the LEE Lines in **Figure 51**. The resulting LEE lines are generally narrower than the current LEE lines publicly available on SSCAFCA's published interactive map.

Table 19. Total Erosion Widths Used in LEE Line Development

Subreach	Total Erosion Width (ft)
1	661
2	718
3	695
4	712
5	609
6	605
7	590
8	523
9	548



E. LOCAL SCOUR

To calculate local scour, proposed hydraulic conditions were calculated as they were for ExC using the existing 100-year, unbulked flows. The hydraulic parameters were based on unbulked flow rates because the bulking factors would be expected to reduce substantially under equilibrium slope conditions, and re-computation of the bulking factors for proposed conditions was beyond the scope of this study. The resulting hydraulic parameters were used as input (**Table 20**) to the flow impinging on a wall (at 5 degrees based on a conservative representation of the modeled flow vectors) and antidune scour calculations per SSCAFCA's *Design Guide* (MEI, 2008). Very few of the subreaches likely experience flow impinging at an angle on the proposed BP, and the few that would experience an angle only experience a small (approximately 5 degree) angle. To be conservative, this maximum angle was applied to all scour along a wall calculation. Resulting local scour depths and corresponding potential solutions are listed in **Table 21**.

Table 20. Proposed 100-year, Unbulked, Hydraulic Parameters

Subreach	Flow (cfs)	Depth Inc (ft)	Area (sq ft)	Hydraulic Depth (ft)	Hydraulic Radius (ft)	Velocity (fps)	Energy Grade Slope (ft/ft)	Shear Stress (psf)
1	5,933	4.70	535	3.87	1.23	11.09	0.04	3.32
2	5,940	3.45	613	2.63	0.76	9.70	0.06	2.98
3	5,981	5.02	925	2.74	1.25	6.46	0.01	1.12
4	6,004	5.25	806	4.12	1.41	7.45	0.02	1.43
5	4,505	6.55	413	4.44	0.91	10.90	0.06	3.54
6	4,510	3.31	472	2.90	1.15	9.55	0.04	2.52
7	4,521	3.37	445	3.01	1.13	10.16	0.04	2.87
8	4,532	5.75	386	4.79	1.38	11.73	0.04	3.58
9	4,568	4.65	428	3.82	0.83	10.66	0.07	3.50

Table 21. Local Scour Calculation Results

Subreach	Flow Impinging on Wall Scour Depth (ft)	Antidune Scour Depth (ft)	Rounded Total Scour Depth (ft)	BP ID	GCS ID
1	4.1	1.8	6.0	1, 9, 10	1
2	3.1	1.2	4.5	2, 11, 12	
3	4.3	1.5	6.0	3	-
4	4.4	0.8	5.5	-	-
5	4.5	1.3	6.0	4, 13	2
6	3.1	1.5	5.0	5	-
7	3.7	1.4	5.5	6, 14	-
8	4.9	1.6	6.5	7, 15	3, 4
9	3.9	1.6	5.5	8, 16	4

MUSLE Wash Load Calculations
Project Name: Montoyas Arroyo RSP
Project Number: 20240328
Prepared By: ELA
Date: 6/4/2024

Color Key		
Input	Linked Cell	Calculation

MUSLE Yields By Sub-Reach bulking factors change a small amount (less than 0.001 for 10% increase in impervious)

	α :	285	β :	0.56	K :	0.24	C :	0.2	P :	1	F_{fs} :	26.07	LS :	0.170	F_{imp} :	0.032
Subreach	V (acre-ft)						q _p (cfs)									
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr				
1	15	216	496	951	1,342	1,792	63	472	1,192	2,652	4,132	5,933				
2	18	222	502	962	1,355	1,807	65	477	1,195	2,659	4,139	5,940				
3	23	227	510	973	1,369	1,825	72	481	1,207	2,678	4,169	5,981				
4	33	245	530	998	1,399	1,860	103	486	1,216	2,692	4,187	6,004				
5	35	245	533	1,003	1,406	1,868	109	467	1,104	2,443	3,460	4,505				
6	38	250	538	1,011	1,415	1,881	114	469	1,107	2,447	3,466	4,510				
7	45	262	555	1,033	1,439	1,906	156	473	1,114	2,456	3,477	4,521				
8	50	269	563	1,043	1,454	1,925	169	476	1,117	2,463	3,484	4,532				
9	81	317	627	1,129	1,559	1,966	221	534	1,158	2,533	3,575	4,568				

Subreach	R _w						Y _s , Clay & Silt (tons)						Y' _s , Clay & Silt adj. for Impervious Area (tons)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
1	12,961	181,659	486,293	1,096,061	1,704,095	2,453,498	2,746	38,495	103,051	232,267	361,116	519,922	2,659	37,273	99,777	224,889	349,645	503,407
2	14,911	185,451	490,534	1,104,657	1,714,805	2,466,674	3,160	39,299	103,949	234,089	363,386	522,715	3,059	38,051	100,647	226,653	351,843	506,111
3	17,881	189,132	497,500	1,116,253	1,731,908	2,489,759	3,789	40,079	105,426	236,546	367,010	527,607	3,669	38,806	102,077	229,032	355,352	510,847
4	26,851	198,564	510,337	1,135,356	1,756,949	2,521,838	5,690	42,078	108,146	240,594	372,316	534,404	5,509	40,741	104,711	232,951	360,490	517,429
5	28,823	194,048	485,247	1,078,632	1,583,452	2,152,446	6,108	41,121	102,829	228,574	335,550	456,126	5,914	39,815	99,563	221,313	324,892	441,637
6	30,846	196,438	488,603	1,084,583	1,590,391	2,161,817	6,537	41,627	103,540	229,835	337,021	458,112	6,329	40,305	100,251	222,534	326,315	443,560
7	40,816	202,794	498,807	1,099,458	1,608,496	2,181,275	8,649	42,974	105,703	232,987	340,857	462,236	8,375	41,609	102,345	225,586	330,030	447,553
8	45,173	206,546	503,627	1,107,771	1,619,556	2,196,200	9,573	43,769	106,724	234,749	343,201	465,398	9,269	42,379	103,334	227,292	332,299	450,615
9	68,517	241,691	545,845	1,176,245	1,708,410	2,232,019	14,520	51,217	115,670	249,259	362,030	472,989	14,058	49,590	111,996	241,341	350,530	457,964

Cf calculations for MPM-Woo

Subreach	C _f (ppm)						AA
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	118,818	112,747	129,000	148,220	160,844	171,263	91,307
2	111,039	112,176	128,470	147,765	160,403	170,840	88,008
3	107,106	111,566	128,357	147,639	160,335	170,785	86,297
4	110,544	108,861	126,990	146,597	159,370	169,892	86,952
5	111,278	106,649	120,836	139,625	145,318	148,152	85,495
6	110,311	106,185	120,551	139,345	145,089	147,855	84,973
7	119,385	104,618	119,428	138,463	144,410	147,291	88,146
8	119,612	103,773	118,976	138,138	143,980	146,914	88,007
9	113,427	103,107	116,171	135,869	141,991	146,310	85,045

Montoyas Arroyo Reach Stabilization Project

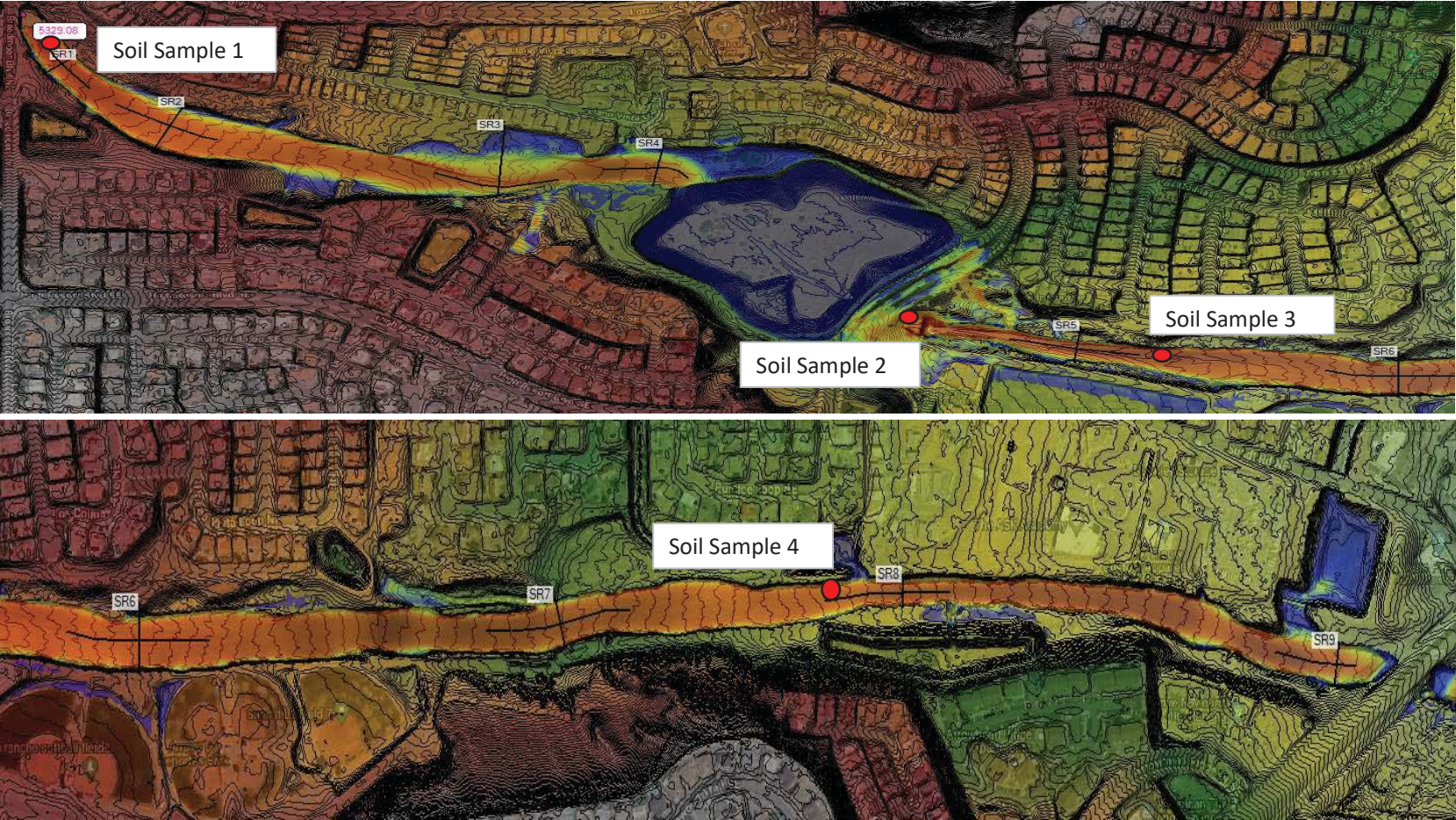
Develop sediment-Rating Curves using the MPM-Woo Equation

JN: 20240328

Created: ELA (4/9/2024)

PM: SCT

Subreach	Soil Sample	qs	Qs	Qsf	Qst	Max Ratio of Sediment	Ratio of Sediment, Total Storm	Bulking Factor
SR1	S1	7	980	980	1961	0.25	0.15	1.15
SR2	S1	4	877	877	1,753	0.23	0.13	1.13
SR3	S1	1	195	195	390	0.06	0.04	1.04
SR4	S1	1	221	221	441	0.07	0.04	1.04
SR5	S2	5	504	504	1,009	0.18	0.12	1.12
SR6	S3	2	369	369	738	0.14	0.10	1.10
SR7	S3	4	579	579	1,159	0.20	0.14	1.14
SR8	S4	7	547	547	1,094	0.19	0.13	1.13
SR9	S4	4	489	489	977	0.18	0.13	1.13



Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
PM: SCT

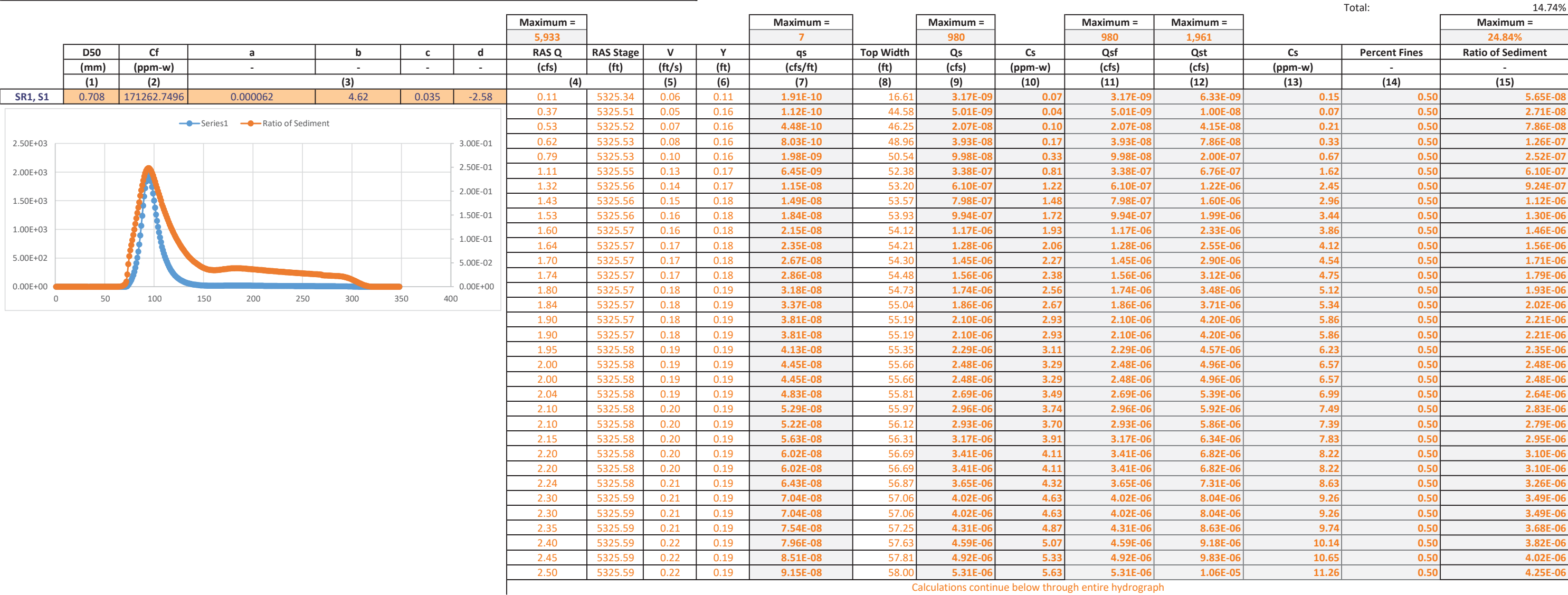
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Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
 S_o = channel slope

- NOTES**

 - (1) From BHI Lab results - see "Soil Data" tab
 - (2) From MUSLE Calcs
 - (3) Coefficients from SSCAFCA Sediment Design Guide Figure C.2. See Tab "Coefficients"
 - (4) RAS Rating Curve for Subreach XS
 - (5) Velocity calculated per rating curve data point. RAS Q/Stream A
 - (6) Hydraulic Depth calculated per rating curve data point. Stream A/Stream TW
 - (7) Calculated per eqn C.3 (left)
 - (8) Stream TW per RAS Rating Curve stage
- (9) $Q_s = q_s \times \text{Top Width}$
 - (10) Calculated per eqn C.5
 - (11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$
 - (12) $Q_{sTotal} = Q_s + Q_{sf}$
 - (13) $C_{sTotal} = (2.65E6 \times Q_{sTotal}) / (Q + 2.65 \times Q_{sTotal})$
 - (14) Percent Fines = Q_{sf} / Q_{st}
 - (15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$



Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
PM: SCT

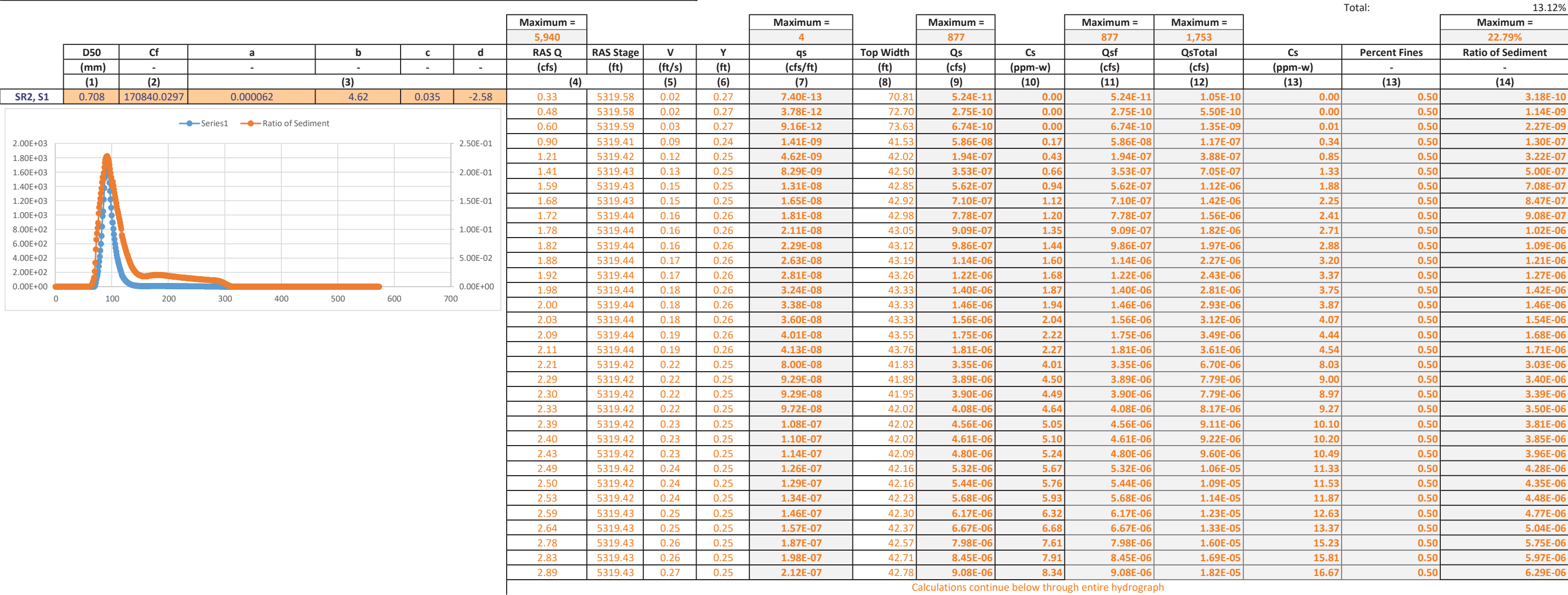
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Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
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- NOTES**

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 - (8) Stream TW per RAS Rating Curve stage
- (9) $Q_s = q_s \times \text{Top Width}$
 - (10) Calculated per eqn C.5
 - (11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$
 - (12) $Q_{sTotal} = Q_s + Q_{sf}$
 - (13) $C_{sTotal} = (2.65E6 \times Q_{sTotal}) / (Q + 2.65 \times Q_{sTotal})$
 - (14) Percent Fines = Q_{sf} / Q_{st}
 - (15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$



Montoyas Arroyo Reach Stabilization Project
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PM: SCT

Calculations based on SSCAFCA's Sediment Design Guide (2008) Appendix C: "P:\20240328\Archive\Received\SSCAFCA\2024.04.03 Sediment Design Guide\SSCAFCA_Sediment Design Guide 12-30-08.pdf"
Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

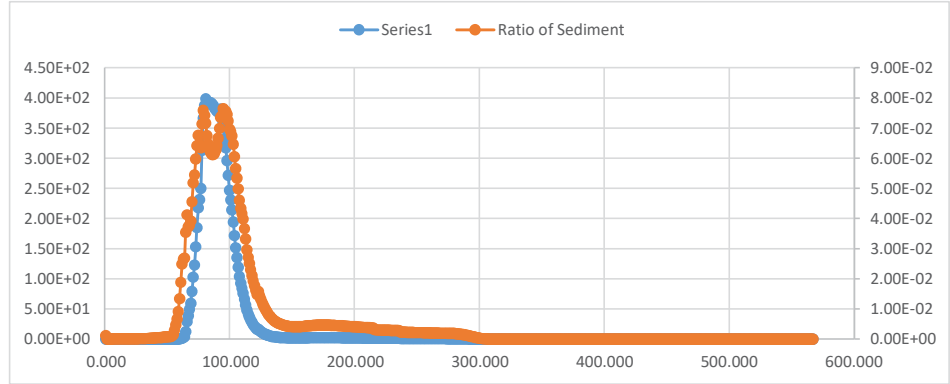
$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
 S_o = channel slope

- NOTES**

 - (1) From BHI Lab results - see "Soil Data" tab
 - (2) From MUSLE Calcs
 - (3) Coefficients from SSCAFCA Sediment Design Guide Figure C.2. See Tab "Coefficients"
 - (4) RAS Rating Curve for Subreach XS
 - (5) Velocity calculated per rating curve data point. RAS Q/Stream A
 - (6) Hydraulic Depth calculated per rating curve data point. Stream A/Stream TW
 - (7) Calculated per eqn C.3 (left)
 - (8) Stream TW per RAS Rating Curve stage
- (9) $Q_s = q_s \times \text{Top Width}$
 - (10) Calculated per eqn C.5
 - (11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$
 - (12) $Q_{sTotal} = Q_s + Q_{sf}$
 - (13) $C_{sTotal} = (2.65E6 \times Q_{sTotal}) / (Q + 2.65 \times Q_{sTotal})$
 - (14) Percent Fines = Q_{sf} / Q_{st}
 - (15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$

Total: 4.38%																						
						Maximum = 5,981					Maximum = 1				Maximum = 195			Maximum = 195	Maximum = 390			Maximum = 6.12%
	D50	Cf	a	b	c	d	RAS Q	RAS Stage	V	Y	qs	Top Width	Qs	Cs	Qsf	QsTotal	Cs	Percent Fines	Ratio of Sediment			
	(mm)	-	-	-	-	-	(cfs)	(ft)	(ft/s)	(ft)	(cfs/ft)	(ft)	(cfs)	(ppm-w)	(cfs)	(cfs)	(ppm-w)	-	-			
	(1)	(2)	(3)				(4)		(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(13)	(14)			
SR3, S1	0.708	170784.8437	0.000062		4.62	0.035	-2.58	0.12	5304.09	0.68	0.04	1.48E-05	4.71	6.95E-05	1519.34	6.95E-05	1.39E-04	3034.06	0.50	1.15E-03		
							0.70	5304.25	0.34	0.09	5.97E-07	22.70	1.36E-05	51.67	1.36E-05	2.71E-05	103.34	0.50	3.90E-05			
							1.18	5304.29	0.38	0.11	1.08E-06	28.05	3.02E-05	67.61	3.02E-05	6.04E-05	135.21	0.50	5.10E-05			
							1.45	5304.31	0.40	0.12	1.37E-06	29.14	3.98E-05	72.75	3.98E-05	7.97E-05	145.50	0.50	5.49E-05			
							1.61	5304.32	0.41	0.13	1.58E-06	29.68	4.68E-05	77.19	4.68E-05	9.35E-05	154.36	0.50	5.83E-05			
							1.74	5304.32	0.42	0.14	1.75E-06	30.14	5.28E-05	80.30	5.28E-05	1.06E-04	160.58	0.50	6.06E-05			
							1.99	5304.34	0.44	0.15	2.12E-06	30.98	6.58E-05	87.57	6.58E-05	1.32E-04	175.13	0.50	6.61E-05			
							2.09	5304.34	0.45	0.15	2.28E-06	31.35	7.16E-05	90.69	7.16E-05	1.43E-04	181.37	0.50	6.84E-05			
							2.17	5304.34	0.45	0.15	2.45E-06	31.56	7.72E-05	94.48	7.72E-05	1.54E-04	188.94	0.50	7.13E-05			
							2.29	5304.35	0.47	0.15	2.78E-06	31.85	8.85E-05	102.57	8.85E-05	1.77E-04	205.12	0.50	7.74E-05			
							2.35	5304.35	0.47	0.16	2.97E-06	32.00	9.49E-05	107.12	9.49E-05	1.90E-04	214.22	0.50	8.08E-05			
							2.39	5304.35	0.48	0.16	3.13E-06	32.06	1.00E-04	111.13	1.00E-04	2.00E-04	222.24	0.50	8.39E-05			
							2.41	5304.35	0.48	0.16	3.16E-06	32.13	1.02E-04	111.61	1.02E-04	2.03E-04	223.20	0.50	8.42E-05			
							2.46	5304.35	0.49	0.16	3.34E-06	32.20	1.07E-04	115.96	1.07E-04	2.15E-04	231.90	0.50	8.75E-05			
							2.48	5304.35	0.49	0.16	3.42E-06	32.27	1.10E-04	117.77	1.10E-04	2.21E-04	235.51	0.50	8.89E-05			
							2.58	5304.36	0.50	0.16	3.87E-06	32.40	1.26E-04	128.74	1.26E-04	2.51E-04	257.44	0.50	9.72E-05			
							2.67	5304.36	0.51	0.16	4.14E-06	32.61	1.35E-04	134.00	1.35E-04	2.70E-04	267.96	0.50	1.01E-04			
							2.72	5304.36	0.52	0.16	4.40E-06	32.68	1.44E-04	139.95	1.44E-04	2.88E-04	279.85	0.50	1.06E-04			
							2.82	5304.36	0.52	0.16	4.75E-06	32.88	1.56E-04	146.66	1.56E-04	3.12E-04	293.28	0.50	1.11E-04			
							2.87	5304.37	0.53	0.17	4.89E-06	33.02	1.61E-04	148.97	1.61E-04	3.23E-04	297.90	0.50	1.12E-04			
							2.90	5304.37	0.53	0.17	5.12E-06	33.02	1.69E-04	154.49	1.69E-04	3.38E-04	308.93	0.50	1.17E-04			
							2.92	5304.37	0.53	0.17	5.13E-06	33.09	1.70E-04	153.98	1.70E-04	3.39E-04	307.92	0.50	1.16E-04			
							2.97	5304.37	0.54	0.17	5.44E-06	33.15	1.80E-04	160.58	1.80E-04	3.60E-04	321.11	0.50	1.21E-04			
							3.00	5304.37	0.54	0.17	5.48E-06	33.22	1.82E-04	160.96	1.82E-04	3.64E-04	321.87	0.50	1.21E-04			
							3.04	5304.37	0.54	0.17	5.67E-06	33.29	1.89E-04	164.63	1.89E-04	3.77E-04	329.20	0.50	1.24E-04			
							3.08	5304.37	0.55	0.17	5.88E-06	33.36	1.96E-04	168.70	1.96E-04	3.92E-04	337.34	0.50	1.27E-04			
							3.17	5304.37	0.56	0.17	6.38E-06	33.49	2.14E-04	178.45	2.14E-04	4.27E-04	356.84	0.50	1.35E-04			
							3.38	5304.38	0.58	0.17	7.47E-06	33.84	2.53E-04	198.18	2.53E-04	5.05E-04	396.28	0.50	1.50E-04			
							3.46	5304.38	0.59	0.17	7.94E-06	33.97	2.70E-04	206.48	2.70E-04	5.40E-04	412.87	0.50	1.56E-04			
							3.54	5304.38	0.59	0.18	8.37E-06	34.10	2.85E-04	213.37	2.85E-04	5.71E-04	426.65	0.50	1.61E-04			
							3.65	5304.38	0.60	0.18	9.13E-06	34.22	3.13E-04	226.81	3.13E-04	6.25E-04	453.51	0.50	1.71E-04			
							3.87	5304.39	0.62	0.18	1.07E-05	34.46	3.70E-04	253.68	3.70E-04	7.41E-04	507.23	0.50	1.91E-04			
							4.14	5304.39	0.65	0.18	1.26E-05	34.80	4.38E-04	280.55	4.38E-04	8.76E-04	560.93	0.50	2.12E-04			
Calculations continue below through entire hydrograph																						



Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
PM: SCT

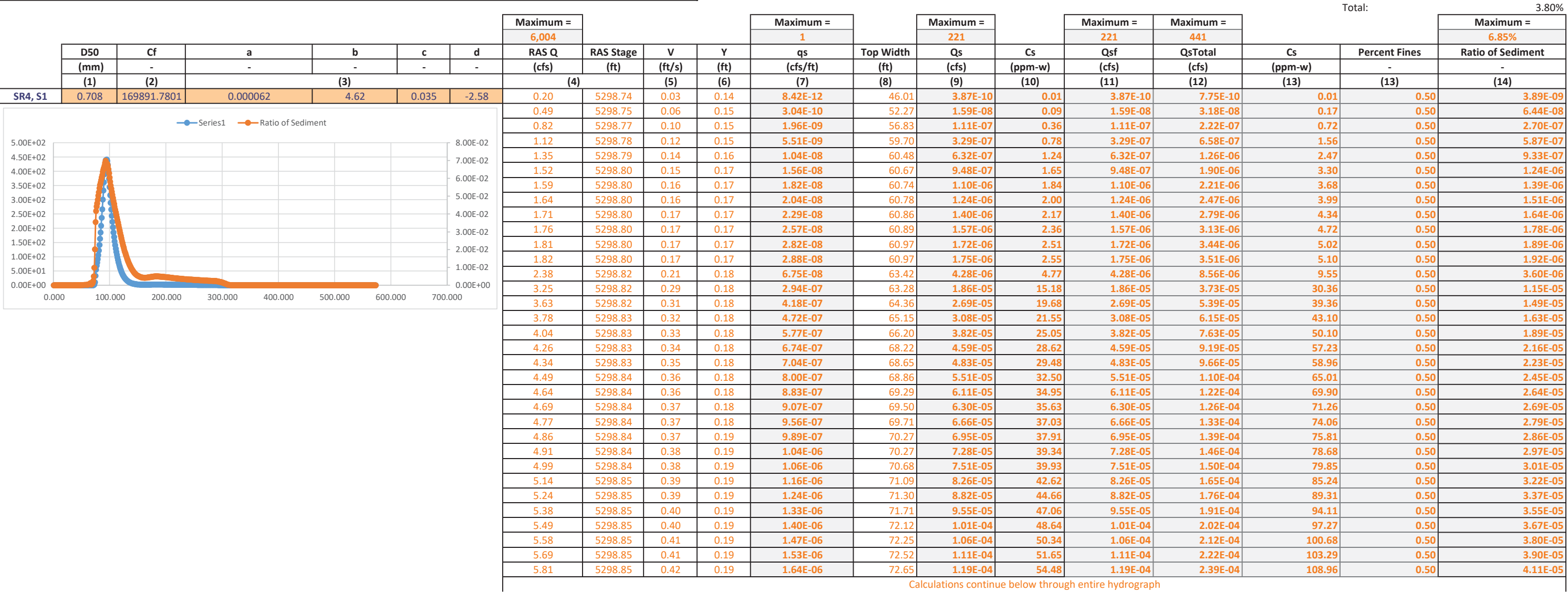
Calculations based on SSCAFCA's Sediment Design Guide (2008) Appendix C: "P:\20240328\Archive\Received\SSCAFCA\2024.04.03 Sediment Design Guide\SSCAFCA_Sediment Design Guide 12-30-08.pdf"
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100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
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 C_f = fine sediment (silt and clay) concentration by weight
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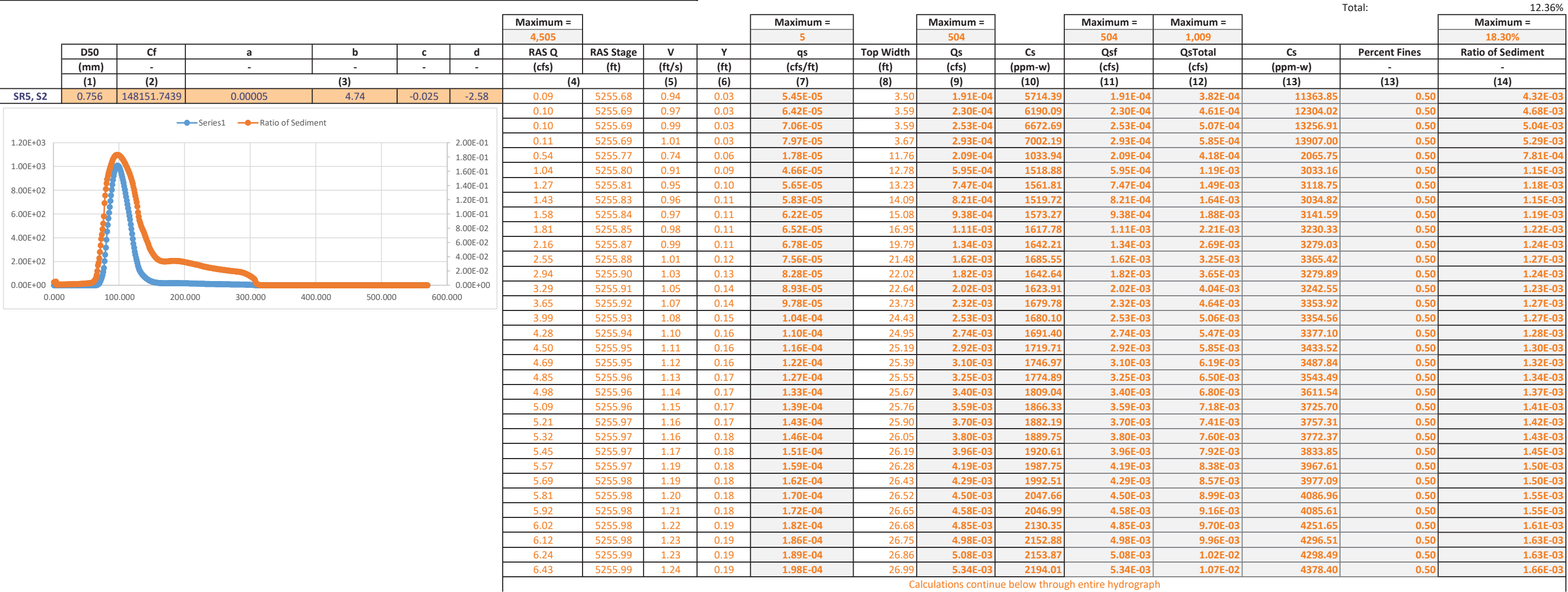
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(14) Percent Fines = Q_{sf} / Q_{st}

(15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$

Total: 9.51%																											
						Maximum = 4,510					Maximum = 2				Maximum = 369			Maximum = 369	Maximum = 738					Maximum = 14.06%			
						RAS Q	RAS Stage	V	Y	qs	Top Width	Qs	Cs	Qsf	QsTotal	Cs	Percent Fines	Ratio of Sediment									
						(cfs)	(ft)	(ft/s)	(ft)	(cfs/ft)	(ft)	(cfs)	(ppm-w)	(cfs)	(cfs)	(ppm-w)	-	-									
						(1)	(2)	(3)		(4)		(5)	(6)	(7)		(8)	(9)	(10)	(11)		(12)	(13)		(13)	(14)		
SR6, S3	0.850	147854.9828	0.00002		5.03	-0.150	-2.56	0.00	5245.35	0.00	0.13	3.78E-25	78.38	2.96E-23	0.00	2.96E-23	5.93E-23	0.00	0.50	5.93E-20							
Series1 Ratio of Sediment																											
								0.08	5245.26	0.02	0.08	1.92E-13	43.76	8.41E-12	0.00	8.41E-12	1.68E-11	0.00	0.50	2.13E-10							
								0.10	5245.25	0.03	0.08	7.64E-13	42.73	3.26E-11	0.00	3.26E-11	6.53E-11	0.00	0.50	6.59E-10							
								0.10	5245.25	0.03	0.08	8.44E-13	42.73	3.61E-11	0.00	3.61E-11	7.22E-11	0.00	0.50	7.14E-10							
								0.10	5245.25	0.03	0.08	8.87E-13	42.73	3.79E-11	0.00	3.79E-11	7.58E-11	0.00	0.50	7.43E-10							
								0.22	5245.28	0.04	0.10	6.25E-12	52.16	3.26E-10	0.00	3.26E-10	6.52E-10	0.01	0.50	2.97E-09							
								1.24	5245.31	0.20	0.11	1.20E-08	59.05	7.11E-07	1.52	7.11E-07	1.42E-06	3.04	0.50	1.15E-06							
								1.56	5245.31	0.23	0.11	2.91E-08	61.47	1.79E-06	3.03	1.79E-06	3.58E-06	6.06	0.50	2.29E-06							
								1.75	5245.32	0.26	0.11	4.60E-08	62.26	2.86E-06	4.35	2.86E-06	5.72E-06	8.69	0.50	3.28E-06							
								1.97	5245.32	0.28	0.11	6.97E-08	63.84	4.45E-06	6.00	4.45E-06	8.90E-06	11.99	0.50	4.52E-06							
								2.32	5245.32	0.31	0.11	1.31E-07	66.01	8.68E-06	9.90	8.68E-06	1.74E-05	19.80	0.50	7.47E-06							
								2.73	5245.33	0.35	0.12	2.28E-07	66.86	1.52E-05	14.78	1.52E-05	3.05E-05	29.55	0.50	1.12E-05							
								3.13	5245.31	0.49	0.11	1.27E-06	59.05	7.47E-05	63.17	7.47E-05	1.49E-04	126.34	0.50	4.77E-05							
								3.53	5245.31	0.53	0.11	1.82E-06	61.07	1.11E-04	83.60	1.11E-04	2.23E-04	167.19	0.50	6.31E-05							
								3.86	5245.32	0.56	0.11	2.48E-06	62.26	1.55E-04	106.14	1.55E-04	3.09E-04	212.27	0.50	8.01E-05							
								4.19	5245.32	0.59	0.11	3.11E-06	63.84	1.99E-04	125.67	1.99E-04	3.97E-04	251.31	0.50	9.48E-05							
								4.44	5245.32	0.61	0.11	3.56E-06	65.87	2.35E-04	140.19	2.35E-04	4.70E-04	280.34	0.50	1.06E-04							
								4.64	5245.32	0.63	0.11	4.25E-06	66.01	2.80E-04	160.20	2.80E-04	5.61E-04	320.35	0.50	1.21E-04							
								4.81	5245.33	0.64	0.11	4.64E-06	66.29	3.08E-04	169.64	3.08E-04	6.15E-04	339.21	0.50	1.28E-04							
								4.95	5245.33	0.65	0.11	5.14E-06	66.44	3.41E-04	182.73	3.41E-04	6.83E-04	365.40	0.50	1.38E-04							
								5.08	5245.33	0.66	0.11	5.58E-06	66.58	3.72E-04	193.97	3.72E-04	7.43E-04	387.87	0.50	1.46E-04							
								5.19	5245.33	0.67	0.12	5.94E-06	66.72	3.97E-04	202.61	3.97E-04	7.93E-04	405.13	0.50	1.53E-04							
								5.30	5245.33	0.68	0.12	6.37E-06	66.86	4.26E-04	212.76	4.26E-04	8.52E-04	425.43	0.50	1.61E-04							
								5.41	5245.33	0.69	0.12	6.75E-06	67.00	4.52E-04	221.42	4.52E-04	9.05E-04	442.75	0.50	1.67E-04							
								5.54	5245.33	0.69	0.11	6.85E-06	72.03	4.93E-04	236.11	4.93E-04	9.87E-04	472.10	0.50	1.78E-04							
								5.66	5245.33	0.70	0.11	7.33E-06	72.22	5.30E-04	247.70	5.30E-04	1.06E-03	495.28	0.50	1.87E-04							
								5.80	5245.33	0.71	0.11	7.92E-06	72.40	5.73E-04	261.63	5.73E-04	1.15E-03	523.12	0.50	1.97E-04							
								5.99	5245.34	0.72	0.11	8.50E-06	72.77	6.19E-04	273.50	6.19E-04	1.24E-03	546.85	0.50	2.06E-04							
								6.11	5245.34	0.73	0.11	8.95E-06	72.96	6.53E-04	283.17	6.53E-04	1.31E-03	566.18	0.50	2.14E-04							
								6.21	5245.34	0.73	0.12	9.30E-06	73.14	6.81E-04	290.24	6.81E-04	1.36E-03	580.31	0.50	2.19E-04							
								6.32	5245.34	0.75	0.12	1.01E-05	73.14	7.40E-04	310.49	7.40E-04	1.48E-03	620.79	0.50	2.34E-04							
								6.50	5245.34	0.76	0.12	1.07E-05	73.51	7.89E-04	321.42	7.89E-04	1.58E-03	642.63	0.50	2.43E-04							
								6.69	5245.34	0.76	0.12	1.10E-05	76.51	8.45E-04	334.52	8.45E-04	1.69E-03	668.81	0.50	2.52E-04							
Calculations continue below through entire hydrograph																											

Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
PM: SCT

Calculations based on SSCAFCA's Sediment Design Guide (2008) Appendix C: "P:\20240328\Archive\Received\SSCAFCA\2024.04.03 Sediment Design Guide\SSCAFCA_Sediment Design Guide 12-30-08.pdf"
Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
 S_o = channel slope

- NOTES**

(1) From BHI Lab results - see "Soil Data" tab

(2) From MUSLE Calcs

(3) Coefficients from SSCAFCA Sediment Design Guide Figure C.2. See Tab "Coefficients"

(4) RAS Rating Curve for Subreach XS

(5) Velocity calculated per rating curve data point. RAS Q/Stream A

(6) Hydraulic Depth calculated per rating curve data point. Stream A/Stream TW

(7) Calculated per eqn C.3 (left)

(8) Stream TW per RAS Rating Curve stage
- (9) $Q_s = q_s \times \text{Top Width}$

(10) Calculated per eqn C.5

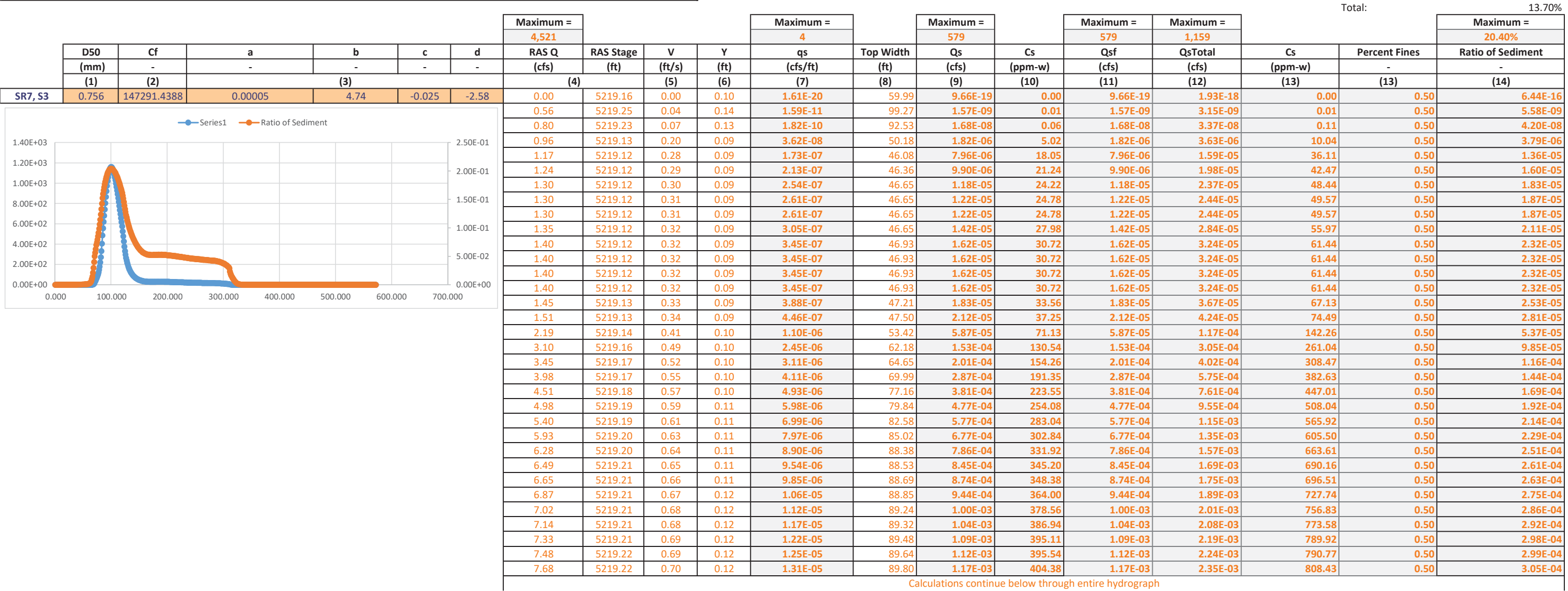
(11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$

(12) $Q_{sTotal} = Q_s + Q_{sf}$

(13) $C_{sTotal} = (2.65E6 \times Q_{sTotal}) / (Q + 2.65 \times Q_{sTotal})$

(14) Percent Fines = Q_{sf} / Q_{st}

(15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$



Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
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Calculations based on SSCAFCA's Sediment Design Guide (2008) Appendix C: "P:\20240328\Archive\Received\SSCAFCA\2024.04.03 Sediment Design Guide\SSCAFCA_Sediment Design Guide 12-30-08.pdf"
Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
 S_o = channel slope

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(1) From BHI Lab results - see "Soil Data" tab

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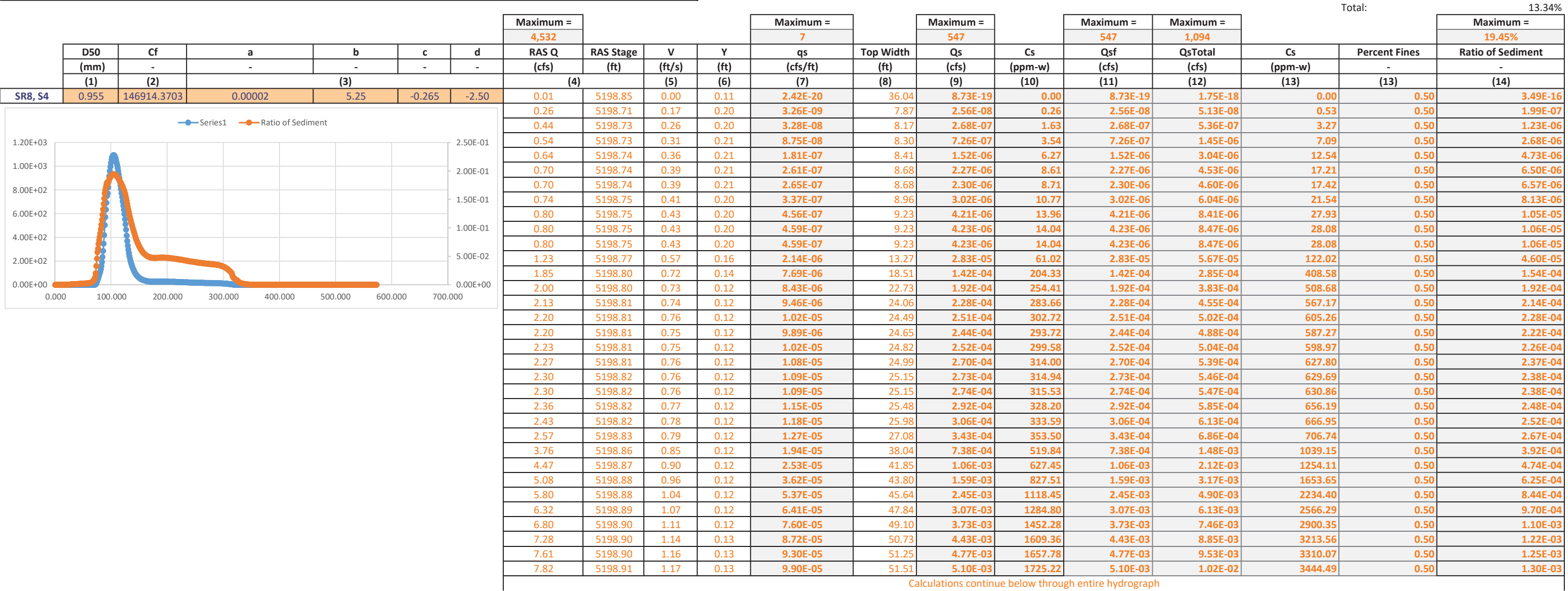
(11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$

(12) $Q_{sTotal} = Q_s + Q_{sf}$

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(14) Percent Fines = Q_{sf} / Q_{st}

(15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$



Montoyas Arroyo Reach Stabilization Project
Develop sediment-Rating Curves using the MPM-Woo Equation
JN: 20240328
Created: ELA (4/9/2024)
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Calculations based on SSCAFCA's Sediment Design Guide (2008) Appendix C: "P:\20240328\Archive\Received\SSCAFCA\2024.04.03 Sediment Design Guide\SSCAFCA_Sediment Design Guide 12-30-08.pdf"
Soil data: P:\20240328\Archive\Received\BHI LAB\Montoyas Arroyo Reach Stabil Plan - Soil Analyses S1-S4.PDF
100yr Average Hydraulic Parameter Calculations: P:\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters\20240328_100yr_HydraulicParameters.xlsx

$$q_s = a V^b Y^c \left(1 - C_f / 10^6\right)^d \tag{C.3}$$

where q_s = unit width **bed-material** load, cfs/ft
 V = average velocity, fps
 Y = hydraulic depth, ft
 C_f = fine sediment (silt and clay) concentration by weight
 S_o = channel slope

- NOTES**

 - (1) From BHI Lab results - see "Soil Data" tab
 - (2) From MUSLE Calcs
 - (3) Coefficients from SSCAFCA Sediment Design Guide Figure C.2. See Tab "Coefficients"
 - (4) RAS Rating Curve for Subreach XS
 - (5) Velocity calculated per rating curve data point. RAS Q/Stream A
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- (9) $Q_s = q_s \times \text{Top Width}$
 - (10) Calculated per eqn C.5
 - (11) $Q_{sf} = C_f \times Q / (2.65 \times 10^6)$
 - (12) $Q_{sTotal} = Q_s + Q_{sf}$
 - (13) $C_{sTotal} = (2.65E6 \times Q_{sTotal}) / (Q + 2.65 \times Q_{sTotal})$
 - (14) Percent Fines = Q_{sf} / Q_{st}
 - (15) Ratio of Sediment = $Q_{st} / \text{RAS } Q$

Total: 12.73%																		
						Maximum = 4,568					Maximum = 4			Maximum = 489			Maximum = 489	Maximum = 977
	D50 (mm)	Cf -	a -	b -	c -	d -	RAS Q (cfs)	RAS Stage (ft)	V (ft/s)	Y (ft)	qs (cfs/ft)	Top Width (ft)	Qs (cfs)	Cs (ppm-w)	Qsf (cfs)	QsTotal (cfs)	Cs (ppm-w)	Percent Fines -
	(1)	(2)	(3)				(4)		(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(13)
SR9, S4	0.955	146310.4998	0.00002	5.25	-0.265	-2.50	0.12	5179.14	0.03	0.14	9.29E-13	24.61	2.29E-11	0.00	2.29E-11	4.57E-11	0.00	0.50
							0.32	5179.22	0.06	0.17	1.06E-11	34.43	3.65E-10	0.00	3.65E-10	7.30E-10	0.01	0.50
							0.44	5179.22	0.07	0.17	5.07E-11	34.54	1.75E-09	0.01	1.75E-09	3.50E-09	0.02	0.50
							0.56	5179.27	0.07	0.20	4.32E-11	37.23	1.61E-09	0.01	1.61E-09	3.22E-09	0.02	0.50
							0.61	5179.27	0.08	0.20	6.73E-11	37.39	2.51E-09	0.01	2.51E-09	5.03E-09	0.02	0.50
							0.67	5179.27	0.09	0.20	1.03E-10	37.46	3.86E-09	0.02	3.86E-09	7.72E-09	0.03	0.50
							0.70	5179.27	0.09	0.20	1.30E-10	39.61	5.16E-09	0.02	5.16E-09	1.03E-08	0.04	0.50
							0.72	5179.27	0.09	0.20	1.50E-10	39.69	5.96E-09	0.02	5.96E-09	1.19E-08	0.04	0.50
							1.33	5179.28	0.16	0.20	2.53E-09	41.08	1.04E-07	0.21	1.04E-07	2.08E-07	0.42	0.50
							1.81	5179.29	0.21	0.20	1.01E-08	42.68	4.30E-07	0.63	4.30E-07	8.59E-07	1.26	0.50
							2.02	5179.30	0.23	0.21	1.62E-08	43.32	7.00E-07	0.92	7.00E-07	1.40E-06	1.83	0.50
							2.19	5179.30	0.24	0.21	2.25E-08	43.81	9.85E-07	1.19	9.85E-07	1.97E-06	2.39	0.50
							2.30	5179.30	0.25	0.21	2.69E-08	44.13	1.19E-06	1.37	1.19E-06	2.37E-06	2.74	0.50
							2.45	5179.31	0.26	0.21	3.54E-08	44.35	1.57E-06	1.70	1.57E-06	3.14E-06	3.40	0.50
							3.28	5179.32	0.33	0.21	1.15E-07	46.28	5.33E-06	4.31	5.33E-06	1.07E-05	8.62	0.50
							3.74	5179.33	0.36	0.21	1.90E-07	48.59	9.24E-06	6.55	9.24E-06	1.85E-05	13.09	0.50
							4.00	5179.33	0.38	0.21	2.44E-07	49.72	1.21E-05	8.05	1.21E-05	2.43E-05	16.09	0.50
							4.19	5179.33	0.40	0.21	2.96E-07	50.01	1.48E-05	9.36	1.48E-05	2.96E-05	18.72	0.50
							4.36	5179.34	0.41	0.21	3.48E-07	50.30	1.75E-05	10.63	1.75E-05	3.50E-05	21.25	0.50
							4.46	5179.34	0.42	0.21	3.81E-07	50.44	1.92E-05	11.43	1.92E-05	3.85E-05	22.86	0.50
							4.60	5179.34	0.42	0.21	4.24E-07	50.73	2.15E-05	12.41	2.15E-05	4.30E-05	24.81	0.50
							4.68	5179.34	0.43	0.21	4.51E-07	52.95	2.39E-05	13.51	2.39E-05	4.77E-05	27.02	0.50
							4.74	5179.34	0.43	0.21	4.68E-07	53.08	2.49E-05	13.90	2.49E-05	4.97E-05	27.81	0.50
							4.87	5179.34	0.44	0.21	5.25E-07	53.21	2.80E-05	15.22	2.80E-05	5.59E-05	30.45	0.50
							4.99	5179.34	0.45	0.21	5.67E-07	53.47	3.03E-05	16.12	3.03E-05	6.07E-05	32.24	0.50
							5.58	5179.35	0.48	0.21	8.53E-07	54.39	4.64E-05	22.04	4.64E-05	9.28E-05	44.08	0.50
							6.95	5179.36	0.58	0.21	2.09E-06	56.27	1.18E-04	44.90	1.18E-04	2.35E-04	89.80	0.50
							7.81	5179.37	0.63	0.22	3.42E-06	57.37	1.96E-04	66.61	1.96E-04	3.93E-04	133.21	0.50
							8.61	5179.37	0.68	0.22	5.05E-06	58.47	2.96E-04	90.93	2.96E-04	5.91E-04	181.84	0.50
							9.27	5179.38	0.72	0.22	6.74E-06	59.40	4.00E-04	114.41	4.00E-04	8.00E-04	228.79	0.50
							9.89	5179.38	0.76	0.22	8.82E-06	60.10	5.30E-04	142.01	5.30E-04	1.06E-03	283.99	0.50
							10.59	5179.38	0.80	0.22	1.15E-05	61.51	7.06E-04	176.61	7.06E-04	1.41E-03	353.16	0.50
							11.02	5179.38	0.82	0.22	1.38E-05	61.99	8.55E-04	205.57	8.55E-04	1.71E-03	411.06	0.50
Calculations continue below through entire hydrograph																		

Sediment Continuity Analysis

Project Name: Montoyas Arroyo RSP

Project Number: 20240328

Prepared By: ELA

Date: 7/17/2024

Note: Reference SSCAFCA Sediment Erosion Design Guide 2008 (see pgs. 3.36 through 3.48)

Color Key		
Input	Linked Cell	Calculation

Subreach	Soil Sample	Recurrence	Qs (cfs) (1)	Sed Vol (ft3) (2)	Supply (ft3) (3)	Agg/Deg (ft3) (4)	W (ft) (5)	L (ft)	delta Z (ft) (6)
SR1	S1	2	1.35	406	3,497	3,091	130	440	0.1
SR2	S1	2	4.11	1,233	406	-827	210	1,088	0.0
SR3	S1	2	16.62	4,987	1,233	-3,753	130	893	0.0
SR4	S1	2	1.52	455	4,987	4,532	170	509	0.1
SR5	S2	2	11.83	3,548	455	-3,093	50	1,092	-0.1
SR6	S3	2	12.69	3,807	3,548	-259	190	1,724	0.0
SR7	S3	2	28.09	8,428	3,807	-4,621	160	1,710	0.0
SR8	S4	2	26.76	8,028	8,428	400	80	1,491	0.0
SR9	S4	2	80.23	24,070	8,028	-16,042	160	777	-0.1
SR1	S1	5	334.82	100,447	143,417	42,970	130	440	0.8
SR2	S1	5	410.87	123,260	100,447	-22,813	210	1,088	-0.1
SR3	S1	5	677.26	203,179	123,260	-79,919	130	893	-0.7
SR4	S1	5	202.14	60,643	203,179	142,535	170	509	1.6
SR5	S2	5	493.33	148,000	60,643	-87,357	50	1,092	-1.6
SR6	S3	5	518.32	155,497	148,000	-7,497	190	1,724	0.0
SR7	S3	5	653.12	195,936	155,497	-40,439	160	1,710	-0.1
SR8	S4	5	545.00	163,500	195,936	32,436	80	1,491	0.3
SR9	S4	5	1037.70	311,311	163,500	-147,811	160	777	-1.2
SR1	S1	10	1690.22	507,066	547,540	40,474	130	440	0.7
SR2	S1	10	1774.26	532,278	507,066	-25,212	210	1,088	-0.1
SR3	S1	10	1283.48	385,045	532,278	147,233	130	893	1.3
SR4	S1	10	897.24	269,172	385,045	115,874	170	509	1.3
SR5	S2	10	1835.82	550,746	269,172	-281,574	50	1,092	-5.2
SR6	S3	10	1673.61	502,084	550,746	48,662	190	1,724	0.1
SR7	S3	10	2354.73	706,418	502,084	-204,335	160	1,710	-0.7
SR8	S4	10	2246.51	673,954	706,418	32,464	80	1,491	0.3
SR9	S4	10	3127.79	938,336	673,954	-264,382	160	777	-2.1
SR1	S1	25	6274.97	1,882,492	1,605,144	-277,348	130	440	-4.8
SR2	S1	25	6570.02	1,971,006	1,882,492	-88,515	210	1,088	-0.4
SR3	S1	25	2489.83	746,948	1,971,006	1,224,058	130	893	10.5
SR4	S1	25	2596.58	778,974	746,948	-32,026	170	509	-0.4
SR5	S2	25	6662.75	1,998,826	778,974	-1,219,852	50	1,092	-22.3
SR6	S3	25	4980.17	1,494,052	1,998,826	504,774	190	1,724	1.5
SR7	S3	25	7289.47	2,186,841	1,494,052	-692,789	160	1,710	-2.5
SR8	S4	25	7625.00	2,287,499	2,186,841	-100,658	80	1,491	-0.8
SR9	S4	25	8131.73	2,439,518	2,287,499	-152,019	160	777	-1.2
SR1	S1	50	12677.00	3,803,099	2,963,109	-839,989	130	440	-14.7
SR2	S1	50	11522.09	3,456,627	3,803,099	346,472	210	1,088	1.5
SR3	S1	50	4303.78	1,291,134	3,456,627	2,165,492	130	893	18.7
SR4	S1	50	4315.84	1,294,752	1,291,134	-3,618	170	509	0.0
SR5	S2	50	12022.16	3,606,649	1,294,752	-2,311,897	50	1,092	-42.3
SR6	S3	50	8962.37	2,688,711	3,606,649	917,938	190	1,724	2.8
SR7	S3	50	13472.59	4,041,776	2,688,711	-1,353,066	160	1,710	-4.9
SR8	S4	50	13668.27	4,100,482	4,041,776	-58,706	80	1,491	-0.5
SR9	S4	50	13580.50	4,074,151	4,100,482	26,331	160	777	0.2
SR1	S1	100	22504.61	6,751,384	4,822,486	-1,928,897	130	440	-33.7
SR2	S1	100	19818.88	5,945,665	6,751,384	805,718	210	1,088	3.5
SR3	S1	100	6074.92	1,822,475	5,945,665	4,123,191	130	893	35.5
SR4	S1	100	5328.50	1,598,551	1,822,475	223,924	170	509	2.6
SR5	S2	100	19126.41	5,737,922	1,598,551	-4,139,371	50	1,092	-75.8
SR6	S3	100	14347.46	4,304,239	5,737,922	1,433,683	190	1,724	4.4
SR7	S3	100	21979.11	6,593,733	4,304,239	-2,289,494	160	1,710	-8.4
SR8	S4	100	21517.08	6,455,125	6,593,733	138,608	80	1,491	1.2
SR9	S4	100	20817.20	6,245,161	6,455,125	209,965	160	777	1.7
SR1	S1	Avg Ann		294,434	254,875	-39,559	130	440	-0.7
SR2	S1	Avg Ann		287,602	294,434	6,832	210	1,088	0.0
SR3	S1	Avg Ann		150,016	287,602	137,586	130	893	1.2
SR4	S1	Avg Ann		108,403	150,016	41,613	170	509	0.5
SR5	S2	Avg Ann		295,201	108,403	-186,798	50	1,092	-3.4
SR6	S3	Avg Ann		237,445	295,201	57,755	190	1,724	0.2
SR7	S3	Avg Ann		346,078	237,445	-108,633	160	1,710	-0.4
SR8	S4	Avg Ann		339,662	346,078	6,416	80	1,491	0.1
SR9	S4	Avg Ann		399,328	339,662	-59,666	160	777	-0.5

Notes

- (1) Sum of Bed Material load column from MPM Woo calculations
- (2) Sum of Bed Material Load from MPM Woo * 5 minute time step * 60 s/min
- (3) Sum of log interpolation of hydrograph for most upstream HEC-HMS element * 5 minute time step * 60 s/min
- (4) Sediment supply minus sediment volume
- (5) Existing measurements approximated in HEC-RAS
- (6) (Agg/Deg) / W / L to get vertical change

Dominant Width and Discharge Calculations

Project Name: Montoyas Arroyo RSP

Project Number: 20240328

Prepared By: ELA

Date: 7/17/2024

Note: Reference SSCAFCA Sediment Erosion Design Guide 2008 (see pgs. 3.36 through 3.48)

Color Key		
Input	Linked Cell	Calculation

F

Subreach 1			Subreach 2			Subreach 3			Subreach 4			Subreach 5		
0.0106 <=Seg			0.0122 <=Seg			0.0102 <=Seg			0.0096 <=Seg			0.0060 <=Seg		
Vaa=	287,602	ft^3, unbulked	Vaa=	150,016	ft^3, unbulked	Vaa=	108,403	ft^3, unbulked	Vaa=	295,201	ft^3, unbulked	Vaa=	237,445	ft^3, unbulked
		ft^3, unbulked			ft^3, unbulked	V-2 yr=		ft^3, unbulked			ft^3, unbulked			ft^3, unbulked
V-5 yr=	123,260	ft^3, unbulked	V-5 yr=	203,179	ft^3, unbulked	V-5 yr=	60,643	ft^3, unbulked	V-5 yr=	148,000	ft^3, unbulked	V-5 yr=	155,497	ft^3, unbulked
V-10 yr=	532,278	ft^3, unbulked	V-10 yr=	385,045		V-10 yr=	269,172		V-10 yr=	550,746		V-10 yr=	502,084	
		cfs			cfs			cfs			cfs			cfs
Q-5 yr=	472	cfs	Q-5 yr=	477	cfs	Q-2 yr=		cfs	Q-5 yr=	486	cfs	Q-5 yr=	467	cfs
Q-10 yr=	1192	cfs	Q-10 yr=	1195		Q-5 yr=	481	cfs	Q-10 yr=	1216		Q-10 yr=	1104	
Qd=	1187	cfs	Qd=	1188	cfs	Qd=	1196	cfs	Qd=	1201	cfs	Qd=	901	cfs
By Interp:	807		By Interp:	308		By Interp:	603		By Interp:	787		By Interp:	637	
Wd=	117.4		Wd=	188.2		Wd=	144.9		Wd=	154.7		Wd=	82.6	
	82	<=Eq 3.47		80	<=Eq 3.47		83	<=Eq 3.47		84	<=Eq 3.47		83	<=Eq 3.47
lamda/Wd=	14.0		lamda/Wd=	14.0		lamda/Wd=	14.0		lamda/Wd=	14.0		lamda/Wd=	14.0	
lamda=	1644		lamda=	2635		lamda=	2028		lamda=	2166		lamda=	1157	
= Wd*lamda/Wd			= Wd*lamda/Wd			= Wd*lamda/Wd			= Wd*lamda/Wd			= Wd*lamda/Wd		
Lv=	822		Lv=	1318		Lv=	1014		Lv=	1083		Lv=	578	
= lamda/2			= lamda/2			= lamda/2			= lamda/2			= lamda/2		
Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)
=	411		=	659		=	507		=	541		=	289	
CSB=	470		CSB=	753		CSB=	579		CSB=	619		CSB=	331	
= Delta(max)+0.5Wd			= Delta(max)+0.5Wd			= Delta(max)+0.5Wd			= Delta(max)+0.5Wd			= Delta(max)+0.5Wd		
For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:		
Q 100-yr:	5,933	cfs	Q 100-yr:	5,940		Q 100-yr:	5,981		Q 100-yr:	6,004		Q 100-yr:	4,505	
Sc:	0.0144	ft/ft	Sc:	0.0144		Sc:	0.0144		Sc:	0.0144		Sc:	0.0150	
Seg:	0.0106	ft/ft	Seg:	0.0122		Seg:	0.0102		Seg:	0.0096		Seg:	0.0060	
EW, 2-yr	108	ft	EW, 2-yr	137	ft	EW, 2-yr	55	ft	EW, 2-yr	127	ft	EW, 2-yr	36	ft
EW, 5-yr	117	ft	EW, 5-yr	188	ft	EW, 5-yr	145	ft	EW, 5-yr	155	ft	EW, 5-yr	51	ft

Approximate Maximum Erosion Distance & Prudent Line Calculations

Project Name: Montoyas Arroyo RSP
Project Number: 20240328
Prepared By: ELA
Date: 6/4/2024
Note: Reference SSCAFCA Sediment Erosion Design Guide 2008 (see pgs. 3.36 through 3.48)

Color Key		
Input	Linked Cell	Calculation

Subreach 6			Subreach 7			Subreach 8			Subreach 9		
	0.0134	<=Seg		0.0143	<=Seg		0.0135	<=Seg		0.0138	<=Seg
Vaa=	346,078	ft^3, unbulked	Vaa=	339,662	ft^3, unbulked	Vaa=	399,328	ft^3, unbulked	Vaa=	0	ft^3, unbulked
		ft^3, unbulked			ft^3, unbulked			ft^3, unbulked			ft^3, unbulked
V-5 yr=	195,936	ft^3, unbulked	V-5 yr=	163,500	ft^3, unbulked	V-5 yr=	311,311	ft^3, unbulked	V-5 yr=	507,066	ft^3, unbulked
V-10 yr=	706,418		V-10 yr=	673,954		V-10 yr=	938,336		V-10 yr=	1,882,492	
		cfs			cfs			cfs			cfs
Q-5 yr=	473	cfs	Q-5 yr=	473	cfs	Q-5 yr=	476	cfs	Q-5 yr=	484	cfs
Q-10 yr=	1107		Q-10 yr=	1114		Q-10 yr=	1117		Q-10 yr=	1132	
Qd=	902	cfs	Qd=	904	cfs	Qd=	906	cfs	Qd=	914	cfs
By Interp:	690		By Interp:	736		By Interp:	577		By Interp:	#NUM!	
Wd=	152.9		Wd=	143.1		Wd=	70.0		Wd=	95.0	
	71	<=Eq 3.47		70	<=Eq 3.47		71	<=Eq 3.47		71	<=Eq 3.47
lamda/Wd=	14.0		lamda/Wd=	14.0		lamda/Wd=	14.0		lamda/Wd=	14.0	
lamda=	2140		lamda=	2003		lamda=	981		lamda=	1329	
= Wd*lamda/Wd			= Wd*lamda/Wd			= Wd*lamda/Wd			= Wd*lamda/Wd		
Lv=	1070		Lv=	1001		Lv=	490		Lv=	665	
= lamda/2			= lamda/2			= lamda/2			= lamda/2		
Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)	Delta(max)	=3.5*Wd	(ft)
=	535		=	501		=	245		=	332	
CSB=	612		CSB=	572		CSB=	280		CSB=	380	
=	Delta(max)+0.5Wd		=	Delta(max)+0.5Wd		=	Delta(max)+0.5Wd		=	Delta(max)+0.5Wd	
For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:			For Montoyas ExCon Hydrology Evaluation:		
Q 100-yr:	4,510		Q 100-yr:	4,521		Q 100-yr:	4,532		Q 100-yr:	4,568	
Sc:	0.0150		Sc:	0.0150		Sc:	0.0150		Sc:	0.0149	
Seg:	0.0134		Seg:	0.0143		Seg:	0.0135		Seg:	0.0138	
EW, 2-yr	147	ft	EW, 2-yr	141	ft	EW, 2-yr	68	ft	EW, 2-yr	92	ft
EW, 5-yr	153	ft	EW, 5-yr	143	ft	EW, 5-yr	70	ft	EW, 5-yr	95	ft

Approximate Maximum Erosion Distance & Prudent Line Calculations

Project Name: Montoyas Arroyo RSP
Project Number: 20240328
Prepared By: ELA
Date: 8/5/2024
Note: Reference SSACFCA Sediment Erosion Design Guide 2008 (see pgs. 3.36 through 3.48)
Lateral Erosion Distance calculated using dominant discharge

Color Key		
Input	Linked Cell	Calculation

Subreach	100-yr Peak Flow (Q ₁₀₀)	Dominant Discharge (Q _d)	Average Existing Slope (S)	Critical Slope (S _c)	Flow Profile	Lateral Erosion Distance (D _{max})	Estimated Dominant Width (W _d)	Subcritical Channel Width (W _d)	λ/W _d	Downvalley Length (L _v)	Total Erosion Width
	(cfs)	(cfs)	(ft/ft)	(ft/ft)	(-)	(ft)	(ft)	(ft)	(-)	(ft)	(ft)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	5933	1187	0.0106	0.014	Subcritical	271.7	117.4	82.2	13.1	769	661
2	5940	1188	0.0122	0.014	Subcritical	265.1	188.2	80.1	13.1	1233	718
3	5981	1196	0.0102	0.014	Subcritical	275.3	144.9	83.1	13.1	950	695
4	6004	1201	0.0096	0.014	Subcritical	278.6	154.7	84.1	13.1	1015	712
5	4505	901	0.0060	0.015	Subcritical	263.2	82.6	82.6	12.6	521	609
6	4510	902	0.0134	0.015	Subcritical	226.3	152.9	71.0	12.6	965	605
7	4521	904	0.0143	0.015	Subcritical	223.6	143.1	70.2	12.6	903	590
8	4532	906	0.0135	0.015	Subcritical	226.3	70.0	71.0	12.6	442	523
9	4568	914	0.0138	0.015	Subcritical	226.5	95.0	71.0	12.6	600	548

Notes:

- For Centerline Setback (CSB), the LEE line in each bank is set back half of the total erosion width from the channel centerline.
- For Bankline Setback (BSB), the LEE line in each bank is set back by a distance of Dmax from the channel bank line.
- (1) 100 year return event peak discharge (Q100) - Unbulked max Q100 from hydraulic parameters spreadsheet
- (2) Dominant Discharge (Qd) calculated in P:\20240328\SW\Calculations\Misc Calcs\Equilibrium Slope\20240328_ExDominantQ-W_2.xlsm
- (3) Average slope (S) of channel bed at the cross section - Reach averaged EXISTING bed slope
- (4) Critical Slope (Sc) based on the flow having a froude number of 1 (Eqn 3.48) - ASSUMES A WIDE RECTANGULAR CHANNEL, UNIFORM FLOW, n = 0.035, AND A WIDTH-DEPTH RATIO (F) OF 40
- (5) Describes whether the flow regime is subcritical or supercritical
- (6) Maximum Lateral Erosion Distance (Dmax or Δmax) is the distance from channel bank to the maximum extent of the meander bend Dmax is computed based on the following formulas:
- | | | |
|--|--|-----------|
| - If Qd is less than or equal to 200 cfs | Dmax = 11.5 * Qd^0.4 | Eq. 3.49a |
| - If Qd is greater than 200 cfs but less than 2000 cfs | Dmax = [0.92 + 4.6 * log(Qd)] * Qd^0.4 | Eq. 3.49b |
| - If Qd greater than 2000 cfs | Dmax = 16.1 * Qd^0.4 | Eq. 3.49c |
| If S < Sc: | | |
| - If Qd is less than or equal to 200 cfs | Dmax = 6.2 * Qd^0.375 * S^-0.188 | Eq. 3.50a |
| - If Qd is greater than 200 cfs but less than 2000 cfs | Dmax = [0.45 + 2.51 * log(Qd)] * Qd^0.375 * S^-0.188 | Eq. 3.50b |
| - If Qd greater than 2000 cfs | Dmax = 8.6 * Qd^0.375 * S^-0.188 | Eq. 3.50c |
- (7) Channel Width calculated in P:\20240328\SW\Calculations\Misc Calcs\Equilibrium Slope\20240328_ExDominantQ-W_2.xlsm
- | | | |
|--------------------------|---------------------------------|----------|
| - For Supercritical Flow | Wd = 4.6 * Qd^0.4 | Eq. 3.36 |
| - For Subcritical Flow | Wd = 2.46 * Qd^0.375 * S^-0.188 | Eq. 3.47 |
- (8) λ is the meander wavelength. λ/Wd is computed based on the following formulas:
- | | | |
|--|--------------------------|-----------|
| - If Qd is less than or equal to 200 cfs | λ/Wd = 10 | Eq. 3.43a |
| - If Qd is greater than 200 cfs but less than 2000 cfs | λ/Wd = 0.8 + 4 * log(Qd) | Eq. 3.43b |
| - If Qd greater than 2000 cfs | λ/Wd = 14 | Eq. 3.43c |
- (9) Downvalley length of arroyo (Lv) over which lateral erosion can occur is 1/2 the wavelength (Page 3.48, Step III)
- $L_v = \lambda / 2 = 0.5 * \lambda / W_d * W_d$
- (10) Total Erosion Width (also referred to as the Lateral Erosion Envelope, LEE) is the estimated total meander width of the arroyo with respect to the downvalley direction
- $LEE = 2 * D_{max} + W_d$, rounded to the nearest foot
- Down Valley Direction is the assumed centerline around which the arroyo will meander
- (11) Check to determine if Q100 is greater or less than 2000 cfs

Scour Analysis - Flow Impinging on WallProject Name: **Montoyas Arroyo RSP**Project Number: **20240328**Prepared By: **ELA**Date: **7/9/2024**

Color Key		
Input	Linked Cell	Calculation

Calculations reference *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance, Hydraulic Engineering Circular No. 23 (HEC-23)*

Subreach	Flow Rate (cfs) (1)	Min. Channel (ft) (1)	W.S. Elev (ft) (1)	Froude # (Fr) (--) (1)	Hydraulic Depth (Y) (ft) (1)	θ (degrees) (2)	Scour Depth (Y _s) ft. (3)
1	5932	5325.6	5329.7	0.46	3.79	5.0	4.1
2	5942	5317.4	5320.5	0.38	2.93	5.0	3.1
3	5918	5304.8	5308.9	0.51	3.81	5.0	4.3
4	6006	5298.9	5303.5	0.50	3.96	5.0	4.4
5	4505	5254.2	5259.4	0.27	4.59	5.0	4.5
6	4510	5243.4	5246.3	0.57	2.64	5.0	3.1
7	4532	5216.2	5219.5	0.55	3.18	5.0	3.7
8	4185	5196.8	5201.5	0.57	4.20	5.0	4.9
9	4577	5176.0	5180.1	0.36	3.78	5.0	3.9

Notes:

- 1) Input from 100yr UNBULKED hydraulic parameters from proposed HEC-RAS:
\\a-abq-fs2\ABQ-Projects\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters - Proposed\20240328_PR100yr_HydraulicParameters.xlsx
HEC-RAS Plan: PR100yr_UB
- 2) Various
- 3) Scour depth computed using equation 4.4 in HEC-23,
where, Y_s = Scour Depth; Y = Hydraulic Depth in Channel; θ = Angle between the impinging flow direction and the flood wall; Fr = Froude #

$$\text{Equation 4.4} - Y_s = Y[(0.73 + 0.14\pi F_r^2) \cos \theta + 4 \sin \theta F_r^{0.33}]$$

Scour Analysis - Antidune Scour

Project Name: **Montoyas Arroyo RSP**

Project Number: **20240328**

Prepared By: **ELA**

Date: **7/9/2024**

Input

Calculation

Subreach	Flow Rate	v	h _a	Ys
	(cfs)	(fps)	(ft)	(ft)
	(1)	(1)	(2)	(2)
1	5931.9	11.5	3.6	1.8
2	5941.9	9.5	2.5	1.2
3	5917.5	10.6	3.1	1.5
4	6006.4	7.9	1.7	0.8
5	4505.0	9.8	2.6	1.3
6	4510.0	10.5	3.0	1.5
7	4532.0	10.3	2.9	1.4
8	4185.1	10.8	3.2	1.6
9	4576.9	10.8	3.2	1.6

$$h_a = 0.14 \frac{2\pi V^2}{g} = 0.28 \pi y F_r^2$$

where
 h_a = antidune height
 V = flow velocity
 g = acceleration of gravity
 y = hydraulic depth of flow
 F_r = Froude Number

Scour associated with the antidunes is estimated as one-half the antidune height.

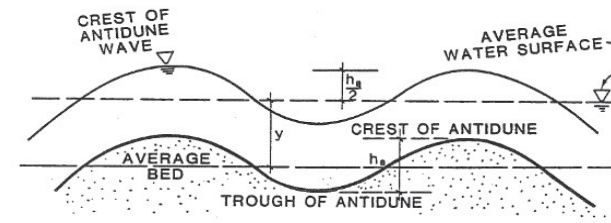


Figure 3.15. Definition sketch for antidune height (SLA, 1985).

Notes:

1. Input from 100yr UNBULKED hydraulic parameters from proposed HEC-RAS:
\\a-abq-fs2\ABQ-Projects\20240328\SW\Calculations\Misc Calcs\HEC-RAS\Hydraulic Parameters - Proposed\
20240328_PR100yr_HydraulicParameters.xlsx
2. Antidune and scour height calculated using AMAFCA Sediment and Erosion Design Guide, Eq. 3.68

IX. APPENDIX C: COST ESTIMATE DETAILS

The tables below list 2022 bid tab unit costs used on the Calabacillas Arroyo West Branch (CAWB) GCS 11, Crossing, and Bank Protection (2022) project and their inflated unit cost using inflation data from RSMeans for the Albuquerque, NM area (most current cost index is 2023) (**Table 22**). As discussed in Section IV, the cost estimate was developed by calculating quantities from conceptual design and grading, then multiplying by a unit cost. Because of the high-level nature of this RSP, many assumptions were made in the quantification of materials:

- GCS crest length of 15-ft, apron length equal to that on LC GCS (80 ft), constructed with 3-ft thick grouted boulders at a slope of 3H:1V
- 3 lines of 1 weep drain per 9 ft of GCS width
- BP made of dumped boulders, 3-ft thick, at 2H:1V with 1.5-ft freeboard above 100-year WSEL
- 2-ft over excavation with an 8-ft downstream trench, graded out at a 1.5H:1V slope
- 2 access roads (one per side of arroyo) along entire channel alignment, 12-ft wide
- Seeding equal to 10% of total disturbed area
- General construction equal to 13% of hard costs (**Table 23**)
- Design and permitting equal to 15% of hard costs (**Table 23**)
- 35% contingency (**Table 23**)
- 7.4375% for NMGRT (**Table 23**)
- No costs estimated for land acquisition
- No costs estimated for access
- No locality adjustment for this project

Final line item costs are listed in **Table 24** and final costs per design element are listed in **Table 25**.

Table 22. Unit Cost Inflation Estimates

Item Name	Unit	Avg 2022 Bid Tab Unit Cost	Original Cost Index (2022)	Most Current Cost Index (2023)	Inflation Rate to 2023	Double to Estimate 2024	Inflated Unit Cost
Site clearing and grubbing	AC	\$2,452.10	241.40	259.00	107.29%	114.58%	\$2,900.00
Excavation, backfill, and compaction	CY	\$5.05	241.40	259.00	107.29%	114.58%	\$5.80
Subgrade preparation, 12"	SY	\$4.95	241.40	259.00	107.29%	114.58%	\$5.70
3,000 PSI structural concrete for GCS cutoff walls	CY	\$1,368.45	241.40	259.00	107.29%	114.58%	\$1,600.00
Weep drains	EA	\$517.60	241.40	259.00	107.29%	114.58%	\$600.00
Gravel (filter) bedding materials	CY	\$73.20	241.40	259.00	107.29%	114.58%	\$90.00
Filter fabric	SF	\$0.55	241.40	259.00	107.29%	114.58%	\$0.70
Grouted basalt boulder riprap w/ tine	CY	\$265.20	241.40	259.00	107.29%	114.58%	\$310.00
Dumped basalt boulder riprap	CY	\$163.55	241.40	259.00	107.29%	114.58%	\$190.00
Native grass seeding, w/ hydromulch	AC	\$2,099.45	241.40	259.00	107.29%	114.58%	\$2,500.00
8" shotcrete, 4,000 PSI	SY	\$175.25	241.40	259.00	107.29%	114.58%	\$210.00

Table 23. Soft Cost Markups

Description	Percentage
General Construction	13%
Design and Permitting	15%
Contingency	35%
NMGRT	7.4375%

Table 24. Conceptual Cost Estimate Line Items

Bid Item	Description	Unit	Inflated Unit Cost	GCS Quantity	GCS Cost	BP Quantity	BP Cost	Repair/Reconstruct Quantity	Repair/Reconstruct Cost	Total Quantity	Total Cost
1	General Construction Costs	LS	-	-	\$229,000	-	\$2,632,896	-	\$88,682	-	\$3,168,312
2	Design and Permitting*	LS	-	-	\$262,000	-	\$1,645,560	-	\$55,427	-	\$1,980,195
3	Site clearing and grubbing	AC	\$2,900	2	\$5,800	6	\$17,400	1	\$2,900	9	\$26,100
4	Excavation, backfill, and compaction	CY	\$6	12,300	\$71,340	243,000	\$1,409,400	2,200	\$12,760	258,000	\$1,496,400
5	Subgrade preparation, 12"	SY	\$6	5,000	\$28,500	44,000	\$250,800	500	\$2,850	50,000	\$285,000
6	3,000 PSI structural concrete for GCS cutoff walls	CY	\$1,600	120	\$192,000	-	-	70	\$112,000	190	\$304,000
7	Weep drains	EA	\$600	130	\$78,000	-	-	40	\$24,000	170	\$102,000
8	Gravel (filter) bedding materials	CY	\$90	-	-	7,300	\$657,000	-	\$0	7,300	\$657,000
9	Filter fabric	SF	\$1	-	-	394,000	\$275,800	-	\$0	394,000	\$275,800
10	Grouted basalt boulder riprap w/ tine	CY	\$310	4,000	\$1,240,000	-	-	400	\$124,000	4,400	\$1,364,000
11	Dumped basalt boulder riprap	CY	\$190	-	-	44,000	\$8,360,000	400	\$76,000	45,000	\$8,550,000
12	Native grass seeding, w/ hydromulch	AC	\$2,500	-	-	-	-	6	\$15,000	6	\$15,000
13	8" shotcrete, 4,000 PSI	SY	\$210	600	\$126,000	-	-	-	-	600	\$126,000
14	Utility Relocation Allowance	AL	-	-	\$240,000	-	\$60,000	-	-	-	\$300,000

*Permitting is assumed to include Clean Water Act Section 404 (Nationwide Permit, Regional Permit or Individual Permit), a survey of Western Burrowing Owl habitat for US Fish and Wildlife Endangered Species Act compliance, and floodplain (Federal Emergency Management Agency) permitting.

Table 25. Conceptual Cost Estimate Costs

	GCS	BP	Repair/Reconstruct	Total
Construction Subtotal	\$2,232,640	\$15,248,856	\$513,619	\$18,649,807
Contingency (35%)	\$781,424	\$5,337,100	\$179,767	\$6,527,432
NMGRT @ 7.4375%	\$224,171	\$1,531,080	\$51,571	\$1,872,557
Total Cost	\$3,238,235	\$22,117,036	\$744,956	\$27,049,797

X. APPENDIX D: DIGITAL DELIVERABLES

Refer to files included as a separate attachment with this RSP.