Construction of a Pedestrian Bridge over the Nenana River and Trail Connections

Denali National Park and Preserve

Floodplain Statement of Findings

PEPC 126557

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1 INTRODUCTION

Executive Order (EO) 11988, *Floodplain Management*, requires the National Park Service (NPS) and other federal agencies to evaluate the likely impacts of actions in floodplains. The objective of EO 11988 is to avoid, to the extent possible, the long-term and short-term adverse impacts associated with occupancy, modification, or destruction of floodplains and to avoid indirect support of development and new construction in such areas wherever there is a practicable alternative. NPS administers floodplain policy through Director's Order 77-2: *Floodplain Management* (DO 77-2) and Procedural Manual 77-2 *Floodplain Management* (PM 77-2). NPS also complies with departmental guidance outlined in 520 DM 1, *Floodplain Management and Wetlands Protection Policy and Responsibilities*, and 520 DM 2, *Floodplain Management and Wetlands Protection Program Requirements*.

It is NPS policy to preserve floodplain functions and values and minimize potentially hazardous conditions associated with flooding, including threats to human health and safety, risk to NPS capital investment, and impacts on natural and beneficial floodplain values. If a proposed action is found to be in, or possibly affecting a floodplain, and relocating the action to a non-floodplain site is considered not to be a viable alternative, then a formal Floodplain Statement of Findings (FSOF) must be prepared unless the action is considered excepted. The FSOF must (a) describe the rationale for selection of a floodplain site, (b) disclose the degree of risk associated with the chosen site (with respect to human life, health and safety, resource protection, and capital investment), and (c) explain strategies for mitigation of flood risk. The FSOF will be available for public review in coordination with the National Environmental Policy Act (NEPA) and other compliance procedures, as applicable. If public review is not provided through the NEPA process (e.g. environmental assessment), another opportunity for public review is required.

This FSOF provides:

1. A detailed justification for selecting a proposed action that would adversely impact the Federal Flood Risk Management Standard (FFRMS) floodplain (Section 2).
2. A detailed and comprehensive description of the flood hazard and risk associated with implementation of the proposed action (Section 3).
3. A thorough description of mitigation measures chosen to minimize or eliminate adverse floodplain impacts associated with the proposed action(s) (Section 4).

1.1 PREPARER

In accordance with DO 77-2 and PM 77-2, I, Paul Burger, the author of this FSOF, affirm I am a hydrologist with the National Park Service and am technically qualified to prepare this document. Additional technical input was provided by James Neighorn, P.E., Lead Hydraulic Engineer, Western Federal Lands Highway Division, Federal Highway Administration, U.S. Department of Transportation. Additional support on non-technical elements of the document was provided by Martha Tomeo, Outdoor Recreation Planner, Denali National Park and Preserve.

1.2 LOCATION

Denali National Park & Preserve, bridge abutment coordinates (Latitude/Longitude) are approximately 63.657244, -148.833169 (north abutment) and 63.656394, -148.832664 (south abutment).

Land ownership: Project lands on the North bank of the Nenana River are owned by National Park Service. Project lands on the South bank of the Nenana River are in the State of Alaska Department of Transportation & Public Facilities right-of-way. There is an area under the northern portion of the bridge that is State of Alaska Department of Natural Resources land.

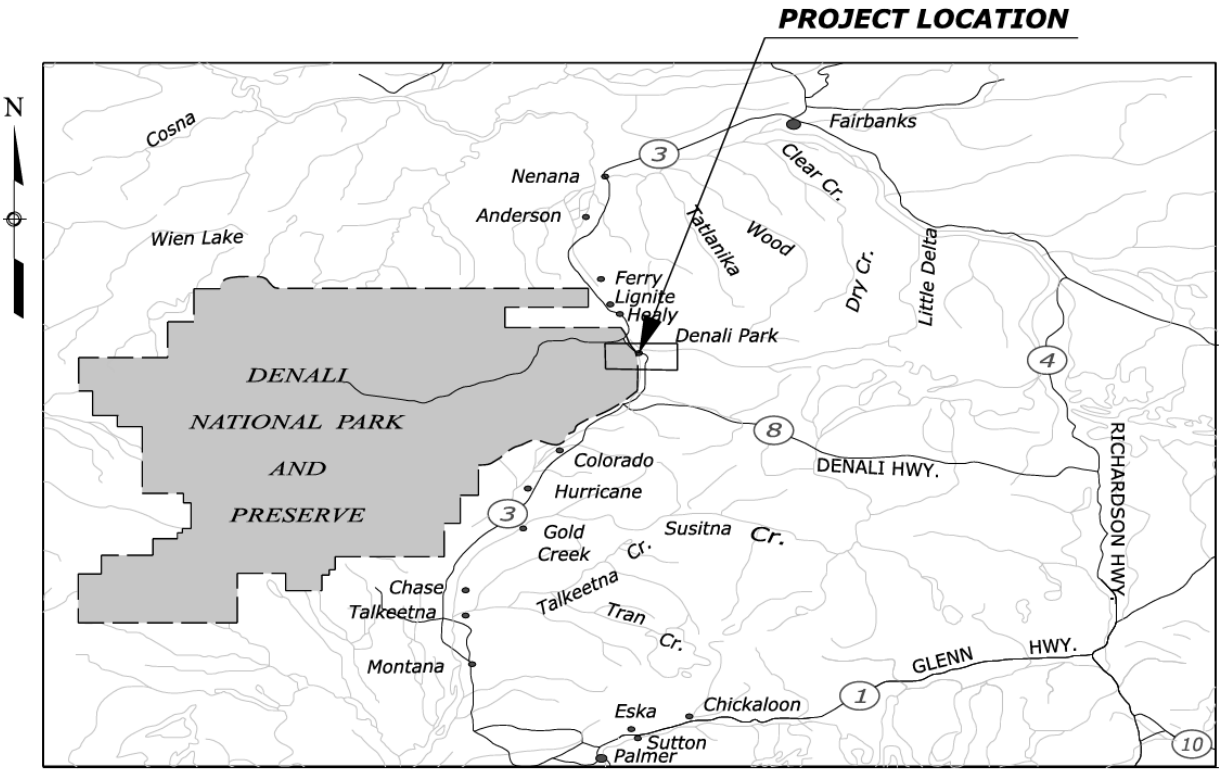


Figure 1. General Project Location

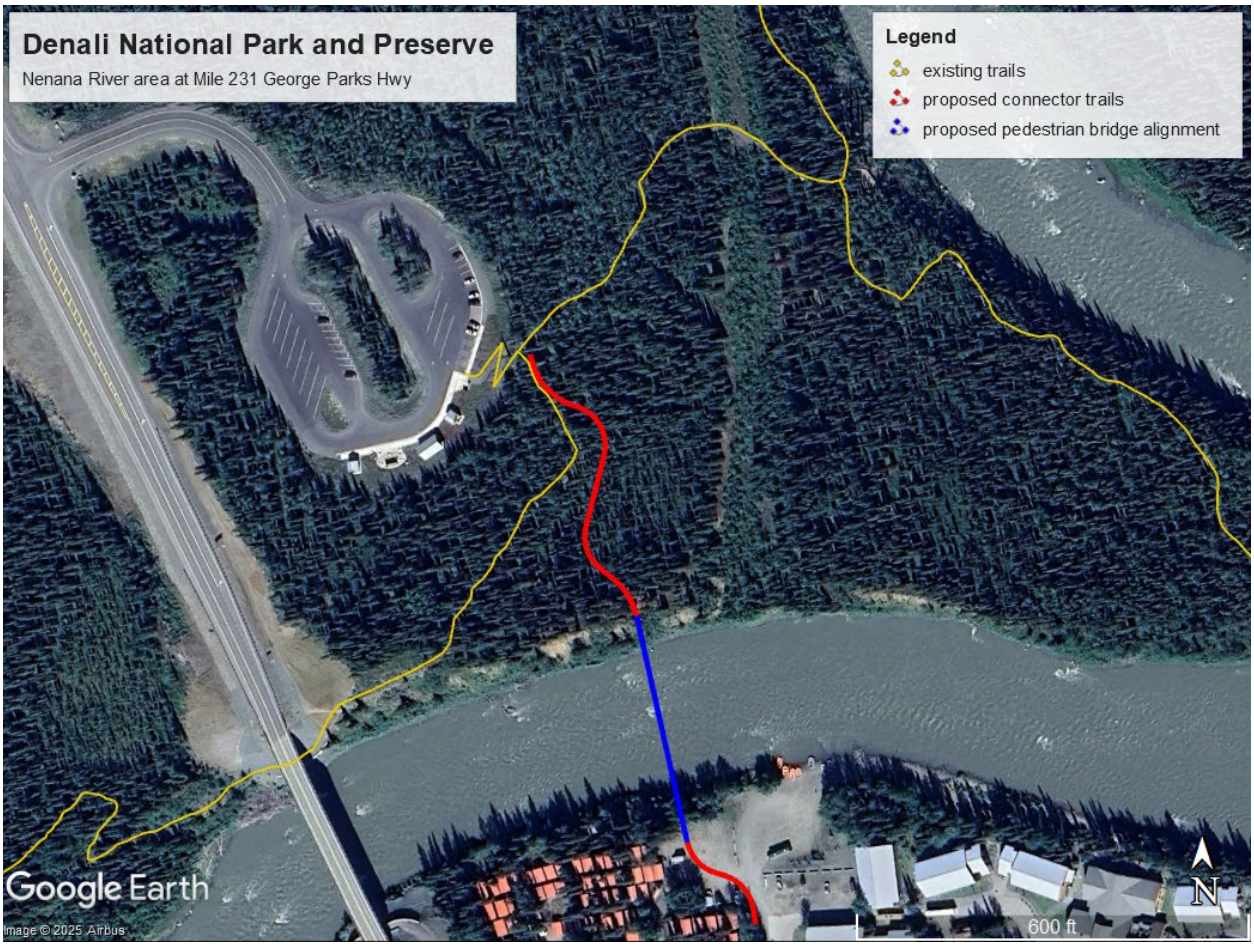


Figure 2. Generalized project location, showing bridge location in blue.

The Nenana River is a perennial glacial fed river that generally flows from south to north. The proposed crossing is located on the north side of Denali Park Village immediately west of the boat launch area and 520-feet east of the Parks Highway 3 bridge. The river meanders around the north side of the village and flows west to east at the proposed crossing.

Upstream (south) of Denali Park Village, the river flows through a wider valley and exhibits a braided morphology, characterized by shifting gravel bars, shallow waters, and multiple intersecting channels. However, as it reaches the village and flows northward, the topography forces the river to consolidate into a narrower, faster, and structurally confined channel.

The active channel width ranges from approximately 220 - 250 feet upstream to 240 - 300 feet downstream with the width of approximately 240 feet at the proposed crossing. The flood-prone width at the crossing is approximately 265 feet. The streambed is composed primarily of boulders and cobbles. Based on image software analysis of photos of the streambed the median particle size D50 is 3.1 inches and the D85 is 5.9 inches. The channel slope is approximately 0.3 percent. The riverbank on the north side of the crossing is characterized by a steep 50-foot bluff. The upper portion (14-feet) of the bluff is primarily composed of sandy lean clay and coarse grained, highly weathered sandstone which experiences bank erosion, undercutting, and slumping that leaves

the banks unvegetated and near vertical in many locations. The lower portion of the bluff consists of fine grained weathered, but strong, rock which forms a more stable bank resistant to channel migration or erosion. This lower portion, which is vegetated with spruce trees and weedy shrubs, is sloped at approximately 1.5 horizontal to 1 vertical. The south bank, or the northern edge of the village, is elevated approximately 10 to 20 feet above the river channel. The village is developed with residential and commercial buildings. The adjacent riparian zone is vegetated with spruce trees and woody shrubs.

The Park Highway 3 bridge as-built plans from 1973 show that the piers built within the waterway are set on deep foundations. The piers are armored with steel casing to protect the concrete from ice/debris impact. Armoring extends from the channel bottom up to the design 50-year flood elevation. Field photos of the steel casing show that abrasion from ice and debris is occurring up to the top of the casing (and possibly above) at the upstream face of the pier. This suggests that uplift of the ice jams at the face of the piers is significant and may extend up to the 100-year flood elevation.

The channel appears to be vertically stable. Large lag deposit boulders or colluvium can be seen across the channel bottom. Inspection reports for the upstream highway bridge show that the channel bottom elevations vary 2 to 3 feet over the last 30 years as sediment moves through the system but show no signs of overall degradation or aggradation. Since the river is glacially fed the bed elevation fluctuates up and down by several feet with periods where gravel bars are deposited then eroded back down throughout a season. The riverbed elevation will generally remain relatively flat and possibly slightly aggraded at times. As mentioned previously, the material forming the steep banks is unconsolidated. This material can be loosened by permafrost.

During high flow or ice jam events the loose steep banks can then be eroded and undercut resulting in lateral bluff retreat or migration along the north side. Near the south end of the crossing, the presence of sand gravel alluvium, particularly adjacent to the boat launch area located immediately downstream, underscores the active sediment transport dynamics in play. In general, there is minimal channel migration potential immediately upstream and downstream of the crossing along the south bank.

Because the Nenana River is glacially fed, its flow drops significantly in the winter causing it to freeze over typically beginning in October. Flowing supercooled water generates frazil ice which accumulates along the banks, forming thick shelf ice that slowly grows toward the center of the channel. The river can eventually bridge over if water velocity in the center channel slows sufficiently to allow for full freeze. The river is susceptible to aufeis, or overflow ice, which can allow pressurized water to force its way through cracks to the surface and spreads over the top of the existing ice, instantly freezing into smooth, thick, laminated layers.

In late April or early May, spring melt causes the river volume to swell rapidly beneath the ice. The rising water breaks the thick winter ice into massive, jagged sheets up to 3 to 4-feet thick. These ice blocks can frequently stack up and create large ice jams that can reach 6 feet in height. When these jams break, the sudden release of water and ice can scour the riverbanks. This mechanical ice scouring is a major reason why the banks around the village remain steep, unconsolidated, and actively eroding.

In addition to the ice, the potential for large wood transport is also high. The river basin contains mature timber along unstable banks. Undercutting or bank retreat continually sends these larger trees into the river, the results of which were evident during the 2025 site visit. Large woody debris have built up near the west abutment of the existing bridge at the Parks Highway. Large lag boulders at this location appear to have initiated the debris jam.

1.3 PROPOSED ACTION

The National Park Service (NPS) in partnership with Alaska Department of Transportation & Public Facilities (DOT & PF), is constructing a new pedestrian bridge across the Nenana River at the Denali Park Village as part of Denali Park Pedestrian Bridge and Trail Connector project.

The proposed trail crossing will include a 340-foot bridge that consists of a 250-foot main span, supported by single 6-foot diameter piers with 45-foot approach spans at each end. The proposed pier supports will be outside of the ordinary high water and will encroach slightly at the edge of the modeled 500-year water surface (See Appendix A for detailed maps showing flood modeling results).

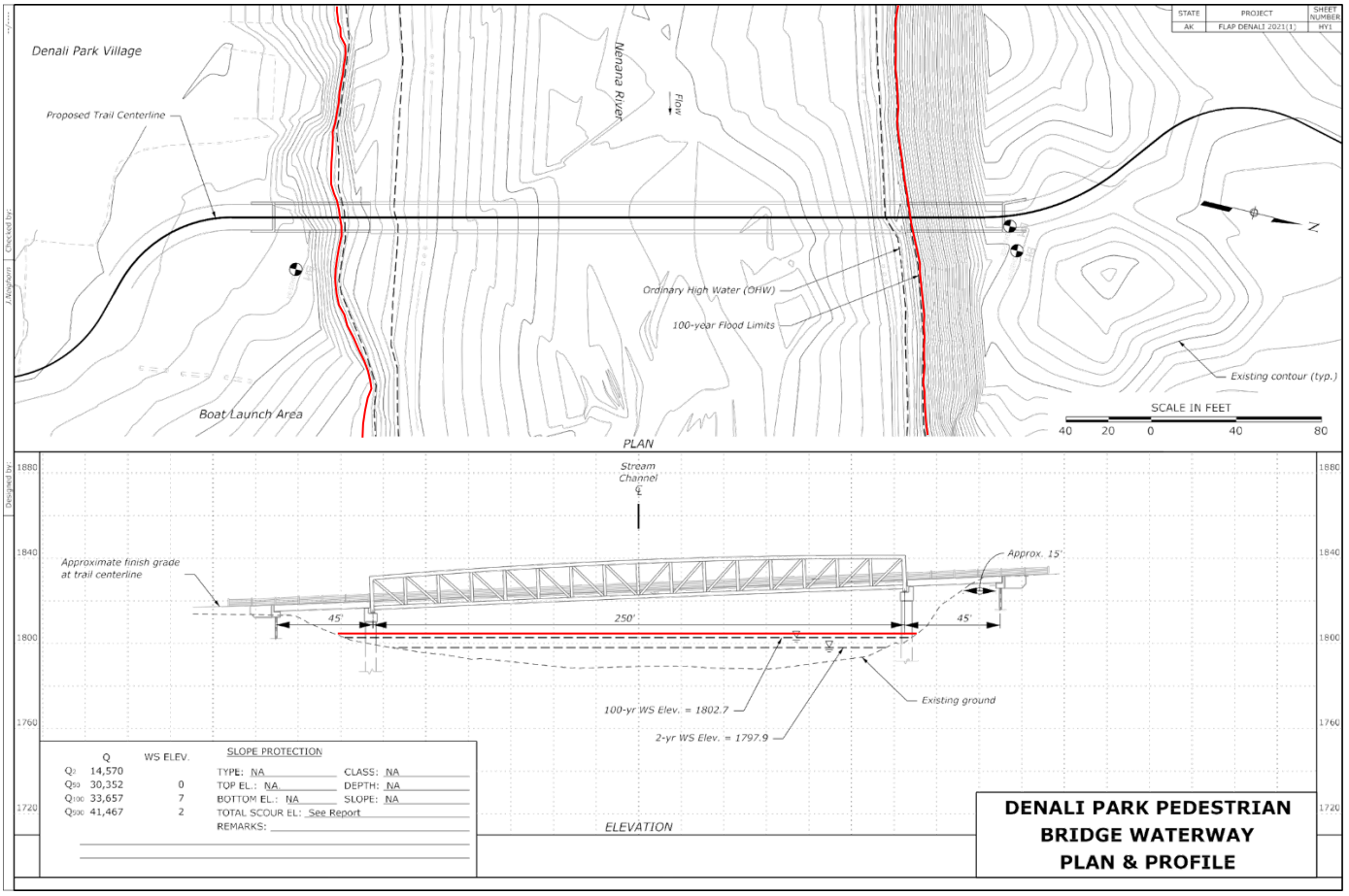


Figure 1. Proposed bridge design and NPS regulatory floodplain (red)

This project would move pedestrians and cyclists off the Parks Highway 231 bridge (Alaska Route 3) and provide access to the DENA trail system. Once complete, the bridge would serve local residents, tourists,

hikers, bikers, and area businesses by providing pedestrian access to DENA and ADOT&PF facilities through a dedicated pedestrian facility.

The project is intended to address pedestrian, bicycle, and vehicle modal conflicts and park facility access concerns by separating vehicle traffic from pedestrian and bicycle use within this high speed (65 miles/hour) congested highway corridor

Other actions included no action, and an alternative bridge location that is slightly east and lower in elevation than the proposed action. The alternative location was less favorable due to the grade challenges and complicated connectivity for accessible trail connections on the north side of the river. The no-action alternative would retain pedestrian access via the highway bridge with multimodal safety concerns. This project has been a high priority for public safety improvements as identified in the 2022 Cantwell to Healy Planning and Environmental Linkages Study; safety issues have increased with the development of the Tsenesdghaas Na' Trailhead facility in 2024 and new NPS trails on the north side of the river that are seeing increasing visitor use including pedestrian access from the south side of the river.

A Value Methodology workshop was held September 11, 2025 to evaluate bridge design types and select the preferred alternative. Alternatives evaluated included steel truss, timber truss, and steel plate girder bridge types. The truss bridges were preferred for having pier supports outside of the Ordinary High Water river channel; the steel truss was selected as the preferred alternative for service life, lower maintenance, widest width for safety and use versatility, best flood/fire resilience, cultural aesthetic for viewshed.

1.4 DETERMINATION OF ACTION CLASS AND REGULATORY FLOODPLAIN

Following PM 77-2, three action classes were considered when establishing the regulatory floodplain:

1. Class I Actions (i.e., non-critical actions) include location or construction of administrative, residential, warehouse, and maintenance buildings; non-excepted parking lots; or other man-made features, which by their nature entice or require individuals to occupy the site, are prone to flood damage, or result in impacts to natural floodplain values.
2. Class II Actions (i.e., critical actions) include any activity for which even a slight chance of flooding is too great, such as construction of schools, medical facilities, emergency services, hazardous material storage, and records/collections storage.
3. Class III Actions include any action that involves human occupation or substantial human exposure in high hazard areas, such as drainages subject to flash flooding.

This project meets the definition of a Class I Action as it is a man-made feature that entices or requires people to occupy the site in an area prone to flooding, or results in impacts to natural floodplain values.

Proposed actions on NPS lands must comply with FFRMS for new construction, substantial improvement, or repairing substantial damage. Per departmental guidance, agencies may select one of three approaches to implement flood resiliency measures:

- **Climate-Informed Science Approach (CISA) –** The elevation and flood hazard area that result from using the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding, including climate change and other physical processes (e.g. land-use change).

- **Freeboard Value Approach (FVA) –** The elevation and flood hazard area that result from adding an additional 2 feet to the base flood elevation (BFE) for non-critical actions and by adding an additional 3 feet to the BFE for critical actions.
- **0.2-Percent Annual-Chance Flood Approach (0.2PFA) –** The area subject to flooding by the 0.2% (500-year) annual-chance flood.

A 0.2% AEP Approach establishing FFRMS flood elevations is employed for this proposed action. The regulatory floodplain in the vicinity of the Nenana River Bridge has been modeled by the FHWA as described in the following section. The 0.2% AEP elevation at the project site is 1804.2 feet.

2 JUSTIFICATION FOR USE OF THE FLOODPLAIN

The primary goal of this project is to provide pedestrian access to the Nenana River Trail system that avoids use of the highway bridge and reduces potential adverse vehicle-visitor interactions. There are no alternatives that connect the Denali Park Village to the trail system without a bridge. This site and design were selected as the least subject to flooding impacts, has minimal disturbance to floodplain values, and minimizes adverse impact to the viewshed.

3 DETAILED FLOOD HAZARD AND FLOOD RISK ANALYSIS

3.1 DESCRIPTION OF SITE-SPECIFIC FLOOD HAZARD

The project site is located within an area which is unmapped by FEMA. No stream flow data is available for the river near the crossing site. Delineation of the watershed was performed using GIS surface and contour data. The calculated contributing basin area is 1195 square miles. The basin consists of more than 85 percent low shrub birch and willow with approximately 0.1 percent lake and 8.2 percent forested areas. Peak discharges were estimated using USGS regression equations from "Estimating the Magnitude and Frequency of Peak Streamflows for Ungaged Sites on Streams in Alaska and Conterminous Basins in Canada" (USGS Report 03-4188) and are listed in Table 1.

Table 1 - Peak Discharges

Site #	Location	Drainage Area (mi^2)	Peak Discharges (cfs)				
			2-yr	25-yr	50-yr	100-yr	500-yr
1	Nenana River	1,195	14,570	27,089	30,352	33,657	41,467

Surface-Water Modeling System, Sediment and River Hydraulics Two-Dimensional (SMS: SRH-2D, 13.3.14) flow model was used for estimating water surface elevations, flow depths, and flow velocities at the location of the proposed bridge. The model was calibrated with bankfull and high-water levels determined in the field and compared with regional curve data as a validity check. Water surface elevations are summarized in Table 2.

Table 2 – Water Surface Elevations

	Recurrence Intervals				
	2-yr	**25-yr**	**50-yr**	**100-yr**	**500-yr**
Water Surface Elevation (ft)	1797.9	1801.2	1802.0	1802.7	1804.2

Model results show a flow depth of 3.0 ft and velocity of 2.0 ft/sec near the proposed piers during the 100-year flow event. For the 500-year event the flow depth was 5.2 ft and velocity was 3.0 ft/sec (Appendix A).

3.2 DESCRIPTION OF SITE-SPECIFIC FLOOD RISK

The proposed project would not encourage occupation of the floodplain. The bridge piers and abutments are within the 500-year flooding zone but the trail and bridge deck are designed to be out of the risk area. Flash flooding is rare on this river and water levels typically rise slowly over the course of hours or days, so there is sufficient time and warning to ensure the bridge is not occupied during peak flows. As a bridge, the structure has sufficient egress to either side and out of the floodplain.

The boat launch located on the south side of the proposed trail bridge produces a large amount of river traffic (rafters) and recreational river use. Pier configurations have been designed so that hazards are not created for river users and potential for debris accumulation is minimized.

This project has low to moderate risk to infrastructure, both the proposed bridge and nearby structures or property. FHWA policy allows up to one-foot rise in the 100-year water surface elevation within an area that is unmapped by FEMA. However, the proposed bridge should also not cause a flood rise impacting nearby structures or property.

Protecting the piers from wood debris and ice jams that occur during spring melt is critical. A HEC-18 (5th Edition, April 2012) scour analysis was completed using extracted hydraulic results from SMS SRH-2D software. The results were exported into the Hydraulic Toolbox (v.4.4) software for scour analysis. The analysis includes pier scour for the 100-year and 500-year flood events.

Geotechnical borings did not indicate bedrock near the streambed surface. Streambed material gradations used in the scour analysis were developed using digital photographs of riverbed surfaces taken near the proposed pier locations. The photographs were processed using the FHWA Hydraulic Toolbox, version 5.4, gradation analysis tool. The D15 is approximately 1.5 inches; D50 is approximately 3.1 inches; D85 is approximately 5.9 inches and D100 is approximately 13.5 inches. The streambed D50 material size

exceeds 0.8 inches, indicating that the channel bottom is armored. Therefore, the course bed scour equation was used for estimating the scour at the piers.

The pier configurations is designed as a single 6-foot diameter set of piers which would be located just within the limits of the 500-year flood. Scour and has been listed in Table 3 (specific calculations are shown in Appendix B).

Table 3. Scour values for Nenana Pedestrian Bridge

	Recurrence Intervals				
	2-yr	**25-yr**	**50-yr**	**100-yr**	**500-yr**
Long-term Degradation (ft)	NA	NA	NA	6.0	6.0
Pier Scour (ft)	NA	NA	NA	0.2	0.4
Total Scour Elevation (ft)	NA	NA	NA	1793.8	1793.6
Notes: Scour values listed have been rounded up.					

Pier designs account for the large forces produced by the 3 to 4-foot thick ice sheets that form. Ice jams consisting of layered ice sheets that can be as thick as 6 feet. Based on hydraulic analysis and geotechnical information, pier designs elevations are as follows:

- Total 100-year pier scour elevation: 1793.8 feet
- Total 500-year pier scour elevation: 1793.6 feet

Designs include pier protective armoring up to or above elevation 1806.7 feet. This would provide an additional 4 feet above the 100-year flood elevation to protect against ice sheets that can stack and flow over the base ice layer or run-up at the face of the pier.

Floodplain values should not be impacted since there will only be minor encroachment of the bridge piers at the edge of the 100-year flood limits. The minimal footprint should have negligible adverse impact on flood attenuation at or near the site.

Bank erosion and lateral shift of the channel thalweg on the north side of the river is expected to naturally occur along the outside of the river bend. This can occur gradually over the life span of the new bridge. The trail approach and bridge abutment designs account for this bank migration.

There will be temporary, minor impacts to riparian habitat during construction and long-term minor impacts to habitat at the pier locations. These effects are not expected to adversely impact overall habitat availability or ecosystem function.

The project will have negligible impacts on groundwater recharge, nutrient cycling, and water quality. Temporary adverse effects on sediment supply (turbidity) and erosion conditions during construction will be mitigated by implantation of a Stormwater Pollution Prevention Plan (SWPPP) as required by the

Alaska Department of Environmental Conservation (DEC). The bridge piers and abutments have been designed to have negligible effects on erosion and sedimentation proximal to the project.

4 FLOODPLAIN IMPACT MITIGATION MEASURES

No embankment fill or abutments will be placed within the modeled 100-year water surface elevation. The main span of the bridge structure was designed to the structural limit for the bridge type proposed at 250-feet. Extending the main span structure would have required placing piers within the active river channel (within OHW). The proposed bridge piers for the 250-foot main span will be outside of the ordinary high water and placed at the edge of the modeled 100-year water surface, though they are within the NPS regulatory floodplain; however, this configuration mitigates risk by reducing the forces on the piers placed outside of the main flow. Modeling of the minor pier encroachment does not indicate any significant changes in the water surface elevations during the 100 or 500-year flood events. The proposed bridge is not expected to increase flooding of adjacent property or insurable structures.

The proposed bridge low chord elevation, or the bridge's lowest point on the south end, has been designed to provide 11.5-feet of clearance or freeboard above the regulatory flood elevation. Setting the bridge low chord at this elevation allows passage of expected flood flows with more than sufficient clearance for river traffic, ice, wood debris, or log jams.

The bridge piers and abutments are within the flooding zone but the trail and bridge deck is designed to be out of the risk area. Flash flooding is rare on this river and water levels typically rise slowly over the course of hours or days, so there is sufficient time and warning to ensure the bridge is not occupied during peak flows. As a bridge, the structure has sufficient egress to either side and out of the floodplain.

Pier protective armoring has been included in the proposed design and will extend up to or above elevation 1806.7 feet. This would provide an additional 2.5 feet above the 500-year flood elevation to protect against ice sheets that can stack and flow over the base ice layer or run-up at the face of the piers.

To minimize risk to boat launch users and river traffic (rafters), the bridge piers will consist of simple single round piers at each end of the bridge. This poses minimal hazard to river users while significantly reducing the potential for debris accumulation. The single round piers also reduces scour potential. A HEC-18 (5th Edition, April 2012) scour analysis was completed using extracted hydraulic results from SMS SRH-2D software and geotechnical information. The results were exported into the Hydraulic Toolbox (v.4.4) software for scour analysis. The analysis shows minimal pier scour for the 100-year and 500-year flood events at elevation 1793.8 and 1793.6 respectively. The bridge pier designs have included this in the structural stability analysis.

The approach abutments have been extended sufficiently away from the existing channel banks to avoid the need to place fill within the river channel. The north abutment and associated abutment support piles have been set back approximately 15 feet from the face of the steep north bank to avoid exposure from long-term bank erosion or channel migration.

5 SUMMARY

The National Park Service has determined that implementing the proposed action to constructing a new pedestrian bridge across the Nenana River at the Denali Park Village as part of Denali Park Pedestrian

Bridge and Trail Connector project. The primary goal of this project is to provide pedestrian access to the Nenana River Trail system that avoids visitor use of the highway bridge and reduces potential adverse vehicle-visitor interactions.

The proposed trail crossing will include a 340-foot bridge that consists of a 250-foot main span, supported by single 6-foot diameter piers with 45-foot approach spans at each end. The proposed pier supports will be outside of the ordinary high water and will encroach slightly at the edge of the modeled 500-year water surface.

The bridge has been designed to keep visitors above the regulatory floodplain and to minimize impacts on floodplain values. As designed, there will be minimal potential risks to NPS infrastructure and investment.

6 REFERENCES

Department of Interior Office of Environmental Policy and Compliance. 2022. Departmental Manual Part 520: Protection of the Natural Environment; Chapter 1: Floodplain Management and Wetlands Protection Policy and Responsibilities (520 DM 1).

Department of Interior Office of Environmental Policy and Compliance. 2022. Departmental Manual Part 520: Protection of the Natural Environment; Chapter 2: Floodplain Management and Wetlands Protection Program Requirements (520 DM 2).

Executive Order 11988, "Floodplain Management." 1980. Executive Order of the President of the United States. May 28.

Hydrologic Engineering Center (HEC). (2022, March). River Analysis System (HEC-RAS), Version 6.2. US Army Corps of Engineers (USACE).

National Park Service (NPS). 2003. Director's Order 77-2: *Floodplain Management*. Washington Office, Washington, D.C.

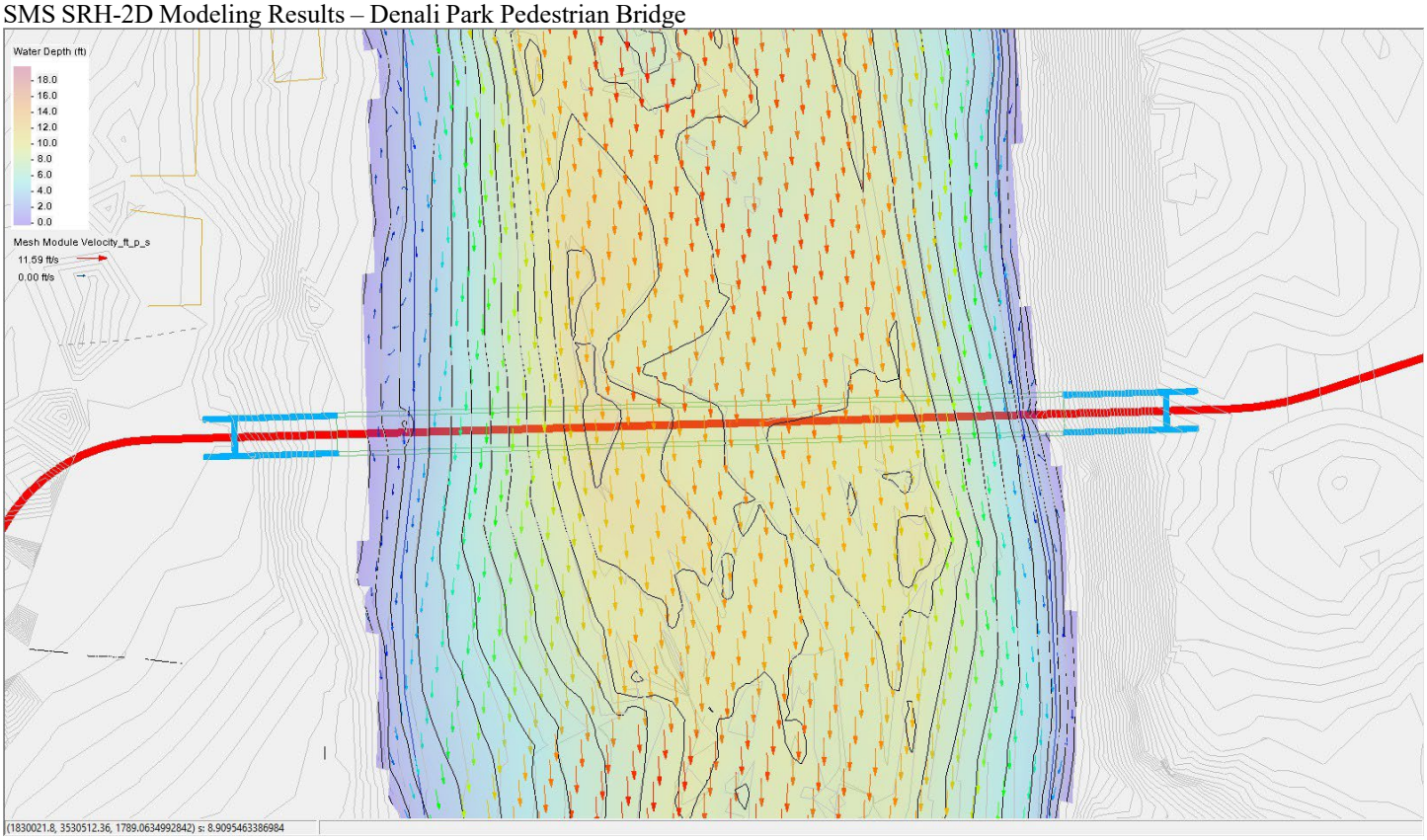
National Park Service (NPS). 2025. Procedural Manual 77-2: *Floodplain Management*. Washington Office, Washington, D.C.

Neighorn, James. 2026. Denali Park Pedestrian Bridge Preliminary Hydraulics Report. Western Federal Lands Highway Division, US Department of Transportation.

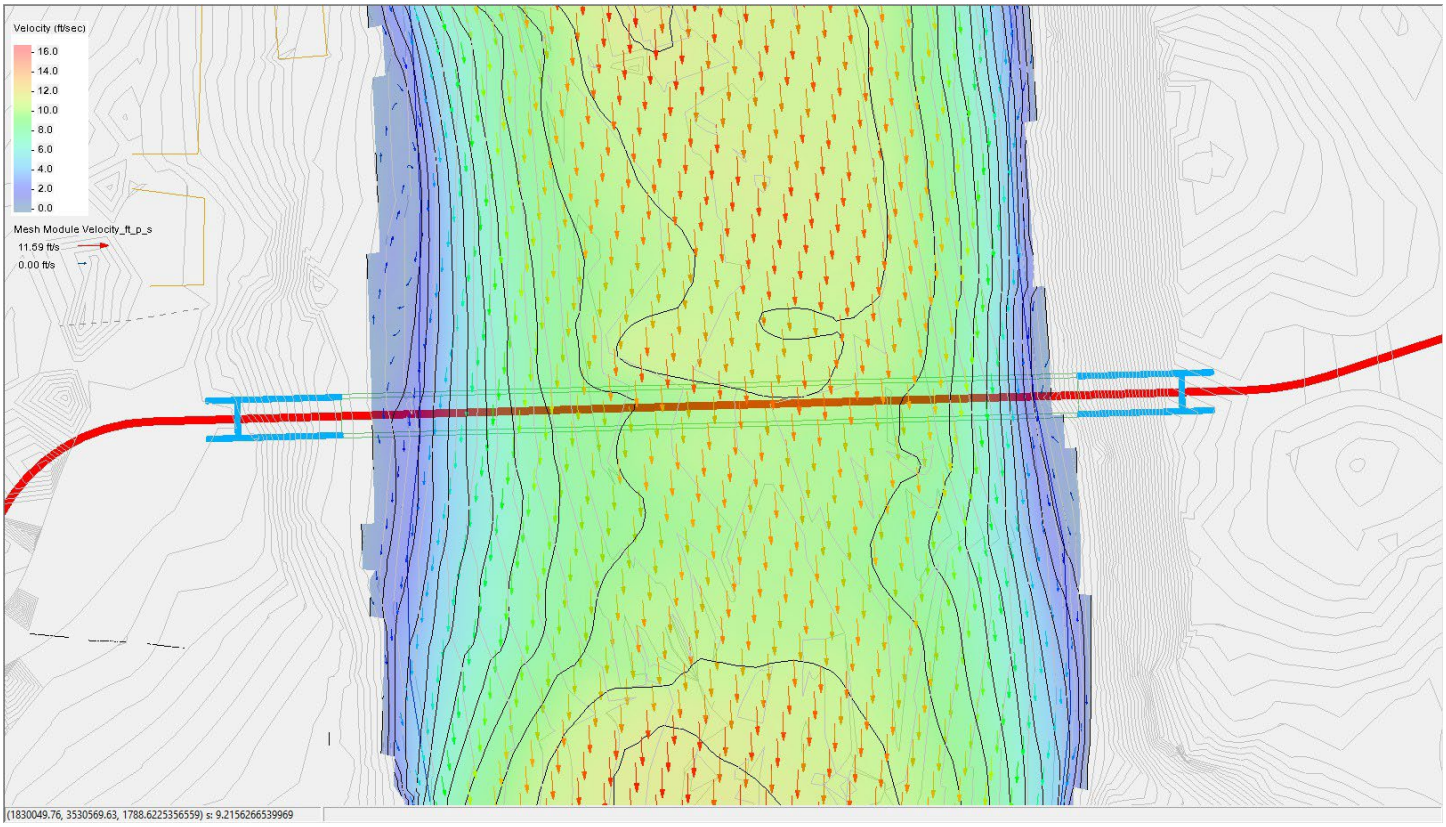
Wiley, J.B., and Curran, J.H., 2003, Estimating annual high-flow statistics and monthly and seasonal low-flow statistics for ungaged sites on streams in Alaska and conterminous basins in Canada: U.S. Geological Survey Water-Resources Investigations Report 2003-4114, 61 p., https://doi.org/10.3133/wri034114.

7 APPENDIX A – FLOOD MODELING RESULTS

SMS SRH-2D Modeling Results – Denali Park Pedestrian Bridge

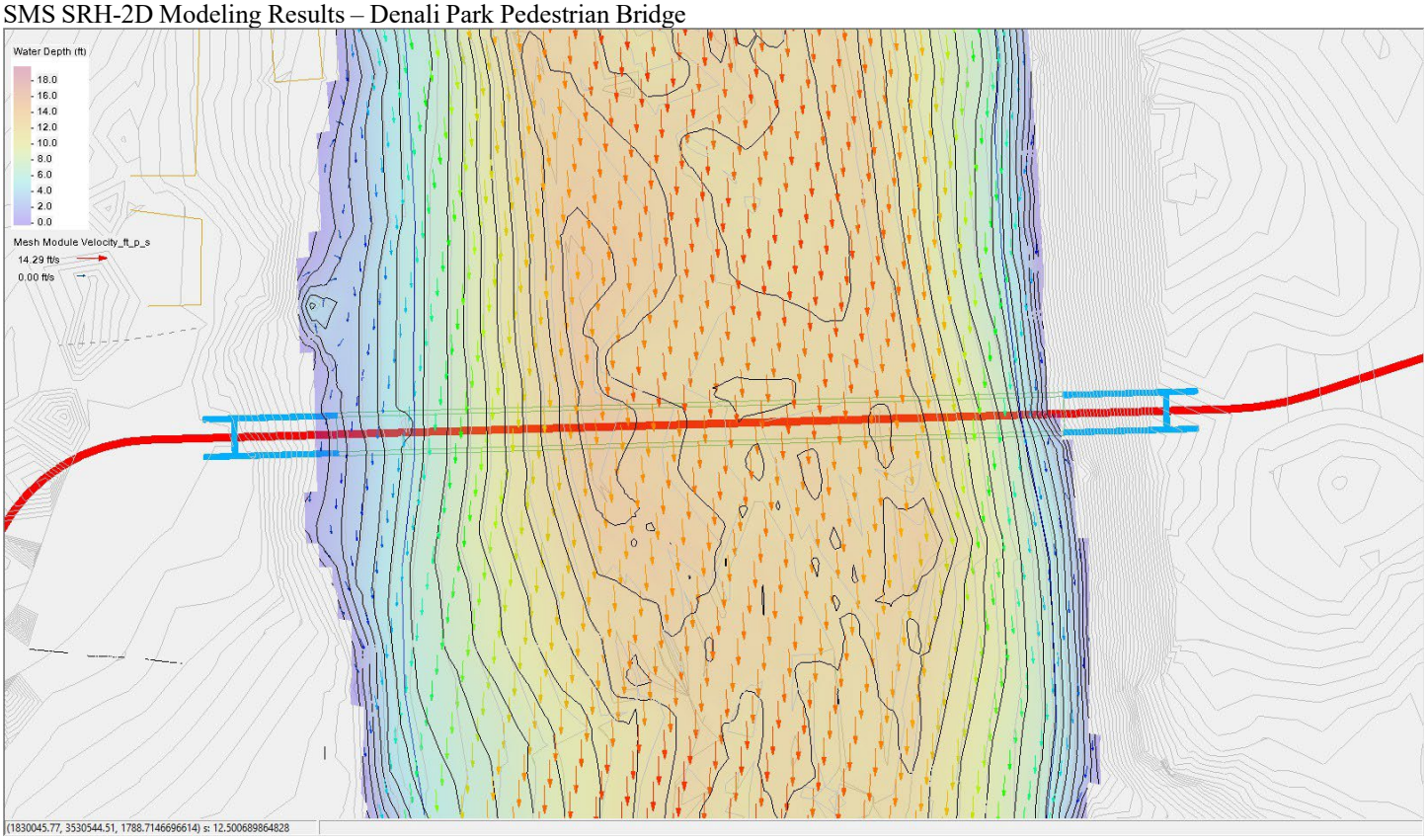


2-year Water Depth

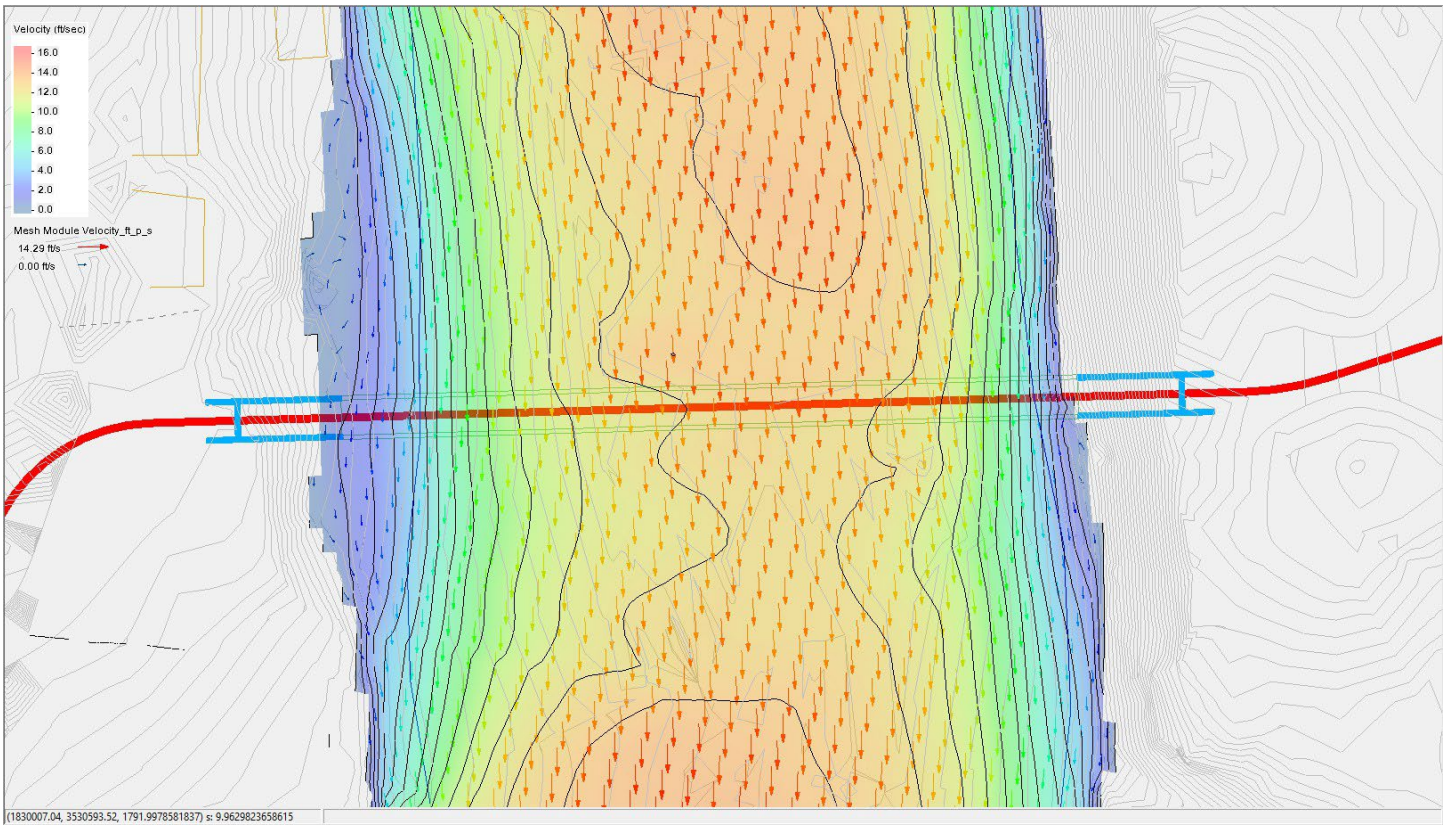


2-year Velocity

SMS SRH-2D Modeling Results – Denali Park Pedestrian Bridge

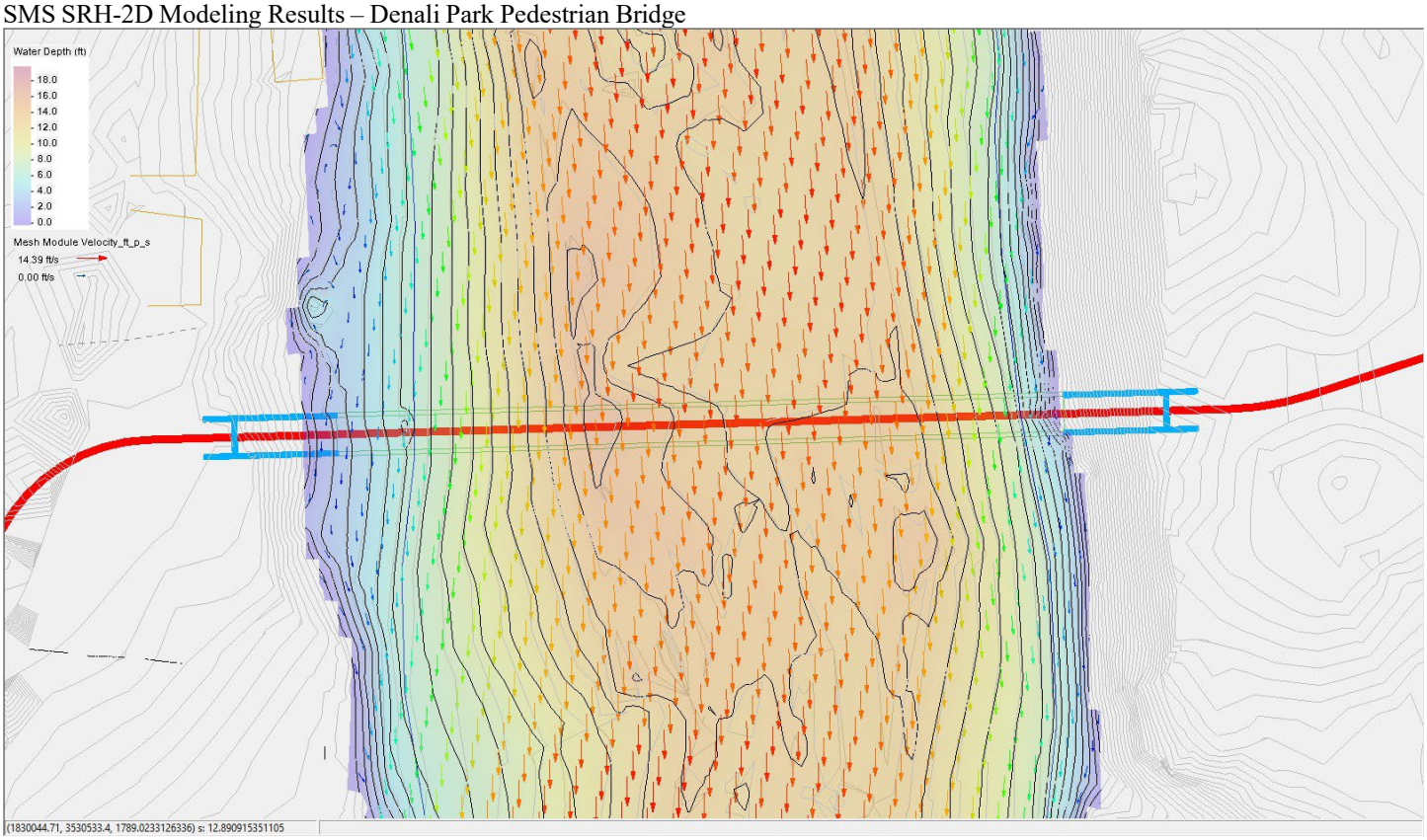


25-year Water Depth

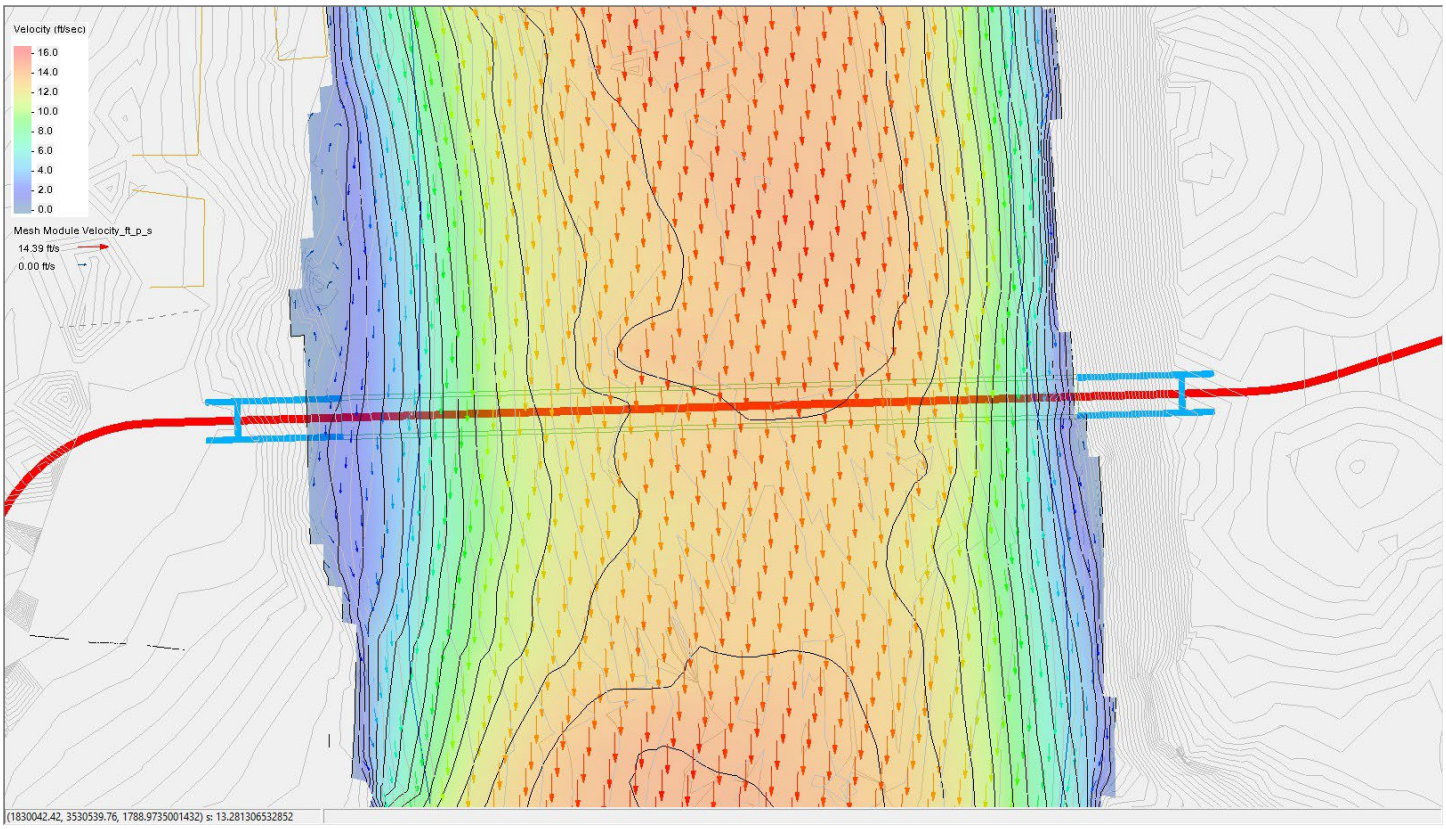


25-year Velocity

SMS SRH-2D Modeling Results – Denali Park Pedestrian Bridge

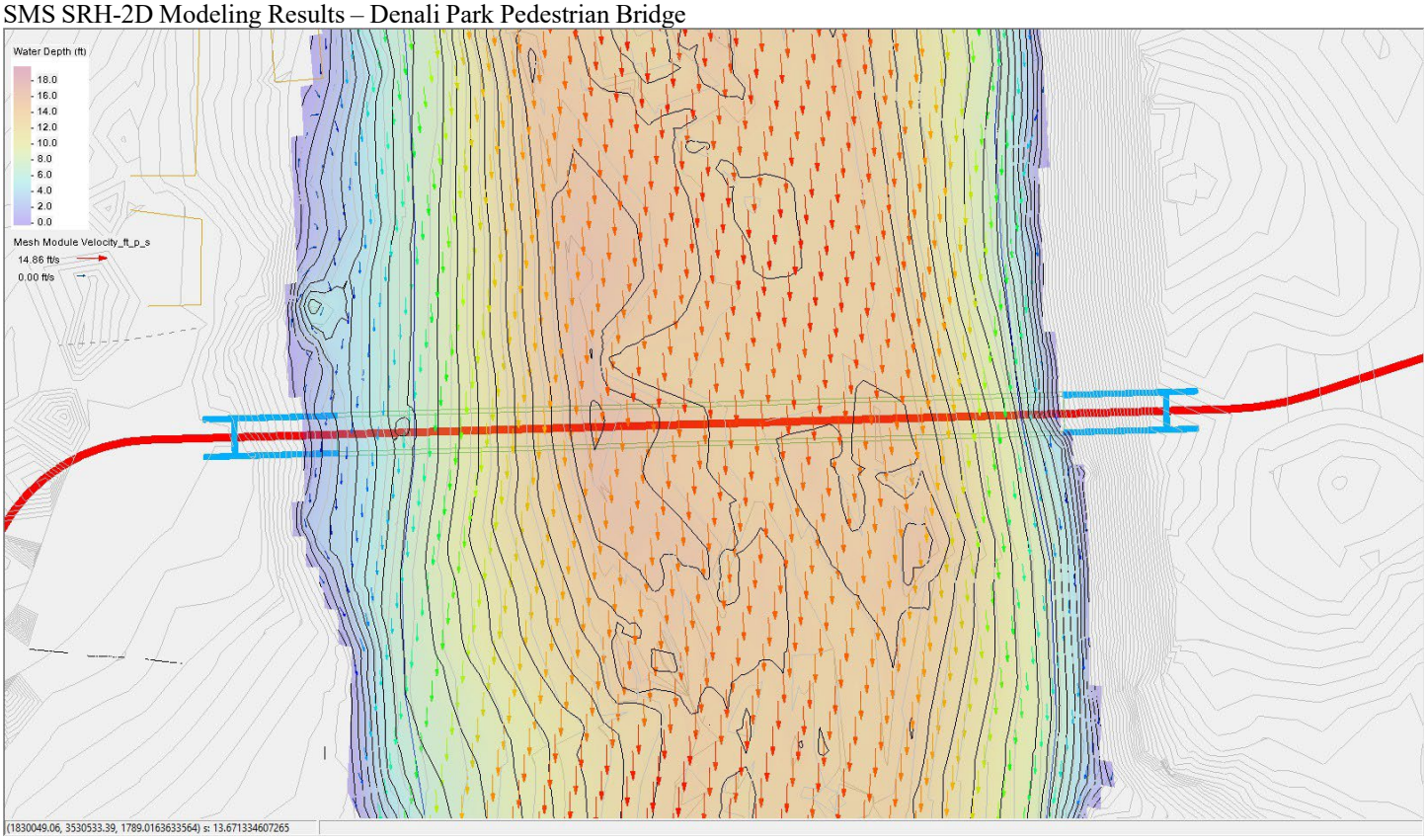


50-year Water Depth

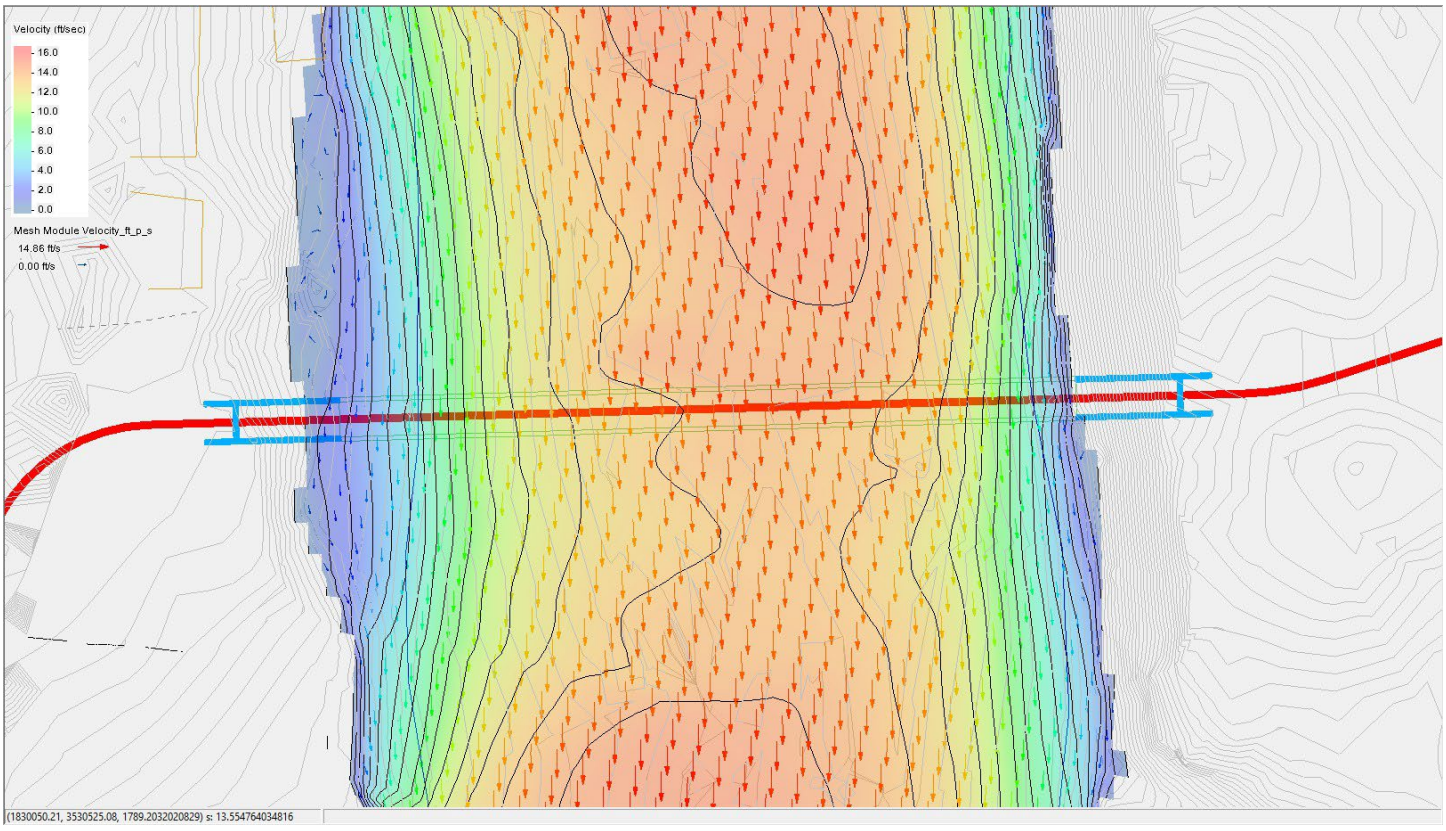


50-year Velocity

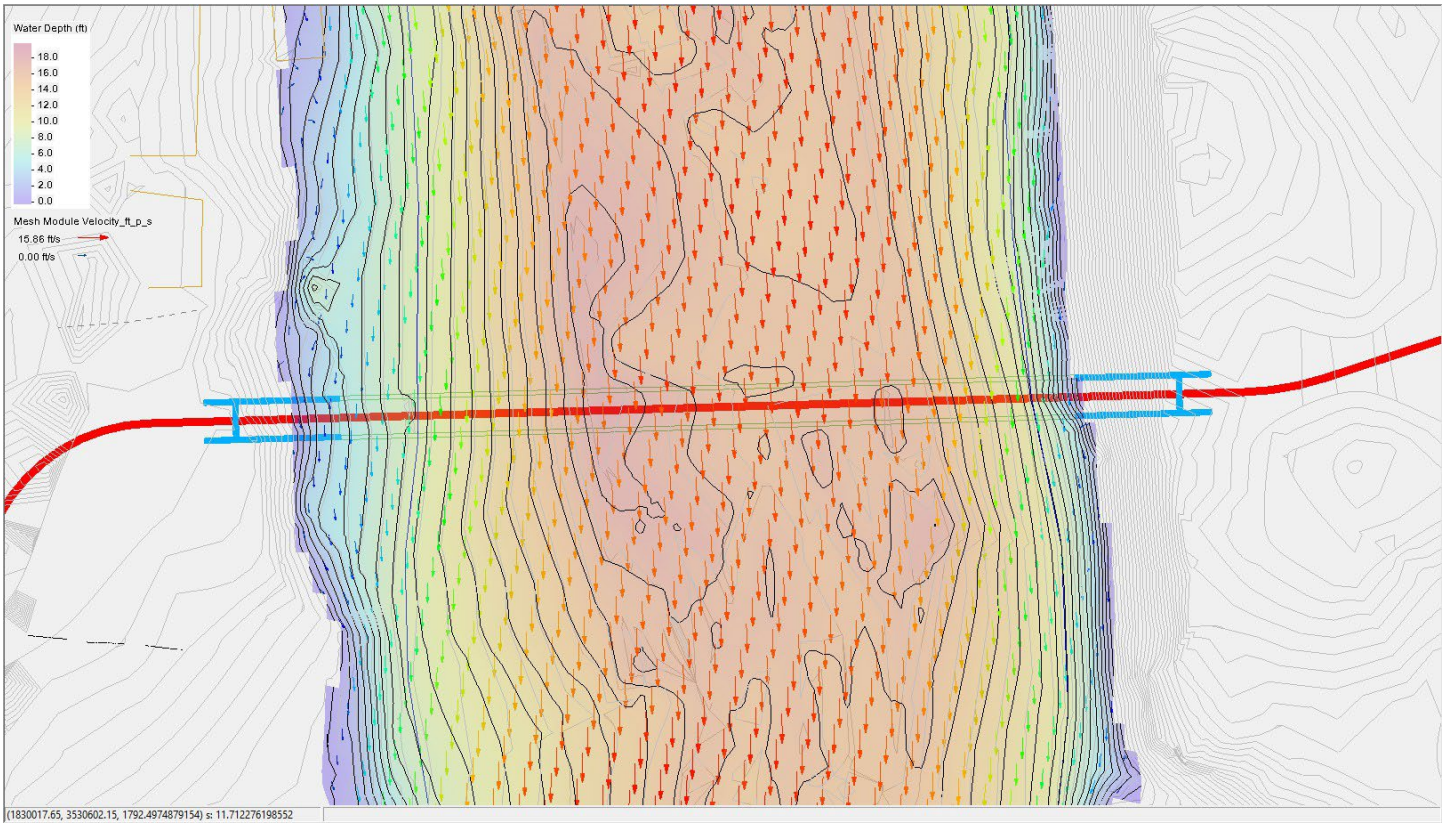
SMS SRH-2D Modeling Results – Denali Park Pedestrian Bridge



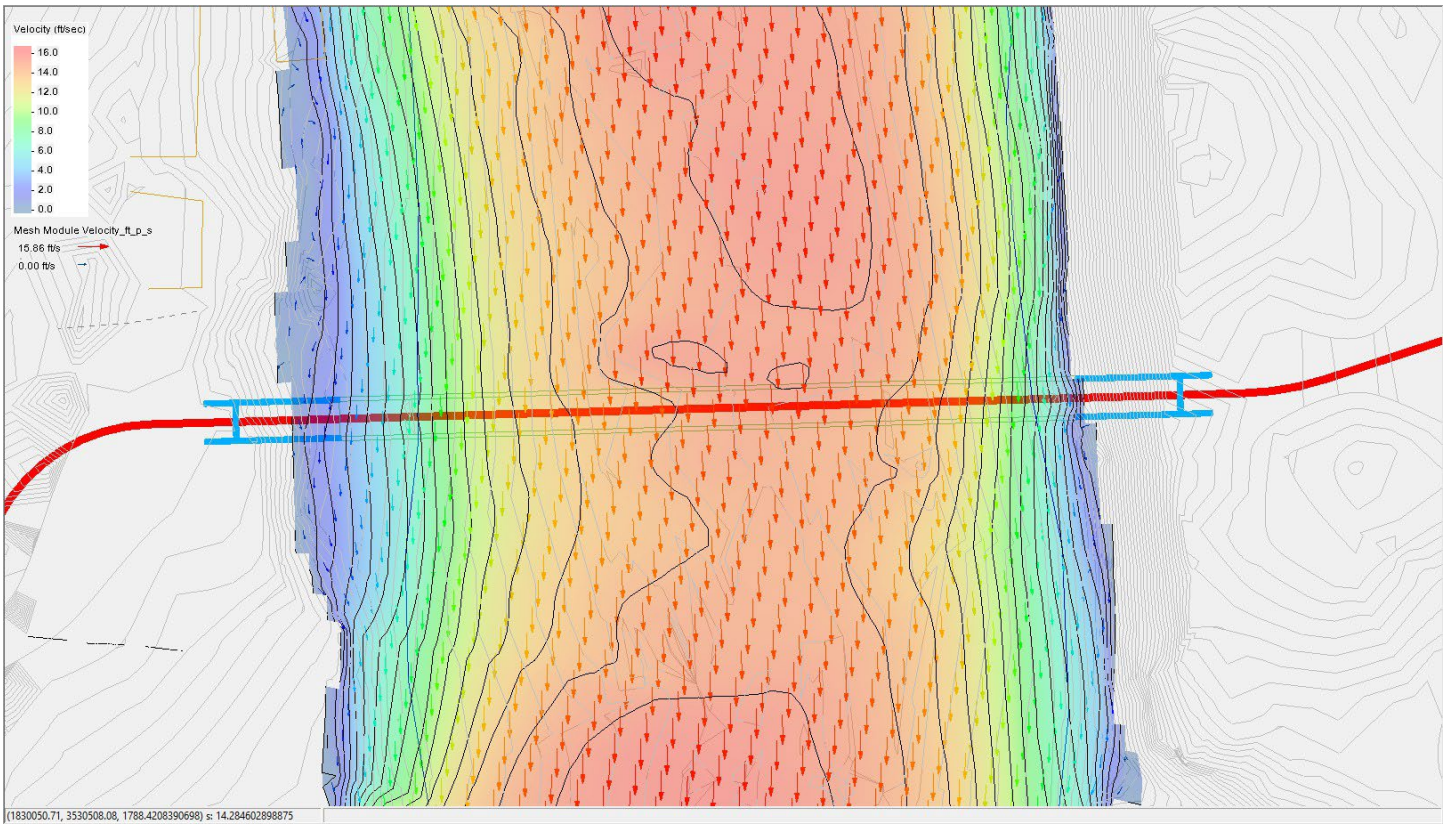
100-year Water Depth



100-year Velocity



500-year Water Depth



500-year Water Velocity

APPENDIX B: SCOUR ESTIMATE

Project: **AK DOT Parks Hwy FLAP Denali 2021(1)**
Desc: **Denali Pedestrian Bridge**
Units: **ENG**

File: **Scour Analysis**
Date: **7/2/2026**
By: **J.Neighorn**

		Location Description			
		100-year for 4' Diameter Pier	500-year for 4' Diameter Pier		
CONSTANTS					
UNITS	SI or ENG	ENG	ENG	ENG	ENG
g	ACCELERATION OF GRAVITY, 9.81 m/s2, 32.2 ft/s2	32.20	32.20	32.20	32.20
Du	D UNIT CONVERSION, 0.001 SI, 0.00328 English	0.00328	0.00328	0.00328	0.00328
LIVE-BED OR CLEAR-WATER DETERMINATION					
y	AVERAGE FLOW DEPTH, m, ft	3.0	5.2		
D50	DIAMETER 50% FINER BED PARTICLES, mm	79	79		
V	AVERAGE VELOCITY, m/s, ft/s	2.0	3.0		
Ku	UNIT COEFFICIENT, 6.19 SI, 11.17 English	11.170	11.170	11.170	11.170
Vc (6.1)	CRITICAL VELOCITY, m/s, ft/s	8.56	9.38	0.00	0.00
LB / CW	LIVE BED or CLEAR WATER	CW	CW		
LIVE-BED CONTRACTION SCOUR					
y1	AVERAGE U/S DEPTH, MAIN CHANNEL, m, ft				
y0	AVERAGE CONTRACTED DEPTH BEFORE SCOUR, m, ft				
Q1	FLOW IN UPSTREAM CHANNEL, m3/s, ft3/S				
Q2	FLOW IN CONTRACTED CHANNEL, m3/s, ft3/S				
W1	WIDTH OF THE UPSTREAM CHANNEL, m, ft				
W2	WIDTH OF THE CONTRACTED SECTION, m, ft				
S1	ENERGY SLOPE OF MAIN CHANNEL, m/m, ft/ft				
w (Fig 6.8)	D50 FALL VELOCITY, m/s				
	UNIT COEFFICIENT, 1.0 SI, 3.28 English	3.28	3.28	3.28	3.28
	D50 FALL VELOCITY, m/s, ft/s	0.000	0.000	0.000	0.000
k1 (p6.10)	TRANSPORT COEFFICIENT	0.00	0.00	0.00	0.00
	BED MATERIAL TRANSPORT MODE				
V*	SHEAR VELOCITY, m/s, ft/s	0.00	0.00	0.00	0.00
y2 (6.2)	AVERAGE DEPTH, CONTRACTED SECTION, m, ft	0.00	0.00	0.00	0.00
yS (6.3)	AVERAGE SCOUR DEPTH, m, ft	0.00	0.00	0.00	0.00
As	AVERAGE SCOUR AREA, m2, ft2	0.00	0.00	0.00	0.00

CLEAR-WATER CONTRACTION SCOUR					
y0	AVERAGE CONTRACTED DEPTH BEFORE SCOUR, m, ft	0.0	0.0	0.0	0.0
D50	MEDIAN DIAMETER BED MATERIAL, mm	79.0	79.0	0.0	0.0
Q	DISCHARGE THROUGH THE BRIDGE, m3/s, ft3/s	0.0	0.0	0.0	0.0
W	BOTTOM WIDTH OF THE CONTRACTED SECTION, m, ft	0.0	0.0	0.0	0.0
Ku	UNIT COEFFICIENT, 0.025 SI, 0.0077 English	0.0077	0.0077	0.0077	0.0077
Dm	DIA. SMALLEST NONTRANSPORT PARTICLE, m, ft	0.3239	0.3239	0.0000	0.0000
y2 (6.4)	AVERAGE DEPTH, CONTRACTED SECTION, m, ft	0.00	0.00	0.00	0.00
yS (6.5)	AVERAGE SCOUR DEPTH, m, ft	0.00	0.00	0.00	0.00
As	AVERAGE SCOUR AREA, m2, ft2	0.00	0.00	0.00	0.00
PRESSURE FLOW CONTRACTION SCOUR					
Hb	DISTANCE LOW CHORD TO STREAM BED, m, ft				
y1	FLOW DEPTH UPSTREAM FACE OF BRIDGE, m, ft				
D50	D50 OF BED MATERIAL IN OPENING, mm				
Va	AVERAGE VELOCITY THROUGH OPENING, m/s, ft/s				
Ku	UNIT COEFFICIENT, 6.19 SI, 11.17 English	11.170	11.170	11.170	11.170
Vc (5.1)	CRITICAL VELOCITY, m/s, ft/s	0.00	0.00	0.00	0.00
ys	VERTICAL SCOUR DEPTH, m, ft	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PIER SCOUR					
y1	FLOW DEPTH U/S OF THE PIER, m, ft	3.0	5.2		
V1	APPROACH VELOCITY, m/s, ft/s	2.0	3.0		
a	PIER WIDTH, m, ft	6	6		
L	PIER LENGTH, m, ft	6	6		
FA	FLOW ANGLE, degrees	0	0		
K1 (Tbl 7.1)	CORRECTION FOR PIER SHAPE (0.9 to 1.1, >5deg, 1)	1.0	1.0		
K3 (Tbl 7.3)	CORRECTION FOR BED FORM (1.1 to 1.3)	1.1	1.1		
Sg	SEDIMENT SPECIFIC GRAVITY	2.65	2.65	2.65	2.65
D50	DIAMETER 50% FINER BED PARTICLES, mm	79	79		
D84	DIAMETER 95% FINER BED PARTICLES, mm	250	250		
Ku	UNIT COEFFICIENT, 6.19 SI, 11.17 English	11.17	11.17	11.17	11.17
Vc50 (6.1)	CRITICAL VELOCITY D50, m/s, ft/s	8.55	9.37	0.00	0.00
L/a	PIER LENGTH/WIDTH RATIO (MAX. L/a = 12))	1.00	1.00	0.00	0.00
Fr	FROUDE RATIO	0.20	0.23	0.00	0.00
GC	SEDIMENT GRADATION COEFFICIENT, D84/D50	3.16	3.16	#DIV/0!	#DIV/0!
H	DENSIMETRIC PARTICLE FROUDE NUIMBER	0.54	0.81	#DIV/0!	#DIV/0!
K2 (7.4)	CORRECTION FOR FLOW ANGLE (1 to 5)	1.00	1.00	0.00	0.00
y1/a		0.50	0.87	#DIV/0!	#DIV/0!
a/D50		23.16	23.16	#DIV/0!	#DIV/0!
V1/Vc		0.23	0.32	#DIV/0!	#DIV/0!
Kw (7.20-21)	WIDE PIER CORRECTION FAC (y1/a<0.8, a/D50>50, Fr<1)	0.00	0.00	#DIV/0!	#DIV/0!
yS (7.3)	SCOUR DEPTH, m, ft	5.22	6.70	0.00	0.00
yS (7.34)	SCOUR DEPTH-COARSE BED, m, ft (D50>20mm & D84/D50>1.5)	0.13	0.37	#DIV/0!	#DIV/0!

ABUTMENT SCOUR - NCHRP 24-20					
y1	AVERAGE U/S DEPTH, MAIN CHANNEL, m, ft				
v1	AVERAGE U/S VELOCITY, MAIN CHANNEL, m/s, ft/s				
y0	AVERAGE CONTRACTED DEPTH BEFORE SCOUR, m, ft				
Vbr	AVERAGE VELOCITY THROUGH BRIDGE, m/s, ft/s				
Bf	FLOODPLAIN WIDTH, m, ft				
	FLOW THROUGH BRIDGE, m3/s, ft3/s				
WW	WATERWAY WIDTH, m, ft				
L	PROJECTED LENGTH EMBANKMENT, m, ft				
D50	DIAMETER 50% FINER BED PARTICLES, mm				
alpha	SCOUR AMPLIFICATION FACTOR (FIG. 8.9 - 8.12)				
Ku	UNIT COEFFICIENT, 6.19 SI, 11.17 English	11.17	11.17	11.17	11.17
L/Bf	L/Bf > 0.75 USE LB, < 0.75 USE CW	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
q1	UPSTREAM UNIT DISCHARGE, m3/s, ft3/s	0.00	0.00	0.00	0.00
q2	UNIT DISCHARGE IN CONSTRICTED OPENING, m3/s, ft3/s	0.00	0.00	0.00	0.00
q2/q1		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
ymax (8.3)	MAXIMUM FLOW DEPTH RESULTING FROM SCOUR, ft, m	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
yS (8.4)	ABUTMENT SCOUR DEPTH, m, ft	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!