Phase 2 Report

VDOT
Virginia Department of Transportation

Shenandoah Valley Rail-With-Trail Assessment

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PHASE 2 EXECUTIVE SUMMARY

Phase 1 of the Shenandoah Valley Rail-With-Trail (SVRWT) Assessment concluded in March 2025. This Phase performed an alternatives analysis, culminating with the development of typical sections. Every part of the rail corridor was assigned a corresponding typical section, which allowed the project team to calculate total mileage by section. This was the foundation of Phase 2, which consists of a corridor assessment. Phase 2 evaluates track and structure conditions in relation to typical sections and requirements for future rail operations. Phase 3 – the final phase of this project – will include cost estimates and documentation of the assessment outcomes. This Phase 2 report is organized around five appendices that detail the corridor assessment. The key findings of each appendix are presented below.

Environmental Desktop Review (Appendix A)

The study team evaluated potential environmental impacts using available spatial data. The study area features several wetlands and streams, is situated on karst topography, and in close proximity to parks, historic sites, conservation easements, and potential hazardous sites. Therefore, future coordination with relevant agencies will be required. This is typically undertaken as part of compliance for the National Environmental Policy Act (NEPA). The rail corridor is listed as an eligible resource, meaning that it has certain protections and requirements under Section 106 of the National Historic Preservation Act. Because rails, ties, and ballasts are often replaced over a rail's lifetime, it is uncertain if these elements contribute to the historicity of the rail corridor. A Section 106 determination would need to be made prior to developing either project option.

Drainage and Stormwater Management Report (Appendix B)

The study team established design recommendations based on drainage, stormwater management, floodplain requirements, and anticipated mitigations for both the rail-to-trail and a rail-with-trail option. They found that, when compared to a rail-to-trail alternative, a rail-with-trail alternative could require as much as 2.3 million cubic feet of additional excavation for a new ditch on one side of the trail. A rail-with-trail option, having a wider footprint, would also require an extension of a minimum of 20 feet for every culvert in the study area. Finally, a rail-with-trail alternative, when compared to a rail-to-trail alternative, would have additional right of way impacts to accommodate required stormwater management facilities commensurate with an increase in impervious surface area.

Track Rehabilitation Report (Appendix C)

The study team developed a strategy to rehabilitate the rail for freight and tourism operations. This strategy outlines the rehabilitation activities required by rail component (ties, rails, ballast, etc.). They determined that, to meet FRA Class 2 rail standards, 35 percent of the corridor would require Level 1 Spot Rehabilitation, which includes lower intensity spot replacements where needed. Thirty percent would require Level 2 Spot Rehabilitation, which includes more intensive replacements where needed. Thirty-five percent would require Full Depth Replacement, which is a full replacement of all rail elements and may include railbed rehabilitation. The most intensive replacements would typically occur in the central segments of the corridor where rail, tie, and ballast replacement would be required.

Bridge Load Rating Report (Appendix D)

The study team examined three out of the 23 bridges in the corridor and assessed their load ratings. The selection of just three bridges – each a different type of bridge – was intended to be a representative sample of the remaining 20 bridges regarding future planning decisions. The study team found that one of the three bridges – an open deck steel/through-truss span bridge - will require rehabilitation to support renewed freight operations at an E-80 load rating. This bridge and likely others of a similar type would require structural retrofits to meet FRA requirements. The study found that one of the three bridges – an open deck steel beam span bridge - had an acceptable load rating for 25mph operations without the need for any structural retrofits. The study team could not determine the age of the final of the three bridges – an open deck steel girder span bridge, meaning that the bridge's steel strength would need to be verified before assessing its load rating. Finally, the study team assessed the suitability for affixing a cantilevered trail on to the sides of these three bridges. Eight structures were identified as potential candidates for supporting a cantilevered walkway. A feasibility analysis of the load rated structures suggested a girder depth of 5'-0" or greater in twin-girder configurations could accommodate such an attachment. Girder depths were primarily obtained from previous inspection reports; in cases where this information was unavailable, visual estimates from field images were used. An exception to this criterion is Asset 6669, which falls below the 5'-0" depth requirement but is considered feasible due to its multi-girder configuration. Additional inspection and structural analysis will be necessary to confirm load effects on these members and verify feasibility. For detailed information on the selected assets, refer to Appendix D-3: Structure Inventory. However, the report does not recommend cantilevered trail attachments due to various issues including shallow beam depth on some bridges, the age of structures, and potential trail user discomfort.

Public Information Meetings Comment Summary (Appendix E)

The study team conducted a multi-faceted public engagement process from March 27, 2025 to April 25, 2025. This period included an online survey and three in-person public meetings, one meeting each in Timberville, Front Royal, and Woodstock. A total of 5,039 participants submitted surveys to the study team during this engagement period. The survey found that 54% of respondents supported a rail-to-trail alternative, 31% supported a rail-with-trail alternative, 15% supported either alternative equally, and 5% did not support any trail conversion. When asked why they supported a rail-to-trail, many participants said that they believed the trail would boost local economies, provide safe recreational spaces, and improve community health. Supporters of the rail-with-trail often cited the economic benefits of reestablishing rail service in the Shenandoah Valley. Open ended comments were summarized through a detailed categorization to visualize themes.

INTRODUCTION

This report is Phase 2 of an assessment of the Norfolk Southern-owned rail right of way that traverses the Shenandoah Valley between the Town of Broadway in Rockingham County and the Town of Front Royal in Warren County. The goal of this assessment is to provide an assessment of the scope, cost, constraints, and other considerations of a rail-to-trail alternative and a rail-with-trail alternative. Phase 1 – the alternatives analysis - developed typical sections that could accommodate a rail-with-trail alternative. This phase did not include an economic impact analysis, engineering survey/design drawings, or a recommendation on which type (rail-to-trail versus rail-with-trail) to advance to construction.

Phase 2 – the corridor assessment – documents a desktop analysis of environmental constraints, the results of field analyses of track and structure conditions, and a public engagement process. Summaries of each of these elements are provided below.

Environmental Impacts

As part of the 2021 rail-to-trail process, the project team completed a desktop environmental survey. This is a type of survey that uses available geographic information service (GIS) data rather than field observations. The project team updated this survey for the Rail-with-Trail Assessment (see Appendix A), extending the study area to match the wider rail-with-trail corridor. As with the rail-to-trail study, this process did not incorporate field reviews of the environmental data and serves as a preliminary investigation prior to a more intensive NEPA process.

The survey includes findings on: threatened and endangered species and critical habitat; wetlands and waters of the U.S.; agricultural/forestal lands and conservation easements; parks, recreation areas, and wildlife and waterfowl refuge; cultural resources; land and water conservation fund properties; karst geography; and hazardous materials. Each of these sections have been updated with data from 2024 where applicable.

The survey did not find any potential significant environmental impacts, but notes that more detailed field work will be required for NEPA compliance. During this level of survey, the actual extent of impacts can be better assessed. Environmental field work can only progress after the type of trail (rail-to-trail or rail-with-trail) is determined.

The survey update incorporated an investigation of potential trailhead sites, which had not been determined at the time of the rail-to-trail environmental survey. This survey also incorporates a detailed discussion of the Section 106 process. This inclusion is a response to public inquiry on how rail elements (the rail, ties, and ballast) are treated during a historic resources review. The rail corridor is listed as an eligible resource, meaning that it has certain protections and requirements under Section 106 of the National Historic Preservation Act. Because rails, ties, and ballasts are often replaced over a rail's lifetime, it is uncertain if these elements contribute to the historicity of the rail corridor. A Section 106 determination would need to be made prior to developing either project option.

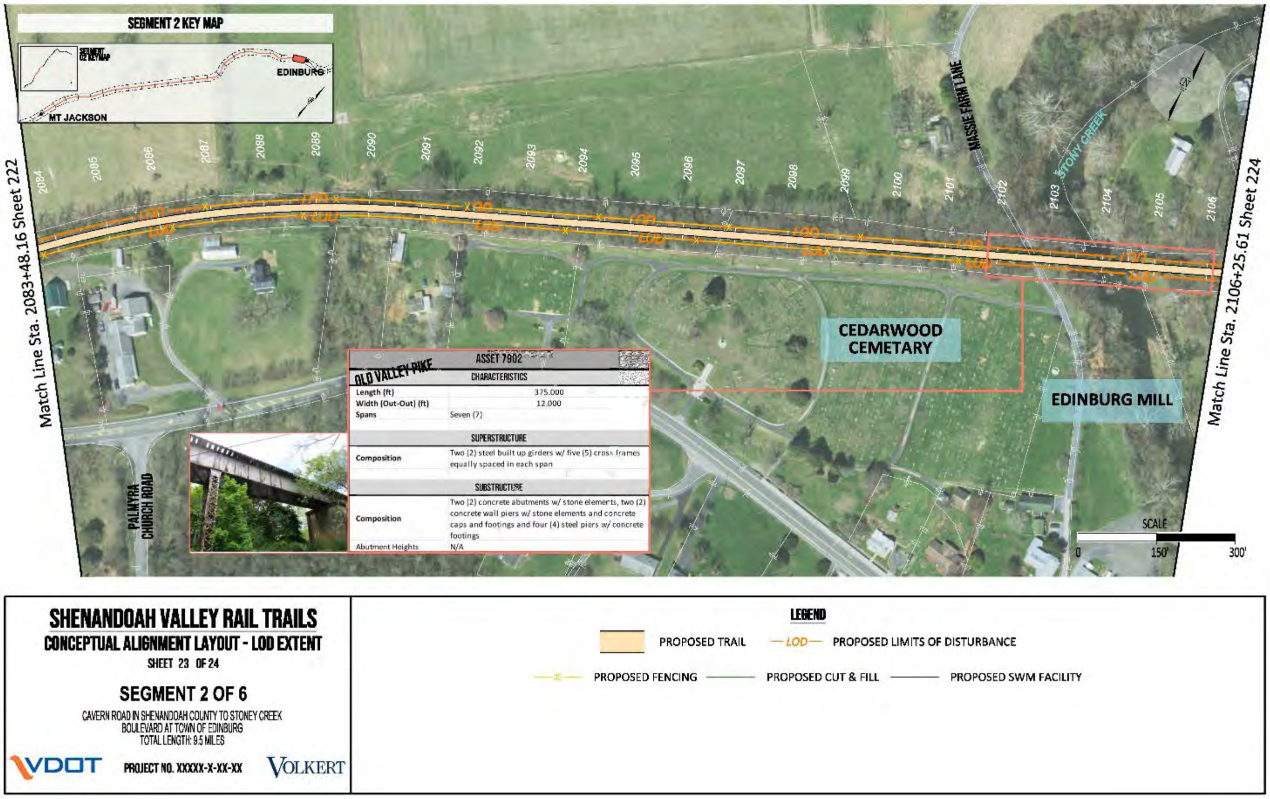
Drainage and Stormwater Management

The project team developed a high-level hydraulics analysis comparing a rail-to-trail alternative to a rail-with-trail alternative based on drainage, stormwater management, and floodplain requirements for the project (see Appendix B). For both alternatives, the project team proposed an open drainage system where water would flow from the trail and drain into roadside ditches running along the corridor. This process also examined the suitability of the corridor's 28 culverts in relation to 10-year storm events.

The report assumes that a rail-to-trail alternative would reuse existing drainage ditches and construct an impervious surface over a semi-pervious one. A rail-with-trail alternative would add an impervious surface to natural areas, require a new drainage ditch, and require multiple stormwater management facilities to comply with off-site water treatment requirements. While both alternatives would require extensions to all 28 culverts, the rail-with-trail option would require extensions of a minimum of 20 feet versus the 10 feet for the rail-to-trail option.

The report also includes the National Flood Insurance Program (NFIP) map, sample limits of disturbance (LOD) maps for each segment (see Figure 1), a Virginia Runoff Reduction Method (VRRM) spreadsheet, and soil maps.

Figure 1: Sample Limits of Disturbance (LOD) Map



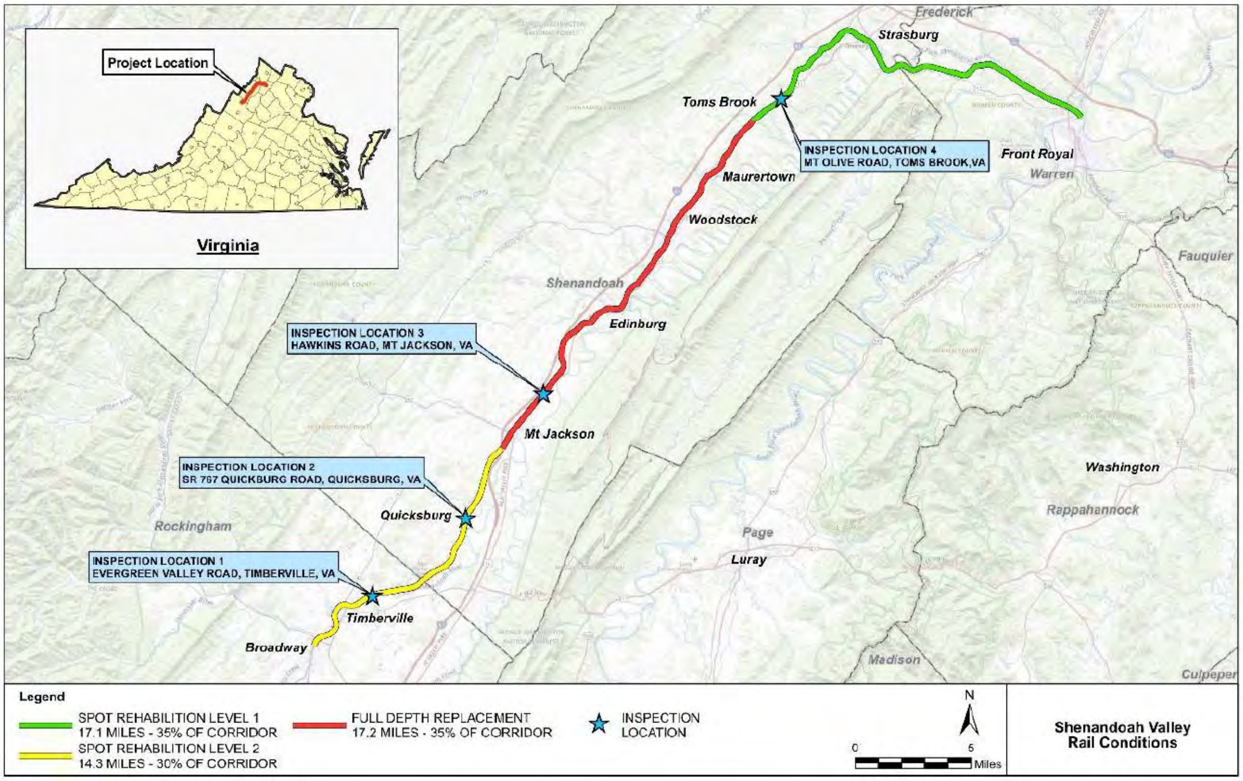
Track Rehabilitation

The project team developed a strategy for the rehabilitation of the corridor for restored rail service for freight and/or tourism. The Phase 1 report, through interviews with potential rail operators, determined the target for rehabilitation to be FRA Class 2 track standards, which would allow freight operations at 25mph and passenger operations at 30mph. The rehabilitation strategy includes targeted rail and tie replacements, ballast surfacing, drainage improvements, and vegetation control along with full-depth replacement where required.

Based on desktop and initial field reviews, the project team identified four field review locations to act as a sample of conditions in the corridor overall. At each of the four locations, the field team surveyed one mile of track. These inspections are documented in the Track Rehabilitation Report (Appendix C).

The project team divided the corridor into three segments based on rehabilitation needs (see Figure 2). The North segment runs from Front Royal to Toms Brook. The Central segment runs from Toms Brook to Mt. Jackson. The South segment runs from Mt. Jackson to Broadway. The North segment would require Level 1 Spot Rehabilitation, which requires only strategic replacements of critical track structure components. The Central segment would require Full-Depth Replacement, which requires a full removal of the existing inadequate track structure and roadbed and replacing the track components with new or like new ones. Finally, the South segment would require Level 2 Spot Rehabilitation, which is a slightly more intensive replacement requirement than Level 1. The Track Rehabilitation Report includes a detailed strategy for rehabilitation on each segment.

Figure 2: North, Central, and South Segments



Bridge Load Rating

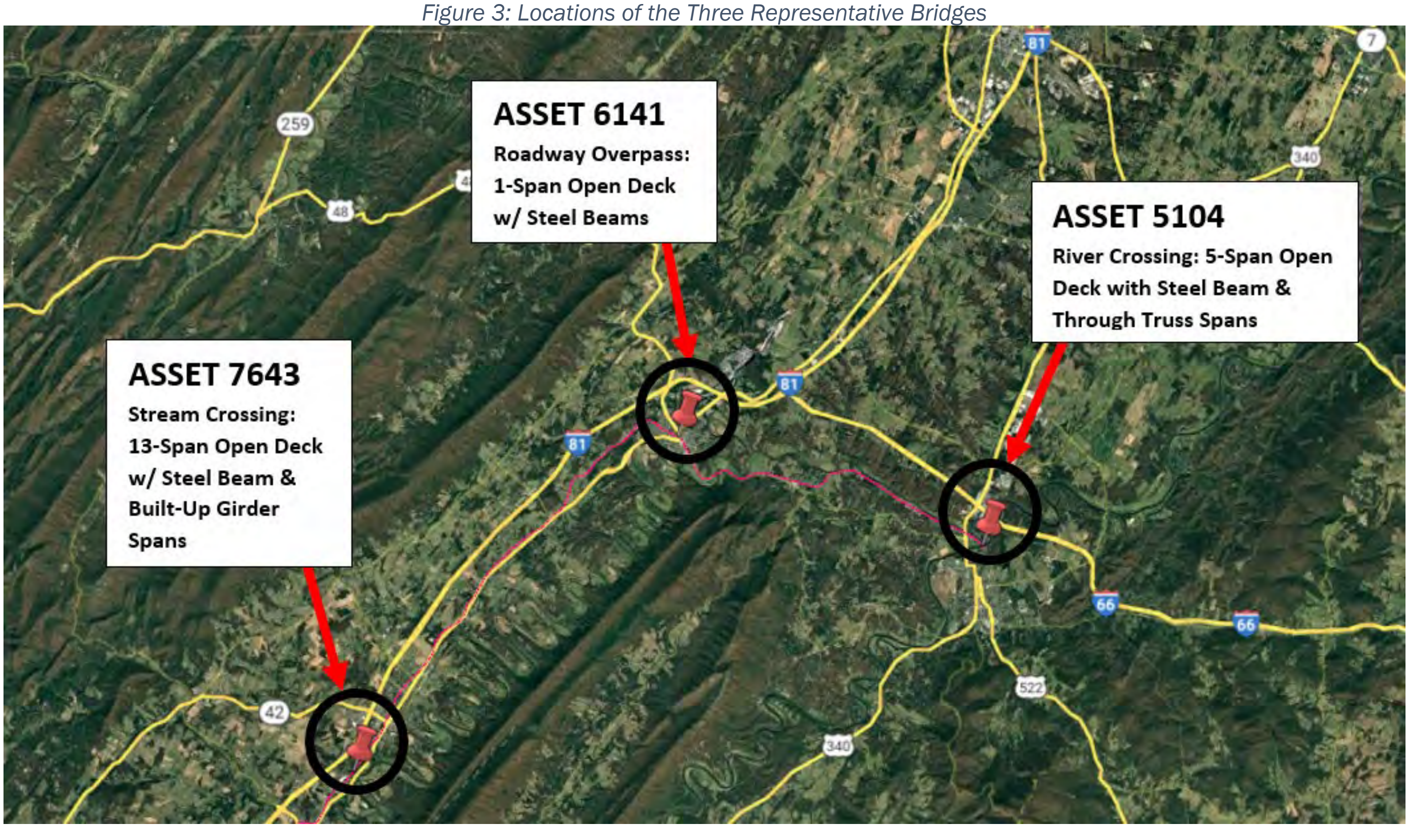
The project team assessed the rated capacity of a representative sample of currently out-of-service rail bridges as part of the Load Ratings Report (see Appendix D). This report also includes approaches to and issues with incorporating a trail immediately adjacent to existing bridges.

The corridor includes 23 rail bridges. To make conceptual planning assumptions about all of the bridges in the corridor, the study team identified three bridges that would be representative of the bridge types along the line (see Figure 3). These included shallow beam spans, deeper girder spans, and through truss spans, all with open timber-tie decks and all built with narrow width designed to accommodate a single track. A field team gathered existing condition information for each of the three bridges. All three were found to be in fair condition and all had varied dates of construction with one bridge's age being unknown.

One of the three bridges (an open deck steel steel/through-truss span bridge) is structurally capable of providing 25mph rail service without any structural retrofits. One bridge (an open deck steel beam span bridge) would require rehabilitation before service could be restored in the corridor. The steel yield strength could not be determined for the final bridge (an open deck steel girder span bridge), whose date of construction is unknown. Prior to restoring service, the steel strength of this bridge and bridges like it would need to be confirmed.

Only 8 bridges were found to be able to accommodate cantilevering; however, the project team does not recommend attaching a cantilevered trail to one side of an existing structure. For bridges with shallow beam spans, there is insufficient depth to support a cantilevered trail. For bridges with deeper girder structures, a cantilever is possible, but this would result in adverse effects to the existing superstructure, substructure, and foundation – requiring significant investigation and retrofit investment. Lastly, trail users would experience physical discomfort on a cantilevered trail caused by deflections of passing trains. These deflections would exceed those experienced on a detached trail bridge.

Figure 3: Locations of the Three Representative Bridges



Public Engagement

VDOT hosted a series of public engagement efforts from March 27th through April 25th, 2025. This included an online survey and three in-person public meetings where the same survey was provided as a paper copy. Altogether, VDOT collected 5,039 completed surveys throughout the public engagement window. The results of this public engagement process are available in Appendix E.

The in-person meetings were held from 5:00 to 7:00 pm on three separate nights in separate locations. The first meeting was on Tuesday, April 8 in Timberville at the Plains District Community Center. The second meeting was on Thursday, April 10 in Front Royal at the Warren County Government Center. The final meeting was on Tuesday, April 15 in Woodstock at Peter Muhlenberg Middle School. In total, 526 people attended the in-person public meetings. Six local news publications reported on the meetings. Links to these articles are available in the appendix.

The survey assessed participant preference. The survey found that 54% of respondents supported a rail-to-trail alternative, 31% supported a rail-with-trail alternative, 13% supported either alternative equally, and 5% did not support any trail conversion. Participants believed that safety should be the top concern for VDOT when deciding between trail types.

The survey also offered participants the opportunity to answer open-ended questions. Open ended comments were summarized in Appendix E through a detailed categorization to visualize themes.

Figure 4: Photo of an In-Person Meeting

Conclusion

Phase 2 of the Shenandoah Valley Rail-with-Trail Assessment provides a corridor assessment that will contribute to the development of cost estimates in Phase 3. The results of Phase 2 demonstrate the complexities of a rail-with-trail version while outlining a strategy towards implementing this alternative. This report should offer decision makers a better understanding of the environmental impacts, drainage and stormwater management needs, track and bridge rehabilitation requirements, and the public perception of a rail-with-trail conversion. The appendix of this report provides significantly more information on each of the topics discussed in this introduction.

APPENDIX A: ENVIRONMENTAL DESKTOP REVIEW

SHENANDOAH VALLEY RAIL-WITH-TRAIL ASSESSMENT ENVIRONMENTAL DESKTOP REVIEW SUMMARY

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1 INTRODUCTION

In September 2024, an environmental desktop review was conducted of the proposed Shenandoah Valley Rail to Trail corridor within the existing Norfolk Southern railroad right-of-way, from Broadway to Front Royal, Virginia. The desktop review provides a preliminary inventory of resources and identifies those that will warrant further consideration during the trail development process. This review does not fulfill the requirements of the National Environmental Policy Act (NEPA). The intent of the desktop review is to highlight potential environmental concerns that will require further investigation should VDOT construct a trail.

Available digital data was gathered from local, state, and federal agencies and authorities. This data was uploaded to project mapping in ArcGIS, wherein queries were run to determine the absence or presence of the resources within a 160-foot wide corridor along the centerline of the rail alignment. While the railroad right-of-way averages approximately 66 feet in width, the desktop review was based on a 160-foot wide corridor (80 feet on either side of centerline) to capture adjacent resources.

After the completion of the rail-to-trail study, VDOT initiated the Shenandoah Valley Rail-With-Trail Assessment as directed by the Virginia General Assembly. Because a rail-with-trail has a wider cross section than a rail-to-trail, the study area corridor was widened from 100-feet (50 feet on either side of the centerline) to 160 feet (80 feet on either side of the centerline). This buffer is generally wider than the existing rail right-of-way but is a useful width for capturing any potential impacts in the immediate area.

The eight resource categories for which queries were run are as follows:

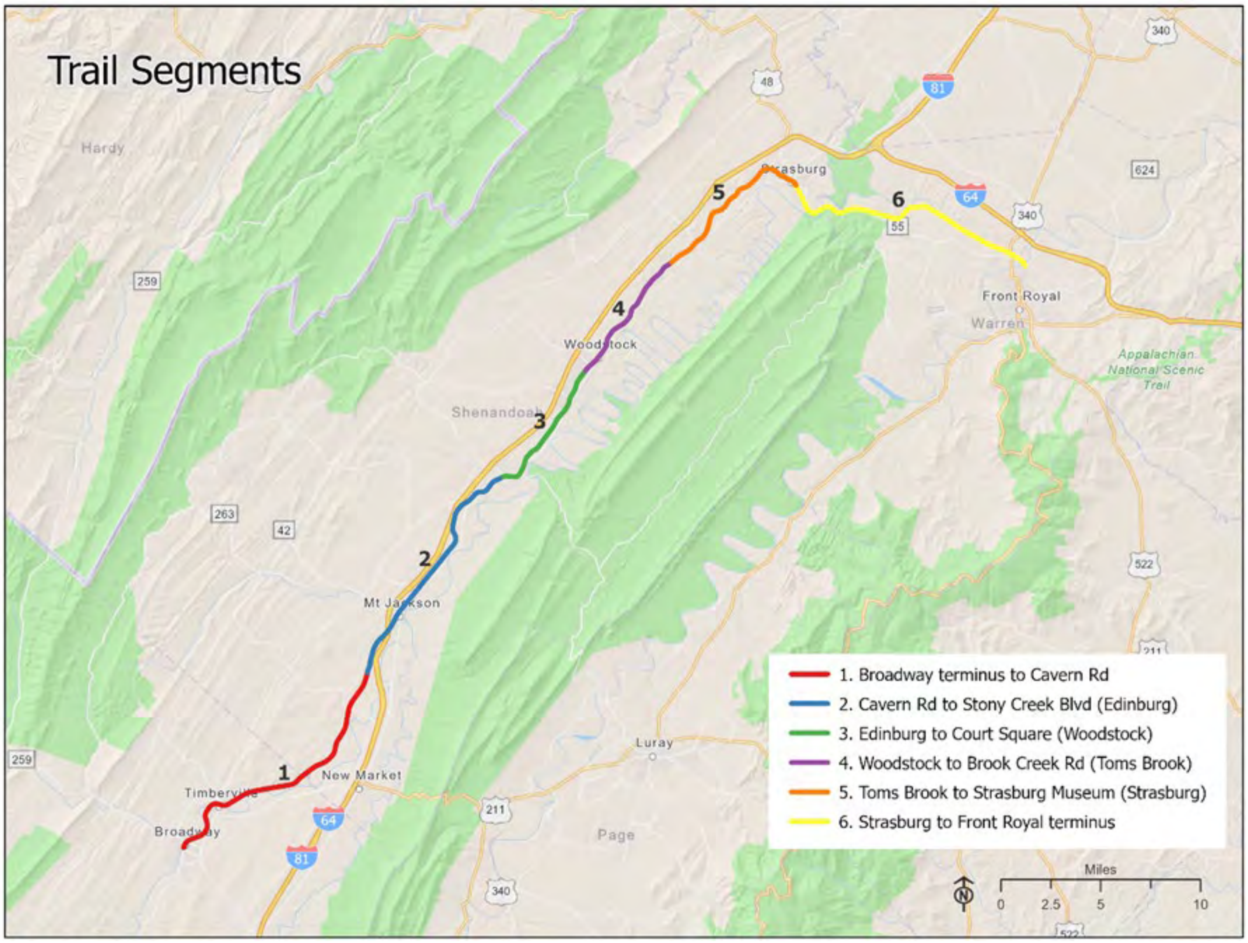
- Threatened and Endangered Species and Critical Habitat
- Wetlands and Waters of the U.S.
- Agricultural and Forestal Lands and Conservation Easements
- Parks, Recreation Areas, and Wildlife and Waterfowl Refuges
- Cultural Resources
- Land and Water Conservation Fund Properties
- Karst Geology
- Hazardous Materials

As proposed, the 49 mile-long trail corridor was divided into six trail segments, from south to north (Figure 1).

- Trail Segment 1: From Broadway terminus to Cavern Road
- Trail Segment 2: From Cavern Road to Stony Creek Blvd. (Edinburg)
- Trail Segment 3: From Edinburg to Court Square (Woodstock)
- Trail Segment 4: From Woodstock to Brook Creek Road (Toms Brook)
- Trail Segment 5: Toms Brook to Strasburg Museum (Strasburg)
- Trail Segment 6: Strasburg to Front Royal Terminus

The remainder of this desktop review provides an inventory of the eight resource categories investigated, within the trail corridor and by trail segment.

Figure 1: Trail Segments of the Proposed Shenandoah Valley Rail-With-Trail Corridor



Source: Michael Baker International

2. THREATENED & ENDANGERED SPECIES & CRITICAL HABITAT

The U.S. Fish and Wildlife Service's (USFWS) Information for Planning and Consultation (IPaC) database was reviewed for the presence of federally listed species, critical habitat, and migratory birds. Table 1 lists the resources with the potential to be present along the 48.5 mile-long corridor. Data from IPaC only pertains to federally protected resources. No Critical Habitat, National Wildlife Refuge (NWR), or Fish Hatchery was identified within or adjacent to the proposed trail corridor. Future coordination with the USFWS and the Virginia Department of Fish and Wildlife will be required should trail development be pursued.

Table 1: Protected Species within the Shenandoah Valley Rail-With-Trail Corridor

Species Category	Common Species Name	Scientific Species Name	Federal Status*
Mammal	Indiana Bat	*Myotis sodalis*	FE
Mammal	Northern Long-eared Bat	*Myotis septentrionalis*	FT
Mammal	Virginia Big-eared Bat	*Corynorhinus (=Plecotus) townsendii virginianus*	FE
Mammal	Tricolored Bat	*Perimyotis subflavus*	PE
Insect	Monarch Butterfly	*Danaus plexippus*	Candidate
Crustacean	Madison Cave Isopod	*Antrolana lira*	FT
Flowering Plant	Harperella	*Ptilimnium nodosum*	FE
Migratory Bird	Bald Eagle	*Haliaeetus leucocephalus*	Eagle Act
Migratory Bird	Golden Eagle	*Aquila chrysaetos*	Eagle Act
Migratory Bird	Black-billed Cuckoo	*Coccyzus erythropthalmus*	BCC
Migratory Bird	Black-capped Chickadee	*Poecile atricapillus practicus*	BCC
Migratory Bird	Bobolink	*Dolichonyx oryzivorus*	BCC
Migratory Bird	Canada Warbler	*Cardellina canadensis*	BCC
Migratory Bird	Cerulean Warbler	*Dendroica cerulea*	BCC
Migratory Bird	Chimney Swift	*Chaetura pelagica*	BCC
Migratory Bird	Eastern Whip-poor-will	*Antrostomus vociferus*	BCC
Migratory Bird	Kentucky Warbler	*Oporornis formosus*	BCC
Migratory Bird	Prairie Warbler	*Dendroica discolor*	BCC
Migratory Bird	Red-headed Woodpecker	*Melanerpes erythrocephalus*	BCC
Migratory Bird	Rusty Blackbird	*Hylocichla mustelina*	BCC

*FE=Federal Endangered; FT=Federal Threatened; PE=Proposed Endangered; BCC=Birds of Conservation Concern

Source: U.S. Fish & Wildlife Service, IPaC Website accessed at https://ecos.fws.gov/ipac/

Digital files from the Virginia Department of Wildlife Resources (DWR), which was formerly known as the Department of Game and Inland Fisheries (DGIF), were accessed via two online sources: the Virginia Fish and Wildlife Information Service (VAFWIS) and the Wildlife Environmental Review Map Service (WERMS). WERMS provides general locations of confirmed observations of federal and state-listed species. Table 2 lists these resources, by trail segment. The general location relative to the Norfolk Southern (NS) Mile Post (MP) is also provided. Within the entirety of the trail corridor, no roost trees or hibernacula were identified for protected bat species.

Table 2: Virginia DWR WERMS – Federal & State Listed Species (Confirmed Observations)

Trail Segment	General Location	Common Species Name	Scientific Species Name	Federal/State Status*
1	Near eastern limits Timbervale MP 95 – MP 97	Loggerhead Shrike (bird)	*Lanius ludovicianus*	ST
1	West of New Market MP 93	Indiana Bat	*Myotis sodalis*	FE SE
2	Stony Creek MP 79	Wood Turtle	*Glyptemys insculpta*	ST
2	Stony Creek MP 79	TE Waters[1]	---	TE Waters
3	Southeastern Edinburg MP 78	Wood Turtle	*Glyptemys insculpta*	ST
3	North Fork Shenandoah River, Between Edinburg & Woodstock MP 76	Brook Floater	*Alassminonta varicosa*	SE
4	---	---	---	---
5	---	---	---	---
6	North Fork Shenandoah River MP 59.5	Brook Floater	*Alassminonta varicosa*	SE
6	North Fork Shenandoah River MP 59.5	Green Floater	*Lasmigona subvirdis*	ST
6	North Fork Shenandoah River MP 59.5	Wood Turtle	*Glyptemys insculpta*	ST
6	North Fork Shenandoah River MP 59.5	TE Waters	---	TE Waters
6	Between Strasburg & Front Royal MP 57	Wood Turtle	*Glyptemys insculpta*	ST
6	Passage Creek MP 55.5	Green Floater	*Lasmigona subviridis*	ST
6	Passage Creek MP 55.5	Brook Floater	*Alassminonta varicosa*	SE
6	Passage Creek MP 55.5	Wood Turtle	*Glyptemys insculpta*	ST
6	Passage Creek MP 55.5	TE Waters	---	TE Waters

*FE=Federal Endangered; FT=Federal Threatened; SE=State Endangered; ST=State Threatened

[1] The Virginia DWR's Threatened and Endangered Species Waters (TEWaters) dataset in the WERMS includes the locations of waters from which listed species have been documented and which agency biologists have determined are currently occupied by such species.

Additional review of the project area should be conducted as the project moves forward to determine the potential for any effects to the species identified in Table 1 and Table 2. This would include coordination with the FWS, VDWR, and the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH). Species survey(s) may be requested by these agencies, especially in areas of confirmed species observations where there may be substantial disturbance for rail to trail conversion, bridge rehabilitation, or drainage/culvert improvements.

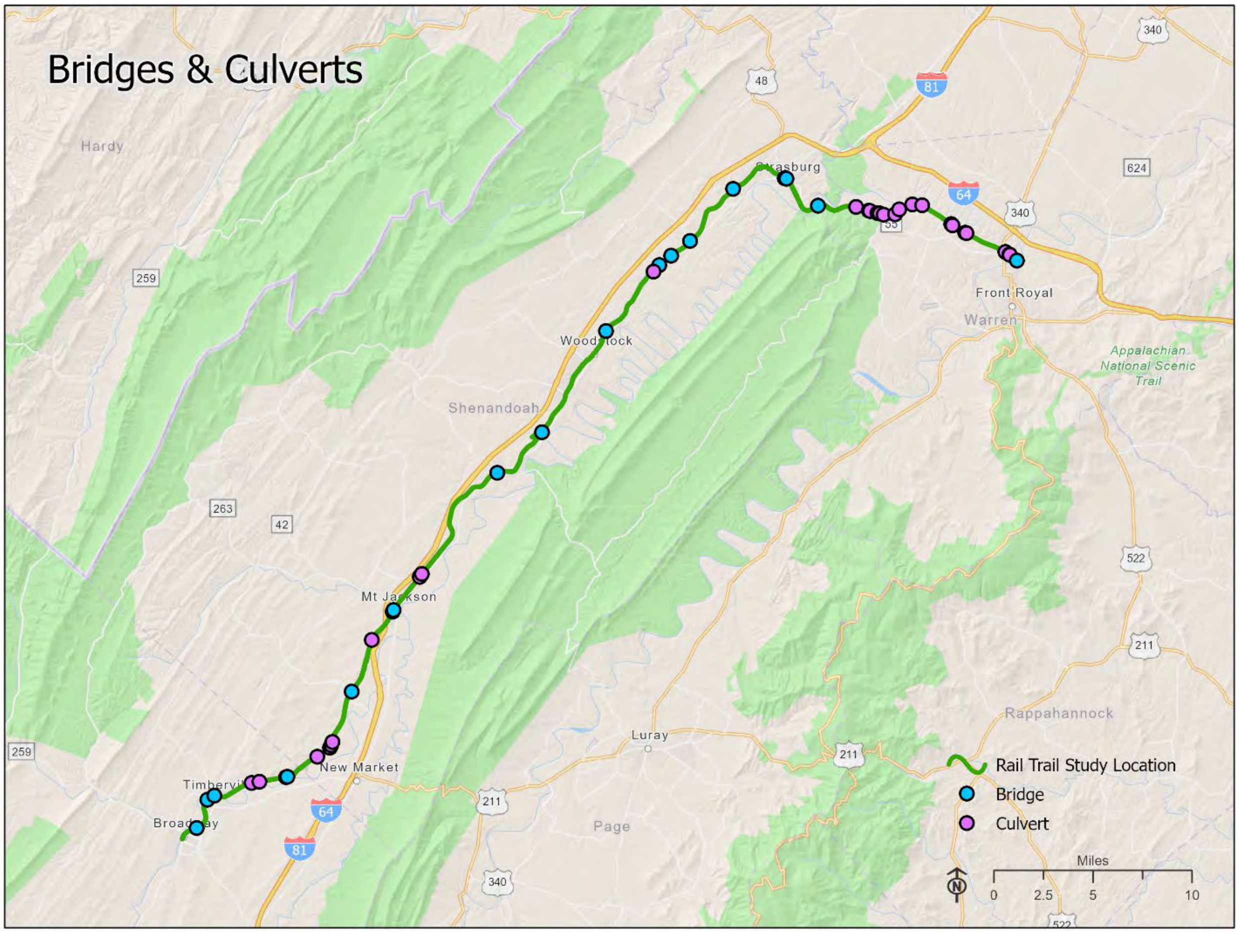
3. WETLANDS AND WATERS OF THE U.S.

National Wetlands Inventory (NWI) Geographic Information System (GIS) data was used to identify potential wetlands and streams that may occur within a 160-foot corridor of the proposed trail alignment (80 feet on each side of the proposed trail centerline). Along its 49-miles, the NS railroad includes 23 bridges and 32 culverts (Figure 2). Table 3 provides a summary of the wetlands along the proposed trail corridor. Table 4 provides a summary of the streams crossed along the trail corridor. Table 5 provides details of wetlands and streams, by trail segment, for the proposed trail corridor. Table 6 provides the wetlands and streams in steep slope areas that may be impacted by grading, retention wall construction, or other earth moving activities. Map Set 1 (Attachment 1) provides detailed mapping of wetlands and water resources, by trail segment.

Based on the NWI mapping, the proposed trail corridor crosses 78 wetlands; of which, 68 (87%) are considered riverine (streams). The second most common wetland is emergent (PEM) with 5 separate sites along the corridor. Of the 68 streams, 19 (28%) are classified as perennial and 49 (72%) are classified as intermittent.

Additional review of the project area should be conducted as the project moves forward to determine the presence, identification, impacts, and mitigation required. This effort should include coordination with the U.S. Army Corps of Engineers, the Virginia Department of Environmental Quality (DEQ), and the Virginia Marine Resources Commission (VMRC). Wetland and stream surveys may be requested by these agencies, especially in areas where there may be substantial disturbance for rail to trail conversions at bridge crossings or drainage/culvert improvements.

Figure 2: Bridges and Culverts along Proposed Trail Corridor



Source: Michael Baker International

Table 3: Wetlands in the NWI Database along Trail Corridor, by Trail Segment

Wetland Type	# Wetlands Along Trail Corridor						Totals
	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	
Riverine	13	11	7	5	7	25	68
Emergent (PEM)	1	0	3	0	1	0	5
Scrub Shrub (PSS)	0	0	0	0	0	1	1
Forested (PFO)	1	0	0	0	0	0	1
Pond	1	1	0	0	1	0	3
Totals	16	12	10	5	9	26	78

Source: Michael Baker International.

Table 4: Stream Crossings in the NWI Database along Trail Corridor, by Trail Segment

Stream Type	# Stream Crossings Along Trail Corridor						Totals
	TS 1	TS 2	TS 3	TS 4	TS 5	TS 6	
Perennial	3	5	2	2	3	4	19
Intermittent	10	6	5	3	4	21	49
Totals	13	11	7	5	7	25	68

Source: Michael Baker International.

Table 5: Streams and Wetlands in the NWI Database along Proposed Trail Corridor, by NS Mile Post

Trail Segment	General Location	Stream Name	Stream Type and/or Wetland Classification
1	Near MP 99	Unnamed Trib. to N. Fork Shenandoah River (NFSR)	Intermittent, Riverine
1	Near PM 97.5	NFSR	Perennial, Riverine
1	Near MP 97.3	Honey Run, Trib to NFSR	Perennial, Riverine
1	Near MP 95.6	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 95.4	Wetland	Palustrine Emergent (PEM)
1	Near MP 95.2	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 95.2	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 94.2	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 93.2	Wetland	Forested (PFO)
1	Near MP 93.1	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 92.5	Wetland	Pond (PUB)
1	Near MP 91.6	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 91.5	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 90.5	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 90.3	Unnamed Trib to NFSR	Intermittent, Riverine
1	Near MP 89.9	Unnamed Trib to NFSR	Perennial, Riverine
2	Near MP 87.6	Unnamed Trib to NFSR	Intermittent, Riverine
2	Near MP 87.2	Wetland	Palustrine Open Water (PUB)
2	Near MP 86.3	Mill Creek, Trib to NFSR	Perennial, Riverine
2	Near MP 83.7	Unnamed Trib to NFSR	Intermittent, Riverine
2	Near MP 83.4	Unnamed Trib to NFSR	Intermittent, Riverine
2	Near MP 83.0	Unnamed Trib to NFSR	Perennial, Riverine

Trail Segment	General Location	Stream Name	Stream Type and/or Wetland Classification
2	Near MP 82.7	Unnamed Trib to NFSR	Intermittent, Riverine
2	Near MP 81.8	Unnamed Trib to NFSR	Perennial, Riverine
2	Near MP 81.2	Unnamed Trib to NFSR	Perennial, Riverine
2	Near MP 80	Unnamed Trib to Sunny Creek	Intermittent, Riverine
2	Near MP 79.5	Unnamed Trib to Sunny Creek	Intermittent, Riverine
2	Near MP 79	Unnamed Trib to Sunny Creek	Perennial, Riverine
3	Near MP 78.6	Unnamed Trib to Sunny Creek	Intermittent, Riverine
3	Near MP 77.9	Wetland	Palustrine Emergent (PEM)
3	Near MP 77.9	Unnamed Trib to NFSR	Intermittent, Riverine
3	Near MP 77.9	Wetland	Palustrine Emergent (PEM)
3	Near MP 77.6	Unnamed Trib	Intermittent, Riverine
3	Near MP 77.6	Wetland	Palustrine Emergent (PEM)
3	Near MP 76.5	Unnamed Trib to NFSR	Perennial, Riverine
3	Near MP 75.7	Unnamed Trib to NFSR	Perennial, Riverine
3	Near MP 74.9	Unnamed Trib	Intermittent, Riverine
3	Near MP 74	Unnamed Trib	Intermittent, Riverine
4	Near MP 72.7	Unnamed Trib	Intermittent, Riverine
4	Near MP 72.3	Unnamed Trib	Intermittent, Riverine
4	Near MP 71.7	Pughs Run, Trib to NFSR	Perennial, Riverine
4	Near MP 70.9	Unnamed Trib	Intermittent, Riverine
4	Near MP 68.3	Jordan Run	Perennial, Riverine
5	Near MP 67.6	Brook Creek	Perennial, Riverine
5	Near MP 66.7	Unnamed Trib	Intermittent, Riverine
5	Near MP 66.4	Wetland	Palustrine Emergent (PEM)
5	Near MP 65.3	Snapps Run	Perennial, Riverine
5	Near MP 63.9	Wetland at Tumbling Run	Palustrine Open Water (PUB)
5	Near MP 62.6, MP 62.5, MP 62.4	Unnamed Trib	Intermittent, Riverine
5	Near MP 62.2	Unnamed Trib	Intermittent, Riverine
5	Near MP 61.7	Unnamed Trib to NFSR	Intermittent, Riverine
5	Near MP 61.4	Unnamed Trib to NFSR	Perennial, Riverine
6	Near MP 60.8	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 60.5	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 60.4	Unnamed Trib to NFSR	Intermittent, Riverine

Trail Segment	General Location	Stream Name	Stream Type and/or Wetland Classification
6	Near MP 60.3	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 60.2	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 60.1	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 59.8	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 59.5	NFSR	Perennial, Riverine
6	Near MP 58.8	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 58.7	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 58.5	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 58.1	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 57.9	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 57.5	Unnamed Trib to NFSR	Perennial, Riverine
6	Near MP 56.9	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 56.7	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 56.4	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 55.8	Wetland	Palustrine Scrub-Shrub (PSS)
6	Near MP 55.7	Passage Creek, Trib to NFSR	Perennial, Riverine
6	Near MP 54.6	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 54.4	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 54	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 53.8	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 53.5	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 52.8	Unnamed Trib to NFSR	Intermittent, Riverine
6	Near MP 51	South Fork Shenandoah River	Perennial, Riverine

Source: Michael Baker International.

Table 6: Streams and Wetlands in steep slope areas in the NWI Database along Proposed Trail Corridor, by NS Mile Post

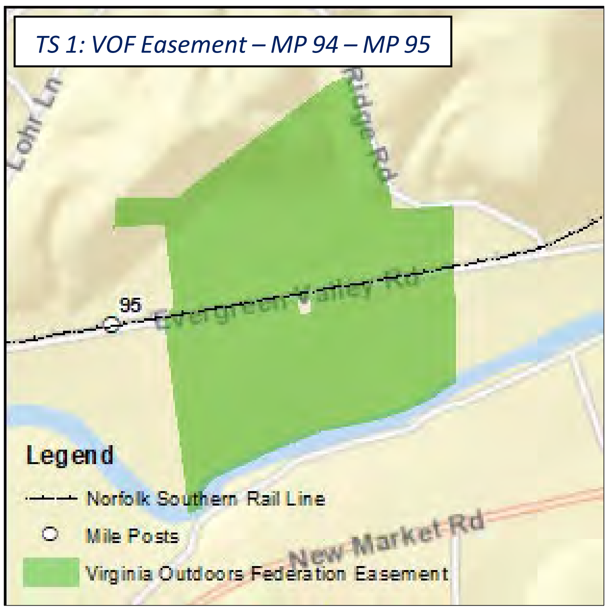
Trail Segment	General Location	Stream Name	Stream Type and/or Wetland Classification
1	Near MP 99	Unnamed Trib. to N. Fork Shenandoah River (NFSR)	Intermittent, Riverine
1	Near MP 93.2	Wetland	Forested (PFO)
1	Near MP 92.5	Wetland	Pond (PUB)
2	Near MP 87.2	Wetland	Palustrine Open Water (PUB)
2	Near MP 79.5	Unnamed Trib to Sunny Creek	Intermittent, Riverine
5	Near MP 66.4	Wetland	Palustrine Emergent (PEM)

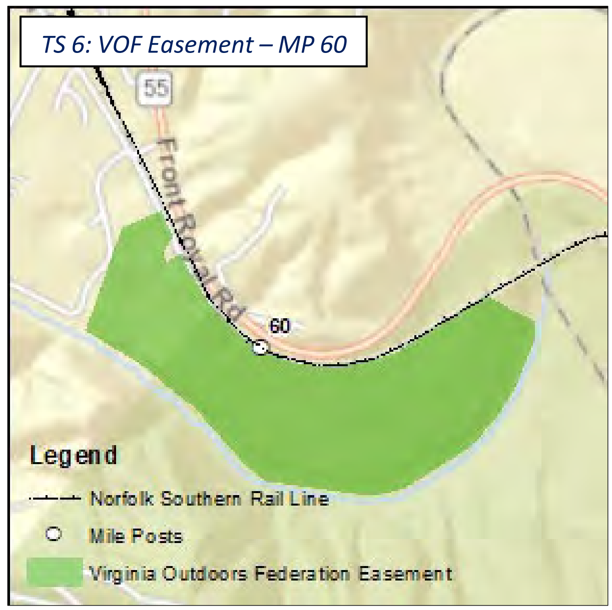
4. AGRICULTURAL/FORESTAL LANDS & CONSERVATION EASEMENTS

Identifying the location of easements aids in trail design and trailhead placement. Locations of conservation easements in the study area are provided on Map Set 2 (Attachment 2).

4.1 Virginia Outdoors Foundation

Based on a review of the Virginia Outdoors Foundation's (VOF) database, there are no VOF-*owned* lands within or adjacent to the proposed trail corridor. However, two parcels with VOF conservation easements are located along Trail Segment 1 (TS 1) and Trail Segment 6 (TS 6). Along Trail Segment 1, between NS Milepost (MP) 94 and MP 95, VOF holds a conservation easement on an approximately 169 acre parcel that straddles the NS railroad. Along Trail Segment 6, at NS MP 60, VOF holds an easement on an approximately 100-acre parcel adjacent to the southern boundary of the NS railroad right-of-way.





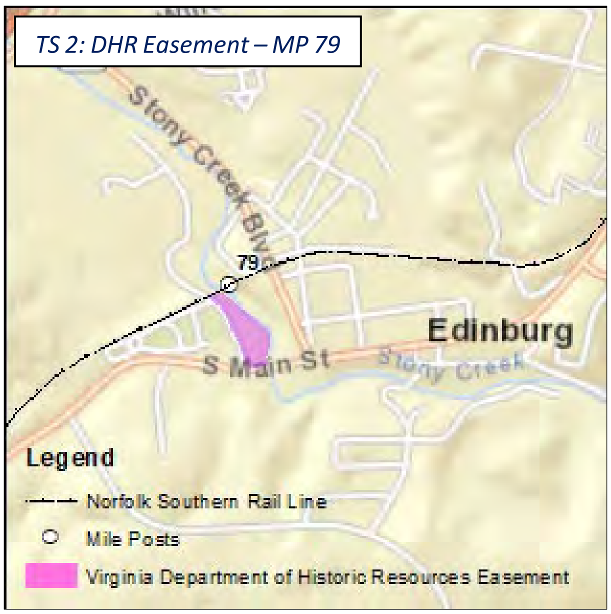
As stated on VOF's website, "VOF has been using open-space easements to protect land for more than 50 years. These voluntary legal agreements limit residential, commercial, and industrial development. Easements are tailored to each property. The restrictions depend on the types of conservation values being protected, such as water quality, wildlife habitat, historic significance, scenic viewsheds, or public access."[2] VOF easements are held in perpetuity; when an easement is violated, "VOF has a legal obligation to enforce the easement and protect its conservation values. In some cases, where impairment is negligible or minimal, the most appropriate response may be landowner education and minor restoration

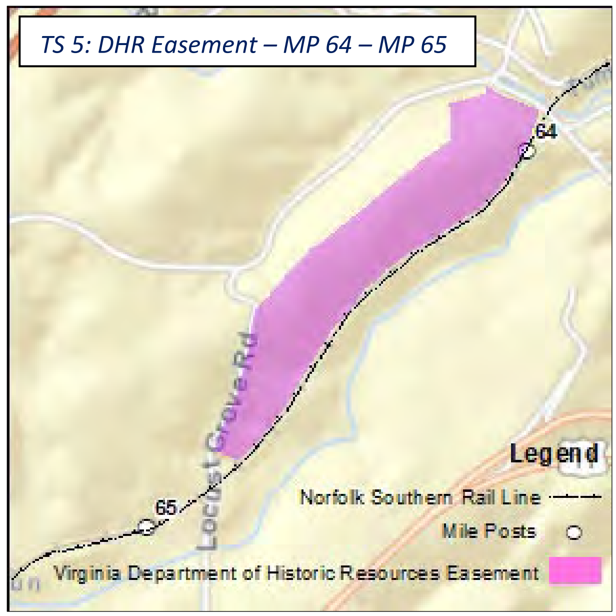
[2] Virginia Outdoors Foundation (VOF) Website. "Open Space Easements". Accessed on 9/10/21 at https://www.vof.org/protect/easements/.

of a site. In cases where conservation values are significantly and immediately threatened, legal action may be necessary. Mediation may also be an appropriate response.”[3]

4.2 Virginia Department of Historic Resources

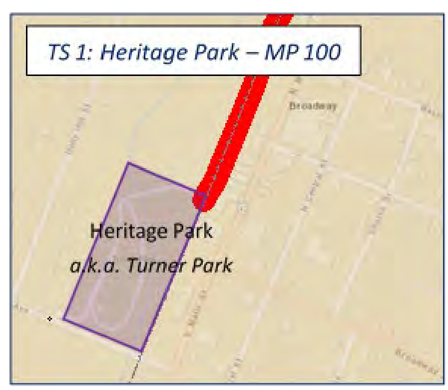
Along Trail Segment 2, near NS MP 79, the Virginia Department of Historic Resources (DHR) holds a conservation easement on an approximately 4.4-acre parcel in the Town of Edinburg. This parcel abuts the existing NS railroad ROW. Along Trail Segment 5, between NS MP 64 and MP 65, DHR holds a conservation easement on two parcels owned by the Shenandoah Valley Battlefield Foundation (SVBF), abutting the NS railroad ROW. The two parcels combined are approximately 69 acres in size. Avoidance of these parcels is recommended.





5. PARKS, RECREATION AREAS, AND WILDLIFE AND WATERFOWL REFUGES

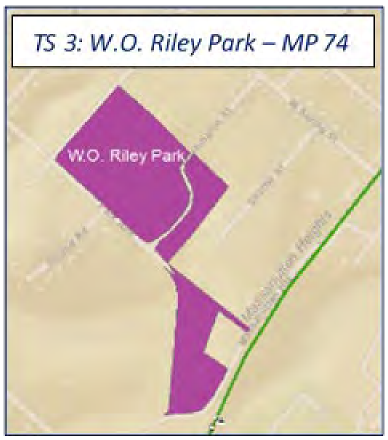
Locations of conservation easements are provided on Map Set 2 (Attachment 2). Potential impacts to resources in this section must be evaluated under Section 4(f) of the U.S. Department of Transportation act of 1966. The southern terminus of the proposed trail corridor would be adjacent to Heritage Park, also referred to as Turner Park. Located adjacent to Trail Segment 1, Heritage Park is a local park in the Town of Broadway.



[3] Ibid, “Easement Stewardship”.

With the exception of Heritage Park, no publicly owned parks, recreation areas, wildlife and waterfowl refuges are located within or adjacent to the existing NS railroad ROW (i.e., the proposed trail corridor). Two local parks are separated from the railroad ROW by public roads; therefore, the park parcels do not have a common property boundary with the railroad ROW/proposed trail corridor.

The first of these two parks is along Trail Segment 3, near NS MP 74. The W. O. Riley Park is a local park in the Town of Woodstock. As shown in the image below, the park is separated from the existing NS railroad ROW by Massanutten Heights. The second of these parks, Strasburg Park, is along Trail Segment 6, between NS MP 60 and MP 61. This is a local park in the Town of Strasburg and is separated from the railroad ROW by E. Queen Street.



Also in Trail Segment 6, between NS MP 61 and MP 58, the existing railroad is within a portion of the George Washington National Forest. A review of the current Management Plan for the George Washington National Forest [4] shows the area surrounding the railroad is absent a management prescription of any kind (i.e., land is not specifically managed for recreation, wildlife or waterfowl use, or historic conservation). Therefore, it is unlikely the conversion of the railroad corridor to a rail-with-trail corridor would warrant Section 4(f) consideration for adjacent Forest Service lands.

By remaining within the existing railroad ROW, the proposed trail corridor would not use publicly owned parks, recreation areas, wildlife or waterfowl refuges. Should it be necessary to acquire lands or access from properties outside the existing railroad ROW, avoidance of these types of resources should be a priority.

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[4] USDA Forest Service Website, "George Washington & Jefferson National Forests" and "2014 Revised GWNF Forest Plan Management Area Prescription Maps." https://www.fs.usda.gov/sites/nfs/files/r08/gwj/publication/George%20Washington%20National%20Forest%20Land%20Management%20Plan%20508c.pdf and https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3800548.pdf

There are no local, regional, state, or federal managed trails within or adjacent to the proposed trail corridor.

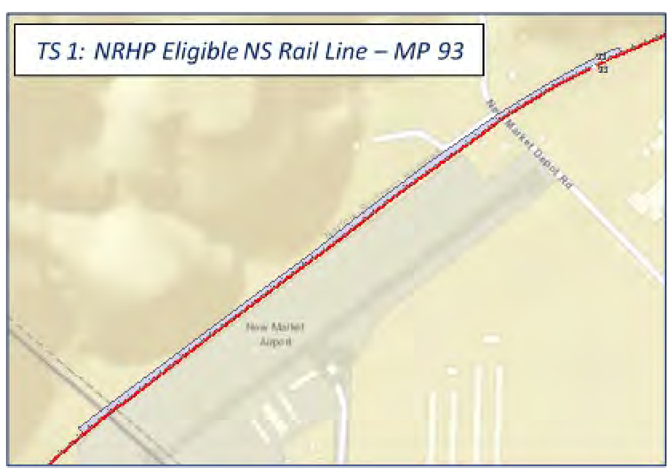
Within or adjacent to the proposed trail corridor, there are no designated or eligible Wild and Scenic Rivers or rivers on the Nationwide Rivers Inventory, as determined by the National Park Service.

Within or adjacent to the proposed trail corridor, the Virginia Department of Conservation and Recreation (DCR) has determined the South Fork of the Shenandoah River is Potentially Eligible as a State Scenic River. Trail Segment 6, NS MP 51, terminates at the northern limits of this section of river. DCR has determined the North Fork of the Shenandoah River is Qualified for designation as a State Scenic River. Trail Segment 6, near NS MP 59.5, crosses this section of river. DCR has also identified both rivers as proposed Blueway Trails. In addition to the trail corridor involvement noted above, Trail Segment 1, near NS MP 97.5, would cross the North Fork of the Shenandoah River where the river is proposed as a Blueway Trail.

6. CULTURAL RESOURCES

The Virginia Department of Historic Resources (DHR) archives database, Virginia Cultural Resource Information System (VCRIS) was reviewed to identify potential resources within 80 feet of either side of the trail corridor. In the VCRIS search results, resources were identified that have been previously surveyed and were determined to be listed in the National Register of Historic Places (NRHP), eligible for listing in the NRHP, and/or listed in the Virginia Landmarks Registry (VLR). In addition, the VCRIS includes resources DHR has determined are potentially eligible for listing in the NRHP, as well as resources not yet evaluated for eligibility by DHR. Properties in the VCRIS database DHR identified as not eligible for listing in the NRHP are not considered historic and, therefore, were not included in the inventory for this desktop review. Individual resources contributing to a historic district were considered as part of the overall historic district. No archeological resources were identified through the VCRIS archives search. Locations of cultural resources are provided on Map Set 3 (Attachment 3).

Table 6 provides a summary, by trail segment, of the historic resources identified. Of the 14 historic resources within 80 feet of the NS railroad centerline, 8 are listed in both the NRHP / VLR and 6 are eligible for listing in the NRHP. Along Trail Segment 1, near NS MP 93, approximately one mile of the NS Railroad has been determined to be eligible for listing on the NRHP.



Further coordination with DHR on the project's potential effects to historic resources will be required, in accordance with the requirements of Section 106 of the National Historic Preservation Act. This holds true for federally funded projects, as well as major state projects. In addition, should funds from the U.S. Department of Transportation (e.g., Federal Highway Administration) be used, compliance with the requirements of Section 4(f) will also be necessary. Given that a portion of the NS Railroad has been determined NRHP eligible, proposed design changes or alterations of the rail line should incorporate measures to preserve the features that make the rail line NRHP eligible. This would include areas with ground disturbance, bridge rehabilitation, and restoration of other rail related structures.

Table 7: NRHP and VLR Listed & Eligible Properties within 80 feet of Railroad Centerline

Trail Segment	NS Milepost *approximate*	DHR ID	Jurisdiction *County*	NRHP STATUS	VLR Status	Historic District	PropertyNames
1	MP 99.8	177-0016	Rockingham	Listed	Listed	-	Auctions (Historic), Broadway Town Hall (Descriptive), Deering Hall (NRHP Listing), Genes' Automative Electric Service (Current), Masonic Temple Hall (Historic), Model A's & T's (Historic), Purina Feed Store (Historic)
1	MP 97	312-5007	Rockingham	Listed	Listed	Timberville Historic District	Timberville Historic District (Historic/Current)
1	MP 93 -MP 94	085-5144	Shenandoah	Eligible	-	-	Norfolk Southern Railroad (Current), Orange, Alexandria, and Manassas Railroad (Historic), Southern Extension, Manassas Gap Railroad (Historic), Southern Railroad (Historic)
1	MP 90 - MP 91	085-0407	Shenandoah	Eligible	-	Quicksburg Historic District	Quicksburg Historic District (Historic/Current)
2	MP 86	265-0004	Shenandoah	Listed	Listed	Mount Jackson Historic District	Mount Jackson Historic District (NRHP Listing)
2	MP 86	265-0004-0079	Shenandoah	Eligible	-	Mount Jackson Historic District	Commercial Building, 5973 King Street (Function/Location), Duron Paint Facility (Historic), Farmers Supply Building (Historic), Feed & Grain Warehouse (Descriptive), Shenandoah Cooperative, Farm Bureau, Incorporated (Historic)
2, 3	MP 79	215-0001	Shenandoah	Listed	Listed	Edinburg Historic District	Edinburg Historic District (NRHP Listing)
3, 4	MP 73 - MP 74	330-0015	Shenandoah	Listed	Listed	Woodstock Historic District	Woodstock Historic District (Current)
4	MP 69.5	085-0935	Shenandoah	Eligible	-	Maurertown Historic District	Maurertown Historic District (Historic/Current)
5, 6	MP 63.5 - MP 64.5, MP 61.5 - 62, MP 58 - MP 60	034-0303	Frederick, Shenandoah, Warren	Eligible	-	-	Cedar Creek Battlefield (Historic)
5	MP 63.7	085-0910	Shenandoah	Eligible	-	Fishers Hill Battlefield	Fishers Hill Historic District (Historic/Current)
5	MP 61 - MP 62	306-0016	Shenandoah	Listed	Listed	Strasburg Historic District	Strasburg Historic District (Historic)
5	MP 61.2	306-0009	Shenandoah	Listed	Listed	-	Southern Railroad Station (Historic), Steam Pottery (Current), Strasburg Museum, 440 E. King Street (Function/Location), Strasburg Stone and Earthenware Manufacturing Company (Historic)
6	MP 51.5	112-5328	Warren	Listed	Listed	Riverton Historic District	Riverton Historic District (NRHP Listing)

*Properties are within 50 feet of centerline of NS Railroad

NRHP = National Register of Historic Places

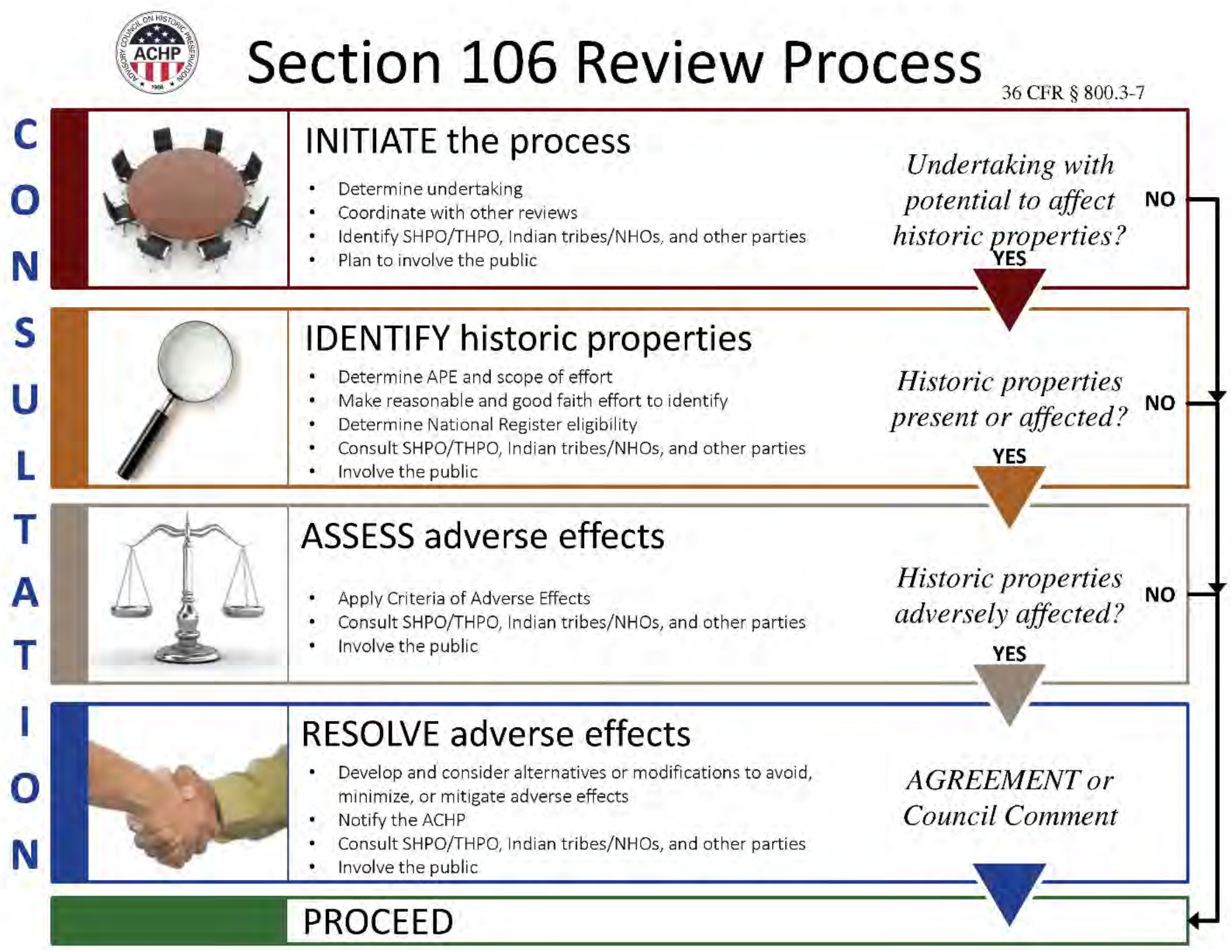
VLR = Virginia Landmarks Register

6.1 Section 106 Process

Section 106 of the National Historic Preservation Act of 1966 (NHPA) requires that federal agencies consider the impact of their undertakings on historic properties. The Section 106 process is detailed in Figure 3.

Every Section 106 process is unique and requires direct consultation with the SHPO regarding appropriate minimization and mitigation efforts. While an agency cannot fully know what avoidance measures the DHR will recommend, several rails-to-trails in Virginia were successfully developed on historic railbeds. The High Bridge Trail and the Virginia Creeper Trail are both aligned to potentially eligible historic railbeds. The New River Trail and Washington & Old Dominion Trail are both aligned along eligible historic railbeds. These resources were surveyed prior to trail development. This means that their eligibility status was known before the trails were completed.

Figure 3: Section 106 Process



Source: https://www.achp.gov/protecting-historic-properties/106-flowchart-handout

6.2 Historic Eligibility of Railroad Components

A railroad is a combination of a railbed, ballast, ties, and tracks and can include bridges, culverts, and other supporting structures. The railbed is the foundation for the railroad and is typically graded earth. The ballast - which is typically crushed stone - holds the ties in place and also improves drainage and limits vegetation, thus persevering the railbed. Railroad ties, which are typically wood but can be concrete or a composite material, lie on the ballast perpendicular to the rails and act to secure the rails in place and distribute loads. Finally, the rails, which sit on the ties, facilitate transportation on the railroad. While the components resting on the railbed last for decades, they do require replacement.

When a SHPO determines a resource is eligible, they will categorize it into one of four criteria. All of the rail corridors noted in the previous section as well as the Norfolk Southern rail corridor in the Shenandoah Valley are eligible or potentially eligible under National Register of Historic Places criteria. This means that when assessing the impacts of creating a rail trail, the DHR would have to determine if the existing ballast, ties, and rails contribute to the historicity of the railbed corridor. If the ballast, ties, and tracks were replaced after the period of time or the event that makes the resource eligible, then those component's relationship to historic resource may be diminished. However, DHR consultation and further survey will be required to fully determine these relationships.

6.3 Considerations for Rail-With-Trail Projects

In 2018, the Advisory Council on Historic Preservation (ACHP) – a federal agency – released a Program Comment to exempt certain activities within rail rights-of-way from the Section 106 process.[5] The ACHP developed these exemptions to decrease review periods and meet the requirements of the Fixing America's Surface Transportation Act (FAST Act). Most of the exempted activities involve maintenance of active rail lines but there are some provisions for rails-with-trails. On the Exempted Activities List, item L covers bicycle and pedestrian facilities, shared use paths, and other trails.[6] The exemptions include maintenance, repair, and replacement of existing facilities as well as the expansion of existing facilities within the rail right-of-way. Any new rail-with-trail project would be subject to the Section 106 process, however, once a rail-with-trail project is completed, future expansions and maintenance activities could potentially be exempted under this Program Comment.

7. LAND AND WATER CONSERVATION FUND PROPERTIES

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[5] U.S. Department of Transportation – Federal Rail Administration. "Final Section 106 Program Comment for Rail Rights-of-Way." March 2, 2020. https://railroads.dot.gov/rail-network-development/environment/final-section-106-program-comment-rail-rights-way

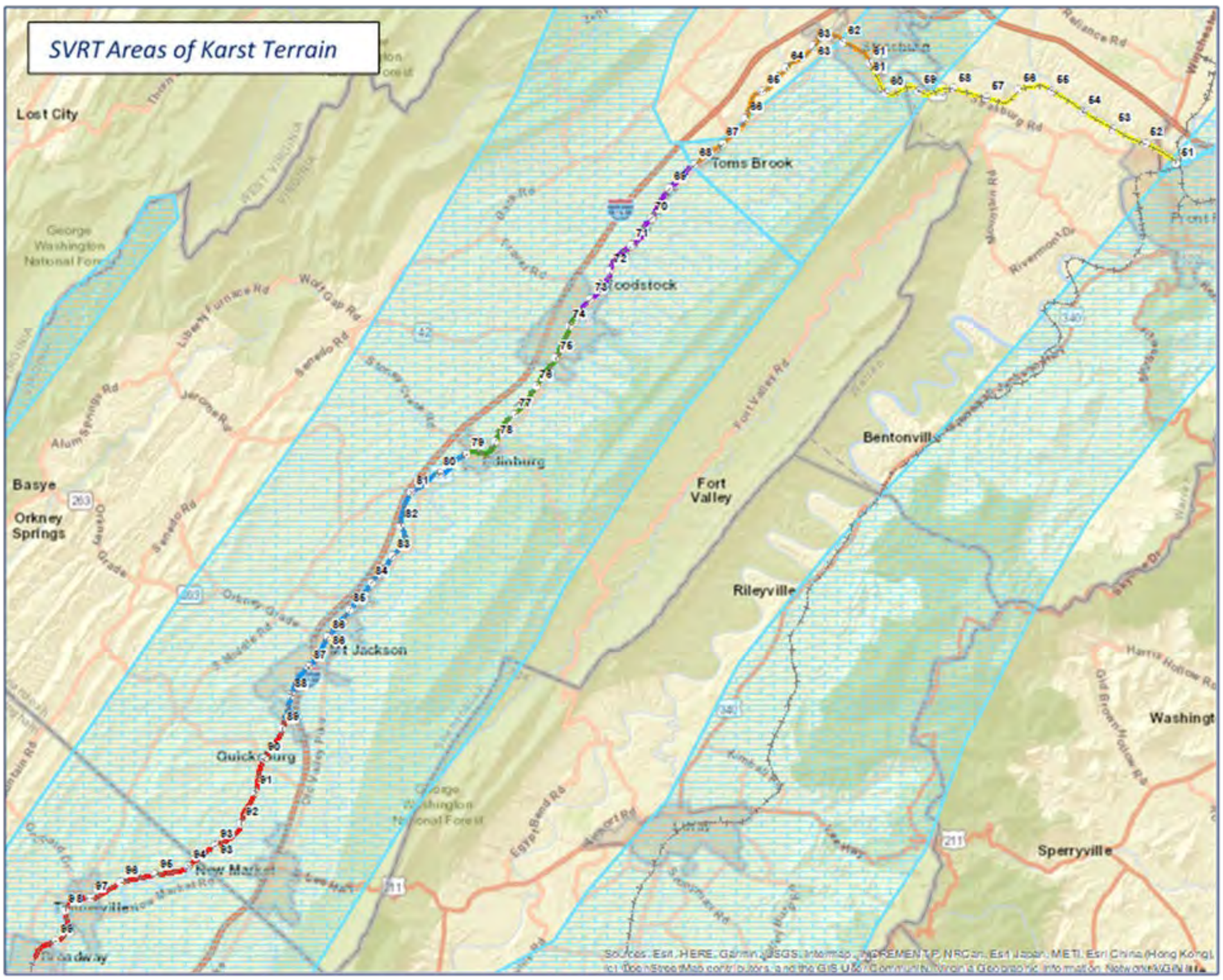
[6] U.S. Department of Transportation – Federal Rail Administration. "Section 106 Program Comment for Rail ROW Appendix A: Exempted Activities List." August 30, 2018. https://railroads.dot.gov/sites/fra.dot.gov/files/fra_net/18088/Exempted%20Activities%20List%20Table%20Section%20106%20Program%20Comment%20for%20Rail%20ROW_8-30-2018.pdf

Land and Water Conservation fund properties are protected under Section 6(f) of the Land and Water Conservation Act. There are no Land and Water Conservation Fund (LWCF) properties within or adjacent to the existing NS railroad ROW.

8. KARST GEOLOGY

The Virginia Department of Mines, Minerals, and Energy (DMME) data on karst terrain in Virginia was reviewed. As Figure 4 shows, most of the proposed trail corridor lies within karst. The two trail segments not within karst areas are Trail Segment 5, from approximately NS MP 62 -MP 66 and Trail Segment 6, from approximately NS MP 51.2 to MP 58.8. The extent of karst geology throughout the project area is illustrated, by trail segment, in Map Set 4 (Attachment 4).

Figure 4: Karst Geology of Project Area



Source: Michael Baker International

Research conducted by the Virginia Transportation Research Council describes karst terrain and areas of concern, as related to transportation-related construction activities.

> *Karst terrain is characterized by sinkholes, depressions, caves, and underground drainage, generally underlain by soluble rocks such as limestone and dolomite. Because natural filtration through soil is limited in karst areas, pollutants in highway stormwater runoff can directly infiltrate underground sources of drinking water and environments that are habitats for sensitive species*.[7]

As the project progresses, further investigations should be conducted regarding where and how ground-disturbing activities and potential runoff could affect karst. Coordination with DMME, DCR, and VDOT should be ongoing to properly manage and comply with applicable karst protection laws and regulations.

9. HAZARDOUS MATERIALS

Data from the Environmental Protection Agency (EPA) and the Virginia DEQ. Databases did not show incidents of petroleum releases or Superfund sites within the proposed trail corridor. However, petroleum releases (sites open, closed, or status unknown), as well as Superfund sites, are located in the vicinity of the trail corridor. Locations of these sites are provided in Map Set 5 (Attachment 5). (Prior to the acquisition of land and/or ROW, a thorough deed research is recommended to confirm the potential for existing contamination and/or legal responsibilities.

10. TRAILHEADS

The project team has identified potential trailheads along the potential trail corridor. Some of these trailheads may be subject to Section 106 of the National Historic Preservation Act, Section 4(f) of the Department of Transportation Act, and/or other State and Federal requirements. Those trailheads are listed in Table 8.

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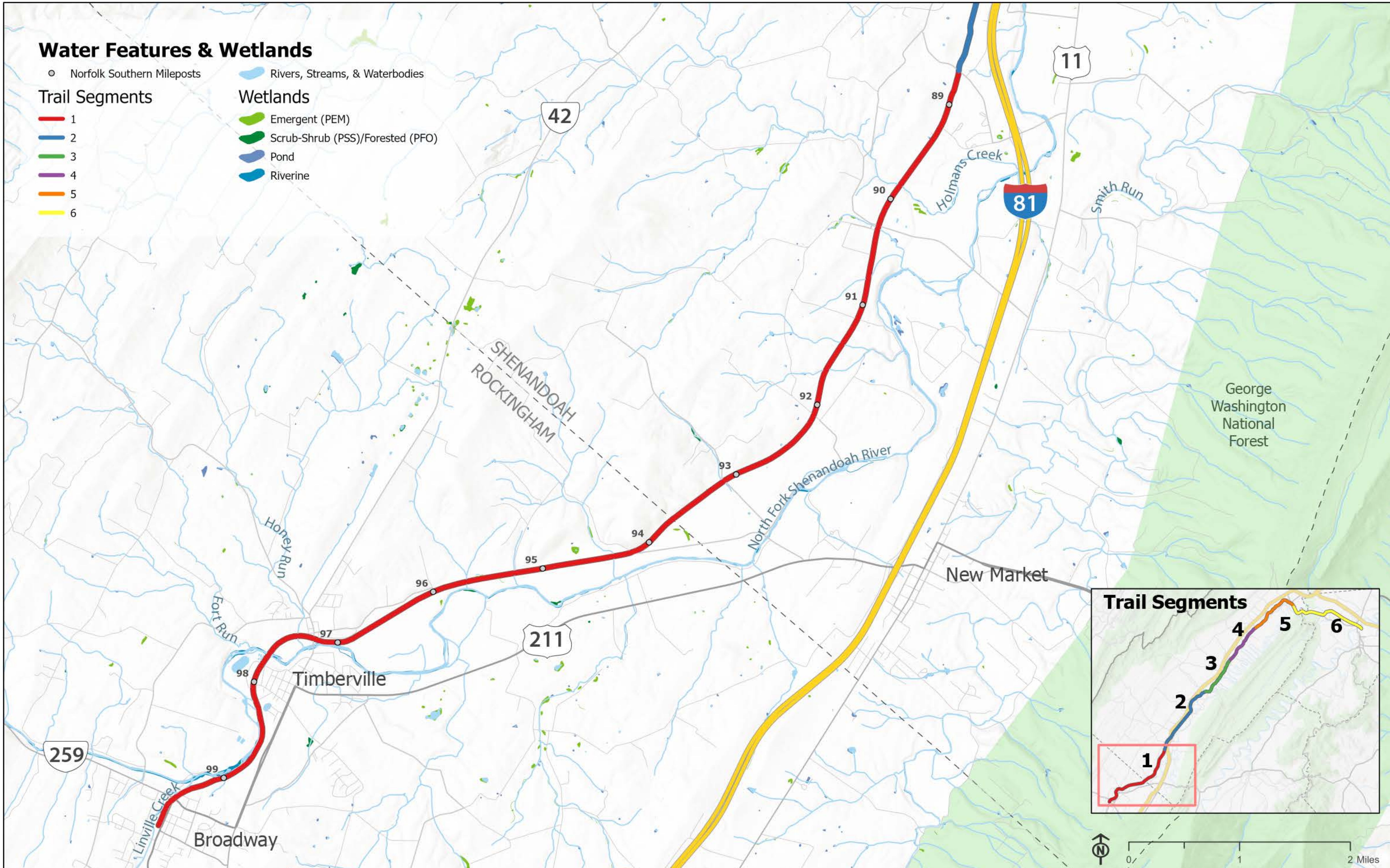
[7] Bridget M. Donaldson, Virginia Transportation Research Council, in cooperation with the USDOT – FHWA. Highway *Runoff in Areas of Karst Topography – Final Report*. March 2004.

Table 8: Potential Trailheads That May Require Section 106 and 4(f) Review

Trail Segment	Trailhead Name	Location	Resource Type	Review Type
1	Broadway	Broadway Community Park on Turner Avenue in Broadway, VA	Park	4(f)
1	Timberville	Timberville Memorial Park on Memorial Park Drive in Timberville, VA.	Park	4(f)
2	Mt Jackson Town Hall	Depot Street in Mt Jackson, VA	Historic District	106 and 4(f)
2	Mt Jackson Colored Cemetery	Nelson Street in Mt Jackson, VA	Cemetery	106 and 4(f)
2	Cedarwood Cemetery	S Main Street in Edinburg, VA	Cemetery	106 and 4(f)
2	Edinburg Mill	Massie Farm Lane in Edinburg, VA	Historic Building	106 and 4(f)
3	Potential Warehouse Rehabilitation	Piccadilly Street in Edinburg, VA	Historic District	106 and 4(f)
3	USFS CCC Interpretive Center	Railroad Ave in Edinburg, VA	Park	4(f)
3	Woodstock	E Court Street	Historic District	106 and 4(f)

ATTACHMENT 1

Map Set 1: Wetlands and Water Resources



Water Features & Wetlands
Norfolk Southern Mileposts
Rivers, Streams, & Waterbodies
Trail Segments
1
2
3
4
5
6
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
42
11
81
211
259
89
90
91
92
93
94
95
96
97
98
99
Holmans Creek
Smith Run
SHENANDOAH
ROCKINGHAM
North Fork Shenandoah River
Honey Run
Fort Run
Linville Creek
Timberville
Broadway
New Market
George Washington National Forest
Trail Segments
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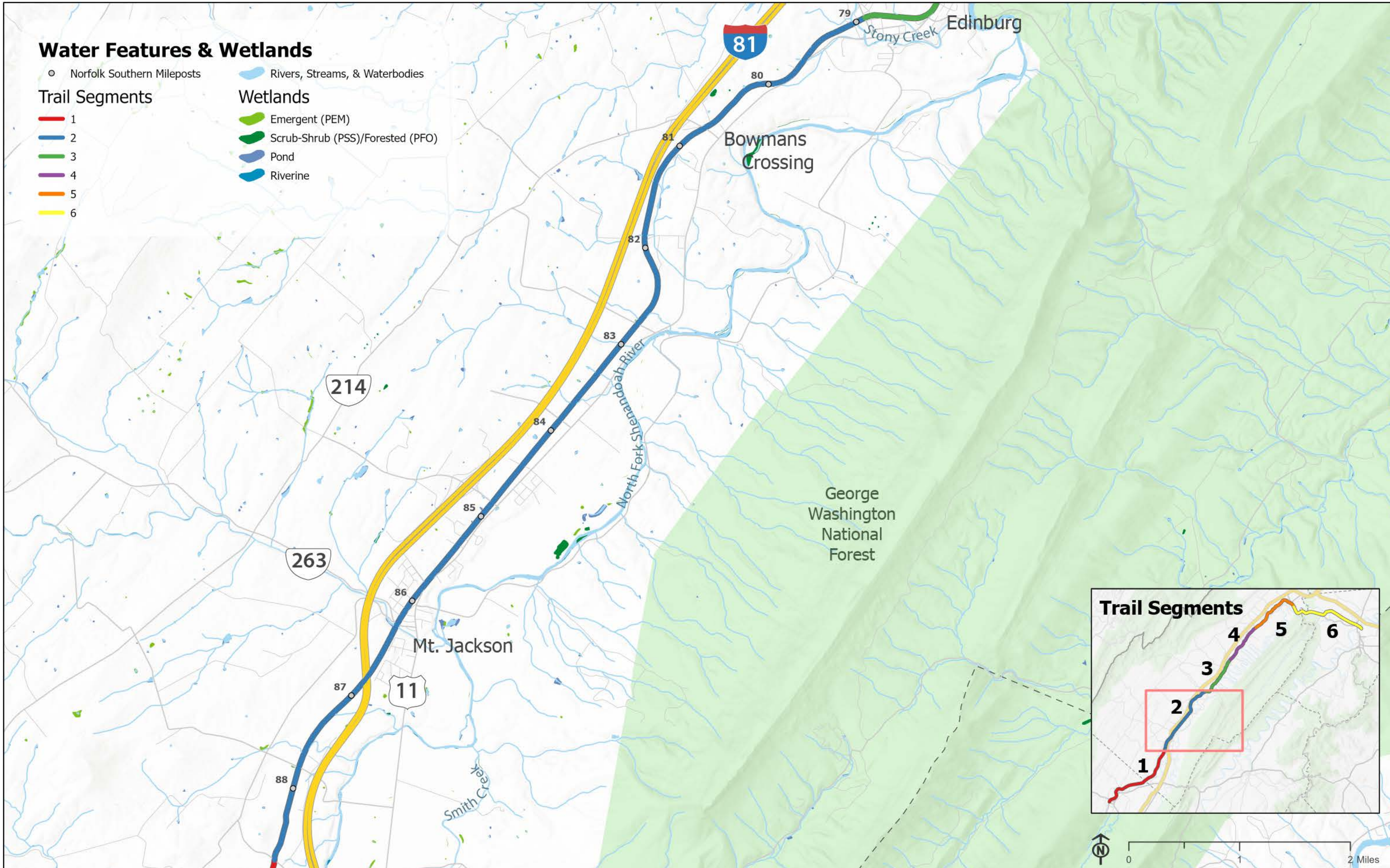
1
2 Miles



Water Features & Wetlands
Norfolk Southern Mileposts
Rivers, Streams, & Waterbodies
Trail Segments
1
2
3
4
5
6
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
81
79
80
81
82
83
84
85
86
87
88
Edinburg
Stony Creek
Bowmans Crossing
North Fork Shenandoah River
214
263
11
Mt. Jackson
Smith Creek
George Washington National Forest
Trail Segments
1
2
3
4
5
6
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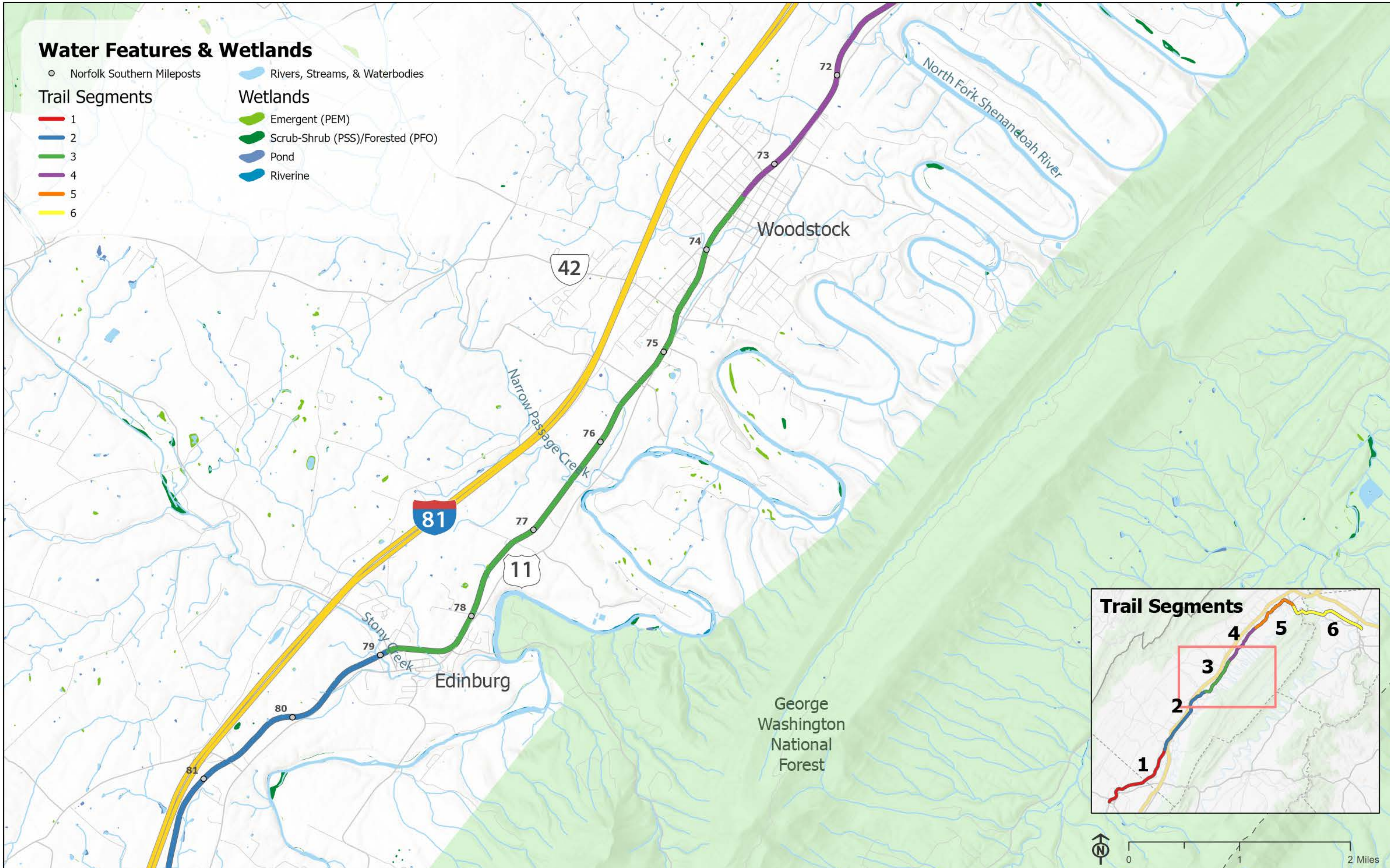
0
1
2 Miles



Water Features & Wetlands
Norfolk Southern Mileposts
Rivers, Streams, & Waterbodies
Trail Segments
1
2
3
4
5
6
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
North Fork Shenandoah River
Woodstock
Narrow Passage Creek
Stony Creek
Edinburg
George Washington National Forest
42
81
11
72
73
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75
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77
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79
80
81
Trail Segments
1
2
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6
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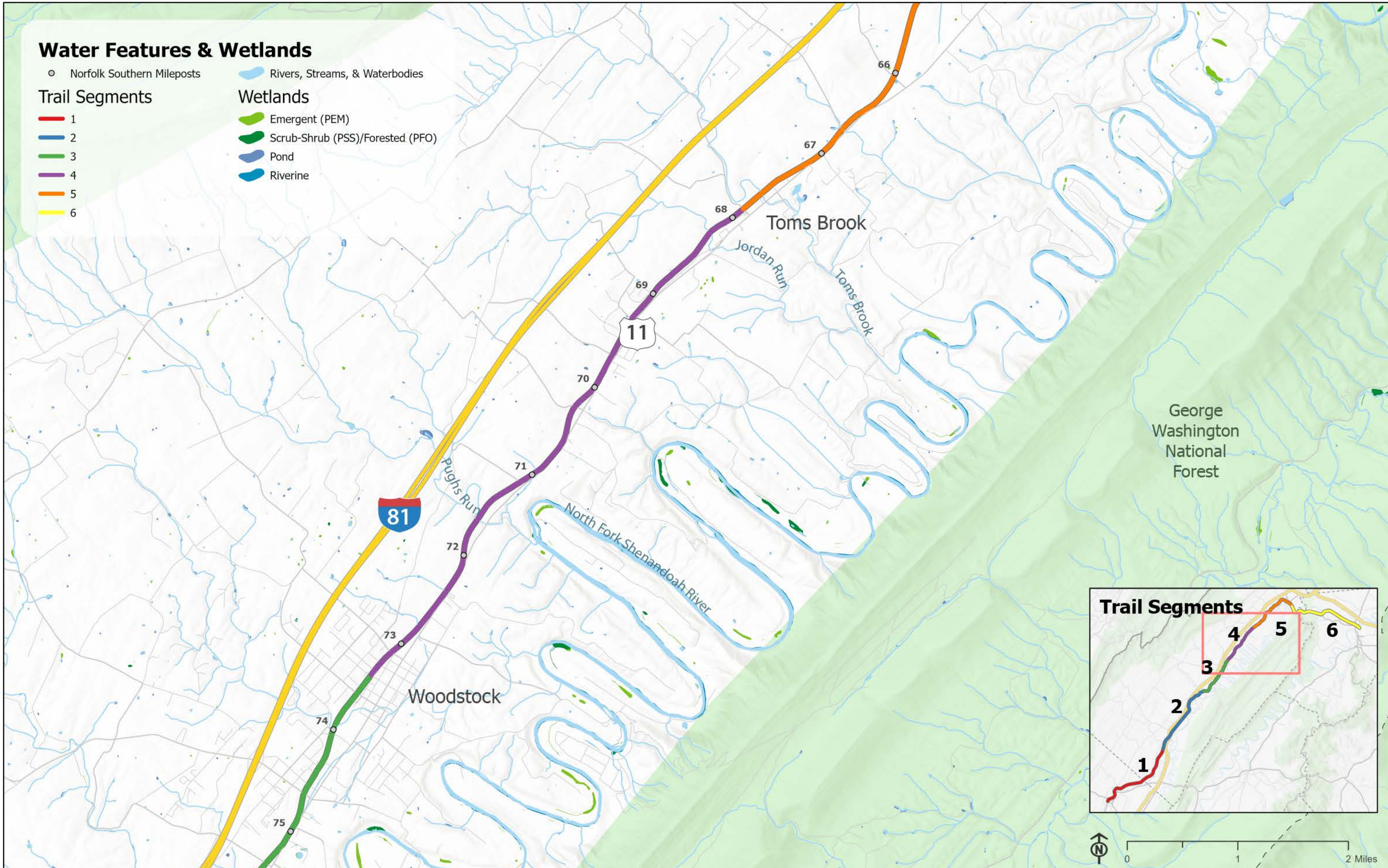
2 Miles



Water Features & Wetlands
Norfolk Southern Mileposts
Rivers, Streams, & Waterbodies
Trail Segments
1
2
3
4
5
6
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
66
67
68
69
70
71
72
73
74
75
Toms Brook
Jordan Run
Toms Brook
11
81
Pughs Run
North Fork Shenandoah River
Woodstock
George Washington National Forest
Trail Segments
1
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3
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6
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2 Miles
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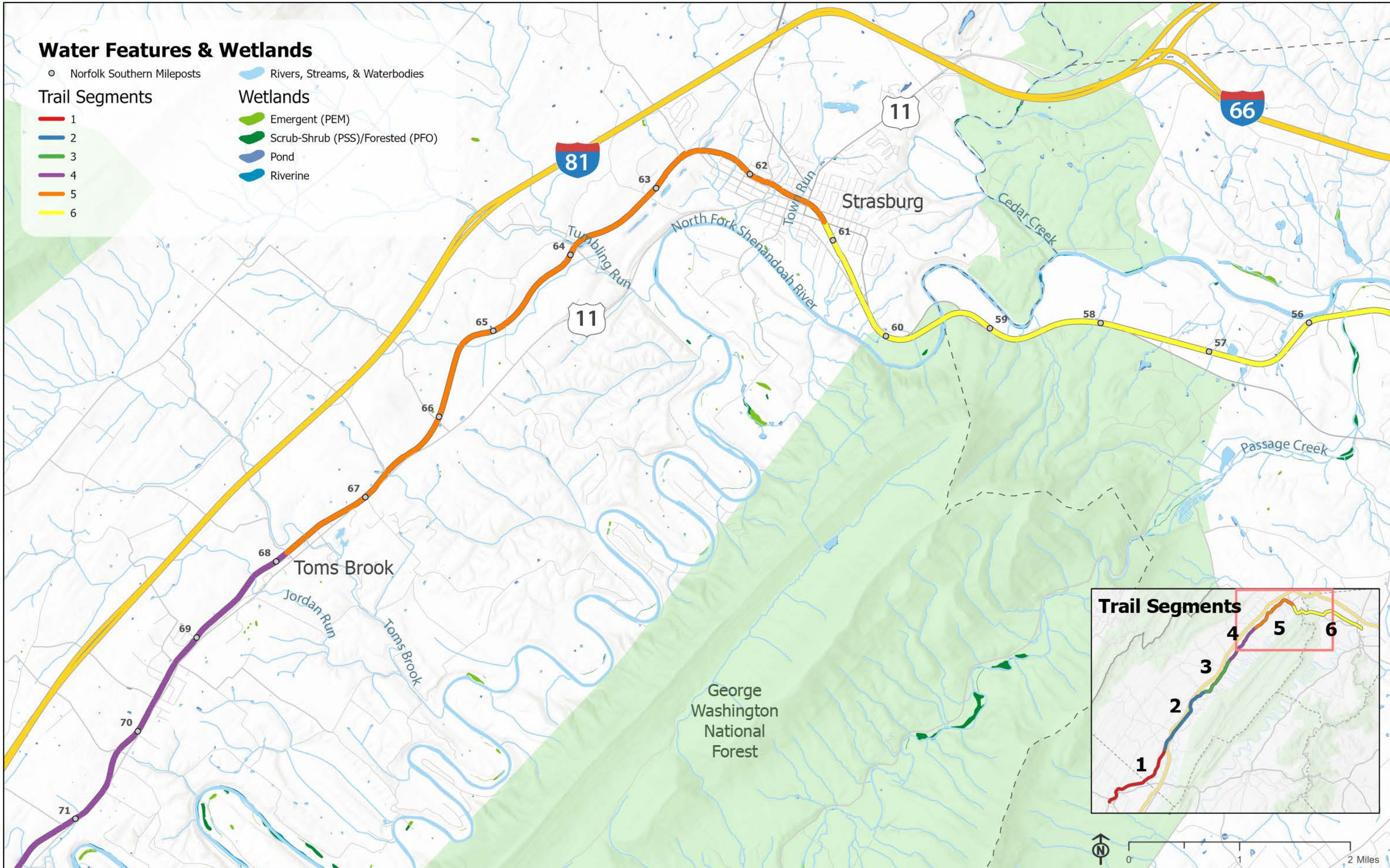

Water Features & Wetlands
Norfolk Southern Mileposts
Rivers, Streams, & Waterbodies
Trail Segments
1
2
3
4
5
6
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
81
11
66
Strasburg
Toms Brook
North Fork Shenandoah River
Tumbling Run
Town Run
Cedar Creek
Passage Creek
Jordan Run
Toms Brook
George Washington National Forest
56
57
58
59
60
61
62
63
64
65
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68
69
70
71
Trail Segments
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N
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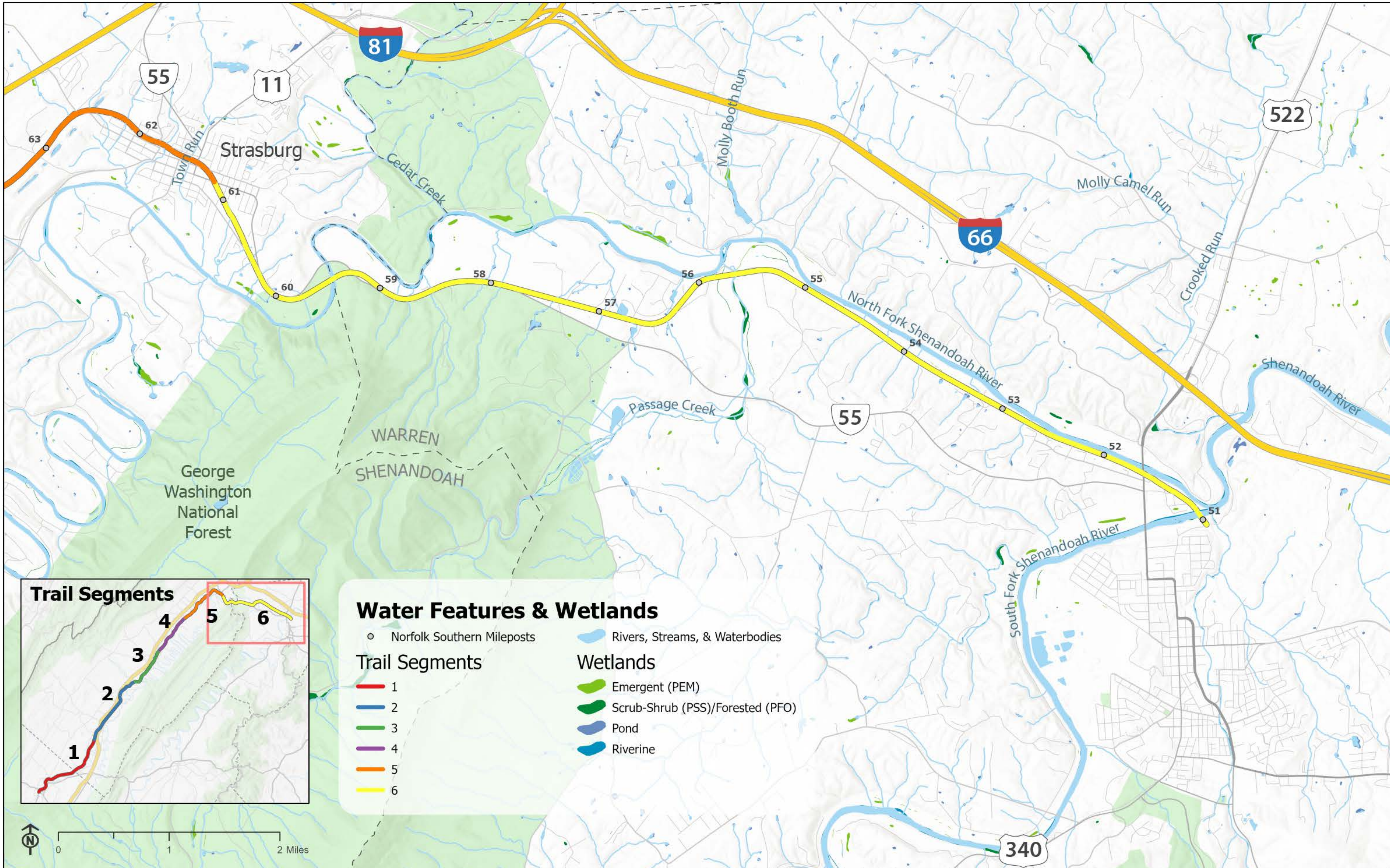
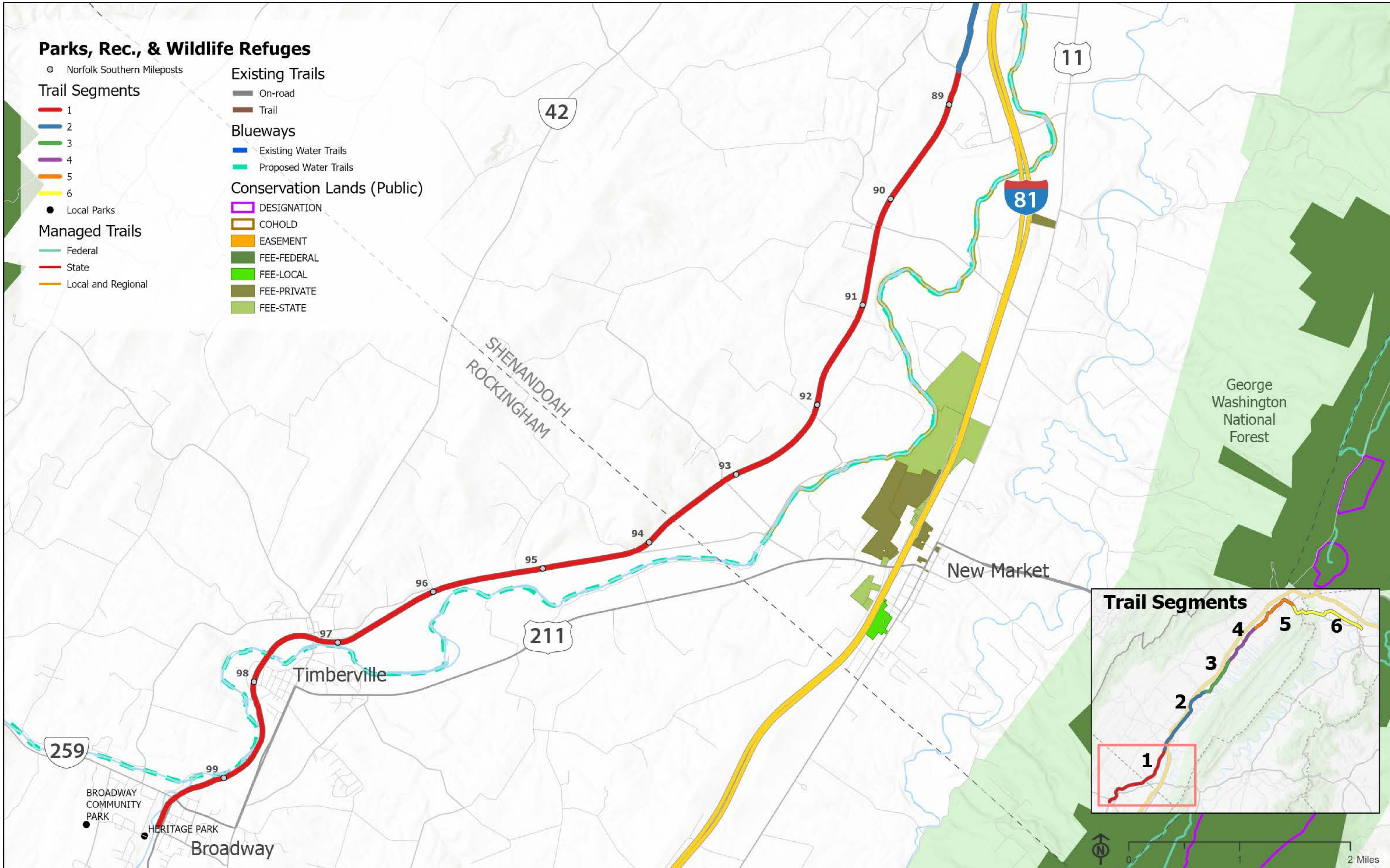
1
2 Miles



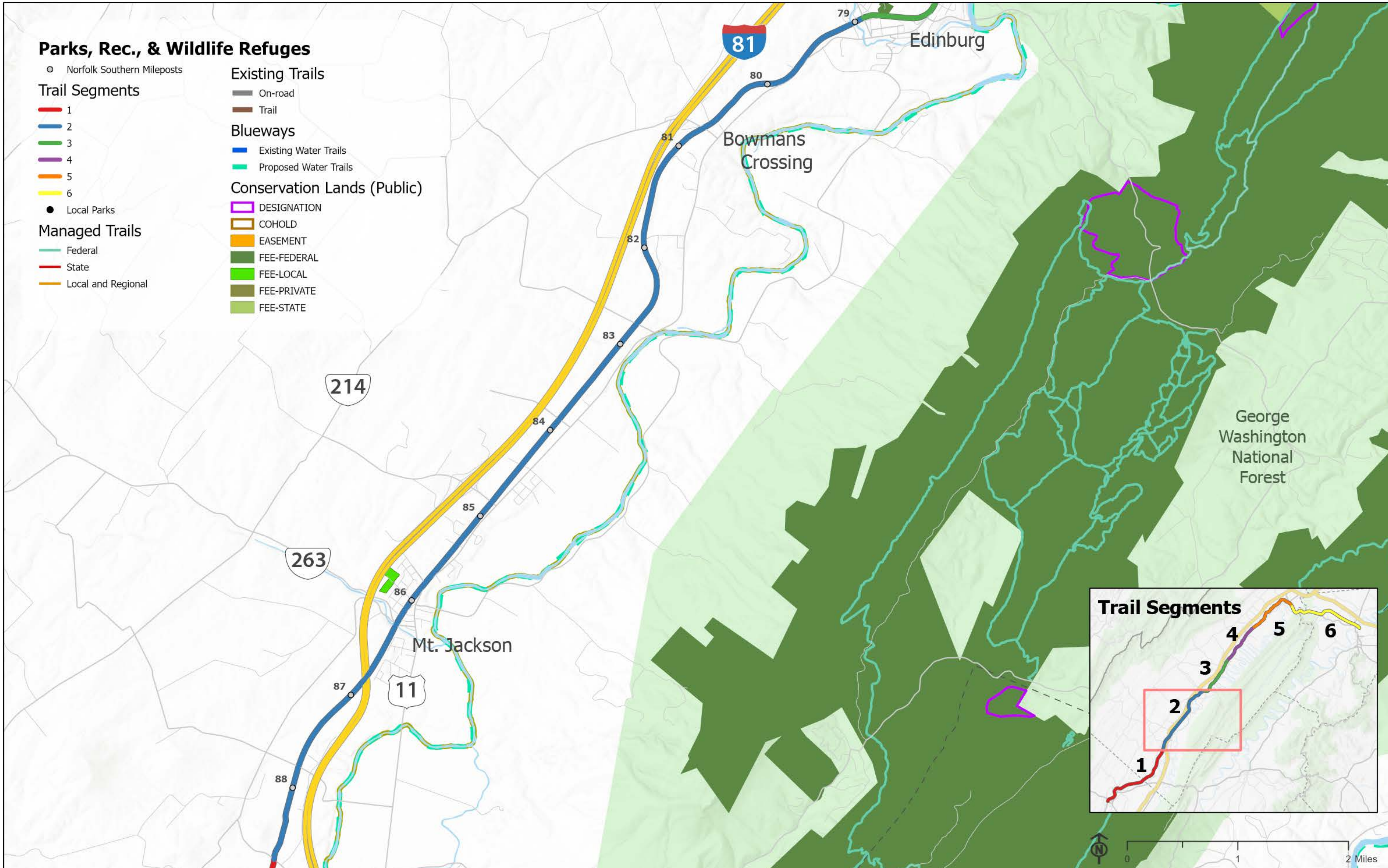
Water Features & Wetlands
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Rivers, Streams, & Waterbodies
Wetlands
Emergent (PEM)
Scrub-Shrub (PSS)/Forested (PFO)
Pond
Riverine
Trail Segments
1
2
3
4
5
6
Strasburg
George Washington National Forest
WARREN
SHENANDOAH
Cedar Creek
Molly Booth Run
Molly Camel Run
Crooked Run
Town Run
Passage Creek
North Fork Shenandoah River
South Fork Shenandoah River
Shenandoah River
81
66
55
11
522
340
63
62
61
60
59
58
57
56
55
54
53
52
51
0
1
2 Miles

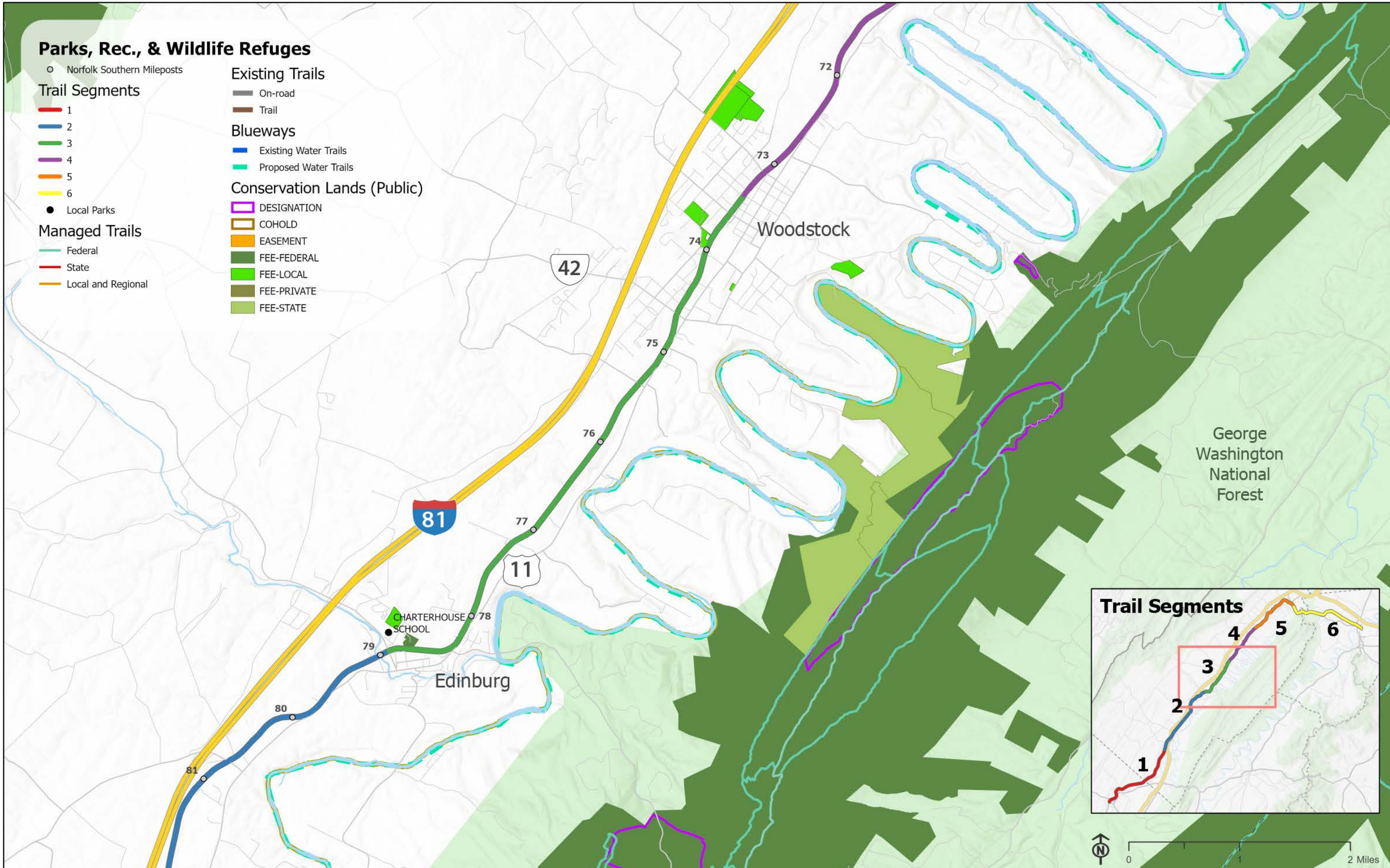
ATTACHMENT 2

Map Set 2: Parks, Recreation Areas, Wildlife/Waterfowl Refuges, & Conservation Easements

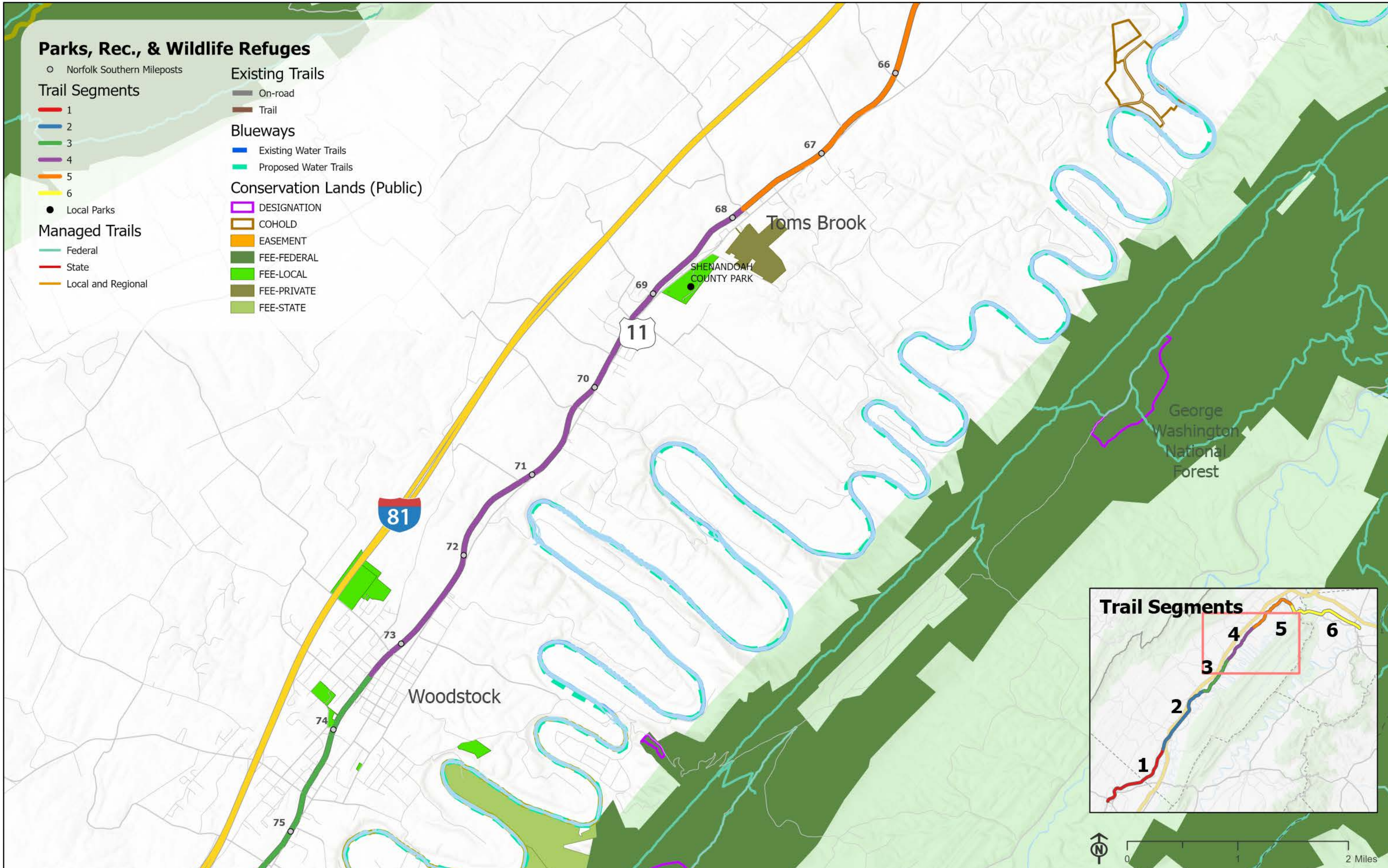


Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
SHENANDOAH
ROCKINGHAM
42
11
81
211
259
89
90
91
92
93
94
95
96
97
98
99
Timberville
New Market
Broadway
BROADWAY COMMUNITY PARK
HERITAGE PARK
George Washington National Forest
Trail Segments
1
2
3
4
5
6
0
1
2 Miles

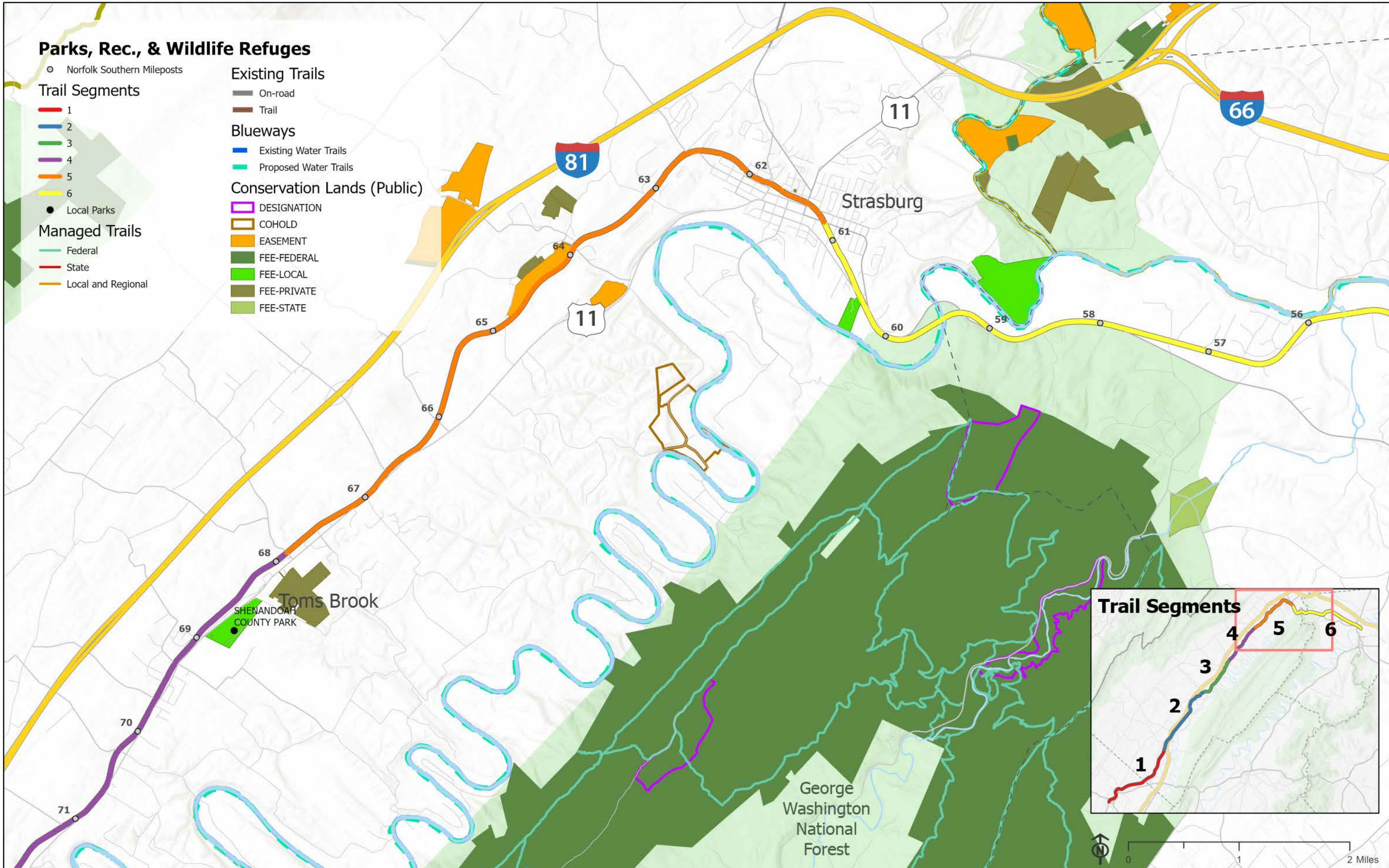

Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
81
Edinburg
Bowmans Crossing
214
263
Mt. Jackson
11
George Washington National Forest
79
80
81
82
83
84
85
86
87
88
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



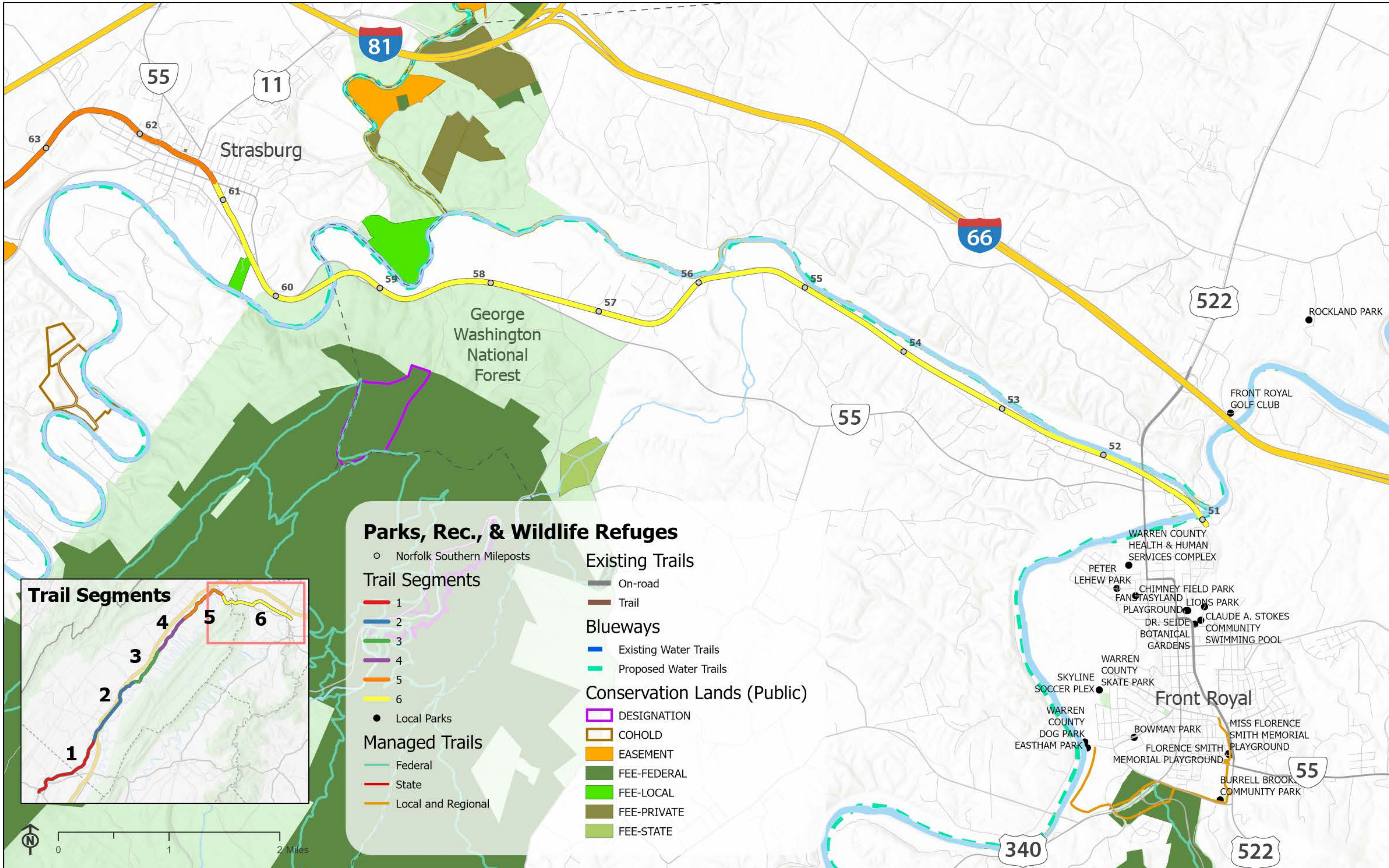
Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
Woodstock
Edinburg
CHARTERHOUSE SCHOOL
George Washington National Forest
72
73
74
75
76
77
78
79
80
81
42
11
81
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
66
67
68
69
70
71
72
73
74
75
Toms Brook
SHENANDOAH COUNTY PARK
11
81
Woodstock
George Washington National Forest
Trail Segments
0
1
2 Miles



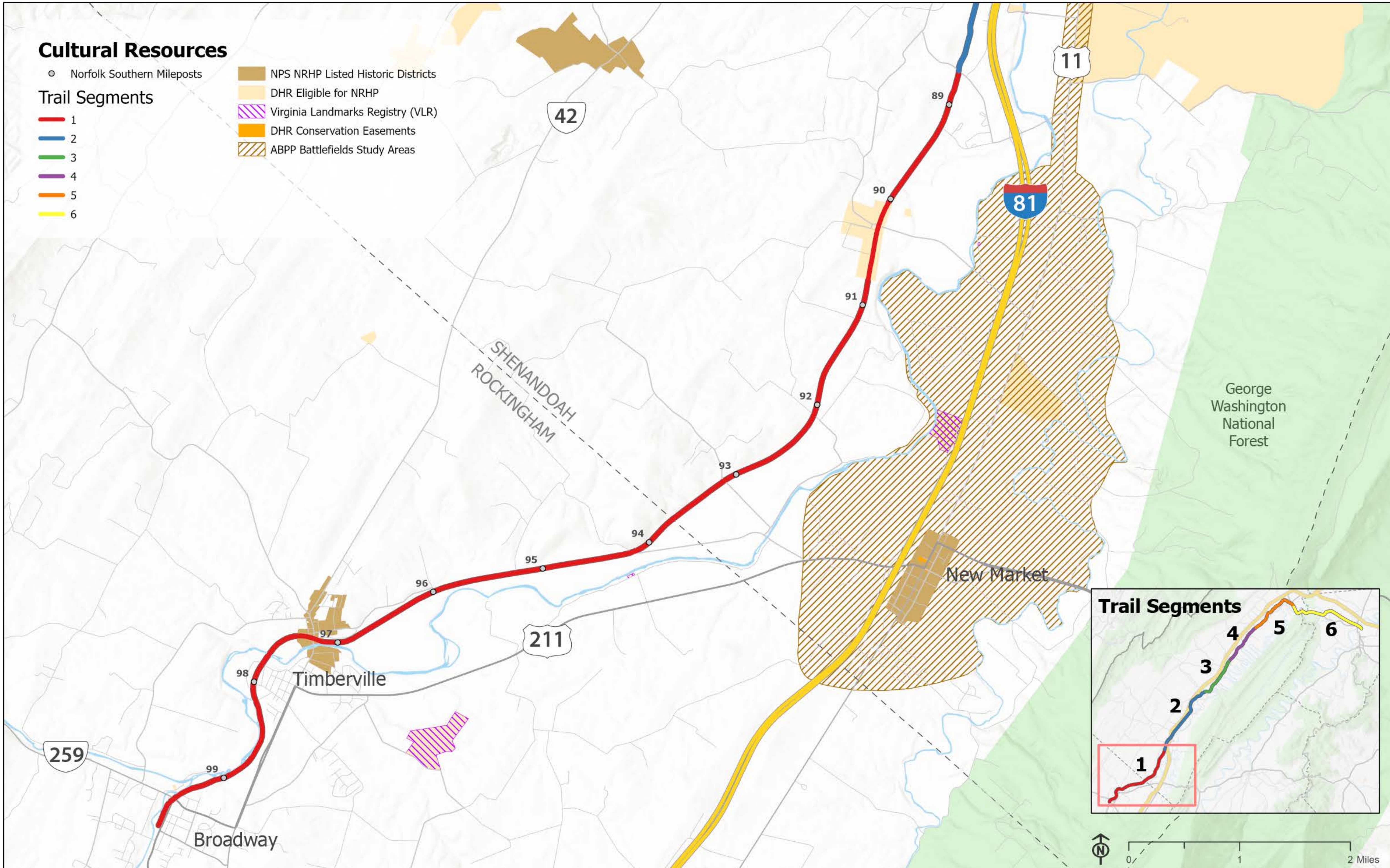
Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
81
11
66
Strasburg
Toms Brook
SHENANDOAH COUNTY PARK
George Washington National Forest
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



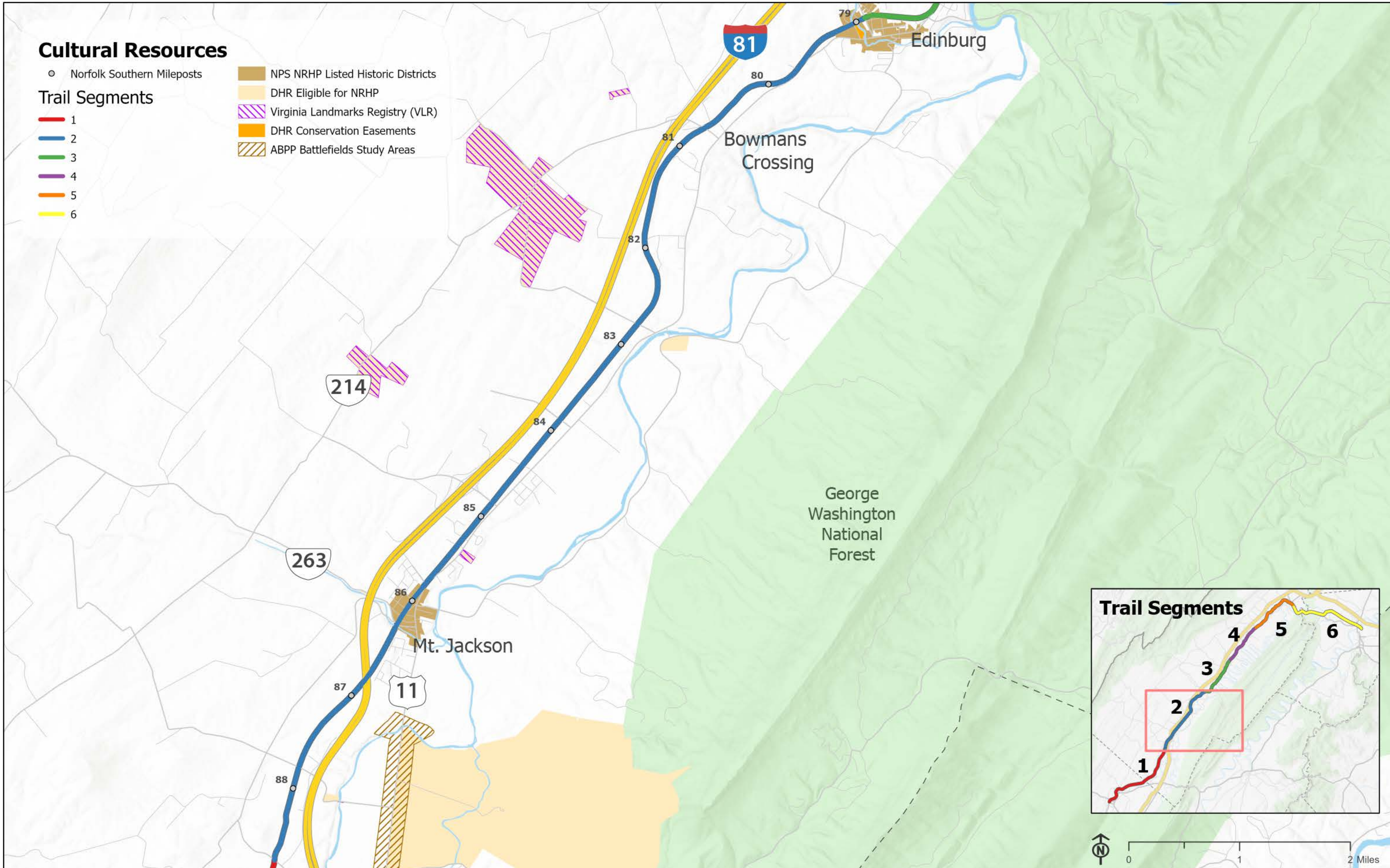
Parks, Rec., & Wildlife Refuges
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Local Parks
Managed Trails
Federal
State
Local and Regional
Existing Trails
On-road
Trail
Blueways
Existing Water Trails
Proposed Water Trails
Conservation Lands (Public)
DESIGNATION
COHOLD
EASEMENT
FEE-FEDERAL
FEE-LOCAL
FEE-PRIVATE
FEE-STATE
Trail Segments
Strasburg
George Washington National Forest
Front Royal
ROCKLAND PARK
FRONT ROYAL GOLF CLUB
WARREN COUNTY HEALTH & HUMAN SERVICES COMPLEX
PETER LEHEW PARK
CHIMNEY FIELD PARK
FANTASYLAND PLAYGROUND
LIONS PARK
CLAUDE A. STOKES COMMUNITY SWIMMING POOL
DR. SEIDE BOTANICAL GARDENS
WARREN COUNTY SKATE PARK
SKYLINE SOCCER PLEX
WARREN COUNTY DOG PARK
EASTHAM PARK
BOWMAN PARK
MISS FLORENCE SMITH MEMORIAL PLAYGROUND
FLORENCE SMITH MEMORIAL PLAYGROUND
BURRELL BROOKS COMMUNITY PARK
0
1
2 Miles

ATTACHMENT 3

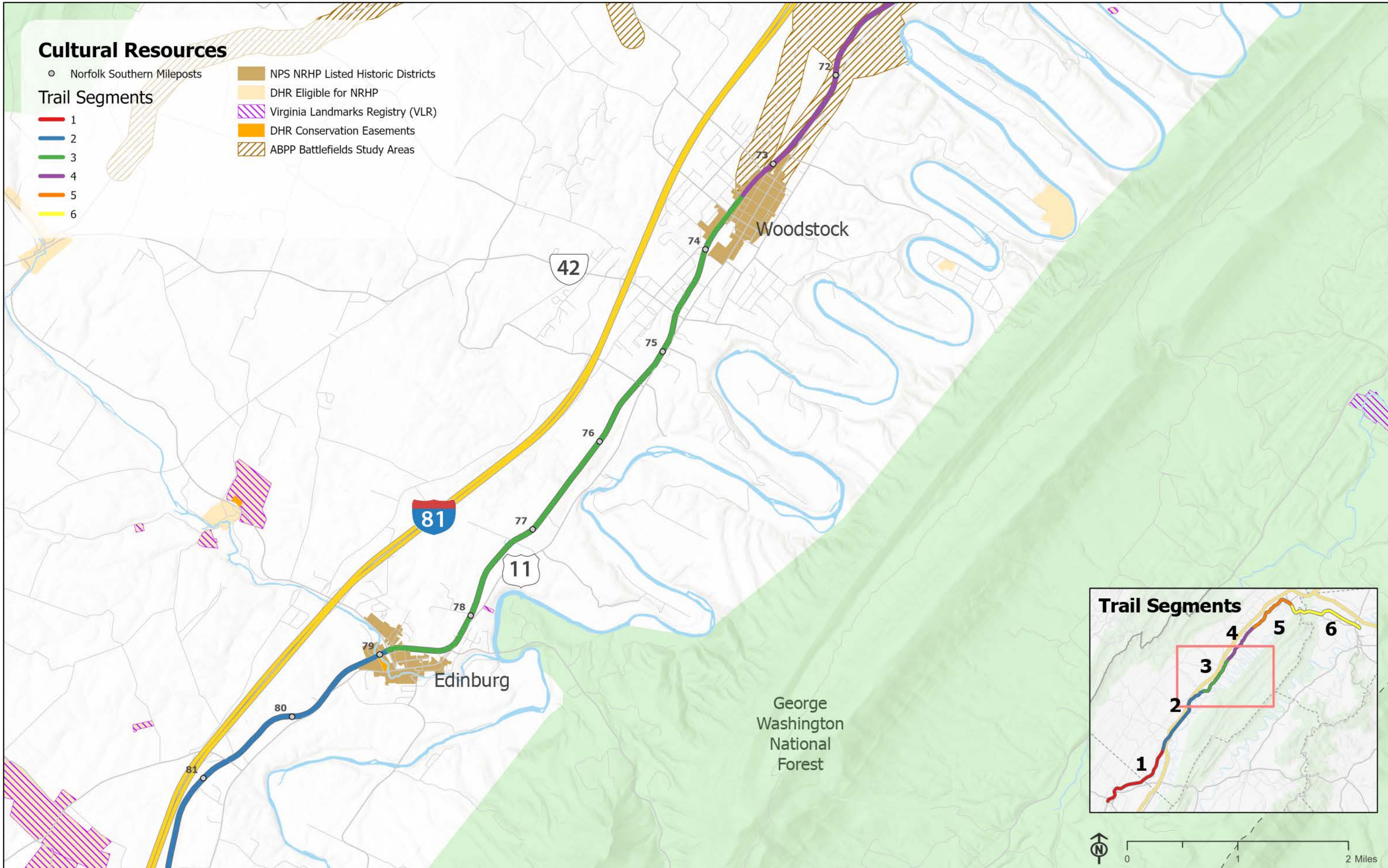
Map Set 3: Cultural Resources



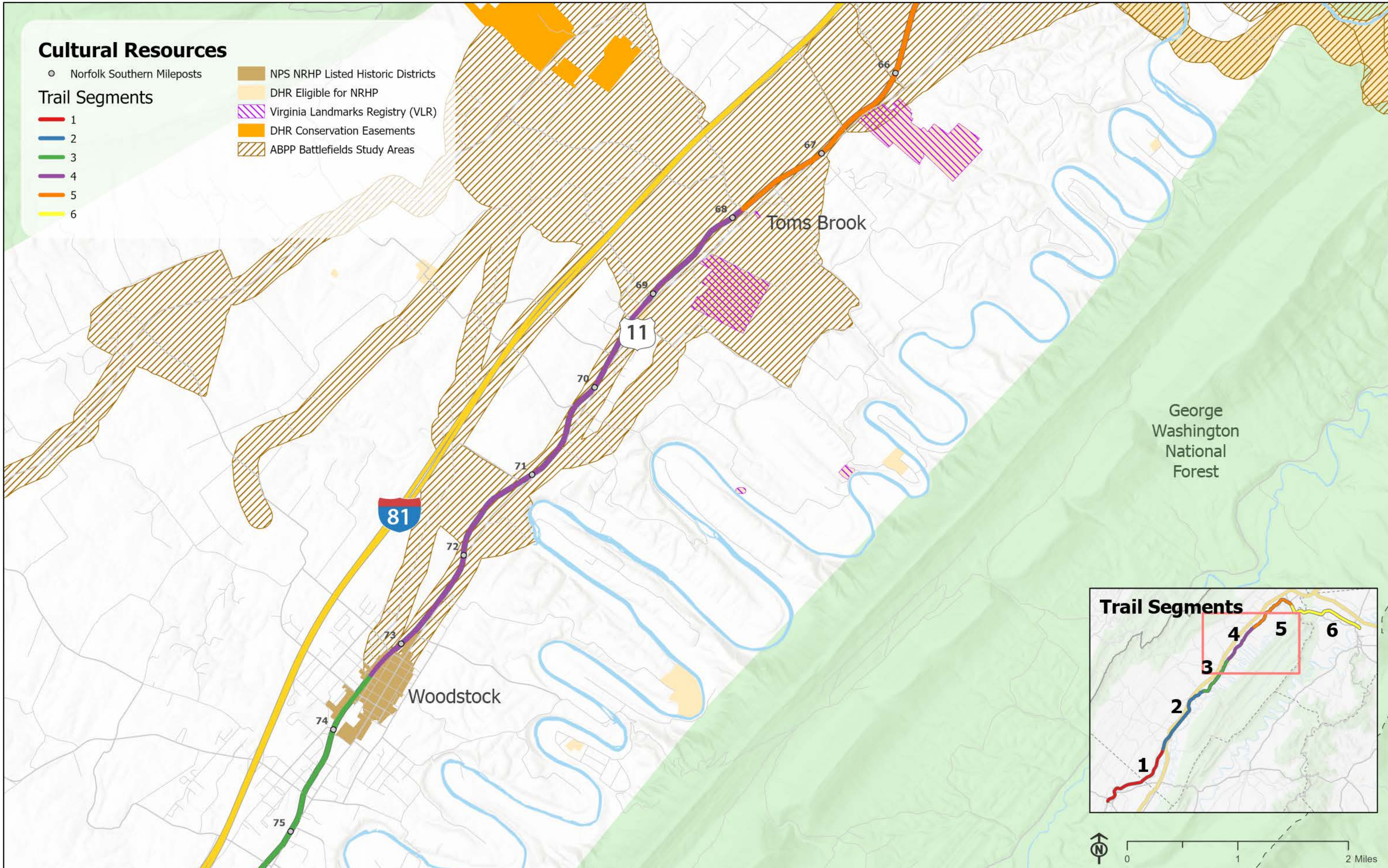
Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
42
11
81
89
90
91
92
93
94
95
96
97
98
99
SHENANDOAH
ROCKINGHAM
George Washington National Forest
New Market
211
Timberville
259
Broadway
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



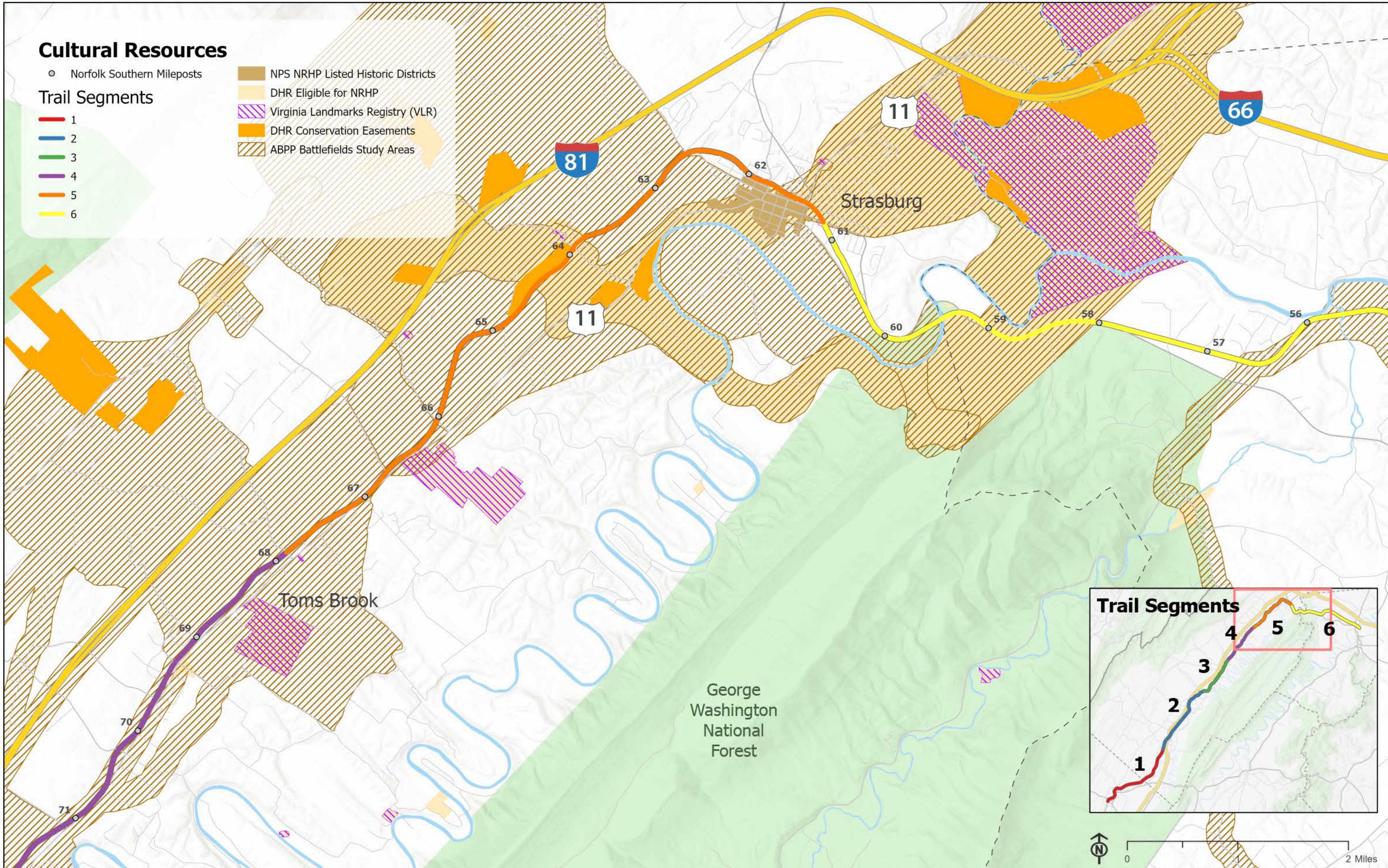
Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
81
Edinburg
Bowmans Crossing
214
263
11
Mt. Jackson
George Washington National Forest
79
80
81
82
83
84
85
86
87
88
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



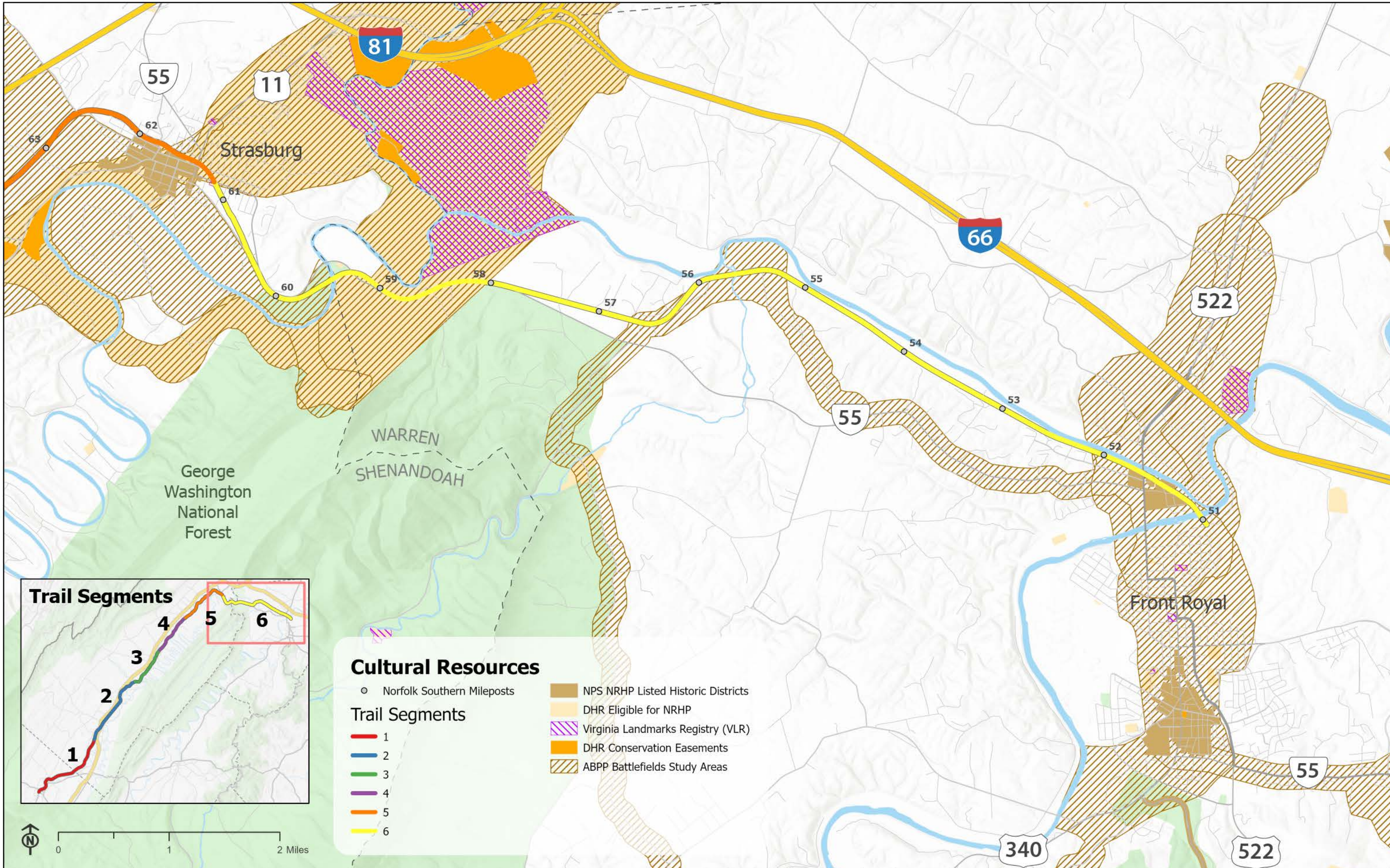
Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
Woodstock
Edinburg
42
81
11
72
73
74
75
76
77
78
79
80
81
George Washington National Forest
Trail Segments
1
2
3
4
5
6
0
1
2 Miles
N



Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
66
67
68
69
70
71
72
73
74
75
Toms Brook
Woodstock
11
81
George Washington National Forest
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



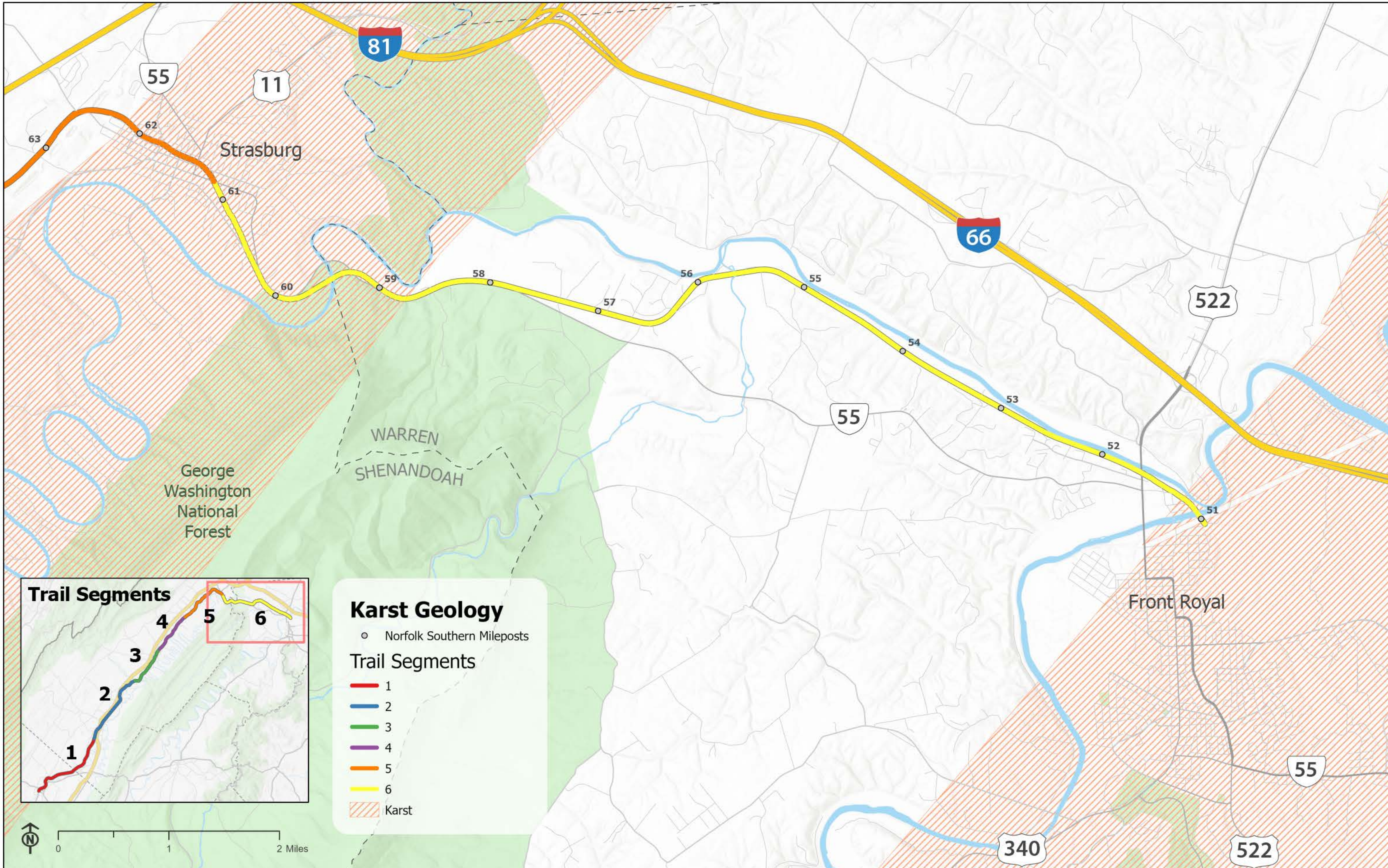
Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
81
11
66
Strasburg
Toms Brook
George Washington National Forest
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
Trail Segments
1
2
3
4
5
6
0
1
2 Miles
N



81
55
11
Strasburg
66
522
55
340
522
55
Front Royal
George Washington National Forest
WARREN
SHENANDOAH
63
62
61
60
59
58
57
56
55
54
53
52
51
Trail Segments
1
2
3
4
5
6
Cultural Resources
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
NPS NRHP Listed Historic Districts
DHR Eligible for NRHP
Virginia Landmarks Registry (VLR)
DHR Conservation Easements
ABPP Battlefields Study Areas
0
1
2 Miles

ATTACHMENT 4

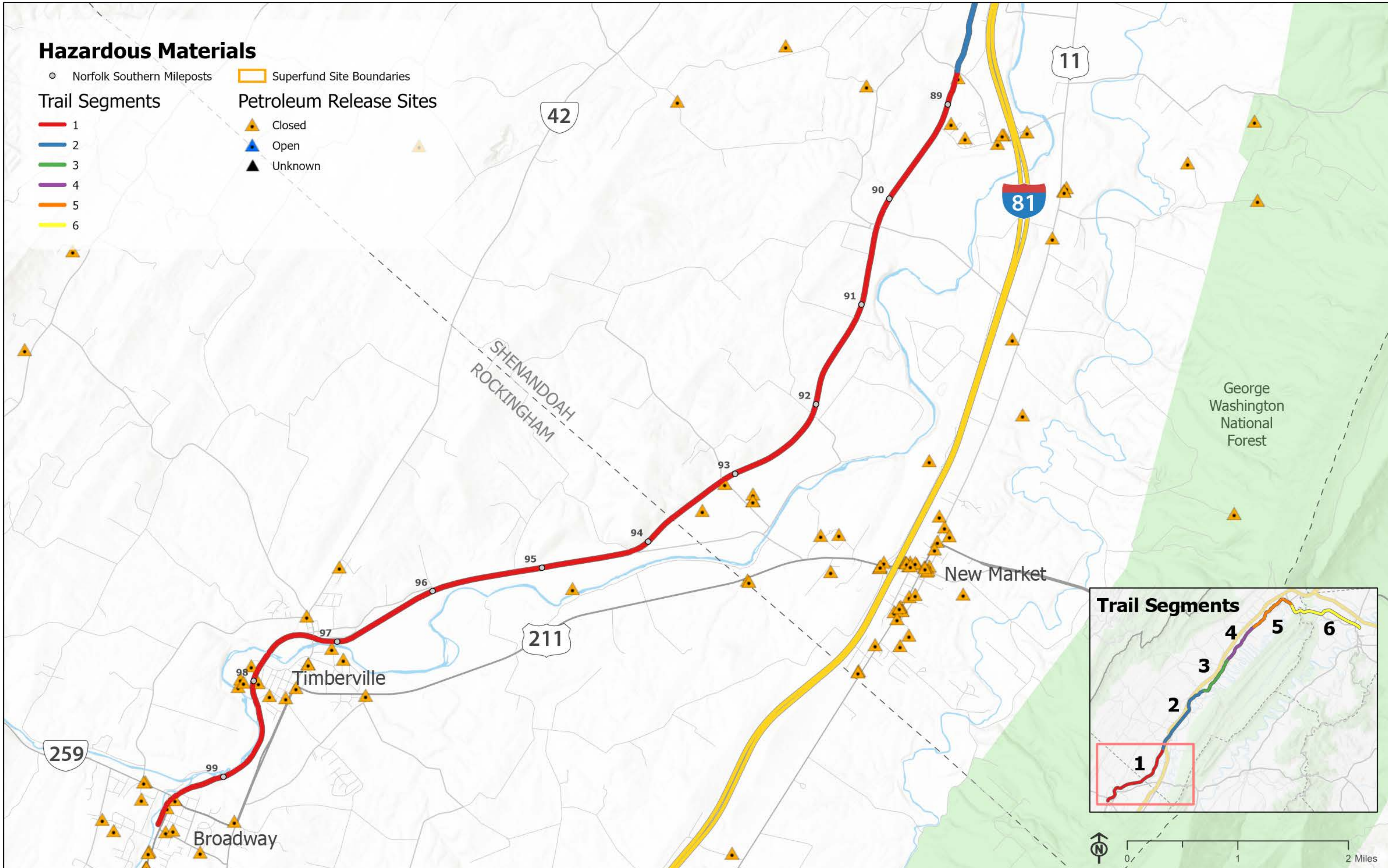
Map Set 4: Karst Geology

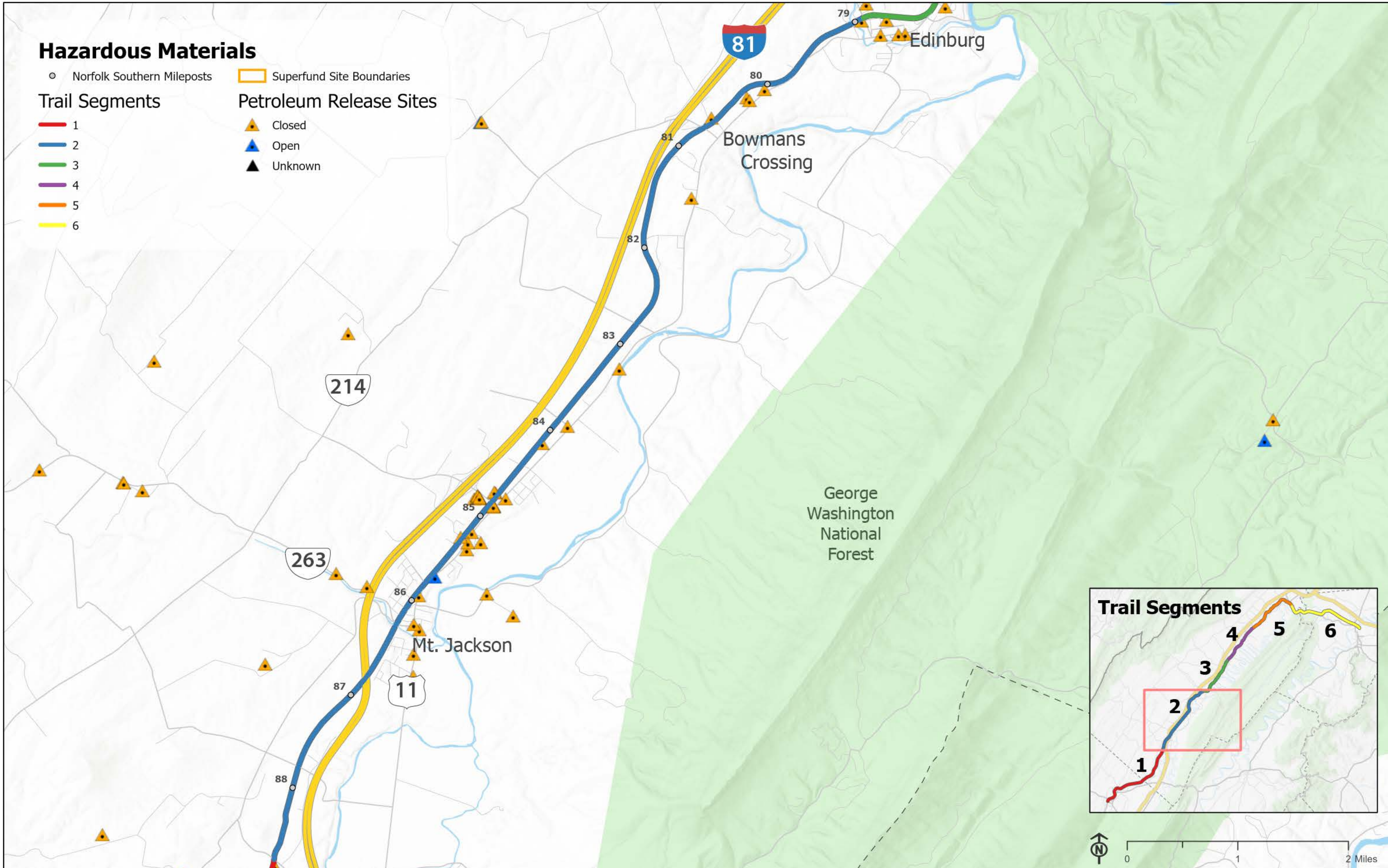


Karst Geology
Norfolk Southern Mileposts
Trail Segments
1
2
3
4
5
6
Karst
Trail Segments
1
2
3
4
5
6
Strasburg
Front Royal
George Washington National Forest
WARREN
SHENANDOAH
81
66
55
11
522
340
63
62
61
60
59
58
57
56
55
54
53
52
51
0
1
2 Miles

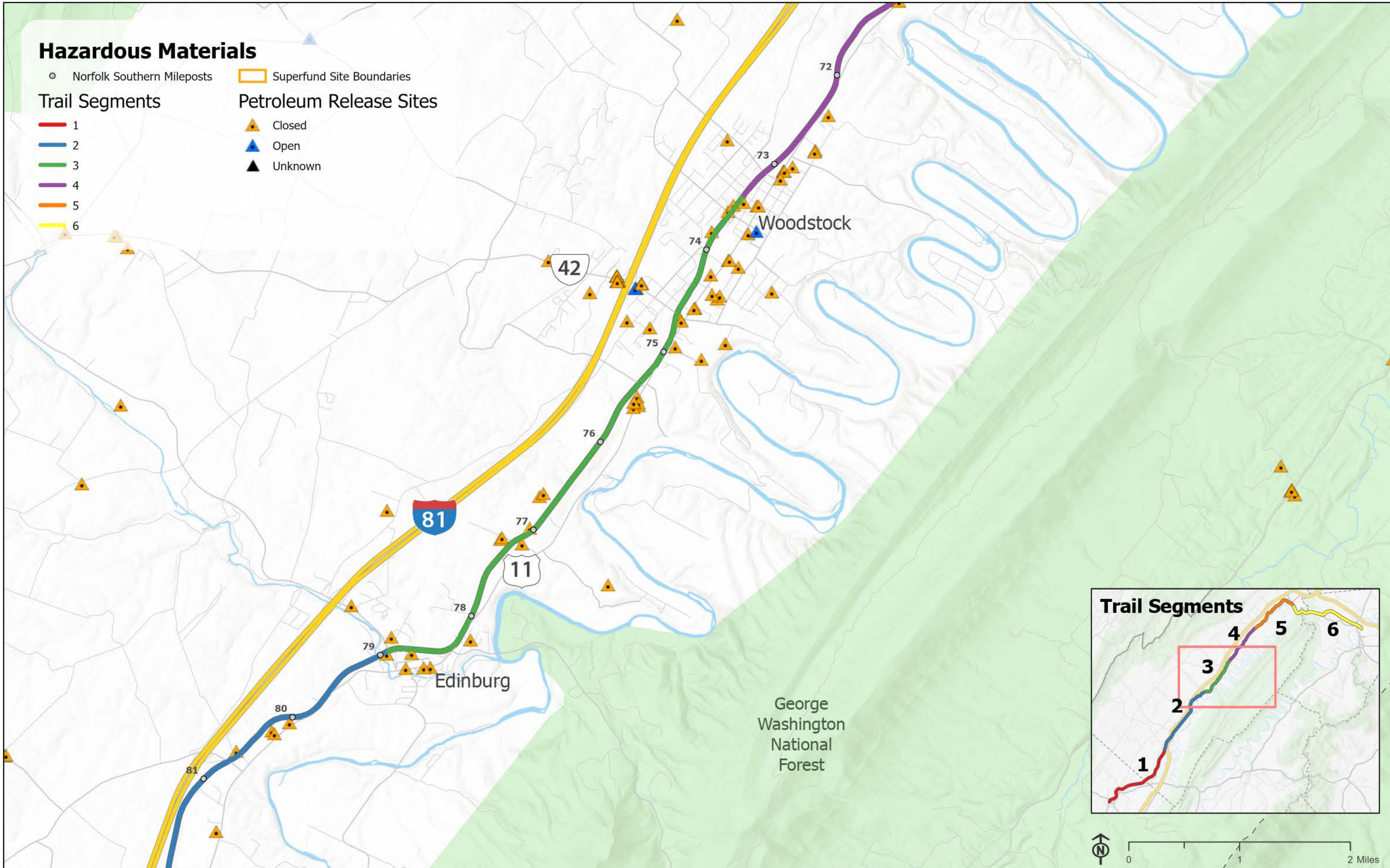
ATTACHMENT 5

Map Set 5: Hazardous Materials

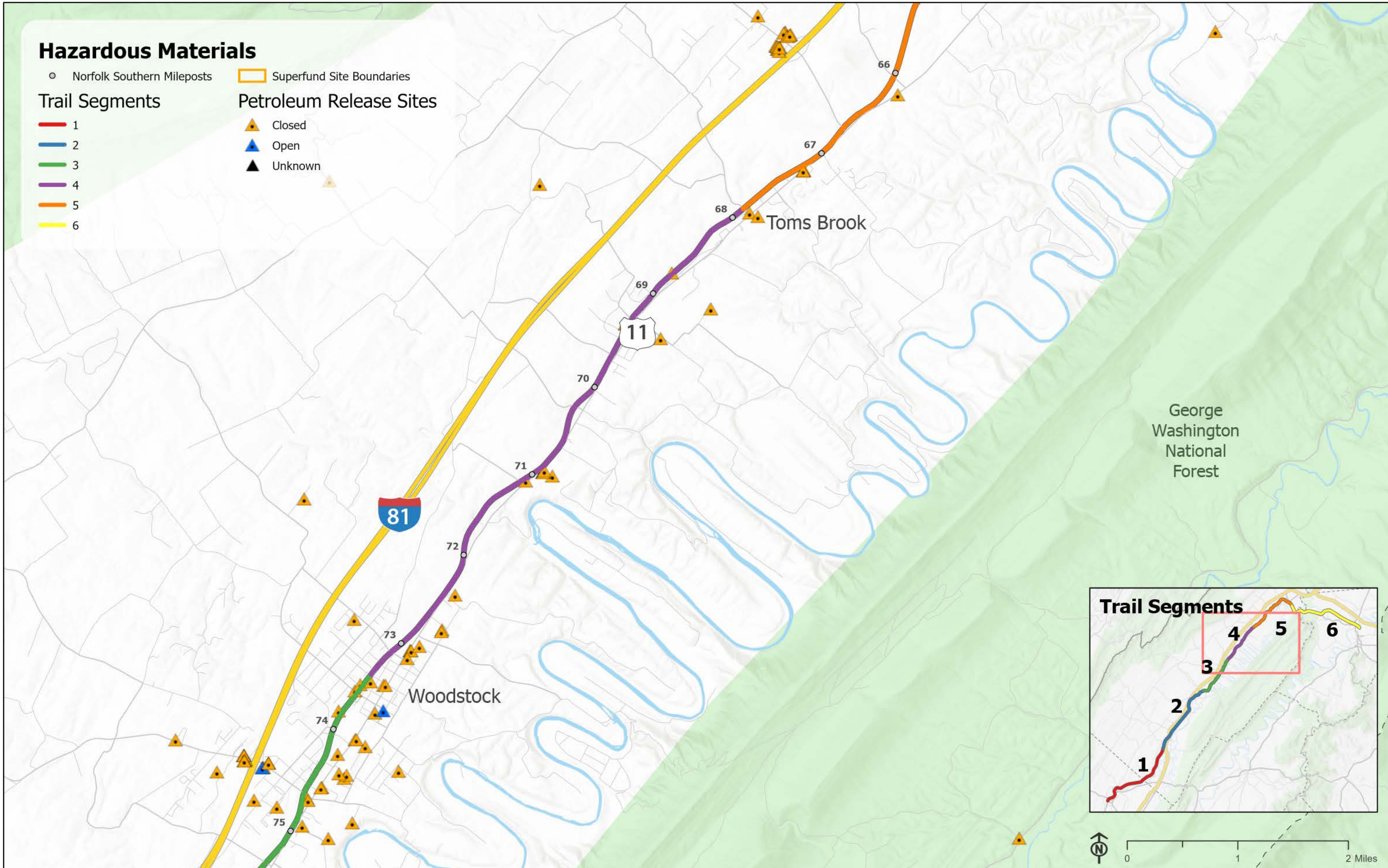

Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
42
11
81
211
259
89
90
91
92
93
94
95
96
97
98
99
SHENANDOAH
ROCKINGHAM
George Washington National Forest
New Market
Timberville
Broadway
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



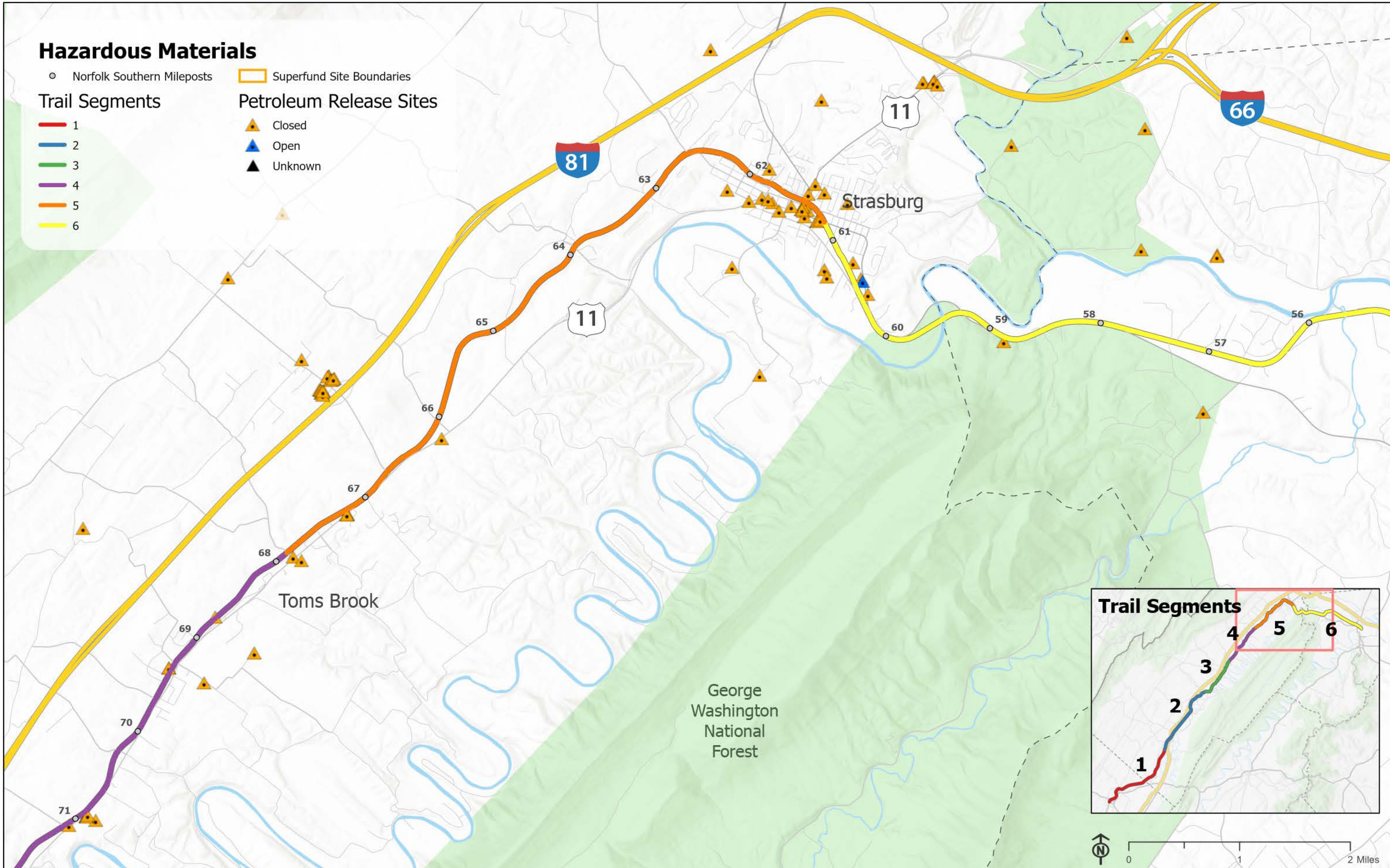
Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
81
Edinburg
Bowmans Crossing
214
263
11
Mt. Jackson
George Washington National Forest
79
80
81
82
83
84
85
86
87
88
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



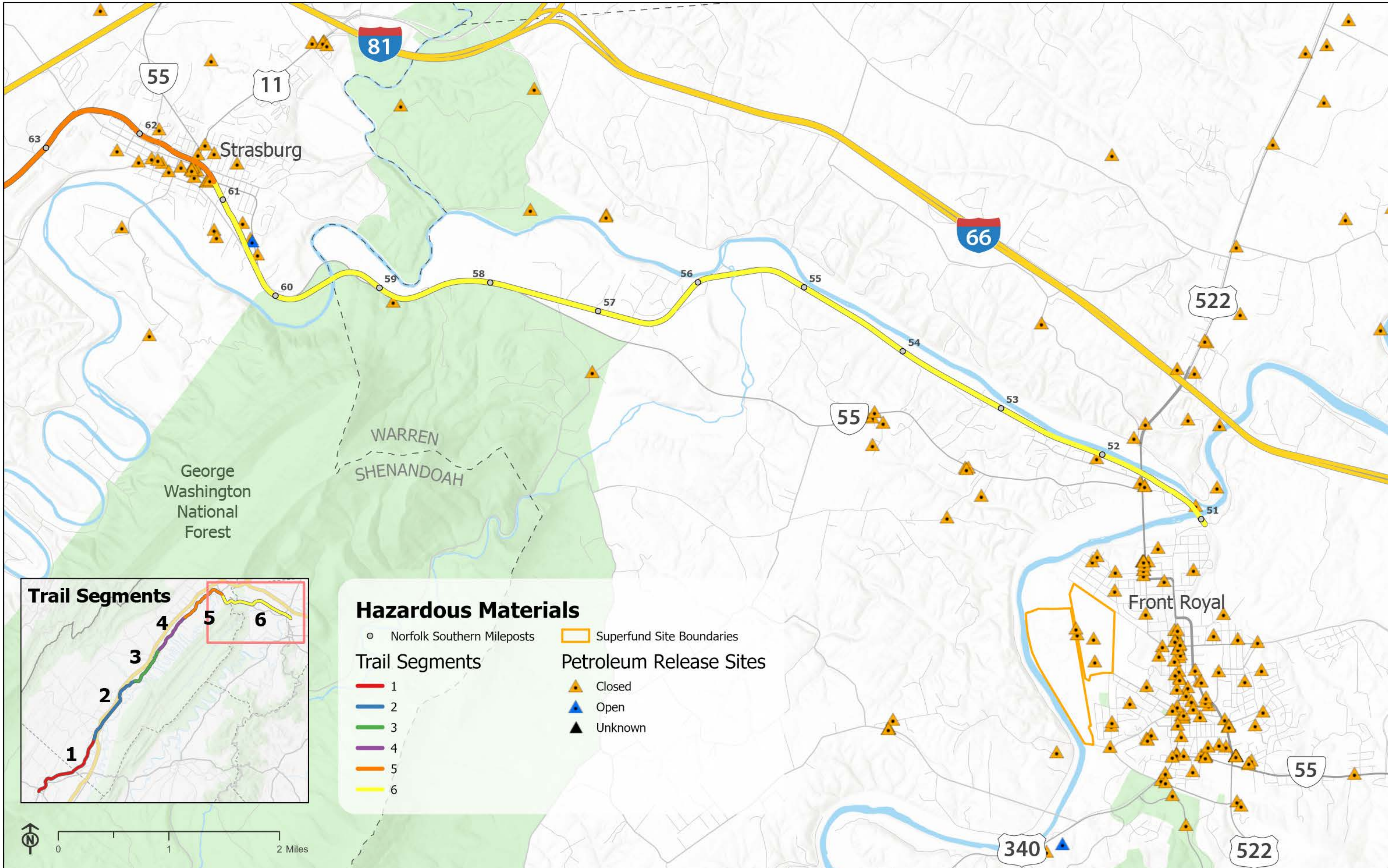
Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
Woodstock
Edinburg
George Washington National Forest
42
81
11
72
73
74
75
76
77
78
79
80
81
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
Toms Brook
Woodstock
George Washington National Forest
11
81
66
67
68
69
70
71
72
73
74
75
Trail Segments
1
2
3
4
5
6
0
1
2 Miles



Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
81
11
66
Strasburg
Toms Brook
George Washington National Forest
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
Trail Segments
0
1
2 Miles


Hazardous Materials
Norfolk Southern Mileposts
Superfund Site Boundaries
Trail Segments
1
2
3
4
5
6
Petroleum Release Sites
Closed
Open
Unknown
Trail Segments
Strasburg
Front Royal
George Washington National Forest
WARREN
SHENANDOAH
81
66
55
11
522
340
63
62
61
60
59
58
57
56
55
54
53
52
51
0
1
2 Miles

APPENDIX B: DRAINAGE AND STORMWATER MANAGEMENT REPORT

Shenandoah Valley Rail-With-Trail Assessment

Warren County, Shenandoah County, Rockingham County - Virginia

Drainage and Stormwater Management Report

Prepared for

VDOT

Virginia Department of Transportation

June 2025

Table of Contents

Appendices

Executive Summary

The Shenandoah Valley Rail-With-Trail Assessment is a high-level evaluation of the constraints and considerations for constructing a trail along the 49-mile Norfolk-Southern-owned rail right of way in Rockingham, Shenandoah, and Warren Counties in Virginia's Shenandoah Valley, henceforth called the Rail-with-Trail option. In addition, the analysis compares the Rail-with-Trail option with one that replaces the railroad tracks with a trail, henceforth called the Rail-to-Trail option. The intent of this report is to establish design recommendations based on the drainage, stormwater management, and floodplain requirements, and quantify anticipated mitigation for each of these options.

Regarding drainage, both options will use an open drainage system similar to the existing condition. The two proposed features for drainage system, ditches and culverts, were used to conduct the comparison between the options. The Rail-with-Trail option has more impervious surface than the Rail-to-Trail option since the existing green surface is converted into a trail. The Rail-with-Trail option will also require a new ditch on the abutters side and a reconstructed ditch between the railroad and the trail. An estimated 2.3 million cubic feet (86,240 cubic yards) of additional excavation is anticipated for the Rail-with-Trail option to construct a new ditch due to the proposed trail replacing the existing ditch.

There are 55 structures; 23 bridges and 32 culverts, within the project limit. Each of the 32 culverts are expected to require a minimum of 20' extension (or full replacement if condition is poor), on at least one side of the trail, to accommodate the additional impervious surface of the Rail-with-Trail option. The total quantity required for the extension to the new toe of slope for Rail-with-Trail is 44% greater than the Rail-to-Trail option. This does not include the bridge rehabilitation or replacement quantities.

Regarding stormwater management (SWM), the Total Phosphorus (TP) that needs to be treated to meet the water quality requirement of the Virginia Erosion and Stormwater Management Program (VESMP) was estimated for the two options. Based on the analysis result, the TP load reduction required for the Rail-with-Trail option is 47% higher than the Rail-to-Trail option. Rail-with-Trail option will require 84 additional SWM facilities compared to the Rail-to-Trail option to meet the water quality compliance, mainly because of the land cover changes between pre- and post-condition. The Rail-to-Trail option converts the land cover from ballast (impervious for SWM purpose) to gravel (impervious as well) while Rail-with Trail option converts grass/wooded area in the pre-condition to gravel in the post-development condition, increasing the area of impervious surface on the corridor.

There are 31 structures; 16 bridges and 15 culverts, located in regulated floodplain within the project limit. Among the 31 structures, 7 of them are in floodplain Zone AE without a floodway and 4 of them are located in Zone AE with floodway. FEMA floodplain Zone AE with a floodway is in a no-rise zone, meaning it is not allowed to raise the Base Flood Elevation (100-year water surface elevation) nor to impact the floodway. The Rail-with-Trail option is more likely to impact the floodplain/floodway because the existing structures need to be extended, or a new structure needs to be added within the floodplain to accommodate the proposed improvements. Because of this, a hydraulics analysis will need to be developed and submitted to FEMA for a Condition Letter Of Map Revision (CLOMR) or a Letter of Map Revision (LOMR). The CLOMR/LOMR process takes a minimum of 6 months for FEMA to review and approve a hydraulics model and report for a crossing.

At this preliminary planning stage, the Rail-with-Trail option will result in the need to construct at least one additional ditch the full length of the corridor, and to widen or replace 32 culverts, as compared to the Rail-to-Trail option. Water quality measures are expected to require the treatment of 47% more Total Phosphorus for the Rail-with-Trail option, which would be mitigated through a combination of stormwater management facilities and the purchase of nutrient credits. Detailed water quantity analysis was not conducted because these data are not available at this stage.

1.0 INTRODUCTION

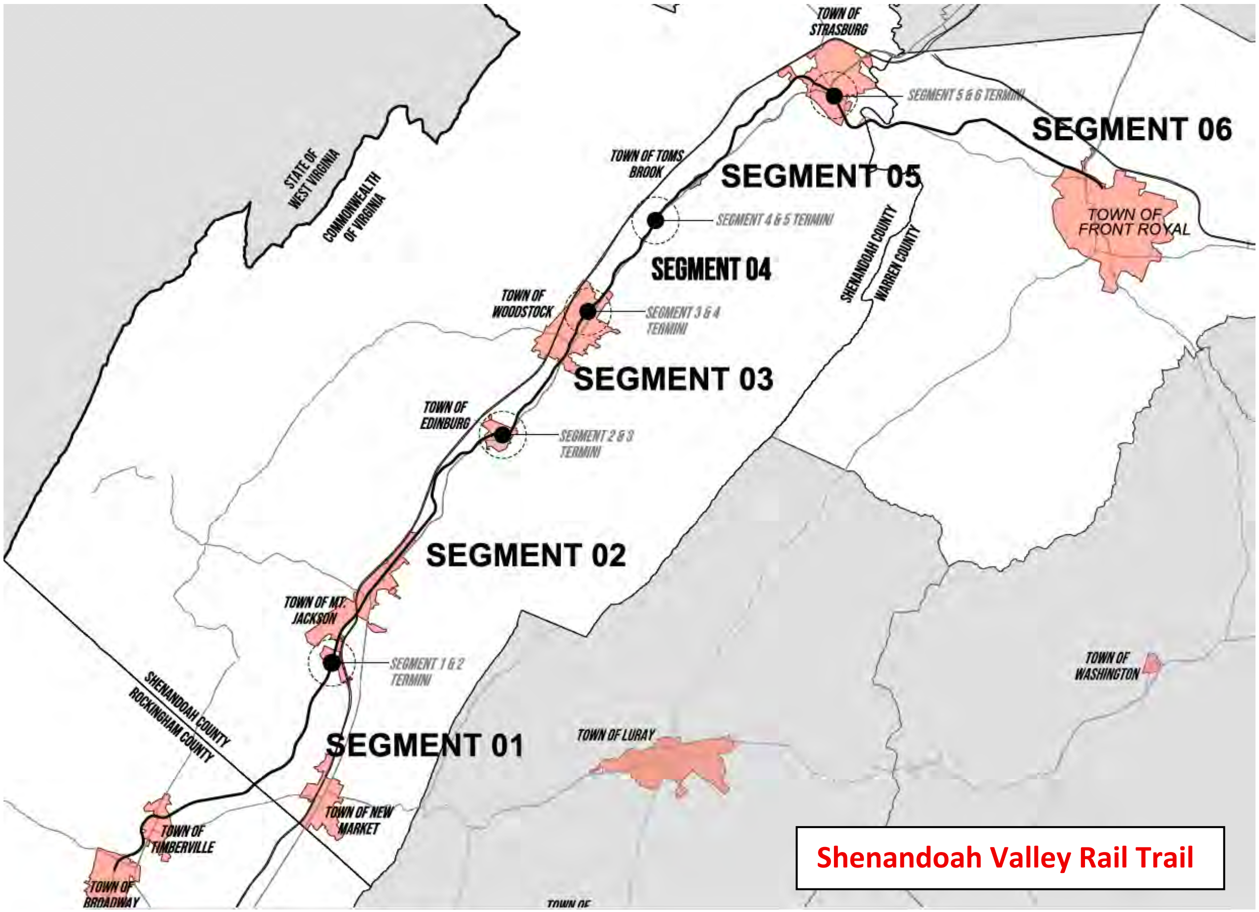
1.1 Purpose of Study

Phase 2 of the Shenandoah Valley Rail-with-Trail Assessment consists of a corridor assessment. The planning effort has two scenarios: Rail-to-Trail and Rail-with-Trail. Rail-to-Trail consists of an existing railroad converted into a trail. Rail-with-Trail consists of an existing railroad with an adjacent trail parallel to a rehabilitated railroad. Both scenarios are broken into six segments and serve multiple communities. This section of the report (Appendix B) compares a high-level Hydrologic and Hydraulic (H&H) analysis for the Rail-to-Trail and Rail-with-Trail based on the drainage, stormwater management, and floodplain requirements for the project. Unlike other appendices of the overall Phase 2 report, Appendix B contrasts the two options.

1.2 Project Overview and Description

Determining on which side of the railroad the trail is located will be based on avoiding or minimizing disturbance to adjacent lands. Both options have a total disturbed area of 179.81-acres. The project was broken into six segments. The limits of study extend approximately 49-miles and run through Warren, Shenandoah, and Rockingham counties. The following map in Figure 1-1 provides a geographical representation of the project location.

Figure 1-1: Project Location



1.3 Existing Condition

1.3.1 FEMA Considerations

The project crosses major streams in multiple locations. Some of the stream crossings are located in regulated FEMA flood A, Zone AE, or Zone AE with Floodway. The National Flood Insurance Program (NFIP) flood insurance rate maps are included in Appendix B-1.

1.3.2 Land use

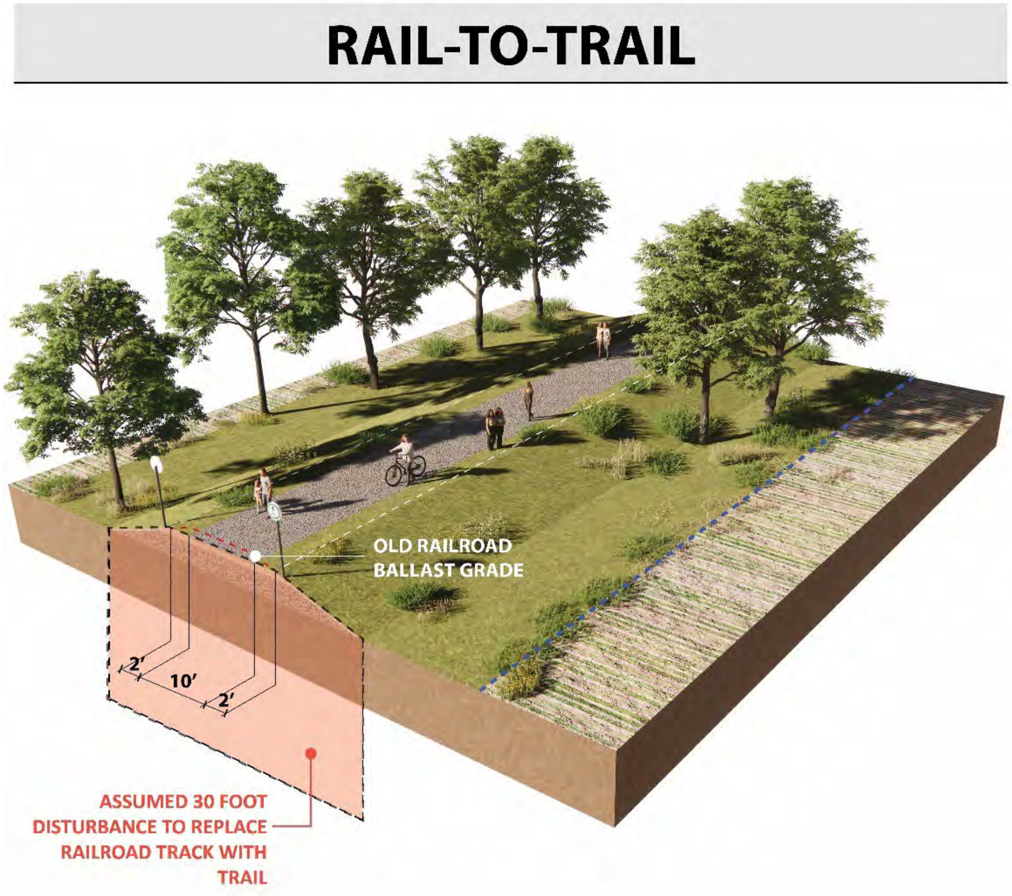
The Shenandoah Valley Rail Trail project is in the Front Royal - Front Royal 1 ESE watershed with 8-digit Hydrologic Unit Code (HUC8) of 02070006. The stormwater in existing conditions mainly drains into the existing ditches on both sides of the railroad track. Then, it crosses the track either with a culvert or bridge and joins one of the major streams around the project site and ultimately flows into the North Fork Shenandoah River. The terrain is a mixture of wooded area and pasture with low-intensity land development.

1.4 Proposed Condition

1.4.1 Rail-to-Trail

The Rail-to-Trail option replaces the existing railroad with a trail. There are various typical sections proposed along the project length depending upon the available open space, topography (flat or steep), surrounding environmental impact, historical features, and structures (building, culvert or bridge). For this high-level hydraulic analysis, the typical section with flat topography has been selected and used. Hydraulics assumptions are not expected to significantly differ across typical sections for the rail-to-trail option. The trail is assumed to have a 10’ wide surface. A path has lanes in each direction and 2’ wide shoulder on both sides (See Figure 1-2). It was assumed that the disturbance would be an additional 8’ outside of the shoulder on both sides of the trail with a total of 30’ disturbance.

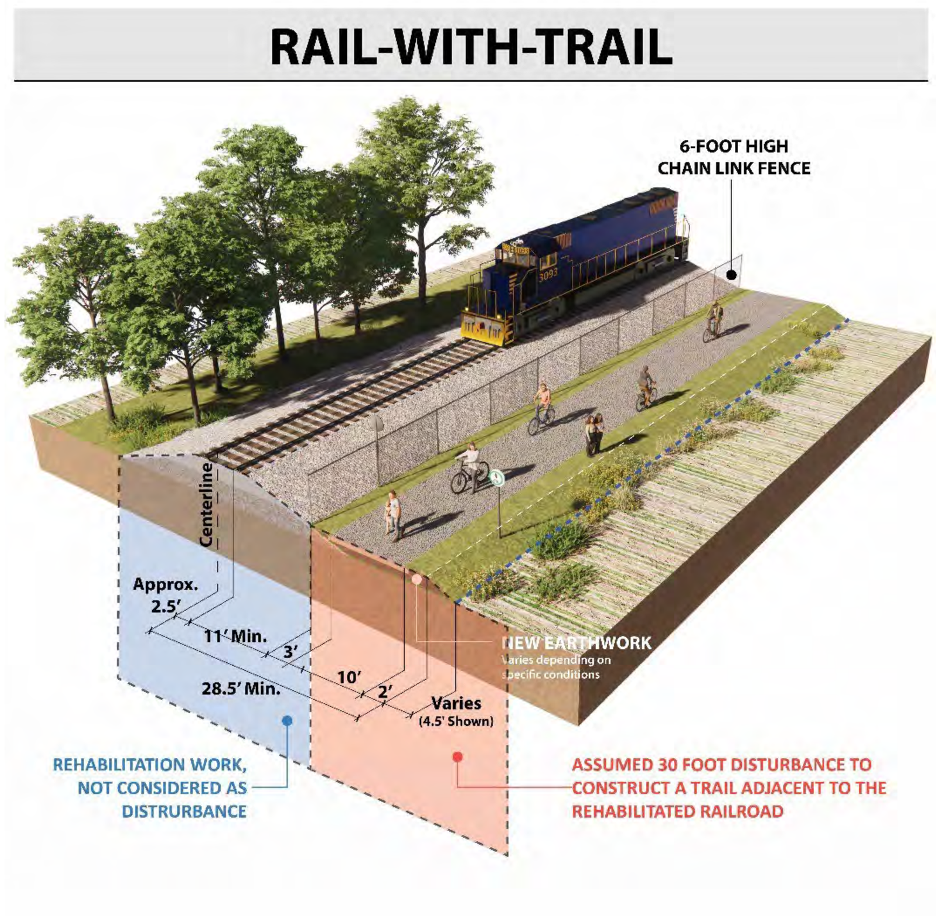
Figure 1-2: Typical Section for the Rail-to-Trail option.



1.4.2 Rail-with-Trail

For the Rail-with-Trail option, the trail will be placed adjacent to the railroad without removing the track. Similar to the Rail-to-Trail option, the typical section for this option will also vary along the corridor. There are various types of topography within the project limit. They vary from flat, steep slope, narrow corridor, and close proximity to existing properties, and floodplain. For simplicity purposes, the flat topography has been chosen even if it is not the majority of the project area (see Figure 1-3) because this is a base case scenario. If one of the other topography scenarios previously mentioned is used as a typical section, the difference between the two options would be significantly modified. The trail and shoulder width, and total disturbance width of 30' will be the same for both options. The difference between the two options is that, in the Rail-with-Trail option, the existing railroad and the ballast will not be impacted and the trail will be constructed parallel to the railroad track. A railway level crossing for the trail to traverse to a more desirable side will be determined on a case-by-case basis, but most likely limited to existing roadway crossings. Rehabilitation made to the railroad track will be considered as routine maintenance work and will not be counted as regulated disturbance for this study.

Figure 1-3: Typical Section for Rail-with-Trail option.



2.0 DESIGN CRITERIA

2.1 Drainage Criteria

Similar to existing conditions, the proposed drainage system for both options is an open drainage system. The sheet flows from the trail will drain into the trailside ditches, and running along the corridor until crossing the path using culverts or merging into major streams.

The design criteria for the drainage ditches will handle the flow for 10-year storm events and the channel erosivity needs to be checked for 2-year storm events, assuming channel erosity is checked for 2-year storm events. Ditch lining needs to be provided if necessary using tractive force method to reduce the velocity to non-erosive velocity.

The culverts need to be sized for 10-year storm events based on Chapter 6 and 8 of the VDOT Drainage Manual. In addition, it also needs to meet the following criteria for both options:

- The headwater elevation should not be higher than an elevation that is 18” below the outer edge of the shoulder at its lowest point in the grade.
- Should not create upstream property damage.
- Headwater over Depth (HW/D) of the culvert is at least 1.0 and not to exceed 1.5.

This report will not cover detailed ditch or culvert analysis because this is a high-level concept study. Detailed survey data or roadway design is not available to conduct the detailed analysis. A general overview of the impact of the proposed improvements on drainage will be discussed in the Result and Discussion Section of this report for both options.

2.2 Stormwater Management Criteria

The Commonwealth of Virginia and VDOT’s Stormwater Management Regulations states that land disturbing activities of an acre or greater require a Construction General Permit (CGP) and coverage under the Virginia Erosion and Stormwater Management Program (VESMP). The project shall meet the water quality and water quantity technical criteria for the VESMP. The Virginia Stormwater Management Handbook and the VDOT Drainage Manual Chapter 11, and VDOT IIM 195.11 regulations were considered to develop the proposed design criteria.

2.2.1 Water Quality

The Water quality design criteria, in Virginia Administrative Code sections 9VAC25-875-580 and 9VAC25-875-590, are required to meet the VESMP requirements for the project. These requirements focus on the removal of pollutants (mainly phosphorus) from stormwater runoff. The VDEQ approved Virginia Runoff Reduction Method (VRRM) version 4.1 is used to determine the total phosphorus needs to be treated for the project. Inputs to the VRRM spreadsheet include the pre- and post-development disturbed area (LOD) in acres, the Hydrologic Soil Group (HSG) and the land cover within the LOD. Based on these inputs data, the total phosphorus that needs to be treated for the whole project will be calculated.

2.2.2 Water Quantity

Water quantity requirements of the VESMP require designers to provide channel protection and flood control strategies for the project. The design criteria shall be based on Virginia Administrative Code section 9VAC25-875-600.

To determine the channel protection requirement of a site, the designer should first determine the type of receiving stormwater conveyance system that will receive discharge from the site. If the downstream conveyance system is a natural system, an Energy Balance Method (EBM) shall be used for one year storm events to meet the channel protection criteria. If the downstream conveyance system is man-made, either EBM or SWM facilities or the post-development flow rate for 2-year storm events should be analyzed for erosivity up to the Limit of Analysis. If the downstream conveyance system is a restored system, either EBM or the development must be consistent with the design parameters of the restored stormwater conveyance system to meet the channel protection requirements of the VESMP for the project.

For flood protection requirements, the post-development 10-year flow should be less than the pre-development conditions or the downstream conveyance system needs to be analyzed for capacity for each outfall to the Limit of Analysis.

2.3 Culvert/Bridge Hydraulics and Floodplain

There are multiple culvert & bridge crossings along the corridor with various sizes and conditions. There are a total of 15 culverts and 16 bridges located in the floodplain within the project limit. The proposed improvements in both cases (Rail-to-Trail or Rail-with-Trail) may impact either the structure itself or the grading within the floodplain. According to VDOT Drainage Manual Chapter 12 and 17, any improvements within the floodplain either on the structure or grading should be analyzed using a back-water analysis (hydraulics analysis using HEC-RAS or similar software) to evaluate the impact of the proposed improvements on the floodplain. Some of the potential changes that possibly impact the floodplain and trigger the floodplain study are:

- Adding a new structure in the floodplain
- Changing the size or type of the existing structure, extending existing culverts, raising or lowering culvert inverts, etc.
- Widening/narrowing the bridge opening, changing superstructure thickness, lowering or raising bridge low chord and deck elevation
- Cut/fill within the floodplain

VDOT requirements vary with the flood zone where the crossing is located. Table 2-1 specifies the criteria for various flood zones.

Table 2-1: Allowable Base Flood Elevation Increases (From VDOT Drainage Manual Chapter 17)

Allowable Base Flood Elevation Increases	
Situation	**Increase in Base Flood Elevation (BFE)**
Insurable structure within the base floodplain	0.0’
FEMA Zone A Area	1.0’*
FEMA Zone AE or A# but Not within a Floodway	1.0’
FEMA Zone AE Floodway	0.0’
FEMA Detailed Study Stream with a Floodway	0.0’
Unmapped or undeveloped area	1.0’
Other Zone designation not considered	NA

*Cumulative impact is no greater than 1.0’

As shown on the table above, if the crossing is located in FEMA flood zone A and AE without the floodway, it is allowed to raise the 100-year water surface elevation (Base Flood Elevation (BFE)) up to one foot in the proposed condition with no property impact. If the FEMA flood zone is AE with the floodway, it is a no-rise zone. This means it is not allowed to raise the BFE and floodway elevation nor width in proposed conditions.

3.0 RESULTS AND DISCUSSION

3.1 Drainage

The proposed ditches and culverts for both options should satisfy the above-mentioned criteria on Table 2-1. Detailed ditch or culvert analyses were not conducted at this stage of study for the reasons identified in Section 2.1 Design Criteria. However, solely for the purpose of comparisons, the impact of the two design alternatives (Rail-to-Trail and Rail-with-Trail option) regarding proposed drainage has been discussed here.

3.1.1 Rail-to-Trail

For the Rail-to-Trail option, the proposed improvements include removal of the existing railroad track and a portion of the ballast, excavation/filling of the existing ground underneath the ballast to construct the proposed gravel trail, and tie back of the edge of the trail (the hinge point) to the existing ditches present on both sides of the track. In the absence of a detailed engineering survey and trail design plans, the location of the toe of the proposed ditch slope had to be assumed. To facilitate a planning level analysis, it was assumed that the proposed trail for the Rail-to-Trail option will be tied back to existing ditches on both sides of the railroad track without impacting the ditch bottom. According to VDOT Drainage Manual Chapter 8 and Railway Company design criteria, the existing drainage systems on both sides of a railroad track shall be designed for 100-year storm event, while a design storm is only 10-years for the proposed trail drainage system. As a result, the existing railroad ditches and culverts should be adequate to handle the proposed flow from the trail and additional excavation of the ditch or upsizing of the culvert will not be required. Most of the culverts may need to be extended by 10 feet (if the culvert is in good condition) on one side or both sides of the trail depending upon the impact of the proposed grading . Quantity analysis for culvert extension is shown in section 3.1.3.

3.1.2. Rail-with-Trail

For the Rail-with-Trail option, the proposed improvements include rehabilitation of the existing railroad track, excavation or filling of a portion of one existing ditch adjacent to the railroad track to accommodate the proposed trail within the existing right-of-way, and excavation of one new ditch on the outside. The assumption is that the existing ditch between the railroad and the proposed trail will be used with minor adjustments to accommodate the trail typical section, while a new ditch on the outside needs to be dug out to handle the design storm of 10-years for the trail. Assumptions and challenges related to the location of the toe of the ditch slope mentioned in section 3.1.1 also apply in the Rail-with-Trail scenario. With the assumption of a 1.5 foot deep new ditch on one side of the proposed trail, approximately 2.3 million cubic feet

(86,240 cubic yards) of additional excavation may be needed for the entirety of the Rail-With-Trail option.

The existing culvert capacity may be adequate for the 10-year storm events because they were originally designed for railroad crossings; however, the culvert needs to be extended across the newly proposed trail to create a drainage channel. Each culvert may need to be extended more than 20' to cross the proposed trail, shoulders, and embankments to the other side if the culvert is in good condition. Quantity analysis for culvert extension is shown in the following section 3.1.3.

3.1.3 Quantity Estimate for Culvert Extension

Table 3-1: Individual culvert extension quantity items

Culvert Extension Quantity Items	Rail-to-Trail	Rail-with-Trail	Difference in Quantity
Box Culverts (CY)	325	450	**Rail-with-Trail +125 CY**
Pipe Culverts (LF)	70	140	**Rail-with-Trail +70 LF**
Excavation (CY)	500	950	**Rail-with-Trail +450 CY**
Reinforced Steel (LBs)	30,000	45,000	**Rail-with-Trail +15,000 LBs**

The length of culvert that needs to be extended will vary depending on how far the toe of the cut/fill line will be. For comparison purposes, it was assumed that the existing 32 culverts will be extended 5' on both sides of the trail for the Rail-to-Trail option. For the Rail-with-Trail option, culverts were assumed to be extended approximately 20' on one side of the proposed trail. Based on these assumptions, culvert extension quantities are estimated to be doubled for the Rail-with-Trail option on pipe culverts and excavation.

3.2 Stormwater Management

3.2.1 Water Quality

As mentioned above in the Stormwater Management Design Criteria sub-section, water quality and water quantity analysis shall be conducted to meet the state stormwater management regulations. In addition to collecting land cover and soil type information about the project site, another important parameter is determining the correct Regulated Land Disturbance of the proposed improvements within the project limit. Regulated Land Disturbance means “a man-made change to the land surface that potentially changes its runoff characteristics including clearing, grading, or excavation”. This area of change is referred to as the Limits of Disturbance (LOD). Based on VDOT Instructional and Informational Memorandum (IIM-LD-195.13), routine maintenance activities like minor rehabilitations and mill and overlay tasks are not considered regulated land disturbance.

Based on this definition, for the Rail-to-Trail option, the removal of railroad track and ballast, excavation/filling of the existing ground underneath the ballast to construct the proposed trail, and the excavation/filling of the adjacent shoulder and embankment was considered disturbance and accounted for in the LOD calculation. For the Rail-with-Trail option, rehabilitation activity to renovate the existing railroad track, adjacent banks, and ditches on both sides of the track were considered routine maintenance and not counted as a disturbance. The construction of the proposed trail, the excavation/filling of the existing ground to construct the proposed trail, and excavation of a new ditch on one side of the trail were also considered a disturbance in the Rail-with-Trail option.

The VRRM spreadsheet with inputs for LOD, land cover and soil type were used for the water quality analysis. The LOD was delineated for each segment (sample LOD plots for each segment are attached in Appendix B-2). The assumption was that there is a 10’ wide trail lane, 2’ on both sides with the Rail-to-Trail, and an additional 8’ wide fill/cut to tie back to existing ground or accommodate the proposed ditch with a total width of 30’.

The land cover for pre- and post-development conditions was identified and measured in acres for each segment. The land covers were separated into four categories: Managed Turf, Mixed Open, Forest, and Impervious Cover. According to the Virginia Department of Environmental Quality (DEQ), the compacted ballast underneath the railroad track and gravel used for proposed trail are both considered impervious for stormwater management analysis purposes. The major difference between the two options is that the Rail-to-Trail involves converting the existing railroad and ballast into impervious cover, while the Rail-with-Trail option would convert the existing grass or wooded area into impervious cover. As a result, it is expected that the Rail-with-Trail option will need to treat more phosphorus.

To identify the Hydrologic Soil Group (HSG) in each segment, a soil map was downloaded from Soil Survey website operated by Natural Resources Conservation Service (NRCS) and the major soil group was identified and used for analysis as a representative of the whole segment. The detailed soil data was attached in Appendix B-4 and a summary of HSG for each segment was summarized below.

Table 3-2: Summary of soil type by percentage for each segment.

Segment	Soil Type by percentage of coverage				Selected HSG
	A	B	C	D	
Segment-1		100%			B
Segment-2		100%			B
Segment-3			100%		C
Segment-4			100%		C
Segment-5		100%			B
Segment-6			100%		C

Once all the input data were gathered, the VRRM spreadsheet was prepared for each segment for both options. The summary of the results is presented below for the two options. Detailed VRRM spreadsheets are provided in Appendix B-3.

Table 3-3: Total Phosphorus Load Reduction Required for both scenarios.

LOD and TP Load Reduction Required					
	Rail-To-Trail		Rail-With-Trail		< 10 lbs/yr
Segment	DA (acres)	TP (lbs/yr)	DA (acres)	TP (lbs/yr)	
1	40.87	12.95	40.87	21.23	No / No
2	35.53	11.96	35.53	18.46	No / No
3	20.14	7.8	20.14	11.06	Yes / No
4	20.07	8.08	20.07	11.02	Yes / No
5	24.56	8.8	24.56	12.76	Yes / No
6	38.64	15.61	38.64	21.22	No / No

The results indicate that the total phosphorus that needs to be treated for the Rail-with-Trail option is 44.5% greater than the Rail-to-Trail option (see table 3-3). According to the VDOT Drainage Manual Chapter 11, if the total phosphorus load reduction is less than 10 lbs/yr or the disturbance is less than 5 acres, the water quality requirements can be met using an offsite treatment (purchasing nutrient credit). If one of those criteria are not met, 75% of the total phosphorus needs to be treated on-site using SWM facilities. For the Rail-to-Trail, 3 of the 6 segments do not meet the criteria for offsite treatment. None of the 6 segments of the Rail-with-Trail option meet the criteria for offsite treatment to meet water quality compliance for offsite treatment to meet water quality compliance.

Table 3-4 shows the number of SWM facilities that are required to treat 75% of the total phosphorus for each option. Based on engineering judgement, it was estimated that one SWM facility treats 0.5 lbs of phosphorus load.

The remaining 25% of the total phosphorus reduction will be treated using an offsite treatment option for purchasing nutrient credits. Table 3-5 summarizes the estimated nutrient credits required for each option.

Table 3-4: Number of SWM facilities required

# of SWM facilities required			
Segment	Rail-to-Trail	Rail-with-Trail	Difference in # of SWM facilities
	# of SWM facilities required	# of SWM facilities required	
1	20	32	**RwT +12**
2	18	28	**RwT +10**
3	Not Req'd.	17	**RwT +17**
4	Not Req'd.	17	**RwT +17**
5	Not Req'd.	20	**RwT +20**
6	24	32	**RwT +8**
Total SWM Facilities	**62**	**146**	**Rail-with-Trail requires 84 additional SWM Facilities**

Table 3-5: Pounds of Nutrient Credits required for each option.

Lbs. of Nutrient Credits required			
Segment	Rail-to-Trail	Rail-with-Trail	Total Credits For Each Option
	Lbs. of Nutrient Credits Required	Lbs. of Nutrient Credits Required	**Rail-to-Trail 35.92 Lbs.** **Rail-with-Trail 23.94 Lbs.**
1	3.2375	5.3075	
2	2.99	4.615	
3	7.8	2.765	
4	8.08	2.755	
5	8.8	3.19	
6	3.9025	5.305	

It is expected that the Rail-to-Trail option will involve the purchase of more nutrient credits than the Rail-with-Trail option since three of the six segments do not meet the criteria for offsite treatment.

3.2.1 Water Quantity

Water quantity analysis needs to be completed on a per outfall basis. To conduct the channel protection analysis, all outfalls need to be identified, the downstream conveyance system needs to be investigated, and the analysis methods need to be selected. Detailed water quantity analysis was not conducted because these data are not available at this stage of conceptual study.

3.3 Culvert/Bridge Hydraulics and Floodplain

The inventory of culverts and bridges, the stream crossing locations, availability of floodplain around the structures, and FEMA designated flood zone information are shown in the table below.

Table 3-6: Number of structures in the floodplain

Number of Structures in the Floodplain				
Segment	**Zone A**	**Zone AE-No Floodway**	**Zone AE with Floodway**	**Remarks**
1	1	7		One Culvert and 7 Bridges
2	2			Two bridges
3	1		1	One Culvert and One Bridge
4	2			Two Bridges
5	1		1	One Culvert and One Bridge
6	12		3	12 Culverts and 3 bridges

Analyzing the impact of the proposed improvements in floodplain for all crossings is not within the scope of this work. However, to compare the impact of the two alternatives (Rail-to-Trail and Rail-with -Trail) on the floodplain, a crossing has been selected, and a focused study has been conducted.

The selected bridge (Asset 5944) is a railroad crossing located in the city of Strasburg, Shenandoah County, VA (See Figure 3-7). This Norfolk Southern Railroad crossing is about 840’ upstream of Front Royal Road / Strasburg Road. As shown in Figure 3-7, the crossing is in FEMA flood zone AE with Floodway so, a no-rise zone.

FEMA provided the hydraulics model for the North Fork Shenandoah River, which was used as a base for the Hydrologic and Hydraulic Analysis of the selected bridge.

Based on the hydraulics model, the existing railroad bridge is a two-span bridge with a total span of 304’, a superstructure thickness of 4.8’ and with a single pier.

For this high-level study, all hydraulics parameters used in the effective model including discharges, Manning’s n-values, boundary conditions, ineffective station and elevation, contraction and expansion coefficient were all assumed to be correct.

To evaluate the impact of the proposed improvements at this crossing, two model plans were created: one for the Rail-to-Trail option and the other for the Rail-with-Trail option. To do the analysis, the effective model was copied into the two model plans, and the geometry of the hydraulics model was updated to reflect the respective alternative designs. For the Rail-to-Trail model, the road profile and the bridge low chord elevation were assumed to be the same as the effective model. For the bridge section, a railing with a height of 2.8’ was added for this model. For the Rail -with-Trail model, in addition to the railing, the bridge deck width was widened to incorporate the new 14’ wide bridge adjacent to the existing bridge with a buffer of 11’. All other parameters are similar to the effective model.

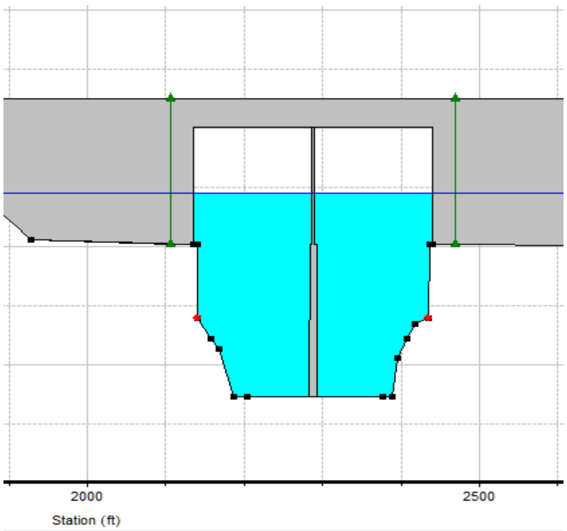
Based on the analysis result assuming the proposed improvements are not changing the hydraulics opening, there will be no impact on the 100-year WSEs in all surrounding cross-sections (see Table 3-8) for both alternatives. That is mainly because there is enough freeboard between the 100-year WSE and the bridge low chord which will not be impacted by changing the superstructure alone. It is also due to the railroad design needing adequate freeboard for base flood elevation to avoid any flooding on the track.

Table 3-8: Summary Results for 100-year WSE for selected Cross-sections

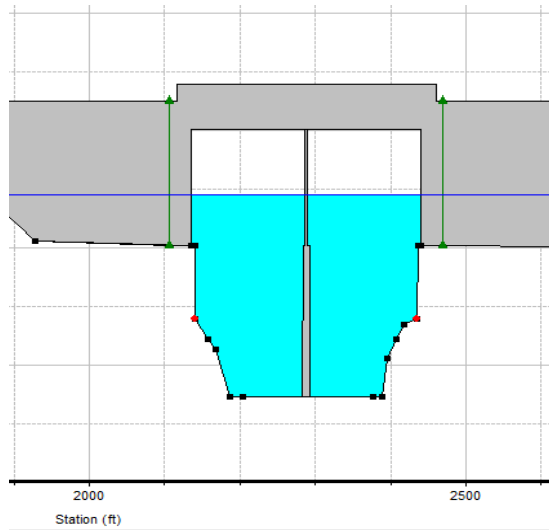
Cross-Section ID	Discharge (CFS)	100-year WSE			
		Effective	RTT	RWT	RWT-with lowered low chord
J	88600	532.27	532.27	532.27	532.32
I	88600	530.96	530.96	530.96	531.02
H	88600	530.75	530.75	530.76	530.82
Bridge					
G	88600	529.41	529.41	529.41	529.41

For the Rail-with-Trail option, if the bridge is standalone (not an extension of the existing railroad bridge) with a low chord designed to be 10’ lower than the current bridge low chord, then the delta of the 100-year WSE will be higher than zero. As shown in Table 3-7 above, it will raise the 100-year WSE on multiple cross-sections upstream of the bridge (see cross-section references in Table 3-8), and it will not meet the state and federal requirements of no-rise zone for the project site.

100-yr WSE for the Effective model bridge

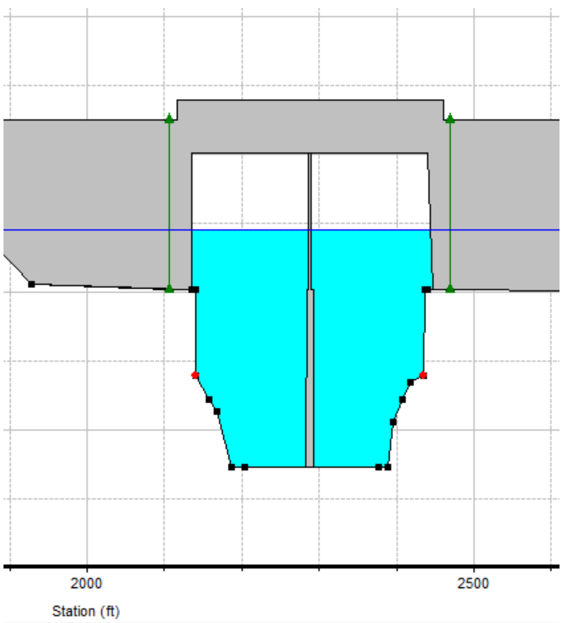


100-yr WSE for the Rail-to-Trail model Bridge



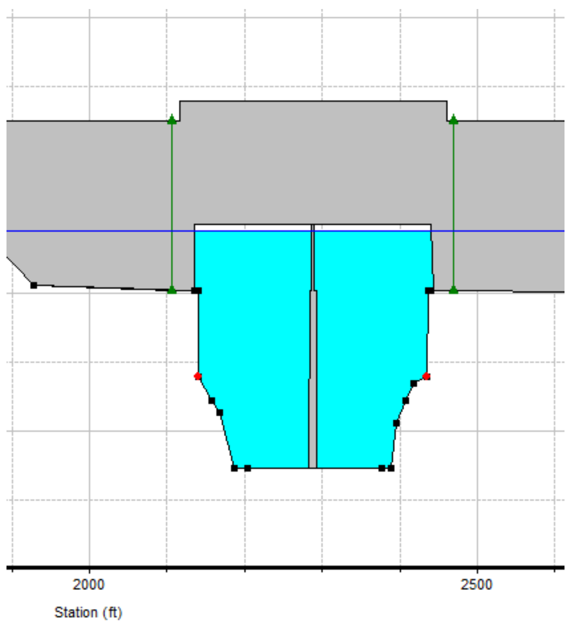
100-yr WSE for the Rail-with-Trail

model bridge



100-yr WSE for the Rail-with-Trail model

bridge with lesser hydraulic opening



Based on this analysis, the Rail-with-Trail option may have a potential to impact the floodplain and floodway more than the Rail-to-Trail option because it may reduce the hydraulic opening of the existing structure.

For structures located in the floodplain, detailed study needs to be developed for updated or modified due to the proposed improvements. The structural design should consider the hydraulics analysis before the final design and confirm the design meets all state and federal requirements. Otherwise, it will have a cost and schedule impact on project completion because it needs review and approval from state and FEMA with a Letter of Map Revision (LOMR) and Conditional Letter of Map Revision (CLOMR).

4.0 CONCLUSION

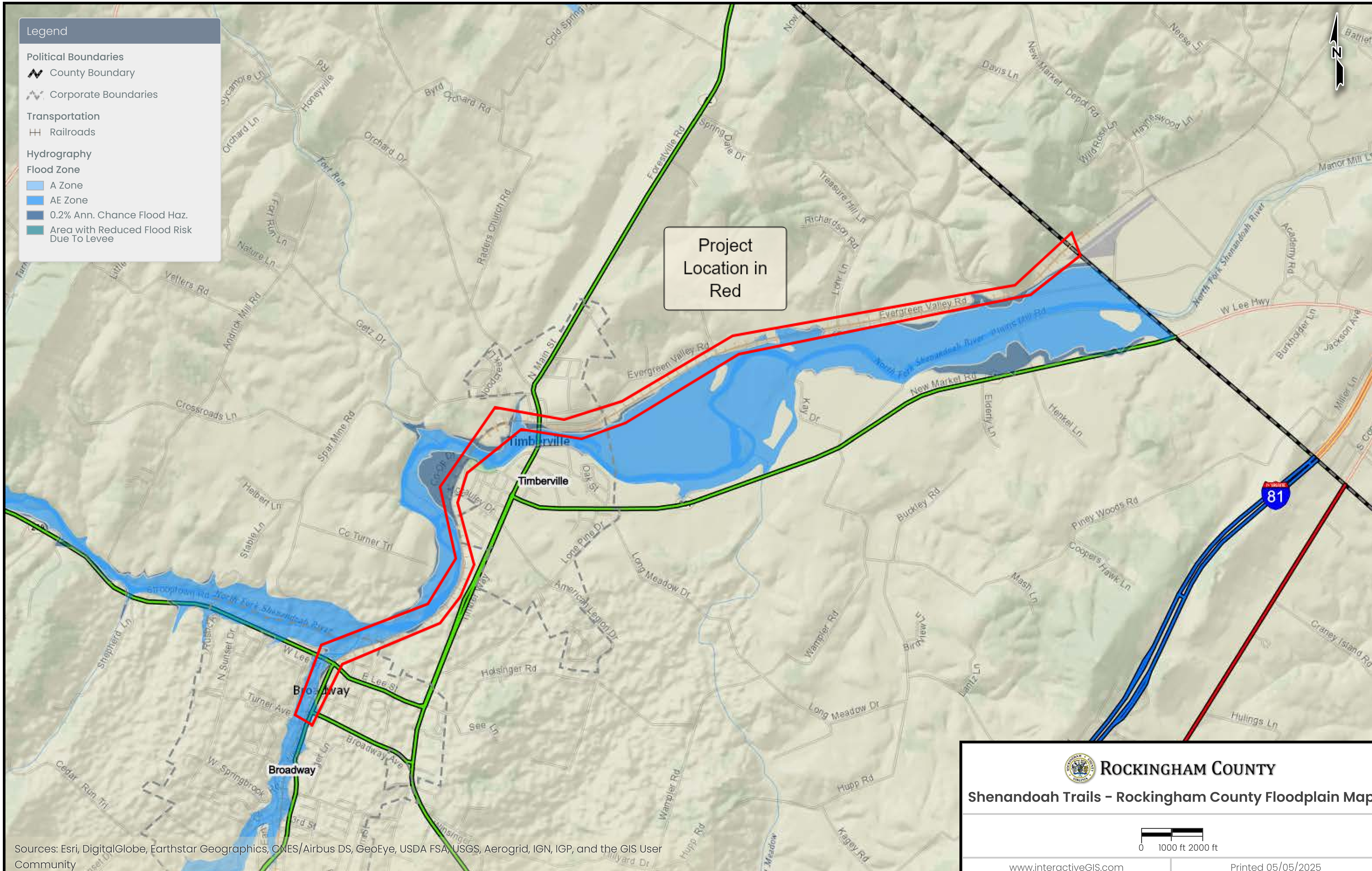
A high-level comparison was made between the Rail-to-Trail and Rail-with-Trail options. When the drainage impact was evaluated, it was found that the Rail-with-Trail option would require additional ditch development and a lengthier extension of culverts in comparison to the Rail-to-Trail option.

Regarding SWM regulation, the VRRM spreadsheet was used on both options to determine the total phosphorus generated by the proposed improvement and required to be treated. The water quality requirement of the project will be achieved using SWM facilities and purchasing nutrient credits. The SWM facilities will treat 75% of the total phosphorus removal and the remaining 25% will be treated by purchasing nutrient credits. The Rail-with-Trail option uses the current segmentation for this Drainage and SWM report. The TP load reduction required for the Rail-with-Trail option is 47% higher than the Rail-to-Trail option. 84 additional SWM facilities are needed to meet the water quality compliance for the Rail-with-Trail as compared to the Rail-to-Trail option, mainly due to the conversion of land use between the pre-and post-condition. The Rail-to-Trail option converts the land use from impervious (compacted ballast) in Pre-condition to impervious (compacted gravel) in post-condition, while the Rail-with-Trail option converts grass/wooded areas in the pre-condition to impervious in the post-condition.

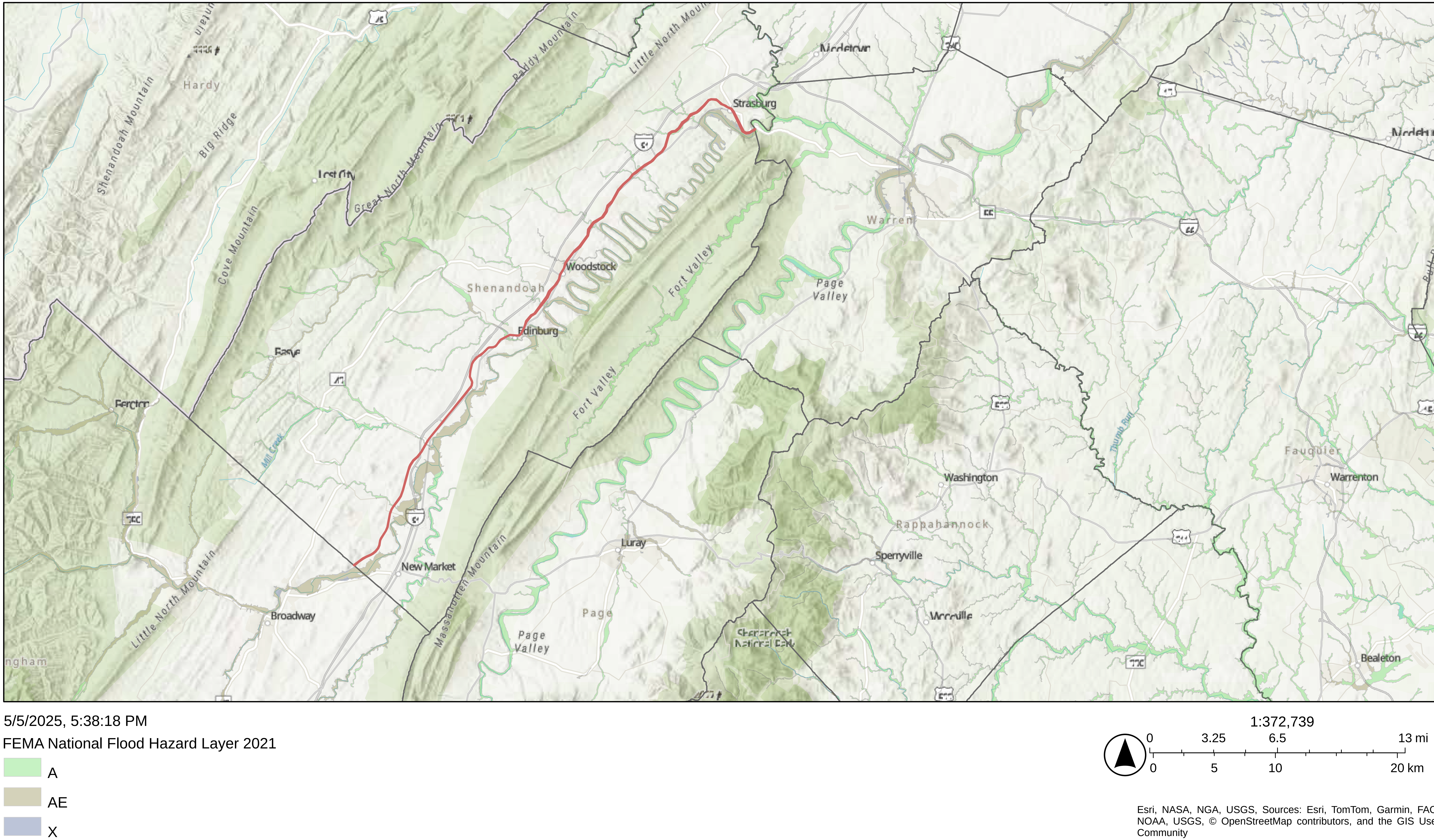
Water quantity analysis requires the identification of all outfalls affected by this project. To conduct the channel protection analysis, the downstream conveyance system needs to be investigated and the correct analysis methods. This information was not available at this conceptual study phase. Therefore, a thorough water quantity analysis was not conducted on this report.

To evaluate the impact of the two proposed options in floodplain, a single bridge crossing was selected and analyzed. Based on the results of the analysis, assuming the proposed improvements would not change the hydraulic opening, there will be no impact on the 100-year water surface elevations (WSE) in all surrounding cross sections for both options. For the Rail-with-Trail option, if a bridge is standalone and the hydraulics opening is significantly reduced, it could cause the base flood elevation to rise above the maximum allowable value, thereby preventing compliance with state and federal requirements. The hydraulics analysis needs to be submitted and approved by FEMA as a CLOMR/LOMR application. This typically takes more than 6 months for the project to be approved before construction commencement.

APPENDIX B-1: NFIP FLOOD INSURANCE MAP


Legend
Political Boundaries
County Boundary
Corporate Boundaries
Transportation
Railroads
Hydrography
Flood Zone
A Zone
AE Zone
0.2% Ann. Chance Flood Haz.
Area with Reduced Flood Risk Due To Levee
Project Location in Red
Timberville
Timberville
Broadway
Broadway
North Fork Shenandoah River
Evergreen Valley Rd
New Market Rd
Forestville Rd
W Lee Hwy
Manor Mill Ln
81
N
Sources: Esri, DigitalGlobe, Earthstar Geographics, CNES/Airbus DS, GeoEye, USDA FSA, USGS, Aerogrid, IGN, IGP, and the GIS User Community
Rockingham County
Shenandoah Trails – Rockingham County Floodplain Map
0 1000 ft 2000 ft
www.interactiveGIS.com
Printed 05/05/2025

Shenandoah Trails - Shenandoah County Floodplain Map

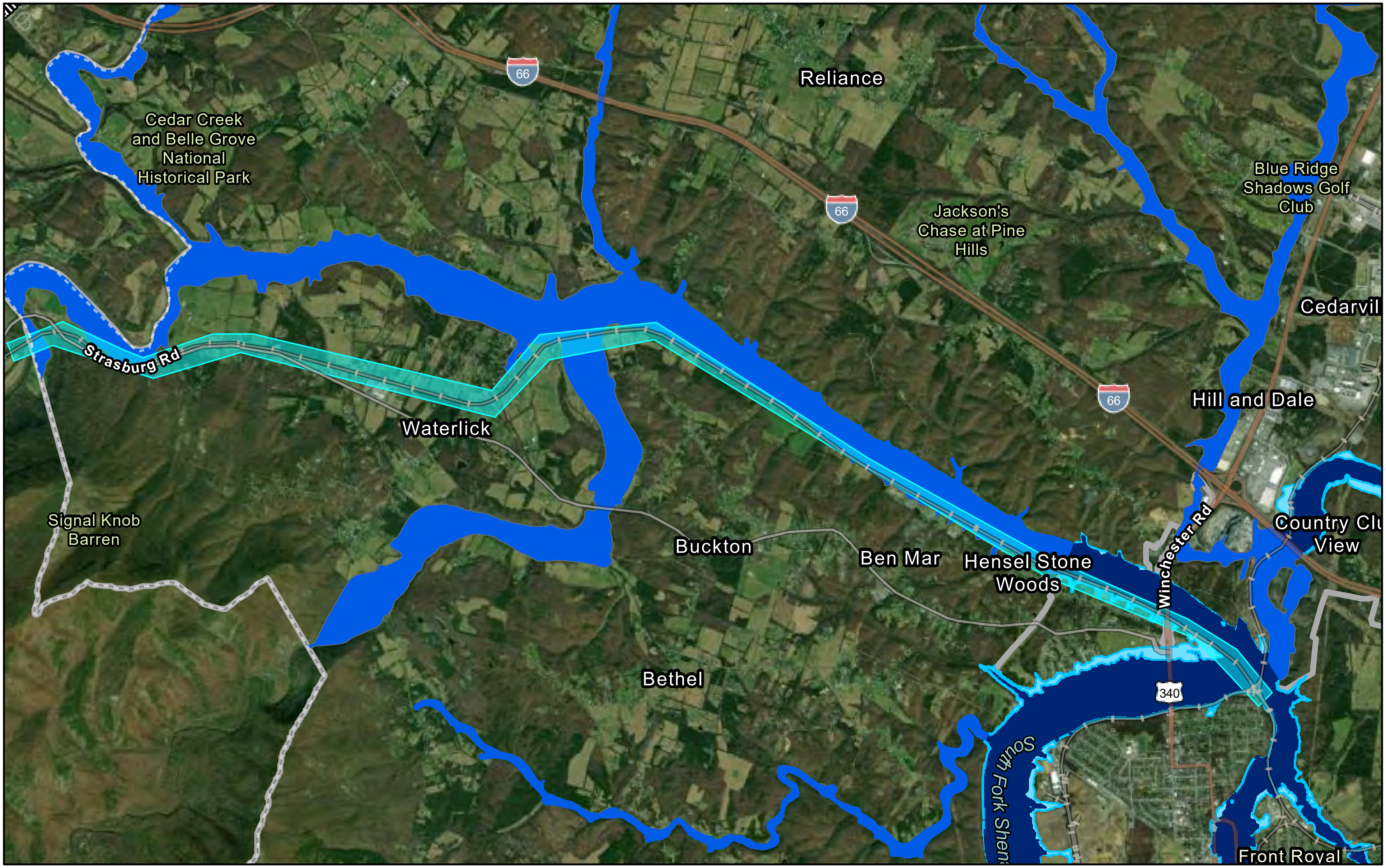


5/5/2025, 5:38:18 PM

FEMA National Flood Hazard Layer 2021

- A
- AE
- X
- Virginia County Boundaries
- Project Area in Shenandoah County

Shenandoah Trails - Warren County Floodplain Map



May 5, 2025

Flood Zones

A

AE

0.2 PCT ANNUAL CHANCE FLOOD HAZARD

1:72,224

0 0.5 1 2 mi

0 0.75 1.5 3 km

Earthstar Geographics, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community

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APPENDIX B-2:
SAMPLE LOD MAP
FOR EACH SEGMENT

ASSET 9970

CHARACTERISTICS	
Length (ft)	184.000
Width (Out-Out) (ft)	10.083
Spans	Four (4)
SUPERSTRUCTURE	
Composition	Two (2) Steel Built Up Girders w/ five (5) equally spaced cross frames
SUBSTRUCTURE	
Composition	Two (2) Concrete Abutments with Stone Elements, Three (3) Wall Concrete Piers
Abutment Heights	N/A

ASSET 9736

CHARACTERISTICS	
Length (ft)	90.000
Width (Out-Out) (ft)	10.000
Spans	Two (2)
SUPERSTRUCTURE	
Composition	Two (2) Steel Built Up Girders w/ five (5) equally spaced cross frames
SUBSTRUCTURE	
Composition	Two (2) Concrete Abutments with Stone Elements, One (1) Wall Concrete Piers
Abutment Heights	N/A

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENT

SHEET 7 OF 27

SEGMENT 1 OF 6

TURNER AVENUE AT TOWN OF BROADWAY TO
CAVERN ROAD IN SHENANDOAH COUNTY
TOTAL LENGTH: 11.5 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL

LOD PROPOSED LIMITS OF DISTURBANCE

X PROPOSED FENCING

PROPOSED CUT & FILL

PROPOSED SWM FACILITY

ASSET 7902

CHARACTERISTICS	
Length (ft)	375.000
Width (Out-Out) (ft)	12.000
Spans	Seven (7)
SUPERSTRUCTURE	
Composition	Two (2) steel built up girders w/ five (5) cross frames equally spaced in each span
SUBSTRUCTURE	
Composition	Two (2) concrete abutments w/ stone elements, two (2) concrete wall piers w/ stone elements and concrete caps and footings and four (4) steel piers w/ concrete footings
Abutment Heights	N/A

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENT

SHEET 23 OF 24

SEGMENT 2 OF 6

CAVERN ROAD IN SHENANDOAH COUNTY TO STONEY CREEK BOULEVARD AT TOWN OF EDINBURG
TOTAL LENGTH: 9.5 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL — LOD — PROPOSED LIMITS OF DISTURBANCE

— X — PROPOSED FENCING — PROPOSED CUT & FILL — PROPOSED SWM FACILITY

ASSET 7643	
CHARACTERISTICS	
Length (ft)	630.000
Width (Out-Out) (ft)	15.200
Spans	Seven (7)
SUPERSTRUCTURE	
Composition	Two (2) steel rolled girders for spans 1&2 and built up girders for Spans 3 and subsequent spans
SUBSTRUCTURE	
Composition	One (1) steel abutment, one (1) steel pier, one (1) intermediate concrete support and one (1) concrete pier.
Abutment Heights	12

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENT

SHEET 6 OF 13

SEGMENT 3 OF 6

STONEY CREEK BOULEVARD AT TOWN OF EDINBURG
TO COURT SQUARE AT TOWN OF WOODSTOCK
TOTAL LENGTH: 5.5 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL

LOD — PROPOSED LIMITS OF DISTURBANCE

X — PROPOSED FENCING

PROPOSED CUT & FILL

PROPOSED SWM FACILITY

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENTS

SHEET 4 OF 13

SEGMENT 4 OF 6

COURT SQUARE AT TOWN OF WOODSTOCK TO
BROOK CREEK ROAD AT TOWN OF TOMS BROOK
TOTAL LENGTH: 5.5 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL
LOD — PROPOSED LIMITS OF DISTURBANCE
— X — PROPOSED FENCING
PROPOSED CUT & FILL
PROPOSED SWM FACILITY

Match Line Sta. 2685+68.99 Sheet 412

ASSET 6765	
CHARACTERISTICS	
Length (ft)	510.00
Width (Out-Out) (ft)	10.00
Spans	Twelve (12)
SUPERSTRUCTURE	
Composition	Two (2) steel built up girders in all spans
SUBSTRUCTURE	
Substructure Composition	Two (2) concrete Abutments w/ stone element, four (4) steel towers supported by concrete footings that support three (3) spans each and three (3) stone wall piers w/ concrete caps
Abutment Heights	N/A

Match Line Sta. 2709+68.21 Sheet 502

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENTS

SHEET 1 OF 16

SEGMENT 5 OF 6

BROOK CREED ROAD AT TOWN OF TOMS BROOK TO
THE TOWN MUSEUM AT THE TOWN OF STRASBURG
TOTAL LENGTH: 7.0 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL

LOD — PROPOSED LIMITS OF DISTURBANCE

X — PROPOSED FENCING

PROPOSED CUT & FILL

PROPOSED SWM FACILITY

ASSET 5944	
CHARACTERISTICS	
Length (ft)	290.00
Width (Out-Out) (ft)	16.67
SUPERSTRUCTURE	
Composition	Two (2) steel deck trusses
SUBSTRUCTURE	
Substructure Composition	One (1) concrete Abutments w/ stone mortar elements, one (1) concrete pier and one (1) concrete abutment
Abutment Heights	N/A

SHENANDOAH VALLEY RAIL TRAILS

CONCEPTUAL ALIGNMENT LAYOUT - LOD EXTENTS

SHEET 5 OF 26

SEGMENT 6 OF 6

THE TOWN MUSEUM AT TOWN OF STRASBURG TO EAST SIDE OF
SOUTH FOR OF THE SHENANDOAH RIVER AT TOWN OF FRONT ROYAL
TOTAL LENGTH: 10.0 MILES

VDOT PROJECT NO. XXXXX-X-XX-XX VOLKERT

LEGEND

PROPOSED TRAIL
LOD — PROPOSED LIMITS OF DISTURBANCE
X — PROPOSED FENCING
PROPOSED CUT & FILL
PROPOSED SWM FACILITY

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APPENDIX B-3: VRRM SPREADSHEET

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 4.1

data input cells	
constant values	
calculation cells	
final results	

CLEAR ALL
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Project Name: Shenandoah Valley Rail to Trail - Segment 1
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 40.87

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0.005*
Post-Development TP Load Reduction for Site (lb/yr):	*12.95*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		13.57			13.57
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		6.87			6.87
Impervious Cover (acres)		20.43			20.43
					40.87

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		20.44			20.44
Impervious Cover (acres)		20.44			20.44
Area Check	**OK.**	**OK.**	**OK.**	**OK.**	40.87

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**12.95**
Linear Project TP Load Reduction Required (lb/yr):	12.95

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	315.80
Final Post-Development TN Load	399.32

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre		
Pre-ReDevelopment	**Listed**	**Adjusted**[1]
Forest Cover (acres)	13.57	13.57
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	33%	33%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	6.87	6.87
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	17%	17%
Impervious Cover (acres)	20.43	20.43
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	50%	50%
Total Site Area (acres)	**40.87**	**40.87**
Site Rv	**0.52**	**0.52**
Treatment Volume and Nutrient Load		
Pre-ReDevelopment Treatment Volume (acre-ft)	1.7658	1.7658
Pre-ReDevelopment Treatment Volume (cubic feet)	76,918	76,918
Pre-ReDevelopment TP Load (lb/yr)	**23.02**	**23.02**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.56	0.56
Baseline TP Load (lb/yr) **(0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)**		*10.62*

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)	
Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	20.44
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
Impervious Cover (acres)	20.44
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**40.87**
Final Post Dev Site Rv	**0.58**
Final Post-Development Treatment Volume (acre-ft)	1.9584
Final Post-Development Treatment Volume (cubic feet)	85,306
Final Post-Development TP Load (lb/yr)	**31.37**
Final Post-Development TP Load per acre (lb/acre/yr)	0.77

Land Cover Summary-Post	
Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	20.44
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
ReDev. Impervious Cover (acres)	20.43
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**40.87**
ReDev Site Rv	**0.57**
Treatment Volume and Nutrient Load	
Post-ReDevelopment Treatment Volume (acre-ft)	1.9580
Post-ReDevelopment Treatment Volume (cubic feet)	85,289
Post-ReDevelopment Load (TP) (lb/yr)*	31.36
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.77
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
TP Load Reduction Required for Redeveloped Area (lb/yr)	**12.95**

Land Cover Summary-Post	
Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	0.95
Post-Development Treatment Volume (acre-ft)	0.0004
Post-Development Treatment Volume (cubic feet)	17
Post-Development TP Load (lb/yr)	**0.00**
TP Load Reduction Required for New Impervious Area (lb/yr)	**0.00**

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 4.1

CLEAR ALL
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data input cells
constant values
calculation cells
final results

Project Name: Shenandoah Valley Rail to Trail - Segment 2
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 35.53

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0*
Post-Development TP Load Reduction for Site (lb/yr):	*11.96*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		13.54			13.54
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		3.17			3.17
Impervious Cover (acres)		18.82			18.82
					35.53

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		17.76			17.76
Impervious Cover (acres)		17.77			17.77
Area Check	OK.	OK.	OK.	OK.	35.53

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	11.96
Linear Project TP Load Reduction Required (lb/yr):	11.96

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	269.24
Final Post-Development TN Load	347.17

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	13.54	13.54
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	38%	38%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	3.17	3.17
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	9%	9%
Impervious Cover (acres)	18.82	18.82
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	53%	53%
Total Site Area (acres)	**35.53**	**35.53**
Site Rv	**0.53**	**0.53**
Treatment Volume and Nutrient Load		
Pre-ReDevelopment Treatment Volume (acre-ft)	1.5766	1.5766
Pre-ReDevelopment Treatment Volume (cubic feet)	68,677	68,677
Pre-ReDevelopment TP Load (lb/yr)	**19.13**	**19.13**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.54	0.54
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*9.24*

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	17.76
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
Impervious Cover (acres)	17.77
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**35.53**
Final Post Dev Site Rv	**0.58**
Final Post-Development Treatment Volume (acre-ft)	1.7028
Final Post-Development Treatment Volume (cubic feet)	74,174
Final Post-Development TP Load (lb/yr)	**27.27**
Final Post-Development TP Load per acre (lb/acre/yr)	0.77

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	17.76
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
ReDev. Impervious Cover (acres)	17.77
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**35.53**
ReDev Site Rv	**0.58**
Treatment Volume and Nutrient Load	
Post-ReDevelopment Treatment Volume (acre-ft)	1.7028
Post-ReDevelopment Treatment Volume (cubic feet)	74,174
Post-ReDevelopment Load (TP) (lb/yr)*	27.27
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.77
Max. Reduction Required (Below Pre-ReDevelopment Load)	20%

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--
Post-Development Treatment Volume (acre-ft)	--
Post-Development Treatment Volume (cubic feet)	--
Post-Development TP Load (lb/yr)	--

TP Load Reduction Required for Redeveloped Area (lb/yr)	**11.96**
TP Load Reduction Required for New Impervious Area (lb/yr)	**0**

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

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CLEAR ALL
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data input cells
constant values
calculation cells
final results

Project Name: Shenandoah Valley Rail to Trail - Segment 3
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 20.14

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0*
Post-Development TP Load Reduction for Site (lb/yr):	*7.80*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			8.76		8.76
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			0.59		0.59
Impervious Cover (acres)			10.79		10.79
					20.14

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			10.07		10.07
Impervious Cover (acres)			10.07		10.07
Area Check	OK.	OK.	OK.	OK.	20.14

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**7.80**
Linear Project TP Load Reduction Required (lb/yr):	**7.80**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	150.07
Final Post-Development TN Load	204.04

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	8.76	8.76
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	43%	43%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	0.59	0.59
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	3%	3%
Impervious Cover (acres)	10.79	10.79
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	54%	54%
Total Site Area (acres)	**20.14**	**20.14**
Site Rv	**0.53**	**0.53**

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	0.8942	0.8942
Pre-ReDevelopment Treatment Volume (cubic feet)	38,952	38,952
Pre-ReDevelopment TP Load (lb/yr)	**10.42**	**10.42**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.52	0.52
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*5.24*

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.07
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
Impervious Cover (acres)	10.07
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**20.14**
Final Post Dev Site Rv	**0.59**

Final Post-Development Treatment Volume (acre-ft)	0.9818
Final Post-Development Treatment Volume (cubic feet)	42,768
Final Post-Development TP Load (lb/yr)	**16.14**
Final Post-Development TP Load per acre (lb/acre/yr)	0.80

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.07
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
ReDev. Impervious Cover (acres)	10.07
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**20.14**
ReDev Site Rv	**0.59**

Treatment Volume and Nutrient Load

Post-ReDevelopment Treatment Volume (acre-ft)	0.9818
Post-ReDevelopment Treatment Volume (cubic feet)	42,768
Post-ReDevelopment Load (TP) (lb/yr)*	**16.14**
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.80
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
TP Load Reduction Required for Redeveloped Area (lb/yr)	**7.80**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--
Post-Development Treatment Volume (acre-ft)	--
Post-Development Treatment Volume (cubic feet)	--
Post-Development TP Load (lb/yr)	--
TP Load Reduction Required for New Impervious Area (lb/yr)	**0**

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CLEAR ALL
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Legend
data input cells
constant values
calculation cells
final results

Project Name: Shenandoah Valley Rail to Trail - Segment 4
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 20.07

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0*
Post-Development TP Load Reduction for Site (lb/yr):	*8.08*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			9.19		9.19
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			0.79		0.79
Impervious Cover (acres)			10.09		10.09
					20.07

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			10.03		10.03
Impervious Cover (acres)			10.04		10.04
Area Check	OK.	OK.	OK.	OK.	20.07

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**8.08**
Linear Project TP Load Reduction Required (lb/yr):	**8.08**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	143.63
Final Post-Development TN Load	203.35

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	9.19	9.19
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	46%	46%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	0.79	0.79
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	4%	4%
Impervious Cover (acres)	10.09	10.09
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	50%	50%
Total Site Area (acres)	**20.07**	**20.07**
Site Rv	**0.50**	**0.50**

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	0.8439	0.8439
Pre-ReDevelopment Treatment Volume (cubic feet)	36,761	36,761
Pre-ReDevelopment TP Load (lb/yr)	**10.01**	**10.01**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.50	0.50
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*5.22*

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.03
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
Impervious Cover (acres)	10.04
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**20.07**
Final Post Dev Site Rv	**0.59**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.03
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
ReDev. Impervious Cover (acres)	10.04
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**20.07**
ReDev Site Rv	**0.59**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	0.9787
Final Post-Development Treatment Volume (cubic feet)	42,633
Final Post-Development TP Load (lb/yr)	**16.09**
Final Post-Development TP Load per acre (lb/acre/yr)	0.80

Post-ReDevelopment Treatment Volume (acre-ft)	0.9787
Post-ReDevelopment Treatment Volume (cubic feet)	42,633
Post-ReDevelopment Load (TP) (lb/yr)*	16.09
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.80
Max. Reduction Required (Below Pre-ReDevelopment Load)	20%
TP Load Reduction Required for Redeveloped Area (lb/yr)	**8.08**

Post-Development Treatment Volume (acre-ft)	--
Post-Development Treatment Volume (cubic feet)	--
Post-Development TP Load (lb/yr)	--
TP Load Reduction Required for New Impervious Area (lb/yr)	**0**

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 4.1

Project Name:	Shenandoah Valley Rail to Trail - Segment 5
Date:	3/15/2025
Linear Development Project?	Yes

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Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* →	24.56
Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0*
Post-Development TP Load Reduction for Site (lb/yr):	*8.80*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		10.33			10.33
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		1.59			1.59
Impervious Cover (acres)		12.64			12.64
					24.56

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		12.28			12.28
Impervious Cover (acres)		12.28			12.28
Area Check	OK.	OK.	OK.	OK.	24.56

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**8.80**
Linear Project TP Load Reduction Required (lb/yr):	**8.80**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	178.25
Final Post-Development TN Load	239.96

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	10.33	10.33
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	42%	42%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	1.59	1.59
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	6%	6%
Impervious Cover (acres)	12.64	12.64
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	51%	51%
Total Site Area (acres)	**24.56**	**24.56**
Site Rv	**0.51**	**0.51**
Treatment Volume and Nutrient Load		
Pre-ReDevelopment Treatment Volume (acre-ft)	1.0530	1.0530
Pre-ReDevelopment Treatment Volume (cubic feet)	45,868	45,868
Pre-ReDevelopment TP Load (lb/yr)	**12.56**	**12.56**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.51	0.51
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*6.39*

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final) Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	12.28
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
Impervious Cover (acres)	12.28
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**24.56**
Final Post Dev Site Rv	**0.58**
Final Post-Development Treatment Volume (acre-ft)	1.1768
Final Post-Development Treatment Volume (cubic feet)	51,263
Final Post-Development TP Load (lb/yr)	**18.85**
Final Post-Development TP Load per acre (lb/acre/yr)	0.77

Land Cover Summary-Post Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	12.28
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	50%
ReDev. Impervious Cover (acres)	12.28
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**24.56**
ReDev Site Rv	**0.58**
Treatment Volume and Nutrient Load	
Post-ReDevelopment Treatment Volume (acre-ft)	1.1768
Post-ReDevelopment Treatment Volume (cubic feet)	51,263
Post-ReDevelopment Load (TP) (lb/yr)*	18.85
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.77
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
TP Load Reduction Required for Redeveloped Area (lb/yr)	**8.80**

Land Cover Summary-Post Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--
Post-Development Treatment Volume (acre-ft)	--
Post-Development Treatment Volume (cubic feet)	--
Post-Development TP Load (lb/yr)	--
TP Load Reduction Required for New Impervious Area (lb/yr)	**0**

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

DEQ Virginia Runoff Reduction Method Re-Development Compliance Spreadsheet - Version 4.1

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Project Name: Shenandoah Valley Rail to Trail - Segment 6
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 38.64

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*0*
Post-Development TP Load Reduction for Site (lb/yr):	*15.61*

Check:

BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			17.82		17.82
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			1.30		1.30
Impervious Cover (acres)			19.52		19.52
					38.64

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			19.32		19.32
Impervious Cover (acres)			19.32		19.32
Area Check	OK.	OK.	OK.	OK.	38.64

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**15.61**
Linear Project TP Load Reduction Required (lb/yr):	15.61

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	276.10
Final Post-Development TN Load	391.46

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	17.82	17.82
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	46%	46%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	1.30	1.30
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	3%	3%
Impervious Cover (acres)	19.52	19.52
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	51%	51%
Total Site Area (acres)	**38.64**	**38.64**
Site Rv	**0.51**	**0.51**
Treatment Volume and Nutrient Load		
Pre-ReDevelopment Treatment Volume (acre-ft)	1.6286	1.6286
Pre-ReDevelopment Treatment Volume (cubic feet)	70,940	70,940
Pre-ReDevelopment TP Load (lb/yr)	**19.20**	**19.20**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.50	0.50
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*10.05*

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	19.32
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
Impervious Cover (acres)	19.32
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Final Site Area (acres)	**38.64**
Final Post Dev Site Rv	**0.59**
Final Post-Development Treatment Volume (acre-ft)	1.8837
Final Post-Development Treatment Volume (cubic feet)	82,054
Final Post-Development TP Load (lb/yr)	**30.97**
Final Post-Development TP Load per acre (lb/acre/yr)	0.80

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	19.32
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	50%
ReDev. Impervious Cover (acres)	19.32
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	50%
Total ReDev. Site Area (acres)	**38.64**
ReDev Site Rv	**0.59**
Treatment Volume and Nutrient Load	
Post-ReDevelopment Treatment Volume (acre-ft)	1.8837
Post-ReDevelopment Treatment Volume (cubic feet)	82,054
Post-ReDevelopment Load (TP) (lb/yr)*	**30.97**
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.80
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
TP Load Reduction Required for Redeveloped Area (lb/yr)	**15.61**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	0.00
Rv(impervious)	--
Post-Development Treatment Volume (acre-ft)	--
Post-Development Treatment Volume (cubic feet)	--
Post-Development TP Load (lb/yr)	--
TP Load Reduction Required for New Impervious Area (lb/yr)	**0**

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

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Project Name: Shenandoah Valley Trail with Rail - Segment 1
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 40.87

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*19.61*
Post-Development TP Load Reduction for Site (lb/yr):	*21.23*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		26.59			26.59
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		10.73			10.73
Impervious Cover (acres)		3.55			3.55
					40.87

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		17.71			17.71
Impervious Cover (acres)		23.16			23.16
Area Check	OK.	OK.	OK.	OK.	40.87

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**18.17**
Linear Project TP Load Reduction Required (lb/yr):	**21.23**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	149.14
Final Post-Development TN Load	413.29

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	26.59	6.98
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	65%	33%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	10.73	10.73
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	26%	50%
Impervious Cover (acres)	3.55	3.55
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	9%	17%
Total Site Area (acres)	**40.87**	**21.26**
Site Rv	**0.15**	**0.27**

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	0.5264	0.4773
Pre-ReDevelopment Treatment Volume (cubic feet)	22,928	20,792
Pre-ReDevelopment TP Load (lb/yr)	**11.96**	**10.74**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.29	0.51
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		5.53

[1] Adjusted Land Cover Summary:
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	17.71
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	43%
Impervious Cover (acres)	23.16
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**40.87**
Final Post Dev Site Rv	**0.63**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	17.71
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	83%
ReDev. Impervious Cover (acres)	3.55
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	17%
Total ReDev. Site Area (acres)	**21.26**
ReDev Site Rv	**0.33**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	19.61
Rv(impervious)	0.95

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	2.1287
Final Post-Development Treatment Volume (cubic feet)	92,725
Final Post-Development TP Load (lb/yr)	**31.86**
Final Post-Development TP Load per acre (lb/acre/yr)	0.78

Post-ReDevelopment Treatment Volume (acre-ft)	0.5762
Post-ReDevelopment Treatment Volume (cubic feet)	25,100
Post-ReDevelopment Load (TP) (lb/yr)*	**15.04**
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.71
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**

Post-Development Treatment Volume (acre-ft)	1.5525
Post-Development Treatment Volume (cubic feet)	67,625
Post-Development TP Load (lb/yr)	**16.83**

TP Load Reduction Required for Redeveloped Area (lb/yr)	**6.44**
TP Load Reduction Required for New Impervious Area (lb/yr)	**11.73**

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Project Name: Shenandoah Valley Trail with Rail - Segment 2
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 35.53

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*18.04*
Post-Development TP Load Reduction for Site (lb/yr):	*18.46*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		27.07			27.07
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		6.35			6.35
Impervious Cover (acres)		2.11			2.11
					35.53

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		15.38			15.38
Impervious Cover (acres)		20.15			20.15
Area Check	OK.	OK.	OK.	OK.	35.53

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**17.68**
Linear Project TP Load Reduction Required (lb/yr):	**18.46**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	100.32
Final Post-Development TN Load	359.37

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	27.07	9.03
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	76%	52%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	6.35	6.35
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	18%	36%
Impervious Cover (acres)	2.11	2.11
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	6%	12%
Total Site Area (acres)	**35.53**	**17.49**
Site Rv	**0.12**	**0.20**
Treatment Volume and Nutrient Load		
Pre-ReDevelopment Treatment Volume (acre-ft)	0.3406	0.2955
Pre-ReDevelopment Treatment Volume (cubic feet)	14,834	12,870
Pre-ReDevelopment TP Load (lb/yr)	**7.79**	**6.67**
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.22	0.38
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		4.55

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	15.38
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	43%
Impervious Cover (acres)	20.15
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**35.53**
Final Post Dev Site Rv	**0.63**
Final Post-Development Treatment Volume (acre-ft)	1.8515
Final Post-Development Treatment Volume (cubic feet)	80,653
Final Post-Development TP Load (lb/yr)	**27.70**
Final Post-Development TP Load per acre (lb/acre/yr)	0.78

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	15.38
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	88%
ReDev. Impervious Cover (acres)	2.11
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	12%
Total ReDev. Site Area (acres)	**17.49**
ReDev Site Rv	**0.29**
Treatment Volume and Nutrient Load	
Post-ReDevelopment Treatment Volume (acre-ft)	0.4234
Post-ReDevelopment Treatment Volume (cubic feet)	18,442
Post-ReDevelopment Load (TP) (lb/yr)*	**12.22**
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.70
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
TP Load Reduction Required for Redeveloped Area (lb/yr)	**6.89**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	18.04
Rv(impervious)	0.95
Post-Development Treatment Volume (acre-ft)	1.4282
Post-Development Treatment Volume (cubic feet)	62,211
Post-Development TP Load (lb/yr)	**15.48**
TP Load Reduction Required for New Impervious Area (lb/yr)	**10.79**

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

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Project Name: Shenandoah Valley Trail with Rail - Segment 3
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 20.14

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*9.59*
Post-Development TP Load Reduction for Site (lb/yr):	*11.06*

Check:

BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			17.13		17.13
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			1.18		1.18
Impervious Cover (acres)			1.83		1.83
					20.14

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			8.72		8.72
Impervious Cover (acres)			11.42		11.42
Area Check	OK.	OK.	OK.	OK.	20.14

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**11.06**
Linear Project TP Load Reduction Required (lb/yr):	11.06

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	55.99
Final Post-Development TN Load	209.99

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	17.13	7.54
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	85%	71%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	1.18	1.18
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	6%	11%
Impervious Cover (acres)	1.83	1.83
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	9%	17%
Total Site Area (acres)	**20.14**	**10.55**
Site Rv	**0.13**	**0.22**

Treatment Volume and Nutrient Load

	Listed	Adjusted	
Pre-ReDevelopment Treatment Volume (acre-ft)	0.2236	0.1916	
Pre-ReDevelopment Treatment Volume (cubic feet)	9,740	8,348	
Pre-ReDevelopment TP Load (lb/yr)	**3.87**	**3.08**	*
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.19	0.29	*
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*2.74*	

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	8.72
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	43%
Impervious Cover (acres)	11.42
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**20.14**
Final Post Dev Site Rv	**0.63**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	8.72
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	83%
ReDev. Impervious Cover (acres)	1.83
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	17%
Total ReDev. Site Area (acres)	**10.55**
ReDev Site Rv	**0.35**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	9.59
Rv(impervious)	0.95

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	1.0640
Final Post-Development Treatment Volume (cubic feet)	46,346
Final Post-Development TP Load (lb/yr)	**16.29**
Final Post-Development TP Load per acre (lb/acre/yr)	0.81

	Post-ReDevelopment Treatment Volume (acre-ft)	0.3047
	Post-ReDevelopment Treatment Volume (cubic feet)	13,275
*	**Post-ReDevelopment Load (TP) (lb/yr)***	**8.07**
	Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.76
	Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
*	**TP Load Reduction Required for Redeveloped Area (lb/yr)**	**5.32**

Post-Development Treatment Volume (acre-ft)	0.7592
Post-Development Treatment Volume (cubic feet)	33,071
Post-Development TP Load (lb/yr)	**8.23**
TP Load Reduction Required for New Impervious Area (lb/yr)	**5.73**

* *Reduction below new development load limitation not required*

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Project Name: Shenandoah Valley Trail with Rail - Segment 4
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 20.07

Check:

BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*11.27*
Post-Development TP Load Reduction for Site (lb/yr):	*11.02*

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			18.38		18.38
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			1.58		1.58
Impervious Cover (acres)			0.11		0.11
					20.07

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			8.69		8.69
Impervious Cover (acres)			11.38		11.38
Area Check	OK.	OK.	OK.	OK.	20.07

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**11.02**
Linear Project TP Load Reduction Required (lb/yr):	11.02

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	39.71
Final Post-Development TN Load	209.26

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	18.38	7.11
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	92%	81%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	1.58	1.58
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	8%	18%
Impervious Cover (acres)	0.11	0.11
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	1%	1%
Total Site Area (acres)	**20.07**	**8.80**
Site Rv	**0.06**	**0.08**

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	8.69
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	43%
Impervious Cover (acres)	11.38
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**20.07**
Final Post Dev Site Rv	**0.63**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	8.69
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	99%
ReDev. Impervious Cover (acres)	0.11
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	1%
Total ReDev. Site Area (acres)	**8.80**
ReDev Site Rv	**0.23**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	11.27
Rv(impervious)	0.95

Treatment Volume and Nutrient Load

	Listed	Adjusted	
Pre-ReDevelopment Treatment Volume (acre-ft)	0.0989	0.0614	
Pre-ReDevelopment Treatment Volume (cubic feet)	4,310	2,673	
Pre-ReDevelopment TP Load (lb/yr)	**2.80**	**1.86**	*
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.14	0.21	*
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*2.29*	

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	1.0602
Final Post-Development Treatment Volume (cubic feet)	46,184
Final Post-Development TP Load (lb/yr)	**16.24**
Final Post-Development TP Load per acre (lb/acre/yr)	0.81

	Post-ReDevelopment Treatment Volume (acre-ft)	0.1680
	Post-ReDevelopment Treatment Volume (cubic feet)	7,319
*	Post-ReDevelopment Load (TP) (lb/yr)*	6.57
	Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.75
	Max. Reduction Required (Below Pre-ReDevelopment Load)	20%
*	**TP Load Reduction Required for Redeveloped Area (lb/yr)**	**4.28**

Post-Development Treatment Volume (acre-ft)	0.8922
Post-Development Treatment Volume (cubic feet)	38,865
Post-Development TP Load (lb/yr)	9.67
TP Load Reduction Required for New Impervious Area (lb/yr)	**6.74**

* *Reduction below new development load limitation not required*

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

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Project Name: Shenandoah Valley Trail with Rail - Segment 5
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 24.56

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*13.19*
Post-Development TP Load Reduction for Site (lb/yr):	*12.76*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land		20.65			20.65
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		3.18			3.18
Impervious Cover (acres)		0.73			0.73
					24.56

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed		10.64			10.64
Impervious Cover (acres)		13.92			13.92
Area Check	OK.	OK.	OK.	OK.	24.56

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**12.76**
Linear Project TP Load Reduction Required (lb/yr):	12.76

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	53.69	Final Post-Development TN Load	248.37

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	20.65	7.46
Weighted Rv(forest)	0.03	0.03
Weighted Loading Rate(forest)	0.06	0.06
% Forest	84%	66%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	3.18	3.18
Weighted Rv(turf)	0.20	0.20
Weighted Loading Rate(turf)	0.68	0.68
% Managed Turf	13%	28%
Impervious Cover (acres)	0.73	0.73
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	3%	6%
Total Site Area (acres)	**24.56**	**11.37**
Site Rv	**0.08**	**0.14**

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	0.1624	0.1294
Pre-ReDevelopment Treatment Volume (cubic feet)	7,075	5,638
Pre-ReDevelopment TP Load (lb/yr)	**4.06**	**3.24** *
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.17	0.29 *
Baseline TP Load (lb/yr) **(0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)**		*2.96*

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.64
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	43%
Impervious Cover (acres)	13.92
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**24.56**
Final Post Dev Site Rv	**0.63**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	10.64
Weighted Rv (turf)	0.20
Wgt. Ld. Rate(turf)	0.68
% Managed Turf	94%
ReDev. Impervious Cover (acres)	0.73
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	6%
Total ReDev. Site Area (acres)	**11.37**
ReDev Site Rv	**0.25**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	13.19
Rv(impervious)	0.95

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	1.2793
Final Post-Development Treatment Volume (cubic feet)	55,728
Final Post-Development TP Load (lb/yr)	**19.15**
Final Post-Development TP Load per acre (lb/acre/yr)	0.78

Post-ReDevelopment Treatment Volume (acre-ft)	0.2351
Post-ReDevelopment Treatment Volume (cubic feet)	10,242
* **Post-ReDevelopment Load (TP) (lb/yr)***	**7.83**
Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.69
Max. Reduction Required (Below Pre-ReDevelopment Load)	**20%**
* **TP Load Reduction Required for Redeveloped Area (lb/yr)**	**4.87**

* *Reduction below new development load limitation not required*

Post-Development Treatment Volume (acre-ft)	1.0442
Post-Development Treatment Volume (cubic feet)	45,486
Post-Development TP Load (lb/yr)	**11.32**
TP Load Reduction Required for New Impervious Area (lb/yr)	**7.89**

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Project Name: Shenandoah Valley Trail with Rail - Segment 6
Date: 3/15/2025
Linear Development Project? Yes

Site Information

Post-Development Project (Treatment Volume and Loads)

Enter Total Disturbed Area *(acres)* → 38.64

Maximum reduction required:	*20%*
The site's net increase in impervious cover (acres) is:	*21.5*
Post-Development TP Load Reduction for Site (lb/yr):	*21.22*

Check:	
BMP Design Specifications List:	2024 Stds & Specs
Linear project?	Yes
Land cover areas entered correctly?	✓
Total disturbed area entered?	✓

Pre-ReDevelopment Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest (acres) -- undisturbed, protected forest or reforested land			35.87		35.87
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			2.36		2.36
Impervious Cover (acres)			0.41		0.41
					38.64

Post-Development Land Cover (acres)

	A Soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest or reforested land					0.00
Mixed Open (acres) -- undisturbed/infrequently maintained grass or shrub land					0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed			16.73		16.73
Impervious Cover (acres)			21.91		21.91
Area Check	OK.	OK.	OK.	OK.	38.64

Post-Development Requirement for Site Area

TP Load Reduction Required (lb/yr)	**21.22**
Linear Project TP Load Reduction Required (lb/yr):	**21.22**

Nitrogen Loads (Informational Purposes Only)

Pre-ReDevelopment TN Load (lb/yr)	74.16
Final Post-Development TN Load	402.87

LAND COVER SUMMARY -- PRE-REDEVELOPMENT

Land Cover Summary-Pre

Pre-ReDevelopment	Listed	Adjusted[1]
Forest Cover (acres)	35.87	14.37
Weighted Rv(forest)	0.04	0.04
Weighted Loading Rate(forest)	0.08	0.08
% Forest	93%	84%
Mixed Open Cover (acres)	0.00	0.00
Weighted Rv(mixed)	0.00	0.00
Weighted Loading Rate(mixed)	0.00	0.00
% Mixed Open	0%	0%
Managed Turf Cover (acres)	2.36	2.36
Weighted Rv(turf)	0.22	0.22
Weighted Loading Rate(turf)	0.75	0.75
% Managed Turf	6%	14%
Impervious Cover (acres)	0.41	0.41
Rv(impervious)	0.95	0.95
Weighted Loading Rate(impervious)	0.86	0.86
% Impervious	1%	2%
Total Site Area (acres)	**38.64**	**17.14**
Site Rv	**0.06**	**0.09**

Treatment Volume and Nutrient Load

Pre-ReDevelopment Treatment Volume (acre-ft)	0.1953	0.1236	
Pre-ReDevelopment Treatment Volume (cubic feet)	8,507	5,385	
Pre-ReDevelopment TP Load (lb/yr)	**5.09**	**3.30**	*
Pre-ReDevelopment TP Load per acre (lb/acre/yr)	0.13	0.19	*
Baseline TP Load (lb/yr) (0.26 lbs/acre/yr applied to pre-redevelopment area excluding pervious land proposed for new impervious cover)		*4.46*	

[1] *Adjusted Land Cover Summary:*
Pre ReDevelopment land cover minus pervious land cover (forest, mixed open or managed turf) acreage proposed for new impervious cover.

Adjusted total acreage is consistent with Post-ReDevelopment acreage (minus acreage of new impervious cover).

Column I shows load reduction requriement for new impervious cover (based on new development load limit, 0.26 lbs/acre/year).

LAND COVER SUMMARY -- POST DEVELOPMENT

Land Cover Summary-Post (Final)

Post ReDev. & New Impervious	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	16.73
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	43%
Impervious Cover (acres)	21.91
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	57%
Final Site Area (acres)	**38.64**
Final Post Dev Site Rv	**0.63**

Land Cover Summary-Post

Post-ReDevelopment	
Forest Cover (acres)	0.00
Weighted Rv(forest)	0.00
Wgt. Ld. Rate(forest)	0.00
% Forest	0%
Mixed Open Cover (acres)	0.00
Weighted Rv(mixed)	0.00
Wgt. Ld. Rate(mixed)	0.00
% Mixed Open	0%
Managed Turf Cover (acres)	16.73
Weighted Rv (turf)	0.22
Wgt. Ld. Rate(turf)	0.75
% Managed Turf	98%
ReDev. Impervious Cover (acres)	0.41
Rv(impervious)	0.95
Wgt. Ld. Rate(imperv.)	0.86
% Impervious	2%
Total ReDev. Site Area (acres)	**17.14**
ReDev Site Rv	**0.24**

Land Cover Summary-Post

Post-Development New Impervious	
New Impervious Cover (acres)	21.50
Rv(impervious)	0.95

Treatment Volume and Nutrient Load

Final Post-Development Treatment Volume (acre-ft)	2.0413
Final Post-Development Treatment Volume (cubic feet)	88,917
Final Post-Development TP Load (lb/yr)	**31.26**
Final Post-Development TP Load per acre (lb/acre/yr)	0.81

	Post-ReDevelopment Treatment Volume (acre-ft)	0.3392
	Post-ReDevelopment Treatment Volume (cubic feet)	14,774
*	**Post-ReDevelopment Load (TP) (lb/yr)***	**12.82**
	Post-ReDevelopment TP Load per acre (lb/acre/yr)	0.75
	Max. Reduction Required (Below Pre-ReDevelopment Load)	20%
*	**TP Load Reduction Required for Redeveloped Area (lb/yr)**	**8.36**

Post-Development Treatment Volume (acre-ft)	1.7021
Post-Development Treatment Volume (cubic feet)	74,143
Post-Development TP Load (lb/yr)	**18.45**
TP Load Reduction Required for New Impervious Area (lb/yr)	**12.86**

* *Reduction below new development load limitation not required*

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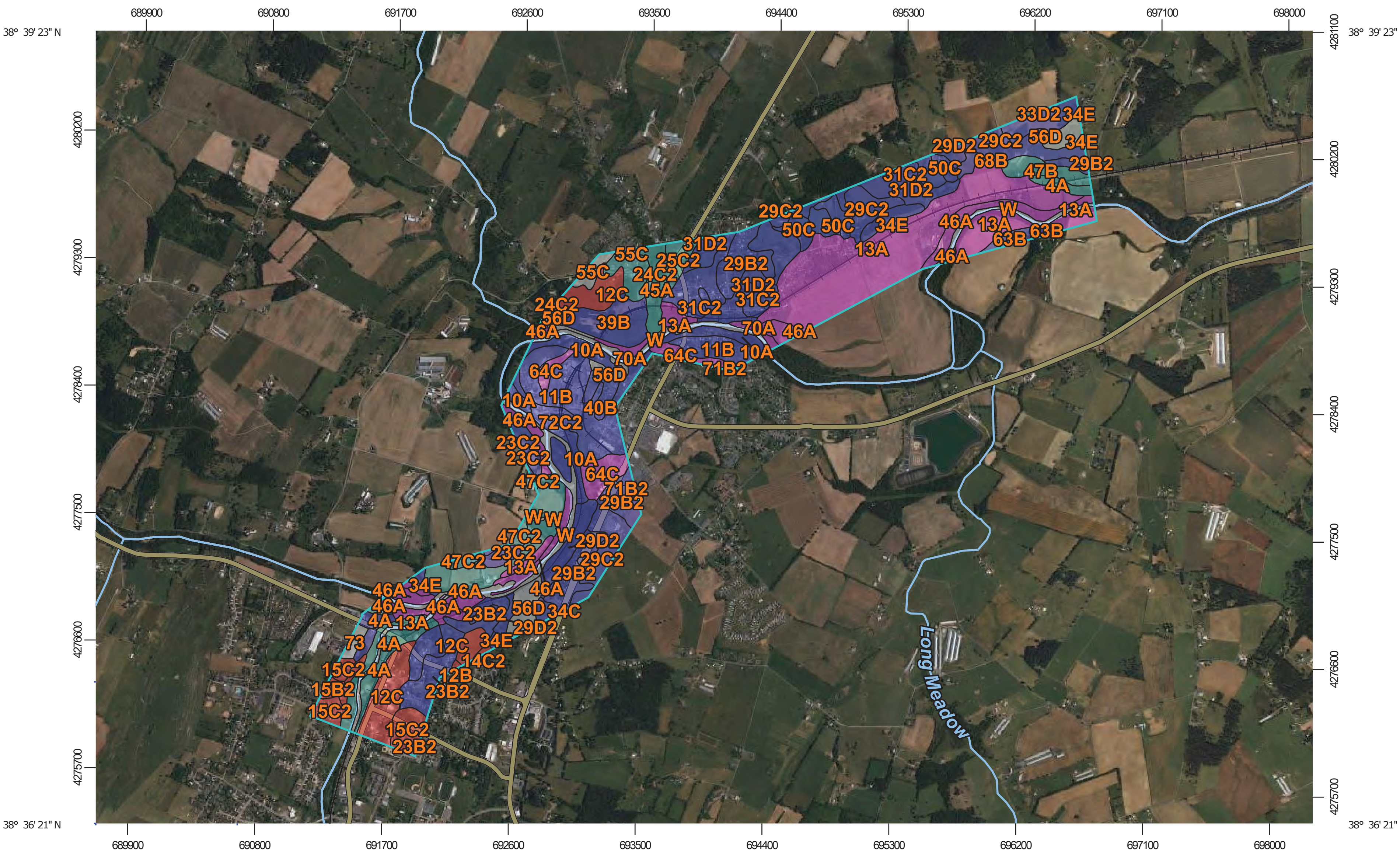
APPENDIX B-4: SOIL MAP

Hydrologic Soil Group—Rockingham County, Virginia

78° 49' 18" W

78° 43' 21" W



78° 49' 18" W

78° 43' 21" W

Map Scale: 1:39,500 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 1500, 3000, 6000, 9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

Soil Survey Area: Rockingham County, Virginia
Survey Area Data: Version 17, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
4A	Aquic Udifluvents, nearly level	C	42.4	3.0%
10A	Buckton loam, 0 to 4 percent slopes, occasionally flooded	B	36.0	2.6%
11B	Burketown fine sandy loam, 2 to 10 percent slopes	B	101.1	7.2%
12B	Carbo-Endcav-Rock outcrop complex, 2 to 7 percent slopes	D	0.8	0.1%
12C	Carbo-Endcav-Rock outcrop complex, 7 to 15 percent slopes	D	65.5	4.7%
13A	Chavies fine sandy loam, 0 to 4 percent slopes, rarely flooded	A	245.0	17.5%
14C2	Chilhowie silty clay, 7 to 15 percent slopes, eroded	D	1.2	0.1%
15B2	Chilhowie silty clay, 2 to 7 percent slopes, rocky, eroded	D	3.9	0.3%
15C2	Chilhowie silty clay, 7 to 15 percent slopes, rocky, eroded	D	27.8	2.0%
15D2	Chilhowie silty clay, 15 to 25 percent slopes, rocky, eroded	D	4.7	0.3%
23B2	Edom silty clay loam, 2 to 7 percent slopes, eroded	B	39.9	2.9%
23C2	Edom silty clay loam, 7 to 15 percent slopes, eroded	B	19.2	1.4%
23D2	Edom silty clay loam, 15 to 25 percent slopes, eroded	B	13.9	1.0%
24C2	Endcav silt loam, 7 to 15 percent slopes, eroded	C	16.9	1.2%
25C2	Endcav silt loam, 7 to 15 percent slopes, rocky, eroded	C	11.4	0.8%
28A	Fluvaquents, nearly level	B/D	1.2	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
29B2	Frederick and Lodi silt loams, 2 to 7 percent slopes, eroded	B	67.4	4.8%
29C2	Frederick and Lodi silt loams, 7 to 15 percent slopes, eroded	B	73.8	5.3%
29D2	Frederick and Lodi silt loams, 15 to 25 percent slopes, eroded	B	28.7	2.1%
31C2	Frederick and Lodi gravelly silt loams, 7 to 15 percent slopes, eroded	B	53.1	3.8%
31D2	Frederick and Lodi gravelly silt loams, 15 to 25 percent slopes, eroded	B	77.8	5.6%
33D2	Frederick and Lodi silt loams, rocky, 15 to 25 percent slopes, eroded	B	19.6	1.4%
34C	Frederick-Rock outcrop complex, 3 to 15 percent slopes	B	4.5	0.3%
34E	Frederick-Rock outcrop complex, 15 to 45 percent slopes	B	15.7	1.1%
39B	Laidig gravelly fine sandy loam, 2 to 7 percent slopes	B	34.5	2.5%
40B	Laidig cobbly fine sandy loam, 2 to 7 percent slopes	B	11.4	0.8%
45A	Massanetta silt loam, 0 to 2 percent slopes	C	21.1	1.5%
46A	Millrock loamy sand, 0 to 4 percent slopes, frequently flooded	A	62.4	4.5%
47B	Monongahela fine sandy loam, 0 to 7 percent slopes	C	66.4	4.7%
47C2	Monongahela fine sandy loam, 7 to 15 percent slopes, eroded	C	9.0	0.6%
50C	Nixa-Frederick-Lodi gravelly loams, 7 to 15 percent slopes	B	23.0	1.6%
55C	Rock outcrop-Carbo complex, 0 to 20 percent slopes		9.6	0.7%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
56D	Rock outcrop-Frederick complex, 15 to 45 percent slopes		33.8	2.4%
63B	Shenval loam, 2 to 7 percent slopes	B	8.6	0.6%
64C	Sherando cobbly sandy loam, 7 to 15 percent slopes	A	32.2	2.3%
68B	Timberville variant silt loam, 0 to 7 percent slopes, frequently flooded	B	6.0	0.4%
70A	Typic Udorthents, nearly level	A	9.5	0.7%
71B2	Unison fine sandy loam, 2 to 7 percent slopes, eroded	B	9.2	0.7%
72C2	Unison cobbly fine sandy loam, 7 to 15 percent slopes, eroded	B	22.6	1.6%
73	Urban land		5.1	0.4%
W	Water		64.2	4.6%
Totals for Area of Interest			**1,400.4**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

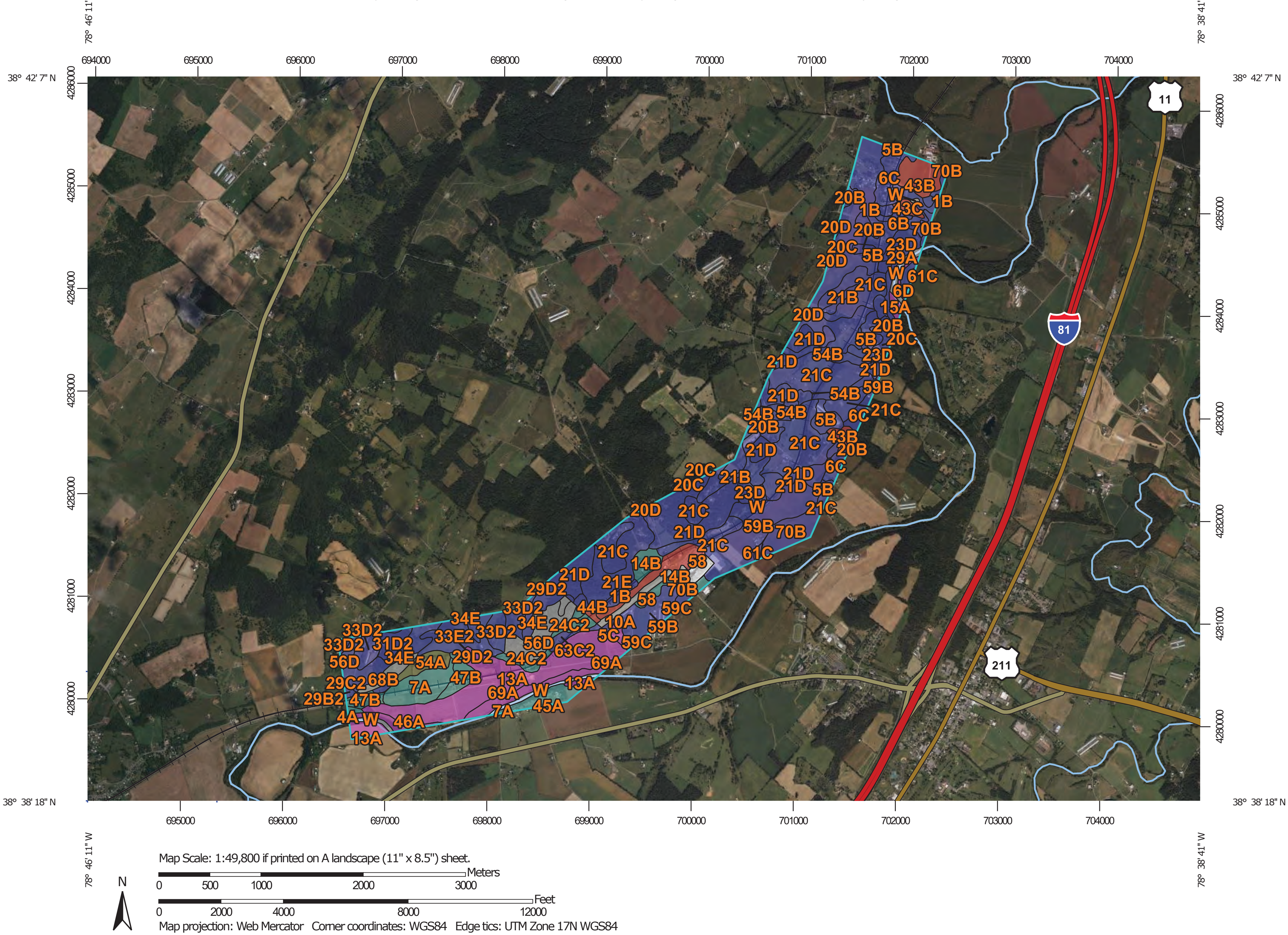
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Rockingham County, Virginia, and Shenandoah County, Virginia



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

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

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:15,800 to 1:20,000.

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

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

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

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

Soil Survey Area: Rockingham County, Virginia
Survey Area Data: Version 17, Sep 5, 2023

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
4A	Aquic Udifluvents, nearly level	C	2.0	0.1%
7A	Buchanan silt loam, 0 to 5 percent slopes	C	44.4	2.3%
13A	Chavies fine sandy loam, 0 to 4 percent slopes, rarely flooded	A	179.4	9.1%
24C2	Endcav silt loam, 7 to 15 percent slopes, eroded	C	15.9	0.8%
29B2	Frederick and Lodi silt loams, 2 to 7 percent slopes, eroded	B	2.4	0.1%
29C2	Frederick and Lodi silt loams, 7 to 15 percent slopes, eroded	B	9.7	0.5%
29D2	Frederick and Lodi silt loams, 15 to 25 percent slopes, eroded	B	41.8	2.1%
31D2	Frederick and Lodi gravelly silt loams, 15 to 25 percent slopes, eroded	B	14.9	0.8%
33C2	Frederick and Lodi silt loams, rocky, 7 to 15 percent slopes, eroded	B	9.7	0.5%
33D2	Frederick and Lodi silt loams, rocky, 15 to 25 percent slopes, eroded	B	36.7	1.9%
33E2	Frederick and Lodi silt loams, rocky, 25 to 45 percent slopes, eroded	B	9.3	0.5%
34E	Frederick-Rock outcrop complex, 15 to 45 percent slopes	B	55.6	2.8%
45A	Massanetta silt loam, 0 to 2 percent slopes	C	21.5	1.1%
46A	Millrock loamy sand, 0 to 4 percent slopes, frequently flooded	A	10.7	0.5%
47B	Monongahela fine sandy loam, 0 to 7 percent slopes	C	34.9	1.8%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
54A	Purdy silt loam, 0 to 2 percent slopes	C/D	18.9	1.0%
56C	Rock outcrop-Frederick complex, 2 to 15 percent slopes		3.1	0.2%
56D	Rock outcrop-Frederick complex, 15 to 45 percent slopes		60.2	3.1%
63C2	Shenval loam, 7 to 15 percent slopes, eroded	B	8.1	0.4%
68B	Timberville variant silt loam, 0 to 7 percent slopes, frequently flooded	B	2.6	0.1%
69A	Tioga fine sandy loam, 0 to 3 percent slopes, rarely flooded	A	29.2	1.5%
W	Water		13.0	0.7%
Subtotals for Soil Survey Area			**624.0**	**31.6%**
Totals for Area of Interest			**1,973.2**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	14.7	0.7%
1C	Alonzville loam, 7 to 15 percent slopes	B	20.5	1.0%
5B	Braddock loam, 2 to 7 percent slopes	B	32.1	1.6%
5C	Braddock loam, 7 to 15 percent slopes	B	1.7	0.1%
6B	Braddock cobbly loam, 2 to 7 percent slopes	B	1.8	0.1%
6C	Braddock cobbly loam, 7 to 15 percent slopes	B	46.4	2.4%
6D	Braddock cobbly loam, 15 to 25 percent slopes	B	1.5	0.1%
10A	Caverns sandy loam, 0 to 2 percent slopes, rarely flooded	A	8.6	0.4%
14B	Coursey loam, 2 to 7 percent slopes	C	33.3	1.7%
15A	Derroc cobbly sandy loam, 0 to 2 percent slopes, frequently flooded	A	5.5	0.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	36.0	1.8%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	161.5	8.2%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	17.0	0.9%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	35.4	1.8%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	281.9	14.3%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	185.0	9.4%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	62.3	3.2%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	3.9	0.2%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	50.9	2.6%
29A	Gladehill fine sandy loam, 0 to 2 percent slopes, occasionally flooded	A	2.7	0.1%
43B	Moomaw fine sandy loam, 2 to 7 percent slopes	D	39.9	2.0%
43C	Moomaw fine sandy loam, 7 to 15 percent slopes	D	7.8	0.4%
44B	Moomaw cobbly fine sandy loam, 2 to 7 percent	D	2.5	0.1%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	0.7	0.0%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	31.0	1.6%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
55A	Toms silt loam, 0 to 2 percent slopes	D	32.6	1.7%
58	Udorthents-Urban land complex		23.8	1.2%
59B	Unison loam, 2 to 7 percent slopes	B	145.3	7.4%
59C	Unison loam, 7 to 15 percent slopes	B	0.5	0.0%
61C	Unison cobbly loam, 7 to 15 percent slopes	B	6.9	0.4%
70B	Wolfgap loam, 1 to 5 percent slopes, rarely flooded	B	44.4	2.2%
W	Water		11.1	0.6%
Subtotals for Soil Survey Area			**1,349.1**	**68.4%**
Totals for Area of Interest			**1,973.2**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

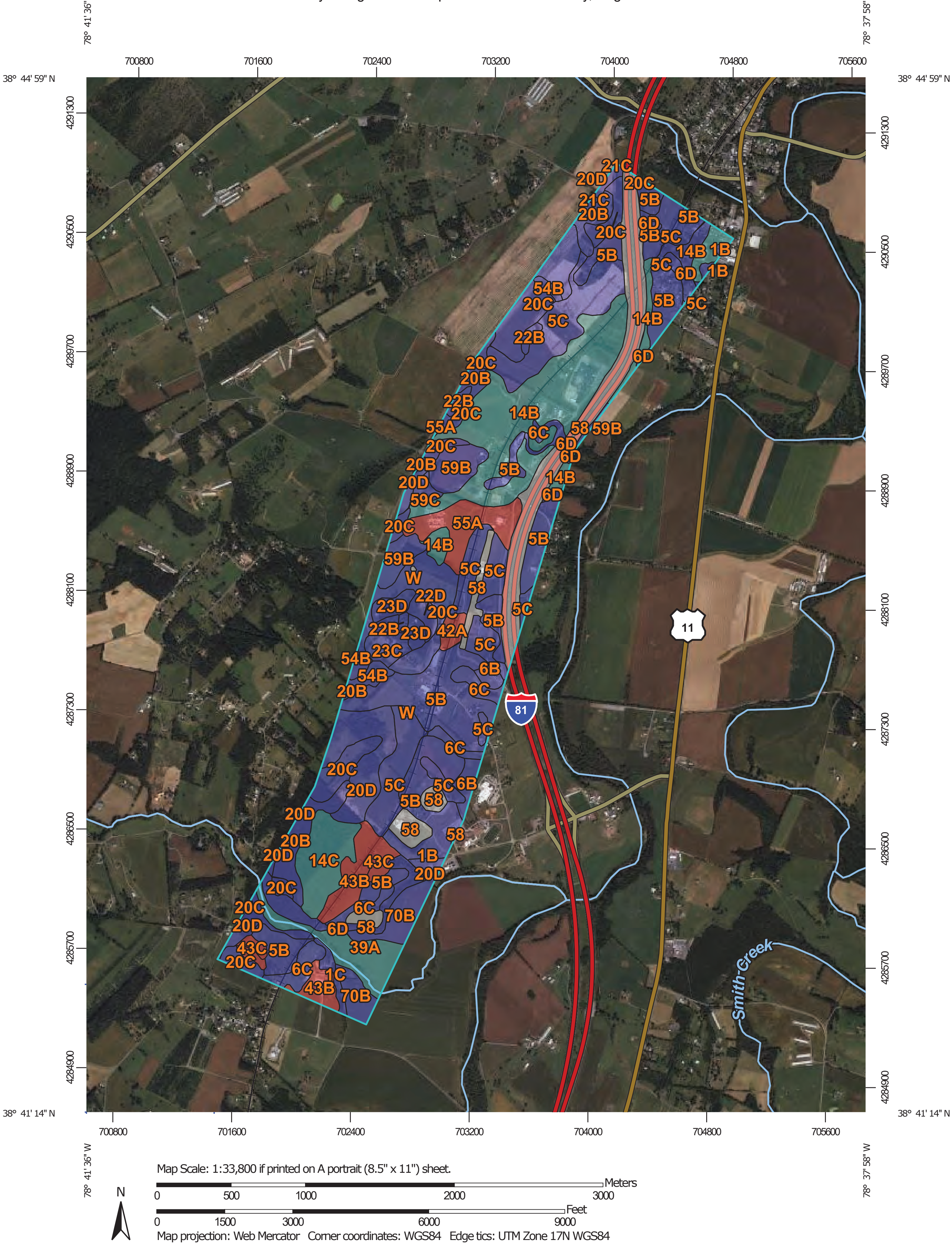
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

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

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	6.6	0.5%
1C	Alonzville loam, 7 to 15 percent slopes	B	6.4	0.4%
5B	Braddock loam, 2 to 7 percent slopes	B	232.0	16.0%
5C	Braddock loam, 7 to 15 percent slopes	B	177.9	12.3%
6B	Braddock cobbly loam, 2 to 7 percent slopes	B	14.0	1.0%
6C	Braddock cobbly loam, 7 to 15 percent slopes	B	38.1	2.6%
6D	Braddock cobbly loam, 15 to 25 percent slopes	B	50.3	3.5%
14B	Coursey loam, 2 to 7 percent slopes	C	192.8	13.3%
14C	Coursey loam, 7 to 15 percent slopes	C	45.5	3.1%
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	44.2	3.0%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	151.8	10.5%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	73.9	5.1%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	0.6	0.0%
22B	Frederick and Poplimento silt loams, 2 to 7 percent slopes, rocky	B	8.7	0.6%
22D	Frederick and Poplimento silt loams, 15 to 25 percent slopes, rocky	B	8.4	0.6%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	17.2	1.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	14.7	1.0%
39A	Massanetta silt loam, 0 to 2 percent slopes, occasionally flooded	C	40.4	2.8%
42A	Maurertown silty clay loam, 0 to 2 percent slopes	D	8.0	0.5%
43B	Moomaw fine sandy loam, 2 to 7 percent slopes	D	47.5	3.3%
43C	Moomaw fine sandy loam, 7 to 15 percent slopes	D	7.0	0.5%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	10.7	0.7%
55A	Toms silt loam, 0 to 2 percent slopes	D	41.3	2.8%
58	Udorthents-Urban land complex		132.2	9.1%
59B	Unison loam, 2 to 7 percent slopes	B	38.1	2.6%
59C	Unison loam, 7 to 15 percent slopes	B	5.9	0.4%
70B	Wolfgap loam, 1 to 5 percent slopes, rarely flooded	B	37.2	2.6%
W	Water		0.8	0.1%
Totals for Area of Interest			**1,452.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

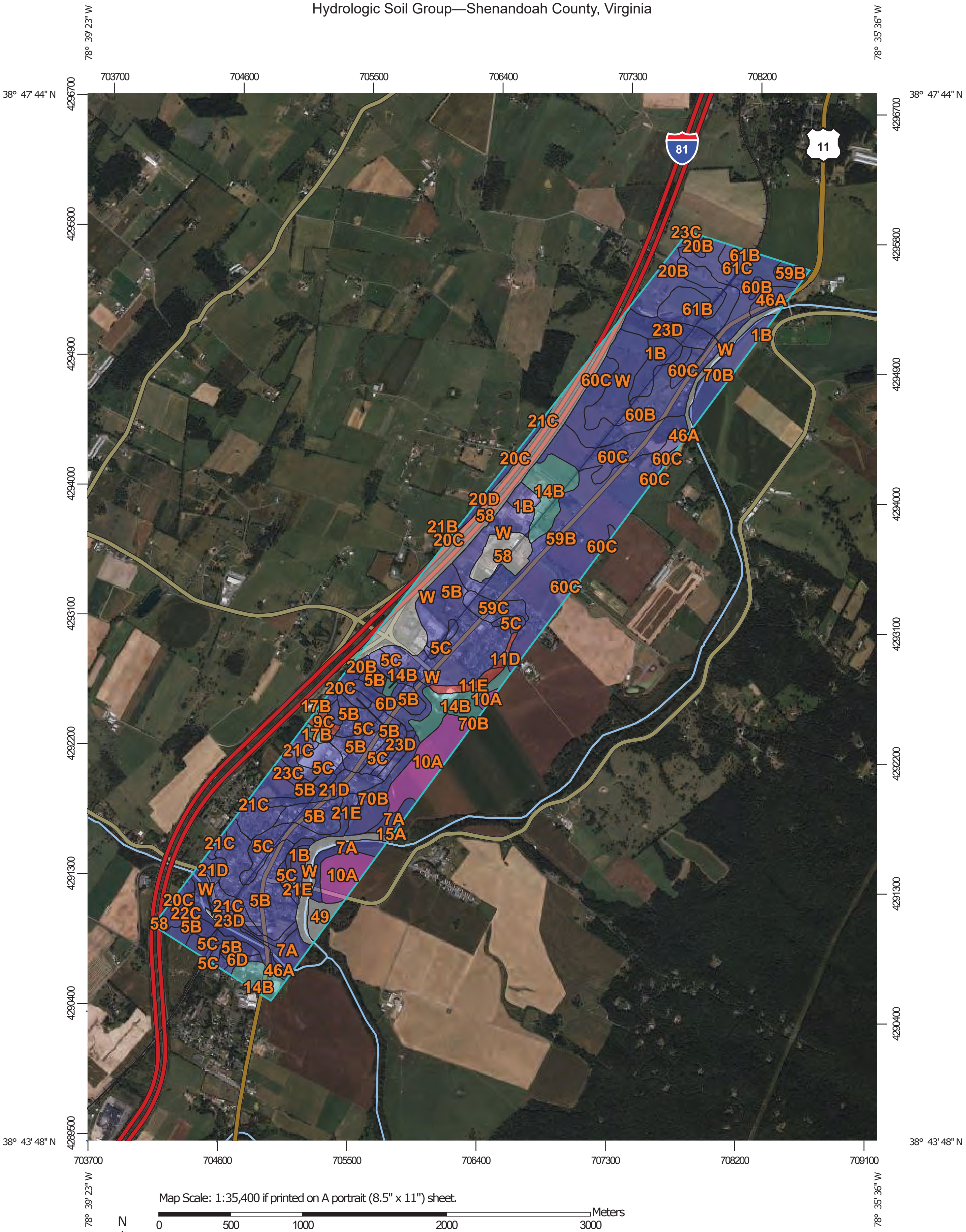
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:35,400 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 1500, 3000, 6000, 9000

Map projection: Web Mercator   Corner coordinates: WGS84   Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	29.2	2.1%
5B	Braddock loam, 2 to 7 percent slopes	B	226.2	16.3%
5C	Braddock loam, 7 to 15 percent slopes	B	85.4	6.1%
6D	Braddock cobbly loam, 15 to 25 percent slopes	B	19.8	1.4%
7A	Broadway silt loam, 0 to 2 percent slopes, occasionally flooded	B	31.4	2.3%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	5.6	0.4%
10A	Caverns sandy loam, 0 to 2 percent slopes, rarely flooded	A	62.6	4.5%
11D	Chilhowie silty clay loam, 15 to 25 percent slopes	D	2.7	0.2%
11E	Chilhowie silty clay loam, 25 to 35 percent slopes	D	7.4	0.5%
14B	Coursey loam, 2 to 7 percent slopes	C	72.6	5.2%
15A	Derroc cobbly sandy loam, 0 to 2 percent slopes, frequently flooded	A	0.3	0.0%
17B	Endcav silt loam, 2 to 7 percent slopes	C	4.5	0.3%
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	33.0	2.4%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	19.7	1.4%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	1.3	0.1%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	1.9	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	44.9	3.2%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	27.9	2.0%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	10.3	0.7%
22C	Frederick and Poplimento silt loams, 7 to 15 percent slopes, rocky	B	2.7	0.2%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	6.3	0.5%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	50.8	3.7%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	12.4	0.9%
49	Pits and Dumps		9.7	0.7%
58	Udorthents-Urban land complex		112.5	8.1%
59B	Unison loam, 2 to 7 percent slopes	B	172.8	12.4%
59C	Unison loam, 7 to 15 percent slopes	B	14.0	1.0%
60B	Unison gravelly loam, 2 to 7 percent slopes	B	66.4	4.8%
60C	Unison gravelly loam, 7 to 15 percent slopes	B	89.2	6.4%
61B	Unison cobbly loam, 2 to 7 percent slopes	B	38.2	2.8%
61C	Unison cobbly loam, 7 to 15 percent slopes	B	44.2	3.2%
70B	Wolfgap loam, 1 to 5 percent slopes, rarely flooded	B	48.9	3.5%
W	Water		34.0	2.4%
Totals for Area of Interest			**1,389.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

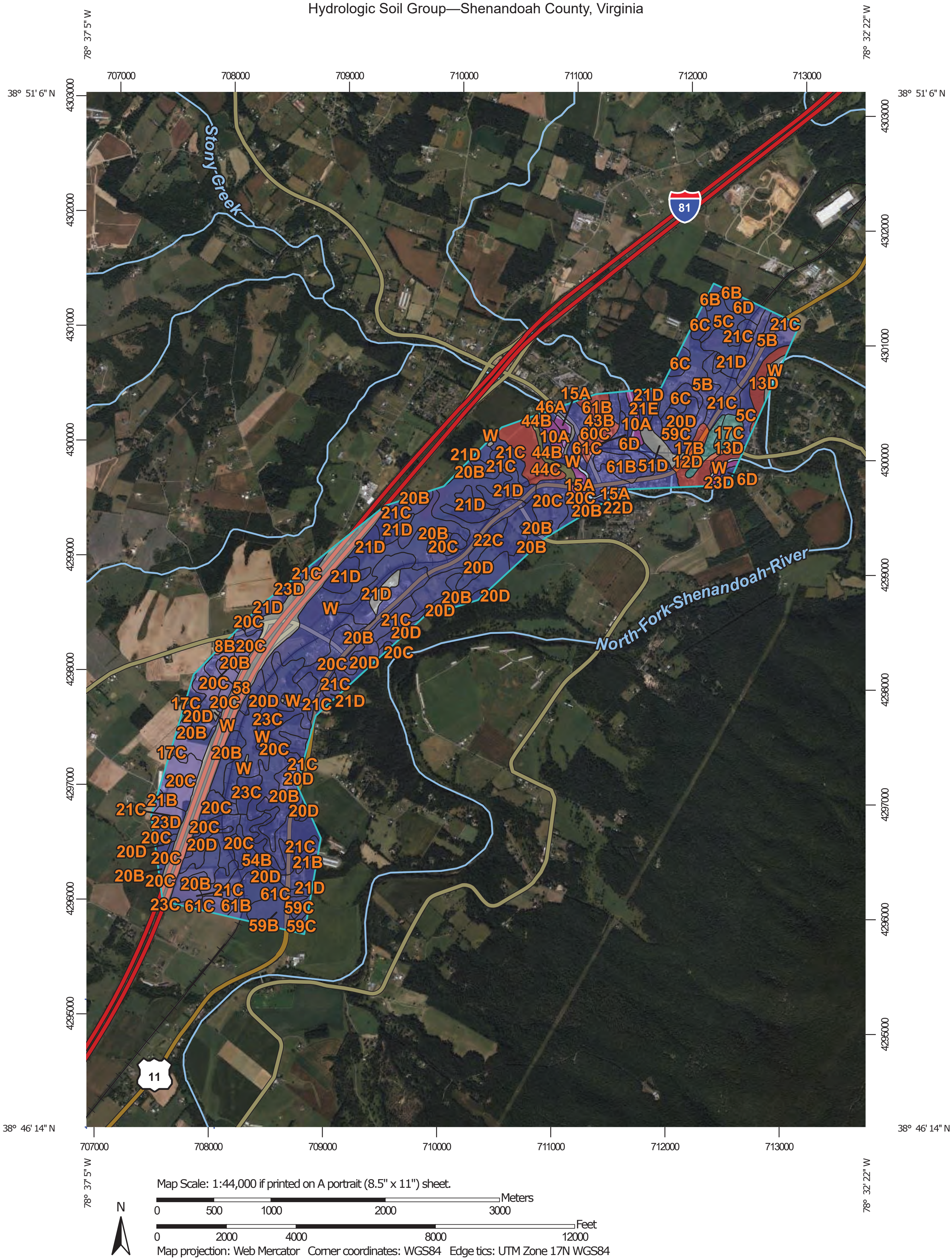
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:44,000 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	6.7	0.3%
5B	Braddock loam, 2 to 7 percent slopes	B	69.1	3.5%
5C	Braddock loam, 7 to 15 percent slopes	B	32.4	1.6%
6B	Braddock cobbly loam, 2 to 7 percent slopes	B	4.6	0.2%
6C	Braddock cobbly loam, 7 to 15 percent slopes	B	23.9	1.2%
6D	Braddock cobbly loam, 15 to 25 percent slopes	B	28.9	1.5%
8B	Carbo silty clay loam, 2 to 7 percent slopes	D	2.6	0.1%
10A	Caverns sandy loam, 0 to 2 percent slopes, rarely flooded	A	21.6	1.1%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	26.2	1.3%
13D	Chilhowie silty clay loam, 15 to 35 percent slopes, very rocky	D	22.4	1.1%
15A	Derroc cobbly sandy loam, 0 to 2 percent slopes, frequently flooded	A	11.3	0.6%
17B	Endcav silt loam, 2 to 7 percent slopes	C	10.6	0.5%
17C	Endcav silt loam, 7 to 15 percent slopes	C	15.4	0.8%
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	260.7	13.1%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	185.9	9.3%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	226.2	11.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	11.8	0.6%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	347.4	17.4%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	155.4	7.8%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	8.2	0.4%
22C	Frederick and Poplimento silt loams, 7 to 15 percent slopes, rocky	B	10.4	0.5%
22D	Frederick and Poplimento silt loams, 15 to 25 percent slopes, rocky	B	28.6	1.4%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	22.4	1.1%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	13.1	0.7%
29A	Gladehill fine sandy loam, 0 to 2 percent slopes, occasionally flooded	A	2.2	0.1%
43B	Moomaw fine sandy loam, 2 to 7 percent slopes	D	28.2	1.4%
44B	Moomaw cobbly fine sandy loam, 2 to 7 percent	D	35.7	1.8%
44C	Moomaw cobbly fine sandy loam, 7 to 15 percent slopes	C/D	8.4	0.4%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	1.5	0.1%
51D	Rock outcrop-Carbo complex, 2 to 25 percent slopes		12.6	0.6%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	10.4	0.5%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
58	Udorthents-Urban land complex		147.7	7.4%
59B	Unison loam, 2 to 7 percent slopes	B	26.6	1.3%
59C	Unison loam, 7 to 15 percent slopes	B	23.4	1.2%
60C	Unison gravelly loam, 7 to 15 percent slopes	B	20.3	1.0%
61B	Unison cobbly loam, 2 to 7 percent slopes	B	33.5	1.7%
61C	Unison cobbly loam, 7 to 15 percent slopes	B	76.4	3.8%
W	Water		21.2	1.1%
Totals for Area of Interest			**1,994.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

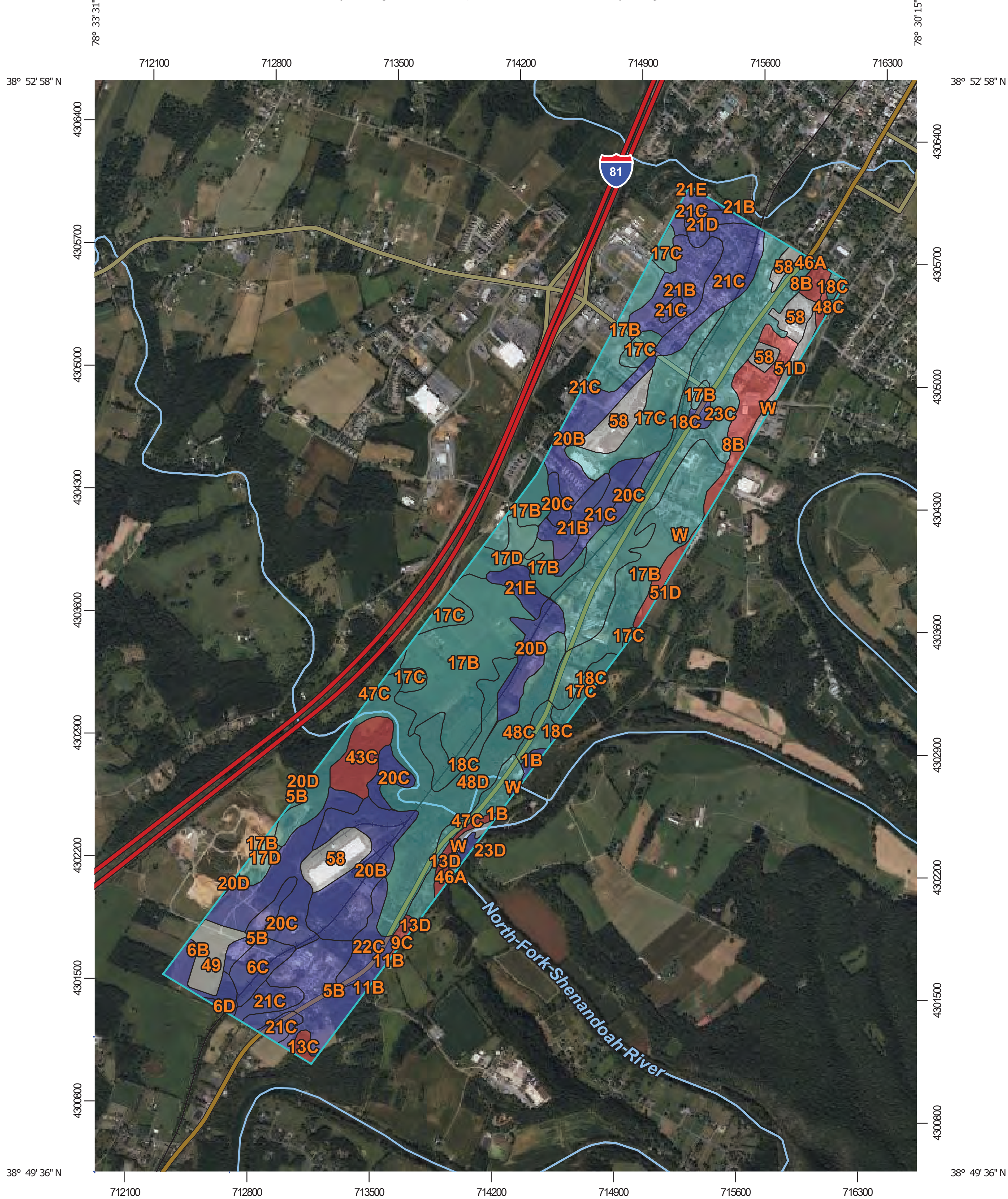
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:30,400 if printed on A portrait (8.5" x 11") sheet.

Meters
0 450 900 1800 2700

Feet
0 1000 2000 4000 6000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	3.7	0.3%
5B	Braddock loam, 2 to 7 percent slopes	B	63.6	4.8%
6B	Braddock cobbly loam, 2 to 7 percent slopes	B	11.4	0.9%
6C	Braddock cobbly loam, 7 to 15 percent slopes	B	17.7	1.3%
6D	Braddock cobbly loam, 15 to 25 percent slopes	B	2.2	0.2%
7A	Broadway silt loam, 0 to 2 percent slopes, occasionally flooded	B	2.8	0.2%
8B	Carbo silty clay loam, 2 to 7 percent slopes	D	46.8	3.5%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	3.4	0.3%
11B	Chilhowie silty clay loam, 2 to 7 percent slopes	D	0.0	0.0%
11C	Chilhowie silty clay loam, 7 to 15 percent slopes	D	0.8	0.1%
11D	Chilhowie silty clay loam, 15 to 25 percent slopes	D	2.4	0.2%
13C	Chilhowie silty clay loam, 7 to 15 percent slopes, very rocky	D	3.7	0.3%
13D	Chilhowie silty clay loam, 15 to 35 percent slopes, very rocky	D	6.9	0.5%
17B	Endcav silt loam, 2 to 7 percent slopes	C	228.1	17.1%
17C	Endcav silt loam, 7 to 15 percent slopes	C	84.1	6.3%
17D	Endcav silt loam, 15 to 25 percent slopes	C	27.4	2.1%
18C	Endcav silt loam, 7 to 15 percent slopes, rocky	C	171.4	12.8%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	90.9	6.8%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	80.0	6.0%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	25.7	1.9%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	49.3	3.7%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	83.4	6.2%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	10.1	0.8%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	11.7	0.9%
22C	Frederick and Poplimento silt loams, 7 to 15 percent slopes, rocky	B	21.4	1.6%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	4.4	0.3%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	0.0	0.0%
43C	Moomaw fine sandy loam, 7 to 15 percent slopes	D	24.1	1.8%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	0.3	0.0%
47C	Opequon silty clay loam, 2 to 15 percent slopes, rocky	C	22.5	1.7%
48C	Opequon silty clay loam, 2 to 15 percent slopes, very rocky	C	10.4	0.8%
48D	Opequon silty clay loam, 15 to 25 percent slopes, very rocky	C	133.1	10.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
49	Pits and Dumps		19.1	1.4%
51D	Rock outcrop-Carbo complex, 2 to 25 percent slopes		8.0	0.6%
58	Udorthents-Urban land complex		59.3	4.4%
W	Water		6.0	0.4%
Totals for Area of Interest			**1,336.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

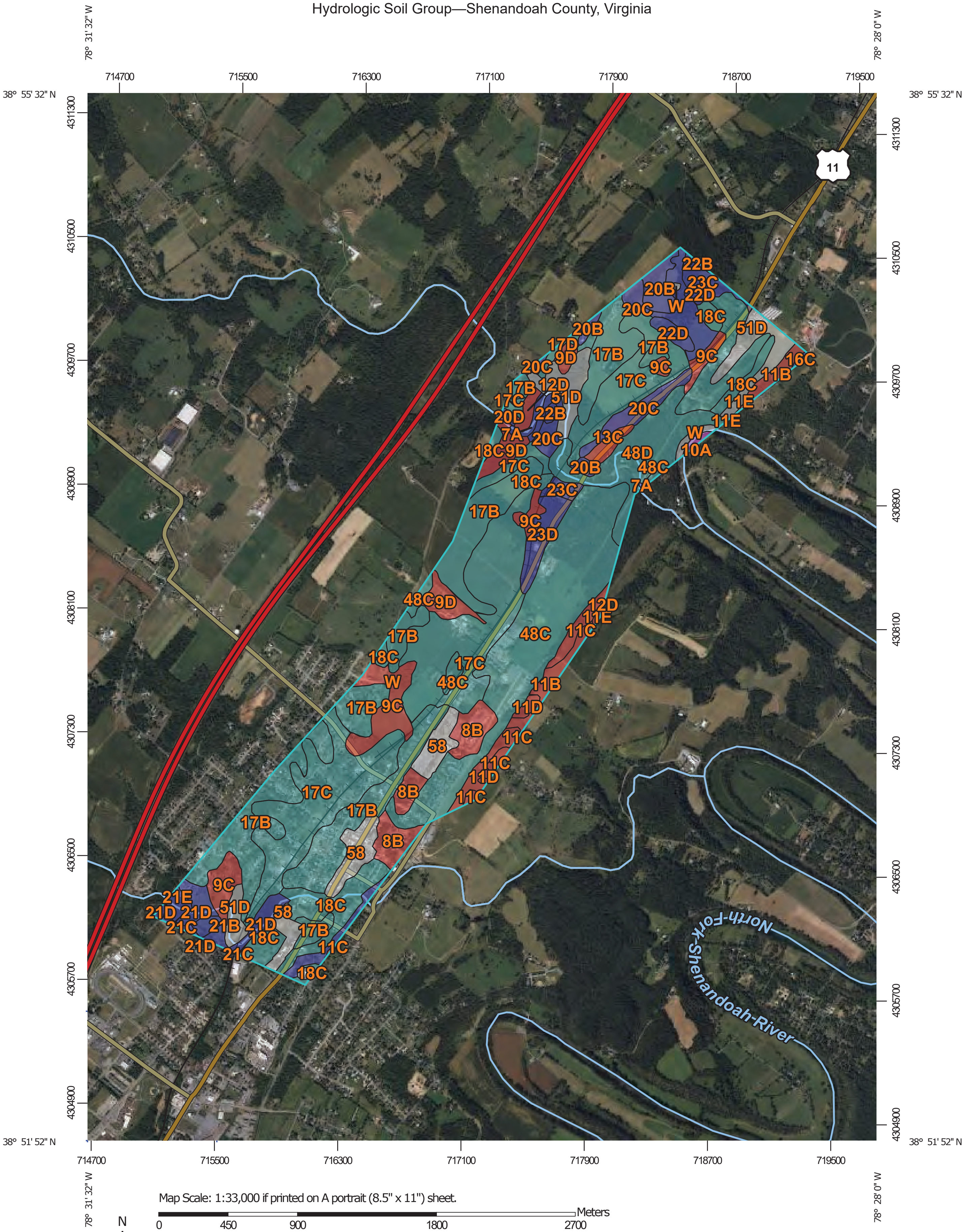
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:33,000 if printed on A portrait (8.5" x 11") sheet.

N

0 450 900 1800 2700 Meters

0 1500 3000 6000 9000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
7A	Broadway silt loam, 0 to 2 percent slopes, occasionally flooded	B	4.3	0.3%
8B	Carbo silty clay loam, 2 to 7 percent slopes	D	40.8	2.9%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	61.3	4.3%
9D	Carbo-Endcav complex, 15 to 35 percent slopes, very rocky	D	29.6	2.1%
10A	Caverns sandy loam, 0 to 2 percent slopes, rarely flooded	A	2.2	0.2%
11B	Chilhowie silty clay loam, 2 to 7 percent slopes	D	21.3	1.5%
11C	Chilhowie silty clay loam, 7 to 15 percent slopes	D	15.1	1.1%
11D	Chilhowie silty clay loam, 15 to 25 percent slopes	D	15.4	1.1%
11E	Chilhowie silty clay loam, 25 to 35 percent slopes	D	1.2	0.1%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	5.4	0.4%
13C	Chilhowie silty clay loam, 7 to 15 percent slopes, very rocky	D	7.2	0.5%
16C	Edom silty clay loam, 7 to 15 percent slopes	B	1.0	0.1%
17B	Endcav silt loam, 2 to 7 percent slopes	C	246.2	17.5%
17C	Endcav silt loam, 7 to 15 percent slopes	C	298.5	21.2%
17D	Endcav silt loam, 15 to 25 percent slopes	C	4.1	0.3%
18B	Endcav silt loam, 2 to 7 percent slopes, rocky	C	37.4	2.7%
18C	Endcav silt loam, 7 to 15 percent slopes, rocky	C	70.8	5.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	21.1	1.5%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	52.8	3.7%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	1.7	0.1%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	4.2	0.3%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	2.1	0.2%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	24.7	1.8%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	5.9	0.4%
22B	Frederick and Poplimento silt loams, 2 to 7 percent slopes, rocky	B	2.4	0.2%
22D	Frederick and Poplimento silt loams, 15 to 25 percent slopes, rocky	B	10.7	0.8%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	15.5	1.1%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	24.4	1.7%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	9.8	0.7%
48C	Opequon silty clay loam, 2 to 15 percent slopes, very rocky	C	191.6	13.6%
48D	Opequon silty clay loam, 15 to 25 percent slopes, very rocky	C	70.0	5.0%
51D	Rock outcrop-Carbo complex, 2 to 25 percent slopes		58.6	4.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
58	Udorthents-Urban land complex		47.1	3.3%
W	Water		4.6	0.3%
Totals for Area of Interest			**1,409.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

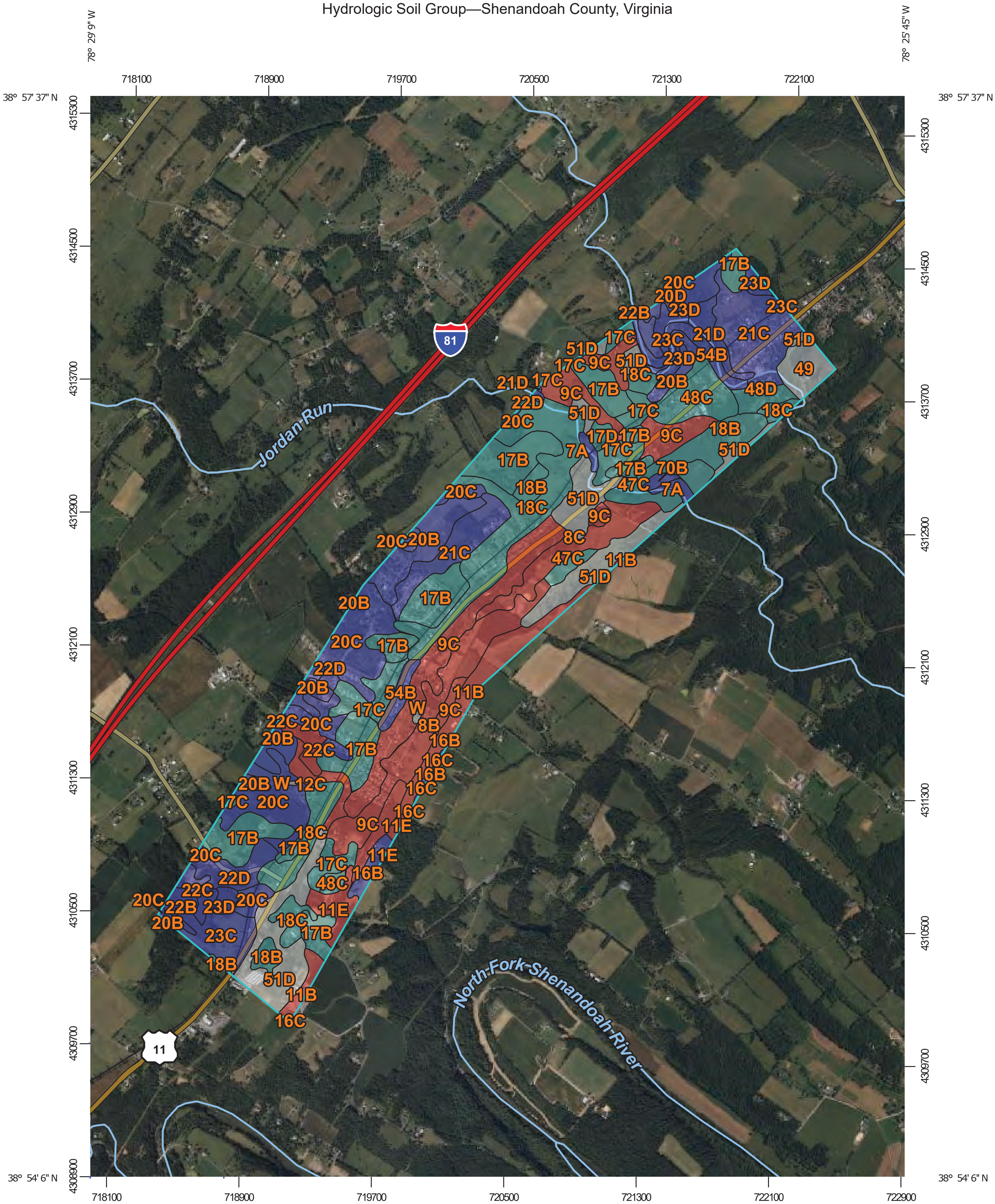
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:31,700 if printed on A portrait (8.5" x 11") sheet.

N

Meters	0	450	900	1800	2700
Feet	0	1500	3000	6000	9000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
7A	Broadway silt loam, 0 to 2 percent slopes, occasionally flooded	B	7.1	0.5%
8B	Carbo silty clay loam, 2 to 7 percent slopes	D	66.5	5.1%
8C	Carbo silty clay loam, 7 to 15 percent slopes	D	35.4	2.7%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	124.2	9.5%
11B	Chilhowie silty clay loam, 2 to 7 percent slopes	D	44.6	3.4%
11E	Chilhowie silty clay loam, 25 to 35 percent slopes	D	17.3	1.3%
12C	Chilhowie silty clay loam, 7 to 15 percent slopes, rocky	D	11.9	0.9%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	9.0	0.7%
16B	Edom silty clay loam, 2 to 7 percent slopes	B	8.2	0.6%
16C	Edom silty clay loam, 7 to 15 percent slopes	B	1.3	0.1%
17B	Endcav silt loam, 2 to 7 percent slopes	C	151.5	11.5%
17C	Endcav silt loam, 7 to 15 percent slopes	C	51.1	3.9%
17D	Endcav silt loam, 15 to 25 percent slopes	C	5.1	0.4%
18B	Endcav silt loam, 2 to 7 percent slopes, rocky	C	37.1	2.8%
18C	Endcav silt loam, 7 to 15 percent slopes, rocky	C	130.1	9.9%
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	60.0	4.6%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	107.7	8.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	1.5	0.1%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	84.3	6.4%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	12.7	1.0%
22B	Frederick and Poplimento silt loams, 2 to 7 percent slopes, rocky	B	8.7	0.7%
22C	Frederick and Poplimento silt loams, 7 to 15 percent slopes, rocky	B	12.8	1.0%
22D	Frederick and Poplimento silt loams, 15 to 25 percent slopes, rocky	B	22.5	1.7%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	32.0	2.4%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	38.0	2.9%
47C	Opequon silty clay loam, 2 to 15 percent slopes, rocky	C	29.3	2.2%
48C	Opequon silty clay loam, 2 to 15 percent slopes, very rocky	C	34.6	2.6%
48D	Opequon silty clay loam, 15 to 25 percent slopes, very rocky	C	10.3	0.8%
49	Pits and Dumps		18.8	1.4%
51D	Rock outcrop-Carbo complex, 2 to 25 percent slopes		113.6	8.6%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	22.6	1.7%
70B	Wolfgap loam, 1 to 5 percent slopes, rarely flooded	B	3.2	0.2%
W	Water		1.2	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Totals for Area of Interest			**1,313.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

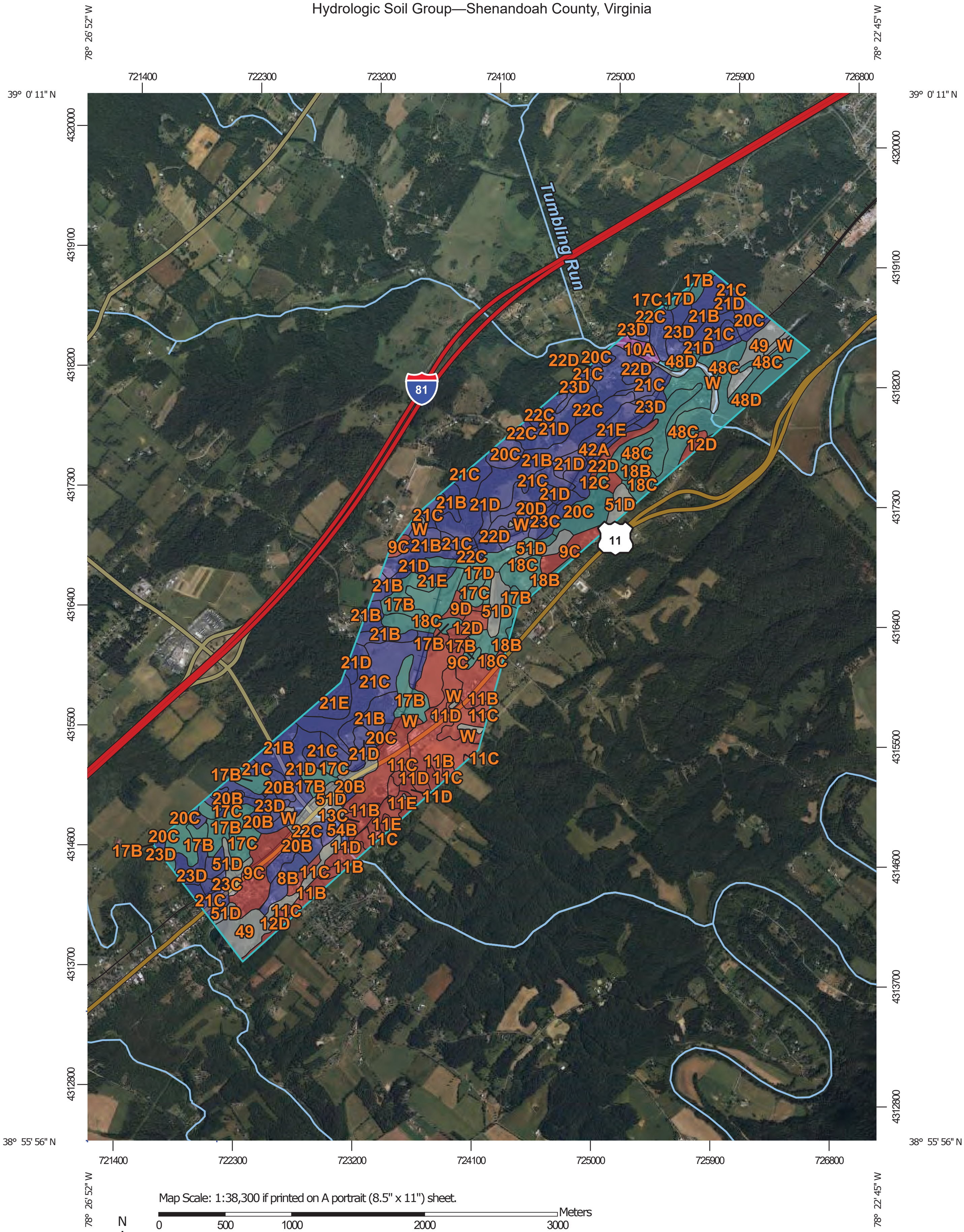
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Shenandoah County, Virginia



Map Scale: 1:38,300 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 1500, 3000, 6000, 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Nov 3, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
8B	Carbo silty clay loam, 2 to 7 percent slopes	D	5.4	0.3%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	137.9	8.5%
9D	Carbo-Endcav complex, 15 to 35 percent slopes, very rocky	D	7.1	0.4%
10A	Caverns sandy loam, 0 to 2 percent slopes, rarely flooded	A	8.9	0.5%
11B	Chilhowie silty clay loam, 2 to 7 percent slopes	D	72.5	4.4%
11C	Chilhowie silty clay loam, 7 to 15 percent slopes	D	15.9	1.0%
11D	Chilhowie silty clay loam, 15 to 25 percent slopes	D	30.4	1.9%
11E	Chilhowie silty clay loam, 25 to 35 percent slopes	D	8.5	0.5%
12C	Chilhowie silty clay loam, 7 to 15 percent slopes, rocky	D	3.3	0.2%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	18.5	1.1%
13C	Chilhowie silty clay loam, 7 to 15 percent slopes, very rocky	D	10.1	0.6%
13D	Chilhowie silty clay loam, 15 to 35 percent slopes, very rocky	D	2.3	0.1%
17B	Endcav silt loam, 2 to 7 percent slopes	C	96.5	5.9%
17C	Endcav silt loam, 7 to 15 percent slopes	C	31.1	1.9%
17D	Endcav silt loam, 15 to 25 percent slopes	C	11.7	0.7%
18B	Endcav silt loam, 2 to 7 percent slopes, rocky	C	10.7	0.7%
18C	Endcav silt loam, 7 to 15 percent slopes, rocky	C	70.6	4.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	41.2	2.5%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	53.0	3.2%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	3.3	0.2%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	143.4	8.8%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	157.1	9.6%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	165.1	10.1%
21E	Frederick and Poplimento gravelly silt loams, 25 to 35 percent slopes	B	43.0	2.6%
22C	Frederick and Poplimento silt loams, 7 to 15 percent slopes, rocky	B	27.4	1.7%
22D	Frederick and Poplimento silt loams, 15 to 25 percent slopes, rocky	B	47.9	2.9%
23C	Frederick and Poplimento silt loams, 2 to 15 percent slopes, very rocky	B	11.7	0.7%
23D	Frederick and Poplimento silt loams, 15 to 35 percent slopes, very rocky	B	60.7	3.7%
39A	Massanetta silt loam, 0 to 2 percent slopes, occasionally flooded	C	19.4	1.2%
42A	Maurertown silty clay loam, 0 to 2 percent slopes	D	8.9	0.5%
48C	Opequon silty clay loam, 2 to 15 percent slopes, very rocky	C	65.6	4.0%
48D	Opequon silty clay loam, 15 to 25 percent slopes, very rocky	C	97.5	6.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
49	Pits and Dumps		41.2	2.5%
51D	Rock outcrop-Carbo complex, 2 to 25 percent slopes		84.2	5.2%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	3.5	0.2%
W	Water		16.2	1.0%
Totals for Area of Interest			**1,631.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

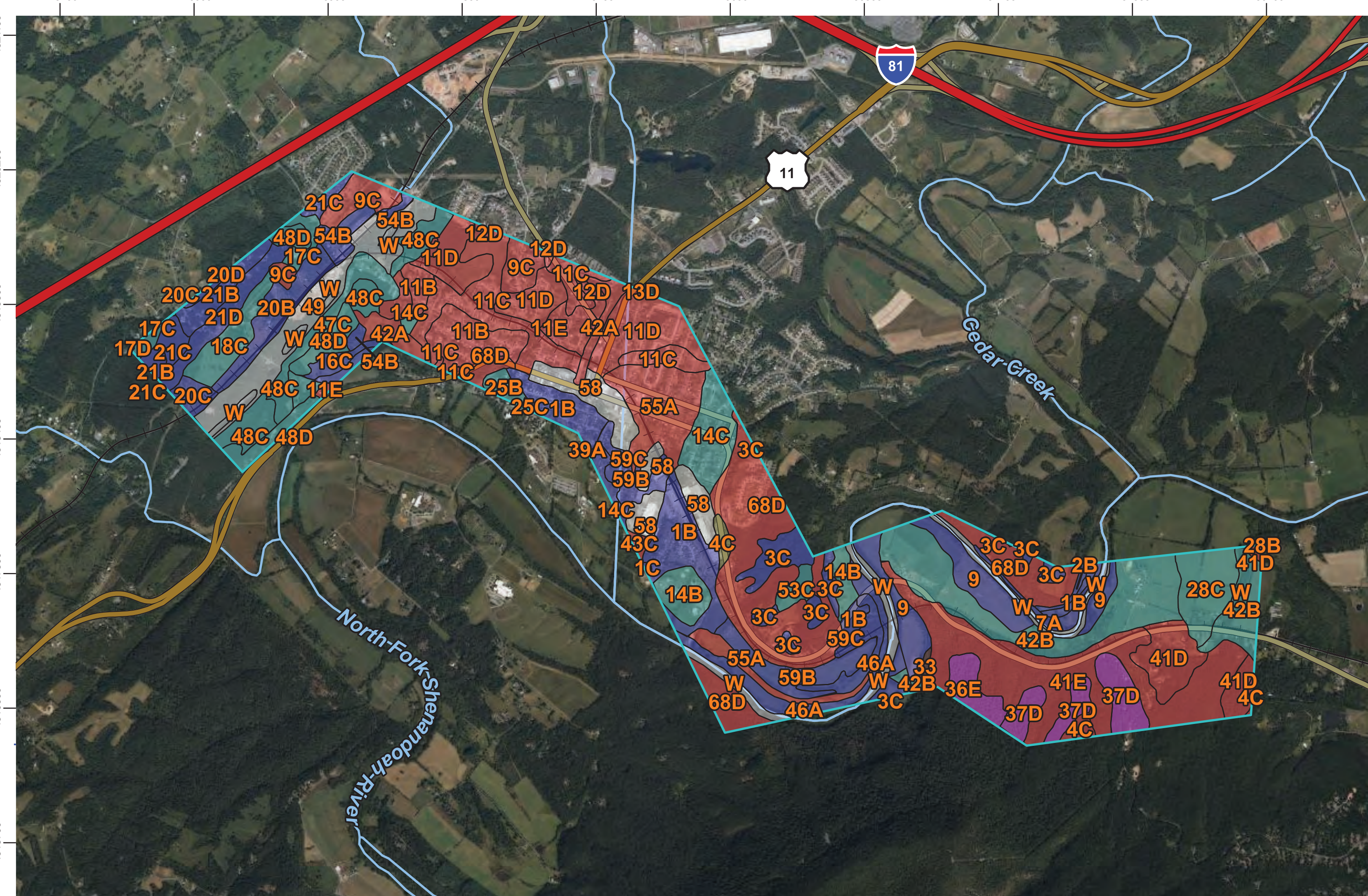
Tie-break Rule: Higher

78° 24' 13" W
78° 17' 52" W

725100 726000 726900 727800 728700 729600 730500 731400 732300 733200

39° 0' 40" N
39° 0' 40" N

4321100 4320200 4319300 4318400 4317500 4316600 4315700



725100 726000 726900 727800 728700 729600 730500 731400 732300 733200 734100

38° 57' 28" N
38° 57' 28" N

78° 24' 13" W
78° 17' 52" W

Map Scale: 1:41,800 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 500 1000 2000 3000

Feet: 0 2000 4000 8000 12000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

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

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Shenandoah County, Virginia
Survey Area Data: Version 18, Sep 5, 2023

Soil Survey Area: Warren County, Virginia
Survey Area Data: Version 19, Sep 5, 2023

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Jun 8, 2020—Nov 3, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Alonzville loam, 2 to 7 percent slopes, rarely flooded	B	104.1	4.4%
1C	Alonzville loam, 7 to 15 percent slopes	B	0.8	0.0%
2B	Berks channery silt loam, 3 to 8 percent slopes	B	3.8	0.2%
3C	Berks-Weikert channery silt loams, 8 to 15 percent slopes	B	53.1	2.2%
4C	Blairton silt loam, 7 to 15 percent slopes	C/D	6.1	0.3%
7A	Broadway silt loam, 0 to 2 percent slopes, occasionally flooded	B	12.0	0.5%
9C	Carbo-Endcav complex, 2 to 15 percent slopes, very rocky	D	48.5	2.1%
11B	Chilhowie silty clay loam, 2 to 7 percent slopes	D	57.9	2.5%
11C	Chilhowie silty clay loam, 7 to 15 percent slopes	D	107.6	4.6%
11D	Chilhowie silty clay loam, 15 to 25 percent slopes	D	115.7	4.9%
11E	Chilhowie silty clay loam, 25 to 35 percent slopes	D	22.2	0.9%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	13.4	0.6%
13D	Chilhowie silty clay loam, 15 to 35 percent slopes, very rocky	D	0.1	0.0%
14B	Coursey loam, 2 to 7 percent slopes	C	40.6	1.7%
14C	Coursey loam, 7 to 15 percent slopes	C	47.8	2.0%
16B	Edom silty clay loam, 2 to 7 percent slopes	B	5.6	0.2%
16C	Edom silty clay loam, 7 to 15 percent slopes	B	11.3	0.5%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
17B	Endcav silt loam, 2 to 7 percent slopes	C	4.9	0.2%
17C	Endcav silt loam, 7 to 15 percent slopes	C	9.8	0.4%
17D	Endcav silt loam, 15 to 25 percent slopes	C	0.2	0.0%
18C	Endcav silt loam, 7 to 15 percent slopes, rocky	C	35.0	1.5%
20B	Frederick and Poplimento silt loams, 2 to 7 percent slopes	B	40.6	1.7%
20C	Frederick and Poplimento silt loams, 7 to 15 percent slopes	B	14.8	0.6%
20D	Frederick and Poplimento silt loams, 15 to 25 percent slopes	B	0.9	0.0%
21B	Frederick and Poplimento gravelly silt loams, 2 to 7 percent slopes	B	28.5	1.2%
21C	Frederick and Poplimento gravelly silt loams, 7 to 15 percent slopes	B	18.4	0.8%
21D	Frederick and Poplimento gravelly silt loams, 15 to 25 percent slopes	B	32.3	1.4%
25B	Gilpin silt loam, 2 to 7 percent slopes	C	9.8	0.4%
25C	Gilpin silt loam, 7 to 15 percent slopes	C	1.4	0.1%
39A	Massanetta silt loam, 0 to 2 percent slopes, occasionally flooded	C	0.4	0.0%
42A	Maurertown silty clay loam, 0 to 2 percent slopes	D	30.9	1.3%
43C	Moomaw fine sandy loam, 7 to 15 percent slopes	D	3.8	0.2%
46A	Nomberville loam, 0 to 2 percent slopes, rarely flooded	B	40.3	1.7%
47C	Opequon silty clay loam, 2 to 15 percent slopes, rocky	C	35.6	1.5%
48C	Opequon silty clay loam, 2 to 15 percent slopes, very rocky	C	55.0	2.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
48D	Opequon silty clay loam, 15 to 25 percent slopes, very rocky	C	43.1	1.8%
49	Pits and Dumps		84.4	3.6%
53C	Sequoia loam, 2 to 15 percent slopes	C	10.9	0.5%
54B	Timberville silt loam, 2 to 7 percent slopes, frequently flooded	B	23.8	1.0%
55A	Toms silt loam, 0 to 2 percent slopes	D	90.3	3.8%
58	Udorthents-Urban land complex		72.5	3.1%
59B	Unison loam, 2 to 7 percent slopes	B	67.4	2.9%
59C	Unison loam, 7 to 15 percent slopes	B	31.9	1.4%
68D	Weikert-Berks channery silt loams, 15 to 35 percent slopes	D	227.3	9.6%
W	Water		47.2	2.0%
Subtotals for Soil Survey Area			**1,712.2**	**72.6%**
Totals for Area of Interest			**2,358.7**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
4C	Buchanan fine sandy loam, 7 to 15 percent slopes, very stony	D	7.4	0.3%
9	Chagrin fine sandy loam, 0 to 2 percent slopes, frequently flooded	B	78.3	3.3%
28B	Monongahela loam, 2 to 7 percent slopes	C	0.0	0.0%
28C	Monongahela loam, 7 to 15 percent slopes	C	47.6	2.0%
33	Newark silt loam, 0 to 2 percent slopes, frequently flooded	B/D	2.6	0.1%
36E	Rigley sandy loam, 25 to 60 percent slopes, very stony	A	23.9	1.0%
37D	Rigley-Weikert-Berks complex, 15 to 25 percent slopes, very stony	A	54.6	2.3%
41D	Weikert-Berks channery silt loams, 15 to 25 percent slopes	D	56.9	2.4%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
41E	Weikert-Berks channery silt loams, 25 to 65 percent slopes	D	186.8	7.9%
42B	Zoar silt loam, 0 to 7 percent	C	172.3	7.3%
W	Water		16.0	0.7%
Subtotals for Soil Survey Area			**646.4**	**27.4%**
Totals for Area of Interest			**2,358.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

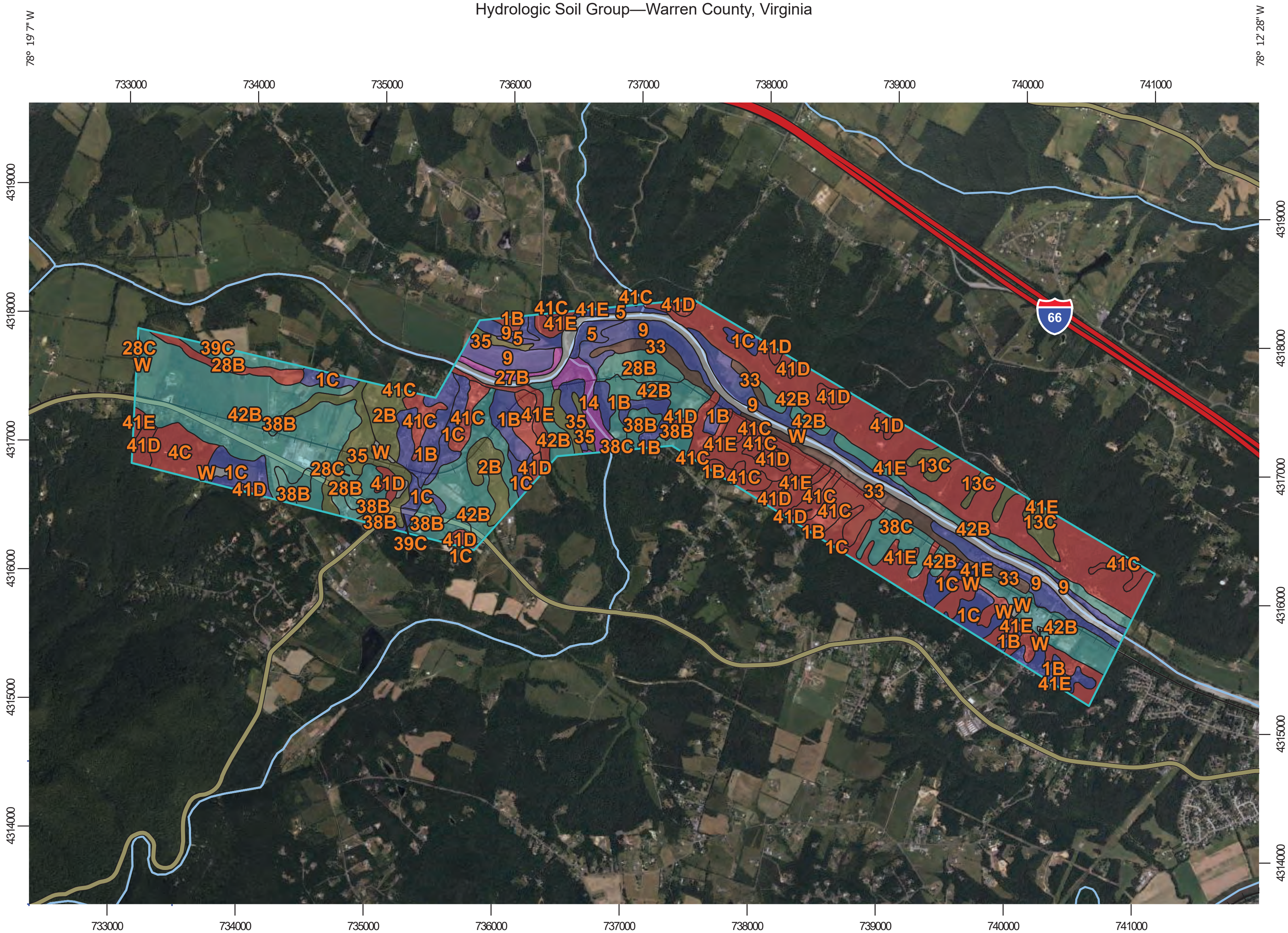
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Hydrologic Soil Group—Warren County, Virginia



Map Scale: 1:43,900 if printed on A landscape (11" x 8.5") sheet.

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0 500 1000 2000 3000 Meters

0 2000 4000 8000 12000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

Streams and Canals

Transportation

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

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

Soil Survey Area: Warren County, Virginia
Survey Area Data: Version 19, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Nov 3, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Berks channery silt loam, 3 to 8 percent slopes	B	124.7	5.3%
1C	Berks channery silt loam, 8 to 15 percent slopes	B	115.9	5.0%
2B	Blairton silt loam, 2 to 7 percent slopes	C/D	59.8	2.6%
4C	Buchanan fine sandy loam, 7 to 15 percent slopes, very stony	D	38.8	1.7%
5	Buckton silt loam, 0 to 2 percent slopes, occasionally flooded	B	44.5	1.9%
9	Chagrin fine sandy loam, 0 to 2 percent slopes, frequently flooded	B	175.5	7.5%
13C	Clearbrook channery silt loam, 7 to 15 percent slopes	C/D	42.2	1.8%
14	Craigsville cobbly sandy loam, 0 to 5 percent slopes, frequently flooded	A	28.6	1.2%
27B	Millrock loamy fine sand, 0 to 7 percent slopes, frequently flooded	A	10.8	0.5%
28B	Monongahela loam, 2 to 7 percent slopes	C	65.9	2.8%
28C	Monongahela loam, 7 to 15 percent slopes	C	4.2	0.2%
33	Newark silt loam, 0 to 2 percent slopes, frequently flooded	B/D	71.8	3.1%
35	Purdy loam, 0 to 2 percent slopes	C/D	82.8	3.5%
38B	Sequoia silt loam, 2 to 7 percent slopes	C	71.2	3.0%
38C	Sequoia silt loam, 7 to 15 percent slopes	C	36.9	1.6%
39C	Unison loam, 7 to 15 percent slopes	B	4.8	0.2%
41C	Weikert-Berks channery silt loams, 8 to 15 percent slopes	D	146.3	6.3%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
41D	Weikert-Berks channery silt loams, 15 to 25 percent slopes	D	104.7	4.5%
41E	Weikert-Berks channery silt loams, 25 to 65 percent slopes	D	471.2	20.2%
42B	Zoar silt loam, 0 to 7 percent	C	526.1	22.5%
W	Water		108.8	4.7%
Totals for Area of Interest			**2,336.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

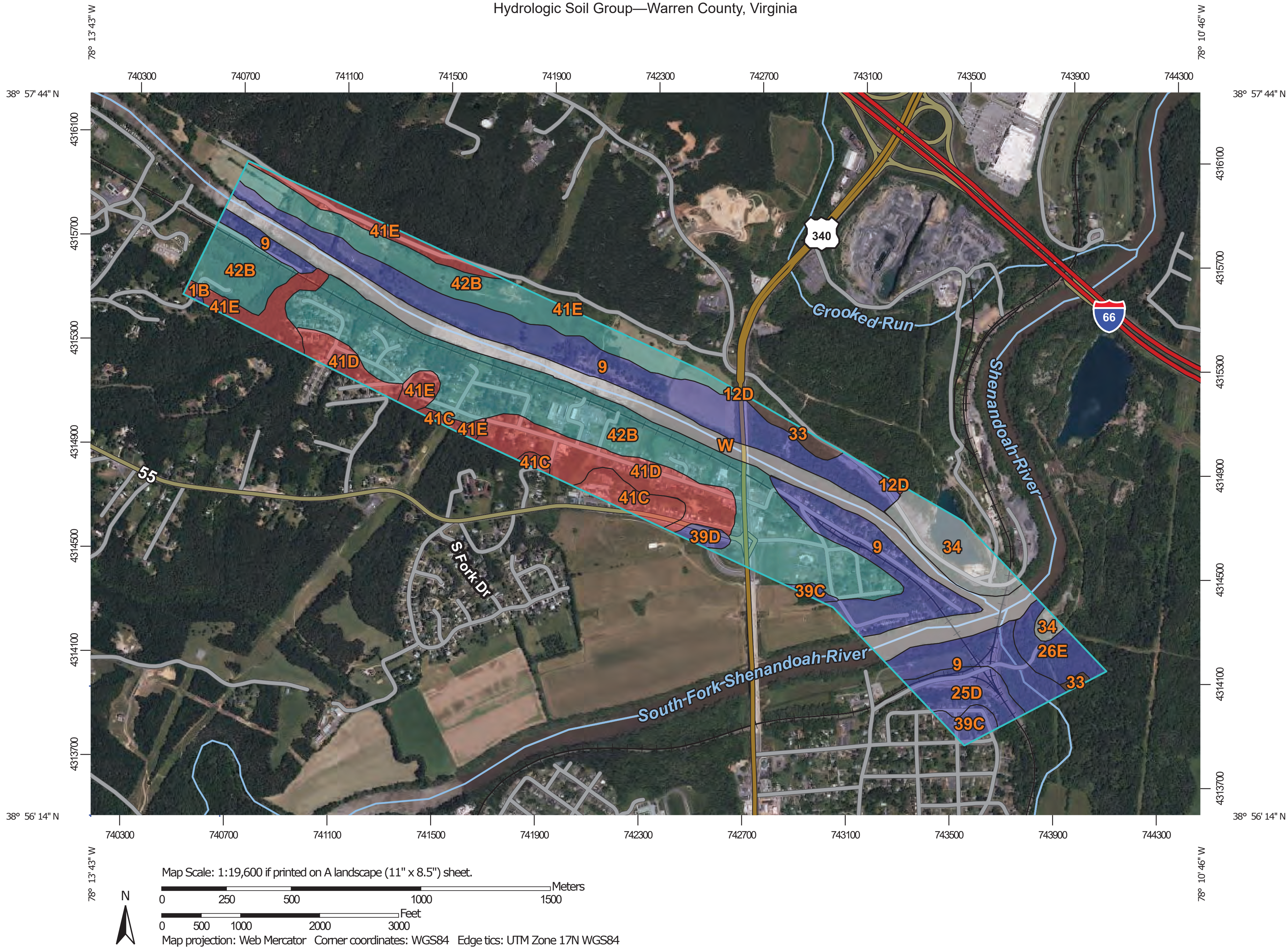
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher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78° 10' 46" W
38° 57' 44" N
38° 56' 14" N
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740700
741100
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741900
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743100
743500
743900
744300
4316100
4315700
4315300
4314900
4314500
4314100
4313700
41E
42B
9
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41D
41C
12D
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39D
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Crooked-Run
Shenandoah-River
South-Fork-Shenandoah-River
S Fork Dr
Map Scale: 1:19,600 if printed on A landscape (11" x 8.5") sheet.
N
Meters
0 250 500 1000 1500
Feet
0 500 1000 2000 3000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

Soil Survey Area: Warren County, Virginia
Survey Area Data: Version 19, Sep 5, 2023

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

Date(s) aerial images were photographed: Jun 8, 2020—Sep 23, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1B	Berks channery silt loam, 3 to 8 percent slopes	B	0.2	0.0%
9	Chagrin fine sandy loam, 0 to 2 percent slopes, frequently flooded	B	130.6	24.2%
12D	Chilhowie silty clay loam, 15 to 25 percent slopes, rocky	D	0.6	0.1%
25D	Lodi silt loam, 15 to 25 percent slopes, very rocky	B	15.1	2.8%
26E	Lodi-Rock outcrop complex, 15 to 45 percent slopes	B	12.7	2.4%
33	Newark silt loam, 0 to 2 percent slopes, frequently flooded	B/D	5.7	1.1%
34	Pits, quarries and dumps		25.5	4.7%
39C	Unison loam, 7 to 15 percent slopes	B	6.8	1.3%
39D	Unison loam, 15 to 25 percent slopes	B	3.2	0.6%
41C	Weikert-Berks channery silt loams, 8 to 15 percent slopes	D	13.2	2.4%
41D	Weikert-Berks channery silt loams, 15 to 25 percent slopes	D	41.9	7.8%
41E	Weikert-Berks channery silt loams, 25 to 65 percent slopes	D	28.4	5.2%
42B	Zoar silt loam, 0 to 7 percent	C	189.9	35.1%
W	Water		66.6	12.3%
Totals for Area of Interest			**540.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

APPENDIX C: TRACK REHABILITATION REPORT

Track Rehabilitation Report

Shenandoah Valley Rail with Trail Assessment

Shenandoah Valley, Virginia
(Railroad Milepost: B-51.0 to CW-99.6)

Virginia Department of Transportation

June 2025

Executive Summary

The report assesses infrastructure conditions and provides a strategic approach to rehabilitation that would be needed should restoring rail service for potential freight and tourism operations be desired. Through a comprehensive combination of desktop research and detailed field inspections, the Shenandoah Valley Rail corridor was categorized into three segments based on their current condition and necessary rehabilitation measures. The northern segment, from Front Royal to Toms Brook (approximately 17.15 miles, representing 35% of the corridor), requires Spot Rehabilitation – Level 1. This segment primarily necessitates targeted repairs and selective upgrades to ties, ballast, and drainage systems to enhance track stability and operational safety.

The central segment, from Toms Brook to Mt. Jackson (approximately 17.14 miles, also 35% of the corridor), requires Full Depth Replacement, indicating significant deterioration throughout this portion of the corridor. This segment exhibits extensive issues, including severely compromised rails, ties, ballast, and underlying track structure, necessitating comprehensive reconstruction to meet operational standards.

The southern segment, extending from Mt. Jackson to Broadway (approximately 14.7 miles, or 30% of the corridor), requires Spot Rehabilitation – Level 2. This section is characterized by moderate deterioration, with substantial areas requiring replacement of ties and ballast, drainage improvements, and vegetation clearing. While less severe than the central segment, these selective rehabilitation measures are critical to restoring this section’s structural integrity and ensuring operational longevity.

Key overarching findings across all segments highlight common concerns such as deteriorated ties, inadequate ballast conditions, impaired drainage systems, and extensive overgrown vegetation. These issues collectively impact the track’s stability, safety, and serviceability, emphasizing the need for prompt and targeted rehabilitation actions tailored to the specific conditions of each segment.

To achieve FRA Class 2 track standards, allowing freight operations at 25 mph and passenger operations at 30 mph, the recommended rehabilitation plan includes targeted rail and tie replacements, ballast surfacing, drainage improvements, and vegetation control along with full-depth replacement where required.

Table of Contents

Introduction & Methodology

Purpose

The purpose of this track rehabilitation report is to provide an assessment of the existing condition and the necessary track rehabilitation recommendations of the existing Shenandoah Valley Rail alignment traversing Rockingham, Shenandoah, and Warren Counties. The inspection and recommendations of the rail corridor assessed included the evaluation of a 49-mile segment of the rail corridor, currently owned by Norfolk Southern Railway, spanning from B-51.00 (Shenandoah River Bridge, Front Royal) to CW-99.60 (Lee Street, Broadway). The existing rail corridor was taken out of service in segments between 1989 and 2020. The goal of the track rehabilitation report is to provide an accurate overview of the existing condition of the rail alignment and what effort is needed to return the corridor to rail service for the potential return to freight and/or tourism operations. This report is a work product of the Shenandoah Valley Rail with Trail Assessment, the purpose of which is to assess the most likely configuration and costs associated with rail assets and rail bridge restoration and the constructing of an adjacent trail.

Methodology

In order to develop recommendations for the entire 49-mile rail corridor it was important to develop a methodology that could utilize desktop reviews and strategic field inspections to create a scalable system that could be applied to the entire corridor. A field inspection was not performed along the entire corridor; only select segments were assessed in the field.

The desktop review began with an analysis of Norfolk Southern's archived track charts dated 2010. Track charts are a railroad's corridor summary reference document providing valuable information on the alignment, grades, operating speed, rail characteristics, crossing features, recent tonnage, and maintenance frequency. Through analysis of the track chart, an overall understanding of the condition of the track was gathered before performing field inspections. This review helped to identify potential locations for condition changes that would need to be field verified to help locate strategic inspection locations to confirm the information.

The desktop review of the track chart characteristics allowed for the corridor to be broken into three conditional segments based on the dates for the last tie program and the age and size of the rail section. Before selecting the four field inspection locations it was important to spot check segments of the corridor to confirm right-of-way access locations and to confirm conditional assumptions. By traversing segments of this corridor, the accuracy of the track charts and selection of the four locations that matched the assumed criteria were confirmed.

The field site inspections involved inspecting four one-mile track segments representing the three conditional segments and allocated as follows: one spot rehabilitation segment with a level one designation requiring minimal strategic replacements, two spot rehabilitation segments with a level two designation requiring additional considerations for strategic replacement of track components, and one full-depth replacement segment requiring full replacement of all track structure components. This segmentation approach allowed for focus of resources on the most pressing issues while creating a scalable model for rehabilitation across the entire corridor. Representative segments were selected for detailed inspection to provide a snapshot of each condition category. The findings from these segments serve as benchmarks, enabling the extrapolation of necessary repairs and maintenance for the remainder of the line.

The field inspections were comprised of a comprehensive evaluation of track infrastructure, including rail condition, tie integrity, ballast stability, vegetation overgrowth, and other track materials (OTM) such as spikes, plates, and anchor. The inspection also considered external factors, such as drainage efficiency and compliance with Federal Railroad Administration (FRA) safety standards as described in the Analysis of Deficiencies section.

Evaluation Criteria

The field inspection was performed by a two-person inspection crew at each one-mile segment and was evaluated during four designated stops, focusing on the following criteria:

- **Rail Condition:** Visual inspection for age, size, wear, defects, and overall integrity.
- **Cross Ties:** Assessment of tie conditions, the percentage requiring replacement, and overall Integrity.
- **Other Track Materials (OTM):** Evaluation of condition and presence of components such as spikes, anchors, and plates.
- **Roadbed and Drainage:** Inspection of ballast condition, drainage effectiveness, and overall stability.
- **Vegetation Control:** Identification of areas needing brush cutting, vegetation, and tree removal.
- **Additional Observations:** Documentation of any other factors affecting the track's integrity and safety.
- **At-Grade Crossings:** Evaluation and review of existing crossings.
- **Turnouts, Sidings, and Connections:** Evaluation of components, special trackwork, and connection to adjacent Class 1 railroads.

These inspections enabled precise classification of each segment type, laying the foundation for tailored recommendations and a more refined series of cost estimates.

Analysis of Deficiencies

The Federal Railroad Administration (FRA) is the governing body regulating track inspections and operating requirements for freight and some passenger operations. When performing track inspections, it is vital that the railroad corridor is evaluated and analyzed based on these regulations to ensure that the corridor is in a state-of-good-repair that allows for safe and efficient operations. This section provides an overview of some of the track infrastructure deficiencies that were analyzed and evaluated by the track inspectors.

Classification of Track

The FRA classifies railroad tracks into different classes based on their construction and maintenance standards. Each class determines the maximum allowable operating speeds for freight and passenger trains to ensure safe operation. Below is a breakdown of the FRA track classes and their corresponding speed limits:

FRA Track Classes and Speed Limits

FRA Track Class	Freight Train Max Speed	Passenger Train Max Speed	Key Characteristics
Excepted	10 MPH	Not Allowed	Slow-speed operations over substandard trackage on low density line
Class 1	10 MPH	15 MPH	Lowest Classification: used for yard & industrial tracks or poorly maintained mainlines
Class 2	25 MPH	30 MPH	Light-duty mainline operations or secondary routes
Class 3	40 MPH	60 MPH	Common for regional railroads or moderate traffic mainlines
Class 4	60 MPH	80 MPH	Well-maintained mainlines for major freight or passenger railroads
Class 5	80 MPH	90 MPH	High-standard tracks on premium mainlines for faster operations

Table 1- FRA Class of Track Classifications

Passenger Trains Typically Operate Faster: Passenger trains have higher maximum speed limits compared to freight trains on the same class of track due to lighter axle loads, more adaptive suspension, and higher safety margins for passenger comfort.

Higher Track Classes Require Higher Standards: As track class increases, stricter requirements for maintenance, track geometry, and safety systems (such as Positive Train Control) are imposed to ensure safe operation at higher speeds.

Freight Limits Are More Conservative: Freight trains generally operate at slower speeds due to their heavier loads, which impose greater stress on the track infrastructure.

This classification system is essential for balancing efficiency, safety, and infrastructure durability across the rail network. Higher-class tracks, while costlier to construct and maintain, enable faster and more efficient train operations, particularly for passenger rail services. Based on interviews with potential rail operators, an FRA Class 2 track standard, allowing freight operations at 25 mph and passenger operations at 30 mph, was identified as the target for rehabilitation of the Shenandoah rail corridor.

Identification of Ties

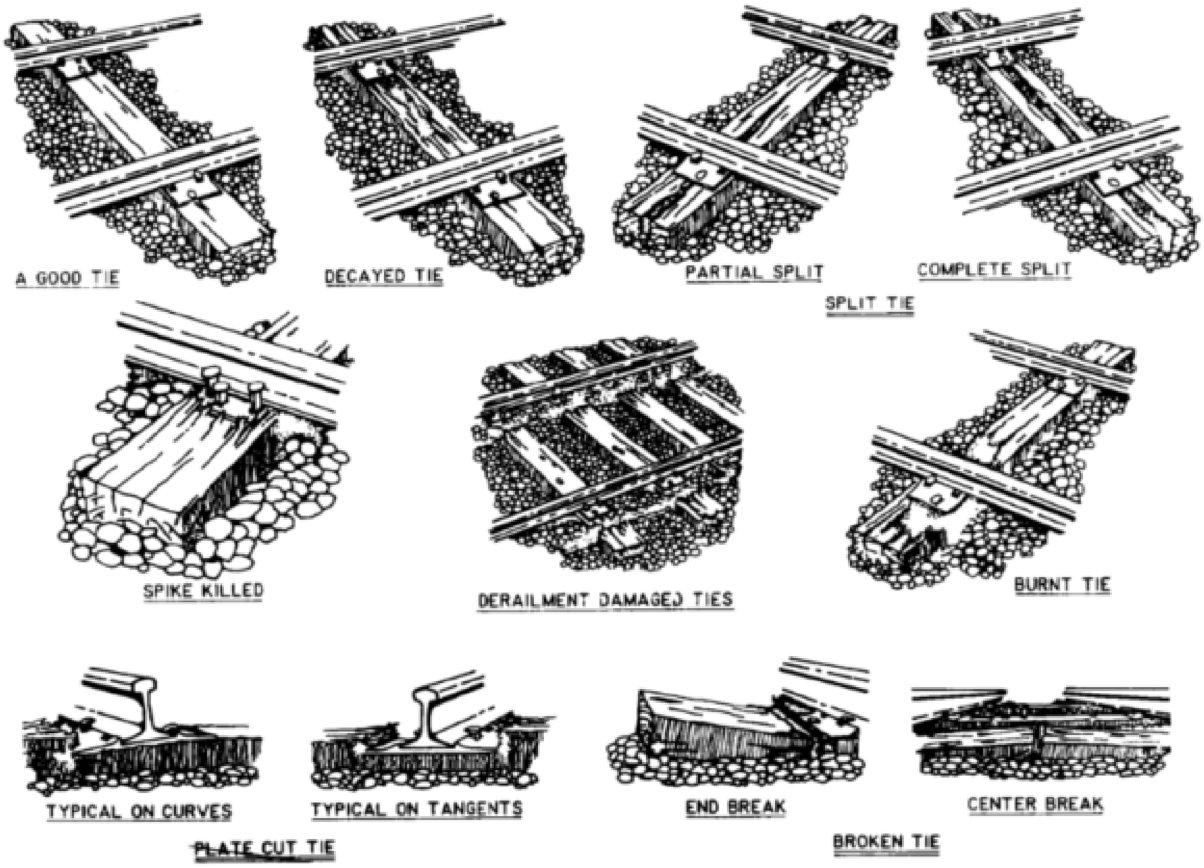


Figure 1 - Cross Tie Visual Defects
Obtained from Railroad Track Standards, Departments of the Army and the Air Force, April 1991.

Under the FRA standards for visual identification, the evaluation of railroad ties considers specific requirements for the number of effective ties within a 39-foot segment of track, varying by class of track. The 39'-foot designation is based off the standard rail stick at the time in the early days of railroading before the invention of continuously welded rail. The 39'-foot rail sticks could be rolled at the mill and transported via rail on existing railroad cars at the time and distributed throughout the system. For Class 1 and 2 tracks, which support lower-speed freight and passenger trains, a minimum of five (5) non-defective ties per 39 feet is required for tangent Class 1 track, and eight (8) non-defective ties per 39 feet is required for tangent Class 2 track. For curves greater than two (2) degrees, the required number of non-defective ties increases to six (6) for Class 1 and nine (9) for Class 2.These standards ensure that the track remains stable under increasing dynamic loads and operational speeds.

Visual identification of ties for replacement focuses on several key factors that affect tie integrity. Inspectors look for signs of excessive splitting, decay, or crushing that compromise a tie's ability to support and anchor the rail. Other indications of a defective tie include deep plate cutting, which can prevent the rail from being held securely, and loose or missing fasteners, which can lead to track misalignment. Additionally, ties that allow for gauge widening, meaning the rails are no longer held firmly in place, are flagged for replacement. If a 39-foot segment falls below the required number of effective ties for the track class, it poses a risk to safety and must be addressed through tie replacement to maintain compliance and operational integrity.

Conversely, ties that meet FRA standards for continued use must exhibit structural soundness and secure rail fastening. A good tie is one that maintains its shape, holds spikes or fasteners firmly, and shows no significant signs of decay or plate cutting. Inspectors verify that these ties can keep the gauge within permissible limits and support the rail under load without visible movement. Even if a tie shows minor surface wear or shallow cracks, it may remain in service if it still meets the minimum tie count requirement per 39 feet for its track class. By systematically evaluating ties using visual identification and ensuring compliance with FRA standards, railroad operators can maintain safe track conditions and reduce the risk of derailments or structural failures under train loading.

Other Track Material (OTM)

Under the FRA standards for visual identification, other track materials such as joint bars, fasteners, and rail anchors are critical components for maintaining track integrity. Joint bars, which connect two rail ends together, are visually inspected for signs of cracking, wear, or deformation. Inspectors look for cracks in the bars, missing bolts, and evidence of rail-end batter, which can compromise the connection. If joint bars are broken, bent, or not tightly holding the rail ends, they are flagged for replacement. For higher classes of track (Class 3 and above), any sign of a defect is a cause for immediate replacement due to the increased stress from higher train speeds. Joint bars that are free of defects, securely bolted, and properly aligned are deemed fit to remain in service.

Fasteners such as spikes, screws, or clips are also closely inspected as part of FRA standards. These fasteners are responsible for securing the rail to the ties and maintaining gauge. Defective fasteners include those that are loose, broken, or missing, as they compromise the stability of the track. Inspectors check for signs of fastener wear, corrosion, or instances where spikes are no longer holding firmly in the tie, often referred to as “spike kill.” For higher-class tracks, the requirement for the number of effective fasteners is more stringent to accommodate higher speeds and loads. Fasteners that are secure, intact, and free from significant wear or corrosion are deemed suitable for continued use, ensuring that the rail remains properly anchored to the ties.

Rail plates help to support and secure the rail section to the tie to distribute the loading and transfer the pressure appropriately throughout the tie into the ballast. Inspectors check for the plates for visual defects and cracking to ensure that the plate is able to support and secure the rail properly. The type of plate being utilized is important to note as it dictates the type of rail fastener that will need to be used. The base of the rail section being utilized determines the size of plate that must be used. This is an important distinction as an increase in the rail section will likely necessitate the replacement of all plates and OTM in a given segment.

Rail anchors, which prevent longitudinal rail movement (known as "rail creep"), are another vital component assessed during visual inspections. Inspectors check for anchors that are missing, displaced, or damaged. Rail anchors must be properly seated against the tie and aligned correctly to resist the forces exerted by train braking and acceleration. If anchors are loose or not contacting the tie firmly, they can no longer serve their function and are identified for replacement. For tracks subject to heavy loads or temperature variations, properly installed anchors are crucial for maintaining rail stability. Anchors that show no signs of wear, are in the correct position, and are tightly seated against the tie are considered fit for service. By ensuring these track materials are visually assessed according to FRA standards, railroads maintain structural integrity and reduce the risk of track failures under train loading.

Roadbed

Under the FRA standards for visual identification, a railroad roadbed is assessed for replacement by observing key signs of degradation that compromise its ability to support track loading safely. Inspectors look for evidence of poor drainage, such as standing water or muddy ballast, which indicates that the roadbed may not be adequately shedding moisture. This can lead to erosion and subgrade instability. Other visual indicators include ballast fouling, where fine particles like dirt or clay infiltrate the ballast and reduce its structural integrity. Track geometry issues, such as dips, sags, or lateral displacement, also signal roadbed weakness. If these conditions are observed, particularly in high-traffic areas, the roadbed is identified for replacement to restore stability and prevent track deformation under the stresses of train operations.

Conversely, a roadbed identified for continued use will display visual characteristics of stability and effective load support. Inspectors look for a clean, well-drained ballast profile with clear, angular stones free of significant contamination. Properly sloped shoulders and ditches that direct water away from the track are signs that the roadbed is effectively managing moisture. The track structure should appear level, with no visible signs of heaving, sagging, or misalignment under train loads. Additionally, if there is no evidence of ballast displacement or erosion, the roadbed is deemed capable of sustaining continued operation. In such cases, regular maintenance activities, like ballast tamping or spot cleaning, are sufficient to ensure the roadbed remains structurally sound. These visual assessments, guided by FRA standards, help ensure that only compromised roadbeds are replaced, maintaining safe and efficient railroad operations.

Rail

Under the FRA standards for visual identification, rail is assessed for removal if it shows signs of defects that compromise track safety and structural integrity under train loads. Inspectors look for visual indicators such as cracks, fractures, or breaks in the rail head, web, or base, which can propagate and lead to rail failure. Common issues like gauge corner cracking, head checks, or vertical split webs are closely monitored, as these defects can compromise the rail’s ability to carry dynamic loads. Additionally, excessive rail wear, including head loss or side wear that exceeds allowable limits for the track class, warrants removal. Rail that exhibits corrugation or deformation, which can cause poor ride quality and increase stress on the track structure, is also identified for replacement to maintain safety and operational efficiency.

Rail identified for continued use must meet the FRA's minimum standards for structural integrity and wear limits. Inspectors ensure the rail shows no visible defects or damage that could compromise its performance under load. A rail with minor surface wear, shallow spalling, or light surface cracking may remain in place if the defects do not affect the structural strength of the rail. Additionally, rails with no excessive wear in the head, web, or base, and that maintain proper alignment and profile, are considered fit for continued use. The rail's ability to distribute train loads evenly and maintain gauge alignment is critical for continued operation. Routine grinding and maintenance help extend the service life of rails by removing minor surface defects before they develop into critical issues.

The FRA standards also emphasize the importance of joint bar integrity and rail end condition for bolted rail sections. Inspectors check for cracks in joint bars, poor bolting, or rail end batter, all of which can compromise joint stability and track continuity. Rail joints that exhibit signs of looseness or misalignment are flagged for repair or replacement. Continuous welded rail (CWR) is also examined for signs of buckling or sun kinks, which can result from thermal expansion and contraction. By systematically identifying rails for removal or retention based on visual criteria, railroads ensure that only structurally sound rails remain in service, reducing the risk of derailments and ensuring the track can handle the stresses of train loading effectively.

Vegetation

Under the FRA standards for visual identification, vegetation control is crucial to maintaining track safety and performance. Vegetation is assessed for removal if it poses a risk to track stability, visibility, or drainage. Inspectors look for overgrown vegetation that obstructs sightlines for train operators, signal visibility, or track inspections. Weeds, grasses, or shrubs growing between ties and along the track bed can trap moisture, leading to track structure deterioration. In addition, roots can infiltrate and destabilize the roadbed, causing tie misalignment or compromising track geometry. Vegetation that impedes proper drainage or encroaches upon the ballast shoulders is flagged for immediate removal to ensure track integrity and safety.

Another critical aspect of visual identification focuses on fire hazards and obstructions to equipment operation. Dry vegetation, such as dead leaves, grasses, or brush along the track, can become a fire risk, especially in areas where trains generate sparks during braking. Additionally, excessive growth on the right-of-way can hinder the safe operation of maintenance equipment, such as tampers or ballast regulators. Trees with limbs hanging too close to the track or vegetation encroaching on clearance zones for trains, signals, or crossings must be trimmed or removed to prevent operational disruptions and ensure compliance with FRA safety standards.

In contrast, some vegetation is allowed to remain in place if it does not threaten the track infrastructure or operations. Low-growing ground cover or grasses that are well-maintained and controlled may help stabilize soil, reduce erosion, and prevent ballast contamination from dust. Vegetation that does not interfere with visibility, drainage, or track access can remain as part of a well-managed right-of-way. By ensuring vegetation is monitored and managed according to FRA standards, railroad operators maintain safe, efficient, and reliable track conditions, minimizing risks to train traffic and infrastructure.

Building on the detailed analysis of track infrastructure deficiencies outlined in the previous section, the following site inspection notes provide an in-depth examination of specific locations along the rail corridor. These notes document the condition of key track components, including rail, ties, other track material (OTM), roadbed, and vegetation, as assessed against FRA standards. Each inspection highlights the unique challenges present at the respective locations, offering insights into the extent of necessary rehabilitation and maintenance. By correlating the deficiencies identified in the broader analysis with the localized observations from these site inspections, this section underscores the immediate actions required to restore the corridor to a state-of-good-repair and ensure safe, efficient rail operations.

At-Grade Crossings

Under the FRA standards for visual identification, railroad at-grade crossings are evaluated for replacement based on key indicators of degradation that may compromise their structural integrity and ability to support track loading safely. Additionally, the crossing must provide a stable and adequate roadway surface to ensure the safe passage of motor vehicles across the at-grade intersection.

Inspectors assess several factors, including excessive mud pumping at the ends of the crossing, settlement or heaving of the crossing materials, and surface deterioration that could pose safety risks. A variety of materials are commonly used for at-grade crossings, including stone, timber, rubber, concrete, and asphalt. Each material type has distinct characteristics that influence its durability and performance, and they are carefully reviewed to determine the remaining lifecycle of the crossing.

Beyond structural integrity, crossing protections and warning devices are considered based on historical safety concerns, geometric and sight-line constraints, the volume and tonnage of rail traffic, roadway traffic density, and other critical design parameters. These assessments align with the standards established by the FRA and the State of Virginia to ensure compliance and safety at all at-grade crossings.

Turnouts, Siding, and Connections

Under the FRA standards for visual identification, turnouts, siding, and rail connections are assessed to ensure they maintain structural integrity and operational efficiency. These track components are critical for routing trains, enabling passing movements, and connecting mainlines with industrial tracks or yards. Their condition is evaluated based on wear, alignment, and degradation that could affect safety and performance.

Turnouts, which allow trains to switch from one track to another, are inspected for worn or broken switch points, misaligned or loose frog components, and excessive flange wear. The condition of switch ties, fastening systems, and the ballast structure beneath the turnout is also examined to identify signs of settlement or inadequate drainage that could lead to track instability.

Sidings, which provide auxiliary tracks for train passing, staging, or storage, are reviewed for rail wear, tie conditions, ballast stability, and the presence of fouled ballast or vegetation that could impact drainage and track performance. Inspectors also assess the siding’s curvature, grade, and turnout connections to ensure it meets operational requirements for the expected train movements.

Rail connections or interchanges, including industrial spurs and junctions, are evaluated for their ability to safely accommodate expected train traffic. Inspectors review joint bar integrity, rail surface conditions, and potential misalignment caused by subsidence or excessive loading. The suitability of these connections is also influenced by traffic volume, axle loads, and the track structure's ability to handle dynamic forces.

As with at-grade crossings, decisions regarding the maintenance, repair, or replacement of turnouts, siding, and rail connections are based on FRA regulations, historical safety data, operational demands, and the standards established by the State of Virginia to ensure the continued safety and efficiency of rail operations.

Site Inspection Notes

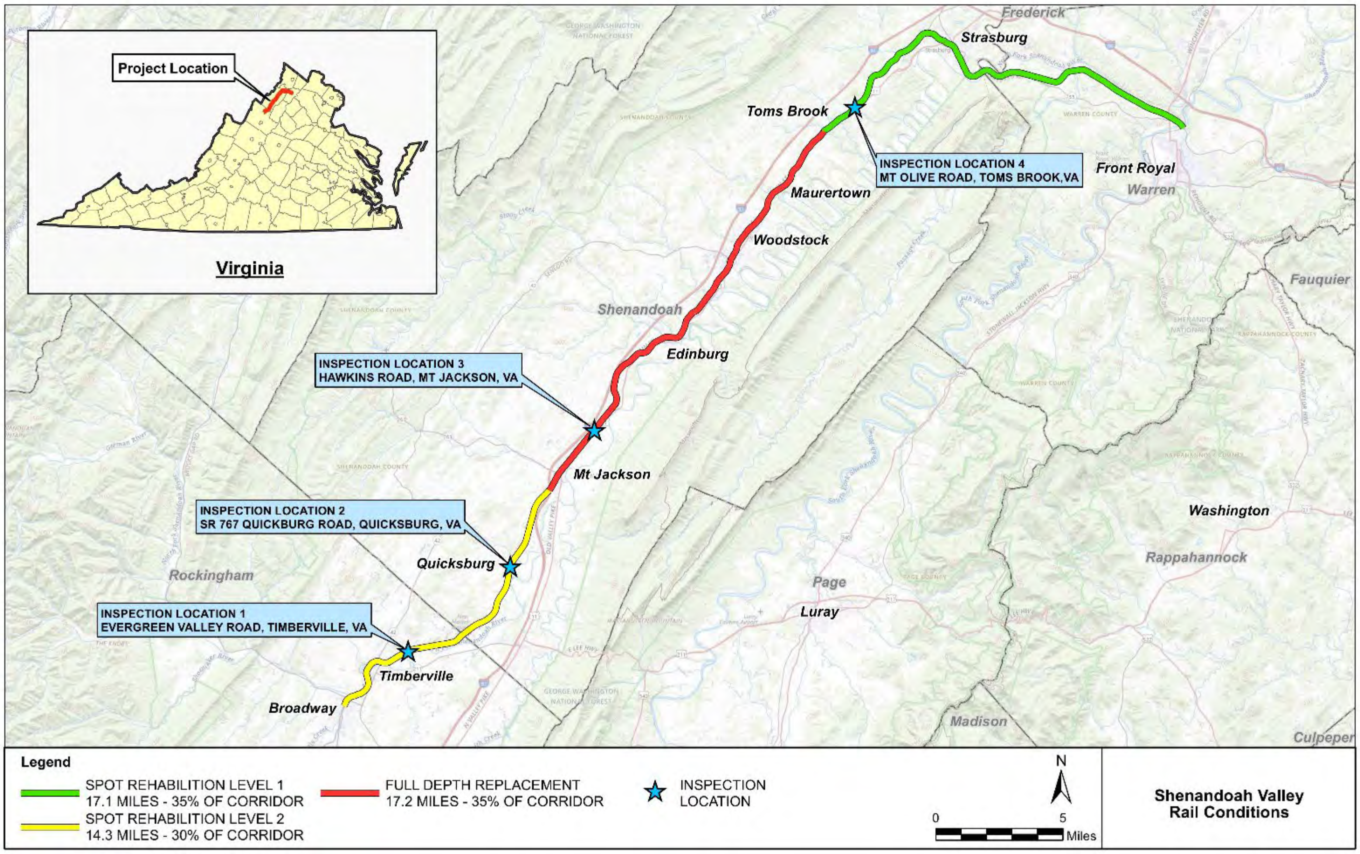


Figure 2 - Site Inspection Locations

Inspection Site Locations

The following inspection sites were selected based on desktop and initial field reviews as locations that provide a thorough sample of field conditions that could be applied to the entire rail corridor for estimating the rehabilitation efforts. One mile of track was inspected at each location.

Inspection Location 1: Evergreen Valley Road, Timberville, Virginia
Inspection Location 2: State Route 767 Quicksburg Road, Quicksburg, Virginia
Inspection Location 3: Hawkins Road, Mt. Jackson, Virginia
Inspection Location 4: Mt. Olive Road, Toms Brook, Virginia

Field investigation notes have been compiled and can be found in the sections below along with a sample of photographs from each inspection location. Additional field investigation photographs can be found within Appendix C-1 of the report.

Figure 3 - Evergreen Valley Road Crossing

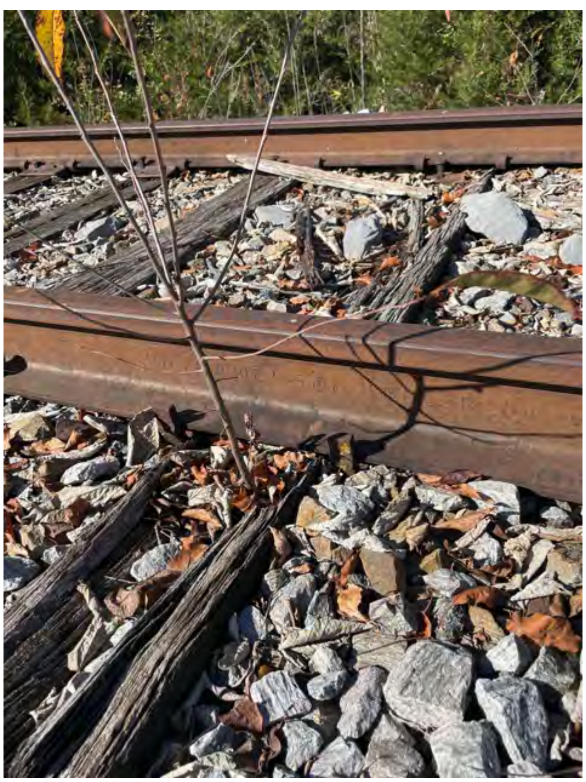


Figure 4 -Defective Crosstie

Inspection Location 1
Location: Evergreen Valley Road, Timberville, Virginia
Railroad Crossing DOT#: 714577J, MP CW-95.99
Inspection Limits: CW-95.24 To CW-96.38

Rail: 1928-100#RB rail that was re-laid and welded in 1988. The rail remains in decent visual condition, though notable rail overflow suggests the possibility of internal defects. There are concerns about the rail's ability to endure significant tonnage, especially given its age and potential for hidden weaknesses.

OTM:. The cut spikes and anchors were found to be in good condition, likely installed when the rail was re-laid in 1988. The plates, dating to the 1940s, were also found to be in good condition. There are no immediate issues with the OTM.

Crossties: Approximately 80% of the ties at this location are in poor condition and require spot replacement to provide adequate support. The ties have signs of decay and splitting.

Roadbed: The roadbed is in relatively good condition, with proper drainage in place. There is excess ballast present, which needs surfacing to improve track stability. Overall, the roadbed condition supports rehabilitation efforts.

Vegetation: Vegetation control is needed, specifically for grass along the track. There is no significant tree overgrowth to address.

At-Grade Crossings: The at-grade crossings that were observed within the inspection limits were asphalt paved crossing in generally good conditions. The crossings included a mix of public and private crossings with active and passive warning devices in place.

Turnouts, Siding Connections: No turnouts, sidings, or connections were inspected or observed

Other Observations: There is landowner encroachment near a bridge where an agricultural irrigation line has been installed under an existing structure near Lohr Lane around MP CW-95.70.

Figure 5 - SR 767 Crossing Vegetation Growth

Figure 6 - Poor Crosstie Condition. 100# Rail and OTM in acceptable condition

Inspection Location 2
Location: State Route 767, Quicksburg, Virginia
Railroad Crossing DOT#: 714560F, MP CW-90.27
Inspection Limits: CW- 89.21 To 90.45

Rail: 1928-100#RB rail that was re-laid and welded in 1988.The rail remains in decent visual condition, though notable rail overflow suggests the possibility of internal defects. There are concerns about the rail's ability to endure significant tonnage, especially given its age and potential for hidden weaknesses. Some rail sections have been transposed, indicating prior maintenance efforts and indicates some replacement of rail will be necessary.

OTM:. The cut spikes and anchors were found to be in good condition, likely installed when the rail was re-laid in 1988. The plates, dating to the 1940s, were also found to be in good condition. There are no immediate issues with the OTM at this inspection location.

Crossties: Approximately 95% of the ties at this location are in poor condition and require spot replacement to provide adequate support. The ties have signs of decay and splitting. The high percentage of deteriorated ties poses a safety risk and impairs track stability. There were several clusters of bad ties which can be alleviated by spot replacement of crossties throughout the entire segment.

Roadbed: The roadbed requires drainage improvements. Specifically, ditches need to be re-established to manage water flow and prevent track instability.

At-Grade Crossings: The crossings included a mix of public and private crossings with active and passive warning devices in place. One public paved asphalt crossing was observed to be in sufficient condition with active warning devices in place at the crossing. The condition of the active warning device is unknown. The other private crossings were in adequate condition and no visible defects were noted.

Turnouts, Siding Connections: No turnouts, sidings, or connections were inspected or observed

Vegetation: Vegetation removal is necessary, with more brush cutting and some tree removal needed.

Inspection Location 3
Location: Hawkins Road, Mt. Jackson, Virginia
Railroad Crossing DOT#: 714536E, MP CW-84.13
Inspection Limits: CW-83.24 To CW-84.20

Rail: This section contains 80/85# jointed rail of unknown date. To ensure safety and reliability, a complete rail replacement to a 115#RE standard is necessary.

OTM: The OTM consists of single-shouldered plates and jointed track with limited or no anchors present. The lack of anchors is a critical deficiency, impacting track stability and safety should this be a CWR territory. The replacement of the rail section would require full replacement of OTM.

Crossties: All crossties are in bad condition and need immediate replacement. The complete deterioration of the ties renders this track unsafe for any form of rail traffic. The replacement of the rail section warrants the replacement of all crossties.

Roadbed: The roadbed is in poor condition, with a minimal ballast section. The ballast is fouled with mud, fines, excess vegetation for a majority of the inspection site. The fouled ballast is leading to drainage issues around the roadbed.

At-Grade Crossings: The crossings found throughout this segment included public and private crossings with active, passive, and no warning devices in place. Several of the private crossings in the industrial area were paved over allowing no rail traffic. All grade crossings would need to be replaced with the updated rail section and would need to have warning devices evaluated. Public At-grade crossings in Mt. Jackson were also found to have been paved and don’t allow for rail traffic.

Turnouts, Siding Connections: There was an industrial turnout connection to the mainline that would need to be replaced if the industry was to resume freight service via rail.

Vegetation: Vegetation removal is needed to clear brush and improve accessibility. The excess vegetation is impacting the drainage quality and would require removal to improve drainage.

Figure 7 – Fouled Ballast, Jointed 85# Rail, Excessive Tie Deterioration

Figure 8 - Poor Crosstie Condition

Figure 9 – Small Diameter Tree Growth within Segment

Figure 10 - Excessive Vegetation Overgrowth

Inspection Location 4
Location: Mt. Olive Road, Toms Brook, Virginia
Railroad Crossing DOT#: 714482B, MP B-66.70
Inspection Limits: B-66.28 To B-67.40

Rail: This section features 1980s 132# RE CWR rail, which is in good visual condition. The rail remains in decent visual condition, though notable rail overflow suggests the possibility of internal defects.

OTM: The plates, cut spikes, and anchors are in good condition. However, additional spiking is recommended to enhance track security.

Crossties: Approximately 95% of the ties are in a condition such that rapid deterioration would occur should they be returned to service after strategic replacement. The ties have signs of decay and splitting. Replacing these ties is essential for maintaining track stability and ensuring safe operations.

Roadbed: Ballast addition and drainage improvements are required. Ditches need to be re-established to manage water flow and maintain roadbed integrity. The excessive vegetation is leading to reduced drainage quality, impacting the roadbed stability.

At-Grade Crossings: No grade crossing were present at this inspection location. However, when traversing the entire corridor near this inspection location several public grade crossings were utilized and found to be good condition with both passive and active warning devices.

Turnouts, Siding Connections: No turnouts, sidings, or connections were inspected or observed within this segment. Strasburg Junction with CSX was inspected and found to have existing turnouts with a lot of overgrowth in vegetation. Should this connection be preferred additional inspections would be required to thoroughly inspect the turnouts.

Vegetation: Excessive overgrowth of vegetation was noted along with trees with significant trunks and root systems. The trunks of the trees should be removed to ensure proper drainage of the roadbed.

Inspection Assessment

To properly categorize and develop a track rehabilitation plan, a track assessment matrix was developed to identify and analyze the inspection based on several key characteristics of the rail corridor. To begin, the corridor has 3 distinct segments; the North, Central, and South segments that have clear termination points with changes in condition and material which correlate to when segments were removed from freight service. Using the segments as a delineator, categories of track condition were then assigned to each segment.

North: B-51.00 (Shenandoah River, Front Royal, Va) to B-68.20 (Jordan's Run, Toms Brook, Va).
Central: B-68.20 (Jordan Run Bridge, Toms Brook, Va) to CW-85.30 (Valley Road, Mt Jackson, Va).
South: CW-85.30 (Valley Road, Mt Jackson, Va) to CW-99.60 (Lee Street, Broadway, Va).

Rail Assessment

North: The rail present was 1980's 132# CWR that was found to have some minor rail overflow. Selective curve worn and defective rail replacement may be required.

Central: The rail was found to consist of 80# and 85# jointed rail with an unknown age. This rail section is undersized and likely has internal defects which could impact the safety of freight operations along with material procurement issues. There were several locations where the rail was missing either from complete removal or unable to be located due to excessive undergrowth or excessive silting in of the track structure. Full rail replacement for the entire segment.

South: The rail was found to be late 1920/30's era 100# RB that was re-laid and fully welded to CWR in 1988. The rail remains in decent visual condition though some notable overflow and transposing (swapping the high rail to low rail to prolong rail use). There are concerns about the rail's ability to endure significant tonnage, especially given its age and potential for hidden weaknesses. Select replacement of curve worn and defective rail is warranted.

Crosstie Assessment

North: Approximately 95% of the crossties are in a condition requiring strategic replacement for maintaining track stability and proper Class 2 track standards. The condition of the crossties were such that increased loadings would likely lead to rapid deterioration once the line was returned to service. The condition throughout this segment was such that a vast majority of the crossties would likely provide inadequate support per the FRA definition as non-defective ties.

Central: Approximately 100% of the crossties are in a condition requiring strategic replacement for maintaining track stability and proper Class 2 track standards. The conditions of the ties throughout this segment were either non-existent or had extremely decayed and were deemed defective. The rail condition assessment requires that the crossties be replaced with the larger base of rail with a new section and the extremely deteriorated crossties.

South: Approximately 80% of the ties are in a condition requiring strategic replacement for maintaining track stability and proper Class 2 track standards. Similarly, to the North segment the tie conditions in this segment would likely lead to rapid deterioration once returning to service without a strategic Class 2 tie replacement program. The existing ties that are to remain in service will see some extended life cycle benefits through the strategic replacement of adjacent ties and the removal of large bad crosstie clusters.

OTM Assessment

North: The existing plates are double-shouldered plates with cut-spike fasteners and rail anchors providing adequate support and longitudinal restraint holding proper gage, alignment, and surface. A majority of the existing OTM can be reused and remain in place within this segment. However, additional OTM has been accounted for within the rehabilitation estimates. The amounts accounted for include additional plates, spikes, and anchors required for the tie renewal program. Additionally, anchors and spikes have been accounted for with curve rail renewals.

Central: The existing OTM is inadequate to provide support for the larger rail section that will need to replace the existing rail. The OTM includes single shoulder plates, inadequate sized plates, and no rail anchors on the jointed track sections located throughout this segment. All OTM will need to be replaced for the entire segment with the installation of the new rail section.

South: The existing OTM for this segment was found to be in an acceptable condition for continued use. The plates and spikes were still providing adequate loading support, and the rail anchors showed no sign of allowing excessive rail movement. A majority of the existing OTM can be reused and remain in place within this segment. However, additional OTM has been accounted for within the rehabilitation estimates. The amounts accounted for include additional plates, spikes, and anchors required for the tie renewal program. Additionally, anchors and spikes have been accounted for with curve rail renewals.

Track Surface, Roadbed, & Ballast Assessment

North: This segment has adequate ballast and very few locations of fouled ballast. The track surface appeared to be in sufficient shape to provide adequate track support and load distribution from the ties through to the subgrade. The ballast was free from fines and provided adequate drainage throughout the ballast section. The track roadbed is well defined and adequate for freight or passenger operations.

Central: The track surface, roadbed, and ballast condition throughout this segment was found to be fouled and inadequate with some locations having little to no visible ballast. The alignment and track profile had multiple locations where the track surface was deteriorated to a point that was no longer within Class 1 track standards.

South: This segment has adequate ballast and very few locations of fouled ballast. The track surface appeared to be in sufficient shape to provide adequate track support and load distribution from the ties through to the subgrade. Some slight track surface profile deviations were observed that should be addressed. The ballast was free from fines and provided adequate drainage throughout the ballast section. There was some excess ballast located throughout the inspection area that could inhibit proper drainage and could lead to premature deterioration of OTM material due to moisture.

Drainage Assessment

North: Existing ditches have been established to promote adequate drainage away from the track structure. However, some of the existing drainage ditches experienced heavy vegetation overgrowth and debris which is inhibiting the drainage.

Central: The existing track drainage was non-existent, and ditches were vastly overgrown with vegetation and blocked with debris. The existing ballast section was extremely fouled which allows for little to no drainage across the track structure.

South: This elevated segment of track provides positive drainage away from the track structure. Some minor overgrowth was blocking the existing track drainage ditches but no major failures or undercapacity structures were identified.

Vegetation and Tree Removal Assessment

North: The northern segment includes a section that is comprised of a right-of-way that is heavily wooded up to the track. The dense vegetation along the right-of-way has created an environment where there is excessive overgrowth and the growth of medium diameter trees.

Central: Excessive overgrowth of brush and vegetation was found throughout the segment. The central segment has been out of service for over 3 decades and has seen excess tree growth with medium to large trees and overhang that needs to be removed throughout the entire corridor.

South: General overgrowth of brush and vegetation was found throughout the segment. Some small diameter tree growth was found at some locations during the inspections. The vegetation removal was found to be necessary throughout the segment and the tree removal for small diameter trees along the right-of-way is needed.

Based on inspection and analysis of a variety of key characteristics of the existing track infrastructure. The segments are categorized as follows:

North - Spot Rehabilitation - Level 1: B-51.00 (Shenandoah River, Front Royal, Va) to B-68.20 (Jordan's Run, Toms Brook, Va).

- The spot rehabilitation can be described as requiring only strategic replacements of critical track structure components to return the section of track to Class 2 standards. Most of the track structure is in adequate condition but would require strategic spot replacements to ensure that proper operating conditions are in order and that any capital improvements to the corridor would have longevity. The Level – 1 designation is minimal spot replacements needed to return the corridor to service.

Central - Full Depth Replacement: B-68.20 (Jordan's Run, Toms Brook, Va) to CW-85.30 (Valley Road, Mt Jackson, Va).

- The full depth replacement can be described as requiring a full removal of the existing inadequate track structure and roadbed and replacing the track components with new or like new track components necessary to return the segment of track to service.

South - Spot Rehabilitation - Level 2: CW-85.30 (Valley Road, Mt Jackson, Va) to CW-99.60 (Lee Street, Broadway, Va).

- The spot rehabilitation can be described as requiring only strategic replacements of critical track structure components to return the section of track to Class 2 standards. Most of the track structure is in adequate condition but would require strategic spot replacements to ensure that proper operating conditions are in order and that any capital improvements to the corridor would have longevity. The Level – 2 designation is selective spot replacements needed to return the corridor to service.

Track Inspection Matrix

Segment	From		To		Length (Miles)	Classification	Rail Replacement	Rail Section	Tie Replacement	OTM	Roadbed, Surface, and Ballast	Drainage	Vegetation Removal	Tree Removal
	City	Milepost	City	Milepost										
North	Front Royal	B-51.00	Tom's Brook	B-68.20	17.20	Spot Rehabilitation - Level 1	Strategic Replacement - Curve Worn & Defective	Existing 132#RE	Strategic Replacement for Class 2 Standards	Replace Broken or Missing	Minor Track Surfacing	Moderate/Heavy Ditch Cleaning Required	Medium Brush and Overgrowth Removal	Medium Tree Removal
Central	Tom's Brook	B-68.20	Mt Jackson	CW-85.30	17.10	Full Depth Replacement	Full Replacement	Existing 80#/85# Replace with new 115# RE	Full Depth Replacement	Full Replacement	Fouled or Inadequate	Major Drainage Improvements Required	Heavy Brush and Overgrowth Removal	Heavy Tree Removal
South	Mt Jackson	CW-85.30	Broadway	CW-99.60	14.30	Spot Rehabilitation - Level 2	Strategic Replacement - Curve Worn & Defective	Existing 100#RB	Strategic Replacement for Class 2 Standards	Replace Broken or Missing	Moderate Track Surfacing	Minor Ditch Cleaning Required	Medium Brush and Overgrowth Removal	Minor Tree Removal Required

Figure 11 - Track Inspection Matrix

Track Rehabilitation Recommendations

The desktop review and site inspections allowed for the segmentation of the rail corridor into three categories to generate a scalable approach to the rehabilitation efforts required in each area. The 49-mile corridor included a wide array of track material and conditions that require upgrades and replacement. The track rehabilitation recommendations are based on operating the corridor as an FRA class of track as Class 2 which allows for the maximum allowable speed of 25 MPH for Freight trains and 30 MPH for Passenger trains. The recommendation of Class 2 track standards provides an increase to the longevity and stability to the track structure after the rehabilitation efforts have been completed as well as a factor of safety against the minimum standards. This will ensure that the track infrastructure is stabilized and rehabbed to a state-of-good-repair that will allow for safe and efficient operations without substantially exceeding the standards.

The corridor was categorized as follows running from North to South along the alignment:

North - Spot Rehabilitation – Level 1: North B-51.00 (Shenandoah River, Front Royal, Va) to B-68.20 (Jordan’s Run, Toms Brook, Va).
Central - Full Depth Replacement: B-68.20 (Jordan’s Run, Toms Brook, Va) to CW-85.30 (Valley Road, Mt Jackson, Va).
South-Spot Rehabilitation – Level 2: CW-85.30 (Valley Road, Mt Jackson, Va) to CW-99.60 (Lee Street, Broadway, Va).

A track rehabilitation plan has been developed for each segment of track based on the category of the findings to ensure that the proper remedial efforts are performed to return the track to a state-of-good-repair with an efficient approach in mind.

A detailed breakdown of the estimated quantities for the rail corridor can be found in Appendix C-2 of the report. A detailed breakdown for the estimated costs of the recommended rehabilitation efforts can be found in Appendix C-3 of the report.

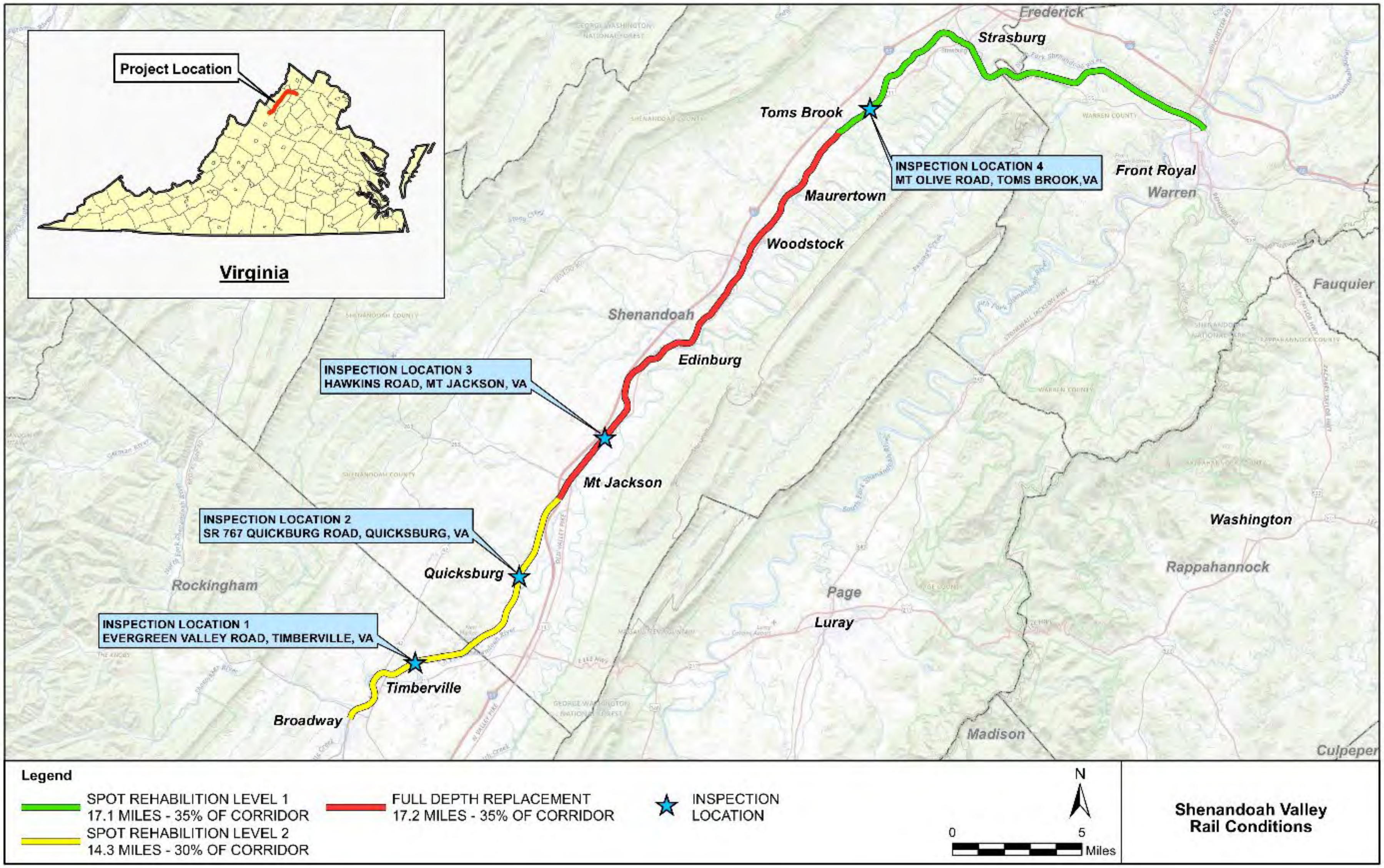


Figure 12 - Shenandoah Valley Rail Conditions

North - Spot Rehabilitation – Level 1: B-51.00 (Shenandoah River, Front Royal, Va) to B-68.20 (Jordan's Run Toms Brook, Va).

Rail

The existing 132# CWR rail throughout this segment of track was found to be in good condition and adequate for the proposed rail operations. It is recommended to account for a 5% replacement of the rail throughout this segment to account for excessively curve worn rail, locations where turnouts will be removed and straight railed, and to remove any internal defects that might be present. The rail should be ultrasonically tested to identify internal defects and flaws that could lead to safety issues and impacts on the operations.

Crosstie

The ties along this segment require a strategic replacement to establish a condition that allows Class 2 track standard of crossties to provide adequate support and a contingency to ensure that the track structure can deliver longevity when it returns to operations. The tie spacing is critical to determine the number of ties to replace along a 39' track segment to meet and exceed the minimum FRA Class 2 standards. The existing tie spacing was found to be 20" which is standard within the freight industry and allows for proper rail loading support to ensure proper distribution to reduce track surface issues while prolonging the rail life with adequate support. At 20" tie spacing it is recommended that 42% of ties are changed providing some contingency above the minimum Class 2 tie requirements for both tangent and curved track sections.

OTM

The existing 132# rail plates are in satisfactory condition and can be reused throughout the entire segment. The replacement of crossties to Class 2 standards will allow for the reuse of the existing plates on the new tie but will require 6 new spikes per tie in tangent and 8 new spikes per tie in curves to ensure proper holding strength. The existing ties that are to remain in track should have an additional spike added to each plate to add additional holding strength to the existing tie and plate. The existing anchors can remain in track except for where there are impacts due to tie or rail replacements in which case when the anchors have been removed, they should be replaced with new anchors to ensure that sufficient holding power is provided.

Track Surface, Roadbed & Ballast

The existing track surface, roadbed, and ballast of the segment was found to be in adequate condition to provide a solid foundation for operations. A skim lift of one inch is recommended to restore the proper alignment and geometry before returning to operations. A skim lift will require track surfacing to help remove any track deviations to help ensure that the loadings are properly distributed throughout the track structure which will additionally help to increase the lifecycle of the track components.

Drainage

The drainage structures and ditches along the right-of-way should be cleared and re-established by removing excess vegetation and debris to ensure adequate drainage. Proper drainage around the track structure is vital to increasing the lifecycle of track components and reducing long-term maintenance costs.

At-Grade Crossings

This segment includes a mix of public and private at-grade crossings, with surfaces ranging from stone to concrete panels. Although no immediate work is recommended on the crossing approaches or track structure, there are concerns regarding the condition and reliability of the active warning systems, especially since the line is currently out of service. While no inspection or testing of these systems has been conducted, the estimate includes provisions for their replacement and upgrade to address outdated technology and potential deficiencies in the electrical and signal systems, should a new operator take over corridor maintenance. The condition of the track components at the grade crossings have likely experienced an accelerated rate of deterioration and replacement of the track components at the all at-grade active and passive crossings has been accounted for within the estimate.

Turnout, Siding, and Connections

This segment includes two potential interchange points to Class 1 railroad carriers Norfolk Southern and CSX. If the rail corridor is to include freight operations re-establishing these historical interchange points will be crucial to the success and vitality of this corridor handling freight. On the north end of the segment at MP B-51.0 in Front Royal, Va is the location of the most recent connection to the corridor at Riverton Jct. on the east side of the Shenandoah River. The connection at this location would require establishing operation and maintenance agreements with Norfolk Southern and would require re-establishing the track connection via a railroad crossing diamond to access the NS tracks. The installation of a crossing diamond across a mainline track has numerous maintenance and operational impacts and is not preferred by railroads. While it is unknown if the connection would be permitted by Norfolk Southern it has been recommended and has been accounted for within the estimate as a necessary track item should freight operations be desired/considered.

Another Class 1 freight carrier that historically connected to the rail corridor is at Strasburg Junction at MP B-62.7. Currently, CSX owns and operates the tracks up to the connection point from the north side of the rail corridor. The existing connection is currently out of service and the condition of the track is unknown. To re-establish this connection an operation and maintenance agreement would need to be established and would follow all applicable CSX standards and requirements.

Should tourist-only operations be the preferred operating alternative of the rail corridor the interchange points and agreements would not be necessary. While most track materials can be delivered in bulk via the rail network without a connection/interchange point material distribution and handling must turn toward roadway delivery increasing the complexity and difficulty of the construction and storage process.

A certain level of rehabilitation will be required at the existing turnouts along the corridor, regardless of the future operating environment. While the final configuration of sidings and industrial connections has not yet been determined, these turnouts represent key points of potential operational use and safety concern. As such, this report includes allowances for spot rehabilitation at turnouts in both the North and South segments. In cases where diverging routes are not anticipated, straight-railing (removing the diverging route from operation) the turnouts is a practical interim measure to minimize maintenance and enhance safety. However, even in those scenarios, baseline rehabilitation is still necessary to ensure structural integrity and operational reliability. Although full rehabilitation of sidings and industrial tracks is not included in the current estimate due to limited information on future use, this approach ensures that critical infrastructure at the turnouts is addressed in the near term.

Central – Full Depth Replacement: B-68.20 (Jordan's Run, Toms Brook, Va) to CW-85.30 (Valley Road, Mt Jackson, Va).

Rail

The 80# and 85# rail throughout this segment is vastly undersized for modern freight operations. The age and size of the existing rail throughout this segment leads to concern about long-term viability with increased loadings. It is recommended for full-depth replacement of the track structure throughout the central segment due to several factors, one being the rail section. A rail section of 115# is recommended to replace the existing rail throughout the segment. The 115# rail section is readily available and provides the minimum current industry standard for readily available rail section providing adequate support of the loadings. The 80# and 85# rail removed can provide some scrap value to offset the replacement.

Crosstie

The tie condition is such that a replacement of 42% would be the minimum number of ties to return the segment back to operational conditions. However, with the replacement of the rail section from 80/85# to 115# this would require all existing plates be replaced with new larger dimension plates to support the increase in rail size. The larger 115# plate footprint would relocate the spiking pattern and require adzing of the existing ties that remain, which could lead to existing ties with limited holding power and rapid deterioration requiring replacement after a return to service. While there could be some cost savings by strategically replacing crossties to Class 2 minimum standards, the overall concern is the condition of the existing ties and the limited life expectancy if they were to remain. Additionally, the ballast and roadbed condition are such that there are vast locations where the ballast is missing or inadequate to support the loadings.

The recommendation is to replace 100% of the crossties to accommodate the new rail section and OTM, to account for track segments that have been removed, and to reduce maintenance costs and concerns once returning to service.

OTM

The replacement of the rail section to 115# will require full replacement of all OTM (plates, spikes, and anchors) to accommodate the increase in the rail base width and to provide adequate support to transfer the loadings from the rail into the subgrade. The base of rail width is important when considering rail replacement and the existing OTM. A rail section of 115# has a base width of 5.5" while the 80#/85# base width is less than 5.5" requiring that all OTM be replaced.

Track Surface, Roadbed & Ballast

The existing ballast is completely fouled, missing, or inadequate to provide proper track support. Undercutting is a method of ballast removal that allows for the track structure to remain in place, while the existing ballast is removed and replaced through the use of a specialized machine or attachment that utilizes a bar chain to cut the deficient ballast out from under the tracks. However, the existing crosstie condition is so poor throughout this segment that the use of an undercutter is not feasible and would destroy the existing crossties requiring additional replacements and likely excessive delays. Thus, a full depth replacement of the ballast and track structure is being recommended.

The recommendation is to utilize the existing roadbed subgrade by removing all existing fouled ballast, fines, and vegetation. Then replace with a new 9” ballast section to ensure proper drainage and track support of the new rail section.

Drainage

The drainage structures and ditches along the right-of-way should be cleared and re-established by removing excess vegetation and debris to ensure adequate drainage. Proper drainage around the track structure is vital to increasing the lifecycle of track components and reducing long-term maintenance costs.

Vegetation & Tree Removal

This segment of the corridor has been out of service for decades which has allowed dense vegetation to cover the entire right-of-way. It is recommended that all vegetation be removed throughout the segment through brush cutting and proper weed spraying to control excess growth. Additionally, large trees have taken over the corridor and require removal beyond just standard brush cutting. Tree removal efforts should be performed throughout this segment of right-of-way to remove all trees and roots growing through the track structure and overhanging the clearance envelop of the corridor.

At-Grade Crossings

The assessment identified multiple at-grade crossings in this area that have been paved over and currently lack active warning devices, despite serving busy roadways. Given these conditions, it is likely that all existing active warning crossings will need to be replaced or upgraded to meet safety and compliance standards. Improvements should include replacing crossing panels to maintain proper track alignment, adjusting roadway approaches for a smooth transition, and ensuring adequate drainage to prevent water pooling that could degrade both the track and roadway surface. There are concerns regarding the condition and reliability of the active warning systems, especially since the line has been out of service for decades. While no inspection or testing of these systems has been conducted, the estimate includes provisions for their replacement and upgrade to address outdated technology and potential deficiencies in the electrical and signal systems, should a new operator take over corridor maintenance. Additionally, missing or worn crossbucks, warning signs, and signal components should be replaced, and pavement markings should be refreshed or installed in accordance with local regulations to improve visibility and safety. No track components have been accounted for within the at-grade crossing item for this segment, as the entire segment is being upgraded and trackwork has been accounted for within the full replacement item.

Turnout, Siding, and Connections

Given the uncertainty regarding future operations and the need for turnouts and sidings along this corridor, no rehabilitation is being recommended on these elements at this time. In central segment, which consists of a small rail section, removal of the siding from service was assumed rather than rehabilitation. The existing turnouts will be removed and replaced with standard track. Once the demand for freight operations has been determined by industries along the corridor, turnouts can be installed as necessary to provide access to the main line track to support this transportation demand.

South - Spot Rehabilitation – Level 2: CW-85.30 (Valley Road, Mt Jackson, Va) to CW-99.60 (Lee Street, Broadway, Va).

Rail

The existing 100# CWR rail throughout this segment of track was found to be in good condition and adequate for the proposed rail operations. It is recommended to account for a 10% replacement of the rail throughout this segment to account for excessively curve worn rail, locations where turnouts will be removed and straight railed, and to remove any internal defects that might be present. The rail should be ultrasonically tested to identify internal defects and flaws that could lead to safety issues and impacts on the operations.

Crosstie

The ties along this segment require a strategic replacement to establish a condition that allows Class 2 track standards of ties to provide adequate support and a contingency to ensure that the track structure can deliver longevity when it returns to operations. The tie spacing is critical to determine the number of ties to replace along a 39’ track segment to meet and exceed the minimum FRA Class 2 standards. The existing tie spacing was found to be 20” which is standard within the freight industry and allows for proper rail loading support to ensure proper distribution to reduce track surface issues while prolonging the rail life with adequate support. At 20” tie spacing it is recommended that 42% of ties are changed providing some contingency above the minimum Class 2 tie requirements for both tangent and curved track sections.

OTM

The existing 100# rail plates are in satisfactory condition and can be reused throughout the entire segment. Replacing the crossties to Class 2 standards will permit the reuse of these plates on the new ties. However, to ensure proper holding strength, six new spikes per tie will be required, or eight per tie in turnouts and curves. The existing ties that are to remain in track should have an additional spike added to each plate to add additional strength to the existing tie and plate. The existing anchors can remain in track except for where there are impacts due to tie or rail replacements in which case when the anchors have been removed, they should be replaced with new anchors to ensure that sufficient holding power is provided.

Track Surface, Roadbed & Ballast

The existing track surface, roadbed, and ballast of the segment was found to be in adequate condition to provide a solid foundation for operations. A skim lift of one inch is recommended to restore the proper alignment and geometry before returning to operations. A skim lift will require track surfacing to help remove any track deviations in alignment and profile to help ensure that the loadings are properly distributed throughout the track structure which will additionally help to increase the lifecycle of the track components.

Drainage

The drainage structures and ditches along the right-of-way should be cleared and re-established by removing excess vegetation and debris to ensure adequate drainage. Proper drainage around the track structure is vital to increasing the lifecycle of track components and reducing long-term maintenance costs.

Vegetation & Tree Removal

This segment of the corridor has been out of service which has allowed for vegetation to overgrow the track structure. It is recommended that all vegetation be removed throughout the segment through brush cutting and proper weed spraying to control excess growth. Some minor tree removal efforts should be performed at select locations for this segment of right-of-way.

At-Grade Crossings

This segment includes a mix of public and private at-grade crossings, with surfaces ranging from stone to concrete panels. Although no immediate work is recommended on the crossing approaches or track structure, there are concerns regarding the condition and reliability of the active warning systems, especially since the line is currently out of service. While no inspection or testing of these systems has been conducted, the estimate includes provisions for their replacement and upgrade to address outdated technology and potential deficiencies in the electrical and signal systems, should a new operator take over corridor maintenance. The condition of the track components at the grade crossings have likely experienced an accelerated rate of deterioration and replacement of the track components at the all at-grade active and passive crossings has been accounted for within the estimate.

To mitigate potential track degradation, drainage improvements should be made by clearing debris and re-establishing proper water flow around the crossings. This will help prevent water accumulation, which could weaken the track substructure and create unsafe conditions. Furthermore, pavement markings should be refreshed or newly installed in accordance with regulatory guidelines to enhance crossing visibility for approaching motorists. These improvements will collectively contribute to a safer and more reliable crossing environment for both rail and road users.

Turnouts, Sidings, and Connections

Given the uncertainty regarding future operations and the need for turnouts and sidings along this corridor, no rehabilitation is being recommended on these elements at this time within this segment. The existing turnouts will be removed and replaced with standard track. Once the demand for freight operations has been determined by industries along the corridor then turnouts can be installed as necessary to provide access to the main line track to support this transportation demand.

The southern segment of the corridor is currently connected to the Norfolk Southern system and would allow for a point of interchange between the corridor and the Class 1 railroad.

The existing connection is physically intact and would require minimal trackwork to re-establish this connection. While the trackwork necessary to re-establish the connection is minimal there would still need to be an operating and interchange agreement in place to establish this connection. This connection to a Class 1 freight carrier would allow for easier access to an established mainline carrier within minimal infrastructure improvements.

Entire Corridor – Additional Considerations: B-51.0 (Shenandoah River, Front Royal, Va) to CW-99.60 (Lee Street, Broadway, Va).

Maintenance Facility

Currently, there is no known existing maintenance facility located anywhere along the rail corridor. This is an important consideration that has not been included in the rehabilitation estimates but would need to be identified when considering returning the rail corridor to operations as a stand-alone shortline railroad or tourist operation. The facility would need rail access to the mainline and provide the ability to maintain the rail fleet. The facility would additionally need to provide office and crew accommodations depending on the proposed operating environment. The maintenance facility would require additional capital expense and likely additional right-of-way.

Right-of-Way Considerations

There were numerous apparent right-of-way encroachments noted throughout the rail corridor. These encroachments are likely due to the fact that the rail corridor has been out of service for many years and decades in some locations. During this period of time parking lots, buildings, storage sheds, utilities, irrigation pipes, etc. were constructed on the right-of-way property line or very near which could create friction between private landowners and the rehabilitation of the rail line. A detailed survey of the corridor should be considered to obtain accurate land boundary information to help identify conflicts. These land conflicts could inhibit construction mobilization and would likely disrupt the current aesthetics in numerous communities along the rail corridor. Areas that are currently lush barriers of vegetation would become an open rail corridor with new sightlines and perhaps unwanted removal of natural barriers.

Rail with Trail

While the findings of Phase I of the Rail with Trail Assessment indicate that a rail-with-trail option can be accommodated with the existing roadbed in its current location, it should be noted that additional track work effort could be required should preliminary engineering discover site conditions that would warrant moving the track alignment. Based off of the Phase I findings, the aforementioned track rehabilitation efforts have not included relocating the track alignment, which would necessitate the need for a full-depth track structure including additional grading, compaction, and subballast placement on the new alignment that would incur significant increases in track work costs. Costs to relocate the track alignment have not been included and would require significant increases in track work costs.

In addition to the planned track improvements, the installation of fencing along select portions of the corridor is recommended to enhance safety and reduce the risk of pedestrian encroachment onto the rail right-of-way. Given the rail-with-trail configuration of this project in Virginia, where recreational users and rail operations will run in close proximity, physical separation is essential to prevent unauthorized access and ensure the safety of both the public and rail personnel. Fencing will be especially important near trailheads, residential areas, schools, and commercial zones with higher foot traffic. It will serve as a visual and physical barrier, helping to prevent accidents, discourage trespassing, and preserve the operational integrity of the rail corridor. The proposed fencing should meet applicable safety standards, potentially using anti-climb or mesh materials and be designed to blend with the surrounding environment while providing clear delineation between the trail and railway.

Conclusion

The purpose of this track rehabilitation report is to provide an assessment of the existing condition and the necessary track rehabilitation recommendations of the existing Shenandoah Valley Rail alignment to allow for the rail corridor to return to service with the potential to offer both freight and tourism rail service throughout the region. The recommendations cover rehabilitation of a 49-mile rail corridor from Front Royal to Broadway, Virginia. The corridor exhibited three distinct conditional segments which were confirmed both with a desktop review of available documents and field inspections of four select one-mile segments covering the three conditions. The northern section of the corridor from B-51.0 (Front Royal) to B-68.2 (Toms Brook) requires Spot Rehabilitation – Level 1 efforts and requires selective rehabilitation to return the corridor to the proper standards and to ensure longevity in either operational environment. The central segment of the corridor from B-68.2 (Toms Brook) to CW-85.3 (Mt Jackson) requires a Full Depth Replacement of the track structure. The southern segment of the corridor from CW-85.3 (Mt Jackson) to CW-99.6 (Broadway) requires Spot Rehabilitation – Level 2 efforts and requires selective rehabilitation to return the corridor to the proper standards and to ensure longevity. The classifications and recommendations of track rehabilitation were found to align with the operational history of the line and correlate to when certain segments were removed from service.

It is important to note that while four site inspections were performed across the corridor, which was aligned with the information that was found with the desktop review, these inspections only account for four miles of the 49-mile corridor, equivalent to 8% of the entire rail corridor. In order to get a more thorough understanding of the rail corridor condition and the existing condition of the track structure, it would be important to remove vegetation and overgrowth throughout the project limits. After removing the excess vegetation, an in-depth track inspection covering the entire 49-mile section could be performed to help get a better understanding of the track rehabilitation efforts required.

Appendix C-1

Field Inspection Photos

SITE VISIT PHOTO SHEET (SHEET 1 OF 5)

PROJECT: SHENANDOAH VALLEY RAIL CORRIDOR

LOCATION: TIMBERVILLE, VA – EVERGREEN VALLEY ROAD (DOT 714577J)

RAILROAD LOCATION: MP CW-95 - SPOT REHABILITATION LEVEL 2

PHOTO #:	FACING:	MP:
1	RR-EAST	CW95

NOTES: RAIL/OTM – 1928 CWR, Relay Welded 1988, 100 RB. Overflow. Cut Spikes with Anchors 1940s

PHOTO #:	FACING:	MP:
2	RR-WEST	CW95

NOTES: TIE – visual approx. 80% ties insufficient

PHOTO #:	FACING:	MP:
3	RR-EAST	CW95

NOTES: ROADBED – Drainage Good, Excess ballast not tamped. Minor vegetation control

PHOTO #:	FACING:	MP:
4	RR-EAST	CW95

NOTES: GENERAL AREA APPEARANCE – Brush growth, roadbed and drainage in good condition.

SITE VISIT PHOTO SHEET (SHEET 2 OF 5)

PROJECT: SHENANDOAH VALLEY RAIL CORRIDOR

LOCATION: QUICKSBURG, VA – SR 767 QUICKBURG ROAD

RAILROAD LOCATION: MP CW-90 - SPOT REHABILITATION LEVEL 2

PHOTO #:	FACING:	MP:
5	RR-EAST	CW90

NOTES: RAIL/OTM – 1928 CWR, Relay Welded 1988, 100 RB. Overflow. Cut Spikes with Anchors 1940s

PHOTO #:	FACING:	MP:
6	RR-EAST	CW90

NOTES: TIE – visual approx. 95% ties insufficient, numerous bad tie clusters present

PHOTO #:	FACING:	MP:
7	RR-EAST	CW90

NOTES: ROADBED – Drainage Poor, Re-establish Ditches. Moderate Vegetation Removal

PHOTO #:	FACING:	MP:
8	RR-WEST	CW90

NOTES: GENERAL AREA APPEARANCE – Brush overgrowth.

SITE VISIT PHOTO SHEET (SHEET 3 OF 5)

PROJECT: SHENANDOAH VALLEY RAIL CORRIDOR

LOCATION: MT JACKSON, VA – HAWKINS ROAD

RAILROAD LOCATION: MP CW-84 - SPOT REHABILITATION LEVEL 3

PHOTO #:	FACING:	MP:
9	RR-WEST	CW84

NOTES: RAIL/OTM – 1914 Jointed, 85 LB. Single Sided Plates No Anchors

PHOTO #:	FACING:	MP:
10	RR-EAST	CW84

NOTES: TIE – visual approx. 100% ties insufficient

PHOTO #:	FACING:	MP:
11	RR-WEST	CW84

NOTES: ROADBED – Drainage Poor. Unable to inspect ballast condition. Mud present. Moderate vegetation control

PHOTO #:	FACING:	MP:
12	RR-EAST	CW84

NOTES: GENERAL AREA APPEARANCE – Fouled ballast and poor track surface.

SITE VISIT PHOTO SHEET (SHEET 4 OF 5)

PROJECT: SHENANDOAH VALLEY RAIL CORRIDOR

LOCATION: TOMS BROOK, VA – MT OLIVE ROAD – SITE INSPECITON LOCATION 4

RAILROAD LOCATION: MP B-68 - SPOT REHABILITATION LEVEL 1

PHOTO #:	FACING:	MP:
13	RR-WEST	B68

NOTES: RAIL/OTM – 1980s CWR, 132 LB RE. Visual good condition. Shy of ballast in some locations.

PHOTO #:	FACING:	MP:
14	RR-EAST	B68

NOTES: TIE – visual approx. 95% ties insufficient

PHOTO #:	FACING:	MP:
15	RR-WEST	B68

NOTES: ROADBED – Drainage Poor. Ballast Poor. Major vegetation control – tree removal necessary

PHOTO #:	FACING:	MP:
16	RR-EAST	B68

NOTES: GENERAL AREA APPEARANCE – Overall in good condition.

SITE VISIT PHOTO SHEET (SHEET 5 OF 5)

PROJECT: SHENANDOAH VALLEY RAIL CORRIDOR

LOCATION: STRASBURG, VA

RAILROAD LOCATION: MP B-63 - STRASBURG JUNCTION CSX

PHOTO #:	FACING:	MP:
17	RR-WEST	B63/CSX

NOTES: RAIL/OTM – Turnout replaced in the 1980s in good overall condition and appearance.

PHOTO #:	FACING:	MP:
18	RR-EAST	B63/CSX

NOTES: TIE – Requires strategic replacement if connection is desired. Ties showing signs of decay.

PHOTO #:	FACING:	MP:
19	RR-WEST	B63/CSX

NOTES: ROADBED – Fouled ballast and excessive drainage impacts due to overgrowth.

PHOTO #:	FACING:	MP:
20	RR-EAST	B63/CSX

NOTES: GENERAL AREA APPEARANCE – Excessive overgrowth of brush and trees. Hard to tell if connection to CSX is still in place.

Appendix C-2

Estimated Quantities

Segment	Category	From			To			Length (Miles)	Track Surfacing (Miles)	Total Rail (Miles)	Rail Replacement (Miles)	Rail Replacement (%)	Total Tie Count (Each)	Tie Replacement (Each)	Tie Replacement (%)
		City	Prefix	Milepost	City	Prefix	Milepost								
North	Spot Replacement - Level 1	Front Royal	B	51.00	Tom's Brook	B	68.20	17.20	17.20	34.40	1.72	5%	54,490	22,890	42%
Central	Full Depth Replacement	Tom's Brook	CW	68.20	Mt Jackson	CW	85.30	17.10	17.10	34.20	34.20	100%	54,180	54,180	100%
South	Spot Replacement - Level 2	Mt Jackson	CW	85.30	Broadway	CW	99.60	14.30	14.30	28.60	2.86	10%	45,310	19,030	42%
							Totals	48.60	48.60	97.20	38.78	40%	153,980	96,100	62%

Segment	Category	From			To			Ballast (Tons)	Vegetation Removal (Acres)	Tree Removal (Acres)	At-Grade Crossings With Active Warning	At-Grade Crossings With Passive Warning
		City	Prefix	Milepost	City	Prefix	Milepost					
North	Spot Replacement - Level 1	Front Royal	B	51.00	Tom's Brook	B	68.20	16,700	125	3.1	8	18
Central	Full Depth Replacement	Tom's Brook	CW	68.20	Mt Jackson	CW	85.30	78,800	124	4.1	9	16
South	Spot Replacement - Level 2	Mt Jackson	CW	85.30	Broadway	CW	99.60	13,900	104	1.7	14	16
							Totals	109,400	353	9.0	31	50

Figure 13 - Estimated Quantities

APPENDIX D: LOAD RATING REPORT

Appendix D: Load Rating Report

Contents

Executive Summary

As part of VDOT's Shenandoah Valley Rail-with-Trail assessment tasks were undertaken to: (1) assessing the rated capacity of a representative sample of currently out-of-service rail bridges, and (2) discuss approaches and issues involved with incorporating trail service immediately adjacent to the existing rail bridges.

The Rail-with-Trail assessment to date has identified 55 structures along the studied rail corridor, consisting of 32 culverts and 23 bridges. Three of the bridges are evaluated as representative and will be used to make conceptual planning assumptions about the suitability of the remaining structures on the corridor for a potential restoration of rail use. For each of the three chosen structures (designated as Assets 5104, 6141, and 7643), a field investigation was conducted to gather existing condition information used to perform the capacity assessments, and to provide sufficient site and structure information to assess the implications of incorporating adjacent trail service.

All three assets were found to be in fair condition with minor section loss typical throughout. Year of construction of the three assets varied with asset 5104 being constructed in 1908, Asset 6141 being constructed in 1936, and Asset 7643 being constructed in an unknown year.

Load ratings were generated for the as-inspected condition for Assets 5104, 6141, and 7643. A lengthy discussion explaining load rating and how to interpret the supplied rating results is included below in the Load Ratings section of the document. The summary of findings are noted here as follows:

Asset 5104 will require rehabilitation to support renewed freight rail operations. Several members do not provide acceptable 286k equivalent E-ratings at both 35mph and 10mph. The controlling load rating for Asset 5104 is E-60.

Asset 6141 rates E-89 which is greater than E-80 and therefore acceptable. This rating indicates that freight rail service could be restored at 25mph without requiring any structural retrofits.

The year of construction for Asset 7643 is unknown, which presented a challenge in determining the existing steel yield strength. Assuming a yield strength of 30 ksi, Asset 7643 has a controlling load rating of E-60 which is less than E-80 and also inadequate to support 286k car loading at a 25 mph operating speed. However, it is sufficient to support 286k car loading at an operating speed of 10 mph. If freight rail service is to be restored at a 25mph operating speed it is recommended to verify the existing steel strength and if it is approximately 30 ksi, retrofits would be required for Asset 7643. Retrofits may not be required if the yield strength of steel is confirmed to be of higher grade.

Affixing trail supporting structures to the existing structures was considered from a structural perspective in this report. It is not recommended to attach the trail to the existing bridges for the bridge types chosen as representative. The representative bridges evaluated included shallow beam spans, deeper girder spans, and through truss spans, all with open timber-tie decks and all built with narrow width designed to accommodate a single track.

At shallow beam structures, the beam depth is insufficient to support a practical cantilever structure to support the trail. At deeper girder structures, a practical cantilever to support the trail is possible. However, there are adverse effects on the existing superstructure, substructure and foundation that will require significant investigation and retrofit investment (For a graphical summary see **Figure 21**). At through truss structures, a cantilevered trail was evaluated in preliminary fashion and had severe impacts to the truss load rating. The trail could be added by building a second through truss connected to the existing truss, coupled with widening the truss piers to carry the trail. The complexity when coupled with the age of the existing trusses suggest this approach is to be avoided. Finally, where there exists a viable structural solution to affix the trail to the existing bridges, the deflections of the existing bridges under train live loads will propagate into the trail and be noticeable and potentially uncomfortable to trail users since the allowable deflections of train bridges exceed those of bridges designed for pedestrian use. In all cases then, it is recommended to build independent trail structures adjacent to the studied bridge types.

Bridge Locations

Figure 1 shows the location of Assets 7643, 6141 and 5104 along the 49-mile study corridor.

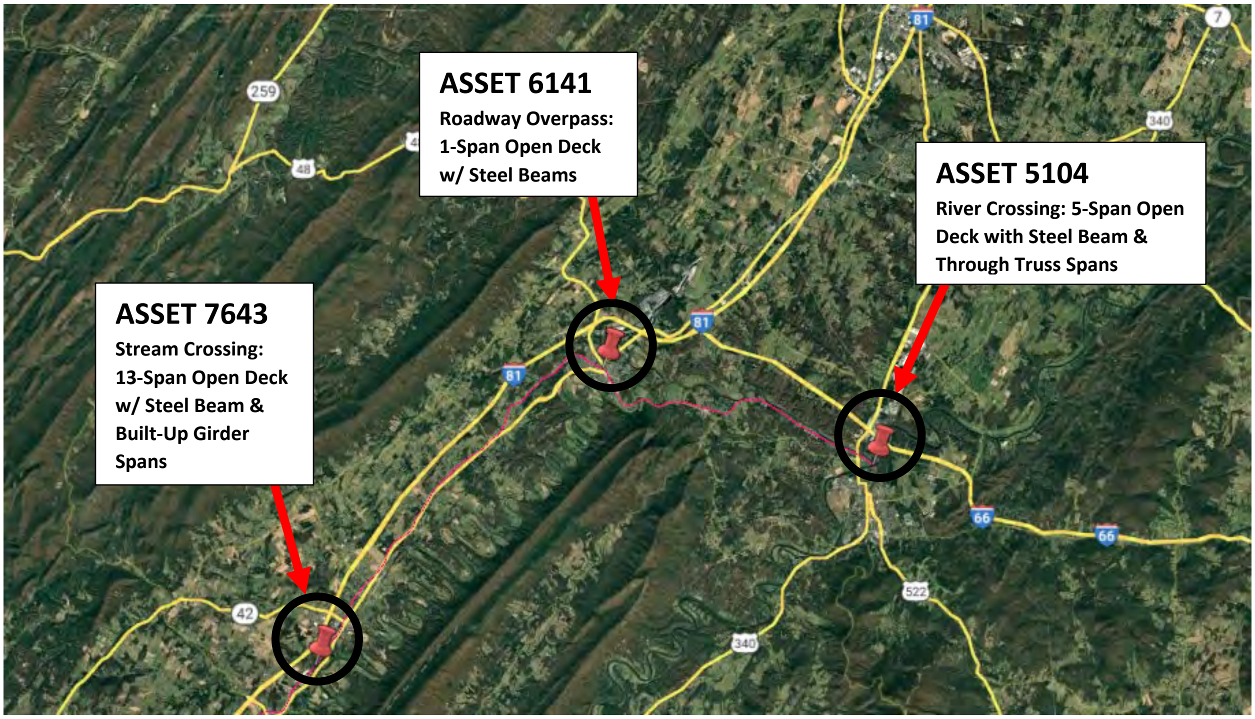


Figure 1. Location Map

Bridge Selections and Descriptions

A total of 55 structures are identified along the corridor. Of these 55 structures, 32 are culverts, and 23 are bridges (according to the AREMA definition of a bridge/culvert). A full list of the structures and any pertinent information available about the structure can be found in **Appendix D-3**. While culverts make up over half of the structures encountered along the rail corridor, evaluation of culvert capacity is not performed at this time due to the relative simplicity of addressing culvert capacity or configuration issues. Of the total 32 culverts along the corridor, it is believed that 19 can accommodate a 10-foot-wide trail without a required culvert extension.

When selecting structures to load rate emphasis was placed on selecting representative bridge sites that present a relatively greater challenge to be modified to accommodate a trail system addition. As shown in **Figure 2**, there are four bridge types occurring in the corridor, three are steel bridge configurations and the fourth are timber bridges. A timber bridge assessment was not performed as part of this study. Bridges along the corridor range from a minimum bridge length of 1’-6” to a maximum of 630’-0”. The culverts that are included in the corridor range from CMP, concrete pipes, and masonry box culverts to drainage structures.

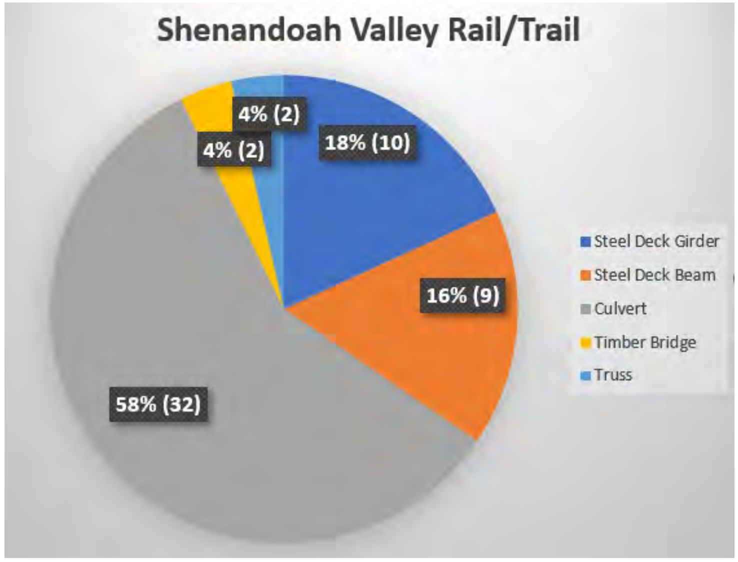


Figure 2. Bridge Types Along Proposed Rail/Trail Length

All three of the bridge assets selected for analysis include open deck steel spans with each configured differently and presenting a variety of span lengths. The assets vary from one another in the topography and feature crossed (Minor Waterway at Asset 7643 with significant bridge height in traversing the valley, Roadway at Asset 6141, and Major Waterway at Asset 5104).

Asset 6141 includes an open deck steel beam span which is typically a shorter span that includes four rolled steel beams (with or without cover plates) to support a single-track using timber ties placed directly onto the steel beams.

Asset 7643 includes open deck steel girder spans. These are similar to steel beam spans, but span greater distances between supports, typically using two deeper section plate girders to support a single track. At Asset 7643 the plate girder sections are presented in pairs to support the single track using built-up members. In this case, the girder section is formed by riveting together independent components including web plate, flange angles and flange cover plates.

Asset 5104 includes open deck steel through-truss spans, which can achieve significant span lengths, relative to girder or beam spans. In a through-truss, the train passes inside or through the truss, supported by a floor system composed of longitudinal stringers framed between transverse floorbeams which are connected to the main truss members to the left and right of the track.

It is noted that record plans for the structures on this line were not available, and a 3D survey scan was needed to generate overall lengths and dimensions for members. Field inspections for each asset were performed and measurements were taken to develop section properties to assist in load rating capacity analysis.

Asset 5104

Figure 3. Asset 5104 Overall View

Asset 5104 is a five-span bridge spanning the Shenandoah River with a total length of approximately 528’-0”. Spans 1 and 5 are identical 36’ open deck steel beam spans with 4-beams supporting the track. Spans 2, 3 and 4 are each 152’ open deck through-truss spans. Spans 2 and 4 are identical to one another, while Span 3 is unique in member sizing and the means of accommodating pier skew in the end panels.

For labeling, The East Abutment is on the southeast end of the bridge. Proceeding southeast to northwest spans are numbered 1-5, and piers numbered 1-4. Upstream is on the right (west) while looking from East Abutment to West Abutment.

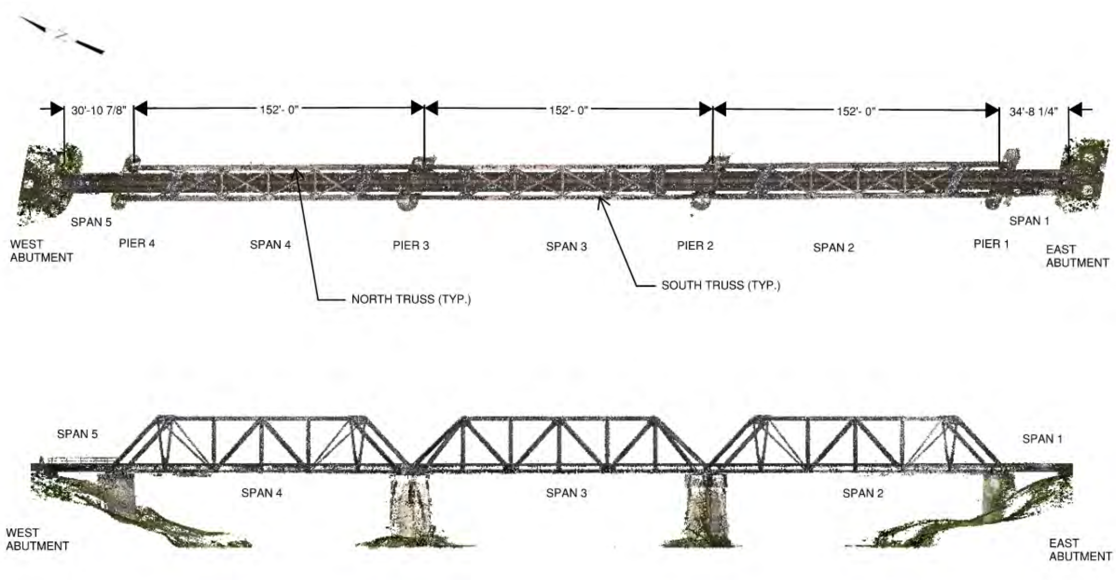


Figure 4. Asset 5104 Plan and Elevation

All truss members are riveted built-up members except for a limited number of dual eye-bars used in Spans 2 & 4 only. The existing truss built-up members use plates, angles and channels in various riveted configurations to form I-shaped and box-shaped members throughout. The eye-bar members are thick plates with a hook at the ends to wrap around a pin located at select member convergence points in the truss. The truss floor components (stringer pairs and floorbeams) are built-up I-sections, while bottom lateral bracing is formed using single angles. The truss ceiling components (struts, bracing and laterals) are all built-up I-sections.

For Spans 1 and 5, the fascia beams (beams 1 & 4) are spaced at 6’ 10” with all beams in the section being rolled beams with a depth of 30.25” with 14” wide flanges, the flanges are 1.3” thick and the web is 0.5” thick. The rolled beams for spans 1 and 5 have no cover plates.

Span 1 only includes an attached walkway.

Conventional timber railroad ties are fastened to the tops of supporting beams or stringers.

Substructure consists of two concrete abutments and three concrete piers at piers 1, 2, and 3 and one masonry and concrete pier at pier 4.

Asset 6141

Figure 5. Asset 6141 Overall View

Asset 6141 is a single span open deck beam bridge spanning Massanutten Street in Strasburg, VA, with a total length of approximately 43’ 2”. The out-to-out width of the tie deck was measured at 10’. Proceeding north to south, beams are numbered G1-G4. North Street is on the left (north) and E Washington Street is on the right (south) while looking from the West Abutment to the East Abutment. Field measured dimensions for the rolled beams: depth = 37”, flange width = 16.75”. Flange thickness was measured at 1.75” thick and web thickness was measured at 0.89” thick. The top of deck consists of timber rail ties typically 12” wide x 12” high and 10’ long. The superstructure consists of two double beam units. Each double beam unit consists of two side by side beams connected by diaphragm plates between the webs, double beam pairs are spaced at 1’ 10”, with the interior beams being spaced at 3’ 2.75”. The substructure consists of two concrete abutments with integral and offset columns accommodating sidewalks. **Figure 5** shows an overall view of Asset 6141, See **Figure 6** for an underside view of the asset displaying the beam pairs.

Figure 6. Asset 6141 Underside

Asset 7643

Figure 7. Asset 7643 Overall View

Asset 7643 has thirteen spans with a total length of approximately 630’ 0”. It appears that the original configuration of the bridge included only six spans situated between tall masonry abutments. The current configuration however includes multiple jump spans added to span over and beyond the original masonry abutments. This is typically done to remove lateral live load surcharge demands applied to an abutment in response to development of an adverse structural response, such as abutment rotation. Spans are arranged as follows (See **Figure 8**):

Span 12 & 13: Two open deck 2-beam jump spans (length and depth varies)

Span 6 & 11: Two open deck 2-girder spans (length = 60’ 10”, depth = 7’ 0 ½”)

Span 7: Open deck 2-girder spans (length = 61’ 0”, depth = 7’ 0 ½”)

Span 8: Open deck 2-girder spans (length = 99’ 3”, depth = 9’ 10”)

Span 9: Open deck 2-girder spans (length = 96’ 11”, depth = 9’ 10”)

Span 10: Open deck 2-girder spans (length = 62’ 10”, depth = 7’ 0 ½”)

Five open deck 2-beam jump spans (length and depth varies)

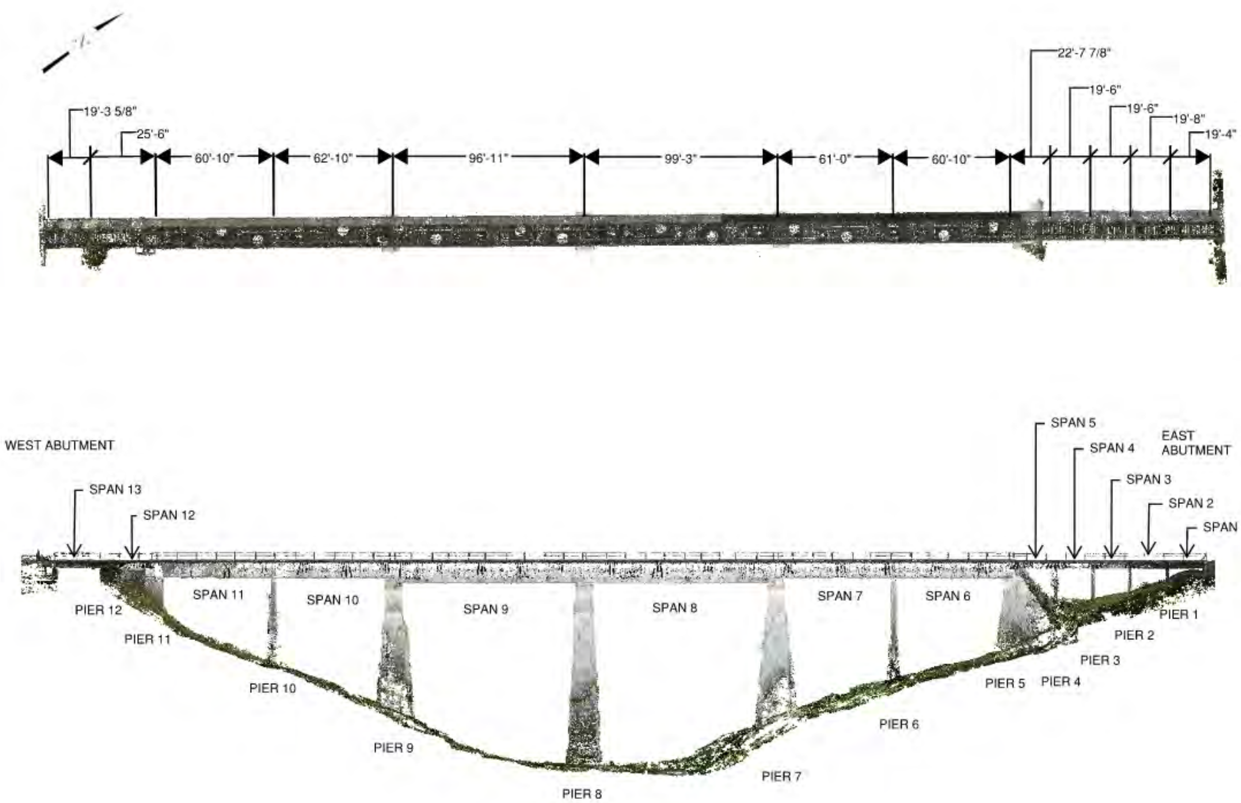


Figure 8. Asset 7643 Plan and Elevation

It is noted that span 12 is longest jump span of the structure when measured out-to-out, additional supports were placed as the beams span through the concrete slab. The span length between supports is 6’ 4½”, see **Figure 9**. The total out-to-out tie deck width of the structure was measured at 15’ 2”, including a 5’ 2”+/- access walkway. Upstream is on the left (west) while looking from The East Abutment to West Abutment. All member properties were assessed from field measurements and scan data. Due to lack of clarity in the scan data, cover plate cutoffs were not incorporated into the rating. Rather, the flexural rating considers capacity at mid-span only. Top of deck consists of timber railroad ties typically 12” wide x 12” high and the steel walkway is made of up steel walkway grating supported by Channels attached to the beam. The handrails consisted of steel angles and are attached to steel angle posts. The original abutments have been converted into piers 5 and 11 due to the addition of the jump spans. The jump spans end with steel abutments. The original bridge has 2 steel bents and three concrete piers. The jump spans use steel bents for all substructure units. **Figure 7** shows an overall view of Asset 7643.

Figure 9. Asset 7643 Span 12

Bridge Condition

Asset 5104

Inspection for Asset 5104 occurred on the week of 11/11/2024, a four-man crew was used. The method of inspection used was rope access. The bridge is in good condition overall. The superstructure is generally in good condition with minimal notable deterioration. Section loss is isolated, primarily affecting the lower chord members at connections. For the approach spans, section loss is isolated to the webs and tops of bottom flanges between the beam pairs where laminar corrosion is present. The paint coating system is failing, and surface corrosion is commonly observed. Laminar corrosion and significant section loss are predominantly absent.

The bearings are in fair condition. The deck is typically in fair condition, with deck ties exhibiting signs of deterioration and splitting.

The substructure is generally in fair condition. The concrete caps display typical cracking with efflorescence, and the masonry shows widening joints and cracking.

Asset 6141

Inspection for Asset 6141 occurred on the week of 11/11/2024. A two-man crew as used to inspect the structure. Ladder access was the chosen method of inspection for the structure. The bridge is in good condition overall. The superstructure is generally in good condition with minimal notable deterioration. Section loss is isolated to the webs and tops of bottom flanges between the beam pairs where laminar corrosion is present. There were areas of impact damage on the underside, but actual section loss was minimal. The paint coating system is in good condition.

The bearings are in good condition. The deck is typically in good condition. Deck ties exhibit signs of minor deterioration.

The substructure is generally in good condition exhibiting only isolated cracking and spalling on the columns likely from impact.

Asset 7643

Asset 7643 was inspected on the week of 11/11/2024, a five-man crew was used for the inspection. The chosen method of inspection was rope access. The bridge is in good condition overall. The superstructure is generally in good condition with minimal notable deterioration. Section loss is isolated, primarily affecting the lateral gusset plates. The paint coating system is failing, and surface corrosion is commonly observed. Laminar corrosion and significant section loss are predominantly absent.

The bearings are in fair condition. The deck is typically in fair condition. Deck ties exhibit signs of deterioration and splitting, particularly at the end spans where foliage impedes evaporation.

The substructure is generally in fair condition. The concrete caps display typical cracking with efflorescence. The masonry shows widening joints and cracking, while the steel bents exhibit deterioration, resulting in paint loss and surface corrosion.

Load Rating

Load ratings were generated for the as-inspected condition for Assets 5104, 6141, and 7643 under Cooper E-80 live loading and 286k car loading. The rating calculations were completed in accordance with Chapter 15, Section 7 of the 2024 AREMA Manual for Railway Engineering.

Load ratings are given in a format which relates bridge member capacity to a particular live load demand. The capacity assessment considers the function and condition of the bridge member being evaluated. For example, a longitudinal girder supporting the track spans between supports and is loaded by a passing train, introducing bending and shearing forces into the girder. The rating assesses the bending and shear-resisting capacity of the girder based on its geometry, material strength and observed deterioration. This capacity is then compared against the bending and shear demands imposed by the train. More specifically, for a given member there exists an allowable stress, a measure of internal pressure the member can safely handle. From this allowable stress, the stress imposed by loads other than live load is deducted to arrive at a “stress reservoir” available to be used by live load. If the applied live load stress is less than the stress reservoir, the member can safely accommodate the live load demand. On the other hand, if the applied live load stress exceeds the stress reservoir, the member is considered overstressed, relative to the allowable. In practice, communicating this is accomplished using E-ratings, normalized to the maximum axle weight of the E-80 load configuration introduced below.

$$E\ rating = 80\,x\,\frac{Allowable\ Stress - Stress\ other\ than\ Live\ Load\ Stress}{E80\ Live\ Load\ Stress}$$

In this report two train configurations are considered. The Cooper E-80 train load is a notional load in current use for bridge design. The E-80 train is represented by a series of axle loads followed by a uniform load, as shown in **Figure 10** below. This is a notional load as there are no trains in use that have this exact axle configuration, but it is configured to provide a conservative estimate of demand imposed by all train types in use. The Cooper train axle spacing has remained unchanged since its general adoption to the American train industry in the early 1900’s, but the weight of the axles has incrementally increased over the years as trains in use have become heavier over time. Older bridges sometimes rate poorly against the demands imposed by Cooper E-80 as they may have been designed for a lower weight train, such as an E-60 train, where the E-60 train is 60/80 or 75% of the weight of an E-80 train. For example, a girder that yields a normal rating of E-60 indicates that the girder can safely carry an E-60 train for its service life, but its service life would be reduced if regularly subjected to trains heavier than an E-60 load level. For each evaluated member, the report also provides a maximum rating (in addition to the normal rating just described). The maximum rating gives the maximum weight train that the bridge member can support on an infrequent basis if needed and as authorized by the owner. Frequent application of maximum load levels will significantly shorten the service life of the bridge.

The second train configuration considered in this report is the ‘286k car’, which is representative of heavy, yet routine, freight train traffic currently in operation. The 286k car imposes demands that are typically 75% to 80% of the demand imposed by the Cooper E-80 load level. A single E-rating is supplied for the 286k configuration. Unlike the format for ratings discussed above where the E-value indicates the upper bound train weight the bridge member can carry under the normal and maximum load conditions, the 286k rating E-value indicates an equivalent E-demand imposed by the 286k loading. Continuing with the above example of a girder rated using the E-80 load with a resulting normal rating of E-60 signifies it can routinely carry an E-60 load level and is considered to have an E-60 capacity. If this same member had a 286k equivalent rating of E-50, this does not signify that the member is limited to an E-50 load level. Rather, it signifies that the demand imposed by the 286k configuration is less demanding than the E-80 load, which will always be the case since the 286k configuration is simply less heavy than the E-80 configuration. Where the 286k equivalent rating is more meaningful is the case where the 286k equivalent E-rating value exceeds the normal E-rating value derived using the E-80 loading. This only occurs when the member does not rate higher than E-80 under a normal rating. Going back to the example girder with a normal rating of E-60; if this girder had a 286k equivalent rating of E-65, this signifies that the demand imposed by the 286k loading exceeds the identified E-60 capacity. That is, the 286k demand exceeds an already downgraded capacity identified in normal rating. In such case, the member is considered overstressed under the 286k load relative to the allowable stresses associated with normal service use of the bridge. Since the 286k load is representative of actual in-service demands placed on the bridge, such a finding is designated as “NG” or No Good in the rating tables supplied. Alternatively, if the 286k equivalent E-rating is less than or equal to the normal E-rating value, this result is designated as OK since this result means that the 286k loading does not exceed the normal operating capacity of the member.

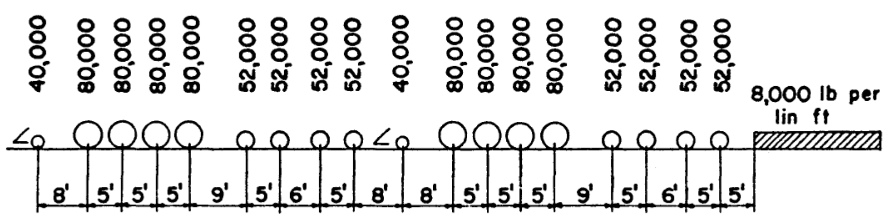


Figure 10. Cooper E-80 Live Load

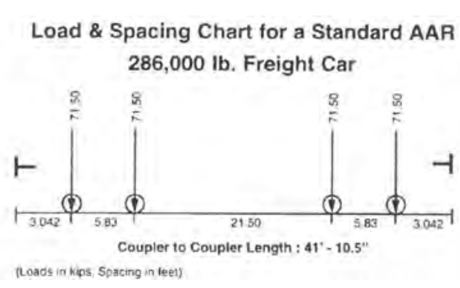


Figure 11. 286k Car Live Load

The rating tables presented throughout provide an Equivalent Cooper E-loading for 286k cars. The formula used to calculate the equivalent Cooper E-loading for 286k cars is:

$$80\ x\,\frac{max.\,stress\ on\ element\ from\ 286k\ Cars}{max.\,stress\ on\ element\ from\ E-80\ loading}$$

See **Appendix D-1** for select rating calculations.

Asset 5104 (Through Truss Span)

Through truss geometry was developed using both field measurements and Lidar scan data. Span 2 and Span 4 through trusses are identical to one another. Due to their similarity a one-span 3D finite element model of the through truss was determined to be sufficient to capture the force effects equally applicable to both spans. Span 3 differed from Span 2 and Span 4 in geometry and section properties; therefore, a separate 3D finite element model was developed for Span 3. The truss member forces determined using the finite element models are then exported to perform ratings for each truss member, where the rating exercise accounts for section loss and rivet holes. The decision to use a 3D model, vs 2D or hand-calculations, to determine truss member forces was driven by the skewed ends of the trusses.

The floor system of the truss consists of ties, stringers and floorbeams. The floor system force determination was made using hand calculations for all spans.

Most members in the through truss are built-up members, assembled by combining steel components (including plates, angles, and channels) using rivets except for eye bars that are located in portions of the bottom chord and at the end diagonals of Spans 2 and 4 only. The bottom chord of Span 3 consists of a built-up member made up of plates and angles. Within the 3D Midas model, gross built up member section geometry was defined using hand calculations and imported into Midas, noting that holes at rivet locations were considered in the rating calculations.

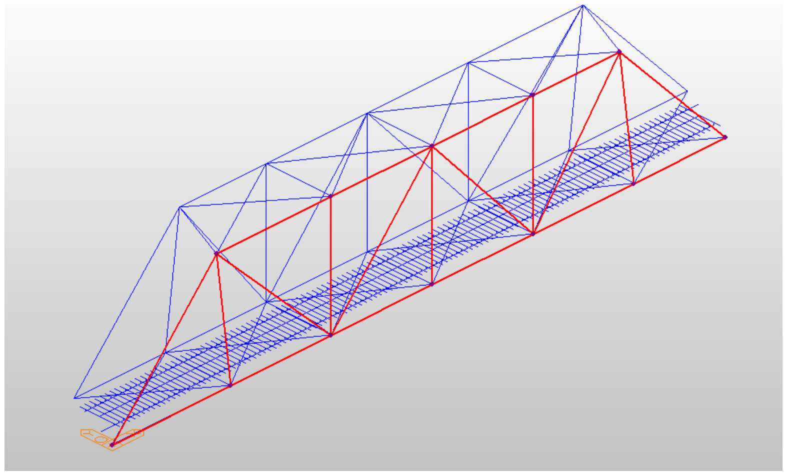


Figure 12. Isometric View of Midas 3D Through Truss (Span 4)
(Near truss highlighted for clarity)

Loads considered include live load, dead load, and wind loading. Live loads include both E-80 and 286k car configurations operating and both 35 mph and 10 mph with and without rocking effects enveloped in the force responses generated. Multiple versions of the axle configuration for both E80 and the 286k live loads are used to capture rocking effects. A version without rocking uses balanced wheel loads at a given axle, while versions with rocking use imbalanced wheel loads at a given axle in accord with AREMA 15-1.3.5.d. Also included are braking, traction, and equipment live loads. Dead load considers self-weight of the structural steel with a 15% self-weight factor applied to account for rivets and gusset plates not explicitly modeled. Additional dead loads include ties and track. It is noted that live load fatigue was not evaluated. While Spans 2 and 4 have eye-bar members which are prone to fatigue issues due a reduced allowable stress range, it was decided that a fatigue evaluation was not feasible due to the lack of historical loading data. It is recommended to perform a fatigue evaluation in the event rail service is expected to resume on the corridor if Span 2 and Span 4 are left in their existing condition. Otherwise a fatigue evaluation can be avoided by replacing the eye-bars with non-fatigue prone members.

Rating calculations found in **Appendix D-1** assess the truss top and bottom chords, end posts, intermediate posts and diagonals, stringers, and floorbeams. Gusset plate and other connection types were not rated. Two speeds are evaluated as the bridge is located at a speed change location, transitioning from 10mph to 35mph per the available track chart.

For all rated members, existing section loss information obtained from the field inspection was incorporated into the evaluation, as documented in the calculations found in **Appendix D-1**.

The date of construction of the existing through truss spans is believed to be 1908 based on a plaque found on an end post of Span 3. Therefore, the steel is assumed to be Open Hearth or ASTM A7 steel with Fy = 30 ksi and Fu = 60 ksi per AREMA Table 15-7-2.

Figure 13. Through Truss Construction Year (Span 3)

The truss spans were found to be in an overall good condition with minor section loss noted at the ends of eye-bars in the bottom chord for spans 2 and 4 (¼” max) (See **Figure 14**). Additional section loss was found at the knee brace connection at verticals members (⅛” max.) which was typical at all vertical members (See **Figure 15**).

Figure 14. Eye-bar Section Loss

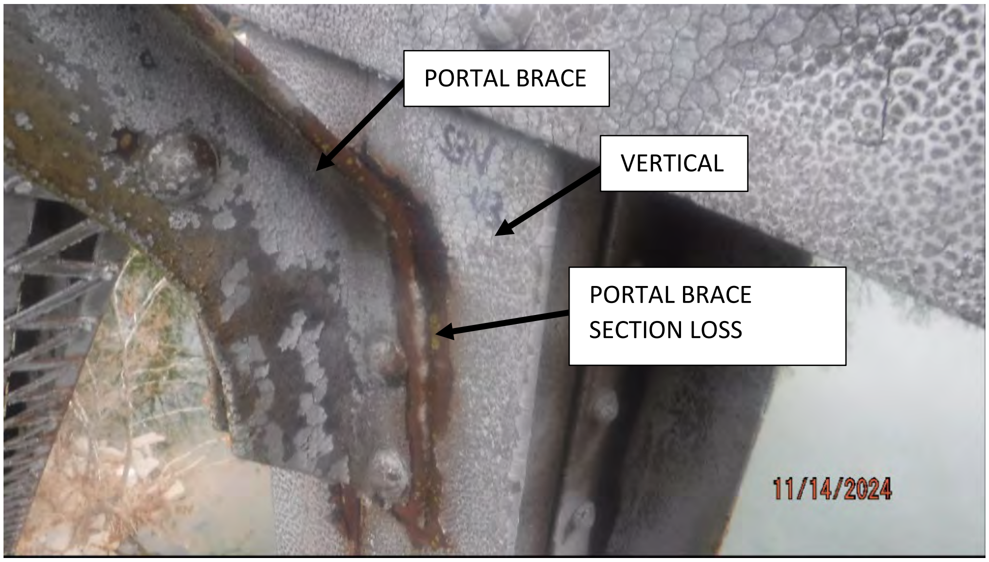


Figure 15. Vertical Section Loss at Portal Brace

Governing Ratings (Span 2/4)						
Speed (mph)	**Type**	**Member**	**Mode**	**Governing:**	**286k Equivalent**	**286k Rating**
35	Normal	Bottom Chord: N.L5-N.L6	Tension	E-60	E-65	NG
	Maximum			E-93		OK
	Normal	Vertical: S.L3-S.U3	Compression	E-100	E-57	OK
	Maximum			E-150		OK
	Normal	Diagonal: N.L2-N.U1	Tension	E-66	E-61	OK
	Maximum			E-103		OK
	Normal	Top Chord: S.L0-S.U1	Compression	E-79	E-61	OK
	Maximum			E-108		OK
10	Normal	Bottom Chord: N.L5-N.L6	Tension	E-64	E-65	NG
	Maximum			E-100		OK
	Normal	Vertical: S.L3-S.U3	Compression	E-111	E-57	OK
	Maximum			E-167		OK
	Normal	Diagonal: N.L2-N.U1	Tension	E-74	E-57	OK
	Maximum			E-115		OK
	Normal	Top Chord: S.L0-S.U1	Compression	E-88	E-61	OK
	Maximum			E-120		OK

Table 1. Spans 2 and 4 Governing Truss Rating Results

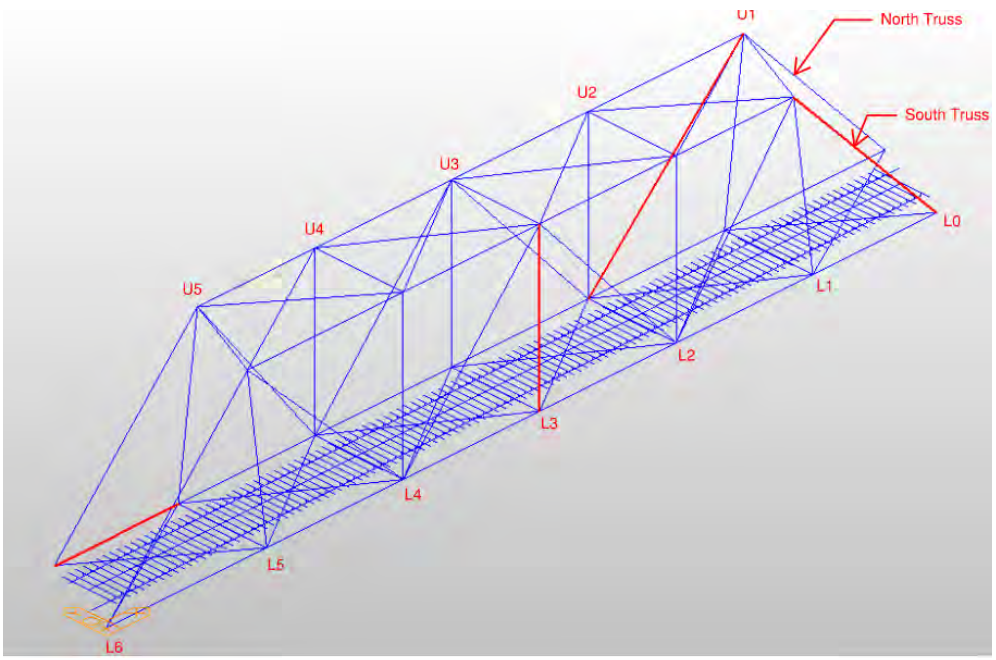


Figure 16. Spans 2 and 4 Truss Controlling Members

Governing Ratings (Span 3)						
Speed (mph)	**Type**	**Member**	**Mode**	**Governing:**	**286k Equivalent**	**286k Rating**
35	Normal	Bottom Chord: N.L5-N.L6	Tension	E-81	E-66	OK
	Maximum			E-124		OK
	Normal	Vertical: N.L1-N.U1	Compression	E-102	E-57	OK
	Maximum			E-153		OK
	Normal	Diagonal: S.L2-S.U1	Tension	E-81	E-57	OK
	Maximum			E-125		OK
	Normal	Top Chord: N.L0-N.U1	Compression	E-81	E-61	OK
	Maximum			E-110		OK
10	Normal	Bottom Chord: N.L5-N.L6	Tension	E-87	E-66	OK
	Maximum			E-134		OK
	Normal	Vertical: N.L1-N.U1	Compression	E-114	E-57	OK
	Maximum			E-171		OK
	Normal	Diagonal: S.L2-S.U1	Tension	E-91	E-57	OK
	Maximum			E-139		OK
	Normal	Top Chord: N.L0-N.U1	Compression	E-90	E-61	OK
	Maximum			E-122		OK

Table 2. Span 3 Governing Truss Rating Results

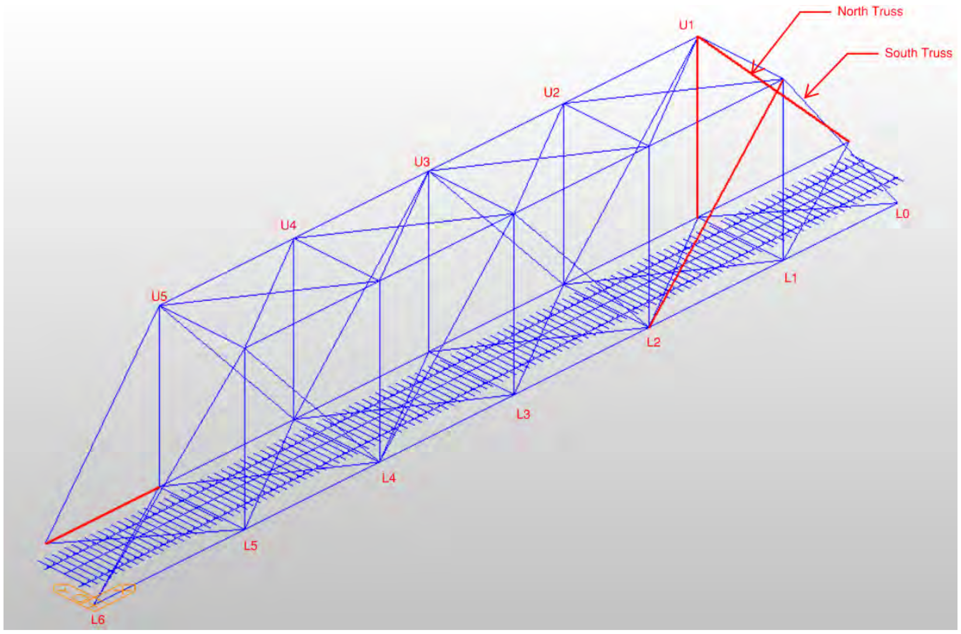


Figure 17. Span 3 Truss Controlling Members

In their current condition Span 2/4 govern the load rating, with the bottom chord (Member N.L5-N.L6) shown in **Figure 16** with a rating of E-60 for tenion at 35 mph . Member N.L5-N.L6 will also not rate for 286k at 35 mph, but will rate for 286k at 10 mph.

Floorbeams

All floorbeams within Span 2 and Span 4 are identical built-up members while Span 3 has a shallower built-up member for the floorbeams. Deterioration for the floorbeams of all spans was noted as minor, as such a 1% section capacity reduction was used to account for any section loss found on the members. In their current condition the floorbeams for all spans will not rate for E-80 at 35mph, but do rate for E-80 at 10mph. At both speeds, all floorbeams rate for 286k carloads.

Stringers

All stringers within Spans 2 and 4 are identical built-up members with the end stringers being slightly longer at 25’ 6”. Stringers for Span 3 are also built-up members with a deeper section, at this time given the scan data provided it was difficult to determine the end stringer lengths for Span 3. Due to this, ratings were provided for the interior stringers. Section loss for all stringers was noted to be minor, therefore a conservative 1% section capacity reduction was used for the members. The stringers for Span 2/4 currently do not rate for E-80 loading at either speed, nor for 286k car at 35mph. The stringers for Span 3 do not rate for E-80 loading at 35mph but can support 286k carload at 35mph.

Governing Ratings (Span 2/4 Floor)						
Speed (mph)	Type	Member	Mode	Governing	286k Equivalent	286k Rating
35	Normal	End Stringer	Flexure	E-60	E-62	NG
	Maximum			E-90		OK
	Normal	Stringer	Flexure	E-62	E-62	OK
	Maximum			E-93		OK
	Normal	Floorbeam	Flexure	E-78	E-62	OK
	Maximum			E-115		OK
10	Normal	End Stringer	Flexure	E-71	E-62	OK
	Maximum			E-107		OK
	Normal	Stringer	Flexure	E-74	E-62	OK
	Maximum			E-111		OK
	Normal	Floorbeam	Flexure	E-94	E-62	OK
	Maximum			E-139		OK

Table 3. Span 2/4 Governing Floor System Rating Results

Governing Ratings (Span 3 Floor)						
Speed (mph)	Type	Member	Mode	Governing	286k Equivalent	286k Rating
35	Normal	Stringer	Flexure	E-71	E-62	OK
	Maximum			E-107		OK
	Normal	Floorbeam	Flexure	E-71	E-62	OK
	Maximum			E-106		OK
10	Normal	Stringer	Flexure	E-85	E-62	OK
	Maximum			E-127		OK
	Normal	Floorbeam	Flexure	E-86	E-62	OK
	Maximum			E-128		OK

Table 4. Span 3 Governing Floor System Rating Results

The load rating for the floor system of Spans 1 through Span 3 is governed by the end stringer located in Span 2/4 with a rating of E-60 for flexure at 35 mph. In its current condition the stringer will not rate for 286k at 35 mph, but will rate for 286k at 10 mph.

Approach Spans

Approach Spans 1 and 5 consist of 2 rolled beam pairs (See **Figure 18**). Span 1 and 5 are identical in build but vary in span length. Span 1 was chosen for analysis due to it longer span length and the addition of a steel walkway on one side of the structure. Section loss was noted as minor for Span 1, therefore, a 1% capacity reduction was used to encompass any section loss found within the member. The steel walkway consists of steel grating, walkway angles, posts, handrails, channels that support the walkway, and an additional stiffener angle (See **Figure 19**). The additional dead load of the walkway was calculated and added to the final load rating calculations attached in **Appendix D-1**. In its current condition Span 1 rates for E-80.

Figure 18. Span 1 Underside

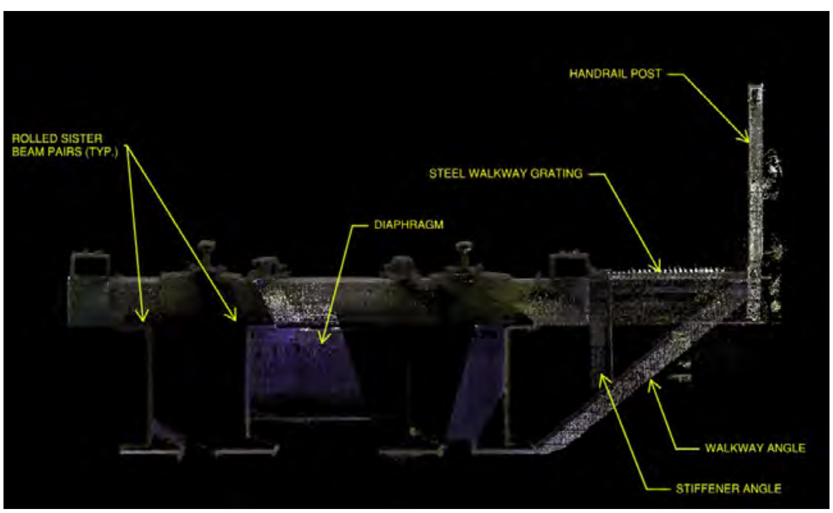


Figure 19. Span 1 Cross Section

Governing Ratings (Span 1/5)					
Speed (mph)	**Type**	**Mode**	**Governing**	**286k Equivalent**	**286k Rating**
35	Normal	Flexure	E-84	E-63	OK
	Maximum		E-126		OK
10	Normal	Flexure	E-100	E-63	OK
	Maximum		E-107		OK

Table 5. Span 1 Governing Rolled Beam Rating Results

The ratings tabulated show that the approach span for Asset 5104 are adequate for E-80 loading and can carry a 286k car load in its as-inspected condition. The controlling rating is E-84 for flexure.

Asset 6141 (Deck Beam Span)

The rating takes into consideration dead, live and wind loads acting on the superstructure. Due to lack of record drawings the dimensions used to develop the bridge and section geometry were taken from scan data and field measurements. The abutments of the structure contained a marker that indicated the year 1936, which is assumed to be the year of construction. Comparing the section properties to Historic References of AISC SCM 2nd Edition, 3rd Printing from May 1936 the member sizes were deemed to be WF 36x16½. Assumptions were made for the yield strength of steel according to AREMA Ch. 15 section 7.3.3.3 Table 15-7-2, the steel was assumed to be ASTM A7 pre-1935 which would equate to a yield strength of 30ksi to be used for the load rating. Net sections for the beams were calculated based on the rivets of the diaphragm connections to the beams. The load rating was completed using a spreadsheet calculation developed by Michael Baker International which evaluates the values of allowable bending stress in tension and allowable bending stress in compression and will use the governing stress for the final load rating factor calculation.

Section loss was taken from the inspection notes provided from the hands-on inspection. For the beams, the measured section loss compared to the net section area of the member resulted in a percent section loss of 4.3% which was used as a capacity reduction factor for the beams. The speed reported in the available track chart is utilized.

Governing Ratings					
Speed (mph)	Type	Cooper E80	Mode	286k Equivalent	286k Rating
25	Normal	E89	Flexure (Tension)	E59	OK
25	Maximum	E135			OK

Table 6. Asset 6141 Governing Rolled Beam Ratings

The member Normal Ratings and Maximum ratings for Cooper E-80 loading are tabulated above with a “OK” or “NG” indicating if the 286k car rates for that speed and rating designation.

The ratings tabulated show that Asset 6141 (Deck Beam Span) is adequate for E-80 loading and can carry 286k car load in its as-inspected condition. The controlling rating is E-89 for flexure.

Asset 7643 (Deck Girder Span)

Of the 13 spans, three representative spans were chosen to be evaluated for the load ratings. Span 5 is a jump span located on the north end of the structure and consists of rolled deck beams, Span 10 is a girder span located on the south end of the structure, and Span 8 is a longer girder span located on the north end of the structure. The rating considers dead, live and wind loads acting on the superstructure. Due to lack of record drawings the dimensions used to develop the bridge and section geometry were taken from scan data and field measurements.

There was no indication of the year of construction for Asset 7643, therefore, assumptions were made for the yield strength of steel according to AREMA Ch. 15 section 7.3.3.3 Table 15-7-2, the steel was assumed to be ASTM A7 pre-1935 which would equate to a yield strength of 30ksi to be used for the load rating of the original girder spans. The jump spans were added at a later unknown date. Rating those spans for 30 ksi steel revealed a deficit, which seemed unlikely, therefore three ratings are provided herein for the jump spans, each considering the steel yield strength to be 30ksi, 36ksi and 50ksi. It is Michael Baker’s opinion that the spans are likely constructed using 50ksi steel. Coupon testing should be performed to verify jump span steel strength assumptions in the event the bridge is to resume service.

Net sections for the girders were calculated based on the rivets of the stiffener connections to the girders. There was not enough information to determine the true spacing of the rivets, photos were used to provide an estimate of rivet spacing. The load rating was completed using spreadsheet calculations developed by Michael Baker International that evaluate the values of allowable bending stress in tension and allowable bending stress in compression and will use the governing stress for the final load rating factor calculation.

Section loss was taken from the inspection notes provided from the hands-on inspection and considered to be minor throughout the three spans that were evaluated. For the girders and the beams for the jump spans a capacity reduction of 2% was used as a conservative estimate. The available track chart does not report a maintenance speed at this location. An operating speed of 25mph and 10 mph were used for the load rating.

Governing Ratings (Span 5)						
Speed (mph)	Fy (KSI)	Type	Cooper E80	Mode	286k Equivalent	286k Rating
25	50	Normal	E-105	Flexure (Tension)	E-62	OK
		Maximum	E-157			OK
	36	Normal	E-74	Flexure (Tension)	E-62	OK
		Maximum	E-111			OK
	30	Normal	E-60	Flexure (Tension)	E-62	NG
		Maximum	E-91			OK
Speed (mph)	Fy (KSI)	Type	Cooper E80	Mode	286k Equivalent	286k Rating
10	50	Normal	E-119	Flexure (Tension)	E-62	OK
		Maximum	E-177			OK
	36	Normal	E-83	Flexure (Tension)	E-62	OK
		Maximum	E-125			OK
	30	Normal	E-68	Flexure (Tension)	E-62	OK
		Maximum	E-103			OK

Table 7. Asset 7643 Governing Rolled Beam Ratings (Span 5)

Governing Ratings (Span 10-11)						
Speed (mph)	Fy (KSI)	Type	Cooper E80	Mode	286k Equivalent	286k Rating
25	30	Normal	E-90	Flexure (Tension)	E-60	OK
		Maximum	E-137			OK
10	30	Normal	E-100	Flexure (Tension)	E-60	OK
		Maximum	E-152			OK
Governing Ratings (Span 8-9)						
Speed (mph)	Fy (KSI)	Type	Cooper E80	Mode	286k Equivalent	286k Rating
25	30	Normal	E-92	Flexure (Tension)	E-61	OK
		Maximum	E-143			OK
10	30	Normal	E-99	Flexure (Tension)	E-61	OK
		Maximum	E-155			OK

Table 8. Asset 7643 Governing Plate Girder Ratings (Span 8-9, 10-11)

The member Normal Ratings and Maximum ratings for Cooper E-80 loading are tabulated above with an “OK” or “NG” indicating if the 286k car rates for that speed and rating designation.

The ratings tabulated show that Asset 7643 (Deck Girder Span) is adequate for E-80 loading and can carry 286k carloads in its as-inspected condition for Spans 8-9 and Spans 10-11 for 25 mph. Span 5 in its as-inspected condition cannot support 286k car loads at 25 mph. Span 5 can support 286k car loads at a reduced operational speed of 10 mph. The controlling rating is E-60 for Span 5 (Jump Span) at 35 mph. It is noted that the jump spans were added at an unknown date, likely to reduce the demand on the abutments. Therefore, a conservative estimate of FY = 30 KSI was used for preliminary ratings. If the steel is Fy = 50ksi, the jump spans rate for E-80. It is recommended that steel coupon testing be performed to verify the yield strength of steel.

Rail-with-Trail Considerations & Recommendations

The Rail-with-Trail option restores rail service while also adding a recreational trail adjacent to the active freight rail track. For the purposes of this analysis, a 10’ wide trail is assumed. The scope considered herein is limited to structural considerations in the immediate vicinity of the representative bridges.

Asset 7643

Figure 20. Asset 7643 Scan Data Overall View

Appendix G of the VDOT published March 2025 Rail-with-Trail Assessment (Shenandoah Valley Rail-With-Trail Assessment) Phase 1 provided commentary on an earlier proposal to add a cantilevered trail walkway to open deck girder portions of existing rail bridges. Multiple concerns were enumerated, including structural concerns. This proposal was considered and it was determined there are significant structural concerns affecting the existing superstructure, substructure and foundations, as outlined on the following figure:

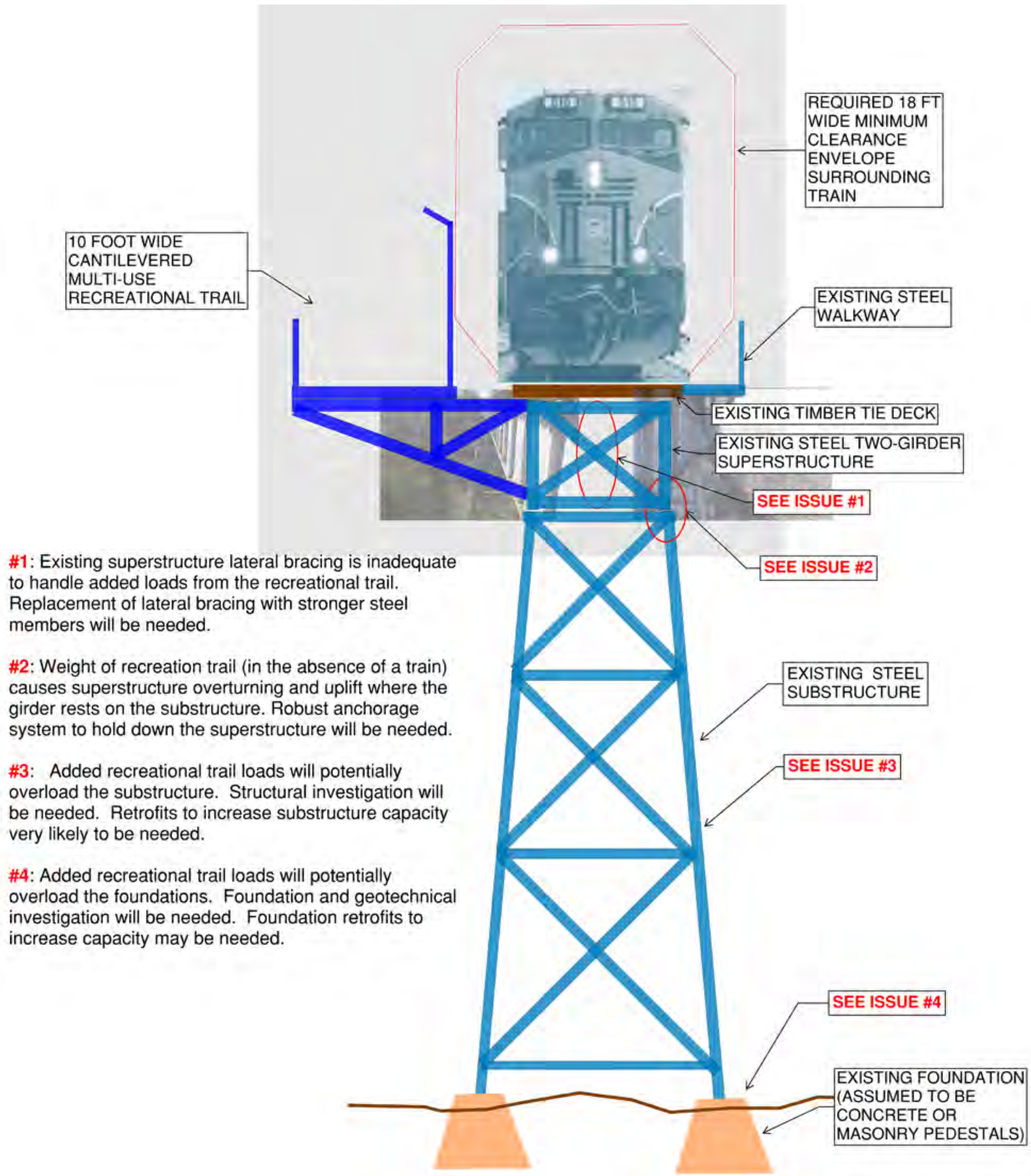


Figure 21. Asset 7643 Cantilever Walkway Concerns

Issues #1 and #2 were numerically assessed using a three-dimensional finite element model of a single bridge span representing Spans 6, 7, 10 & 11. Within the model, walkway cantilevers were set to coincide with existing periodic X-braces between the girders, as shown in Figure 22.

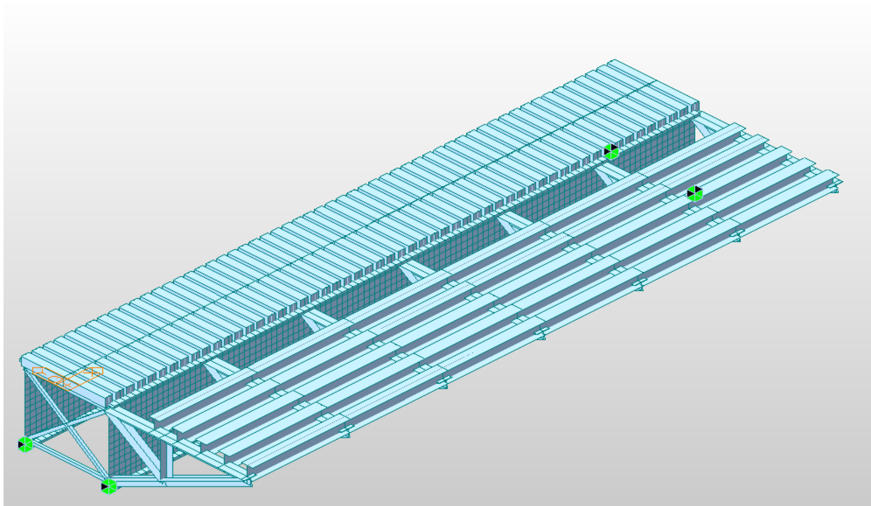


Figure 22. Asset 7643 Cantilever Walkway Model

Preliminary walkway member sizes were assumed, and live loads were applied to the model. Live loads include Cooper E80 loading with impact corresponding to 25mph train speed, plus pedestrian live load of 85psf applied over the added 10-ft walkway width. The goal of the model is to assess force demands applied to the existing X-bracing spaced at approximately 13’ 9” center-to-center and to capture the reactions developed at the existing girder bearings.

As expected, the compression developed in the X-bracing is excessive relative to the design capacity of the existing bracing, with a demand of approximately 34,400 LBS relative to an allowable load of 7000 LBS for the existing L3 ½” x 3 ½” x 7/16 single angle members. It is feasible to replace the X-bracing with double-angle sections to strengthen the bracing. To ensure sufficient overall torsional response, X-bracing replacement would be accompanied with replacement of the top lateral bracing system and addition of a bottom lateral bracing system not included in the original structure.

The added vertical demands on the existing deck plate girders have not been fully assessed. With existing ratings in the E-90 range, it is probable that the added walkway loading will allow the structure to continue to rate at or above E-80. Additional investigation would be required to confirm. If girder strengthening is needed, flange cover plates and supplemental web stiffener plates are viable modifications.

It is noted that the existing deck plate girder spans are relatively stiff, compared to the stiffness requirements indirectly prescribed through allowable live load deflection criteria. For railroad structures, live load deflection is limited to L/640 (AREMA 15-1.2.5), while for structures with shared pedestrian and vehicular use, deflection is routinely limited to L/1000 (AASHTO 2.5.2.6.2, 10th Ed.). Spans 8 & 9 experience an E80 live load deflection of approximately 0.91 inches, or L/1314, which increases to 1.03 inches, or L/1162 with the addition of pedestrian live load. The increase in deflection due to pedestrian live load considers a load increase on the existing girder only; that is, any deflection localized to the walkway is not estimated at this time. Similarly, Spans 6, 7, 10 & 11 experience an E80 live load deflection of approximately 0.51 inches, or L/1488, which increases to 0.56 inches, or L/1337 with the addition of pedestrian live load. It is anticipated that the stiffness of the existing spans would be sufficient to satisfy the AASHTO L/1000 limit with the added walkway.

The cantilevered walkway loads are highly eccentric to the base structure and cause uplift to develop on the girder opposite the walkway. This condition is present under dead load only, and under dead load plus pedestrian live load. When a train is on the bridge, the weight of the train counteracts the uplift. The approximate maximum uplift load acting at the bearing is 98,000 lbs. Investigation and design will be needed to safely accommodate this condition, including investigation of future bearing maintenance operations.

The downward bearing reaction increases from approximately 366,000 LBS per span to 482,000 LBS per span with the addition of walkway and pedestrian loading. The existing steel substructure units, which receive load from two spans, will very likely require strengthening to accommodate this load increase. Similarly, the foundations of the existing substructures will need to be assessed and potentially retrofitted to accommodate added vertical loading and overturning moment due to the walkway eccentricity.

Due to the above concerns, along with safety and operational concerns noted in the referenced March 2025 report, it is recommended to utilize a separate pedestrian structure dedicated to conveying the trail rather than affix a cantilever onto the existing structure.

Asset 6141

At Asset 6141, and similar open deck beam bridges, the depth of the existing rail superstructure is insufficient to host a practical cantilever to support the trail walkway. In which case, dedicated adjacent beams to support the walkway will be needed, along with the means to support such beams. Configurations which provide support for pedestrian bridge beams without adding loads to the existing bridge foundations are recommended (See **Figures 23-25**).

Figure 23. One-Span Pedestrian Bridge on Separate Foundations Behind Existing Abutment

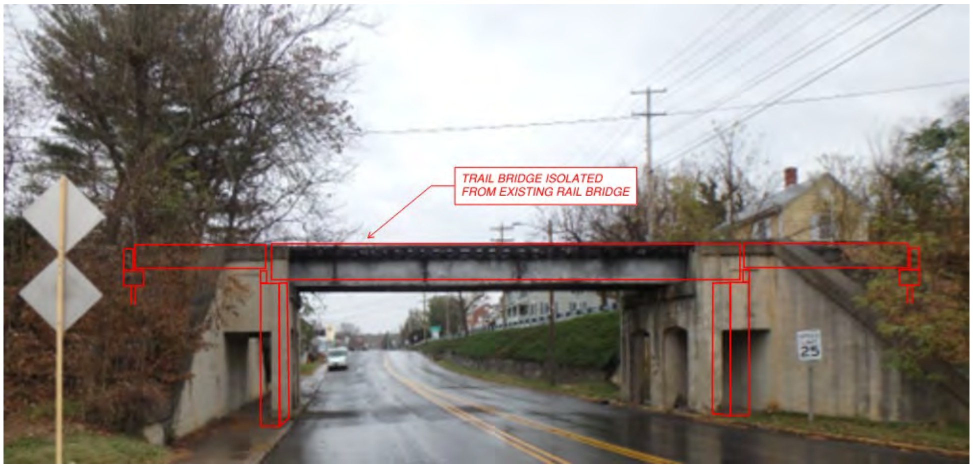


Figure 24. Three-Span Pedestrian Bridge on Separate Foundations Allowing Smaller/Lighter Superstructure and Foundation Construction.

A longitudinal projection of the above profile views gives additional perspective on the relative size of a proposed trail bridge adjacent to the existing single-track bridge.

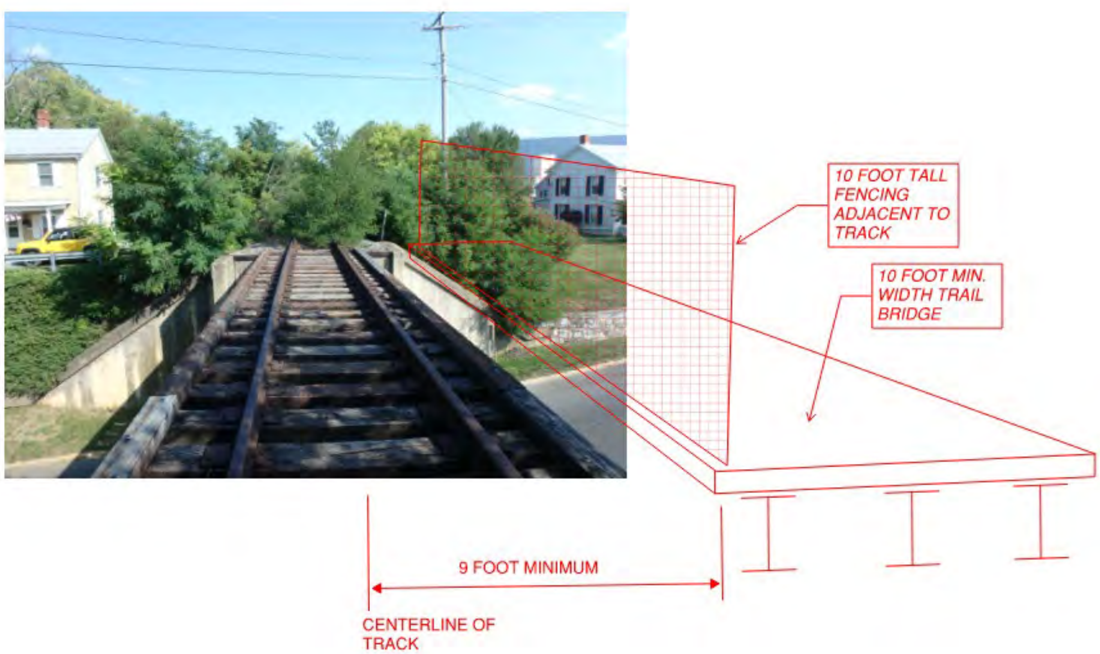


Figure 25. Asset 6141 Walkway Profile

Asset 5104

As shown in the truss ratings, Spans 2 and 4 have relatively low capacity and if freight rail service is returned, they will likely need to operate under rail traffic speed restrictions and/or require modifications to improve the load ratings. Adding pedestrian accommodations directly affixed to the trusses will certainly require truss strengthening at Spans 2 and 4 and likely require strengthening at Span 3.

Affixing the proposed trail walkway to the truss in the same manner discussed above for Asset 7643 is not feasible. That is, erecting a walkway supporting cantilever from the truss will significantly alter the development and distribution of forces through the truss members and joints, introducing significant torsion into the truss, twisting the truss about its center while imposing bending forces into joints not designed to accommodate bending. An alternative that mitigates the introduction of such twisting is next considered.

A possible addition that could be assessed is to widen the through truss by adding another truss plane. Such addition would not fundamentally alter the flow of forces in the existing structure, but would increase the force demands in existing members, an effect which can be assessed and mitigated through potentially significant member strengthening. Such modification is shown in schematic form in **Figure 26**.

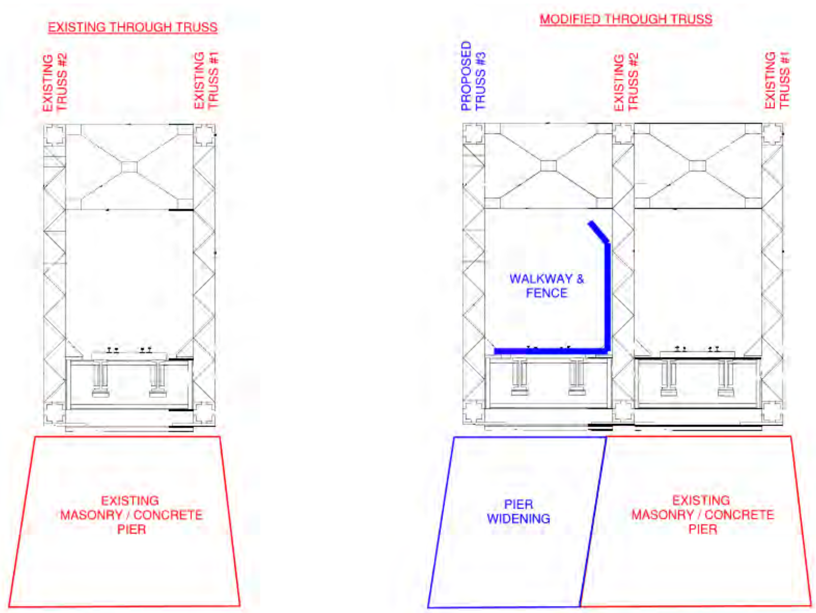


Figure 26. Asset 5104 Additional Truss Plane Concept (Not Recommended)

Some primary reasons to avoid this solution include:

An added truss plane approach is an inefficient use of materials and construction labor relative to less intrusive methods of introducing trail traffic. To avoid the above noted twisting of the existing truss, the added structural steel would mirror the existing truss in formation and be supported on extended piers. A much more efficient solution for the walkway superstructure could be developed by using an independent superstructure supported on widened or independent piers.

Extending the through-truss as shown in **Figure 26** intimately links the new construction with existing construction approaching 120 years of age. Eventual replacement of the existing truss would be needed and is greatly complicated by the presence of an integrated trail. Such replacement effort could potentially eliminate the added pedestrian access before its useful life is reached.

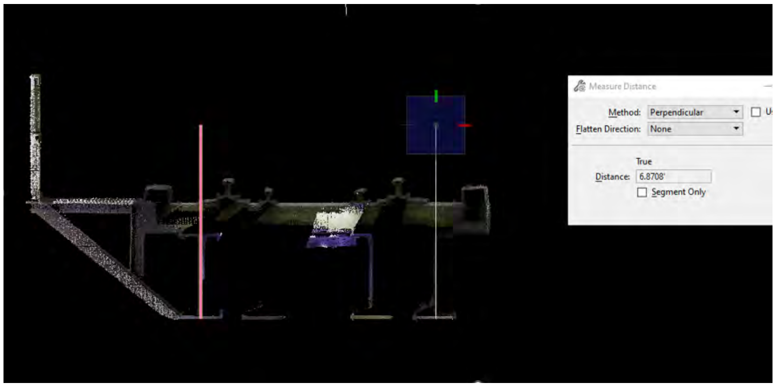
Railroad structures are designed to undergo greater deflections under live load than structures intended for regular use by pedestrians. Extending the truss in the manner described will add stiffness the bridge, relative to current conditions, but it is probable that live load deflection will continue to be excessive for routine pedestrian use, resulting in pedestrians feeling discomfort when trains pass through the truss. Midspan deflections approaching 3” are considered acceptable for this rail span, while a pedestrian bridge would limit the deflection to half of that value for user comfort.

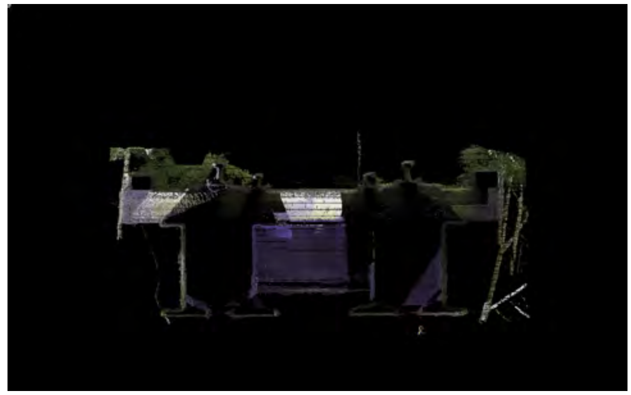
Appendix D-1: Rating Calculations

Contents

ROLLED BEAM RATING FOR SPANS 1 & 5

RATING SUMMARY

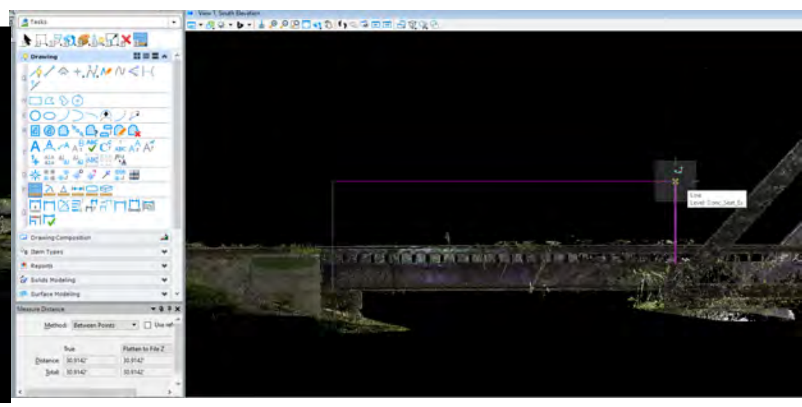




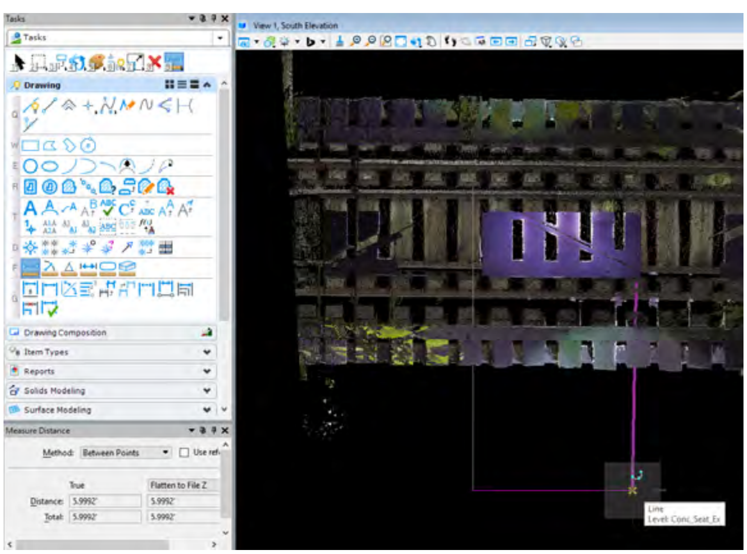
Fascia to Fascia: 6.8708'

Depth: 30.25"
Flw: 14"
Flt: 1.3"
Wt: 0.515"

Span w/Walkway: 34.69'



Span w/o Walkway: 30.9'



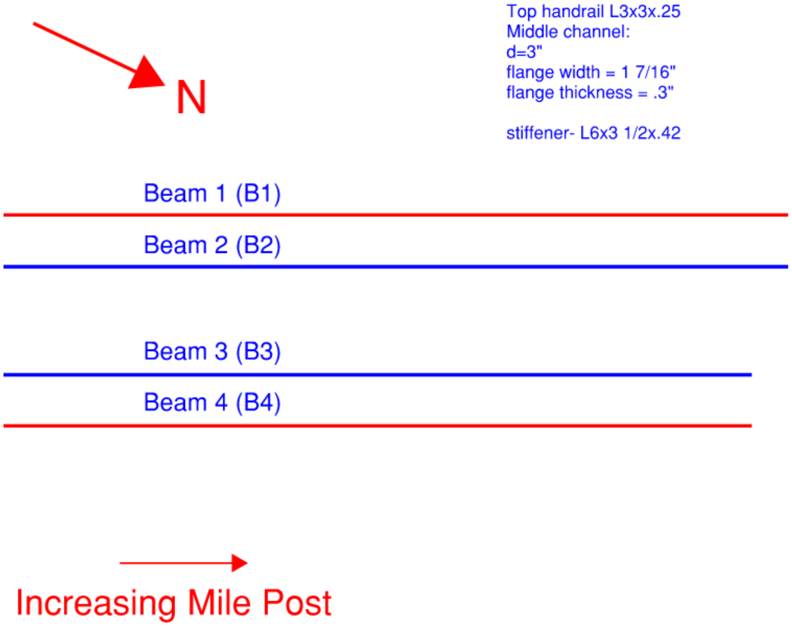
Bracing Distance : 6'-0"

Element	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
Walkway Gratring	7.4		3	33.9			752.58
Walkway Angles		8.7			5.22	1	45.414
Posts		4.9		4.5		7	154.35
Handrails		4.9		33.9		2	332.22
Channel		6		3.5		7	147
Stiffener		15.3		2.15		1	32.895
						Total Weight	1464.459
						LB/FT	43.19938053
						ADD 5%	45.35934956

Asset 5104 Over S Fork Shenandoah River

Span 1
Walkway 1" tall x.19" thick
brackets - rail
Sit on L5x3 1/2x.31 Ls
Posts L3x3x.26
Top handrail L3x3x.25
Middle channel:
d=3"
flange width = 1 7/16"
flange thickness = .3"

stiffener- L6x3 1/2x.42



Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**34.70**	ft	
Number of Girders	**4**		
Fascia CL to Fascia CL	**6.87**	ft	
Girder Type	**rolled**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**2%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**5**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**55.00**	lb/lf	
Lateral Bracing Distance	**72.00**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.25**	ft	
Tie Height	**10.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**10.00**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)

Girder Geometry

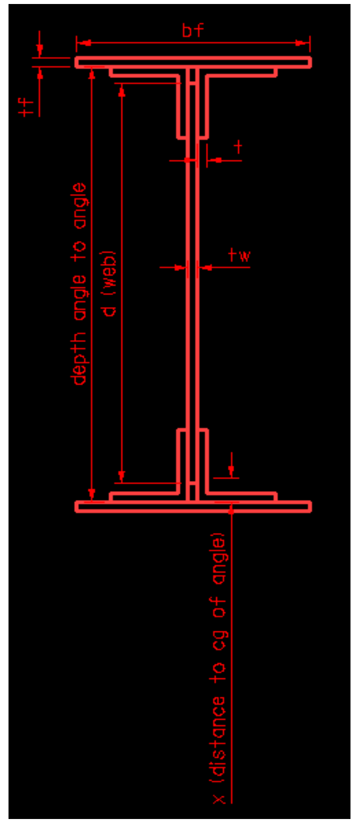
Depth angle to angle	30.250	in	
Effective Rivet/Bolt hole diameter	0.00	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	14.00	in
t_f	1.300	in

Top Flange Angles (0 if they don't exist)

x	0.00	in	
y	0.00	in	
t	0.000	in	
A (each angle)	0.00	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	0.00	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	0.00		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	0.00	in4	(ref. wksht. TF_Angle_Pair)



Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00		
			This is an assumption based off of photos
Gage	0.00	in	(photo 014)
Pitch	0.00	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web

d	30.250	in
tw	0.515	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	0.00	
# of Holes in long row	0.00	
Gage	0.00	in
Pitch	0.00	in

Bottom Flange or Cover Plate (0 if does not exist)

b_f	**14.00**	in
t_f	**1.300**	in

Bottom Flange Angles (0 if they don't exist)

x	**0.00**	in	
y	**0.00**	in	
t	**0.000**	in	
A (each angle)	0.00	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	0.00	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	0.00	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	0.00	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

Rows	**0.00**	in
Gage	**0.00**	in
Pitch	**0.00**	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	**0**	
Gage 1	**0.00**	in
Gage 2	**0.00**	in
Pitch	**0.00**	in

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	30.25	in
Effective rivet hole diameter	0	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		14	in
tf		1.3	in
A	1.3 x 14 =	18.2	in2
x	32.85 - (0.5 x 1.3) =	32.2	in
Ax	18.2 x 32.2 =	586.04	in3
d	32.2 - 16.42 =	15.78	in
Ad2	18.2 x 15.78^2 =	4531.95	in4

Top Flange Angles

x		0	in
t		0	in
A (angle)		0	in2
Ixxo, Double Angles		0	in4
A	2 x 0 =	0	in2
y.bar		0.00	in
x	32.85 - 1.3 - 0 =	31.55	in
Ax	0 x 31.55 =	0	in3
d	31.55 - 16.42 =	15.13	in
Ad2	0 x 15.13^2 =	0	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1.3 + 0 =	1.3	in
A*	2 x 0 x 1.3 =	0.0000	in^2
x	32.85 - 1.3 / 2 =	32.2	in
Ax	0 x 32.2 =	0	in^3
d	32.2 - 16.42 =	15.78	in
Ad^2	0 x 15.78^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.515 =	0.515	in
A*	0	0.0000	in^2
x	35 - 1.3 - (0.00001 +0.0001)/2 =	31.54995	in
Ax	0 x 31.549945 =	0	in^3
d	31.549945 - 16.42 =	15.1299	in
Ad^2	0 x 15.1299^2 =	0	in^4

NET SECTION

Web			
d		30.25	in
t_w		0.52	in
A	0.515 x 30.25 =	15.57875	in^2
x	1.3 + 0 + (0.5 x 30.25) =	16.425	in
Ax	15.57875 x 16.425 =	255.88	in^3
d	16.42 - 16.425 =	0.005	in
Ad^2	15.57875 x 0.005^2 =	0	in^4
I_{web}	).515) x (30.25)^3 / 12 =	1188	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		0.00	
# of Holes in long row		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0.515 =	0.515	in
A*	0	0.0000	in^2
x	centered on web =	16.425	in
Ax	0 x 16.425 =	0	in^3
d	max =	0.00	in
Ad^2	Total for all holes =	0.00	in^4
I_{holes}	0 x 0.515 x 0^3/12 =	0	in^4

Holes Through Bottom Flange L's and Web			
Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.515 =	0.515	in
A*	#DIV/0!	0.0000	in^2
x	+ (0 + 0) / 2 =	1.3	in
Ax	0 x 1.3 =	0	in^3
d	16.42 - 1.3 =	15.12	in
Ad^2	0 x 15.12^2 =	0	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1.3 + 0 =	1.3	in
A	#DIV/0!	0.0000	in^2
x	0.5 x 1.3 =	0.65	in
Ax	0 x 0.65 =	0	in^3
d	16.42 - 0.65 =	15.77	in
Ad^2	0 x 15.77^2 =	0	in^4

Bottom Flange Angles			
x		0.00	in
t		0.00	in
A (angle)		0.00	in^2
Ixxo, Double Angles		0.00	in^4
A	2 x 0 =	0	in^2
y.bar		0.00	in
Ax	0 x 0 =	0.00	in^3
d	16.42 - 0 =	16.42	in
Ad^2	0 x 16.42^2 =	0	in^4

Bottom Cover Plates			
b_f		14.00	in
t_f		1.30	in
A	1.3 x 14 =	18.2	in^2
x	0.5 x 1.3 =	0.65	in
Ax	18.2 x 0.65 =	11.83	in^3
d	16.42 - 0.65 =	15.77	in
Ad^2	18.2 x 15.77^2 =	4526.21	in^4

NET SECTION

Girder Properties

Girder d	1.3 + 0 + 30.25 + 0 + 1.3 =	32.85	in
ΣA	18.2 + 0 - 0 - 0 + 15.57875 - 0 - 0 - 0 + 0 + 18.2 =	51.98	in^2
ΣAx	586.04 + 0 - 0 - 0 + 255.88 - 0 - 0 - 0 + 0 + 11.83 =	853.75	in^3
Xcg	= ΣAx / ΣA =	16.42	in
$ΣAd^2$	4531.95 + 0 - 0 - 0 + 0 -0 - 0 - 0 + 0 + 4526.21 =	9058.16	in^4
I	$ΣAd^2 + I_{web} + I_{flanges} - I_{holes}$ =	10246.16	in^4
S_{BOTTOM}	10246.16 / 16.42 =	624	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	30.25	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		14.00	in
t_f		1.30	in
A	1.3 x 14 =	18.2	in^2
x	32.85 - (0.5 x 1.3) =	32.2	in
Ax	18.2 x 32.2 =	586.04	in^3
d	32.2 - 16.42 =	15.78	in
Ad^2	18.2 x 15.78^2 =	4531.95	in^4

Top Flange Angles

x		0.00	in
t		0.00	in^2
A (each angle)		0.00	in^4
A	2 x 0 =	0	in^2
Ixx, double angles		0.00	in^4
y.bar		0.00	in
x	32.85 - 1.3 - 0 =	31.55	in
Ax	0 x 31.55 =	0	in^3
d	31.55 - 16.42 =	15.13	in
Ad^2	0 x 15.13^2 =	0	in^4

Web

d		30.25	in
t_w		0.52	in
A	0.515 x 30.25 =	15.5788	in^2
x	30.25 / 2 +1.3+0	16.425	in
Ax	15.5788 x 16.425 =	255.88	in^3
d	16.42 - 16.425 =	0.005	in
Ad^2	15.5788 x 0.005^2 =	0	in^4
I_{web}	(0.515) x (30.25)^3 / 12 =	1187.96	in^4

Bottom Flange Angles

x (angle)		0.00	in
t		0.00	in
A (angle)		0.00	in
A	2 x 0 =	0	in^2
Ixx, double angles		0.00	in^4
y.bar		0.00	in
Ax	0 x 0 =	0	in^3
d	16.42 - 0 =	16.42	in
Ad^2	0 x 16.42^2 =	0	in^4

Bottom Cover Plate

b_f		14.00	in
t_f		1.30	in
A	1.3 x 14 =	18.2	in^2
x	0.5 x 1.3 =	0.65	in
Ax	18.2 x 0.65 =	11.83	in^3
d	16.42 - 0.65 =	15.77	in
Ad^2	18.2 x 15.77^2 =	4526.21	in^4

GROSS SECTION

Girder Properties

Girder d	1.3 + 30.25 + 1.3 + 2 x 0 =	32.85	in
ΣA	18.2 + 0 + 15.5788 + 0 + 18.2 =	51.979	in^2
ΣAx	586.04 + 0 + 255.88 + 0 + 11.83 =	853.8	in^3
Xcg	= ΣAx / ΣA =	16.42	in
ΣAd^2	4531.95 + 0 + 0 + 0 + 4526.21 =	9,058	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	10,246	in^4
S_{TOP}	10246 / (32.85 - 16.42) =	624	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		72	in
y (for top flange angle)		0	in
Iyy.pl (for top flange plate, or cover plate)	1.3 * 14^3/12="	297.3	in^4
Iyy.2A (for top flange double angle)		0.00	in
Iyy (compression flange)	297.3 + 0 =	297.30	in^4
A (compression flange & web)	18.2 + 0 + 15.5788 / 2 =	25.9894	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	3.38	in
A_f	18.2 + 0 =	18.2	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (72 / 3.38)^2 =	16,375	psi
Eq. 2 (0.131πE) / (ld √(1+μ) / A_f)			
	(0.131π x 29,000,000) / ((72 x 32.85 x √1+0.3) / (18.2)) =	80,547	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	rolled	
	Allowable Stress =	16.50	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (72 / 3.38)^2 =	23,818	psi
			23.82	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (72 x 32.85 / 18.2) =	117,522	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	rolled	
		Allowable Stress =	24.00	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

34.7	Span Length (ft)	6.87	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	4	Number of Girders	0.00	Deck Width (ft)
1.25	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
10.00	Tie Height (in)			5	Number of Diaphragms
10.00	Tie Width (in)			55.00	Weight of Diaphragm (LB/FT)
10.00	Tie Length (ft)			rolled	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**518.35**	k-ft
E80 Shear	**68.99**	k

286k Car

286k Car Moment	**409.50**	k-ft
286k Car Shear	**68.99**	k

315k Car

315k Car Moment	**448.98**	k-ft
315k Car Shear	**57.98**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	34.70	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	2	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.16	k/ft
Wind on Live Load Moment	24.08	k-ft
Wind on Live Load Shear	2.78	k

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	2
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2)	
Percentage of wheel load taken by one beam	10.00%

Dead Load on One Girder

Girder	51.9788/144*490="	176.9	lb / ft
Diaphragms			
Number		5	
Total Length		34.35	
Weight per foot		55.00	lb / ft
Total Weight		1889.25	lbs
Number of girders		4	
Weight per foot of beam		13.6	lb / ft
Add 5% for Connections		x1.05	
Total Steel Load	1.05 x (176.9 + 13.6) =	200	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		4	
Rail Weight/LF of beam		50	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	10/12 x 10/12 x 10 x 60 =	417	lb
Number of ties	34.7 ft / 1.25 ft =	27.76	ties
Number of Beams		4	
Tie Weight/ LF of beam		83	lb / ft

Michael Baker INTERNATIONAL

RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		6.95	ft^3
Ties per LF of Bridge		0.8	ties
Average Area of Ties per LF of Bridge		5.56	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		4	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		4	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**50.00**	lb / ft
Total Dead Load		**383**	**lb / ft**
		0.38	k / ft
Moment	**0.38 x 34.7^2 / 8 =**	**57.19**	**k-ft**
Shear	**0.38 x 34.7 / 2 =**	**6.59**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				624	in^3
S_{TOP} (Compression - Gross Section)				624	in^3
A_{web}				15.57875	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				16.50	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				24.00	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 2.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(624 x 16.5 / 12) x (1 - CRF) =	841	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(624 x 24 / 12) x (1 - CRF) =	1223	k-ft
Maximum Compression Stress Capacity - Normal Rating	(624 x 16.5 / 12) x (1 - CRF) =	841	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(624 x 24 / 12) x (1 - CRF) =	1223	k-ft
Maximum Shear Stress Capacity - Normal Rating	(15.57875 x 10.5) x (1 - CRF) =	160	k
Maximum Shear Stress Capacity - Maximum Rating	(15.57875 x 18) x (1 - CRF) =	275	k

Girder Ratings for Tension Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	30.19%	10.00%	40.2	E84	E126	E106	E159	E97	E145
35	0.80	30.19%	10.00%	40.2	E84	E126	E106	E159	E97	E145
30	0.71	26.87%	10.00%	36.9	E86	E129	E108	E163	E99	E149
25	0.61	22.95%	10.00%	33.0	E88	E133	E112	E168	E102	E153
20	0.49	18.42%	10.00%	28.4	E91	E137	E116	E174	E105	E158
15	0.35	13.29%	10.00%	23.3	E95	E143	E120	E181	E110	E165
10	0.20	7.55%	10.00%	17.6	E100	E150	E126	E190	E115	E173

Girder Ratings for Compression Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	30.19%	10.00%	40.2	E84	E126	E106	E159	E97	E145
35	0.80	30.19%	10.00%	40.2	E84	E126	E106	E159	E97	E145
30	0.71	26.87%	10.00%	36.9	E86	E129	E108	E163	E99	E149
25	0.61	22.95%	10.00%	33.0	E88	E133	E112	E168	E102	E153
20	0.49	18.42%	10.00%	28.4	E91	E137	E116	E174	E105	E158
15	0.35	13.29%	10.00%	23.3	E95	E143	E120	E181	E110	E165
10	0.20	7.55%	10.00%	17.6	E100	E150	E126	E190	E115	E173

Girder Ratings for Shear Stress

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	30.19%	10.00%	40.2	E125	E220	E125	E220	E148	E261
35	0.80	30.19%	10.00%	40.2	E125	E220	E125	E220	E148	E261
30	0.71	26.87%	10.00%	36.9	E128	E225	E128	E225	E152	E268
25	0.61	22.95%	10.00%	33.0	E131	E232	E131	E232	E156	E276
20	0.49	18.42%	10.00%	28.4	E136	E240	E136	E240	E162	E285
15	0.35	13.29%	10.00%	23.3	E142	E250	E142	E250	E169	E297
10	0.20	7.55%	10.00%	17.6	E149	E262	E149	E262	E177	E312

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E84	E106	E97
Maximum	E126	E159	E145

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

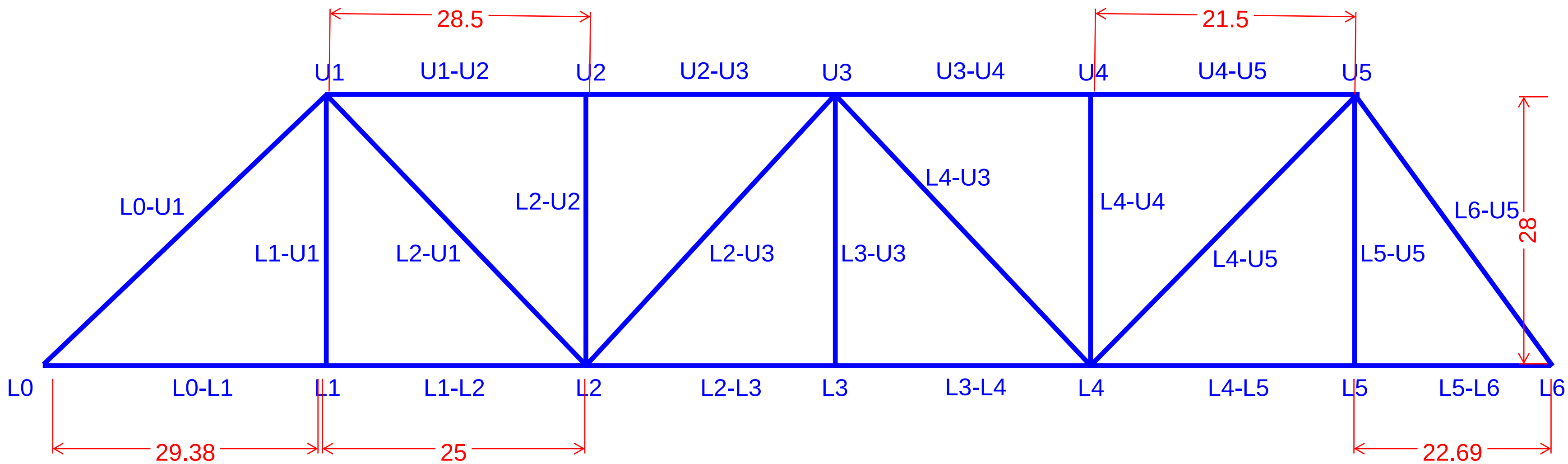
Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E84	E63	E69
Maximum	E126	-	-

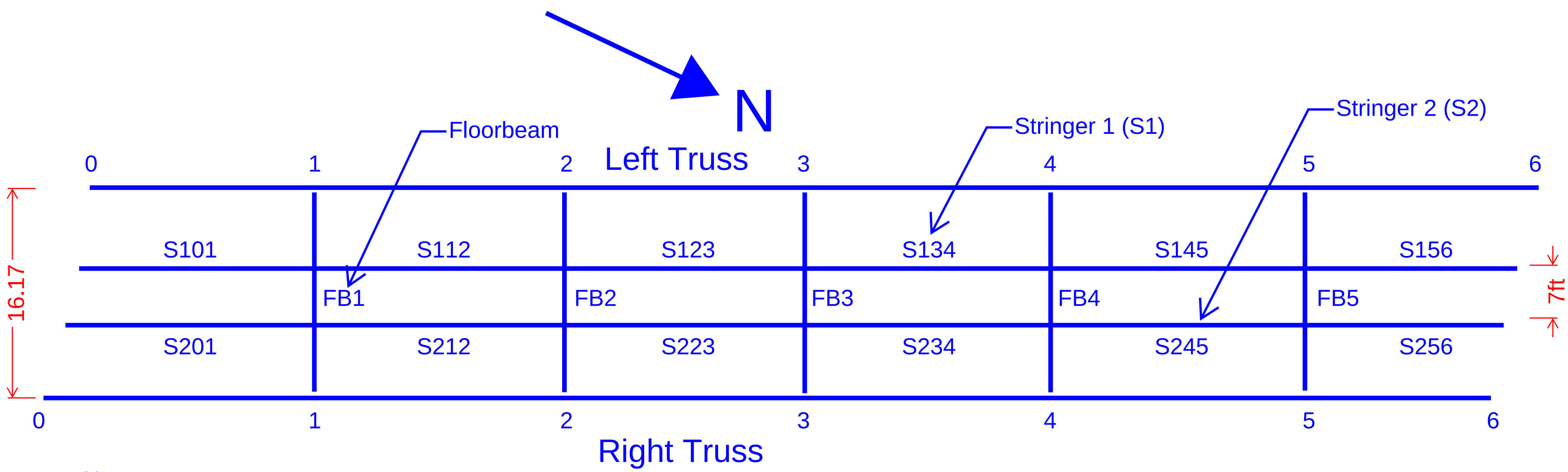
TRUSS RATING FOR SPANS 2 & 4

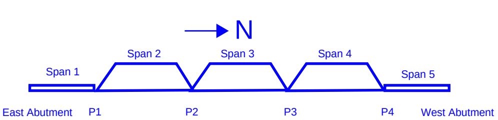
MIDAS MODEL INPUTS:
GEOMETRY & LOADING

Asset 5104 Over S Fork Shenandoah River

By: DS
Chk: JBT 3/19/25







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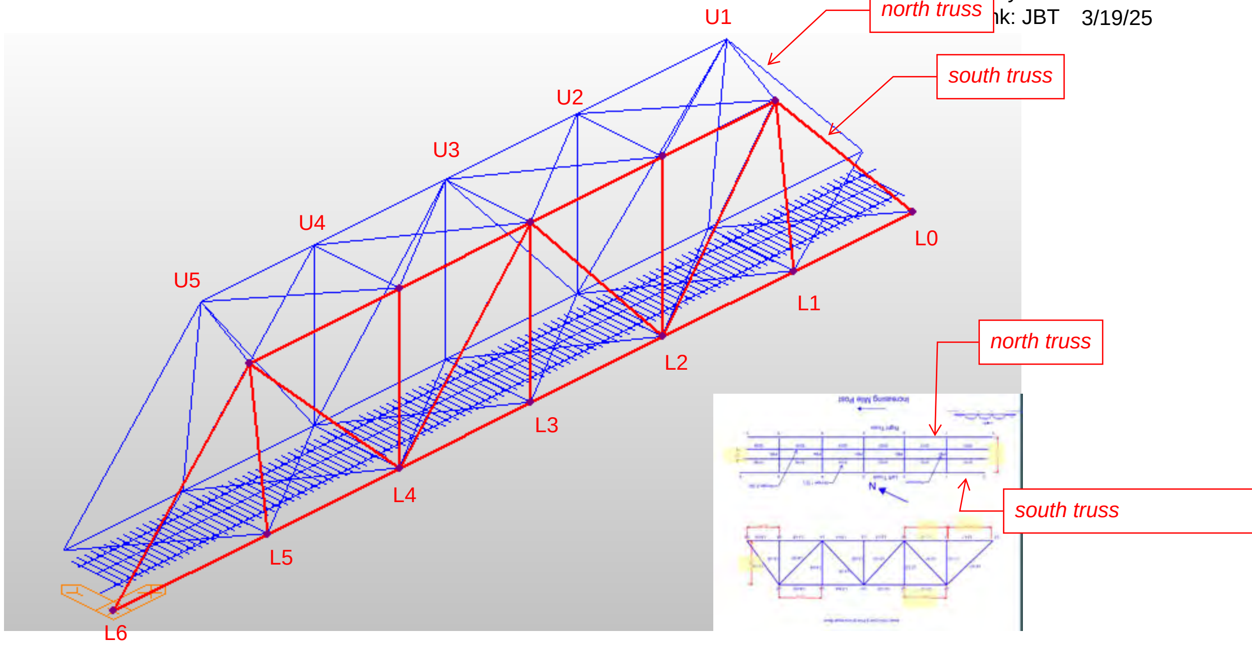
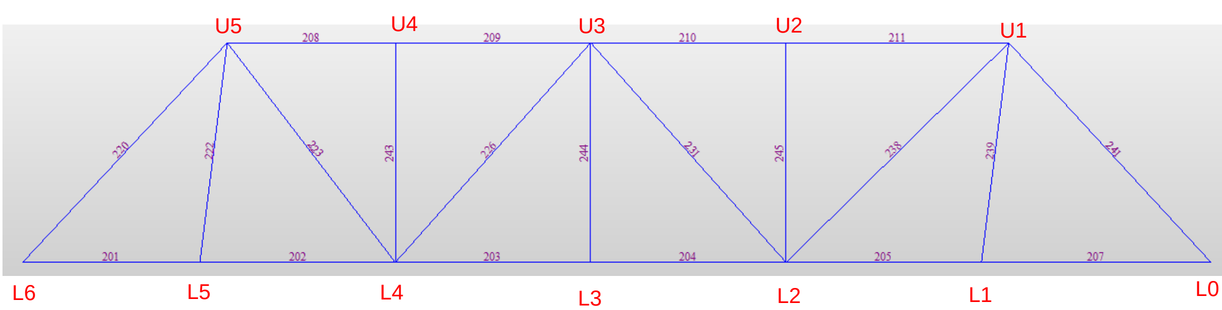
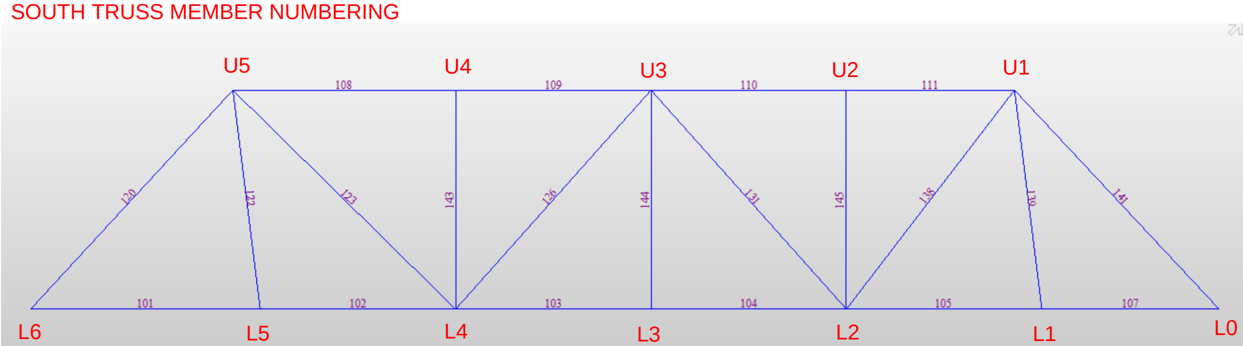


NORTH TRUSS MEMBER NUMBERING



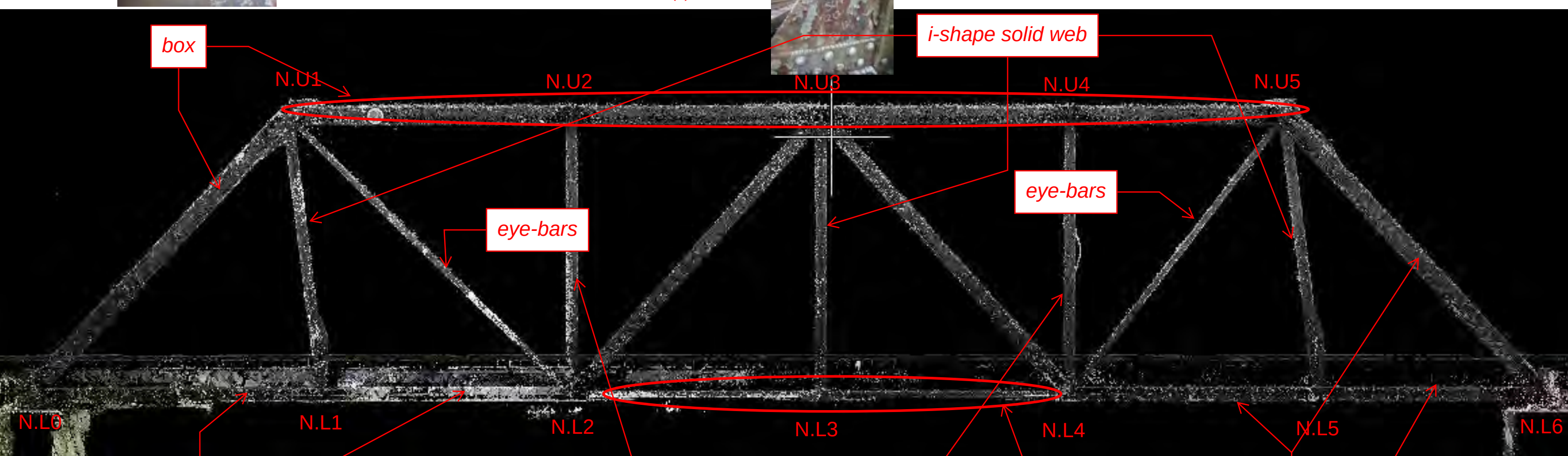
SOUTH TRUSS MEMBER NUMBERING



SPAN 2/4

Upper Chord:
Channel No
info on
thicknesses
Fw: 4.25"
Ft: .78"
Wt: .625
O-O: 24.125"
d: 20.125

S.U5
S.U4
S.U3
S.U2
S.U1
L0-U1
Angle:
L4x4x0.6
Web:
20.5x0.625
SL2-SU1
Eye Bar
6.25"x1.75"
SL2-SU2
L6x3.5x0.38
SL2-UL3
Channel:
O-O: 17.25
Cd: 13.125
Fw: ?
Ft: 0.74"
Wt: 0.645"
SL3-SU3
L6x3.5x0.37
Web:
7.75x0.25
L0-L1
Channel:
O-O: 28.625"
Cd: 15.125"
Fw: 3.5"
Ft: 0.67"
Wt: 0.536"
SL1-SU1
Angle:
L6x3.5x0.4
Web:
8x0.3125
SL3-SL4
Eye Bars
(2)6.25x1.25
(2)6.25x1.75
SL2-SL3
Eye Bar
(2)6.25"x1.75"
(2)6.25"x1.25"
S.L6
S.L5
S.L4
S.L3
S.L2
S.L1
S.L0

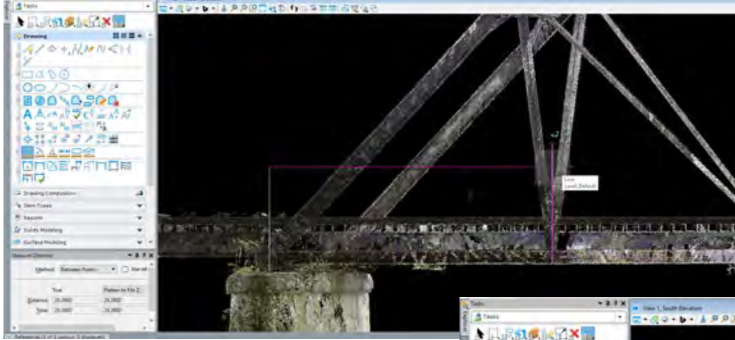


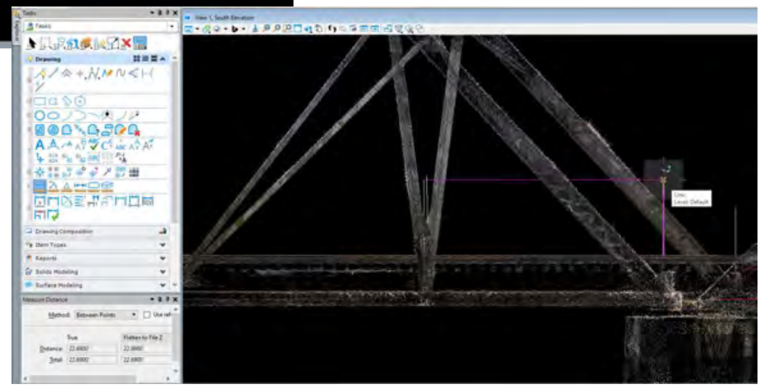
box
i-shape solid web
N.U1
N.U2
N.U3
N.U4
N.U5
eye-bars
eye-bars
N.L6
N.L1
N.L2
N.L3
N.L4
N.L5
N.L6
box
I-shape laced web
eye-bars
box

eye-bars
I-shape laced web
I-shape solid web
box

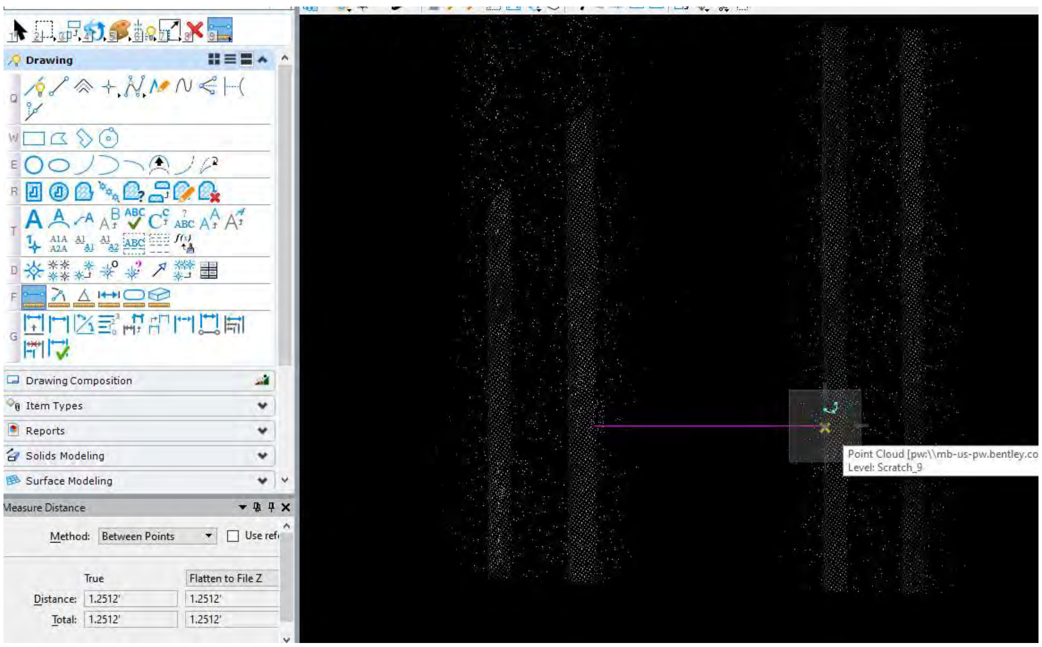
BOTTOM CHORD
L0-L1, L1-L2
28.625 O-O
Measured in Field

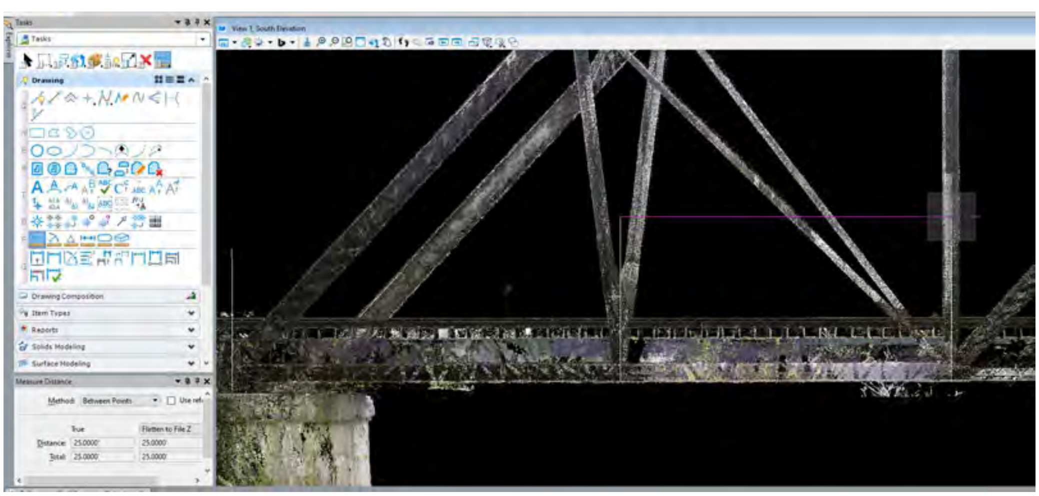
By: DS
Chk: JBT 3/19/25





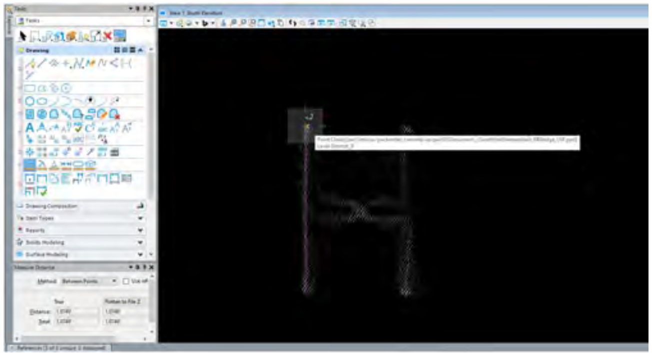
BOTTOM CHORD
L2-L3, L3-L4
1.25' O-O

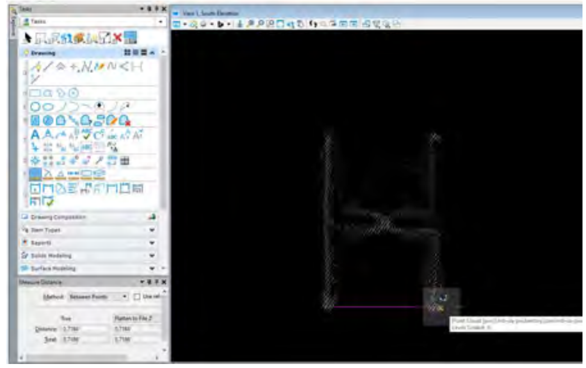


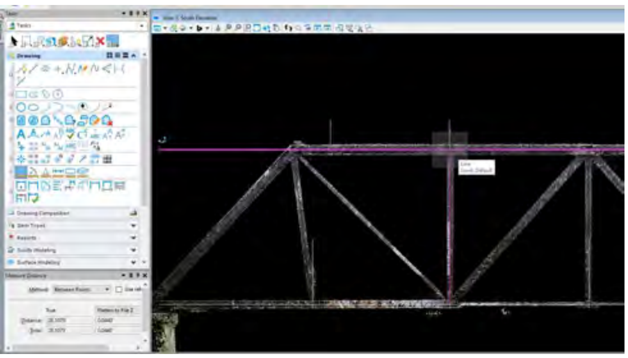


VERTICALS
L2-U2,
L4-U4

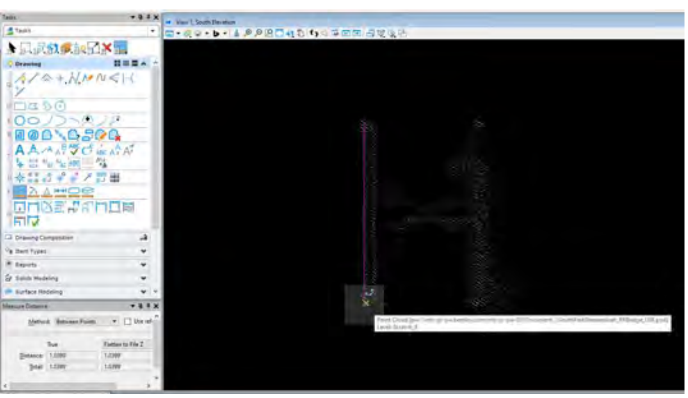
By: DS
Chk: JBT 3/19/25

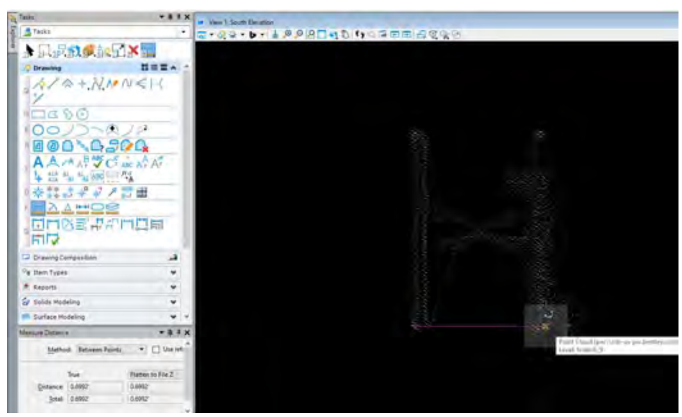


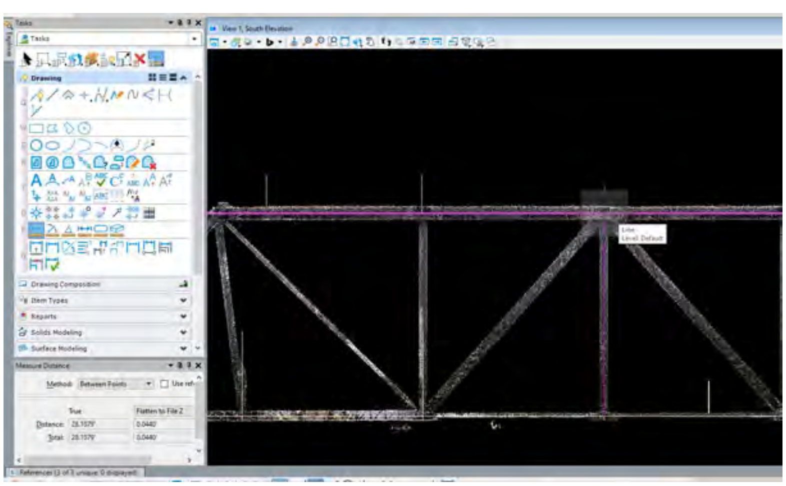




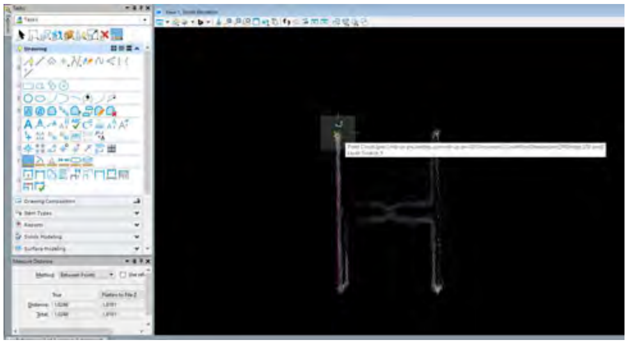
VERTICALS
L3-U3

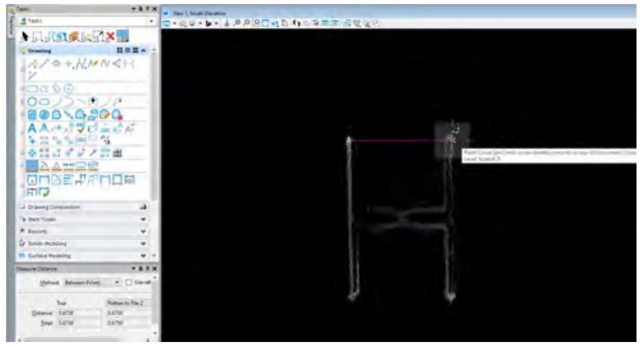


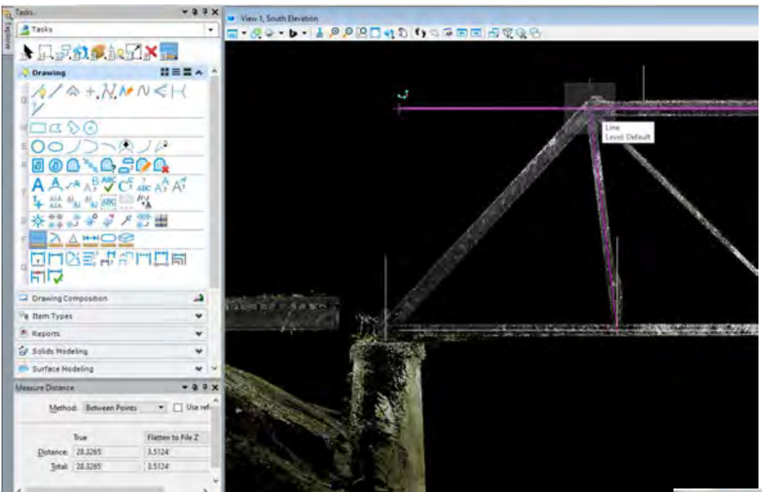




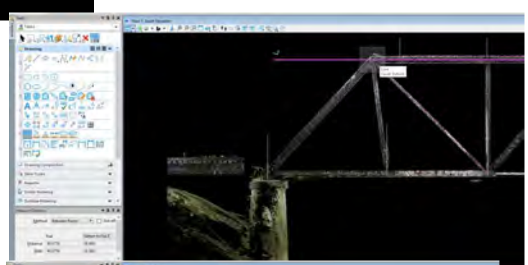
Diagonals L1-U1

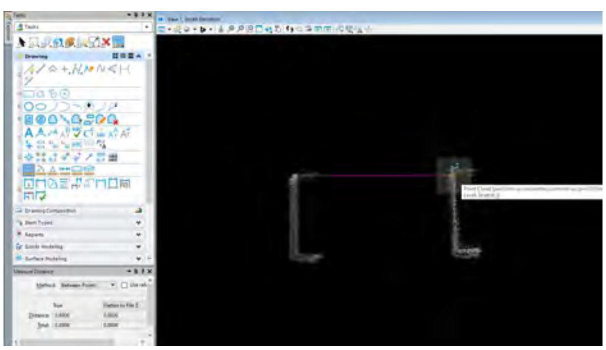


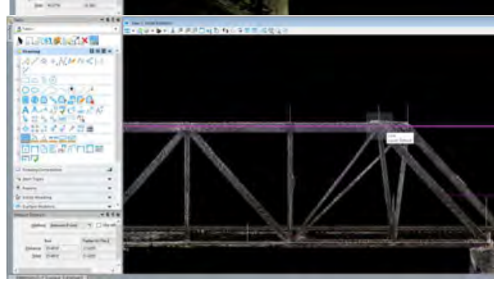




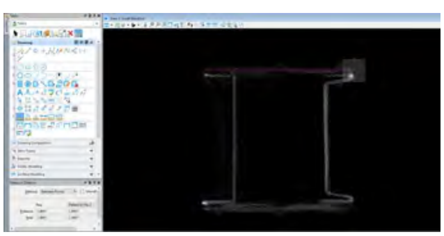
Diagonals L2-U1 & L4-U5

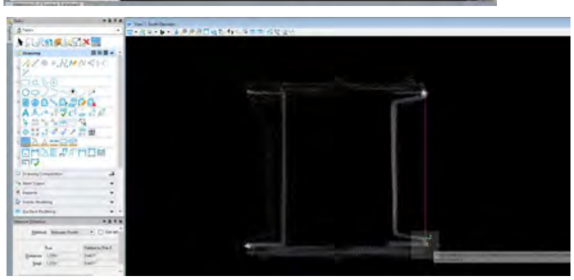


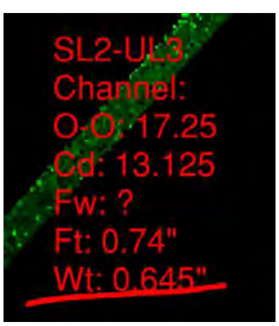


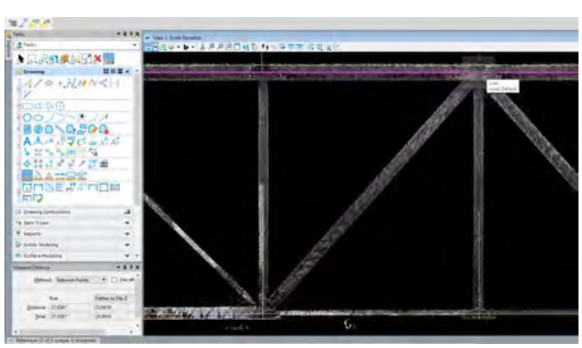


Diagonals L2-U3 Measured in the field



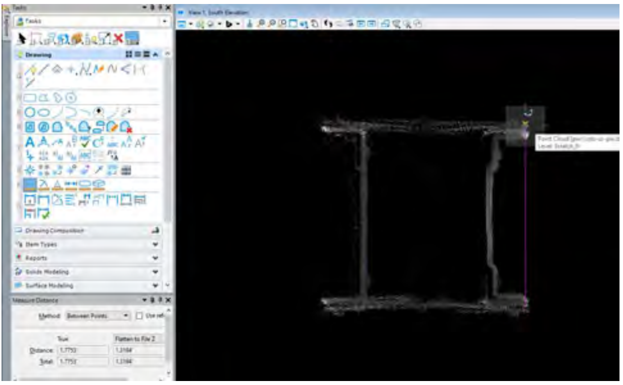


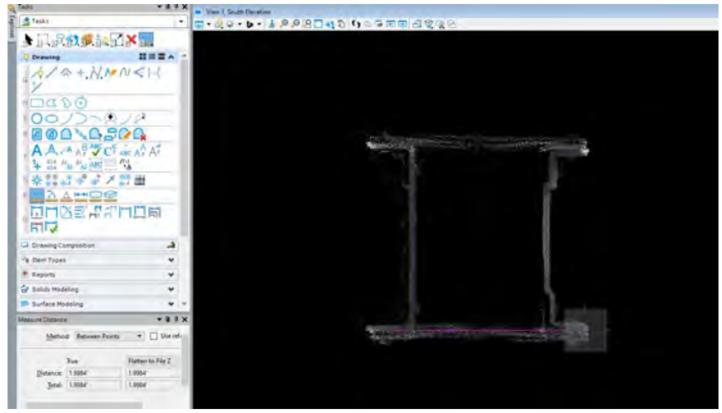


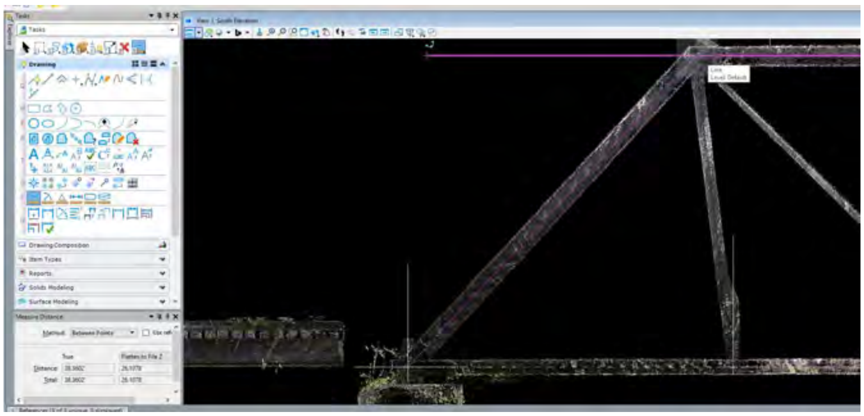


By: DS
Chk: JBT 3/19/25

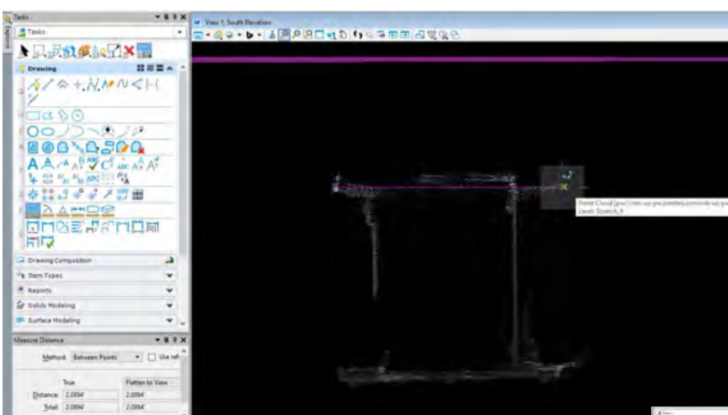
End Post
L0-U1

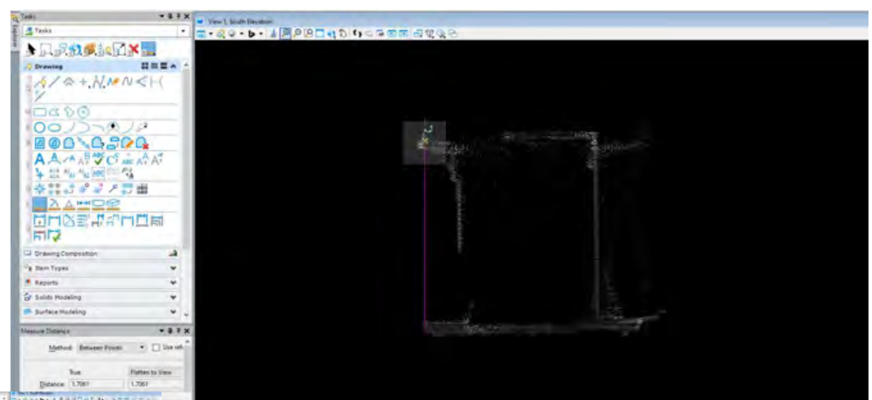


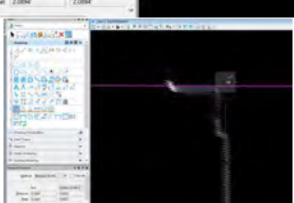


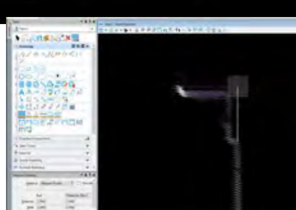


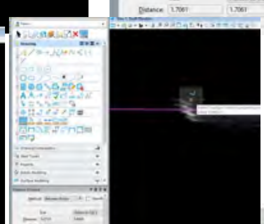
Top Chord
U1-U2 ETC.

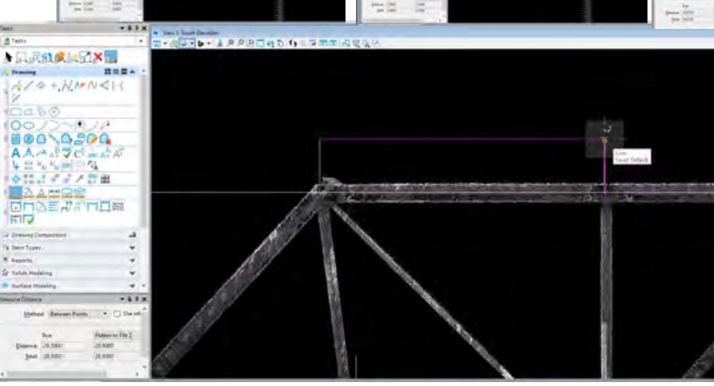


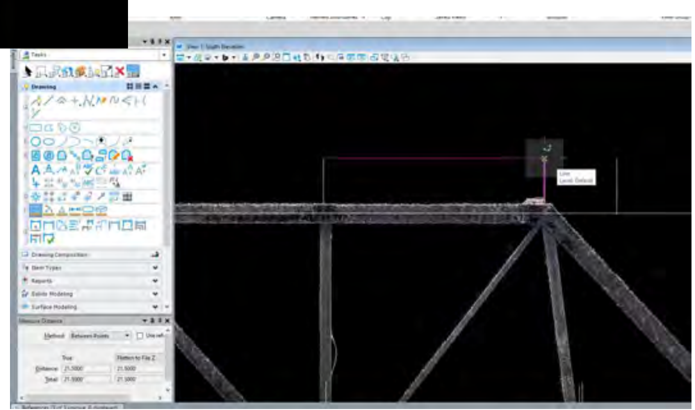












SECTION LOSS

By: DS
Chk: JBT 3/19/25

NORTH LOWER CHORD
EYEBAR SECTION
LOSS (1/4" UP TO 2"?)

SOUTH LOWER CHORD
EYEBAR SECTION
LOSS (1/4" UP TO 2"?)

7415	Span 2, ST, L4, eye bars have heavy pack rust between eyes isolated areas of up to 1/4"D section loss
7416	Span 2, ST, L4, eye bars have heavy pack rust between eyes isolated areas of up to 1/4"D section loss

By: DS
Chk: JBT

PROJECT : *VDOT Shenandoah Valley Load Ratings*

TASK : *Span 2/4 Truss Rating* PROJECT NO : *202063*

SUBJECT :

CALCULATED BY : *DS* DATE : *3/19/2025* CHECKED BY : JBT DATE : 3/19/25

Michael Baker INTERNATIONAL

MEMBER PROPERTIES

*Note: list "Eyebar" in this column if eyebar exists in order for spreadsheet to use correct allowable stress factor

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Member	**Start Joint**	**End Joint**	**Section Number**	**Section Type***	**Material Specification**	**Fy [ksi]**	**Fu [ksi]**	**E [ksi]**	**Unbraced Length X [ft]**	**Unbraced Length Y [ft]**	**Description**	**Include Bending?**	**Include Compr.?**
Bottom Chord	S.L0-S.L1	**S.L0**	**S.L1**	107	Box	**Steel**	**30**	**60**	**29000**	22.69	22.69	Bottom Chord	**no**	**no**
	S.L1-S.L2	**S.L1**	**S.L2**	105	Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	S.L2-S.L3	**S.L2**	**S.L3**	104	Eyebar	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	S.L3-S.L4	**S.L3**	**S.L4**	103	Eyebar	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	S.L4-S.L5	**S.L4**	**S.L5**	102	Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	S.L5-S.L6	**S.L5**	**S.L6**	101	Box	**Steel**	**30**	**60**	**29000**	29.38	29.38	Bottom Chord	**no**	**no**
	N.L0-N.L1	**N.L0**	**N.L1**	207	Box	**Steel**	**30**	**60**	**29000**	29.38	29.38	Bottom Chord	**no**	**no**
	N.L1-N.L2	**N.L1**	**N.L2**	205	Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	N.L2-N.L3	**N.L2**	**N.L3**	204	Eyebar	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	N.L3-N.L4	**N.L3**	**N.L4**	203	Eyebar	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	N.L4-N.L5	**N.L4**	**N.L5**	202	Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	Bottom Chord	**no**	**no**
	N.L5-N.L6	**N.L5**	**N.L6**	201	Box	**Steel**	**30**	**60**	**29000**	22.69	22.69	Bottom Chord	**no**	**no**
Verticals	S.L2-S.U2	**S.L2**	**S.U2**	145	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
	S.L3-S.U3	**S.L3**	**S.U3**	144	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
	S.L4-S.U4	**S.L4**	**S.U4**	143	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
	N.L2-N.U2	**N.L2**	**N.U2**	245	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
	N.L3-N.U3	**N.L3**	**N.U3**	244	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
	N.L4-N.U4	**N.L4**	**N.U4**	243	I-Shape	**Steel**	**30**	**60**	**29000**	28.11	28.11	Verticals	**no**	**yes**
Internal Diagonals	S.L1-S.U1	**S.L1**	**S.U1**	139	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	28.33	28.33	Internal Diagonals	**no**	**yes**
	S.L2-S.U1	**S.L2**	**S.U1**	138	Eyebar	**Steel**	**30**	**60**	**29000**	35.50	35.50	Internal Diagonals	**no**	**yes**
	S.L2-S.U3	**S.L2**	**S.U3**	131	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	37.66	37.66	Internal Diagonals	**no**	**yes**
	S.L4-S.U3	**S.L4**	**S.U3**	126	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	37.66	37.66	Internal Diagonals	**no**	**yes**
	S.L4-S.U5	**S.L4**	**S.U5**	123	Eyebar	**Steel**	**30**	**60**	**29000**	40.07	40.07	Internal Diagonals	**no**	**yes**
	S.L5-S.U5	**S.L5**	**S.U5**	122	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	28.33	28.33	Internal Diagonals	**no**	**yes**
	N.L1-N.U1	**N.L1**	**N.U1**	239	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	28.33	28.33	Internal Diagonals	**no**	**yes**
	N.L2-N.U1	**N.L2**	**N.U1**	238	Eyebar	**Steel**	**30**	**60**	**29000**	40.07	40.07	Internal Diagonals	**no**	**yes**
	N.L2-N.U3	**N.L2**	**N.U3**	231	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	37.66	37.66	Internal Diagonals	**no**	**yes**
	N.L4-N.U3	**N.L4**	**N.U3**	226	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	37.66	37.66	Internal Diagonals	**no**	**yes**
	N.L4-N.U5	**N.L4**	**N.U5**	223	Eyebar	**Steel**	**30**	**60**	**29000**	35.50	35.50	Internal Diagonals	**no**	**yes**
	N.L5-N.U5	**N.L5**	**N.U5**	222	Built-Up I-Shape	**Steel**	**30**	**60**	**29000**	28.33	28.33	Internal Diagonals	**no**	**yes**
hords	S.L0-S.U1	**S.L0**	**S.U1**	141	Built-Up Box	**Steel**	**30**	**60**	**29000**	38.36	38.36	End Posts & Top Chords	**no**	**yes**
	S.U1-S.U2	**S.U1**	**S.U2**	108to111	Built-Up Box	**Steel**	**30**	**60**	**29000**	28.50	28.50	End Posts & Top Chords	**no**	**yes**
	S.U2-S.U3	**S.U2**	**S.U3**	108to111	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	End Posts & Top Chords	**no**	**yes**
	S.U3-S.U4	**S.U3**	**S.U4**	108to111	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	End Posts & Top Chords	**no**	**yes**

PROJECT : *VDOT Shenandoah Valley Load Ratings*
TASK : *Span 2/4 Truss Rating* PROJECT NO : *202063*
SUBJECT :
CALCULATED BY : *DS* DATE : *3/19/2025* CHECKED BY : JBT DATE : 3/19/25

Michael Baker INTERNATIONAL

MEMBER PROPERTIES

*Note: list "Eyebar" in this column if eyebar exists in order for spreadsheet to use correct allowable stress factor

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Member	Start Joint	End Joint	Section Number	Section Type*	Material Specification	Fy [ksi]	Fu [ksi]	E [ksi]	Unbraced Length X [ft]	Unbraced Length Y [ft]	Description	Include Bending?	Include Compr.?
End Posts & Top C	S.U4-S.U5	**S.U4**	**S.U5**	108to111	Built-Up Box	**Steel**	**30**	**60**	**29000**	21.50	21.50	End Posts & Top Chords	**no**	**yes**
	S.L6-S.U5	**S.L6**	**S.U5**	120	Built-Up Box	**Steel**	**30**	**60**	**29000**	38.36	38.36	End Posts & Top Chords	**no**	**yes**
	N.L0-N.U1	**N.L0**	**N.U1**	241	Built-Up Box	**Steel**	**30**	**60**	**29000**	38.36	38.36	End Posts & Top Chords	**no**	**yes**
	N.U1-N.U2	**N.U1**	**N.U2**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	28.50	28.50	End Posts & Top Chords	**no**	**yes**
	N.U2-N.U3	**N.U2**	**N.U3**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	End Posts & Top Chords	**no**	**yes**
	N.U3-N.U4	**N.U3**	**N.U4**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.00	25.00	End Posts & Top Chords	**no**	**yes**
	N.U4-N.U5	**N.U4**	**N.U5**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	21.50	21.50	End Posts & Top Chords	**no**	**yes**
	N.L6-N.U5	**N.L6**	**N.U5**	220	Built-Up Box	**Steel**	**30**	**60**	**29000**	38.36	38.36	End Posts & Top Chords	**no**	**yes**

SECTION DETAILS

					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
								TOP COVERPLATE (HP1)						TOP ANGLES (A1 & A2)										
SPAN 2/4	Member	Start Joint	End Joint	Model Membr No.	Section Number	Section Type*	NOTES	W	W.SL	T	T.SL	*dW (in)*	*dT (in)*	HLEG	HLEG.SL	VLEG	VLEG.SL	T	THLEG.SL	TVLEG.SL	*d.HLEG*	*d.VLEG*	*d.THLEG*	*d.TVLEG*
Bottom Chord	S.L0-S.L1	S.L0	S.L1	107	107	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	S.L1-S.L2	S.L1	S.L2	105	105	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	S.L2-S.L3	S.L2	S.L3	104	104	Eyebar						0	0								0	0	0	0
	S.L3-S.L4	S.L3	S.L4	103	103	Eyebar						0	0								0	0	0	0
	S.L4-S.L5	S.L4	S.L5	102	102	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	S.L5-S.L6	S.L5	S.L6	101	101	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	N.L0-N.L1	N.L0	N.L1	207	207	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	N.L1-N.L2	N.L1	N.L2	205	205	Box						0	0	3.5		1		0.67		0.134	3.5	1	0.67	0.536
	N.L2-N.L3	N.L2	N.L3	204	204	Eyebar						0	0								0	0	0	0
	N.L3-N.L4	N.L3	N.L4	203	203	Eyebar						0	0								0	0	0	0
	N.L4-N.L5	N.L4	N.L5	202	202	Box						0	0	3.5		1		0.5		0.134	3.5	1	0.5	0.366
	N.L5-N.L6	N.L5	N.L6	201	201	Box						0	0	3.5		1		0.5		0.134	3.5	1	0.5	0.366
Verticals	S.L2-S.U2	S.L2	S.U2	145	145	I-Shape						0	0	6		3.5		0.38			6	3.5	0.38	0.38
	S.L3-S.U3	S.L3	S.U3	144	144	I-Shape						0	0	6		3.5		0.37			6	3.5	0.37	0.37
	S.L4-S.U4	S.L4	S.U4	143	143	I-Shape						0	0	6		3.5		0.38			6	3.5	0.38	0.38
	N.L2-N.U2	N.L2	N.U2	245	245	I-Shape						0	0	6		3.5		0.38			6	3.5	0.38	0.38
	N.L3-N.U3	N.L3	N.U3	244	244	I-Shape						0	0	6		3.5		0.37			6	3.5	0.37	0.37
	N.L4-N.U4	N.L4	N.U4	243	243	I-Shape						0	0	6		3.5		0.38			6	3.5	0.38	0.38
Internal Diagonals	S.L1-S.U1	S.L1	S.U1	139	139	Built-Up I-Shape						0	0	6		3.5		0.4			6	3.5	0.4	0.4
	S.L2-S.U1	S.L2	S.U1	138	138	Eyebar						0	0								0	0	0	0
	S.L2-S.U3	S.L2	S.U3	131	131	Built-Up I-Shape						0	0	3		1		0.74		0.095	3	1	0.74	0.645
	S.L4-S.U3	S.L4	S.U3	126	126	Built-Up I-Shape						0	0	3		1		0.74		0.095	3	1	0.74	0.645
	S.L4-S.U5	S.L4	S.U5	123	123	Eyebar						0	0								0	0	0	0
	S.L5-S.U5	S.L5	S.U5	122	122	Built-Up I-Shape						0	0	6		3.5		0.4			6	3.5	0.4	0.4
	N.L1-N.U1	N.L1	N.U1	239	239	Built-Up I-Shape						0	0	6		3.5		0.4			6	3.5	0.4	0.4
	N.L2-N.U1	N.L2	N.U1	238	238	Eyebar						0	0								0	0	0	0
	N.L2-N.U3	N.L2	N.U3	231	231	Built-Up I-Shape						0	0	3		1		0.74		0.095	3	1	0.74	0.645
	N.L4-N.U3	N.L4	N.U3	226	226	Built-Up I-Shape						0	0	3		1		0.74		0.095	3	1	0.74	0.645
	N.L4-N.U5	N.L4	N.U5	223	223	Eyebar						0	0								0	0	0	0
	N.L5-N.U5	N.L5	N.U5	222	222	Built-Up I-Shape						0	0	6		3.5		0.4			6	3.5	0.4	0.4
End Posts & Top Chords	S.L0-S.U1	S.L0	S.U1	141	141	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	S.U1-S.U2	S.U1	S.U2	111	108to111	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	S.U2-S.U3	S.U2	S.U3	110	108to111	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	S.U3-S.U4	S.U3	S.U4	109	108to111	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	S.U4-S.U5	S.U4	S.U5	108	108to111	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	S.L6-S.U5	S.L6	S.U5	120	120	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.L0-N.U1	N.L0	N.U1	241	241	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.U1-N.U2	N.U1	N.U2	211	208to211	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.U2-N.U3	N.U2	N.U3	210	208to211	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.U3-N.U4	N.U3	N.U4	209	208to211	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.U4-N.U5	N.U4	N.U5	208	208to211	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6
	N.L6-N.U5	N.L6	N.U5	220	220	Built-Up Box						0	0	4		4		0.6			4	4	0.6	0.6

		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
		EXT WEB PLATES (VP1 & VP2)		EXT WEB CP (VCP4 & VCP5)		INT WEB PLATE (VP3)		BOTTOM ANGLES (A3 & A4)											BOT COVERPLATE (HP2)						INT LACING (FYI Only, Not USED)		
SPAN 2/4	Member	d.W	d.T	d.W	d.T	d.W	d.T	HLEG	HLEG.SL	VLEG	VLEG.SL	T	THLEG.SL	TVLEG.SL	d.HLEG	d.VLEG	d.THLEG	d.HLEG	W	W.SL	T	T.SL	dW	dT	dW	dT	X OR Z
Bottom Chord	S.L0-S.L1			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	S.L1-S.L2			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	S.L2-S.L3	6.25	1.625	6.25	1.125			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	S.L3-S.L4	6.25	1.625	6.25	1.125			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	S.L4-S.L5			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	S.L5-S.L6			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	N.L0-N.L1			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	N.L1-N.L2			13.125	0.536			3.5	0	1	0	0.67	0	0.134	3.5	1	0.67	0.536	0	0	0	0	0	0			
	N.L2-N.L3	6.25	1.625	6.25	1.125			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	N.L3-N.L4	6.25	1.625	6.25	1.125			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	N.L4-N.L5			13.125	0.536			3.5	0	1	0	0.5	0	0.134	3.5	1	0.5	0.366	0	0	0	0	0	0			
	N.L5-N.L6			13.125	0.536			3.5	0	1	0	0.5	0	0.134	3.5	1	0.5	0.366	0	0	0	0	0	0			
Verticals	S.L2-S.U2			0	0			6		3.5		0.38	0		6	3.5	0.38	0.38	0	0	0	0	0	0			
	S.L3-S.U3			0	0	7.75	0.25	6		3.5		0.37	0		6	3.5	0.37	0.37	0	0	0	0	0	0			
	S.L4-S.U4			0	0			6		3.5		0.38	0		6	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L2-N.U2			0	0			6		3.5		0.38	0		6	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L3-N.U3			0	0	7.75	0.25	6		3.5		0.37	0		6	3.5	0.37	0.37	0	0	0	0	0	0			
	N.L4-N.U4			0	0			6		3.5		0.38	0		6	3.5	0.38	0.38	0	0	0	0	0	0			
Internal Diagonals	S.L1-S.U1					8	0.31	6		3.5		0.4	0		6	3.5	0.4	0.4	0	0	0	0	0	0			
	S.L2-S.U1	6.25	1.75					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	S.L2-S.U3			11.125	0.645			3	0	1	0	0.74	0	0.095	3	1	0.74	0.645	0	0	0	0	0	0			
	S.L4-S.U3			11.125	0.645			3	0	1	0	0.74	0	0.095	3	1	0.74	0.645	0	0	0	0	0	0			
	S.L4-S.U5	6.25	1.75					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	S.L5-S.U5					8	0.31	6	0	3.5	0	0.4	0	0	6	3.5	0.4	0.4	0	0	0	0	0	0			
	N.L1-N.U1					8	0.31	6	0	3.5	0	0.4	0	0	6	3.5	0.4	0.4	0	0	0	0	0	0			
	N.L2-N.U1	6.25	1.75					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	N.L2-N.U3			11.125	0.645			3	0	1	0	0.74	0	0.095	3	1	0.74	0.645	0	0	0	0	0	0			
	N.L4-N.U3			11.125	0.645			3	0	1	0	0.74	0	0.095	3	1	0.74	0.645	0	0	0	0	0	0			
	N.L4-N.U5	6.25	1.75					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	N.L5-N.U5					8	0.31	6	0	3.5	0	0.4	0	0	6	3.5	0.4	0.4	0	0	0	0	0	0			
End Posts & Top Chords	S.L0-S.U1	20.5	0.625					4		4		0.6	0		4	4	0.6	0.6	0	0	0	0	0	0			
	S.U1-S.U2	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	S.U2-S.U3	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	S.U3-S.U4	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	S.U4-S.U5	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	S.L6-S.U5	20.5	0.625					4		4		0.6	0		4	4	0.6	0.6					0	0			
	N.L0-N.U1	20.5	0.625					4		4		0.6	0		4	4	0.6	0.6					0	0			
	N.U1-N.U2	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	N.U2-N.U3	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	N.U3-N.U4	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	N.U4-N.U5	20.5	0.625					4		4		0.6	0	0	4	4	0.6	0.6					0	0			
	N.L6-N.U5	20.5	0.625					4		4		0.6	0		4	4	0.6	0.6					0	0			

		47	48	49
		BOT LACING (FYI Only, Not USED)		
SPAN 2/4	Member	*dW*	*dT*	X OR Z
Bottom Chord	S.L0-S.L1			
	S.L1-S.L2			
	S.L2-S.L3			
	S.L3-S.L4			
	S.L4-S.L5			
	S.L5-S.L6			
	N.L0-N.L1			
	N.L1-N.L2			
	N.L2-N.L3			
	N.L3-N.L4			
	N.L4-N.L5			
	N.L5-N.L6			
Verticals	S.L2-S.U2			
	S.L3-S.U3			
	S.L4-S.U4			
	N.L2-N.U2			
	N.L3-N.U3			
	N.L4-N.U4			
Internal Diagonals	S.L1-S.U1			
	S.L2-S.U1			
	S.L2-S.U3			
	S.L4-S.U3			
	S.L4-S.U5			
	S.L5-S.U5			
	N.L1-N.U1			
	N.L2-N.U1			
	N.L2-N.U3			
	N.L4-N.U3			
	N.L4-N.U5			
	N.L5-N.U5			
End Posts & Top Chords	S.L0-S.U1			
	S.U1-S.U2			
	S.U2-S.U3			
	S.U3-S.U4			
	S.U4-S.U5			
	S.L6-S.U5			
	N.L0-N.U1			
	N.U1-N.U2			
	N.U2-N.U3			
	N.U3-N.U4			
	N.U4-N.U5			
	N.L6-N.U5			

		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
					HP1		HP2		VP1		VP2		VP3		VCP4		VCP5		A1 (Horiz. Leg)		A1 (Vert. Leg)		A2 (Horiz. Leg)		A2 (Vert. Leg)		A3 (Horiz. Leg)		A3 (Vert. Leg)		A4 (Horiz. Leg)		A4 (Vert. Leg)	
SPAN 2/4	Member	OTO.x	OTO.y	L (ft)	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.
Bottom Chord	S.L0-S.L1	28.625	15.125	22.69											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L1-S.L2	28.625	15.125	25											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L2-S.L3	15	6.25	25																														
	S.L3-S.L4	15	6.25	25																														
	S.L4-S.L5	28.625	15.125	25											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L5-S.L6	28.625	15.125	29.38											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L0-N.L1	28.625	15.125	29.38											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L1-N.L2	28.625	15.125	25											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L2-N.L3	15	6.25	25																														
	N.L3-N.L4	15	6.25	25																														
	N.L4-N.L5	28.625	15.125	25											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L5-N.L6	28.625	15.125	22.69											2	0.9375	2	0.9375	1	0.9375			1	0.9375			1	0.9375			1	0.9375		
Verticals	S.L2-S.U2	8.6232	12.9	28.1079															1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.L3-S.U3	8.3904	12.468	28.1079									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.L4-S.U4	8.6232	12.9	28.1079															1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L2-N.U2	8.6232	12.9	28.1079															1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L3-N.U3	8.454	12.468	28.1079									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L4-N.U4	8.3904	12.9	28.1079															1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
Internal Diagonals	S.L1-S.U1	8.0856	12.2952	28.3265									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.L2-S.U1	10.6872	6.25	35.5																														
	S.L2-S.U3	17.25	13.125	37.66															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L4-S.U3	17.25	13.125	37.66															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L4-S.U5	10.6872	6.25	40.07																														
	S.L5-S.U5	8.0856	12.2952	28.3265									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L1-N.U1	8.0856	12.2952	28.3265									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L2-N.U1	10.6872	6.25	40.07																														
	N.L2-N.U3	17.25	13.125	37.66															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L4-N.U3	17.25	13.125	37.66															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L4-N.U5	10.6872	6.25	35.5																														
	N.L5-N.U5	8.0856	12.2952	28.3265									2	0.9375					1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
End Posts & Top Chords	S.L0-S.U1	24	21.3036	38.36					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U1-S.U2	25.0728	20.4732	28.5					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U2-S.U3	25.0728	20.4732	25					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U3-S.U4	25.0728	20.4732	25					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U4-S.U5	25.0728	20.4732	21.5					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.L6-S.U5	24	21.3036	38.36					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L0-N.U1	24	21.3036	38.36					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U1-N.U2	25.0728	20.4732	28.5					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U2-N.U3	25.0728	20.4732	25					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U3-N.U4	25.0728	20.4732	25					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U4-N.U5	25.0728	20.4732	21.5					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L6-N.U5	24	21.3036	38.36					2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375

PROJECT :	Asset 5104 Span 2/4		Michael Baker INTERNATIONAL
TASK :	Bridge Loads for Truss Model	PROJECT NO :	
SUBJECT :			
CALCULATED BY : DS	DATE : 03/05/25	CHECKED BY : JBT	DATE : 03/05/25

-These loads are calculated for the 3D Midas model being used to determine axial forces and overall superstructure deformations
-Inspection notes and LIDAR scan are used for dimensions and geometry
-Design Live Load is Cooper E80 and 286K

Rail Gauge:	5.00	ft
Superelevation:	0.00	in (see track chart)
Degree of Curvature:	0.00	degrees (see track chart)
Span Length:	152	ft (each truss length)
Upper Chord	1.71	ft
End Diagonal	1.78	ft
Lower Chord (L0-L2)	1.26	ft
Lower Chord (L2-L4)	0.52	
Diagonal 1 & 6	1.02	ft
Diagonal 2 & 5	0.52	ft
Diagonal 3 & 4	1.09	ft
Vertical 1 &3	1.08	ft
Vertical 2	1.04	
Top of Rail to T/Girder:	1.50	ft (tie + rail height)
Truss Spacing:	16.17	ft
Tie Height:	10.00	in (see attached snips in excel file)
Tie Width:	10.00	in (see attached snips in excel file)
Tie Length:	10.00	ft (see attached snips in excel file)
Tie Spacing:	1.25	ft (see attached snips in excel file)
Grating Wt:	0.00	lb/ft
Heaviest E80 Axle:	80.00	k
Heaviest 286k Axle:	71.50	k

Dead Loads Computation

Track:	0.20	klf (Apply to CL track)
Walkway:	0.00	klf
Self Weight Factor:	1.15	(accounts for steel connections, miscellaneous timber)

15-7.3.2.5 Wind Forces on Loaded Bridge:

Trans. Wind on Train:	0.200	klf (Apply to CL track, 8' above deck, transverse)
Vind on Upper Chord Members:	0.034	klf (Apply to flange, transverse)
Vind on End Diagonal Members:	0.036	klf (Apply to flange, transverse)
n Lower Chord (L0-L2) Members:	0.025	klf (Apply to flange, transverse)
n Lower Chord (L2-L4) Members:	0.010	klf (Apply to flange, transverse)
ind on Diagonal 1 & 6 Members:	0.020	klf (Apply to flange, transverse)
ind on Diagonal 2 & 5 Members:	0.010	klf (Apply to flange, transverse)
ind on Diagonal 3 & 4 Members:	0.022	klf (Apply to flange, transverse)
Vind on Vertical 1 &3 Members:	0.022	klf (Apply to flange, transverse)
ns. Wind on Vertical 2 Members:	0.021	klf (Apply to flange, transverse)

15-1.3.9 Lateral Forces from Equipment:

E80 Equipment Force:	20.00	k (Apply transversly, at portal frames at CL track, each direction)
286k Equipment Force:	17.88	k (Apply transversly, at portal frames at CL track, each direction)

15-1.3.12 Longitudinal Forces:

Braking Force:	1.50	klf (Apply to CL track, 8' above deck, longitudinally)
Traction Force:	2.03	klf (Apply to CL track, 3' above deck, longitudinally)

TRUSS RATING FOR SPANS 2 & 4

RATING SUMMARY

PROJECT : *VDOT Shenandoah Valley Load Ratings*

TASK : *Span 2/4 Truss Rating* PROJECT NO : *202063*

Michael Baker INTERNATIONAL

SUBJECT :

CALCULATED BY : *DS* DATE : *3/19/2025* CHECKED BY : JBT DATE : 3/19/25

RATINGS SUMMARY

	Bottom Chord - Axial Only							Vertical - Axial Only						
Truck Configuration	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	0.744	-	N/A	E-60	-	201	N.L5-N.L6	1.251	-	N/A	E-100	-	144	S.L3-S.U3
Cooper E-80 (Max)	1.157	-	N/A	E-93	-	201	N.L5-N.L6	1.872	-	N/A	E-150	-	144	S.L3-S.U3
286k AAR (Normal)	0.920	**0.81**	E-65	E-60	NG	201	N.L5-N.L6	1.751	**0.71**	E-57	E-100	OK	144	S.L3-S.U3
286k AAR (Max)	1.429	**0.81**	E-65	E-93	OK	201	N.L5-N.L6	2.621	**0.71**	E-57	E-150	OK	144	S.L3-S.U3

	Diagonal - Axial Only							Top Chord - Axial Only						
Truck Configuration	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	0.830	-	N/A	E-66	-	238	N.L2-N.U1	0.987	-	N/A	E-79	-	141	S.L0-S.U1
Cooper E-80 (Max)	1.287	-	N/A	E-103	-	238	N.L2-N.U1	1.344	-	N/A	E-108	-	141	S.L0-S.U1
286k AAR (Normal)	1.166	**0.76**	E-61	E-71	OK	223	N.L4-N.U5	1.291	**0.76**	E-61	E-79	OK	141	S.L0-S.U1
286k AAR (Max)	1.809	**0.76**	E-61	E-110	OK	223	N.L4-N.U5	1.759	**0.76**	E-61	E-108	OK	141	S.L0-S.U1

Speed: **35 mph**

	Bottom Chord - Axial Only							Vertical - Axial Only						
Truck Configuration	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	0.804	-	N/A	E-64	-	201	N.L5-N.L6	1.392	-	N/A	E-111	-	144	S.L3-S.U3
Cooper E-80 (Max)	1.250	-	N/A	E-100	-	201	N.L5-N.L6	2.083	-	N/A	E-167	-	144	S.L3-S.U3
286k AAR (Normal)	0.989	**0.81**	E-65	E-64	NG	201	N.L5-N.L6	1.949	**0.71**	E-57	E-111	OK	144	S.L3-S.U3
286k AAR (Max)	1.537	**0.81**	E-65	E-100	OK	201	N.L5-N.L6	2.917	**0.71**	E-57	E-167	OK	144	S.L3-S.U3

	Diagonal - Axial Only							Top Chord - Axial Only						
Truck Configuration	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	0.924	-	N/A	E-74	-	238	N.L2-N.U1	1.098	-	N/A	E-88	-	141	S.L0-S.U1
Cooper E-80 (Max)	1.433	-	N/A	E-115	-	238	N.L2-N.U1	1.496	-	N/A	E-120	-	141	S.L0-S.U1
286k AAR (Normal)	1.304	**0.71**	E-57	E-74	OK	138	S.L2-S.U1	1.437	**0.76**	E-61	E-88	OK	141	S.L0-S.U1
286k AAR (Max)	2.024	**0.71**	E-57	E-115	OK	138	S.L2-S.U1	1.957	**0.76**	E-61	E-120	OK	141	S.L0-S.U1

Speed: **10 mph**

TRUSS RATING FOR SPANS 2 & 4

RATING CALCULATIONS
for
CONTROLLING MEMBER

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

TRUSS MEMBER LOAD FACTOR RATINGS

General Information

* Two load scenarios must be investigated. These are as follows:

1. Axial DL + Max Axial (LL + I)
2. Axial DL + Min Axial (LL + I)

Symbology

[ ] = required input

Load and P.O.I. Information

Load and P.O.I. Details:

Element ID:	**201**	
Section ID:	201	
Moving Load Case:	**Cooper E-80**	
Member:	N.L5-N.L6	
Include Bending?	**no**	
Include Compression?	**no**	
$K_{normal\ rating}$ =	**0.55**	*(Gross Tension, AREMA Table 15-1-11)*
$K1_{normal\ rating}$ =	**0.47**	*(Net Tension, AREMA Table 15-1-11)*
$K_{max\ rating}$ =	**0.80**	*(AREMA 7.3.3.3)*
$K1_{max\ rating}$ =	**0.67**	*(AREMA 7.3.3.4)*

Applied Service Forces:

Span Length =	**152**	ft
Impact =	20.9%	
Speed =	**35**	mph
Impact reduction due to speed =	0.80	
Impact for Live Load (except Rocking Effect) =	16.7%	

	Axial			Bending			Shear		
Dead Load Force [Group I] =	P_{DL} =	**67.89**	**kips**	M_{DL} =	**0.00**	**kip-ft**	V_{DL} =	**0.00**	**kips**
Max Wind Load Force =	$P_{W,max}$ =	13.61	kips	$M_{W,max}$ =	0.00	kip-ft	$V_{W,max}$ =	0.00	kips
Min Wind Load Force =	$P_{W,min}$ =	-13.46	kips	$M_{W,min}$ =	0.00	kip-ft	$V_{W,min}$ =	0.00	kips
Dead + Wind Load Force [Group II] =	P_{DL+W} =	**81.50**	**kips**	M_{DL+W} =	**0.00**	**kip-ft**	V_{DL+W} =	**0.00**	**kips**
Max Live Load + Rocking Force =	$P_{LL,RE,max}$ =	280.74	kips	$M_{LL,RE,max}$ =	0.00	kip-ft	$V_{LL,RE,max}$ =	0.00	kips
Min Live Load + Rocking Force =	$P_{LL,RE,min}$ =	0.00	kips	$M_{LL,RE,min}$ =	0.00	kip-ft	$V_{LL,RE,min}$ =	0.00	kips
Max Rocking Only Plus Impact Force =	$P_{LL,RE+I,max}$ =	-18.94	kips	$M_{LL,RE+I,max}$ =	0.00	kip-ft	$V_{LL,RE+I,max}$ =	0.00	kips
Min Rocking Only Plus Impact Force =	$P_{LL,RE+I,min}$ =	0.00	kips	$M_{LL,RE+I,min}$ =	0.00	kip-ft	$V_{LL,RE+I,min}$ =	0.00	kips
Max Live Load (without Rocking) Force =	P_{LL} =	296.40	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Min Live Load (without Rocking) Force =	P_{LL} =	0.00	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Max Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	346.00	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Min Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	0.00	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Max LL+I Force [Group I] =	P_{LL+I} =	**346.00**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Min LL+I Force [Group I] =	P_{LL+I} =	**0.00**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Max LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**500.09**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**
Min LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**-154.09**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**

("+" = tens.; "-" = compr.)

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

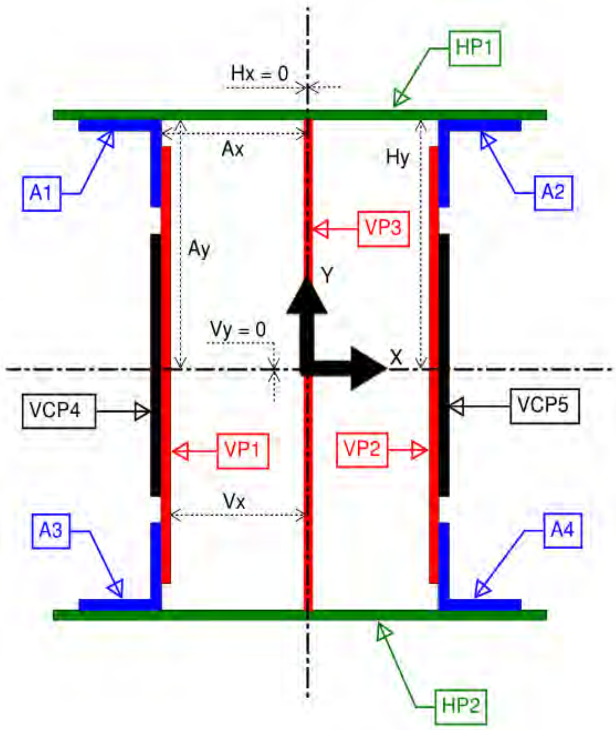
Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Material Properties:

Minimum Steel Yield Strength, F_y =	30	ksi
Minimum Steel Tensile Strength, F_u =	60	ksi
Modulus of Elasticity, E =	29000	ksi

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no	0	0	-	-	0	7.5625	-	-	-	0	0
HP2	no	0	0	-	-	0	-7.5625	-	-	-	0	0
VP1	no	0	0	-10.8125	0	-	-	-	-	-	0	0
VP2	no	0	0	10.8125	0	-	-	-	-	-	0	0
VP3	no	0	0	0	0	-	-	-	-	-	0	0
VCP4	yes	13.125	0.536	-10.8125	0	-	-	-	-	-	2	0.9375
VCP5	yes	13.125	0.536	10.8125	0	-	-	-	-	-	2	0.9375
A1 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	7.5625	out	1	0.9375
A1 (Vert. Leg)	yes	1	0.366	-	-	-	-	-10.8125	-	out	0	0
A2 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	7.5625	out	1	0.9375
A2 (Vert. Leg)	yes	1	0.366	-	-	-	-	10.8125	-	out	0	0
A3 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	-7.5625	out	1	0.9375
A3 (Vert. Leg)	yes	1	0.366	-	-	-	-	-10.8125	-	out	0	0
A4 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	-7.5625	out	1	0.9375
A4 (Vert. Leg)	yes	1	0.366	-	-	-	-	10.8125	-	out	0	0

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

X-X Axis Section Properties:

Total height of section (along y-y axis) =	15.125	in
Effective length factor, $K_{x\text{-}x}$ =	0.875	
Unbraced length, $L_{x\text{-}x}$ =	22.69	ft

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{x\text{-}x}$ (in^4)	A_{net} (in^2)
HP1	0.00	7.56	0.00	0.00	7.56	0.00	0.00	0.00
HP2	0.00	-7.56	0.00	0.00	-7.56	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	7.04	0.00	0.00	100.99	0.00	0.00	100.99	6.30
VCP5	7.04	0.00	0.00	100.99	0.00	0.00	100.99	6.30
A1 (Horiz. Leg)	1.75	7.31	12.80	0.04	7.31	93.58	93.61	1.40
A1 (Vert. Leg)	0.23	6.81	1.58	0.01	6.81	10.77	10.78	0.23
A2 (Horiz. Leg)	1.75	7.31	12.80	0.04	7.31	93.58	93.61	1.40
A2 (Vert. Leg)	0.23	6.81	1.58	0.01	6.81	10.77	10.78	0.23
A3 (Horiz. Leg)	1.75	-7.31	-12.80	0.04	-7.31	93.58	93.61	1.40
A3 (Vert. Leg)	0.23	-6.81	-1.58	0.01	-6.81	10.77	10.78	0.23
A4 (Horiz. Leg)	1.75	-7.31	-12.80	0.04	-7.31	93.58	93.61	1.40
A4 (Vert. Leg)	0.23	-6.81	-1.58	0.01	-6.81	10.77	10.78	0.23
Σ	**22.00**		**0.00**	**202.16**		**417.39**	**619.54**	**19.14**

y_{bar} =	0.00	in	c_{top}=	7.56	in
I_x =	620	in^4	c_{bottom}=	7.56	in
A =	22.00	in^2	S_{top} =	81.92	in^3
r_x =	5.31	in	S_{bottom} =	81.92	in^3

Project: *VDOT Shenandoah Valley Load Ratings*	
Task: *Span 2/4 Truss Rating*	**Project No:** *202063*
Subject:	
Calculated By: *DS* **Date:** *3/19/2025*	**Checked By:** *JBT* **Date:** *3/19/2025*

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = 28.625 in

Effective length factor, $K_{y\text{-}y}$ = 0.875

Unbraced length, $L_{y\text{-}y}$ = 22.69 ft

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	-10.81	0.00	0.00	-10.81	0.00	0.00
VP2	0.00	10.81	0.00	0.00	10.81	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	7.04	-11.08	-77.95	0.17	-11.08	863.74	863.91
VCP5	7.04	11.08	77.95	0.17	11.08	863.74	863.91
A1 (Horiz. Leg)	1.75	-12.56	-21.98	1.79	-12.56	276.18	277.97
A1 (Vert. Leg)	0.23	-11.00	-2.55	0.00	-11.00	28.05	28.06
A2 (Horiz. Leg)	1.75	12.56	21.98	1.79	12.56	276.18	277.97
A2 (Vert. Leg)	0.23	11.00	2.55	0.00	11.00	28.05	28.06
A3 (Horiz. Leg)	1.75	-12.56	-21.98	1.79	-12.56	276.18	277.97
A3 (Vert. Leg)	0.23	-11.00	-2.55	0.00	-11.00	28.05	28.06
A4 (Horiz. Leg)	1.75	12.56	21.98	1.79	12.56	276.18	277.97
A4 (Vert. Leg)	0.23	11.00	2.55	0.00	11.00	28.05	28.06
Σ	**22.00**		**0.00**	**7.49**		**2944.41**	**2951.90**

y_{bar} =	0.00	in	c_{left}=	14.31	in
I_y =	2952	in^4	c_{left}=	14.31	in
A =	22.00	in^2	S_{left} =	206.25	in^3
r_y =	11.58	in	S_{right} =	206.25	in^3

$r_{y,compr\ flg.}$ = 0.00 in

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Compression Capacity Calculations

Normal Axial: (AREMA Table 15-1-11)

x-x axis

$F_{allowable}$ = 0.55*Fy for KL/r ≤ $0.629/\sqrt{(F_y/E)}$

$F_{allowable}$ = 0.60*Fy-(17,500*Fy/E)$^{3/2}$*KL/r for $0.629/\sqrt{(F_y/E)}$ < KL/r < $5.034/\sqrt{(F_y/E)}$

$F_{allowable}$ = 0.514*π^2*E/(KL/r)^2 for $5.034/\sqrt{(F_y/E)}$ ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_y/E)}$ =	19.56	
$5.034/\sqrt{(F_y/E)}$ =	156.51	
KL =	19.85	ft
=	238	in
r =	5.31	in
KL/r =	44.89	

$F_{allowable}$ =	15.93	ksi

Normal Axial: (AREMA Table 15-1-11)

y-y axis

$F_{allowable}$ = 0.55*Fy for KL/r ≤ $0.629/\sqrt{(F_y/E)}$

$F_{allowable}$ = 0.60*Fy-(17,500*Fy/E)$^{3/2}$*KL/r for $0.629/\sqrt{(F_y/E)}$ < KL/r < $5.034/\sqrt{(F_y/E)}$

$F_{allowable}$ = 0.514*π^2*E/(KL/r)^2 for $5.034/\sqrt{(F_y/E)}$ ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_y/E)}$ =	19.56	
$5.034/\sqrt{(F_y/E)}$ =	156.51	
KL =	19.85	ft
=	238	in
r =	11.58	in
KL/r =	20.57	

$F_{allowable}$ =	17.05	ksi

Controlling Normal $F_{allowable}$ =	15.93	ksi
Controlling Normal $P_{allowable}$ =	-350	kips

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Maximum Axial: (AREMA Table 15-7-1)

x-x axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	19.85	ft
=	238	in
r =	5.31	in
KL/r =	44.89	

$F_{allowable}$ = 21.18 ksi

Maximum Axial: (AREMA Table 15-7-1)

y-y axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	19.85	ft
=	238	in
r =	11.58	in
KL/r =	20.57	

$F_{allowable}$ = 23.89 ksi

Controlling Max $F_{allowable}$ =	21.18	ksi
Controlling Max $P_{allowable}$ =	-466	kips

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Normal:

Group I: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Normal} = \frac{(-350 - 68)}{(0)}$$

$RF_{Normal} =$ 999.00

Group II: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Normal} = \frac{(1.25*-350 - 82)}{(-154)}$$

$RF_{Normal} =$ 3.37

$RF_{Normal} =$ 999.00

Maximum:

Group I: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Maximum} = \frac{(-466 - 68)}{(0)}$$

$RF_{Normal} =$ 999.00

Group II: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Maximum} = \frac{(1.25*-466 - 82)}{(-154)}$$

$RF_{Normal} =$ 4.31

$RF_{Maximum} =$ 999.00

Strength Performance Ratios

Normal:

Group I: $PR_{Normal} = [D + L*(1 + I)] / C$

$$PR_{Normal} = \frac{[\ 68 + 0\ ]}{-350}$$

$PR_{Normal} =$ N/A

Group II: $PR_{Normal} = [D + L*(1 + I)] / C$

$$PR_{Normal} = \frac{[\ 82 + -154\ ]}{1.25*-350}$$

$PR_{Normal} =$ 0.17

$PR_{Normal} =$ 0.00

Maximum:

Group I: $PR_{Maximum} = [D + L*(1 + I)] / C$

$$PR_{Maximum} = \frac{[\ 68 + 0\ ]}{-466}$$

$PR_{Maximum} =$ N/A

Group II: $PR_{Maximum} = [D + L*(1 + I)] / C$

$$PR_{Maximum} = \frac{[\ 82 + -154\ ]}{1.25*-466}$$

$PR_{Maximum} =$ 0.12

$PR_{Maximum} =$ 0.00

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Tensile Resistance

* The tensile resistance is taken as the lesser of yielding of the gross section or fracture of the net section.

Yielding of the Gross Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = \quad P_{ny} = \quad K*F_yA_g$

$K = 0.55$
$F_y = 30$ ksi
$A_g = 22.00$ in^2

$P_r = \quad P_{ny} = \quad 0.55*30*22$

$\boxed{P_r = 363 \text{ kips}}$

Yielding of the Gross Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = \quad P_{ny} = \quad K*F_yA_g$

$K = 0.80$
$F_y = 30$ ksi
$A_g = 22.00$ in^2

$P_r = \quad P_{ny} = \quad 0.8*30*22$

$\boxed{P_r = 528 \text{ kips}}$

Fracture of the Net Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = \quad P_{nu} = \quad K*F_uA_n$

$K = 0.47$
$F_u = 60$ ksi
$A_n = 19.14$ in^2

$P_r = \quad P_{nu} = \quad 0.47*60*19$

$\boxed{P_r = 540 \text{ kips}}$

Fracture of the Net Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = \quad P_{nu} = \quad K*F_uA_n$

$K = 0.67$
$F_u = 60$ ksi
$A_n = 19.14$ in^2

$P_r = \quad P_{nu} = \quad 0.67*60*19$

$\boxed{P_r = 769 \text{ kips}}$

Governing Tensile Resistance:

$P_{r\ tension,normal} =$ Lesser of $P_{ny} =$ 363 k OR $P_{nu} =$ 540 k

$\boxed{P_{r\ tension,normal} = 363 \text{ kips}}$

$P_{r\ tension,maximum} =$ Lesser of $P_{ny} =$ 528 k OR $P_{nu} =$ 769 k

$\boxed{P_{r\ tension,maximum} = 528 \text{ kips}}$

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Rating Factor Equations:

RF = (C - D) / [L*(1 + I)]

Normal Rating Factor:

Controlling Value	Group I	Group II
	P_{DL} = 68 kips	P_{DL} = 82 kips
	$P_{r\ tension}$ = 363 kips	$P_{r\ tension}$ = 363 kips
	P_{LL+I} = 346 kips	P_{LL+I} = 500 kips
	$RF_{Normal} = \frac{(363 - 68)}{(346)}$	$RF_{Normal} = \frac{(1.25*363 - 82)}{(500)}$
RF_{Normal} = 0.74	RF_{Normal} = 0.85	RF_{Normal} = 0.74

Maximum Rating Factor:

Controlling Value	Group I	Group II
	P_{DL} = 68 kips	P_{DL} = 82 kips
	$P_{r\ tension}$ = 528 kips	$P_{r\ tension}$ = 528 kips
	P_{LL+I} = 346 kips	P_{LL+I} = 500 kips
	$RF_{Maximum} = \frac{(528 - 68)}{(346)}$	$RF_{Maximum} = \frac{(1.25*528 - 82)}{(500)}$
$RF_{Maximum}$ = 1.16	$RF_{Maximum}$ = 1.33	$RF_{Maximum}$ = 1.16

Strength Performance Ratios

Normal:

Controlling Value	Group I	Group II
	PR_{Normal} = [D + L*(1 + I)] / C	PR_{Normal} = [D + L*(1 + I)] / C
	$PR_{Normal} = \frac{[\ 68 + 346\ ]}{363}$	$PR_{Normal} = \frac{[\ 82 + 500\ ]}{1.25*363}$
PR_{Normal} = 1.66	PR_{Normal} = 1.14	PR_{Normal} = 1.66

Maximum:

Controlling Value	Group I	Group II
	$PR_{Maximum}$ = [D +L*(1 + I)] / C	$PR_{Maximum}$ = [D +L*(1 + I)] / C
	$PR_{Maximum} = \frac{[\ 68 + 346\ ]}{528}$	$PR_{Maximum} = \frac{[\ 82 + 500\ ]}{1.25*528}$
$PR_{Maximum}$ = 1.14	$PR_{Maximum}$ = 0.78	$PR_{Maximum}$ = 1.14

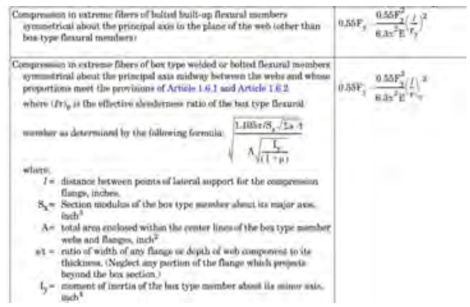
Project: *VDOT Shenandoah Valley Load Ratings*	
Task: *Span 2/4 Truss Rating*	**Project No:** *202063*
Subject:	
Calculated By: *DS* **Date:** *3/19/2025*	**Checked By:** *JBT* **Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Combined Compression & Bending Resistance:



Compression in extreme fibers of bolted built-up flexural members symmetrical about the principal axis in the plane of the web (other than box-type flexural members)	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2E}\left(\frac{l}{r_y}\right)^2$
Compression in extreme fibers of box type welded or bolted flexural members symmetrical about the principal axis midway between the webs and whose proportions meet the provisions of Article 1.6.1 and Article 1.6.2 where $(lr)_e$ is the effective slenderness ratio of the box type flexural member as determined by the following formula: $\sqrt{\frac{1.105\pi l S_x \sqrt{\Sigma s/t}}{A\sqrt{\frac{I_y}{(1+\mu)}}}}$ where, l = distance between points of lateral support for the compression flange, inches. S_x = Section modulus of the box type member about its major axis, inch³ A = total area enclosed within the center lines of the box type member webs and flanges, inch² s/t = ratio of width of any flange or depth of web component to its thickness. (Neglect any portion of the flange which projects beyond the box section.) I_y = moment of inertia of the box type member about its minor axis, inch⁴	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2E}\left(\frac{l}{r}\right)_e^2$

Normal:

$L = L_y$ =	23	ft
r_y =	0	in
F_y =	30000	psi
E =	29000000	psi
$F_{b1,allowable}$ =	-20351575.62	ksi
		(Table 15-1-11)(non-box)
F_y =	30	ksi
$F_{b1,allowable}$ =	-20351575.62	ksi
$F_{a,allowable}$ =	15.93	ksi

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	3.09	15.73	ksi	Applied Axial f_a =	-3.30	3.70	22.73	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA 15-1.3.14.1)*		**fa / 1.25*Fa =**	**0.17**		*(AREMA 15-1.3.14.1)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.17**	**<**	**1.00**	**OK**
DL only P/R =	**0.19**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.19**	**<**	**1.00**	**OK**
LL only P/R =	**0.99**	**<**	**1.00**	**OK**	**LL only P/R =**	**1.14**	**>**	**1.00**	**NG**
Combined RF =	**0.82**	**<**	**1.00**	**NG**	**Combined RF =**	**0.71**	**<**	**1.00**	**NG**

Controlling RF:

999.00

Maximum:

$L = L_y$ =	23	ft
r_y =	0	in
F_y =	30000	psi
E =	29000000	psi
$F_{b1,allowable}$ =	-29654535.36	ksi
		(AREMA Table 15-7-1)
F_y =	30	ksi
$F_{b1,allowable}$ =	-29654535.36	ksi
$F_{a,allowable}$ =	21.18	ksi

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	3.09	15.73	ksi	Applied Axial f_a =	-3.30	3.70	22.73	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA Table 15-7-1c)*		**fa / Fa =**	**0.16**		*(AREMA Table 15-7-1c)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.16**	**<**	**1.00**	**OK**
DL only P/R =	**0.15**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.14**	**<**	**1.00**	**OK**
LL only P/R =	**0.74**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.86**	**<**	**1.00**	**OK**
Combined RF =	**1.15**	**>**	**1.00**	**OK**	**Combined RF =**	**1.00**	**>**	**1.00**	**OK**

Controlling RF:

999.00

Normal Rating Factor	0.74
Maximum Rating Factor	1.16
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Shear:

Only vertical plates are considered to contribute to shear resistance (i.e. angle legs are excluded)

Normal:

$F_r = 0.35*Fy =$ 10.5 ksi

$P_r =$ 147.7 kips

Controlling Value:	Group I:	Group II:
	$RF_{Normal} = \frac{(148 - 0)}{(0)}$	$RF_{Normal} = \frac{(1.25*148 - 0)}{(0)}$
$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00

Maximum:

K = 0.80

0.75*K = 0.60

$F_r = 0.75*K*Fy$ 18.0 ksi

$P_r =$ 253.3 kips

Controlling Value:	Group I:	Group II:
	$RF_{Maximum} = \frac{(253 - 0)}{(0)}$	$RF_{Maximum} = \frac{(1.25*253 - 0)}{(0)}$
$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00

Project: *VDOT Shenandoah Valley Load Ratings*
Task: *Span 2/4 Truss Rating* **Project No:** *202063*
Subject:
Calculated By: *DS* **Date:** *3/19/2025* **Checked By:** *JBT* **Date:** *3/19/2025*

Michael Baker INTERNATIONAL

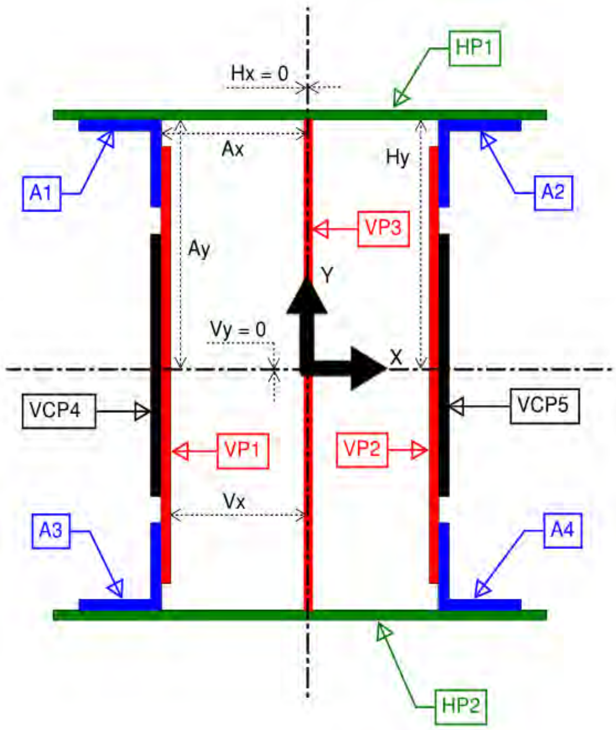
Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Material Properties:

Minimum Steel Yield Strength, F_y = 30 ksi
Minimum Steel Tensile Strength, F_u = 60 ksi
Modulus of Elasticity, E = 29000 ksi

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no	0	0	-	-	0	7.5625	-	-	-	0	0
HP2	no	0	0	-	-	0	-7.5625	-	-	-	0	0
VP1	no	0	0	-10.8125	0	-	-	-	-	-	0	0
VP2	no	0	0	10.8125	0	-	-	-	-	-	0	0
VP3	no	0	0	0	0	-	-	-	-	-	0	0
VCP4	yes	13.125	0.536	-10.8125	0	-	-	-	-	-	2	0.9375
VCP5	yes	13.125	0.536	10.8125	0	-	-	-	-	-	2	0.9375
A1 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	7.5625	out	1	0.9375
A1 (Vert. Leg)	yes	1	0.366	-	-	-	-	-10.8125	-	out	0	0
A2 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	7.5625	out	1	0.9375
A2 (Vert. Leg)	yes	1	0.366	-	-	-	-	10.8125	-	out	0	0
A3 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	-7.5625	out	1	0.9375
A3 (Vert. Leg)	yes	1	0.366	-	-	-	-	-10.8125	-	out	0	0
A4 (Horiz. Leg)	yes	3.5	0.5	-	-	-	-	-	-7.5625	out	1	0.9375
A4 (Vert. Leg)	yes	1	0.366	-	-	-	-	10.8125	-	out	0	0

Project: *VDOT Shenandoah Valley Load Ratings*		Michael Baker INTERNATIONAL	
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

X-X Axis Section Properties:

Total height of section (along y-y axis) =	15.125	in
Effective length factor, $K_{x\text{-}x}$ =	0.875	
Unbraced length, $L_{x\text{-}x}$ =	22.69	ft

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{x\text{-}x}$ (in^4)	A_{net} (in^2)
HP1	0.00	7.56	0.00	0.00	7.56	0.00	0.00	0.00
HP2	0.00	-7.56	0.00	0.00	-7.56	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	7.04	0.00	0.00	100.99	0.00	0.00	100.99	6.30
VCP5	7.04	0.00	0.00	100.99	0.00	0.00	100.99	6.30
A1 (Horiz. Leg)	1.75	7.31	12.80	0.04	7.31	93.58	93.61	1.40
A1 (Vert. Leg)	0.23	6.81	1.58	0.01	6.81	10.77	10.78	0.23
A2 (Horiz. Leg)	1.75	7.31	12.80	0.04	7.31	93.58	93.61	1.40
A2 (Vert. Leg)	0.23	6.81	1.58	0.01	6.81	10.77	10.78	0.23
A3 (Horiz. Leg)	1.75	-7.31	-12.80	0.04	-7.31	93.58	93.61	1.40
A3 (Vert. Leg)	0.23	-6.81	-1.58	0.01	-6.81	10.77	10.78	0.23
A4 (Horiz. Leg)	1.75	-7.31	-12.80	0.04	-7.31	93.58	93.61	1.40
A4 (Vert. Leg)	0.23	-6.81	-1.58	0.01	-6.81	10.77	10.78	0.23
Σ	**22.00**		**0.00**	**202.16**		**417.39**	**619.54**	**19.14**

y_{bar} =	0.00	in	c_{top}=	7.56	in
I_x =	620	in^4	c_{bottom}=	7.56	in
A =	22.00	in^2	S_{top} =	81.92	in^3
r_x =	5.31	in	S_{bottom} =	81.92	in^3

Project: *VDOT Shenandoah Valley Load Ratings*
Task: *Span 2/4 Truss Rating* **Project No:** *202063*
Subject:
Calculated By: *DS* **Date:** *3/19/2025* **Checked By:** *JBT* **Date:** *3/19/2025*

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Y-Y Axis Section Properties:

Total width of section (along x-x axis) =	28.625	in
Effective length factor, $K_{y\text{-}y}$ =	0.875	
Unbraced length, $L_{y\text{-}y}$ =	22.69	ft

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	-10.81	0.00	0.00	-10.81	0.00	0.00
VP2	0.00	10.81	0.00	0.00	10.81	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	7.04	-11.08	-77.95	0.17	-11.08	863.74	863.91
VCP5	7.04	11.08	77.95	0.17	11.08	863.74	863.91
A1 (Horiz. Leg)	1.75	-12.56	-21.98	1.79	-12.56	276.18	277.97
A1 (Vert. Leg)	0.23	-11.00	-2.55	0.00	-11.00	28.05	28.06
A2 (Horiz. Leg)	1.75	12.56	21.98	1.79	12.56	276.18	277.97
A2 (Vert. Leg)	0.23	11.00	2.55	0.00	11.00	28.05	28.06
A3 (Horiz. Leg)	1.75	-12.56	-21.98	1.79	-12.56	276.18	277.97
A3 (Vert. Leg)	0.23	-11.00	-2.55	0.00	-11.00	28.05	28.06
A4 (Horiz. Leg)	1.75	12.56	21.98	1.79	12.56	276.18	277.97
A4 (Vert. Leg)	0.23	11.00	2.55	0.00	11.00	28.05	28.06
Σ	**22.00**		**0.00**	**7.49**		**2944.41**	**2951.90**

y_{bar} =	0.00	in	c_{left}=	14.31	in			
I_y =	2952	in^4	c_{left}=	14.31	in			
A =	22.00	in^2	S_{left} =	206.25	in^3			
r_y =	11.58	in	S_{right} =	206.25	in^3	$r_{y,compr\ flg.}$ =	0.00	in

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Compression Capacity Calculations

Normal Axial: (AREMA Table 15-1-11)

x-x axis

$F_{allowable} = 0.55*Fy$ for $KL/r \leq 0.629/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$ for $0.629/\sqrt{(F_{y/}E)} < KL/r < 5.034/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$ for $5.034/\sqrt{(F_{y/}E)} \leq KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_{y/}E)}$ =	19.56	
$5.034/\sqrt{(F_{y/}E)}$ =	156.51	
KL =	19.85	ft
=	238	in
r =	5.31	in
KL/r =	44.89	

$F_{allowable}$ =	15.93	ksi

Normal Axial: (AREMA Table 15-1-11)

y-y axis

$F_{allowable} = 0.55*Fy$ for $KL/r \leq 0.629/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$ for $0.629/\sqrt{(F_{y/}E)} < KL/r < 5.034/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$ for $5.034/\sqrt{(F_{y/}E)} \leq KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_{y/}E)}$ =	19.56	
$5.034/\sqrt{(F_{y/}E)}$ =	156.51	
KL =	19.85	ft
=	238	in
r =	11.58	in
KL/r =	20.57	

$F_{allowable}$ =	17.05	ksi

Controlling Normal $F_{allowable}$ =	15.93	ksi
Controlling Normal $P_{allowable}$ =	-350	kips

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Maximum Axial: (AREMA Table 15-7-1)

x-x axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	19.85	ft
=	238	in
r =	5.31	in
KL/r =	44.89	

$F_{allowable}$ =	21.18	ksi

Maximum Axial: (AREMA Table 15-7-1)

y-y axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	19.85	ft
=	238	in
r =	11.58	in
KL/r =	20.57	

$F_{allowable}$ =	23.89	ksi

Controlling Max $F_{allowable}$ =	21.18	ksi
Controlling Max $P_{allowable}$ =	-466	kips

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Normal:

Group I: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Normal} = \frac{(-350 - 68)}{(0)}$$

$RF_{Normal} =$ 999.00

Group II: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Normal} = \frac{(1.25*-350 - 82)}{(-154)}$$

$RF_{Normal} =$ 3.37

$RF_{Normal} =$ 999.00

Maximum:

Group I: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Maximum} = \frac{(-466 - 68)}{(0)}$$

$RF_{Normal} =$ 999.00

Group II: $RF_{Normal} = (C - D) / [L*(1 + I)]$

$$RF_{Maximum} = \frac{(1.25*-466 - 82)}{(-154)}$$

$RF_{Normal} =$ 4.31

$RF_{Maximum} =$ 999.00

Strength Performance Ratios

Normal:

Group I: $PR_{Normal} = [D + L*(1 + I)] / C$

$$PR_{Normal} = \frac{[\ 68 + 0\ ]}{-350}$$

$PR_{Normal} =$ N/A

Group II: $PR_{Normal} = [D + L*(1 + I)] / C$

$$PR_{Normal} = \frac{[\ 82 + -154\ ]}{1.25*-350}$$

$PR_{Normal} =$ 0.17

$PR_{Normal} =$ 0.00

Maximum:

Group I: $PR_{Maximum} = [D + L*(1 + I)] / C$

$$PR_{Maximum} = \frac{[\ 68 + 0\ ]}{-466}$$

$PR_{Maximum} =$ N/A

Group II: $PR_{Maximum} = [D + L*(1 + I)] / C$

$$PR_{Maximum} = \frac{[\ 82 + -154\ ]}{1.25*-466}$$

$PR_{Maximum} =$ 0.12

$PR_{Maximum} =$ 0.00

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 2/4 Truss Rating*		Project No: *202063*	
Subject:			
Calculated By: *DS*	Date: *3/19/2025*	Checked By: *JBT*	Date: *3/19/2025*

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Tensile Resistance

* The tensile resistance is taken as the lesser of yielding of the gross section or fracture of the net section.

Yielding of the Gross Section, Normal Axial: (AREMA Table 15-1-12)

$P_r =$ $P_{ny} =$ $K^*F_yA_g$

$K =$ 0.55
$F_y =$ 30 ksi
$A_g =$ 22.00 in^2

$P_r =$ $P_{ny} =$ 0.55*30*22

$P_r =$ 363 kips

Yielding of the Gross Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r =$ $P_{ny} =$ $K^*F_yA_g$

$K =$ 0.80
$F_y =$ 30 ksi
$A_g =$ 22.00 in^2

$P_r =$ $P_{ny} =$ 0.8*30*22

$P_r =$ 528 kips

Fracture of the Net Section, Normal Axial: (AREMA Table 15-1-12)

$P_r =$ $P_{nu} =$ $K^*F_uA_n$

$K =$ 0.47
$F_u =$ 60 ksi
$A_n =$ 19.14 in^2

$P_r =$ $P_{nu} =$ 0.47*60*19

$P_r =$ 540 kips

Fracture of the Net Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r =$ $P_{nu} =$ $K^*F_uA_n$

$K =$ 0.67
$F_u =$ 60 ksi
$A_n =$ 19.14 in^2

$P_r =$ $P_{nu} =$ 0.67*60*19

$P_r =$ 769 kips

Governing Tensile Resistance:

$P_{r\ tension,normal} =$ Lesser of $P_{ny} =$ 363 k OR $P_{nu} =$ 540 k

$P_{r\ tension,normal} =$ 363 kips

$P_{r\ tension,maximum} =$ Lesser of $P_{ny} =$ 528 k OR $P_{nu} =$ 769 k

$P_{r\ tension,maximum} =$ 528 kips

Project: VDOT Shenandoah Valley Load Ratings			
Task: Span 2/4 Truss Rating		Project No: 202063	
Subject:			
Calculated By: DS	Date: 3/19/2025	Checked By: JBT	Date: 3/19/2025

Michael Baker INTERNATIONAL

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Rating Factor Equations:

$$RF = (C - D) / [L*(1 + I)]$$

Normal Rating Factor:

Controlling Value:	Group I:		Group II:	
	P_{DL} =	68 kips	P_{DL} =	82 kips
	$P_{r\ tension}$ =	363 kips	$P_{r\ tension}$ =	363 kips
	P_{LL+I} =	309 kips	P_{LL+I} =	463 kips
	$RF_{Normal} = \frac{(363 - 68)}{(309)}$		$RF_{Normal} = \frac{(1.25*363 - 82)}{(463)}$	
RF_{Normal} = 0.80	RF_{Normal} =	0.96	RF_{Normal} =	0.80

Maximum Rating Factor:

Controlling Value:	Group I:		Group II:	
	P_{DL} =	68 kips	P_{DL} =	82 kips
	$P_{r\ tension}$ =	528 kips	$P_{r\ tension}$ =	528 kips
	P_{LL+I} =	309 kips	P_{LL+I} =	463 kips
	$RF_{Maximum} = \frac{(528 - 68)}{(309)}$		$RF_{Maximum} = \frac{(1.25*528 - 82)}{(463)}$	
$RF_{Maximum}$ = 1.25	$RF_{Maximum}$ =	1.49	$RF_{Maximum}$ =	1.25

Strength Performance Ratios

Normal:

Controlling Value:	Group I:		Group II:	
	$PR_{Normal} = [D + L*(1 + I)] / C$		$PR_{Normal} = [D + L*(1 + I)] / C$	
	$PR_{Normal} = \frac{[\ 68 + 309\ ]}{363}$		$PR_{Normal} = \frac{[\ 82 + 463\ ]}{1.25*363}$	
PR_{Normal} = 1.56	PR_{Normal} =	1.04	PR_{Normal} =	1.56

Maximum:

Controlling Value:	Group I:		Group II:	
	$PR_{Maximum} = [D + L*(1 + I)] / C$		$PR_{Maximum} = [D + L*(1 + I)] / C$	
	$PR_{Maximum} = \frac{[\ 68 + 309\ ]}{528}$		$PR_{Maximum} = \frac{[\ 82 + 463\ ]}{1.25*528}$	
$PR_{Maximum}$ = 1.07	$PR_{Maximum}$ =	0.71	$PR_{Maximum}$ =	1.07

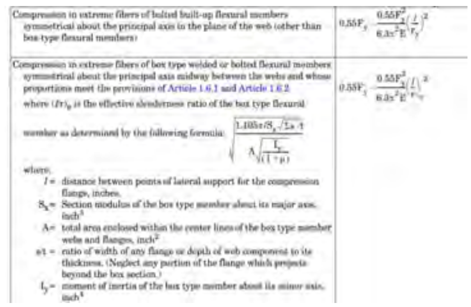
Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Combined Compression & Bending Resistance:



Compression in extreme fibers of bolted built-up flexural members symmetrical about the principal axis in the plane of the web (other than box type flexural members)	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r_y}\right)^2$
Compression in extreme fibers of box type welded or bolted flexural members symmetrical about the principal axis midway between the webs and whose proportions meet the provisions of Article 1.6.1 and Article 1.6.2 where $(l/r)_e$ is the effective slenderness ratio of the box type flexural member as determined by the following formula: $\sqrt{\frac{1.105\pi l S_x \sqrt{\sum s/t}}{A\sqrt{\frac{I_y}{(1+\mu)}}}}$ where: l = distance between points of lateral support for the compression flange, inches. S_x = Section modulus of the box type member about its major axis, inch³ A = total area enclosed within the center lines of the box type member webs and flanges, inch² s/t = ratio of width of any flange or depth of web component to its thickness. (Neglect any portion of the flange which projects beyond the box section.) I_y = moment of inertia of the box type member about its minor axis, inch⁴	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r}\right)_e^2$

Normal:

$L = L_y$ =	23	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-20351575.62	ksi	*\ Table 15-1-11)(non-box)*
F_y =	30	ksi	
$F_{b1,allowable}$ =	-20351575.62	ksi	
$F_{a,allowable}$ =	15.93	ksi	

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	3.09	14.04	ksi	Applied Axial f_a =	-3.30	3.70	21.05	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA 15-1.3.14.1)*		**fa / 1.25*Fa =**	**0.17**		*(AREMA 15-1.3.14.1)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.17**	**<**	**1.00**	**OK**
DL only P/R =	**0.19**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.19**	**<**	**1.00**	**OK**
LL only P/R =	**0.88**	**<**	**1.00**	**OK**	**LL only P/R =**	**1.06**	**>**	**1.00**	**NG**
Combined RF =	**0.91**	**<**	**1.00**	**NG**	**Combined RF =**	**0.77**	**<**	**1.00**	**NG**

Controlling RF:
999.00

Maximum:

$L = L_y$ =	23	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-29654535.36	ksi	*(AREMA Table 15-7-1)*
F_y =	30	ksi	
$F_{b1,allowable}$ =	-29654535.36	ksi	
$F_{a,allowable}$ =	21.18	ksi	

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	3.09	14.04	ksi	Applied Axial f_a =	-3.30	3.70	21.05	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA Table 15-7-1c)*		**fa / Fa =**	**0.16**		*(AREMA Table 15-7-1c)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.16**	**<**	**1.00**	**OK**
DL only P/R =	**0.15**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.14**	**<**	**1.00**	**OK**
LL only P/R =	**0.66**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.80**	**<**	**1.00**	**OK**
Combined RF =	**1.29**	**>**	**1.00**	**OK**	**Combined RF =**	**1.08**	**>**	**1.00**	**OK**

Controlling RF:
999.00

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 2/4 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/19/2025*	**Checked By:** *JBT*	**Date:** *3/19/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	0.80
Maximum Rating Factor	1.25
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	10 mph

Element 201 **Truss_Rating**

Shear:

Only vertical plates are considered to contribute to shear resistance (i.e. angle legs are excluded)

Normal:

$F_r = 0.35*Fy =$ 10.5 ksi

$P_r =$ 147.7 kips

Controlling Value:	Group I:	Group II:
	$RF_{Normal} = \frac{(148 - 0)}{(0)}$	$RF_{Normal} = \frac{(1.25*148 - 0)}{(0)}$
$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00

Maximum:

K = 0.80

0.75*K = 0.60

$F_r = 0.75*K*Fy$ 18.0 ksi

$P_r =$ 253.3 kips

Controlling Value:	Group I:	Group II:
	$RF_{Maximum} = \frac{(253 - 0)}{(0)}$	$RF_{Maximum} = \frac{(1.25*253 - 0)}{(0)}$
$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00

TRUSS RATING FOR SPANS 2 & 4

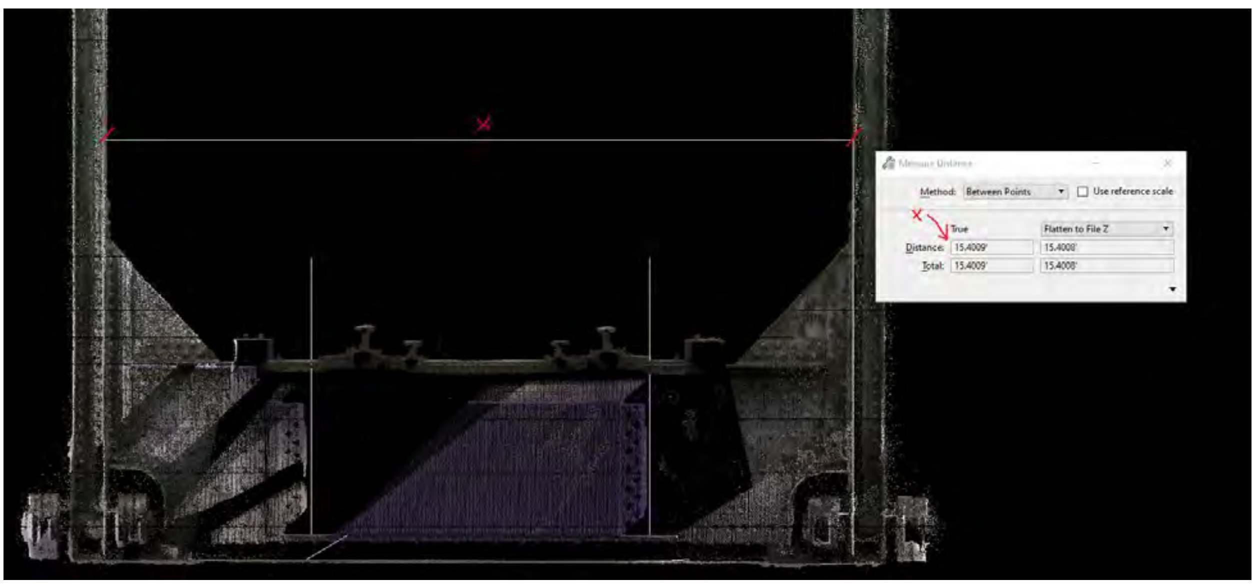
RATING CALCULATIONS
for
FLOORBEAM

Span 4 Floorbeam Section Properties

Flange L6x6x0.59

Web 48.375”x0.5625”

Stringer Spacing: 6.9547’



Floorbeam span length: 15.4009’

Floorbeam Rivet Spacing

Gage: 3”, Pitch 2.5”

Note: The dapped end if the floorbeam reducing shear capacity is offset by the addition of riveted web cover plates. The evaluation included herein does not explicitly model the dapping and does not include the cover plates. As such, the modeled shear capacity is at or below the in-situ conditions.

SUMMARY

Task

This worksheet is configured to perform load rating for floorbeams supporting two stringers each in the back and ahead spans feeding into the floorbeam. A single track situated midway between the stringers is assumed. The floorbeam must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall floorbeam section property calculations. The spreadsheet does not calculate the dead load or wind load acting on the stringers. Rather, the stringer reactions due to these loads are direct inputs, taken from the spreadsheet used to rate the stringers. These loads, along with live load are assumed to be transmitted to the floorbeam via the stringers. Live load is interpolated herein from AREMA Table 15-1-15 as a pier reaction using the average length of the back and ahead spans feeding into the floorbeam. The E80 pier reactions from Table 15-1-15 are adjusted to represent 286k and 315k live load cases using conversion factors supplied by Norfolk Southern. Span imbalance is atypical and expected to be minor when present. Torsional effects of minor span imbalance, when present, are not considered in the section capacity calculations. Fatigue is not assessed.

Floorbeam Section Details (Note: Floorbeam & Stringer spans and stringer reactions addressed separately on worksheet *Rating Calculations*)

Floorbeam Type	fastened	rolled, welded, or fastened
Fy	30,000	psi (AREMA Table 15-7-2, MBE Table 6A.6.2.1-1)
Capacity Reduction	1%	due to section loss (geometry inputs below account for section loss, see Narrative)

Fastened Section Details (0 if not fastened)

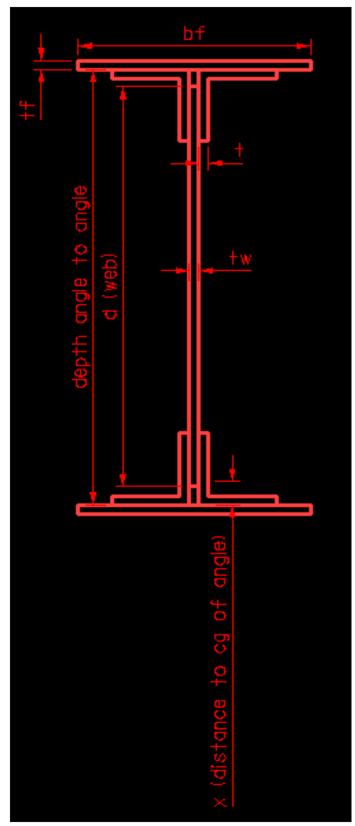
Depth angle to angle	48.375	in	
Effective Rivet/Bolt hole diameter	0.94	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	0.000	in
t_f	0.000	in

Top Flange Angles (0 if they don't exist)

x	6.000	in	
y	6.000	in	
t	0.590	in	
A (each angle)	6.73	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	45.99	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.72	in	(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	99.77	in4	(ref. wksht. TF_Angle_Pair)



Holes Through Top Flange (0 if does not exist OR in compression at Section Location)

Rows	0.00	
Gage	0.00	in
Pitch	0.00	in

Pitch = distance btwn centers of adjacent fasteners, measured along one or more lines of fasteners. Gage = dist. btwn adjacent lines of fasteners, or dist from the back of angle or other shape to 1st line of fasteners.

Holes Through Top Flange Angles and Web (0 if does not exist OR in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web *NOTE: See Supplemental Cover Plate added in worksheet "Net Section" for LE-88.74 ONLY*

d	48.375	in
tw	0.563	in

Holes Through Web at Stringer to FB Connection

Total # of Holes	13.00	
# of Holes in long row	7.00	
Gage	2.00	in
Pitch	2.00	in

Michael Baker INTERNATIONAL

SUMMARY

Bottom Flange or Cover Plate (0 if does not exist)

b_f	0.000	in
t_f	0.000	in

Bottom Flange Angles (0 if they don't exist)

x	6.000	in	
y	6.000	in	
t	0.590	in	
A (each angle)	6.73	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	45.99	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.72	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	99.77	in4	(ref. wksht. BF_Angle_Pair)

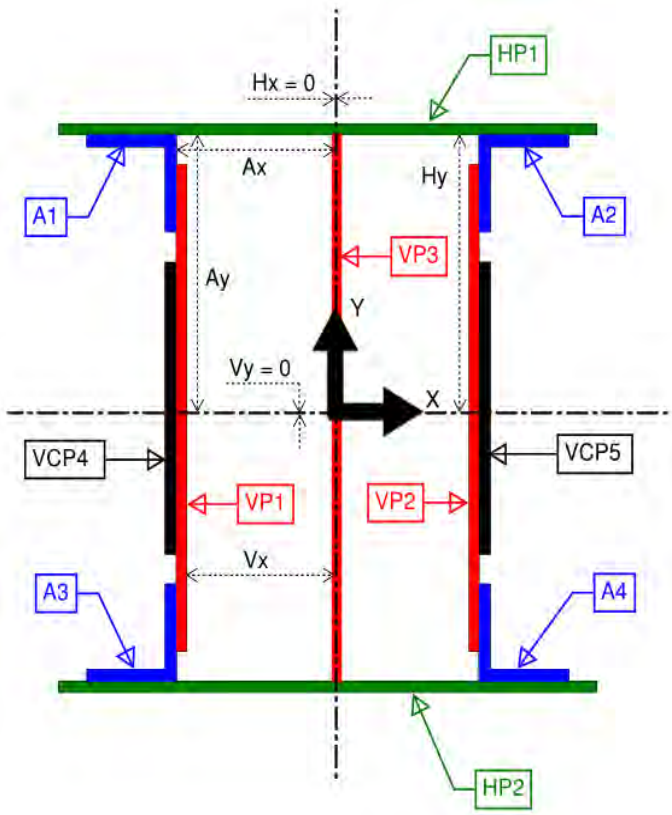
Holes Through Bottom Flange (0 if does not exist OR in compression at Section Location)

Rows	0.00	
Gage	1.00	in
Pitch	1.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR in compression at Section Location)

Rows	2	
Gage 1	6.00	in
Gage 2	6.00	in
Pitch	3.00	in

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	6.00	0.59	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	6.00	0.59	-	-	-	-	-0.28125	-	out		
A2 (Horiz. Leg)	yes	6.00	0.59	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	6.00	0.59	-	-	-	-	0.28125	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5625** in

Project: VDOT Shenandoah Valley Asset 5104		Michael Baker INTERNATIONAL
Task: Span 2/4 Floorbeam Rating	Project No:	
Subject: Span 2/4 Floorbeam Rating		
Calculated By: DS Date: 2/19/2025	Checked By: JBT	Date: 3/19/25

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A1 (Horiz. Leg)	3.54	0.30	1.04	0.10	-1.42	7.16	7.27		3.54
A1 (Vert. Leg)	3.19	3.30	10.52	7.79	1.58	7.94	15.73		3.19
A2 (Horiz. Leg)	3.54	0.30	1.04	0.10	-1.42	7.16	7.27		3.54
A2 (Vert. Leg)	3.19	3.30	10.52	7.79	1.58	7.94	15.73		3.19
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.72	0.00	0.00		0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.72	0.00	0.00		0.00
Σ	**13.46**		**23.12**	**15.78**		**30.21**	**45.99**	**Σ**	**13.46**

y_{bar} =	1.72	in	c_{top}=	1.28	in
I_x =	45.99	in^4	c_{bottom}=	4.72	in
A =	13.46	in^2	S_{top} =	35.86	in^3
r_x =	1.85	in	S_{bottom} =	9.75	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	3.54	-3.28	-11.62	10.62	-3.28	38.11	48.73
A1 (Vert. Leg)	3.19	-0.58	-1.84	0.09	-0.58	1.06	1.15
A2 (Horiz. Leg)	3.54	3.28	11.62	10.62	3.28	38.11	48.73
A2 (Vert. Leg)	3.19	0.58	1.84	0.09	0.58	1.06	1.15
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**13.46**		**0.00**	**21.43**		**78.35**	**99.77**

y_{bar} =	0.00	in	c_{left}=	6.28	in
I_y =	99.77	in^4	c_{right}=	6.28	in
A =	13.46	in^2	S_{left} =	15.88	in^3
r_y =	2.72	in	S_{right} =	15.88	in^3

Project: *VDOT Shenandoah Valley Asset 5104*

Michael Baker INTERNATIONAL

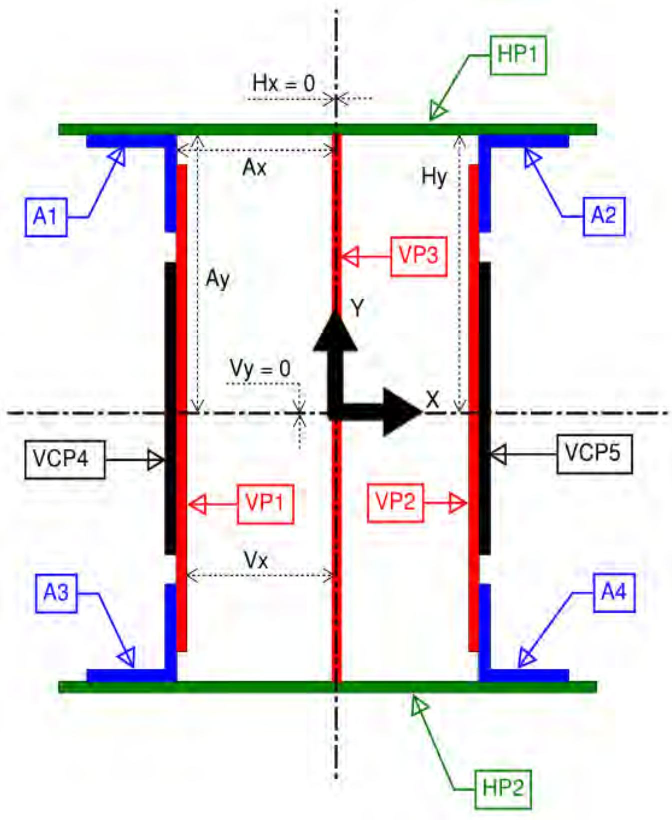
Task: *Span 2/4 Floorbeam Rating* **Project No:**

Subject: *Span 2/4 Floorbeam Rating*

Calculated By: *DS* **Date:** *2/19/2025* **Checked By:** *JBT* **Date:** 3/19/25

BF_Angle_Pair

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	**no**			-	-			-	-	-		
HP2	**no**			-	-			-	-	-		
VP1	**no**					-	-	-	-	-		
VP2	**no**					-	-	-	-	-		
VP3	**no**					-	-	-	-	-		
VCP4	**no**					-	-	-	-	-		
VCP5	**no**					-	-	-	-	-		
A1 (Horiz. Leg)	**no**			-	-	-	-	-		**out**		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	**no**			-	-	-	-	-	0	**out**		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	**yes**	6.00	0.59	-	-	-	-	-	**0**	**out**		
A3 (Vert. Leg)	yes	6.00	0.59	-	-	-	-	**-0.28125**	-	out		
A4 (Horiz. Leg)	**yes**	6.00	0.59	-	-	-	-	-	0	**out**		
A4 (Vert. Leg)	yes	6.00	0.59	-	-	-	-	0.28125	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5625** in

Michael Baker INTERNATIONAL

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.72	0.00	0.00		0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.72	0.00	0.00		0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.72	0.00	0.00		0.00
A3 (Horiz. Leg)	3.54	0.30	1.04	0.10	-1.42	7.16	7.27		3.54
A3 (Vert. Leg)	3.19	3.30	10.52	7.79	1.58	7.94	15.73		3.19
A4 (Horiz. Leg)	3.54	0.30	1.04	0.10	-1.42	7.16	7.27		3.54
A4 (Vert. Leg)	3.19	3.30	10.52	7.79	1.58	7.94	15.73		3.19
Σ	**13.46**		**23.12**	**15.78**		**30.21**	**45.99**	Σ	**13.46**

y_{bar} =	1.72	in	c_{top}=	1.28	in	
I_x =	45.99	in^4	c_{bottom}=	4.72	in	
A =	13.46	in^2	S_{top} =	35.86	in^3	9.75
r_x =	1.85	in	S_{bottom} =	9.75	in^3	35.86

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	3.54	-3.28	-11.62	10.62	-3.28	38.11	48.73
A3 (Vert. Leg)	3.19	-0.58	-1.84	0.09	-0.58	1.06	1.15
A4 (Horiz. Leg)	3.54	3.28	11.62	10.62	3.28	38.11	48.73
A4 (Vert. Leg)	3.19	0.58	1.84	0.09	0.58	1.06	1.15
Σ	**13.46**		**0.00**	**21.43**		**78.35**	**99.77**

y_{bar} =	0.00	in	c_{left}=	6.28	in
I_y =	99.77	in^4	c_{right}=	6.28	in
A =	13.46	in^2	S_{left} =	15.88	in^3
r_y =	2.72	in	S_{right} =	15.88	in^3

PROJECT : *VDOT Shenandoah Valley Asset 5104*			Michael Baker INTERNATIONAL
TASK : *Span 2/4 Floorbeam Rating*		PROJECT NO :	
SUBJECT : *Span 2/4 Floorbeam Rating*			
CALCULATED BY : *DS*	DATE : *2/19/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	48.375	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		0	in
tf		0	in
A	0 x 0 =	0	in2
x	48.375 - (0.5 x 0) =	48.375	in
Ax	0 x 48.375 =	0	in3
d	48.375 - 25.18 =	23.195	in
Ad2	0 x 23.195^2 =	0	in4

Top Flange Angles

x		6	in
t		0.59	in
A (angle)		6.7319	in2
Ixxo, Double Angles		45.98807	in4
A	2 x 6.7319 =	13.4638	in2
y.bar		1.72	in
x	48.375 - 0 - 1.72 =	46.66	in
Ax	13.4638 x 46.655 =	628.15	in3
d	46.655 - 25.18 =	21.475	in
Ad2	13.4638 x 21.475^2 =	6209	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.59 =	0.59	in
A*	0	0.0000	in^2
x	48.375 - 0.59 / 2 =	48.08	in
Ax	0 x 48.08 =	0	in^3
d	48.08 - 25.18 =	22.9	in
Ad^2	0 x 22.9^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.59 + 0.5625 =	1.7425	in
A*	0	0.0000	in^2
x	48.375 - 0 - (0 +0)/2 =	48.375	in
Ax	0 x 48.375 =	0	in^3
d	48.375 - 25.18 =	23.195	in
Ad^2	0 x 23.195^2 =	0	in^4

PROJECT : *VDOT Shenandoah Valley Asset 5104*		Michael Baker INTERNATIONAL
TASK : *Span 2/4 Floorbeam Rating*	PROJECT NO :	
SUBJECT : *Span 2/4 Floorbeam Rating*		
CALCULATED BY : *DS* DATE : *2/19/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

NET SECTION

Web			
d		48.38	in
t_w		0.56	in
A	0.5625 x 48.375 =	27.2109	in^2
x	0 + 0 + (0.5 x 48.375) =	24.1875	in
Ax	27.2109375 x 24.1875 =	658.16	in^3
d	25.18 - 24.1875 =	0.9925	in
Ad^2	7.2109375 x 0.9925^2 =	26.8	in^4
I_{web}	625) x (48.375)^3 / 12 =	5306	in^4
Supplemental Web Cover Plate in End Zones			
x.tw'	Input	**0.000**	in
y.tw'	48.375 - 6 - 6 =	36.38	in
A'	27.2109375+0 x 36.375 =	27.21094	in^2

Holes Through Web at Diaphragm Connection			
Total # of Holes		13.00	
# of Holes in long row		7.00	
Gage		2.00	in
Pitch		2.00	in
Grip	0.5625 =	0.5625	in
A*	7 x 0.9375 x 0.5625 =	3.6914	in^2
x	centered on web =	24.1875	in
Ax	3.6914 x 24.1875 =	89	in^3
d	max =	12.00	in
Ad^2	Total for all holes =	119.26	in^4
I_{holes}	13 x 0.5625 x 0.9375^3/12 =	0.5	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		6.00	in
Gage 2		6.00	in
Pitch		3.00	in
Grip	2 x 0.59 + 0.5625 =	1.7425	in
A*	‹ 3^2 / (4 x 6) x 1.7425 =	2.6138	in^2
x	+ (6 + 6) / 2 =	6	in
Ax	2.6138 x 6 =	16	in^3
d	25.18 - 6 =	19.18	in
Ad^2	2.6138 x 19.18^2 =	962	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		1.00	in
Pitch		1.00	in
Grip	0 + 0.59 =	0.59	in
A	2 x 0.9375 x 0.59 =	0.0000	in^2
x	0.5 x 0.59 =	0.295	in
Ax	0 x 0.295 =	0	in^3
d	25.18 - 0.295 =	24.885	in
Ad^2	0 x 24.885^2 =	0	in^4

Bottom Flange Angles			
x		6.00	in
t		0.59	in
A (angle)		6.73	in^2
Ixxo, Double Angles		45.99	in^4
A	2 x 6.7319 =	13.4638	in^2
y.bar		1.72	in
Ax	13.4638 x 1.72 =	23.16	in^3
d	25.18 - 1.72 =	23.46	in
Ad^2	13.4638 x 23.46^2 =	7410.09	in^4

Bottom Cover Plates			
b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	25.18 - 0 =	25.18	in
Ad^2	0 x 25.18^2 =	0	in^4

NET SECTION

Girder Properties

Girder d	0 + 0 + 48.375 + 0 + 0 =	48.375	in
ΣA	0 + 13.4638 - 0 - 0 + 27.2109375 - 3.6914 - 2.6138 - 0 + 13.4638 + 0 =	47.83	in^2
ΣAx	0 + 628.15 - 0 - 0 + 658.16 - 89 - 16 - 0 + 23.16 + 0 =	1204.47	in^3
Xcg	= ΣAx / ΣA =	25.18	in
ΣAd^2	0 + 6209 - 0 - 0 + 26.8 -119.260615384615 - 962 - 0 + 7410.09 + 0 =	12564.63	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	17962.11	in^4
S_{BOTTOM}	17962.11 / 25.18 =	713	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	48.375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	48.375 - (0.5 x 0) =	48.375	in
Ax	0 x 48.375 =	0	in^3
d	48.375 - 24.19 =	24.185	in
Ad^2	0 x 24.185^2 =	0	in^4

Top Flange Angles

x		6.00	in
t		0.59	in^2
A (each angle)		6.73	in^4
A	2 x 6.7319 =	13.4638	in^2
Ixx, double angles		45.99	in^4
y.bar		1.72	in
x	48.375 - 0 - 1.72 =	46.66	in
Ax	13.4638 x 46.655 =	628.15	in^3
d	46.655 - 24.19 =	22.47	in
Ad^2	13.4638 x 22.465^2 =	6794.86	in^4

Web

d		48.38	in
t_w		0.56	in
A	0.5625 x 48.375 =	27.2109	in^2
x	48.375 / 2 +0+0	24.1875	in
Ax	27.2109 x 24.1875 =	658.16	in^3
d	24.19 - 24.1875 =	0.0025	in
Ad^2	27.2109 x 0.0025^2 =	0	in^4
I_{web}	).5625) x (48.375)^3 / 12 =	5306.45	in^4

Bottom Flange Angles

x (angle)		6.00	in
t		0.59	in
A (angle)		6.73	in
A	2 x 6.7319 =	13.4638	in^2
Ixx, double angles		45.99	in^4
y.bar		1.72	in
Ax	13.4638 x 1.72 =	23.16	in^3
d	24.19 - 1.72 =	22.47	in
Ad^2	13.4638 x 22.47^2 =	6797.88	in^4

Bottom Cover Plate

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	24.19 - 0 =	24.19	in
Ad^2	0 x 24.19^2 =	0	in^4

Girder Properties

Girder d	0 + 48.375 + 0 + 2 x 0 =	48.375	in
ΣA	0 + 13.4638 + 27.2109 + 13.4638 + 0 =	54.139	in^2
ΣAx	0 + 628.15 + 658.16 + 23.16 + 0 =	1309.5	in^3
Xcg	= ΣAx / ΣA =	24.19	in
ΣAd^2	0 + 6794.86 + 0 + 6797.88 + 0 =	13,593	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	18,991	in^4
S_{TOP}	18991 / (48.375 - 24.19) =	785	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)(set equal to Stringer Gage)		84	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	0 * 0^3/12="	0	in^4
Iyy.2A (for top flange double angle)		99.77	in
Iyy (compression flange)	0 + 99.77 =	99.80	in^4
A (compression flange & web)	0 + 13.4638 + 27.2109 / 2 =	27.06925	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	1.92	in
A_f	0 + 13.4638 =	13.4638	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (84 / 1.92)^2 =	15,975	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((84 x 48.375 x √1+0.3) / (13.4638)) =	34,683	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	15.98	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (84 / 1.92)^2 =	23,234	psi
			23.23	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (84 x 48.375 / 13.4638) =	50,604	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.23	ksi

RATING CALCULATIONS

DESCRIPTION:

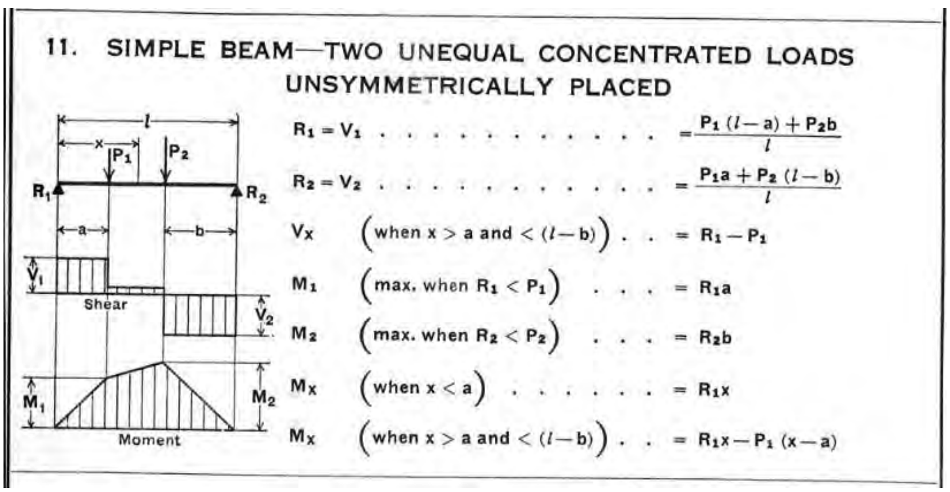
Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

Calculate point loads acting on the floorbeam at the stringer locations. Referencing Figure 11, P1 on the left is reduced while P2 on the right is increased consistent with directing rocking effect and wind in the clockwise direction.



Stringer Rating File: VDOT Shenandoah Valley Asset 5104 Load Rating_Span Stringer 4.xlsm
VDOT Shenandoah Valley Asset 5104 Load Rating_Span 4 End Stringer.xlsm

Number of Stringers	2		(recall from Stringer Rating)
Number of Tracks	1		
Deck Type	**open**		
Back Span Length	**25.50**	ft	(recall from End Stringer Rating)
Back Span DL Rxn	**6.12**	k	
Back Span WS+WLL Rxn (+ & -)	**4.08**	k	
Ahead Span Length	**25.00**	ft	(recall from Interior Stringer Rating)
Ahead Span DL Rxn	**6.00**	k	
Ahead Span WS+WLL Rxn (+ & -)	**4.00**	k	
Average Span Length, L.s =	25.25	ft	
Total DL Rxn	12.12	k	
Total WS Rx	8.08	k	
Floorbeam Span, L.f =	**16.17**	ft	

RATING CALCULATIONS

Stringer Gage = L - a - b = 7.00 ft
a = 4.59 ft
b = 4.59 ft

(Without Vertical LL) Solve for P1 and P2 for Case without Wind:

P1.dl = 12.12 k
P2.dl = 12.12 k

(Without Vertical LL) Solve for P1 and P2 for Case with Wind causing Clockwise Rotation:

P1.dl-ws = 4.04 k
P2.dl+ws = 20.20 k

Recall Live Load per Rail reactions from attached worksheets for E80, 286k and 315k Live Loads. For 2-stringer arrangement centered below the track, each stringer delivers the per Rail reaction. Apply IM & RE for calibrated Pi

Pi.E80 = 153.1 k
Pi.286 = 118.1 k
Pi.315 = 129.0 k

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL.s)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects (using Avg Stringer Span)	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d

Rocking Effects (percentage of wheel load)	20%
RE = Wheel Percentage * Rail Spacing/L.F = 100/L.F	6.18%

Speed (mph)	SRF	Impact Vert. Eff.	+RE	+RE Impact	-RE	-RE Impact %
35	0.80	31.04%	6.18%	37.2	-6.18%	24.9
35	0.80	31.04%	6.18%	37.2	-6.18%	24.9
30	0.71	27.63%	6.18%	33.8	-6.18%	21.4
25	0.61	23.59%	6.18%	29.8	-6.18%	17.4
20	0.49	18.94%	6.18%	25.1	-6.18%	12.8
15	0.35	13.66%	6.18%	19.8	-6.18%	7.5
10	0.20	7.76%	6.18%	13.9	-6.18%	1.6

RATING CALCULATIONS

Speed (mph)	P1.E80 (k)	P2.E80 (k)	P1.286 (k)	P2.286 (k)	P1.315 (k)	P1.315 (k)
35	191	210	147	162	161	177
35	191	210	147	162	161	177
30	186	205	143	158	157	173
25	180	199	139	153	151	167
20	173	192	133	148	145	161
15	165	184	127	141	139	155
10	156	174	120	135	131	147

By inspection, maximum moment and maximum shear due to stringer introducted load occurs AT Load P2. The maximum shear due to stringer introduced load is uniform from P2 over to R2.

Dead Load only via stringers:

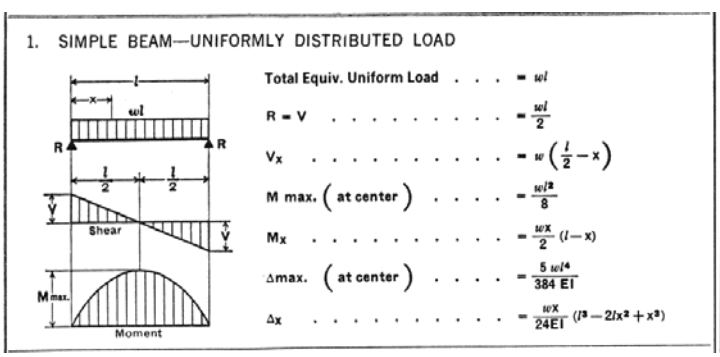
R2.DL = V2 = 12.12 k
M2.DL = 55.5702 k-ft

Dead Load + Wind Load via stringers:

R2.DL+W = V2 = 15.62 k
M2.DL+W = 71.61 k-ft

Proportionally, moment due to floorbeam self weight is trivial in comparison with moments due to stringer introduced loads. Solve for floorbeam self-weight moment occuring AT load P2 to superimpose this demand onto the stringer-introduced moments. Also, solve for maximum self-weight shear at the reaction location R2 to superimpose onto the stringer-introduced shear.

Recall, L.f = 16.17 ft
Recall, b = 4.59 ft
x = L.f - b = 11.59 ft



Recall, FB Area = 54.14 in2
w = 0.18 k/ft

R2.self = 1.49 k
M.x at P2 = M2.self = 4.89 k-t

RATING CALCULATIONS

Summarize Dead and Dead+Wind Loading Effects

V.DL = R2.DL + R2.self = 13.61 k
M.DL = M2.DL + M2.self = 60.46 k-ft

V.DL+W = R2.DL+W + R2.self = 17.11 k
M.DL+W = M2.DL+W + M2.self = 76.50 k-ft

Summarize Live Load Effects

Speed (mph)	V.E80 (k)	M.E80 (k-ft)	V.286 (k)	M.286 (k-ft)	V.315 (k)	M.315 (k-ft)
35	205	939	158	724	172	791
35	205	939	158	724	172	791
30	200	915	154	705	168	771
25	193	887	149	684	163	747
20	186	854	144	658	157	719
15	178	817	137	630	150	688
10	169	775	130	598	142	653

Existing Properties (from Net Section and Gross Section Calculations)

Recall: Fy = 30000 psi

S_{BOTTOM} (Tension - Net Section)				713	in^3
S_{TOP} (Compression - Gross Section)				785	in^3
A_{web} --- NOTE, for LE-88.74 ONLY, redirect Aweb from Nominal between stringers to A' in outside bays with cover plate				27.21094	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				15.98	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.23	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

PROJECT : *VDOT Shenandoah Valley Asset 5104*			Michael Baker INTERNATIONAL
TASK : *Span 2/4 Floorbeam Rating*		PROJECT NO :	
SUBJECT : *Span 2/4 Floorbeam Rating*			
CALCULATED BY : *DS*	DATE : *2/19/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 1.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(713 x 16.5 / 12) x (1 - CRF) =	971	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(713 x 24 / 12) x (1 - CRF) =	1412	k-ft
Maximum Compression Stress Capacity - Normal Rating	(785 x 15.975 / 12) x (1 - CRF) =	1035	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(785 x 23.23 / 12) x (1 - CRF) =	1504	k-ft
Maximum Shear Stress Capacity - Normal Rating	(27.2109375 x 10.5) x (1 - CRF) =	283	k
Maximum Shear Stress Capacity - Maximum Rating	(27.2109375 x 18) x (1 - CRF) =	485	k

RATING CALCULATIONS

Group I Girder Ratings for Tension Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E78	E115	E101	E149	E92	E137
35	E78	E115	E101	E149	E92	E137
30	E80	E118	E103	E153	E95	E140
25	E82	E122	E107	E158	E98	E145
20	E85	E127	E111	E164	E101	E150
15	E89	E132	E116	E172	E106	E157
10	E94	E139	E122	E181	E112	E166

Group I Girder Ratings for Compression Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E83	E123	E108	E160	E99	E146
35	E83	E123	E108	E160	E99	E146
30	E85	E126	E111	E164	E101	E150
25	E88	E130	E114	E169	E104	E155
20	E91	E135	E118	E175	E108	E161
15	E95	E141	E124	E183	E113	E168
10	E101	E149	E130	E193	E119	E177

Group I Girder Ratings for Shear Stress

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E87	E166	E113	E215	E103	E197
35	E87	E166	E113	E215	E103	E197
30	E89	E170	E116	E221	E106	E202
25	E92	E176	E119	E228	E109	E209
20	E96	E182	E124	E237	E113	E216
15	E100	E191	E130	E247	E119	E226
10	E105	E201	E137	E260	E125	E238

Group I Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E78	E101	E92
Maximum	E115	E149	E137

RATING CALCULATIONS

Group II Allowable Stress Factor = 1.25

Group II Girder Ratings for Tension Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E97	E144	E126	E187	E115	E171
35	E97	E144	E126	E187	E115	E171
30	E99	E148	E129	E191	E118	E175
25	E103	E152	E133	E198	E122	E181
20	E107	E158	E138	E205	E126	E188
15	E111	E165	E144	E214	E132	E196
10	E117	E174	E152	E226	E139	E207

Group II Girder Ratings for Compression Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E104	E154	E135	E199	E123	E182
35	E104	E154	E135	E199	E123	E182
30	E106	E158	E138	E205	E126	E187
25	E110	E163	E142	E211	E130	E193
20	E114	E169	E148	E219	E135	E201
15	E119	E177	E155	E229	E142	E210
10	E126	E186	E163	E241	E149	E221

Group II Girder Ratings for Shear Stress

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E132	E230	E171	E299	E156	E273
35	E132	E230	E171	E299	E156	E273
30	E135	E236	E175	E306	E160	E280
25	E139	E244	E181	E316	E165	E289
20	E145	E253	E188	E328	E172	E300
15	E151	E265	E196	E343	E179	E314
10	E159	E279	E207	E361	E189	E331

Group II Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E97	E126	E115
Maximum	E144	E187	E171

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RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E78	E101	E92
Maximum	E115	E149	E137

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E78	E62	E67
Maximum	E115	-	-

TRUSS RATING FOR SPANS 2 & 4

RATING CALCULATIONS
for
END STRINGER

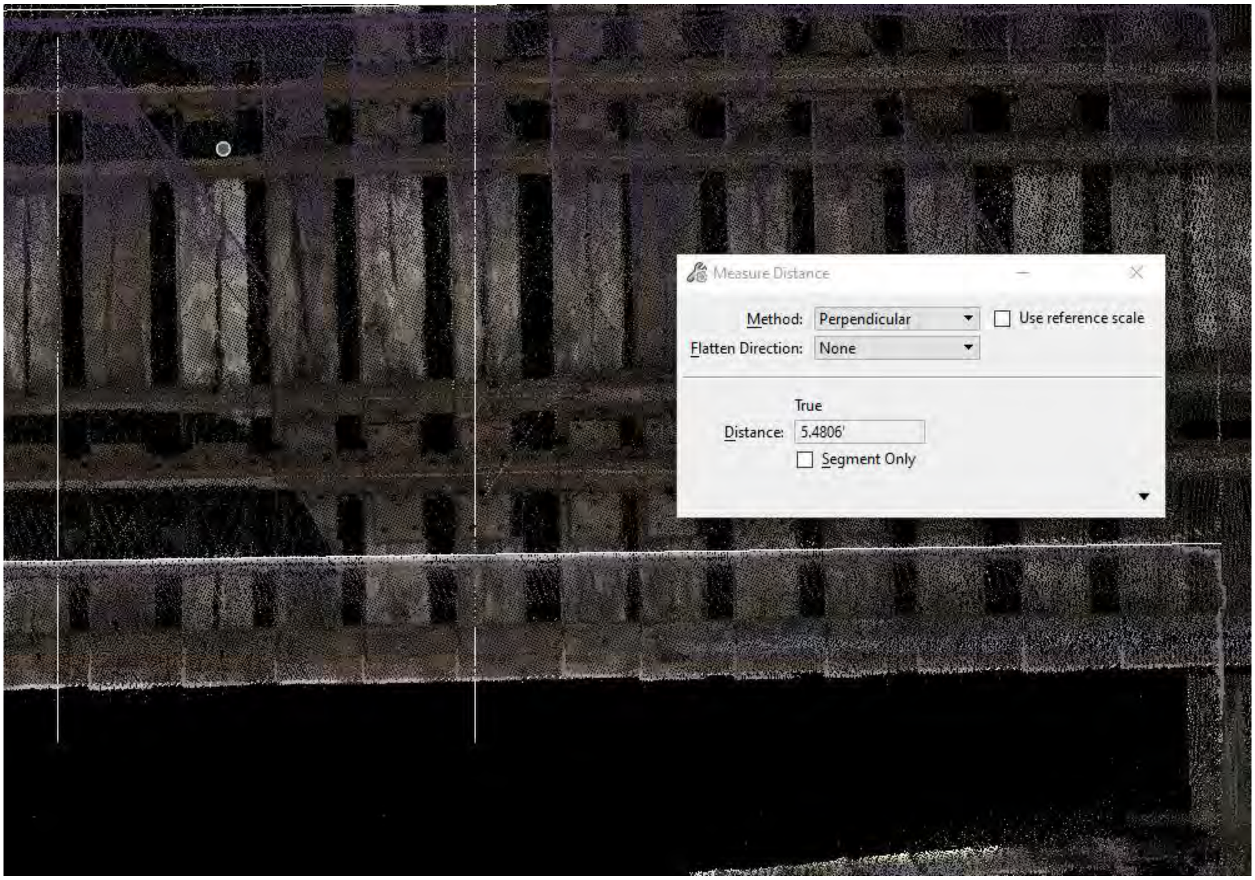
Asset 5104 Span 2/4 Stringer Section Properties

END STRINGER LENGTH = 25.5'

Stringer Flanges: 6.25x6x0.79

Web: 33.125”x0.69”

Depth = 33.125”



Top Lateral Bracing Distance: 5.4806’

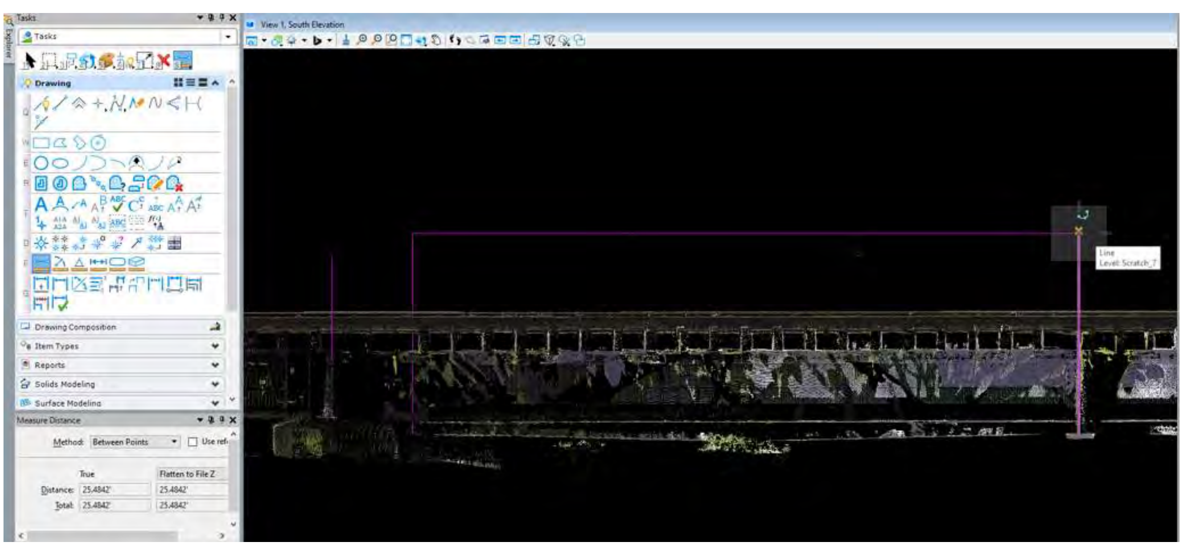
Stringer bolt spacing: 3” Gage, 2.5” Pitch

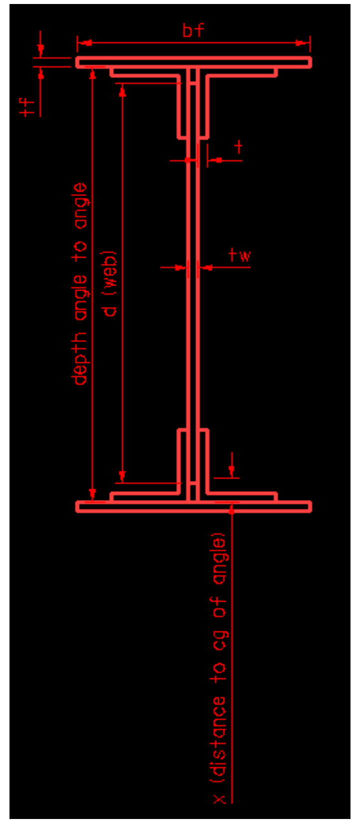
Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**25.50**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**7.00**	ft	
Girder Type	**fastened**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**1%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**65.77**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.25**	ft	
Tie Height	**10.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**10.00**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)





Girder Geometry

Depth angle to angle	33.125	in	
Effective Rivet/Bolt hole diameter	0.94	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	0.00	in
t_f	0.000	in

Top Flange Angles (0 if they don't exist)

x	6.25	in	
y	6.00	in	
t	0.790	in	
A (each angle)	9.05	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	59.54	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.76		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	155.98	in4	(ref. wksht. TF_Angle_Pair)

Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00		
			This is an assumption based off of photos (photo 014)
Gage	0.00	in	
Pitch	0.00	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web

d	33.125	in
tw	0.690	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	0.00	
# of Holes in long row	0.00	
Gage	0.00	in
Pitch	0.00	in

Bottom Flange or Cover Plate (0 if does not exist)

b_f	0.00	in
t_f	0.000	in

Bottom Flange Angles (0 if they don't exist)

x	6.25	in	
y	6.00	in	
t	0.790	in	
A (each angle)	9.05	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	59.54	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.76	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	155.98	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

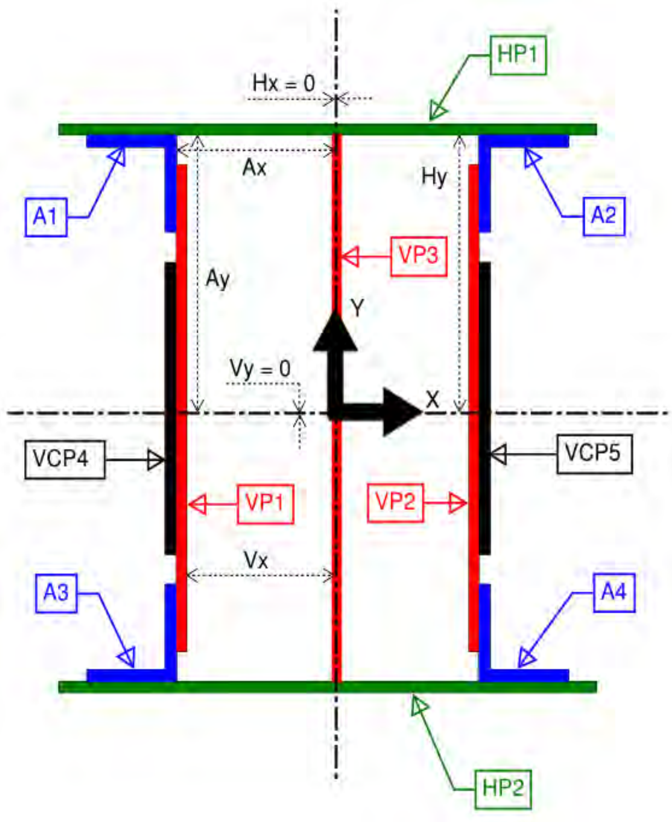
Rows	0.00	in
Gage	0.00	in
Pitch	0.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	2	
Gage 1	3.00	in
Gage 2	3.00	in
Pitch	2.50	in

TF_Angle_Pair

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	-0.345	-	out		
A2 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	0.345	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.19** in

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	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{x\text{-}x}$ (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A1 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44		4.94
A1 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33		4.12
A2 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44		4.94
A2 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33		4.12
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00		0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00		0.00
Σ	**18.11**		**31.85**	**19.13**		**40.40**	**59.54**	**Σ**	**18.11**

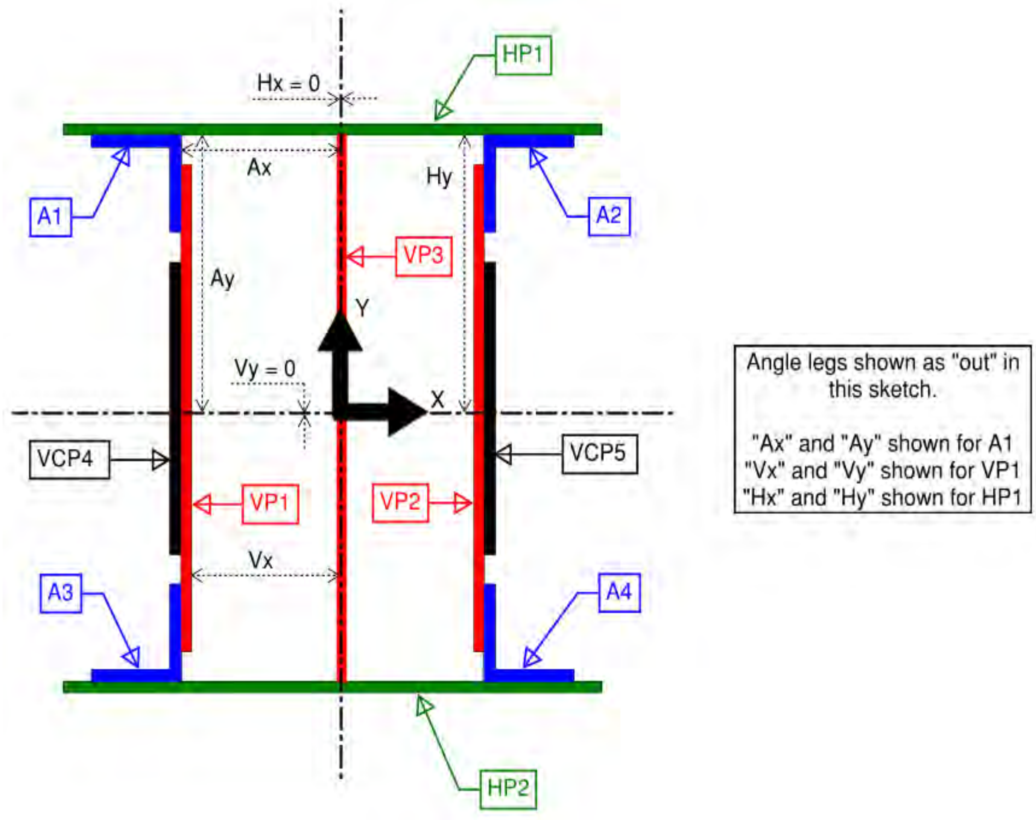
y_{bar} =	1.76	in	c_{top}=	1.24	in
I_x =	59.54	in^4	c_{bottom}=	4.76	in
A =	18.11	in^2	S_{top} =	47.97	in^3
r_x =	1.81	in	S_{bottom} =	12.51	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	4.94	-3.47	-17.13	16.07	-3.47	59.45	75.52
A1 (Vert. Leg)	4.12	-0.74	-3.05	0.21	-0.74	2.25	2.47
A2 (Horiz. Leg)	4.94	3.47	17.13	16.07	3.47	59.45	75.52
A2 (Vert. Leg)	4.12	0.74	3.05	0.21	0.74	2.25	2.47
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**18.11**		**0.00**	**32.57**		**123.41**	**155.98**

y_{bar} =	0.00	in	c_{left}=	6.60	in
I_y =	155.98	in^4	c_{right}=	6.60	in
A =	18.11	in^2	S_{left} =	23.65	in^3
r_y =	2.94	in	S_{right} =	23.65	in^3

BF_Angle_Pair

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	**no**			-	-			-	-	-		
HP2	**no**			-	-			-	-	-		
VP1	**no**					-	-	-	-	-		
VP2	**no**					-	-	-	-	-		
VP3	**no**					-	-	-	-	-		
VCP4	**no**					-	-	-	-	-		
VCP5	**no**					-	-	-	-	-		
A1 (Horiz. Leg)	**no**			-	-	-	-	-		**out**		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	**no**			-	-	-	-	-	0	**out**		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	**yes**	**6.25**	**0.79**	-	-	-	-	-	**0**	**out**		
A3 (Vert. Leg)	yes	**6.00**	**0.79**	-	-	-	-	**-0.345**	-	out		
A4 (Horiz. Leg)	**yes**	**6.25**	**0.79**	-	-	-	-	-	0	**out**		
A4 (Vert. Leg)	yes	**6.00**	**0.79**	-	-	-	-	0.345	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.19** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00		0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00		0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00		0.00
A3 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44		4.94
A3 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33		4.12
A4 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44		4.94
A4 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33		4.12
Σ	**18.11**		**31.85**	**19.13**		**40.40**	**59.54**	**Σ**	**18.11**

y_{bar} =	1.76	in	c_{top}=	1.24	in
I_x =	59.54	in^4	c_{bottom}=	4.76	in
A =	18.11	in^2	S_{top} =	47.97	in^3
r_x =	1.81	in	S_{bottom} =	12.51	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	4.94	-3.47	-17.13	16.07	-3.47	59.45	75.52
A3 (Vert. Leg)	4.12	-0.74	-3.05	0.21	-0.74	2.25	2.47
A4 (Horiz. Leg)	4.94	3.47	17.13	16.07	3.47	59.45	75.52
A4 (Vert. Leg)	4.12	0.74	3.05	0.21	0.74	2.25	2.47
Σ	**18.11**		**0.00**	**32.57**		**123.41**	**155.98**

y_{bar} =	0.00	in	c_{left}=	6.60	in
I_y =	155.98	in^4	c_{right}=	6.60	in
A =	18.11	in^2	S_{left} =	23.65	in^3
r_y =	2.94	in	S_{right} =	23.65	in^3

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	33.125	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		0	in
tf		0	in
A	0 x 0 =	0	in2
x	33.125 - (0.5 x 0) =	33.125	in
Ax	0 x 33.125 =	0	in3
d	33.125 - 17.31 =	15.815	in
Ad2	0 x 15.815^2 =	0	in4

Top Flange Angles

x		6.25	in
t		0.79	in
A (angle)		9.0534	in2
Ixxo, Double Angles		59.53876	in4
A	2 x 9.0534 =	18.1068	in2
y.bar		1.76	in
x	33.125 - 0 - 1.76 =	31.37	in
Ax	18.1068 x 31.365 =	567.92	in3
d	31.365 - 17.31 =	14.055	in
Ad2	18.1068 x 14.055^2 =	3577	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.79 =	0.79	in
A*	2 x 0.9375 x 0.79 =	0.0000	in^2
x	33.125 - 0.79 / 2 =	32.73	in
Ax	0 x 32.73 =	0	in^3
d	32.73 - 17.31 =	15.42	in
Ad^2	0 x 15.42^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.79 + 0.69 =	2.27	in
A*	0	0.0000	in^2
x	33.125 - 0 - (0 +0)/2 =	33.125	in
Ax	0 x 33.125 =	0	in^3
d	33.125 - 17.31 =	15.815	in
Ad^2	0 x 15.815^2 =	0	in^4

Web			
d		33.13	in
t_w		0.69	in
A	0.69 x 33.125 =	22.85625	in^2
x	0 + 0 + (0.5 x 33.125) =	16.5625	in
Ax	22.85625 x 16.5625 =	378.56	in^3
d	17.31 - 16.5625 =	0.7475	in
Ad^2	22.85625 x 0.7475^2 =	12.77	in^4
I_{web}	).69) x (33.125)^3 / 12 =	2090	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		0.00	
# of Holes in long row		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0.69 =	0.69	in
A*	0	0.0000	in^2
x	centered on web =	16.5625	in
Ax	0 x 16.5625 =	0	in^3
d	max =	0.00	in
Ad^2	Total for all holes =	0.00	in^4
I_{holes}	0 x 0.69 x 0.9375^3/12 =	0	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		3.00	in
Gage 2		3.00	in
Pitch		2.50	in
Grip	2 x 0.79 + 0.69 =	2.27	in
A*	x 2.5^2 / (4 x 3) x 2.27 =	3.0740	in^2
x	+ (3 + 3) / 2 =	3	in
Ax	3.074 x 3 =	9	in^3
d	17.31 - 3 =	14.31	in
Ad^2	3.074 x 14.31^2 =	629	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.79 =	0.79	in
A	#DIV/0!	0.0000	in^2
x	0.5 x 0.79 =	0.395	in
Ax	0 x 0.395 =	0	in^3
d	17.31 - 0.395 =	16.915	in
Ad^2	0 x 16.915^2 =	0	in^4

Bottom Flange Angles			
x		6.25	in
t		0.79	in
A (angle)		9.05	in^2
Ixxo, Double Angles		59.54	in^4
A	2 x 9.0534 =	18.1068	in^2
y.bar		1.76	in
Ax	18.1068 x 1.76 =	31.87	in^3
d	17.31 - 1.76 =	15.55	in
Ad^2	18.1068 x 15.55^2 =	4378.27	in^4

Bottom Cover Plates			
b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	17.31 - 0 =	17.31	in
Ad^2	0 x 17.31^2 =	0	in^4

NET SECTION

Girder Properties

Girder d	0 + 0 + 33.125 + 0 + 0 =	33.125	in
ΣA	0 + 18.1068 - 0 - 0 + 22.85625 - 0 - 3.074 - 0 + 18.1068 + 0 =	56.00	in^2
ΣAx	0 + 567.92 - 0 - 0 + 378.56 - 0 - 9 - 0 + 31.87 + 0 =	969.35	in^3
Xcg	= ΣAx / ΣA =	17.31	in
ΣAd^2	0 + 3577 - 0 - 0 + 12.77 -0 - 629 - 0 + 4378.27 + 0 =	7339.04	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	9548.12	in^4
S_{BOTTOM}	9548.12 / 17.31 =	552	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles 33.125 in
Clear Distance Web to Flange Angle 0 in

Top Cover Plates

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	33.125 - (0.5 x 0) =	33.125	in
Ax	0 x 33.125 =	0	in^3
d	33.125 - 16.56 =	16.565	in
Ad^2	0 x 16.565^2 =	0	in^4

Top Flange Angles

x		6.25	in
t		0.79	in^2
A (each angle)		9.05	in^4
A	2 x 9.0534 =	18.1068	in^2
Ixx, double angles		59.54	in^4
y.bar		1.76	in
x	33.125 - 0 - 1.76 =	31.37	in
Ax	18.1068 x 31.365 =	567.92	in^3
d	31.365 - 16.56 =	14.81	in
Ad^2	18.1068 x 14.805^2 =	3968.79	in^4

Web

d		33.13	in
t_w		0.69	in
A	0.69 x 33.125 =	22.8563	in^2
x	33.125 / 2 +0+0	16.5625	in
Ax	22.8563 x 16.5625 =	378.56	in^3
d	16.56 - 16.5625 =	0.0025	in
Ad^2	22.8563 x 0.0025^2 =	0	in^4
I_{web}	(0.69) x (33.125)^3 / 12 =	2089.95	in^4

Bottom Flange Angles

x (angle)		6.25	in
t		0.79	in
A (angle)		9.05	in
A	2 x 9.0534 =	18.1068	in^2
Ixx, double angles		59.54	in^4
y.bar		1.76	in
Ax	18.1068 x 1.76 =	31.87	in^3
d	16.56 - 1.76 =	14.8	in
Ad^2	18.1068 x 14.8^2 =	3966.11	in^4

Bottom Cover Plate

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	16.56 - 0 =	16.56	in
Ad^2	0 x 16.56^2 =	0	in^4

Girder Properties

Girder d	0 + 33.125 + 0 + 2 x 0 =	33.125	in
ΣA	0 + 18.1068 + 22.8563 + 18.1068 + 0 =	59.070	in^2
ΣAx	0 + 567.92 + 378.56 + 31.87 + 0 =	978.4	in^3
Xcg	= ΣAx / ΣA =	16.56	in
ΣAd^2	0 + 3968.79 + 0 + 3966.11 + 0 =	7,935	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	10,144	in^4
S_{TOP}	10144 / (33.125 - 16.56) =	612	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		65.7672	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	0 * 0^3/12="	0	in^4
Iyy.2A (for top flange double angle)		155.98	in
Iyy (compression flange)	0 + 155.98 =	156.00	in^4
A (compression flange & web)	0 + 18.1068 + 22.8563 / 2 =	29.53495	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	2.3	in
A_f	0 + 18.1068 =	18.1068	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55\,(F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (65.7672 / 2.3)^2 =	16,276	psi
Eq. 2 $(0.131\pi E) / (\,ld\,\sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((65.7672 x 33.125 x √1+0.3) / (18.1068)) =	87,001	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	16.28	ksi

Michael Baker INTERNATIONAL

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (65.7672 / 2.3)^2 =	23,673	psi
			23.67	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (65.7672 x 33.125 / 18.1068) =	126,938	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.67	ksi

PROJECT : *VDOT Shenandoah Valley Asset 5104*			
TASK : *SPAN 2/4 End Stringer Rating*		PROJECT NO :	
SUBJECT : *Span 2/4 End Stringer Rating*			
CALCULATED BY : *DS*	DATE : *2/18/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

Michael Baker INTERNATIONAL

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

25.5	Span Length (ft)	7	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.25	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
10.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
10.00	Tie Length (ft)			fastened	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**630.63**	k-ft
E80 Shear	**114.59**	k

286k Car

286k Car Moment	**486.89**	k-ft
286k Car Shear	**114.59**	k

315k Car

315k Car Moment	**532.06**	k-ft
315k Car Shear	**100.68**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	25.50	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	26.01	k-ft
Wind on Live Load Shear	4.08	k

PROJECT : *VDOT Shenandoah Valley Asset 5104*			Michael Baker INTERNATIONAL
TASK : *SPAN 2/4 End Stringer Rating*		PROJECT NO :	
SUBJECT : *Span 2/4 End Stringer Rating*			
CALCULATED BY : *DS*	DATE : *2/18/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2)	
Percentage of wheel load taken by one beam	14.29%

Dead Load on One Girder

Girder	59.0699/144*490="	201.0	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 5% for Connections		x1.05	
Total Steel Load	1.05 x (201 + 0) =	211	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	10/12 x 10/12 x 10 x 60 =	417	lb
Number of ties	25.5 ft / 1.25 ft =	20.4	ties
Number of Beams		2	
Tie Weight/ LF of beam		167	lb / ft

PROJECT : *VDOT Shenandoah Valley Asset 5104*			Michael Baker INTERNATIONAL
TASK : *SPAN 2/4 End Stringer Rating*		**PROJECT NO :**	
SUBJECT : *Span 2/4 End Stringer Rating*			
CALCULATED BY : *DS*	**DATE :** *2/18/2025*	**CHECKED BY :** *JBT*	**DATE :** 3/19/25

RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		6.95	ft^3
Ties per LF of Bridge		0.8	ties
Average Area of Ties per LF of Bridge		5.56	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**0.00**	lb / ft
Total Dead Load		**478**	**lb / ft**
		0.48	k / ft
Moment	**0.48 x 25.5^2 / 8 =**	**39.02**	**k-ft**
Shear	**0.48 x 25.5 / 2 =**	**6.12**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				552	in^3
S_{TOP} (Compression - Gross Section)				612	in^3
A_{web}				22.85625	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				16.28	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.67	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 1.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(552 x 16.5 / 12) x (1 - CRF) =	751	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(552 x 24 / 12) x (1 - CRF) =	1093	k-ft
Maximum Compression Stress Capacity - Normal Rating	(612 x 16.276 / 12) x (1 - CRF) =	822	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(612 x 23.67 / 12) x (1 - CRF) =	1195	k-ft
Maximum Shear Stress Capacity - Normal Rating	(22.85625 x 10.5) x (1 - CRF) =	238	k
Maximum Shear Stress Capacity - Maximum Rating	(22.85625 x 18) x (1 - CRF) =	407	k

Girder Ratings for Tension Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	14.29%	45.3	E60	E90	E78	E116	E71	E106
35	0.80	31.02%	14.29%	45.3	E60	E90	E78	E116	E71	E106
30	0.71	27.61%	14.29%	41.9	E61	E92	E79	E119	E73	E109
25	0.61	23.58%	14.29%	37.9	E63	E95	E82	E123	E75	E112
20	0.49	18.93%	14.29%	33.2	E65	E98	E85	E127	E77	E116
15	0.35	13.65%	14.29%	27.9	E68	E102	E88	E132	E81	E121
10	0.20	7.76%	14.29%	22.0	E71	E107	E92	E138	E85	E127

Girder Ratings for Compression Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	14.29%	45.3	E66	E99	E86	E128	E78	E117
35	0.80	31.02%	14.29%	45.3	E66	E99	E86	E128	E78	E117
30	0.71	27.61%	14.29%	41.9	E68	E101	E88	E131	E80	E120
25	0.61	23.58%	14.29%	37.9	E70	E104	E90	E135	E83	E123
20	0.49	18.93%	14.29%	33.2	E72	E108	E93	E139	E85	E128
15	0.35	13.65%	14.29%	27.9	E75	E112	E97	E145	E89	E133
10	0.20	7.76%	14.29%	22.0	E79	E117	E102	E152	E93	E139

Girder Ratings for Shear Stress

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	14.29%	45.3	E109	E191	E109	E191	E125	E217
35	0.80	31.02%	14.29%	45.3	E109	E191	E109	E191	E125	E217
30	0.71	27.61%	14.29%	41.9	E112	E195	E112	E195	E128	E222
25	0.61	23.58%	14.29%	37.9	E115	E201	E115	E201	E131	E229
20	0.49	18.93%	14.29%	33.2	E119	E208	E119	E208	E136	E237
15	0.35	13.65%	14.29%	27.9	E124	E217	E124	E217	E142	E247
10	0.20	7.76%	14.29%	22.0	E130	E227	E130	E227	E148	E258

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E60	E78	E71
Maximum	E90	E116	E106

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

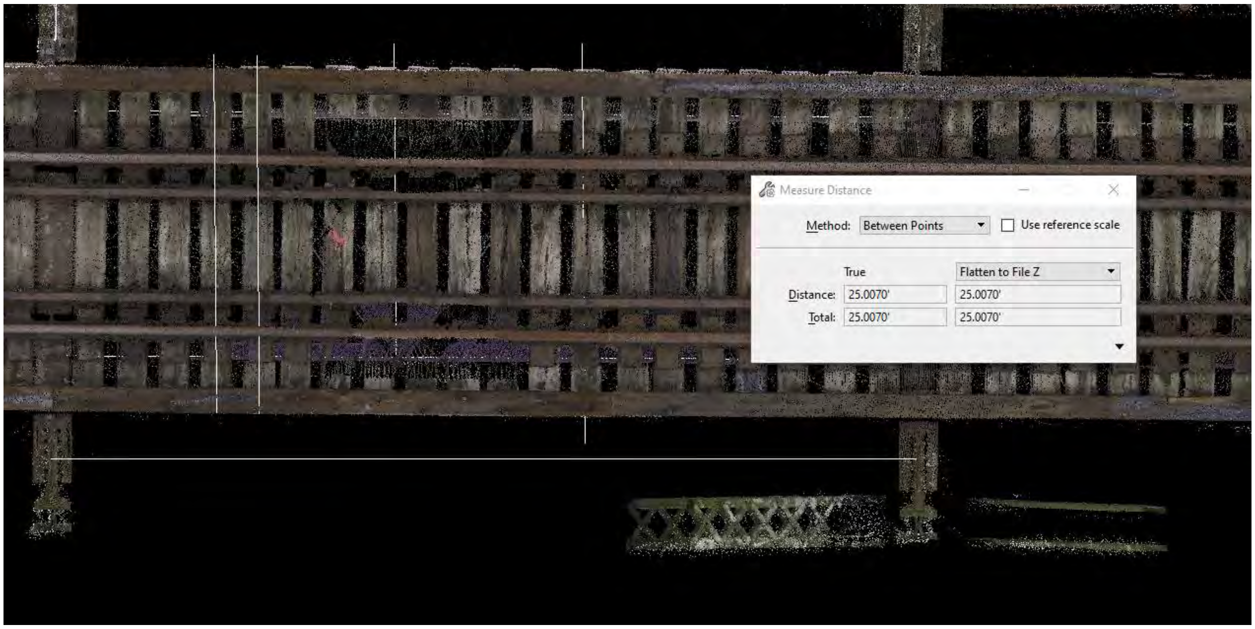
Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E60	E62	E67
Maximum	E90	-	-

TRUSS RATING FOR SPANS 2 & 4

RATING CALCULATIONS
for
INTERIOR STRINGER

Asset 5104 Span 2/4 Stringer Section Properties

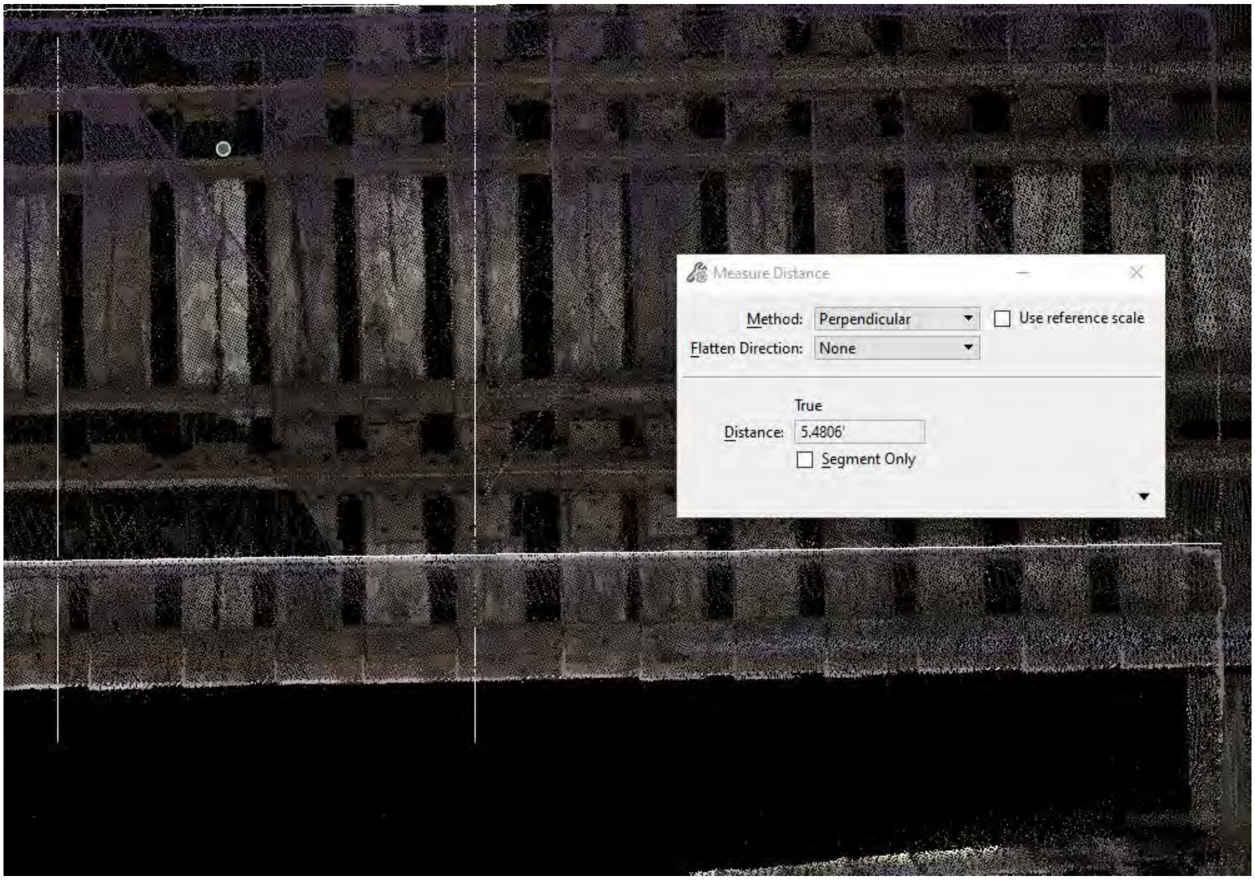


Stringer Span Length = 25’

Stringer Flanges: 6.25x6x0.79

Web: 33.125”x0.69”

Depth = 33.125”



Top Lateral Bracing Distance: 5.4806’

Stringer bolt spacing: 3” Gage, 2.5” Pitch

PROJECT : *VDOT Shenandoah Valley Asset 5104*			Michael Baker INTERNATIONAL
TASK : *SPAN 2/4 Stringer Rating*		PROJECT NO :	
SUBJECT : *Span 2/4 Stringer Rating*			
CALCULATED BY : *DS*	DATE : *2/18/2025*	CHECKED BY : *JBT*	DATE : 3/19/25

SUMMARY

Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**25.00**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**7.00**	ft	
Girder Type	**fastened**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**1%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**65.77**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.25**	ft	
Tie Height	**10.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**10.00**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)

Girder Geometry

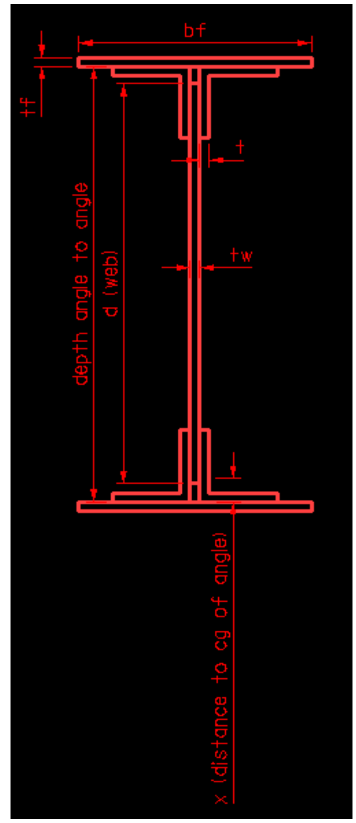
Depth angle to angle	**33.125**	in	
Effective Rivet/Bolt hole diameter	**0.94**	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	**0.00**	in
t_f	**0.000**	in

Top Flange Angles (0 if they don't exist)

x	**6.25**	in	
y	**6.00**	in	
t	**0.790**	in	
A (each angle)	9.05	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	59.54	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.76		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	155.98	in4	(ref. wksht. TF_Angle_Pair)



Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	**0.00**		
			This is an assumption based off of photos (photo 014)
Gage	**0.00**	in	
Pitch	**0.00**	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	**0**	
Gage 1	**0.00**	in
Gage 2	**0.00**	in
Pitch	**0.00**	in

Web

d	**33.125**	in
tw	**0.690**	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	**0.00**	
# of Holes in long row	**0.00**	
Gage	**0.00**	in
Pitch	**0.00**	in

Bottom Flange or Cover Plate (0 if does not exist)

b_f	0.00	in
t_f	0.000	in

Bottom Flange Angles (0 if they don't exist)

x	6.25	in	
y	6.00	in	
t	0.790	in	
A (each angle)	9.05	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	59.54	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.76	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	155.98	in4	(ref. wksht. BF_Angle_Pair)

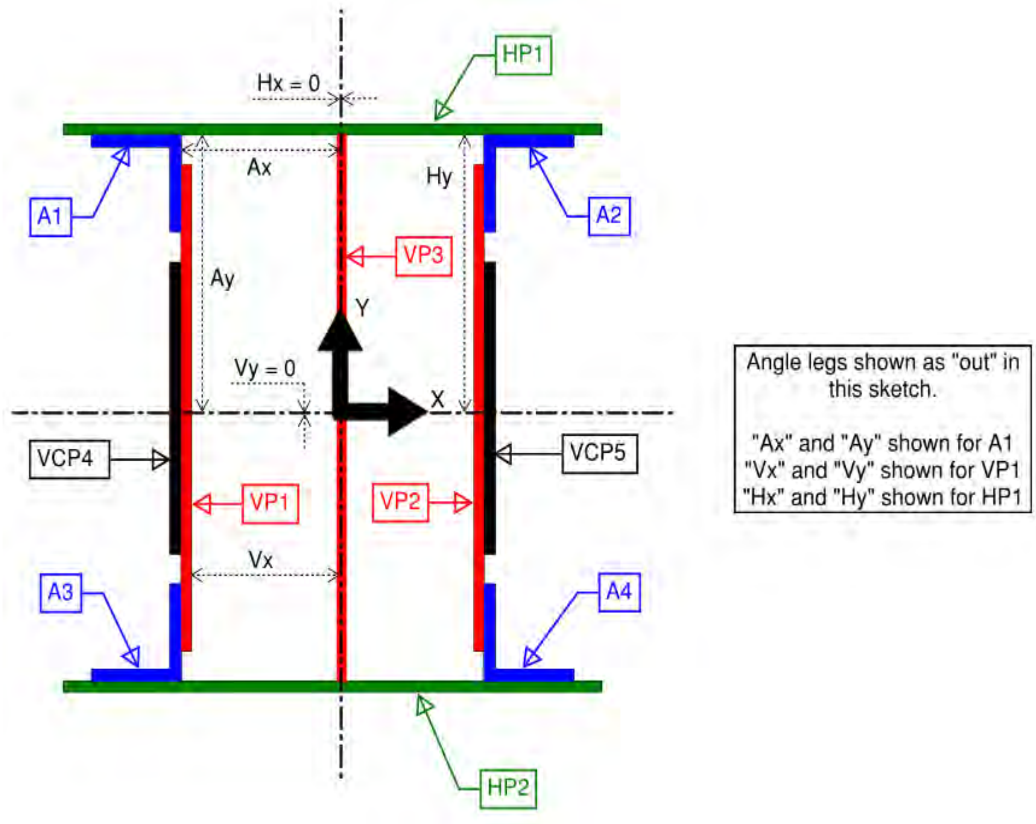
Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00	in
Gage	0.00	in
Pitch	0.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	2	
Gage 1	3.00	in
Gage 2	3.00	in
Pitch	2.50	in

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	-0.345	-	out		
A2 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	0.345	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.19** in

Michael Baker INTERNATIONAL

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)
HP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
HP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP3	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A1 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44
A1 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33
A2 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44
A2 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00
∑	**18.11**		**31.85**	**19.13**		**40.40**	**59.54**

	A_{net} (in^2)
HP1	0.00
HP2	0.00
VP1	0.00
VP2	0.00
VP3	0.00
VCP4	0.00
VCP5	0.00
A1 (Horiz. Leg)	4.94
A1 (Vert. Leg)	4.12
A2 (Horiz. Leg)	4.94
A2 (Vert. Leg)	4.12
A3 (Horiz. Leg)	0.00
A3 (Vert. Leg)	0.00
A4 (Horiz. Leg)	0.00
A4 (Vert. Leg)	0.00
∑	**18.11**

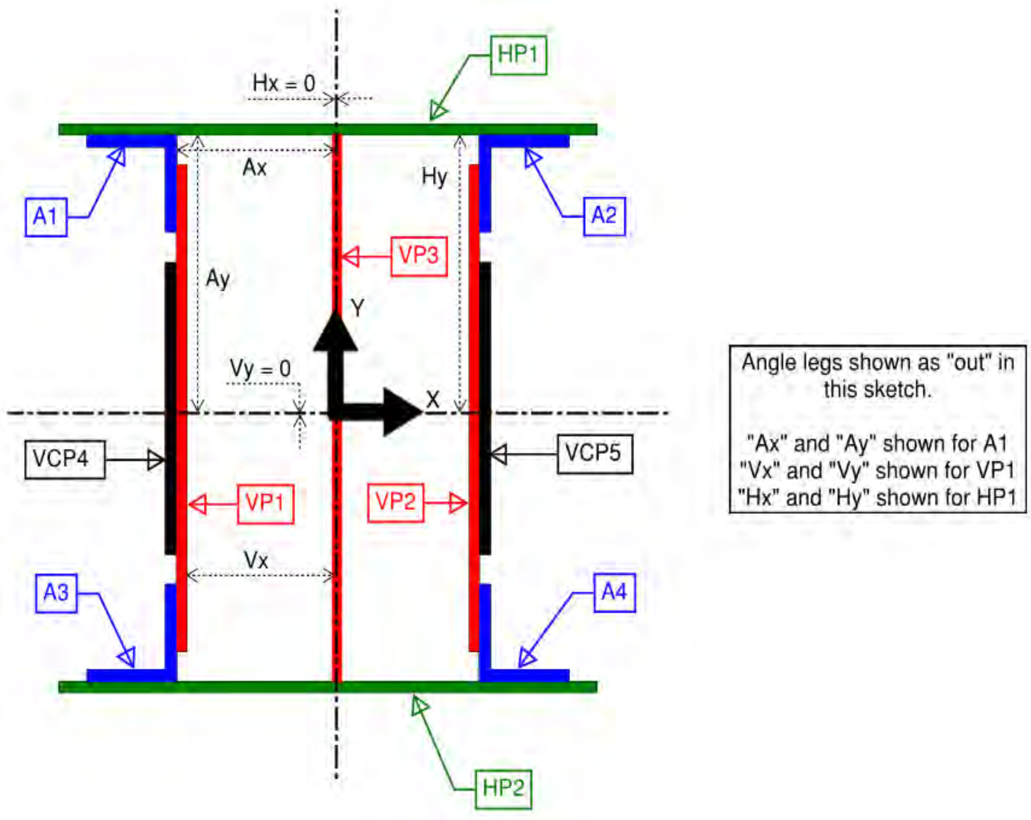
y_{bar} =	1.76	in	c_{top}=	1.24	in
I_x =	59.54	in^4	c_{bottom}=	4.76	in
A =	18.11	in^2	S_{top} =	47.97	in^3
r_x =	1.81	in	S_{bottom} =	12.51	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	4.94	-3.47	-17.13	16.07	-3.47	59.45	75.52
A1 (Vert. Leg)	4.12	-0.74	-3.05	0.21	-0.74	2.25	2.47
A2 (Horiz. Leg)	4.94	3.47	17.13	16.07	3.47	59.45	75.52
A2 (Vert. Leg)	4.12	0.74	3.05	0.21	0.74	2.25	2.47
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
∑	**18.11**		**0.00**	**32.57**		**123.41**	**155.98**

y_{bar} =	0.00	in	c_{left}=	6.60	in
I_y =	155.98	in^4	c_{right}=	6.60	in
A =	18.11	in^2	S_{left} =	23.65	in^3
r_y =	2.94	in	S_{right} =	23.65	in^3

BF_Angle_Pair

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	no			-	-	-	-	-		out		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A3 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	-0.345	-	out		
A4 (Horiz. Leg)	yes	6.25	0.79	-	-	-	-	-	0	out		
A4 (Vert. Leg)	yes	6.00	0.79	-	-	-	-	0.345	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.19** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)
HP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
HP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP1	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP2	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VP3	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.76	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.76	0.00	0.00
A3 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44
A3 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33
A4 (Horiz. Leg)	4.94	0.40	1.95	0.26	-1.36	9.18	9.44
A4 (Vert. Leg)	4.12	3.40	13.97	9.31	1.64	11.02	20.33
Σ	**18.11**		**31.85**	**19.13**		**40.40**	**59.54**

	A_{net} (in^2)
HP1	0.00
HP2	0.00
VP1	0.00
VP2	0.00
VP3	0.00
VCP4	0.00
VCP5	0.00
A1 (Horiz. Leg)	0.00
A1 (Vert. Leg)	0.00
A2 (Horiz. Leg)	0.00
A2 (Vert. Leg)	0.00
A3 (Horiz. Leg)	4.94
A3 (Vert. Leg)	4.12
A4 (Horiz. Leg)	4.94
A4 (Vert. Leg)	4.12
Σ	**18.11**

y_{bar} =	1.76	in	c_{top}=	1.24	in
I_x =	59.54	in^4	c_{bottom}=	4.76	in
A =	18.11	in^2	S_{top} =	47.97	in^3
r_x =	1.81	in	S_{bottom} =	12.51	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	4.94	-3.47	-17.13	16.07	-3.47	59.45	75.52
A3 (Vert. Leg)	4.12	-0.74	-3.05	0.21	-0.74	2.25	2.47
A4 (Horiz. Leg)	4.94	3.47	17.13	16.07	3.47	59.45	75.52
A4 (Vert. Leg)	4.12	0.74	3.05	0.21	0.74	2.25	2.47
Σ	**18.11**		**0.00**	**32.57**		**123.41**	**155.98**

y_{bar} =	0.00	in	c_{left}=	6.60	in
I_y =	155.98	in^4	c_{right}=	6.60	in
A =	18.11	in^2	S_{left} =	23.65	in^3
r_y =	2.94	in	S_{right} =	23.65	in^3

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	33.125	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		0	in
tf		0	in
A	0 x 0 =	0	in2
x	33.125 - (0.5 x 0) =	33.125	in
Ax	0 x 33.125 =	0	in3
d	33.125 - 17.31 =	15.815	in
Ad2	0 x 15.815^2 =	0	in4

Top Flange Angles

x		6.25	in
t		0.79	in
A (angle)		9.0534	in2
Ixxo, Double Angles		59.53876	in4
A	2 x 9.0534 =	18.1068	in2
y.bar		1.76	in
x	33.125 - 0 - 1.76 =	31.37	in
Ax	18.1068 x 31.365 =	567.92	in3
d	31.365 - 17.31 =	14.055	in
Ad2	18.1068 x 14.055^2 =	3577	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.79 =	0.79	in
A*	2 x 0.9375 x 0.79 =	0.0000	in^2
x	33.125 - 0.79 / 2 =	32.73	in
Ax	0 x 32.73 =	0	in^3
d	32.73 - 17.31 =	15.42	in
Ad^2	0 x 15.42^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.79 + 0.69 =	2.27	in
A*	0	0.0000	in^2
x	33.125 - 0 - (0 +0)/2 =	33.125	in
Ax	0 x 33.125 =	0	in^3
d	33.125 - 17.31 =	15.815	in
Ad^2	0 x 15.815^2 =	0	in^4

NET SECTION

Web			
d		33.13	in
t_w		0.69	in
A	0.69 x 33.125 =	22.85625	in^2
x	0 + 0 + (0.5 x 33.125) =	16.5625	in
Ax	22.85625 x 16.5625 =	378.56	in^3
d	17.31 - 16.5625 =	0.7475	in
Ad^2	22.85625 x 0.7475^2 =	12.77	in^4
I_{web}	).69) x (33.125)^3 / 12 =	2090	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		0.00	
# of Holes in long row		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0.69 =	0.69	in
A*	0	0.0000	in^2
x	centered on web =	16.5625	in
Ax	0 x 16.5625 =	0	in^3
d	max =	0.00	in
Ad^2	Total for all holes =	0.00	in^4
I_{holes}	0 x 0.69 x 0.9375^3/12 =	0	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		3.00	in
Gage 2		3.00	in
Pitch		2.50	in
Grip	2 x 0.79 + 0.69 =	2.27	in
A*	x 2.5^2 / (4 x 3) x 2.27 =	3.0740	in^2
x	+ (3 + 3) / 2 =	3	in
Ax	3.074 x 3 =	9	in^3
d	17.31 - 3 =	14.31	in
Ad^2	3.074 x 14.31^2 =	629	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.79 =	0.79	in
A	#DIV/0!	0.0000	in^2
x	0.5 x 0.79 =	0.395	in
Ax	0 x 0.395 =	0	in^3
d	17.31 - 0.395 =	16.915	in
Ad^2	0 x 16.915^2 =	0	in^4

Bottom Flange Angles			
x		6.25	in
t		0.79	in
A (angle)		9.05	in^2
Ixxo, Double Angles		59.54	in^4
A	2 x 9.0534 =	18.1068	in^2
y.bar		1.76	in
Ax	18.1068 x 1.76 =	31.87	in^3
d	17.31 - 1.76 =	15.55	in
Ad^2	18.1068 x 15.55^2 =	4378.27	in^4

Bottom Cover Plates			
b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	17.31 - 0 =	17.31	in
Ad^2	0 x 17.31^2 =	0	in^4

NET SECTION

Girder Properties

Girder d	0 + 0 + 33.125 + 0 + 0 =	33.125	in
ΣA	0 + 18.1068 - 0 - 0 + 22.85625 - 0 - 3.074 - 0 + 18.1068 + 0 =	56.00	in^2
ΣAx	0 + 567.92 - 0 - 0 + 378.56 - 0 - 9 - 0 + 31.87 + 0 =	969.35	in^3
Xcg	= ΣAx / ΣA =	17.31	in
ΣAd^2	0 + 3577 - 0 - 0 + 12.77 -0 - 629 - 0 + 4378.27 + 0 =	7339.04	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	9548.12	in^4
S_{BOTTOM}	9548.12 / 17.31 =	552	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles 33.125 in
Clear Distance Web to Flange Angle 0 in

Top Cover Plates

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	33.125 - (0.5 x 0) =	33.125	in
Ax	0 x 33.125 =	0	in^3
d	33.125 - 16.56 =	16.565	in
Ad^2	0 x 16.565^2 =	0	in^4

Top Flange Angles

x		6.25	in
t		0.79	in^2
A (each angle)		9.05	in^4
A	2 x 9.0534 =	18.1068	in^2
Ixx, double angles		59.54	in^4
y.bar		1.76	in
x	33.125 - 0 - 1.76 =	31.37	in
Ax	18.1068 x 31.365 =	567.92	in^3
d	31.365 - 16.56 =	14.81	in
Ad^2	18.1068 x 14.805^2 =	3968.79	in^4

Web

d		33.13	in
t_w		0.69	in
A	0.69 x 33.125 =	22.8563	in^2
x	33.125 / 2 +0+0	16.5625	in
Ax	22.8563 x 16.5625 =	378.56	in^3
d	16.56 - 16.5625 =	0.0025	in
Ad^2	22.8563 x 0.0025^2 =	0	in^4
I_{web}	(0.69) x (33.125)^3 / 12 =	2089.95	in^4

Bottom Flange Angles

x (angle)		6.25	in
t		0.79	in
A (angle)		9.05	in
A	2 x 9.0534 =	18.1068	in^2
Ixx, double angles		59.54	in^4
y.bar		1.76	in
Ax	18.1068 x 1.76 =	31.87	in^3
d	16.56 - 1.76 =	14.8	in
Ad^2	18.1068 x 14.8^2 =	3966.11	in^4

Bottom Cover Plate

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	16.56 - 0 =	16.56	in
Ad^2	0 x 16.56^2 =	0	in^4

Girder Properties

Girder d	0 + 33.125 + 0 + 2 x 0 =	33.125	in
ΣA	0 + 18.1068 + 22.8563 + 18.1068 + 0 =	59.070	in^2
ΣAx	0 + 567.92 + 378.56 + 31.87 + 0 =	978.4	in^3
Xcg	= ΣAx / ΣA =	16.56	in
ΣAd^2	0 + 3968.79 + 0 + 3966.11 + 0 =	7,935	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	10,144	in^4
S_{TOP}	10144 / (33.125 - 16.56) =	612	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		65.7672	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	0 * 0^3/12="	0	in^4
Iyy.2A (for top flange double angle)		155.98	in
Iyy (compression flange)	0 + 155.98 =	156.00	in^4
A (compression flange & web)	0 + 18.1068 + 22.8563 / 2 =	29.53495	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	2.3	in
A_f	0 + 18.1068 =	18.1068	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (65.7672 / 2.3)^2 =	16,276	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((65.7672 x 33.125 x √1+0.3) / (18.1068)) =	87,001	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	16.28	ksi

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GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (65.7672 / 2.3)^2 =	23,673	psi
			23.67	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (65.7672 x 33.125 / 18.1068) =	126,938	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.67	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

25	Span Length (ft)	7	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.25	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
10.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
10.00	Tie Length (ft)			fastened	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**610.56**	k-ft
E80 Shear	**113.34**	k

286k Car

286k Car Moment	**470.13**	k-ft
286k Car Shear	**113.34**	k

315k Car

315k Car Moment	**513.63**	k-ft
315k Car Shear	**99.74**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	25.00	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	25.00	k-ft
Wind on Live Load Shear	4.00	k

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2) Percentage of wheel load taken by one beam	14.29%

Dead Load on One Girder

Girder	59.0699/144*490="	201.0	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 5% for Connections		x1.05	
Total Steel Load	1.05 x (201 + 0) =	211	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	10/12 x 10/12 x 10 x 60 =	417	lb
Number of ties	25 ft / 1.25 ft =	20	ties
Number of Beams		2	
Tie Weight/ LF of beam		167	lb / ft

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RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		6.95	ft^3
Ties per LF of Bridge		0.8	ties
Average Area of Ties per LF of Bridge		5.56	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**0.00**	lb / ft
Total Dead Load		**478**	**lb / ft**
		0.48	k / ft
Moment	**0.48 x 25^2 / 8 =**	**37.50**	**k-ft**
Shear	**0.48 x 25 / 2 =**	**6.00**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				552	in^3
S_{TOP} (Compression - Gross Section)				612	in^3
A_{web}				22.85625	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				16.28	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.67	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

PROJECT : *VDOT Shenandoah Valley Asset 5104*	
TASK : *SPAN 2/4 Stringer Rating*	PROJECT NO :
SUBJECT : *Span 2/4 Stringer Rating*	
CALCULATED BY : *DS* DATE : *2/18/2025*	CHECKED BY : *JBT* DATE : 3/19/25

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RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 1.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(552 x 16.5 / 12) x (1 - CRF) =	751	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(552 x 24 / 12) x (1 - CRF) =	1093	k-ft
Maximum Compression Stress Capacity - Normal Rating	(612 x 16.276 / 12) x (1 - CRF) =	822	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(612 x 23.67 / 12) x (1 - CRF) =	1195	k-ft
Maximum Shear Stress Capacity - Normal Rating	(22.85625 x 10.5) x (1 - CRF) =	238	k
Maximum Shear Stress Capacity - Maximum Rating	(22.85625 x 18) x (1 - CRF) =	407	k

Girder Ratings for Tension Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.06%	14.29%	45.3	E62	E93	E81	E121	E74	E110
35	0.80	31.06%	14.29%	45.3	E62	E93	E81	E121	E74	E110
30	0.71	27.65%	14.29%	41.9	E64	E95	E83	E124	E76	E113
25	0.61	23.61%	14.29%	37.9	E65	E98	E85	E127	E78	E116
20	0.49	18.95%	14.29%	33.2	E68	E101	E88	E132	E80	E120
15	0.35	13.67%	14.29%	28.0	E70	E105	E92	E137	E84	E125
10	0.20	7.77%	14.29%	22.1	E74	E111	E96	E144	E88	E131

Girder Ratings for Compression Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.06%	14.29%	45.3	E68	E102	E89	E133	E81	E121
35	0.80	31.06%	14.29%	45.3	E68	E102	E89	E133	E81	E121
30	0.71	27.65%	14.29%	41.9	E70	E105	E91	E136	E83	E124
25	0.61	23.61%	14.29%	37.9	E72	E108	E94	E140	E86	E128
20	0.49	18.95%	14.29%	33.2	E75	E111	E97	E145	E89	E132
15	0.35	13.67%	14.29%	28.0	E78	E116	E101	E151	E92	E138
10	0.20	7.77%	14.29%	22.1	E82	E122	E106	E158	E97	E144

Girder Ratings for Shear Stress

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.06%	14.29%	45.3	E111	E193	E111	E193	E126	E219
35	0.80	31.06%	14.29%	45.3	E111	E193	E111	E193	E126	E219
30	0.71	27.65%	14.29%	41.9	E113	E197	E113	E197	E129	E224
25	0.61	23.61%	14.29%	37.9	E117	E203	E117	E203	E133	E231
20	0.49	18.95%	14.29%	33.2	E121	E210	E121	E210	E137	E239
15	0.35	13.67%	14.29%	28.0	E126	E219	E126	E219	E143	E249
10	0.20	7.77%	14.29%	22.1	E132	E230	E132	E230	E150	E261

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E62	E81	E74
Maximum	E93	E121	E110

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

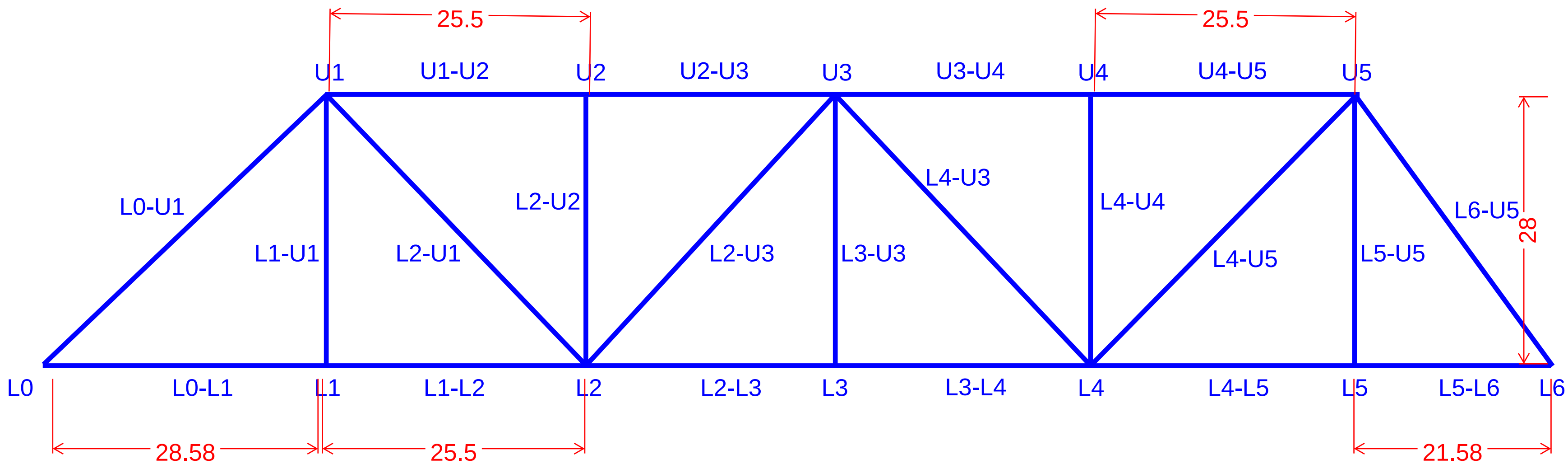
Governing Ratings including E-80 Equivalents for 286k and 315k loads

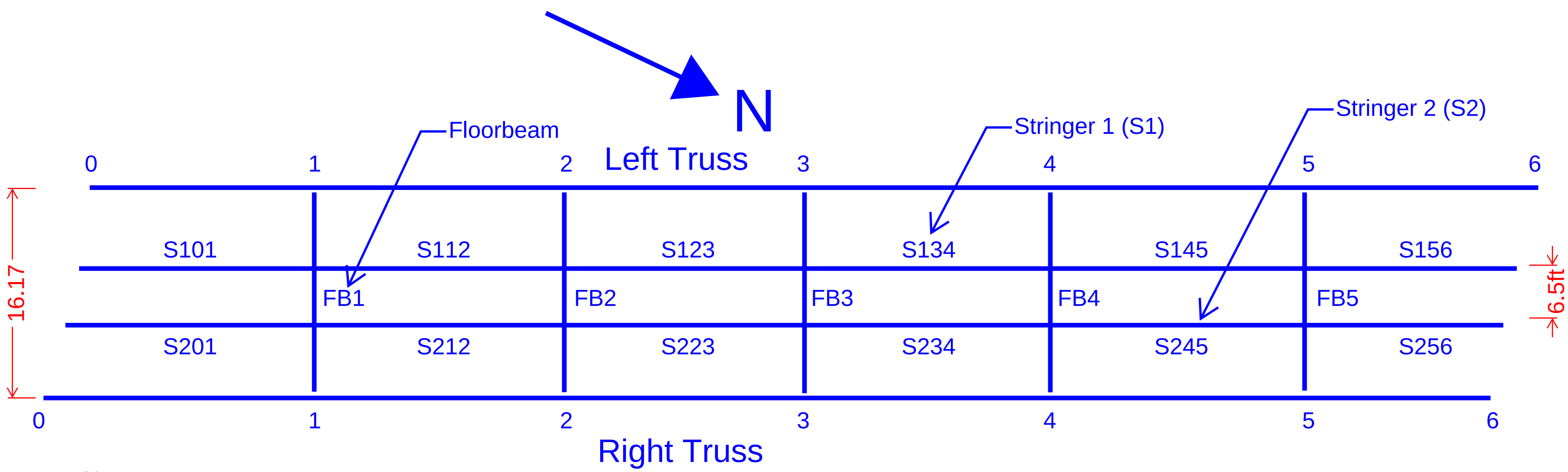
Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E62	E62	E67
Maximum	E93	-	-

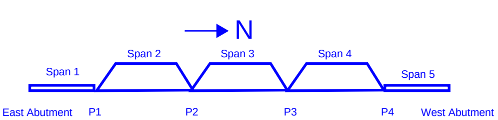
TRUSS RATING FOR SPAN 3

MIDAS MODEL INPUTS:
GEOMETRY & LOADING

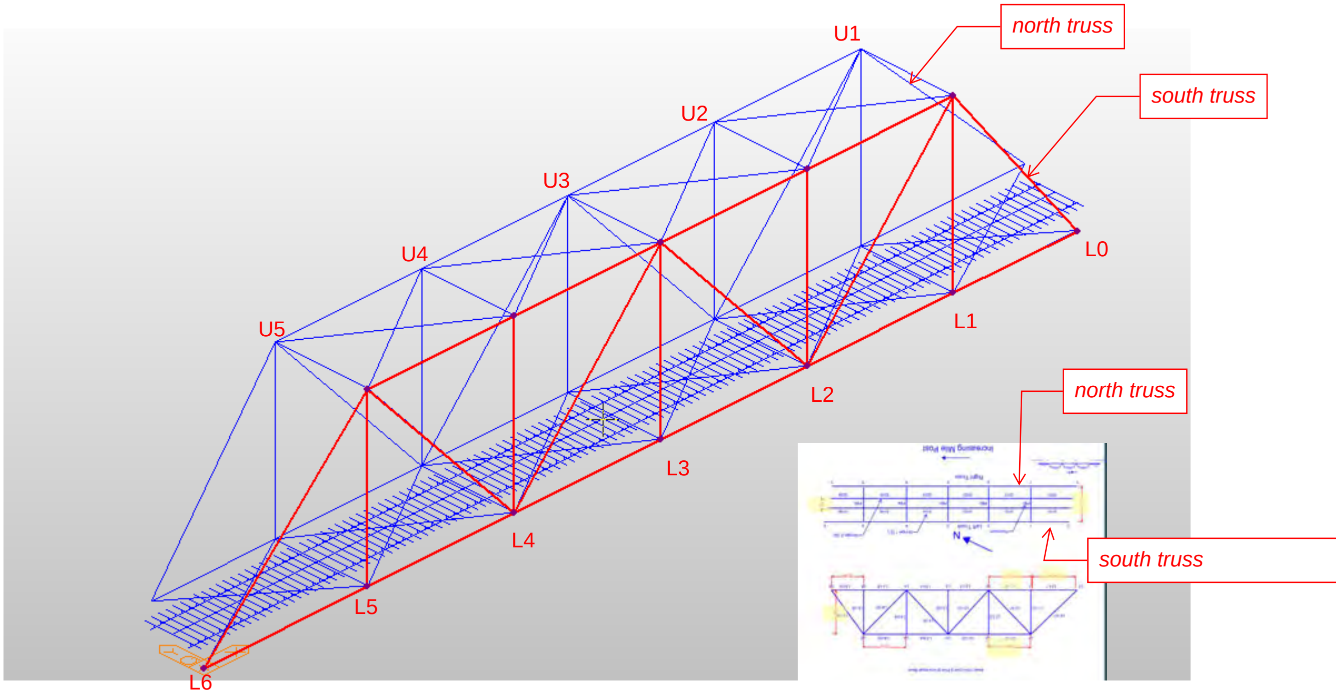
Asset 5104 Over S Fork Shenandoah River
(Span 3)



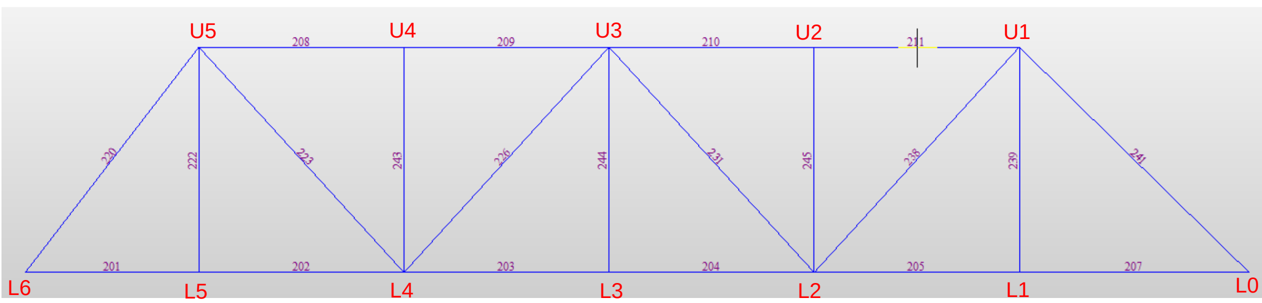




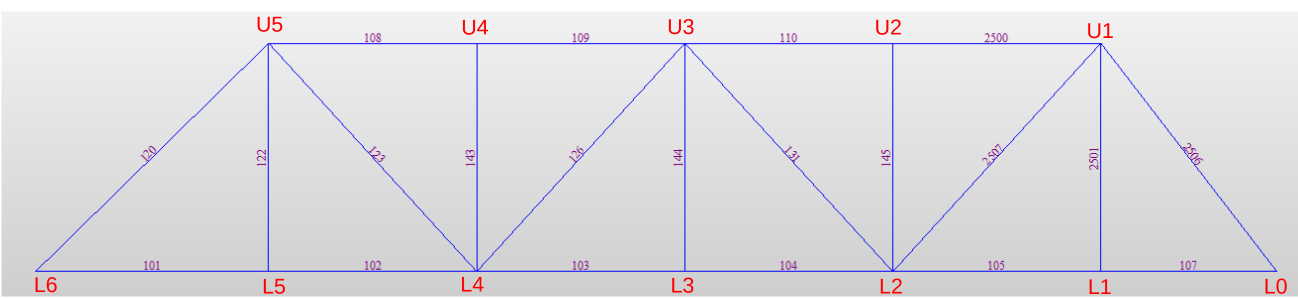
Increasing Mile Post



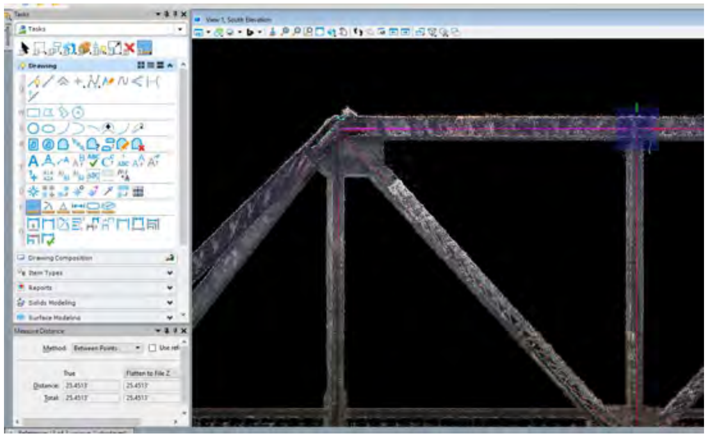
NORTH TRUSS MEMBER NUMBERING

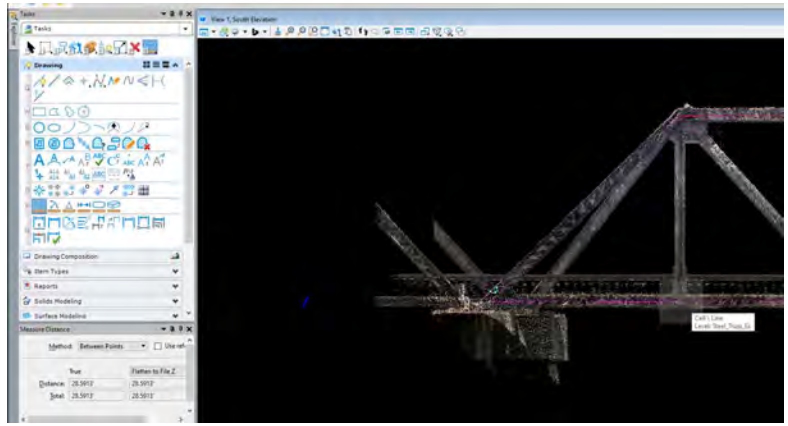


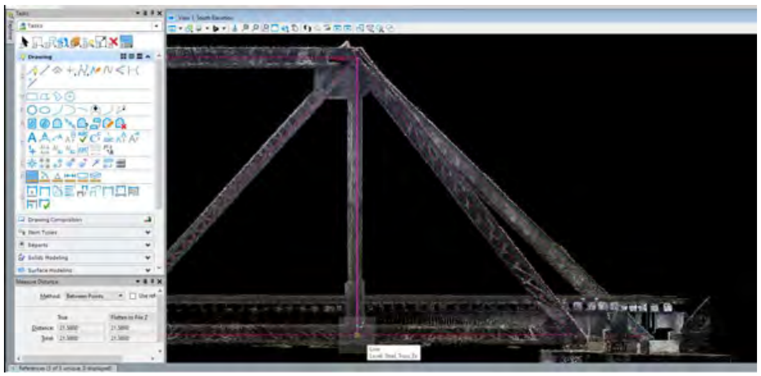
SOUTH TRUSS MEMBER NUMBERING

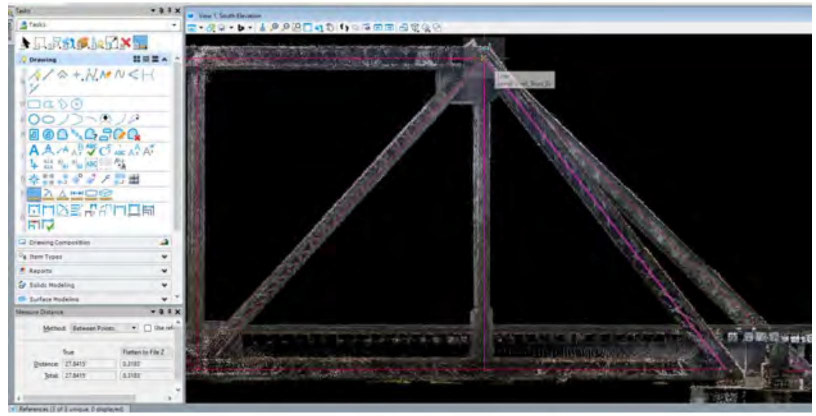


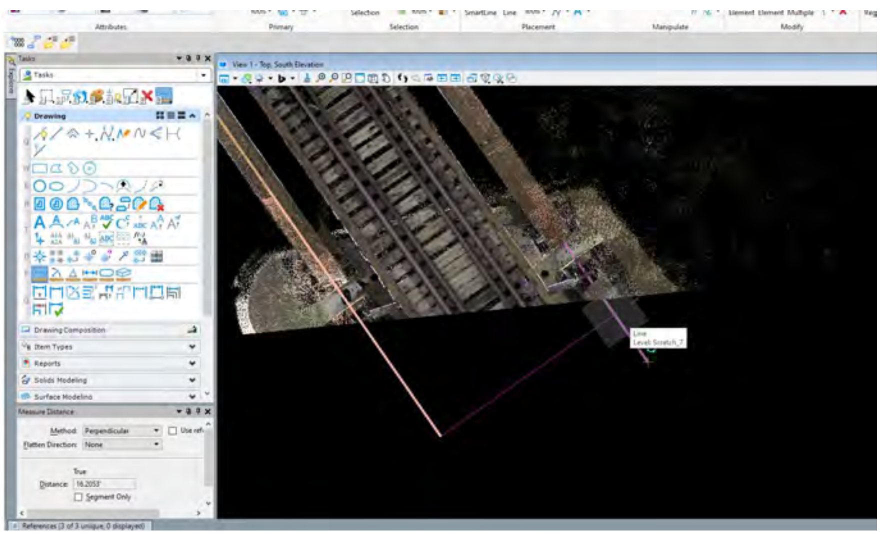
By: DS
Chk: JBT 3/20/2025

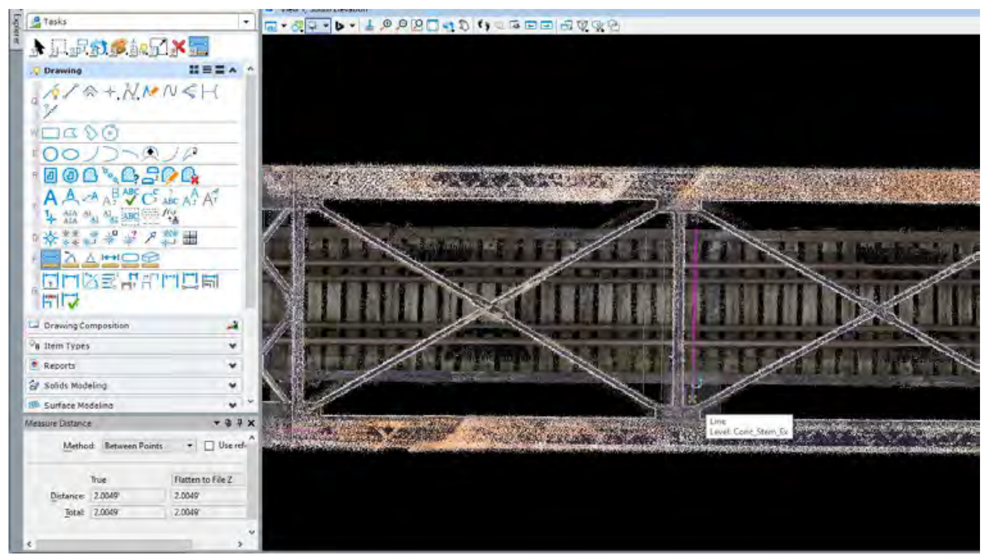






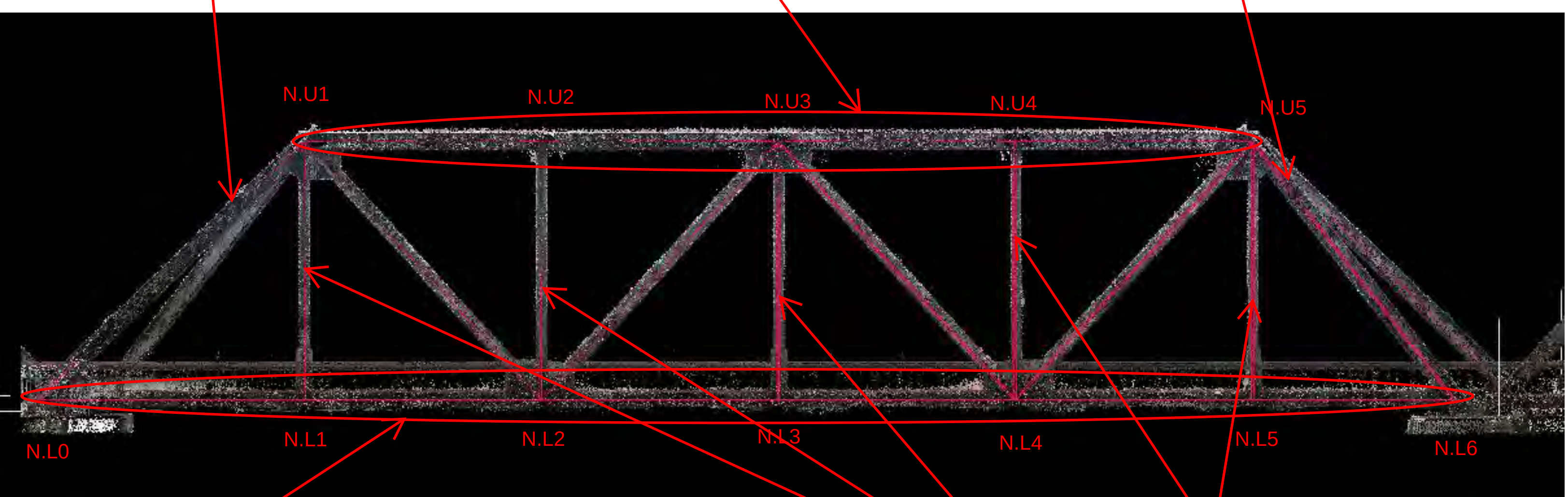






SPAN 3

BUILT-UP BOX WITH
COVER PLATE (END
POST AND TOP
CHORD



BOX

I-SHAPE LACED WEB

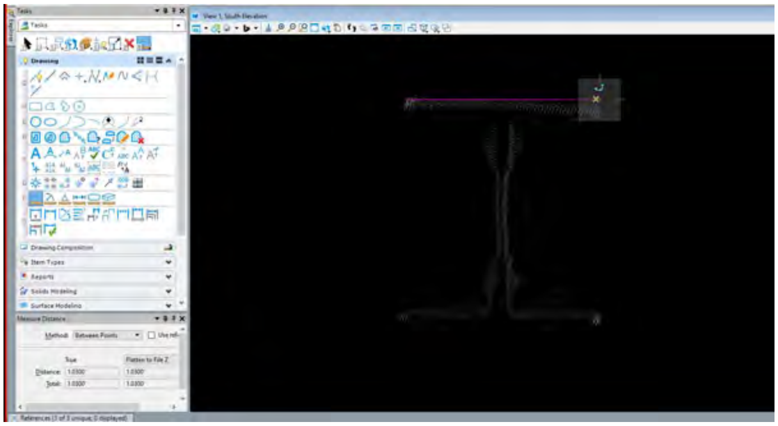
BOX

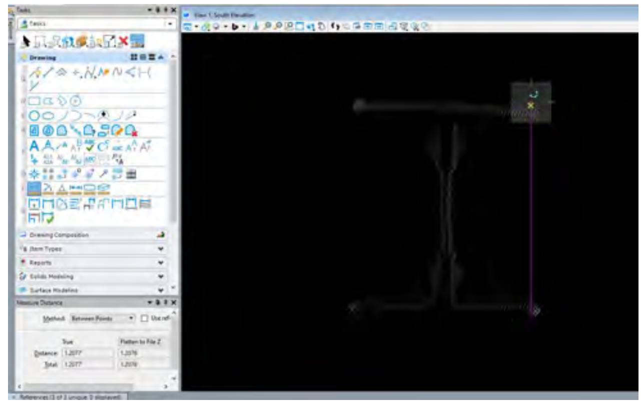
I-SHAPE LACED WEB

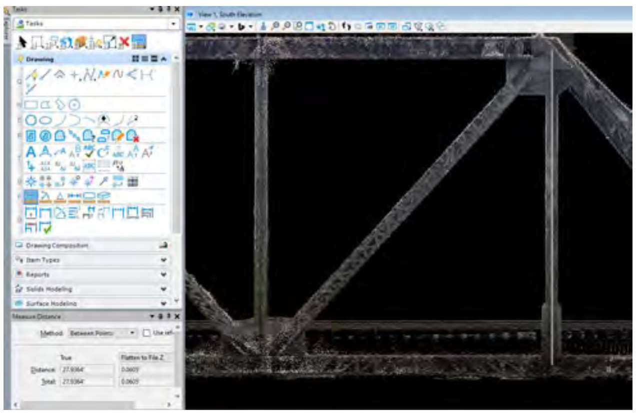
BUILT-UP BOX WITH
COVER PLATE (END
POST AND TOP
CHORD

BOX

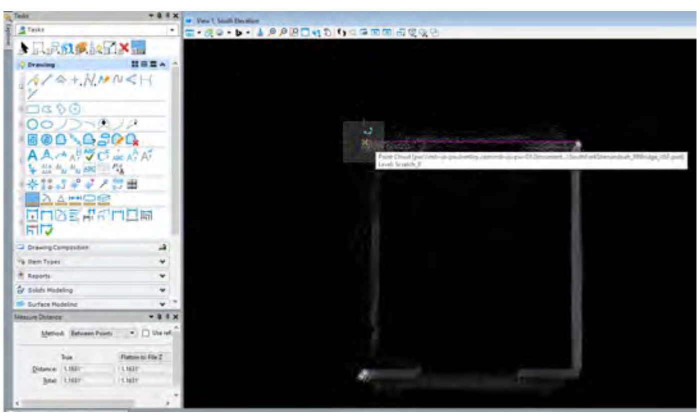
Vertical S.L4-UL4 (TYP.)

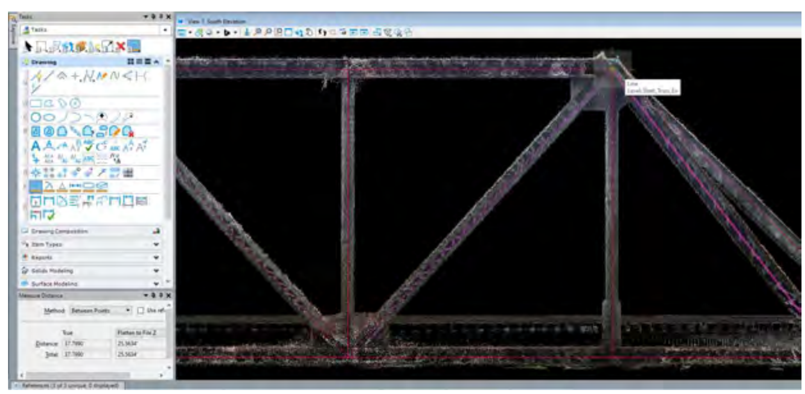


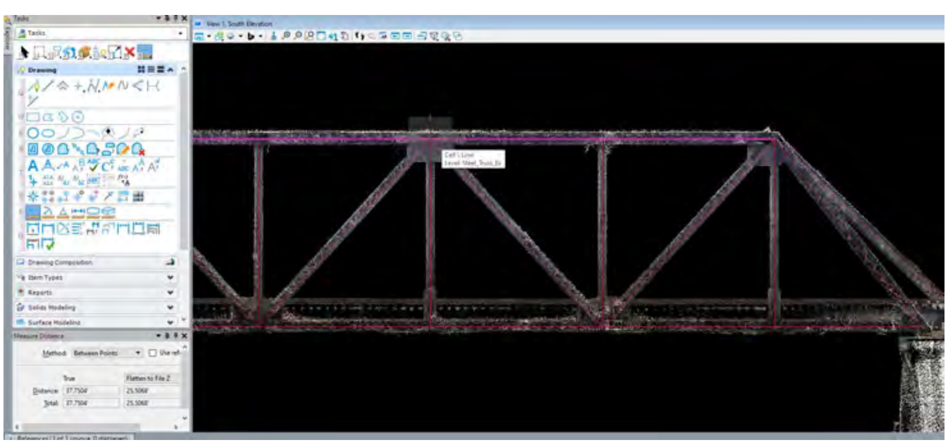




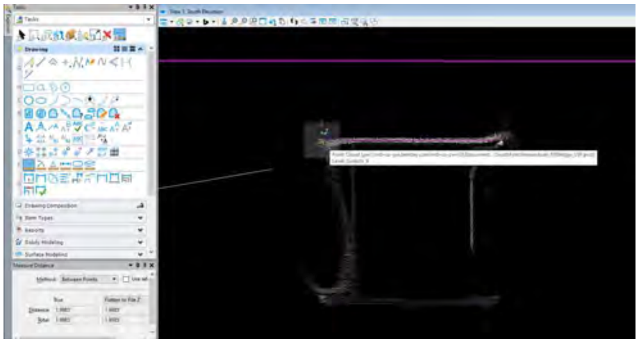
Diagonals S.L4-UL3 (TYP.)

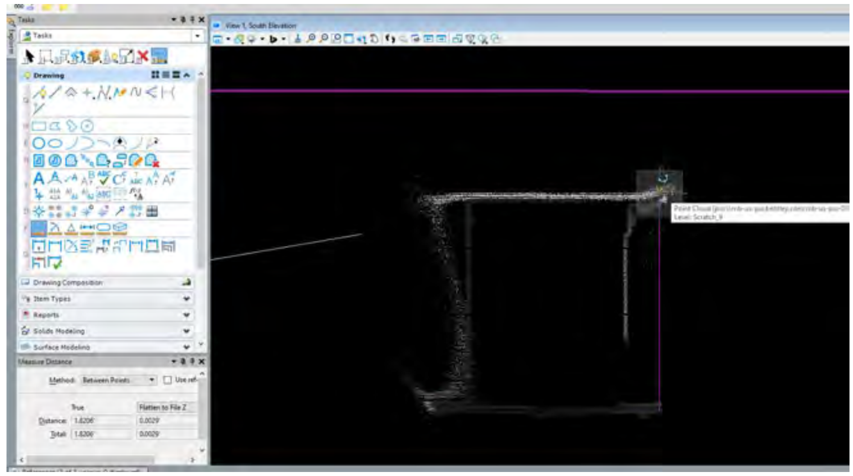




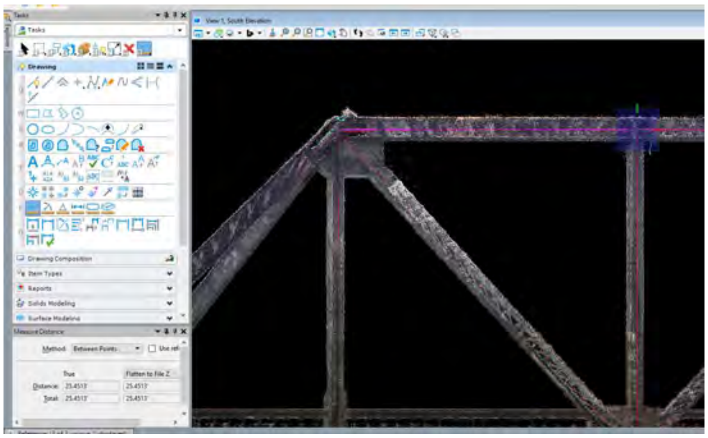


End Post and Top Chord S.L6-UL5 & SU5 - SU4

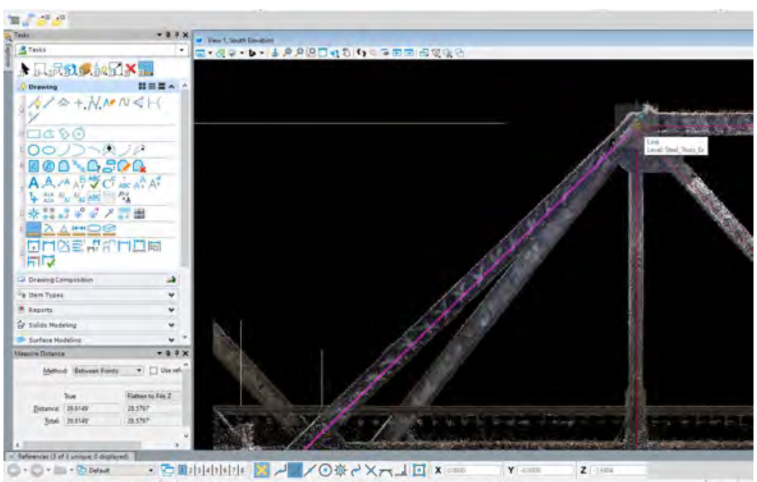




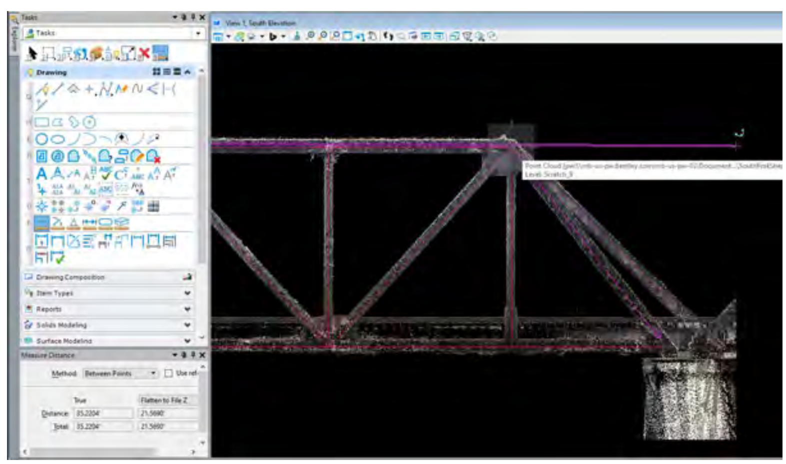
Top Chord SU5 - SU4 & End Post SL6 - SU5



Top Chord Length



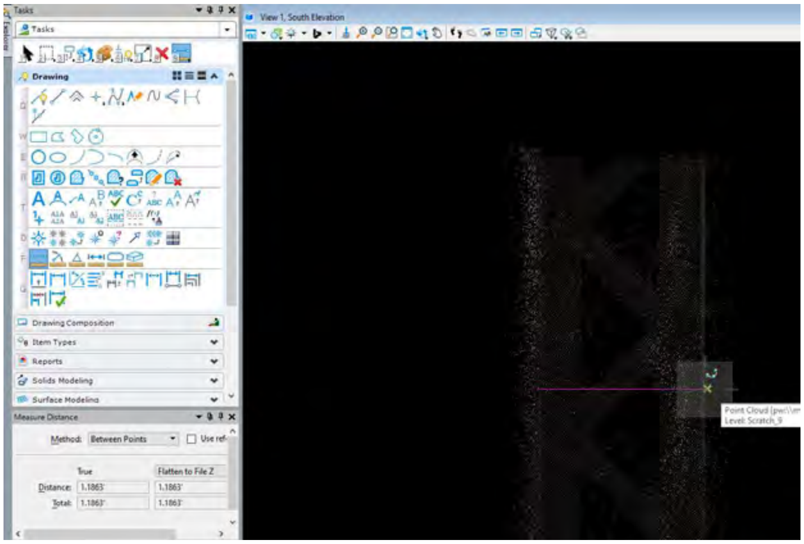
L0-U1 Length

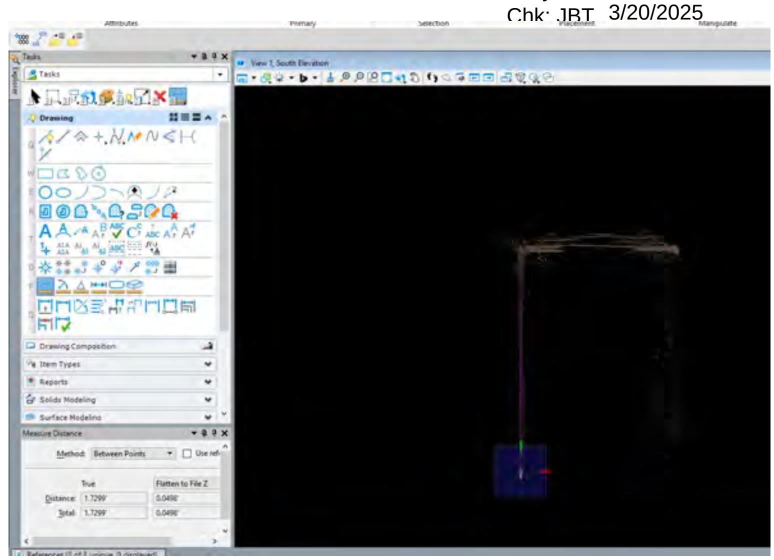


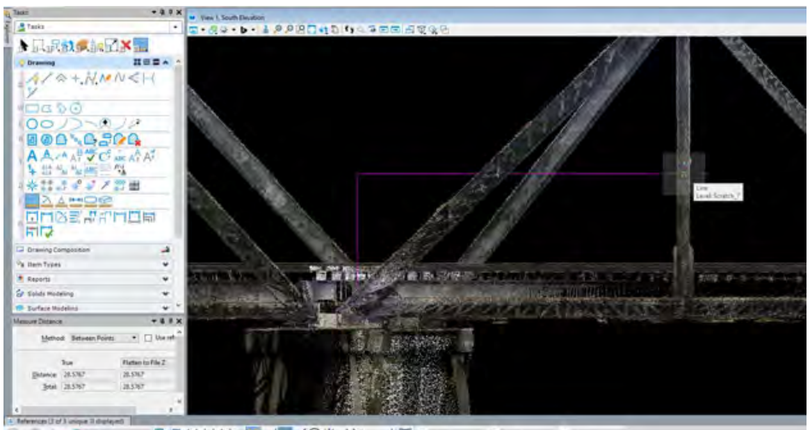
L6-U5 Length

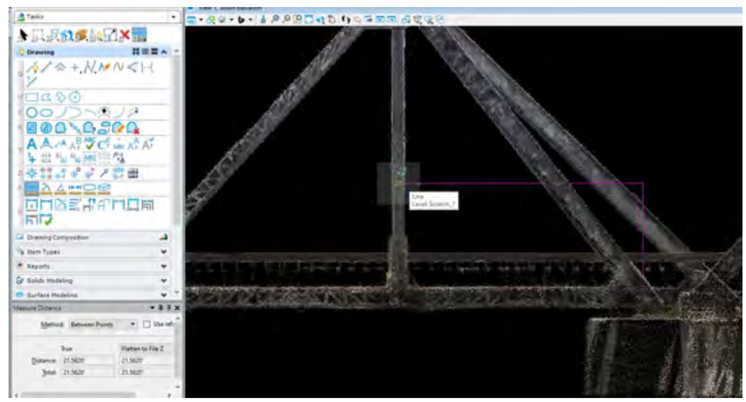
Bottom Chord SL0-SL1

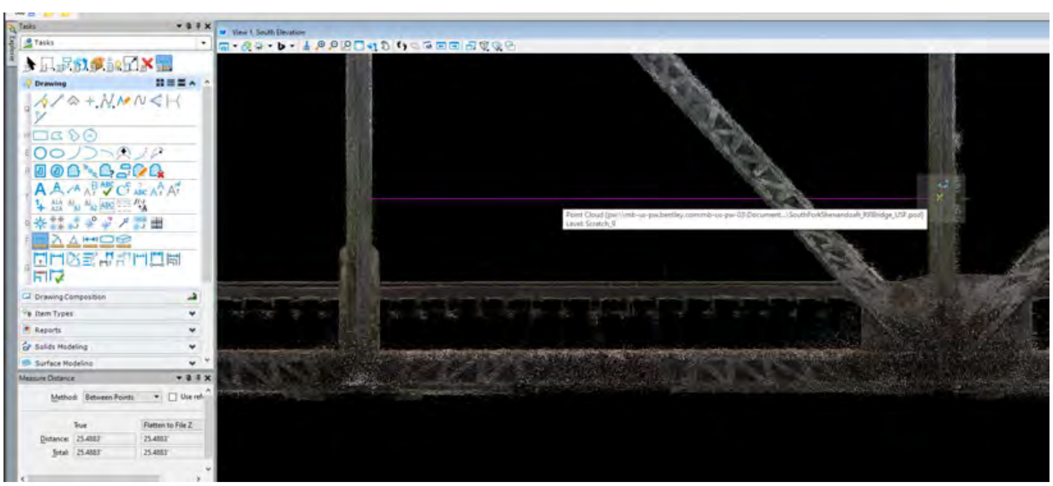
By: DS
Chk: JBT 3/20/2025





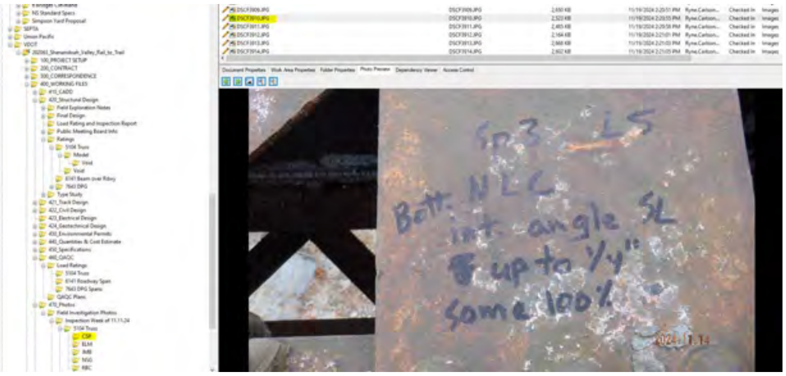


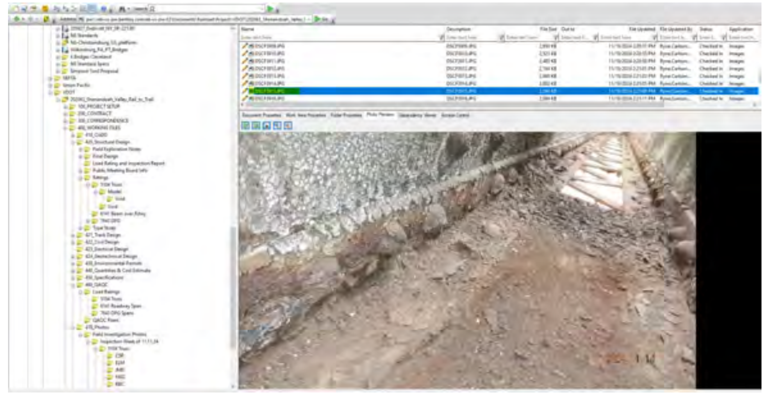




SPAN 3 SECTION LOSS

By: DS
Chk: JBT 3/20/2025

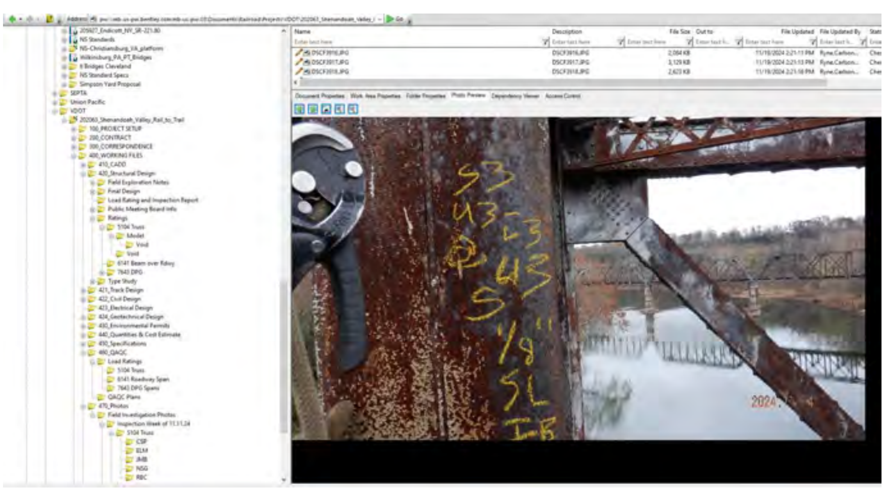


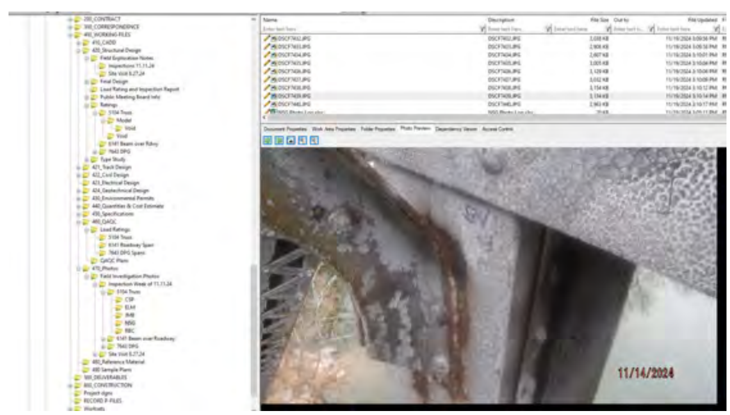


Note: per photos, loss coincident with bottom chord section with batten plate. Batten not accounted for in section properties evaluation. Apply loss to angle leg of 1/16" to capture some loss potentially occurring at sections away from the batten plate.

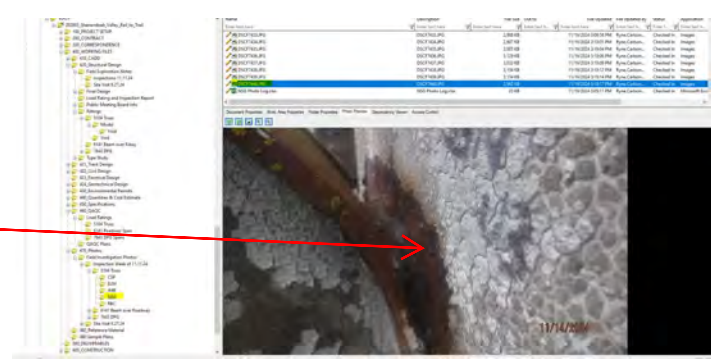
SPAN 3 BOTTOM CHORD

SPAN 3 VERTICALS





CALLED OUT AS 1/4" DEPTH, MINOR SECTION LOSS AT KNEE BRACE, SAY 1/8"



PROJECT : *VDOT Shenandoah Valley Load Ratings*		Michael Baker INTERNATIONAL
TASK : *Span 3 Truss Rating*	PROJECT NO : *202063*	
SUBJECT :		
CALCULATED BY : *DS* DATE : *3/20/2025*	CHECKED BY : JBT	DATE : 3/20/2025

MEMBER PROPERTIES

*Note: list "Eyebar" in this column if eyebar exists in order for spreadsheet to use correct allowable stress factor

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Member	**Start Joint**	**End Joint**	**Section Number**	**Section Type***	**Material Specification**	**Fy [ksi]**	**Fu [ksi]**	**E [ksi]**	**Unbraced Length X [ft]**	**Unbraced Length Y [ft]**	**Description**	**Include Bending?**	**Include Compr.?**
Bottom Chord	S.L0-S.L1	**S.L0**	**S.L1**	107	Built-Up Box	**Steel**	**30**	**60**	**29000**	21.58	21.58	Bottom Chord	**no**	**no**
	S.L1-S.L2	**S.L1**	**S.L2**	105	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	S.L2-S.L3	**S.L2**	**S.L3**	104	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	S.L3-S.L4	**S.L3**	**S.L4**	103	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	S.L4-S.L5	**S.L4**	**S.L5**	102	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	S.L5-S.L6	**S.L5**	**S.L6**	101	Built-Up Box	**Steel**	**30**	**60**	**29000**	28.61	28.61	Bottom Chord	**no**	**no**
	N.L0-N.L1	**N.L0**	**N.L1**	207	Built-Up Box	**Steel**	**30**	**60**	**29000**	28.61	28.61	Bottom Chord	**no**	**no**
	N.L1-N.L2	**N.L1**	**N.L2**	205	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	N.L2-N.L3	**N.L2**	**N.L3**	204	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	N.L3-N.L4	**N.L3**	**N.L4**	203	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	N.L4-N.L5	**N.L4**	**N.L5**	202	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	Bottom Chord	**no**	**no**
	N.L5-N.L6	**N.L5**	**N.L6**	201	Built-Up Box	**Steel**	**30**	**60**	**29000**	21.58	21.58	Bottom Chord	**no**	**no**
Verticals	S.L1-S.U1	**S.L1**	**S.U1**	2501	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	S.L2-S.U2	**S.L2**	**S.U2**	145	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	S.L3-S.U3	**S.L3**	**S.U3**	144	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	S.L4-S.U4	**S.L4**	**S.U4**	143	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	S.L5-S.U5	**S.L5**	**S.U5**	122	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	N.L1-N.U1	**N.L1**	**N.U1**	239	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	N.L2-N.U2	**N.L2**	**N.U2**	245	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	N.L3-N.U3	**N.L3**	**N.U3**	244	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	N.L4-N.U4	**N.L4**	**N.U4**	243	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
	N.L5-N.U5	**N.L5**	**N.U5**	222	I-Shape	**Steel**	**30**	**60**	**29000**	27.94	27.94	Verticals	**no**	**yes**
Internal Diagonals	S.L2-S.U1	**S.L2**	**S.U1**	2507	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	S.L2-S.U3	**S.L2**	**S.U3**	131	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	S.L4-S.U3	**S.L4**	**S.U3**	126	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	S.L4-S.U5	**S.L4**	**S.U5**	123	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	N.L2-N.U1	**N.L2**	**N.U1**	238	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	N.L2-N.U3	**N.L2**	**N.U3**	231	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	N.L4-N.U3	**N.L4**	**N.U3**	226	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
	N.L4-N.U5	**N.L4**	**N.U5**	223	Box	**Steel**	**30**	**60**	**29000**	37.80	37.80	Internal Diagonals	**no**	**yes**
End Posts & Top Chords	S.L0-S.U1	**S.L0**	**S.U1**	2506	Built-Up Box	**Steel**	**30**	**60**	**29000**	35.22	35.22	End Posts & Top Chords	**no**	**yes**
	S.U1-S.U2	**S.U1**	**S.U2**	108to2500	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	S.U2-S.U3	**S.U2**	**S.U3**	108to2500	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	S.U3-S.U4	**S.U3**	**S.U4**	108to2500	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	S.U4-S.U5	**S.U4**	**S.U5**	108to2500	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	S.L6-S.U5	**S.L6**	**S.U5**	120	Built-Up Box	**Steel**	**30**	**60**	**29000**	39.90	39.90	End Posts & Top Chords	**no**	**yes**
	N.L0-N.U1	**N.L0**	**N.U1**	241	Built-Up Box	**Steel**	**30**	**60**	**29000**	39.90	39.90	End Posts & Top Chords	**no**	**yes**
	N.U1-N.U2	**N.U1**	**N.U2**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	N.U2-N.U3	**N.U2**	**N.U3**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	N.U3-N.U4	**N.U3**	**N.U4**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	N.U4-N.U5	**N.U4**	**N.U5**	208to211	Built-Up Box	**Steel**	**30**	**60**	**29000**	25.50	25.50	End Posts & Top Chords	**no**	**yes**
	N.L6-N.U5	**N.L6**	**N.U5**	220	Built-Up Box	**Steel**	**30**	**60**	**29000**	35.22	35.22	End Posts & Top Chords	**no**	**yes**

SECTION DETAILS

					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
								TOP COVERPLATE (HP1)						TOP ANGLES (A1 & A2)										
SPAN 3	Member	Start Joint	End Joint	Model Membr No.	Section Number	Section Type*	NOTES	W	W.SL	T	T.SL	*dW (in)*	*dT (in)*	HLEG	HLEG.SL	VLEG	VLEG.SL	T	THLEG.SL	TVLEG.SL	*d.HLEG*	*d.VLEG*	*d.THLEG*	*d.TVLEG*
Bottom Chord	S.L0-S.L1	S.L0	S.L1	107	107	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	S.L1-S.L2	S.L1	S.L2	105	105	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	S.L2-S.L3	S.L2	S.L3	104	104	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	S.L3-S.L4	S.L3	S.L4	103	103	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	S.L4-S.L5	S.L4	S.L5	102	102	Built-Up Box						0	0	3.5		3.5		0.38	0.0625		3.5	3.5	0.3175	0.38
	S.L5-S.L6	S.L5	S.L6	101	101	Built-Up Box						0	0	3.5		3.5		0.38	0.0625		3.5	3.5	0.3175	0.38
	N.L0-N.L1	N.L0	N.L1	207	207	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	N.L1-N.L2	N.L1	N.L2	205	205	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	N.L2-N.L3	N.L2	N.L3	204	204	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	N.L3-N.L4	N.L3	N.L4	203	203	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	N.L4-N.L5	N.L4	N.L5	202	202	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
	N.L5-N.L6	N.L5	N.L6	201	201	Built-Up Box						0	0	3.5		3.5		0.38			3.5	3.5	0.38	0.38
Verticals	S.L1-S.U1	S.L1	S.U1	2501	2501	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	S.L2-S.U2	S.L2	S.U2	145	145	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	S.L3-S.U3	S.L3	S.U3	144	144	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	S.L4-S.U4	S.L4	S.U4	143	143	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	S.L5-S.U5	S.L5	S.U5	122	122	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	N.L1-N.U1	N.L1	N.U1	239	239	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	N.L2-N.U2	N.L2	N.U2	245	245	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	N.L3-N.U3	N.L3	N.U3	244	244	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	N.L4-N.U4	N.L4	N.U4	243	243	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
	N.L5-N.U5	N.L5	N.U5	222	222	I-Shape						0	0	6		4		0.37	0.125		6	4	0.245	0.37
Internal Diagonals	S.L2-S.U1	S.L2	S.U1	2507	2507	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	S.L2-S.U3	S.L2	S.U3	131	131	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	S.L4-S.U3	S.L4	S.U3	126	126	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	S.L4-S.U5	S.L4	S.U5	123	123	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	N.L2-N.U1	N.L2	N.U1	238	238	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	N.L2-N.U3	N.L2	N.U3	231	231	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	N.L4-N.U3	N.L4	N.U3	226	226	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
	N.L4-N.U5	N.L4	N.U5	223	223	Box						0	0	3.75		1		0.62		-0.082	3.75	1	0.62	0.702
End Posts & Top Chords	S.L0-S.U1	S.L0	S.U1	2506	2506	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	S.U1-S.U2	S.U1	S.U2	2500	108to2500	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	S.U2-S.U3	S.U2	S.U3	110	108to2500	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	S.U3-S.U4	S.U3	S.U4	109	108to2500	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	S.U4-S.U5	S.U4	S.U5	108	108to2500	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	S.L6-S.U5	S.L6	S.U5	120	120	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.L0-N.U1	N.L0	N.U1	241	241	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.U1-N.U2	N.U1	N.U2	211	208to211	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.U2-N.U3	N.U2	N.U3	210	208to211	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.U3-N.U4	N.U3	N.U4	209	208to211	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.U4-N.U5	N.U4	N.U5	208	208to211	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48
	N.L6-N.U5	N.L6	N.U5	220	220	Built-Up Box		24		0.44		24	0.44	3.5		3.5		0.48			3.5	3.5	0.48	0.48

		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
		EXT WEB PLATES (VP1 & VP2)		EXT WEB CP (VCP4 & VCP5)		INT WEB PLATE (VP3)		BOTTOM ANGLES (A3 & A4)											BOT COVERPLATE (HP2)						NT LACING (FYI Only, Not USED		
SPAN 3	Member	*d.W*	*d.T*	*d.W*	*d.T*	*d.W*	*d.T*	HLEG	HLEG.SL	VLEG	VLEG.SL	T	THLEG.SL	TVLEG.SL	*d.HLEG*	*d.VLEG*	*d.THLEG*	*d.HLEG*	W	W.SL	T	T.SL	*dW*	*dT*	*dW*	*dT*	X OR Z
Bottom Chord	S.L0-S.L1	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	S.L1-S.L2	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	S.L2-S.L3	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	S.L3-S.L4	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	S.L4-S.L5	20	0.45					3.5	0	3.5	0	0.38	0.0625	0	3.5	3.5	0.3175	0.38	0	0	0	0	0	0			
	S.L5-S.L6	20	0.45					3.5	0	3.5	0	0.38	0.0625	0	3.5	3.5	0.3175	0.38	0	0	0	0	0	0			
	N.L0-N.L1	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L1-N.L2	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L2-N.L3	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L3-N.L4	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L4-N.L5	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
	N.L5-N.L6	20	0.45					3.5	0	3.5	0	0.38	0	0	3.5	3.5	0.38	0.38	0	0	0	0	0	0			
Verticals	S.L1-S.U1					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	S.L2-S.U2					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	S.L3-S.U3					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	S.L4-S.U4					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	S.L5-S.U5					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	N.L1-N.U1					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	N.L2-N.U2					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	N.L3-N.U3					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	N.L4-N.U4					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
	N.L5-N.U5					13.75	0.375	6		4		0.37	0.125		6	4	0.245	0.37	0	0	0	0	0	0			
Internal Diagonals	S.L2-S.U1			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	S.L2-S.U3			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	S.L4-S.U3			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	S.L4-S.U5			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	N.L2-N.U1			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	N.L2-N.U3			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	N.L4-N.U3			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
	N.L4-N.U5			13	0.702			3.75	0	1	0	0.62	0	-0.082	3.75	1	0.62	0.702	0	0	0	0	0	0			
End Posts & Top Chords	S.L0-S.U1	20.5	0.5					3.5		3.5		0.48	0		3.5	3.5	0.48	0.48	0		0		0	0			
	S.U1-S.U2	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	S.U2-S.U3	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	S.U3-S.U4	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	S.U4-S.U5	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	S.L6-S.U5	20.5	0.5					3.5		3.5		0.48	0		3.5	3.5	0.48	0.48	0		0		0	0			
	N.L0-N.U1	20.5	0.5					3.5		3.5		0.48	0		3.5	3.5	0.48	0.48	0		0		0	0			
	N.U1-N.U2	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	N.U2-N.U3	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	N.U3-N.U4	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	N.U4-N.U5	20.5	0.5					3.5		3.5		0.48	0	0	3.5	3.5	0.48	0.48	0		0		0	0			
	N.L6-N.U5	20.5	0.5					3.5		3.5		0.48	0		3.5	3.5	0.48	0.48	0		0		0	0			

		47	48	49
		BOT LACING (FYI Only, Not USED)		
SPAN 3	Member	dW	dT	X OR Z
Bottom Chord	S.L0-S.L1			
	S.L1-S.L2			
	S.L2-S.L3			
	S.L3-S.L4			
	S.L4-S.L5			
	S.L5-S.L6			
	N.L0-N.L1			
	N.L1-N.L2			
	N.L2-N.L3			
	N.L3-N.L4			
	N.L4-N.L5			
	N.L5-N.L6			
Verticals	S.L1-S.U1			
	S.L2-S.U2			
	S.L3-S.U3			
	S.L4-S.U4			
	S.L5-S.U5			
	N.L1-N.U1			
	N.L2-N.U2			
	N.L3-N.U3			
	N.L4-N.U4			
	N.L5-N.U5			
Internal Diagonals	S.L2-S.U1			
	S.L2-S.U3			
	S.L4-S.U3			
	S.L4-S.U5			
	N.L2-N.U1			
	N.L2-N.U3			
	N.L4-N.U3			
	N.L4-N.U5			
End Posts & Top Chords	S.L0-S.U1			
	S.U1-S.U2			
	S.U2-S.U3			
	S.U3-S.U4			
	S.U4-S.U5			
	S.L6-S.U5			
	N.L0-N.U1			
	N.U1-N.U2			
	N.U2-N.U3			
	N.U3-N.U4			
	N.U4-N.U5			
	N.L6-N.U5			

		50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
					HP1		HP2		VP1		VP2		VP3		VCP4		VCP5		A1 (Horiz. Leg)		A1 (Vert. Leg)		A2 (Horiz. Leg)		A2 (Vert. Leg)		A3 (Horiz. Leg)		A3 (Vert. Leg)		A4 (Horiz. Leg)		A4 (Vert. Leg)	
SPAN 3	Member	OTO.x	OTO.y	L (ft)	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.	No. Holes	Hole Dia.
Bottom Chord	S.L0-S.L1	14.25	20.75	21.58					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L1-S.L2	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L2-S.L3	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L3-S.L4	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L4-S.L5	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L5-S.L6	14.25	20.75	28.61					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L0-N.L1	14.25	20.75	28.61					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L1-N.L2	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L2-N.L3	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L3-N.L4	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L4-N.L5	14.25	20.75	25.5					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L5-N.L6	14.25	20.75	21.58					2	0.9375	2	0.9375									1	0.9375			1	0.9375			1	0.9375			1	0.9375
Verticals	S.L1-S.U1	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L2-S.U2	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L3-S.U3	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L4-S.U4	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	S.L5-S.U5	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L1-N.U1	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L2-N.U2	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L3-N.U3	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L4-N.U4	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
	N.L5-N.U5	12.4	13.75	27.94									2	0.9375							1	0.9375			1	0.9375			1	0.9375			1	0.9375
Internal Diagonals	S.L2-S.U1	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L2-S.U3	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L4-S.U3	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	S.L4-S.U5	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L2-N.U1	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L2-N.U3	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L4-N.U3	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
	N.L4-N.U5	14.125	15	37.8															1	0.9375			1	0.9375			1	0.9375			1	0.9375		
End Posts & Top Chords	S.L0-S.U1	24	20.94	35.22	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U1-S.U2	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U2-S.U3	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U3-S.U4	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.U4-S.U5	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	S.L6-S.U5	24	20.94	39.9	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L0-N.U1	24	20.94	39.9	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U1-N.U2	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U2-N.U3	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U3-N.U4	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.U4-N.U5	24	20.94	25.5	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375
	N.L6-N.U5	24	20.94	35.22	2	0.9375			2	0.9375	2	0.9375							1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375	1	0.9375

PROJECT :	Asset 5104 Span 3				
TASK :	Bridge Loads for Truss Model	PROJECT NO :			
SUBJECT :					
CALCULATED BY :	DS	DATE : 03/05/25	CHECKED BY :	JBT	DATE : 03/05/25

Michael Baker INTERNATIONAL

-These loads are calculated for the 3D Midas model being used to determine axial forces and overall superstructure deformations

-Inspection notes and LIDAR scan are used for dimensions and geometry

-Design Live Load is Cooper E80 and 286K

Rail Gauge:	5.00	ft
Superelevation:	0.00	in (see track chart)
Degree of Curvature:	0.00	degrees (see track chart)
Span Length:	152	ft (each truss length)
Upper Chord	1.82	ft
End Diagonal	1.82	ft
Lower Chord	1.73	ft
Diagonals	1.25	ft
Vertical	1.03	ft
Top of Rail to T/Girder:	1.50	ft (tie + rail height)
Truss Spacing:	16.17	ft
Tie Height:	10.00	in (see attached snips in excel file)
Tie Width:	10.00	in (see attached snips in excel file)
Tie Length:	10.00	ft (see attached snips in excel file)
Tie Spacing:	1.25	ft (see attached snips in excel file)
Grating Wt:	0.00	lb/ft
Handrail Wt:	0.00	lb/ft
Heaviest E80 Axle:	80.00	k
Heaviest 286k Axle:	71.50	k

Dead Loads Computation

Track:	0.20	klf (Apply to CL track)
Walkway:	0.00	klf
Self Weight Factor:	1.15	(accounts for steel connections, miscellaneous timber)

15-7.3.2.5 Wind Forces on Loaded Bridge:

Trans. Wind on Train:	0.200	klf (Apply to CL track, 8' above deck, transverse)
Vind on Upper Chord Members:	0.036	klf (Apply to flange, transverse)
Vind on End Diagonal Members:	0.036	klf (Apply to flange, transverse)
Vind on Lower Chord Members:	0.035	klf (Apply to flange, transverse)
ıs. Wind on Diagonals Members:	0.025	klf (Apply to flange, transverse)
ans. Wind on Vertical Members:	0.021	klf (Apply to flange, transverse)

15-1.3.9 Lateral Forces from Equipment:

E80 Equipment Force:	20.00	k (Apply transversly, at portal frames at CL track, each direction)
286k Equipment Force:	17.88	k (Apply transversly, at portal frames at CL track, each direction)

15-1.3.12 Longitudinal Forces:

Braking Force:	1.50	klf (Apply to CL track, 8' above deck, longitudinally)
Traction Force:	2.03	klf (Apply to CL track, 3' above deck, longitudinally)

TRUSS RATING FOR SPAN 3

RATING SUMMARY

PROJECT : *VDOT Shenandoah Valley Load Ratings*			
TASK : *Span 3 Truss Rating*		PROJECT NO : *202063*	
SUBJECT :			
CALCULATED BY : *DS*	DATE : *3/20/2025*	CHECKED BY : JBT	DATE : 3/20/2025

Michael Baker INTERNATIONAL

RATINGS SUMMARY

Truck Configuration	Bottom Chord - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Vertical - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	1.012	-	N/A	E-81	-	201	N.L5-N.L6	1.281	-	N/A	E-102	-	239	N.L1-N.U1
Cooper E-80 (Max)	1.550	-	N/A	E-124	-	201	N.L5-N.L6	1.914	-	N/A	E-153	-	239	N.L1-N.U1
286k AAR (Normal)	1.234	**0.82**	E-66	E-81	OK	201	N.L5-N.L6	1.802	**0.71**	E-57	E-102	OK	239	N.L1-N.U1
286k AAR (Max)	1.890	**0.82**	E-66	E-124	OK	201	N.L5-N.L6	2.692	**0.71**	E-57	E-153	OK	239	N.L1-N.U1

Truck Configuration	Diagonal - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Top Chord - Combined Compression and Bending Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	1.018	-	N/A	E-81	-	2507	S.L2-S.U1	1.012	-	N/A	E-81	-	241	N.L0-N.U1
Cooper E-80 (Max)	1.564	-	N/A	E-125	-	2507	S.L2-S.U1	1.373	-	N/A	E-110	-	241	N.L0-N.U1
286k AAR (Normal)	1.420	**0.72**	E-57	E-81	OK	2507	S.L2-S.U1	1.328	**0.76**	E-61	E-81	OK	241	N.L0-N.U1
286k AAR (Max)	2.180	**0.72**	E-57	E-125	OK	2507	S.L2-S.U1	1.803	**0.76**	E-61	E-110	OK	241	N.L0-N.U1

Speed: **35 mph**

Truck Configuration	Bottom Chord - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Vertical - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	1.090	-	N/A	E-87	-	201	N.L5-N.L6	1.427	-	N/A	E-114	-	239	N.L1-N.U1
Cooper E-80 (Max)	1.669	-	N/A	E-134	-	201	N.L5-N.L6	2.132	-	N/A	E-171	-	239	N.L1-N.U1
286k AAR (Normal)	1.321	**0.82**	E-66	E-87	OK	201	N.L5-N.L6	2.006	**0.71**	E-57	E-114	OK	239	N.L1-N.U1
286k AAR (Max)	2.023	**0.82**	E-66	E-134	OK	201	N.L5-N.L6	2.998	**0.71**	E-57	E-171	OK	239	N.L1-N.U1

Truck Configuration	Diagonal - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member	Top Chord - Axial Only Rating Factor	Ratio	Equiv.	Rating		Midas Element	Member
Cooper E-80 (Normal)	1.133	-	N/A	E-91	-	2507	S.L2-S.U1	1.126	-	N/A	E-90	-	241	N.L0-N.U1
Cooper E-80 (Max)	1.740	-	N/A	E-139	-	2507	S.L2-S.U1	1.528	-	N/A	E-122	-	241	N.L0-N.U1
286k AAR (Normal)	1.588	**0.71**	E-57	E-91	OK	2507	S.L2-S.U1	1.478	**0.76**	E-61	E-90	OK	241	N.L0-N.U1
286k AAR (Max)	2.438	**0.71**	E-57	E-139	OK	2507	S.L2-S.U1	2.006	**0.76**	E-61	E-122	OK	241	N.L0-N.U1

Speed: **10 mph**

TRUSS RATING FOR SPAN 3

RATING CALCULATIONS
for
CONTROLLING BOTTOM CHORD

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

TRUSS MEMBER LOAD FACTOR RATINGS

General Information

* Two load scenarios must be investigated. These are as follows:

1. Axial DL + Max Axial (LL + I)
2. Axial DL + Min Axial (LL + I)

Symbology

[ ] = required input

Load and P.O.I. Information

Load and P.O.I. Details:

Element ID:	**201**	
Section ID:	201	
Moving Load Case:	**Cooper E-80**	
Member:	N.L5-N.L6	
Include Bending?	**no**	Include Compression? **no**
$K_{normal\ rating}$ =	**0.55**	*(Gross Tension, AREMA Table 15-1-11)*
$K1_{normal\ rating}$ =	**0.47**	*(Net Tension, AREMA Table 15-1-11)*
$K_{max\ rating}$ =	**0.80**	*(AREMA 7.3.3.3)*
$K1_{max\ rating}$ =	**0.67**	*(AREMA 7.3.3.4)*

Applied Service Forces:

Span Length =	**152**	ft
Impact =	20.9%	
Speed =	**35**	mph
Impact reduction due to speed =	0.80	
Impact for Live Load (except Rocking Effect) =	16.7%	

		Axial			Bending			Shear	
Dead Load Force [Group I] =	P_{DL} =	**64.72**	**kips**	M_{DL} =	**0.00**	**kip-ft**	V_{DL} =	**0.00**	**kips**
Max Wind Load Force =	$P_{W,max}$ =	18.92	kips	$M_{W,max}$ =	0.00	kip-ft	$V_{W,max}$ =	0.00	kips
Min Wind Load Force =	$P_{W,min}$ =	-18.87	kips	$M_{W,min}$ =	0.00	kip-ft	$V_{W,min}$ =	0.00	kips
Dead + Wind Load Force [Group II] =	P_{DL+W} =	**83.64**	**kips**	M_{DL+W} =	**0.00**	**kip-ft**	V_{DL+W} =	**0.00**	**kips**
Max Live Load + Rocking Force =	$P_{LL,RE,max}$ =	265.00	kips	$M_{LL,RE,max}$ =	0.00	kip-ft	$V_{LL,RE,max}$ =	0.00	kips
Min Live Load + Rocking Force =	$P_{LL,RE,min}$ =	0.00	kips	$M_{LL,RE,min}$ =	0.00	kip-ft	$V_{LL,RE,min}$ =	0.00	kips
Max Rocking Only Plus Impact Force =	$P_{LL,RE+I,max}$ =	-13.65	kips	$M_{LL,RE+I,max}$ =	0.00	kip-ft	$V_{LL,RE+I,max}$ =	0.00	kips
Min Rocking Only Plus Impact Force =	$P_{LL,RE+I,min}$ =	0.00	kips	$M_{LL,RE+I,min}$ =	0.00	kip-ft	$V_{LL,RE+I,min}$ =	0.00	kips
Max Live Load (without Rocking) Force =	P_{LL} =	276.29	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Min Live Load (without Rocking) Force =	P_{LL} =	0.00	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Max Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	322.53	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Min Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	0.00	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Max LL+I Force [Group I] =	P_{LL+I} =	**322.53**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Min LL+I Force [Group I] =	P_{LL+I} =	**0.00**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Max LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**489.04**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**
Min LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**-166.51**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**

("+" = tens.; "-" = compr.)

Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 3 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

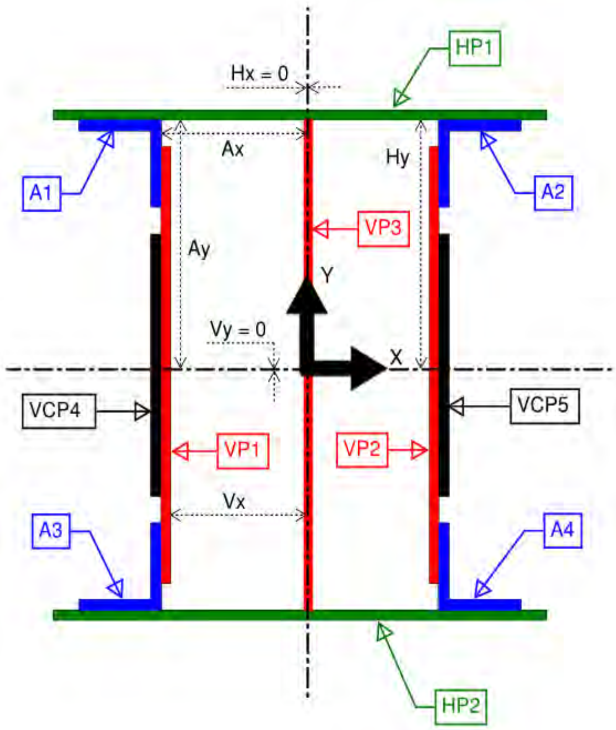
Material Properties:

Minimum Steel Yield Strength, F_y = 30 ksi

Minimum Steel Tensile Strength, F_u = 60 ksi

Modulus of Elasticity, E = 29000 ksi

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no	0	0	-	-	0	10.375	-	-	-	0	0
HP2	no	0	0	-	-	0	-10.375	-	-	-	0	0
VP1	yes	20	0.45	-3.175	0	-	-	-	-	-	2	0.9375
VP2	yes	20	0.45	3.175	0	-	-	-	-	-	2	0.9375
VP3	no	0	0	0	0	-	-	-	-	-	0	0
VCP4	no	0	0	-3.625	0	-	-	-	-	-	0	0
VCP5	no	0	0	3.625	0	-	-	-	-	-	0	0
A1 (Horiz. Leg)	yes	3.5	0.38	-	-	-	-	-	10.375	out	0	0
A1 (Vert. Leg)	yes	3.5	0.38	-	-	-	-	-3.625	-	out	1	0.9375
A2 (Horiz. Leg)	yes	3.5	0.38	-	-	-	-	-	10.375	out	0	0
A2 (Vert. Leg)	yes	3.5	0.38	-	-	-	-	3.625	-	out	1	0.9375
A3 (Horiz. Leg)	yes	3.5	0.38	-	-	-	-	-	-10.375	out	0	0
A3 (Vert. Leg)	yes	3.5	0.38	-	-	-	-	-3.625	-	out	1	0.9375
A4 (Horiz. Leg)	yes	3.5	0.38	-	-	-	-	-	-10.375	out	0	0
A4 (Vert. Leg)	yes	3.5	0.38	-	-	-	-	3.625	-	out	1	0.9375

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

X-X Axis Section Properties:

Total height of section (along y-y axis) = 20.75 in
Effective length factor, K_{x-x} = 0.875
Unbraced length, L_{x-x} = 21.58 ft

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	10.38	0.00	0.00	10.38	0.00	0.00		0.00
HP2	0.00	-10.38	0.00	0.00	-10.38	0.00	0.00		0.00
VP1	9.00	0.00	0.00	300.00	0.00	0.00	300.00		8.38
VP2	9.00	0.00	0.00	300.00	0.00	0.00	300.00		8.38
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
A1 (Horiz. Leg)	1.33	10.19	13.55	0.02	10.19	137.97	137.98		1.33
A1 (Vert. Leg)	1.19	8.44	10.00	0.96	8.44	84.35	85.32		0.92
A2 (Horiz. Leg)	1.33	10.19	13.55	0.02	10.19	137.97	137.98		1.33
A2 (Vert. Leg)	1.19	8.44	10.00	0.96	8.44	84.35	85.32		0.92
A3 (Horiz. Leg)	1.33	-10.19	-13.55	0.02	-10.19	137.97	137.98		1.33
A3 (Vert. Leg)	1.19	-8.44	-10.00	0.96	-8.44	84.35	85.32		0.92
A4 (Horiz. Leg)	1.33	-10.19	-13.55	0.02	-10.19	137.97	137.98		1.33
A4 (Vert. Leg)	1.19	-8.44	-10.00	0.96	-8.44	84.35	85.32		0.92
Σ	**28.06**		**0.00**	**603.91**		**889.28**	**1493.20**	**Σ**	**25.77**

y_{bar} =	0.00	in	c_{top}=	10.38	in
I_x =	1493	in^4	c_{bottom}=	10.38	in
A =	28.06	in^2	S_{top} =	143.92	in^3
r_x =	7.29	in	S_{bottom} =	143.92	in^3

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Y-Y Axis Section Properties:

Total width of section (along x-x axis) =	14.25	in
Effective length factor, $K_{y\text{-}y}$ =	0.875	
Unbraced length, $L_{y\text{-}y}$ =	21.58	ft

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	9.00	-3.40	-30.60	0.15	-3.40	104.04	104.19
VP2	9.00	3.40	30.60	0.15	3.40	104.04	104.19
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	-3.63	0.00	0.00	-3.63	0.00	0.00
VCP5	0.00	3.63	0.00	0.00	3.63	0.00	0.00
A1 (Horiz. Leg)	1.33	-5.38	-7.15	1.36	-5.38	38.42	39.78
A1 (Vert. Leg)	1.19	-3.82	-4.52	0.01	-3.82	17.26	17.27
A2 (Horiz. Leg)	1.33	5.38	7.15	1.36	5.38	38.42	39.78
A2 (Vert. Leg)	1.19	3.82	4.52	0.01	3.82	17.26	17.27
A3 (Horiz. Leg)	1.33	-5.38	-7.15	1.36	-5.38	38.42	39.78
A3 (Vert. Leg)	1.19	-3.82	-4.52	0.01	-3.82	17.26	17.27
A4 (Horiz. Leg)	1.33	5.38	7.15	1.36	5.38	38.42	39.78
A4 (Vert. Leg)	1.19	3.82	4.52	0.01	3.82	17.26	17.27
Σ	**28.06**		**0.00**	**5.79**		**430.80**	**436.59**

y_{bar} =	0.00	in	c_{left}=	7.13	in
I_y =	437	in^4	c_{left}=	7.13	in
A =	28.06	in^2	S_{left} =	61.28	in^3
r_y =	3.94	in	S_{right} =	61.28	in^3

$r_{y,compr\ flg.}$ = 0.00 in

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Compression Capacity Calculations

Normal Axial: (AREMA Table 15-1-11)

x-x axis

$F_{allowable} = 0.55*Fy$ for $KL/r \leq 0.629/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$ for $0.629/\sqrt{(F_{y/}E)} < KL/r < 5.034/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$ for $5.034/\sqrt{(F_{y/}E)} \leq KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_{y/}E)}$ =	19.56	
$5.034/\sqrt{(F_{y/}E)}$ =	156.51	
KL =	18.88	ft
=	227	in
r =	7.29	in
KL/r =	31.06	

$F_{allowable}$ = 16.56 ksi

Normal Axial: (AREMA Table 15-1-11)

y-y axis

$F_{allowable} = 0.55*Fy$ for $KL/r \leq 0.629/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$ for $0.629/\sqrt{(F_{y/}E)} < KL/r < 5.034/\sqrt{(F_{y/}E)}$

$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$ for $5.034/\sqrt{(F_{y/}E)} \leq KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_{y/}E)}$ =	19.56	
$5.034/\sqrt{(F_{y/}E)}$ =	156.51	
KL =	18.88	ft
=	227	in
r =	3.94	in
KL/r =	57.45	

$F_{allowable}$ = 15.35 ksi

Controlling Normal $F_{allowable}$ =	15.35	ksi
Controlling Normal $P_{allowable}$ =	-431	kips

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 3 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Maximum Axial: (AREMA Table 15-7-1)

x-x axis

$F_{allowable}$ = K*Fy	for		KL/r ≤ 3388/√(F_y)
$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r	for	3388/√(F_y)	< KL/r < 27111/√(F_y)
$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2]	for	27111/√(F_y)	≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	18.88	ft
=	227	in
r =	7.29	in
KL/r =	31.06	

$F_{allowable}$ = 22.72 ksi

Maximum Axial: (AREMA Table 15-7-1)

y-y axis

$F_{allowable}$ = K*Fy	for		KL/r ≤ 3388/√(F_y)
$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r	for	3388/√(F_y)	< KL/r < 27111/√(F_y)
$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2]	for	27111/√(F_y)	≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	18.88	ft
=	227	in
r =	3.94	in
KL/r =	57.45	

$F_{allowable}$ = 19.78 ksi

Controlling Max $F_{allowable}$ =	19.78	ksi
Controlling Max $P_{allowable}$ =	-555	kips

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 3 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Normal:

	Group I:	Group II:
	$RF_{Normal} = (C - D) / [L*(1 + I)]$	$RF_{Normal} = (C - D) / [L*(1 + I)]$
	$RF_{Normal} = \frac{(-431 - 65)}{(0)}$	$RF_{Normal} = \frac{(1.25*-431 - 84)}{(-167)}$
$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 3.73

Maximum:

	Group I:	Group II:
	$RF_{Normal} = (C - D) / [L*(1 + I)]$	$RF_{Normal} = (C - D) / [L*(1 + I)]$
	$RF_{Maximum} = \frac{(-555 - 65)}{(0)}$	$RF_{Maximum} = \frac{(1.25*-555 - 84)}{(-167)}$
$RF_{Maximum} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 4.67

Strength Performance Ratios

Normal:

	Group I:	Group II:
	$PR_{Normal} = [D + L*(1 + I)] / C$	$PR_{Normal} = [D + L*(1 + I)] / C$
	$PR_{Normal} = \frac{[\ 65 + 0\ ]}{-431}$	$PR_{Normal} = \frac{[\ 84 + -167\ ]}{1.25*-431}$
$PR_{Normal} =$ 0.00	$PR_{Normal} =$ N/A	$PR_{Normal} =$ 0.15

Maximum:

	Group I:	Group II:
	$PR_{Maximum} = [D + L*(1 + I)] / C$	$PR_{Maximum} = [D + L*(1 + I)] / C$
	$PR_{Maximum} = \frac{[\ 65 + 0\ ]}{-555}$	$PR_{Maximum} = \frac{[\ 84 + -167\ ]}{1.25*-555}$
$PR_{Maximum} =$ 0.00	$PR_{Maximum} =$ N/A	$PR_{Maximum} =$ 0.12

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Tensile Resistance

* The tensile resistance is taken as the lesser of yielding of the gross section or fracture of the net section.

Yielding of the Gross Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = \quad P_{ny} = \quad K*F_yA_g$

$K = 0.55$

$F_y = 30$ ksi

$A_g = 28.06$ in^2

$P_r = \quad P_{ny} = \quad 0.55*30*28$

$\boxed{P_r = 463 \text{ kips}}$

Yielding of the Gross Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = \quad P_{ny} = \quad K*F_yA_g$

$K = 0.80$

$F_y = 30$ ksi

$A_g = 28.06$ in^2

$P_r = \quad P_{ny} = \quad 0.8*30*28$

$\boxed{P_r = 673 \text{ kips}}$

Fracture of the Net Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = \quad P_{nu} = \quad K*F_uA_n$

$K = 0.47$

$F_u = 60$ ksi

$A_n = 25.77$ in^2

$P_r = \quad P_{nu} = \quad 0.47*60*26$

$\boxed{P_r = 727 \text{ kips}}$

Fracture of the Net Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = \quad P_{nu} = \quad K*F_uA_n$

$K = 0.67$

$F_u = 60$ ksi

$A_n = 25.77$ in^2

$P_r = \quad P_{nu} = \quad 0.67*60*26$

$\boxed{P_r = 1036 \text{ kips}}$

Governing Tensile Resistance:

$P_{r\ tension,normal} =$ Lesser of $P_{ny} =$ 463 k OR $P_{nu} =$ 727 k

$\boxed{P_{r\ tension,normal} = 463 \text{ kips}}$

$P_{r\ tension,maximum} =$ Lesser of $P_{ny} =$ 673 k OR $P_{nu} =$ 1,036 k

$\boxed{P_{r\ tension,maximum} = 673 \text{ kips}}$

Project: *VDOT Shenandoah Valley Load Ratings*		Michael Baker INTERNATIONAL	
Task: *Span 3 Truss Rating*	**Project No:** *202063*		
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Rating Factor Calculations

Rating Factor Equations:

$$RF = (C - D) / [L*(1 + I)]$$

Normal Rating Factor:

Controlling Value:	Group I:		Group II:	
	P_{DL} =	65 kips	P_{DL} =	84 kips
	$P_{r\ tension}$ =	463 kips	$P_{r\ tension}$ =	463 kips
	P_{LL+I} =	323 kips	P_{LL+I} =	489 kips
	$RF_{Normal} = \frac{(463 - 65)}{(323)}$		$RF_{Normal} = \frac{(1.25*463 - 84)}{(489)}$	
RF_{Normal} = 1.01	RF_{Normal} =	1.23	RF_{Normal} =	1.01

Maximum Rating Factor:

Controlling Value:	Group I:		Group II:	
	P_{DL} =	65 kips	P_{DL} =	84 kips
	$P_{r\ tension}$ =	673 kips	$P_{r\ tension}$ =	673 kips
	P_{LL+I} =	323 kips	P_{LL+I} =	489 kips
	$RF_{Maximum} = \frac{(673 - 65)}{(323)}$		$RF_{Maximum} = \frac{(1.25*673 - 84)}{(489)}$	
$RF_{Maximum}$ = 1.55	$RF_{Maximum}$ =	1.89	$RF_{Maximum}$ =	1.55

Strength Performance Ratios

Normal:

Controlling Value:	Group I:		Group II:	
	$PR_{Normal} = [D + L*(1 + I)] / C$		$PR_{Normal} = [D + L*(1 + I)] / C$	
	$PR_{Normal} = \frac{[\ 65 + 323\ ]}{463}$		$PR_{Normal} = \frac{[\ 84 + 489\ ]}{1.25*463}$	
PR_{Normal} = 1.28	PR_{Normal} =	0.84	PR_{Normal} =	1.28

Maximum:

Controlling Value:	Group I:		Group II:	
	$PR_{Maximum} = [D + L*(1 + I)] / C$		$PR_{Maximum} = [D + L*(1 + I)] / C$	
	$PR_{Maximum} = \frac{[\ 65 + 323\ ]}{673}$		$PR_{Maximum} = \frac{[\ 84 + 489\ ]}{1.25*673}$	
$PR_{Maximum}$ = 0.88	$PR_{Maximum}$ =	0.57	$PR_{Maximum}$ =	0.88

Project: *VDOT Shenandoah Valley Load Ratings*

Michael Baker INTERNATIONAL

Task: *Span 3 Truss Rating* **Project No:** *202063*

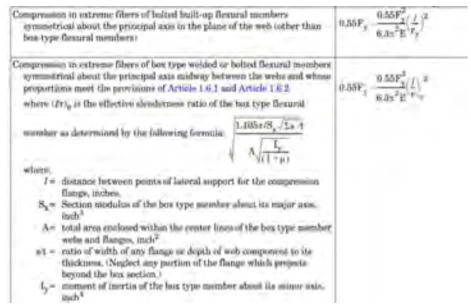
Subject:

Calculated By: *DS* **Date:** *3/20/2025* **Checked By:** *JBT* **Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Combined Compression & Bending Resistance:



Compression in extreme fibers of bolted built-up flexural members symmetrical about the principal axis in the plane of the web (other than box type flexural members)	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r_y}\right)^2$
Compression in extreme fibers of box type welded or bolted flexural members symmetrical about the principal axis midway between the webs and whose proportions meet the provisions of Article 1.6.1 and Article 1.6.2 where $(l/r)_e$ is the effective slenderness ratio of the box type flexural member as determined by the following formula: $\sqrt{\frac{1.105\pi l S_x \sqrt{\Sigma s/t}}{A\sqrt{\frac{I_y}{(1+\mu)}}}}$ where, l = distance between points of lateral support for the compression flange, inches. S_x = Section modulus of the box type member about its major axis, inch^3 A = total area enclosed within the center lines of the box type member webs and flanges, inch^2 s/t = ratio of width of any flange or depth of web component to its thickness. (Neglect any portion of the flange which projects beyond the box section.) I_y = moment of inertia of the box type member about its minor axis, inch^4	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r}\right)_e^2$

Normal:

$L = L_y$ =	22	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-18409071.72	ksi	(Table 15-1-11)(non-box)
F_y =	30	ksi	
$F_{b1,allowable}$ =	-18409071.72	ksi	
$F_{a,allowable}$ =	15.35	ksi	

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	2.31	11.49	ksi	Applied Axial f_a =	-2.95	2.98	17.43	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA 15-1.3.14.1)*		**fa / 1.25*Fa =**	**0.15**		*(AREMA 15-1.3.14.1)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.15**	**<**	**1.00**	**OK**
DL only P/R =	**0.15**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.16**	**<**	**1.00**	**OK**
LL only P/R =	**0.75**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.91**	**<**	**1.00**	**OK**
Combined RF =	**1.13**	**>**	**1.00**	**OK**	**Combined RF =**	**0.93**	**<**	**1.00**	**NG**

Controlling RF:

999.00

Maximum:

$L = L_y$ =	22	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-26824088.64	ksi	*(AREMA Table 15-7-1)*
F_y =	30	ksi	
$F_{b1,allowable}$ =	-26824088.64	ksi	
$F_{a,allowable}$ =	19.78	ksi	

Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
Applied Axial f_a =	0.00	2.31	11.49	ksi	Applied Axial f_a =	-2.95	2.98	17.43	ksi
Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
fa / Fa =	**0.00**		*(AREMA Table 15-7-1c)*		**fa / Fa =**	**0.15**		*(AREMA Table 15-7-1c)*	
P/R =	**0.00**	**<**	**1.00**	**OK**	**P/R =**	**0.15**	**<**	**1.00**	**OK**
DL only P/R =	**0.12**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.12**	**<**	**1.00**	**OK**
LL only P/R =	**0.58**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.70**	**<**	**1.00**	**OK**
Combined RF =	**1.52**	**>**	**1.00**	**OK**	**Combined RF =**	**1.25**	**>**	**1.00**	**OK**

Controlling RF:

999.00

Normal Rating Factor	1.01
Maximum Rating Factor	1.55
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 201 **Truss_Rating**

Shear:

Only vertical plates are considered to contribute to shear resistance (i.e. angle legs are excluded)

Normal:

$F_r = 0.35*Fy =$ 10.5 ksi

$P_r =$ 189.0 kips

Controlling Value:	Group I:	Group II:
	$RF_{Normal} = \frac{(189 - 0)}{(0)}$	$RF_{Normal} = \frac{(1.25*189 - 0)}{(0)}$
$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00

Maximum:

K = 0.80

0.75*K = 0.60

$F_r = 0.75*K*Fy$ 18.0 ksi

$P_r =$ 324.0 kips

Controlling Value:	Group I:	Group II:
	$RF_{Maximum} = \frac{(324 - 0)}{(0)}$	$RF_{Maximum} = \frac{(1.25*324 - 0)}{(0)}$
$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00

TRUSS RATING FOR SPAN 3

RATING CALCULATIONS
for
CONTROLLING TOP CHORD

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

TRUSS MEMBER LOAD FACTOR RATINGS

General Information

* Two load scenarios must be investigated. These are as follows:

1. Axial DL + Max Axial (LL + I)
2. Axial DL + Min Axial (LL + I)

Symbology

[ ] = required input

Load and P.O.I. Information

Load and P.O.I. Details:

Element ID:	**241**	
Section ID:	241	
Moving Load Case:	**Cooper E-80**	
Member:	N.L0-N.U1	
Include Bending?	**no**	Include Compression? **yes**
$K_{normal\ rating}$ =	**0.55**	*(Gross Tension, AREMA Table 15-1-11)*
$K1_{normal\ rating}$ =	**0.47**	*(Net Tension, AREMA Table 15-1-11)*
$K_{max\ rating}$ =	**0.80**	*(AREMA 7.3.3.3)*
$K1_{max\ rating}$ =	**0.67**	*(AREMA 7.3.3.4)*

Applied Service Forces:

Span Length =	**152**	ft
Impact =	20.9%	
Speed =	**35**	mph
Impact reduction due to speed =	0.80	
Impact for Live Load (except Rocking Effect) =	16.7%	

		Axial			Bending			Shear	
Dead Load Force [Group I] =	P_{DL} =	**-109.20**	**kips**	M_{DL} =	**0.00**	**kip-ft**	V_{DL} =	**0.00**	**kips**
Max Wind Load Force =	$P_{W,max}$ =	22.25	kips	$M_{W,max}$ =	0.00	kip-ft	$V_{W,max}$ =	0.00	kips
Min Wind Load Force =	$P_{W,min}$ =	-21.27	kips	$M_{W,min}$ =	0.00	kip-ft	$V_{W,min}$ =	0.00	kips
Dead + Wind Load Force [Group II] =	P_{DL+W} =	**-130.47**	**kips**	M_{DL+W} =	**0.00**	**kip-ft**	V_{DL+W} =	**0.00**	**kips**
Max Live Load + Rocking Force =	$P_{LL,RE,max}$ =	0.00	kips	$M_{LL,RE,max}$ =	0.00	kip-ft	$V_{LL,RE,max}$ =	0.00	kips
Min Live Load + Rocking Force =	$P_{LL,RE,min}$ =	-477.99	kips	$M_{LL,RE,min}$ =	0.00	kip-ft	$V_{LL,RE,min}$ =	0.00	kips
Max Rocking Only Plus Impact Force =	$P_{LL,RE+I,max}$ =	0.00	kips	$M_{LL,RE+I,max}$ =	0.00	kip-ft	$V_{LL,RE+I,max}$ =	0.00	kips
Min Rocking Only Plus Impact Force =	$P_{LL,RE+I,min}$ =	-31.97	kips	$M_{LL,RE+I,min}$ =	0.00	kip-ft	$V_{LL,RE+I,min}$ =	0.00	kips
Max Live Load (without Rocking) Force =	P_{LL} =	0.00	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Min Live Load (without Rocking) Force =	P_{LL} =	-451.55	kips	M_{LL} =	0.00	kip-ft	V_{LL} =	0.00	kips
Max Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	0.00	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Min Live Load (without Rocking) Plus Impact Force =	P_{LL+I} =	-527.11	kips	M_{LL+I} =	0.00	kip-ft	V_{LL+I} =	0.00	kips
Max LL+I Force [Group I] =	P_{LL+I} =	**0.00**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Min LL+I Force [Group I] =	P_{LL+I} =	**-559.09**	**kips**	M_{LL+I} =	**0.00**	**kip-ft**	V_{LL+I} =	**0.00**	**kips**
Max LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**0.60**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**
Min LL+I Force + Longit. and Lateral [Group II] =	$P_{LL+I+LF+N}$ =	**-559.69**	**kips**	$M_{LL+I+LF+N}$ =	**0.00**	**kip-ft**	$V_{LL+I+LF+N}$ =	**0.00**	**kips**

("+" = tens.; "-" = compr.)

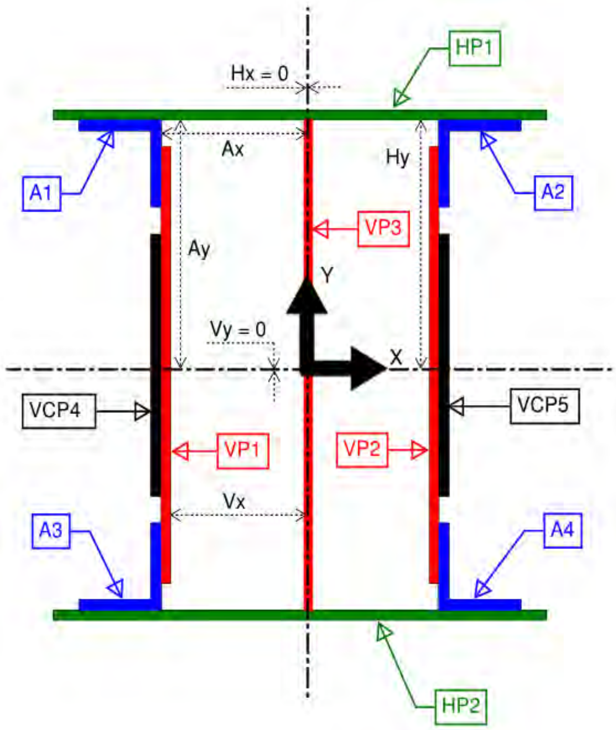
Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Material Properties:

Minimum Steel Yield Strength, F_y = 30 ksi
Minimum Steel Tensile Strength, F_u = 60 ksi
Modulus of Elasticity, E = 29000 ksi

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	yes	24	0.44	-	-	0	10.03	-	-	-	2	0.9375
HP2	no	0	0	-	-	0	-10.03	-	-	-	0	0
VP1	yes	20.5	0.5	-8	0	-	-	-	-	-	2	0.9375
VP2	yes	20.5	0.5	8	0	-	-	-	-	-	2	0.9375
VP3	no	0	0	0	0	-	-	-	-	-	0	0
VCP4	no	0	0	-8.5	0	-	-	-	-	-	0	0
VCP5	no	0	0	8.5	0	-	-	-	-	-	0	0
A1 (Horiz. Leg)	yes	3.5	0.48	-	-	-	-	-	10.03	out	1	0.9375
A1 (Vert. Leg)	yes	3.5	0.48	-	-	-	-	-8.5	-	out	1	0.9375
A2 (Horiz. Leg)	yes	3.5	0.48	-	-	-	-	-	10.03	out	1	0.9375
A2 (Vert. Leg)	yes	3.5	0.48	-	-	-	-	8.5	-	out	1	0.9375
A3 (Horiz. Leg)	yes	3.5	0.48	-	-	-	-	-	-10.03	out	1	0.9375
A3 (Vert. Leg)	yes	3.5	0.48	-	-	-	-	-8.5	-	out	1	0.9375
A4 (Horiz. Leg)	yes	3.5	0.48	-	-	-	-	-	-10.03	out	1	0.9375
A4 (Vert. Leg)	yes	3.5	0.48	-	-	-	-	8.5	-	out	1	0.9375

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

X-X Axis Section Properties:

Total height of section (along y-y axis) = 20.94 in
Effective length factor, $K_{x\text{-}x}$ = 0.875
Unbraced length, $L_{x\text{-}x}$ = 39.90 ft

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{x\text{-}x}$ (in^4)	A_{net} (in^2)
HP1	10.56	10.25	108.24	0.17	7.77	636.91	637.08	9.95
HP2	0.00	-10.03	0.00	0.00	-12.51	0.00	0.00	0.00
VP1	10.25	0.00	0.00	358.96	-2.48	63.23	422.20	9.56
VP2	10.25	0.00	0.00	358.96	-2.48	63.23	422.20	9.56
VP3	0.00	0.00	0.00	0.00	-2.48	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-2.48	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-2.48	0.00	0.00	0.00
A1 (Horiz. Leg)	1.68	9.79	16.45	0.03	7.31	89.68	89.71	1.35
A1 (Vert. Leg)	1.45	8.04	11.65	1.10	5.56	44.75	45.85	1.12
A2 (Horiz. Leg)	1.68	9.79	16.45	0.03	7.31	89.68	89.71	1.35
A2 (Vert. Leg)	1.45	8.04	11.65	1.10	5.56	44.75	45.85	1.12
A3 (Horiz. Leg)	1.68	-9.79	-16.45	0.03	-12.27	253.09	253.12	1.35
A3 (Vert. Leg)	1.45	-8.04	-11.65	1.10	-10.52	160.54	161.65	1.12
A4 (Horiz. Leg)	1.68	-9.79	-16.45	0.03	-12.27	253.09	253.12	1.35
A4 (Vert. Leg)	1.45	-8.04	-11.65	1.10	-10.52	160.54	161.65	1.12
Σ	**43.58**		**108.24**	**722.63**		**1859.50**	**2582.14**	**Σ 38.94**

y_{bar} =	2.48	in	c_{top}=	7.99	in
I_x =	2582	in^4	c_{bottom}=	12.95	in
A =	43.58	in^2	S_{top} =	323.32	in^3
r_x =	7.70	in	S_{bottom} =	199.33	in^3

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Y-Y Axis Section Properties:

Total width of section (along x-x axis) =	24	in
Effective length factor, $K_{y\text{-}y}$ =	0.875	
Unbraced length, $L_{y\text{-}y}$ =	39.90	ft

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	10.56	0.00	0.00	506.88	0.00	0.00	506.88
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	10.25	-8.25	-84.56	0.21	-8.25	697.64	697.85
VP2	10.25	8.25	84.56	0.21	8.25	697.64	697.85
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	-8.50	0.00	0.00	-8.50	0.00	0.00
VCP5	0.00	8.50	0.00	0.00	8.50	0.00	0.00
A1 (Horiz. Leg)	1.68	-10.25	-17.22	1.72	-10.25	176.51	178.22
A1 (Vert. Leg)	1.45	-8.74	-12.67	0.03	-8.74	110.73	110.76
A2 (Horiz. Leg)	1.68	10.25	17.22	1.72	10.25	176.51	178.22
A2 (Vert. Leg)	1.45	8.74	12.67	0.03	8.74	110.73	110.76
A3 (Horiz. Leg)	1.68	-10.25	-17.22	1.72	-10.25	176.51	178.22
A3 (Vert. Leg)	1.45	-8.74	-12.67	0.03	-8.74	110.73	110.76
A4 (Horiz. Leg)	1.68	10.25	17.22	1.72	10.25	176.51	178.22
A4 (Vert. Leg)	1.45	8.74	12.67	0.03	8.74	110.73	110.76
∑	**43.58**		**0.00**	**514.28**		**2544.23**	**3058.51**

y_{bar} =	0.00	in	c_{left}=	12.00	in			
I_y =	3059	in^4	c_{left}=	12.00	in			
A =	43.58	in^2	S_{left} =	254.88	in^3			
r_y =	8.38	in	S_{right} =	254.88	in^3	$r_{y,compr\ flg.}$ =	0.00	in

Project: *VDOT Shenandoah Valley Load Ratings*		Michael Baker INTERNATIONAL	
Task: *Span 3 Truss Rating*	**Project No:** *202063*		
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Compression Capacity Calculations

Normal Axial: (AREMA Table 15-1-11)

x-x axis

$F_{allowable} = 0.55*Fy$	for		$KL/r \le 0.629/\sqrt{(F_y/E)}$
$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$	for	$0.629/\sqrt{(F_y/E)}$	$< KL/r < 5.034/\sqrt{(F_y/E)}$
$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$	for	$5.034/\sqrt{(F_y/E)}$	$\le KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_y/E)}$ =	19.56	
$5.034/\sqrt{(F_y/E)}$ =	156.51	
KL =	34.91	ft
=	419	in
r =	7.70	in
KL/r =	54.43	

$F_{allowable}$ = 15.48 ksi

Normal Axial: (AREMA Table 15-1-11)

y-y axis

$F_{allowable} = 0.55*Fy$	for		$KL/r \le 0.629/\sqrt{(F_y/E)}$
$F_{allowable} = 0.60*Fy-(17{,}500*Fy/E)^{3/2}*KL/r$	for	$0.629/\sqrt{(F_y/E)}$	$< KL/r < 5.034/\sqrt{(F_y/E)}$
$F_{allowable} = 0.514*\pi^2*E/(KL/r)^2$	for	$5.034/\sqrt{(F_y/E)}$	$\le KL/r$

F_y =	30	ksi
E =	29000	ksi
$0.629/\sqrt{(F_y/E)}$ =	19.56	
$5.034/\sqrt{(F_y/E)}$ =	156.51	
KL =	34.91	ft
=	419	in
r =	8.38	in
KL/r =	50.01	

$F_{allowable}$ = 15.69 ksi

Controlling Normal $F_{allowable}$ =	15.48	ksi
Controlling Normal $P_{allowable}$ =	-675	kips

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Maximum Axial: (AREMA Table 15-7-1)

x-x axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	34.91	ft
=	419	in
r =	7.70	in
KL/r =	54.43	

$F_{allowable}$ =	20.12	ksi

Maximum Axial: (AREMA Table 15-7-1)

y-y axis

$F_{allowable}$ = K*Fy for KL/r ≤ 3388/√(F_y)

$F_{allowable}$ = 1.091*K-[K√(Fy)/37,300]*KL/r for 3388/√(F_y) < KL/r < 27111/√(F_y)

$F_{allowable}$ = K/(0.55*Fy)*[147,000,000/(KL/r)^2] for 27111/√(F_y) ≤ KL/r

F_y =	30	ksi
E =	29000	ksi
K =	0.80	
3388/√(F_y) =	19.56	
27111/√(F_y) =	156.53	
KL =	34.91	ft
=	419	in
r =	8.38	in
KL/r =	50.01	

$F_{allowable}$ =	20.61	ksi

Controlling Max $F_{allowable}$ =	20.12	ksi
Controlling Max $P_{allowable}$ =	-877	kips

Project: *VDOT Shenandoah Valley Load Ratings*			Michael Baker INTERNATIONAL
Task: *Span 3 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Rating Factor Calculations

Normal:

	Group I:	Group II:
	$RF_{Normal} = (C - D) / [L*(1 + I)]$	$RF_{Normal} = (C - D) / [L*(1 + I)]$
	$RF_{Normal} = \frac{(-675 - -109)}{(-559)}$	$RF_{Normal} = \frac{(1.25*-675 - -130)}{(-560)}$
$RF_{Normal} =$ 1.01	$RF_{Normal} =$ 1.01	$RF_{Normal} =$ 1.27

Maximum:

	Group I:	Group II:
	$RF_{Normal} = (C - D) / [L*(1 + I)]$	$RF_{Normal} = (C - D) / [L*(1 + I)]$
	$RF_{Maximum} = \frac{(-877 - -109)}{(-559)}$	$RF_{Maximum} = \frac{(1.25*-877 - -130)}{(-560)}$
$RF_{Maximum} =$ 1.37	$RF_{Normal} =$ 1.37	$RF_{Normal} =$ 1.72

Strength Performance Ratios

Normal:

	Group I:	Group II:
	$PR_{Normal} = [D + L*(1 + I)] / C$	$PR_{Normal} = [D + L*(1 + I)] / C$
	$PR_{Normal} = \frac{[\ -109 + -559\ ]}{-675}$	$PR_{Normal} = \frac{[\ -130 + -560\ ]}{1.25*-675}$
$PR_{Normal} =$ 0.99	$PR_{Normal} =$ 0.99	$PR_{Normal} =$ 0.82

Maximum:

	Group I:	Group II:
	$PR_{Maximum} = [D + L*(1 + I)] / C$	$PR_{Maximum} = [D + L*(1 + I)] / C$
	$PR_{Maximum} = \frac{[\ -109 + -559\ ]}{-877}$	$PR_{Maximum} = \frac{[\ -130 + -560\ ]}{1.25*-877}$
$PR_{Maximum} =$ 0.76	$PR_{Maximum} =$ 0.76	$PR_{Maximum} =$ 0.63

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Tensile Resistance

* The tensile resistance is taken as the lesser of yielding of the gross section or fracture of the net section.

Yielding of the Gross Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = P_{ny} = K*F_yA_g$

$K = 0.55$
$F_y = 30$ ksi
$A_g = 43.58$ in^2

$P_r = P_{ny} = 0.55*30*44$

$\boxed{P_r = 719 \text{ kips}}$

Yielding of the Gross Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = P_{ny} = K*F_yA_g$

$K = 0.80$
$F_y = 30$ ksi
$A_g = 43.58$ in^2

$P_r = P_{ny} = 0.8*30*44$

$\boxed{P_r = 1046 \text{ kips}}$

Fracture of the Net Section, Normal Axial: (AREMA Table 15-1-12)

$P_r = P_{nu} = K*F_uA_n$

$K = 0.47$
$F_u = 60$ ksi
$A_n = 38.94$ in^2

$P_r = P_{nu} = 0.47*60*39$

$\boxed{P_r = 1098 \text{ kips}}$

Fracture of the Net Section, Maximum Axial: (AREMA Table 15-7-1)

$P_r = P_{nu} = K*F_uA_n$

$K = 0.67$
$F_u = 60$ ksi
$A_n = 38.94$ in^2

$P_r = P_{nu} = 0.67*60*39$

$\boxed{P_r = 1565 \text{ kips}}$

Governing Tensile Resistance:

$P_{r\ tension,normal}$ = Lesser of P_{ny} = 719 k OR P_{nu} = 1,098 k

$\boxed{P_{r\ tension,normal} = 719 \text{ kips}}$

$P_{r\ tension,maximum}$ = Lesser of P_{ny} = 1,046 k OR P_{nu} = 1,565 k

$\boxed{P_{r\ tension,maximum} = 1046 \text{ kips}}$

Project: VDOT Shenandoah Valley Load Ratings		Michael Baker INTERNATIONAL
Task: Span 3 Truss Rating	Project No: 202063	
Subject:		
Calculated By: DS Date: 3/20/2025	Checked By: JBT Date: 3/20/2025	

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Rating Factor Calculations

Rating Factor Equations:

$$RF = (C - D) / [L*(1 + I)]$$

Normal Rating Factor:

Controlling Value:	Group I:	Group II:
	P_{DL} = -109 kips	P_{DL} = -130 kips
	$P_{r\ tension}$ = 719 kips	$P_{r\ tension}$ = 719 kips
	P_{LL+I} = 0 kips	P_{LL+I} = 1 kips
	$RF_{Normal} = \frac{(719 - -109)}{(0)}$	$RF_{Normal} = \frac{(1.25*719 - -130)}{(1)}$
RF_{Normal} = 999.00	RF_{Normal} = 999.00	RF_{Normal} = N/A

Maximum Rating Factor:

Controlling Value:	Group I:	Group II:
	P_{DL} = -109 kips	P_{DL} = -130 kips
	$P_{r\ tension}$ = 1046 kips	$P_{r\ tension}$ = 1046 kips
	P_{LL+I} = 0 kips	P_{LL+I} = 1 kips
	$RF_{Maximum} = \frac{(1,046 - -109)}{(0)}$	$RF_{Maximum} = \frac{(1.25*1,046 - -130)}{(1)}$
$RF_{Maximum}$ = 999.00	$RF_{Maximum}$ = 999.00	$RF_{Maximum}$ = N/A

Strength Performance Ratios

Normal:

Controlling Value:	Group I:	Group II:
	$PR_{Normal} = [D + L*(1 + I)] / C$	$PR_{Normal} = [D + L*(1 + I)] / C$
	$PR_{Normal} = \frac{[-109 + 0]}{719}$	$PR_{Normal} = \frac{[-130 + 1]}{1.25*719}$
PR_{Normal} = N/A	PR_{Normal} = N/A	PR_{Normal} = N/A

Maximum:

Controlling Value:	Group I:	Group II:
	$PR_{Maximum} = [D +L*(1 + I)] / C$	$PR_{Maximum} = [D +L*(1 + I)] / C$
	$PR_{Maximum} = \frac{[-109 + 0]}{1,046}$	$PR_{Maximum} = \frac{[-130 + 1]}{1.25*1,046}$
$PR_{Maximum}$ = N/A	$PR_{Maximum}$ = N/A	$PR_{Maximum}$ = N/A

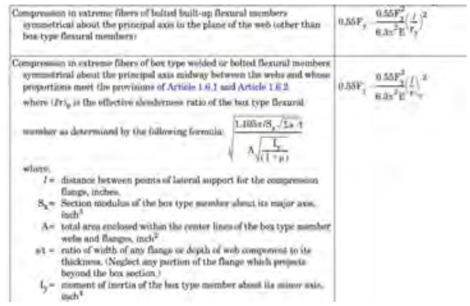
Project: *VDOT Shenandoah Valley Load Ratings*			
Task: *Span 3 Truss Rating*		**Project No:** *202063*	
Subject:			
Calculated By: *DS*	**Date:** *3/20/2025*	**Checked By:** *JBT*	**Date:** *3/20/2025*

Michael Baker INTERNATIONAL

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Combined Compression & Bending Resistance:



Compression in extreme fibers of bolted built-up flexural members symmetrical about the principal axis in the plane of the web (other than box type flexural members)	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r_y}\right)^2$
Compression in extreme fibers of box type welded or bolted flexural members symmetrical about the principal axis midway between the webs and whose proportions meet the provisions of Article 1.6.1 and Article 1.6.2 where $(l/r)_e$ is the effective slenderness ratio of the box type flexural member as determined by the following formula: $\sqrt{\frac{1.105\pi l S_x \sqrt{\Sigma s/t}}{A\sqrt{\frac{I_y}{1+\mu}}}}$ where, l = distance between points of lateral support for the compression flange, inches. S_x = Section modulus of the box type member about its major axis, inch[3] A = total area enclosed within the center lines of the box type member webs and flanges, inch[2] s/t = ratio of width of any flange or depth of web component to its thickness. (Neglect any portion of the flange which projects beyond the box section.) I_y = moment of inertia of the box type member about its minor axis, inch[4]	$0.55F_y - \frac{0.55F_y^2}{6.3\pi^2 E}\left(\frac{l}{r}\right)_e^2$

Normal:

$L = L_y$ =	40	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-62932513.23	ksi	\ Table 15-1-11)(non-box)
F_y =	30	ksi	
$F_{b1,allowable}$ =	-62932513.23	ksi	
$F_{a,allowable}$ =	15.48	ksi	

	Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
	Applied Axial f_a =	-15.34	-2.51	-12.83	ksi	Applied Axial f_a =	-15.84	-2.99	-12.84	ksi
	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
	fa / Fa =	**0.99**		*(AREMA 15-1.3.14.1)*		**fa / 1.25*Fa =**	**0.82**		*(AREMA 15-1.3.14.1)*	
	P/R =	**0.99**	**<**	**1.00**	**OK**	**P/R =**	**0.82**	**<**	**1.00**	**OK**
	DL only P/R =	**0.16**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.15**	**<**	**1.00**	**OK**
	LL only P/R =	**0.83**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.66**	**<**	**1.00**	**OK**
Controlling RF:										
1.01	**Combined RF =**	**1.01**	**>**	**1.00**	**OK**	**Combined RF =**	**1.27**	**>**	**1.00**	**OK**

Maximum:

$L = L_y$ =	40	ft	
r_y =	0	in	
F_y =	30000	psi	
E =	29000000	psi	
$F_{b1,allowable}$ =	-91699752.00	ksi	*(AREMA Table 15-7-1)*
F_y =	30	ksi	
$F_{b1,allowable}$ =	-91699752.00	ksi	
$F_{a,allowable}$ =	20.12	ksi	

	Group I:	Total	DL only	LL only		**Group II:**	Total	DL only	LL only	
	Applied Axial f_a =	-15.34	-2.51	-12.83	ksi	Applied Axial f_a =	-15.84	-2.99	-12.84	ksi
	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $+f_{b1}$ =	0.00	0.00	0.00	ksi
	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi	Applied Bending $-f_{b1}$ =	0.00	0.00	0.00	ksi
	fa / Fa =	**0.76**		*(AREMA Table 15-7-1c)*		**fa / Fa =**	**0.79**		*(AREMA Table 15-7-1c)*	
	P/R =	**0.76**	**<**	**1.00**	**OK**	**P/R =**	**0.79**	**<**	**1.00**	**OK**
	DL only P/R =	**0.12**	**<**	**1.00**	**OK**	**DL only P/R =**	**0.12**	**<**	**1.00**	**OK**
	LL only P/R =	**0.64**	**<**	**1.00**	**OK**	**LL only P/R =**	**0.51**	**<**	**1.00**	**OK**
Controlling RF:										
1.37	**Combined RF =**	**1.37**	**>**	**1.00**	**OK**	**Combined RF =**	**1.72**	**>**	**1.00**	**OK**

Normal Rating Factor	1.01
Maximum Rating Factor	1.37
Normal Bending Rating Factor	
Maximum Bending Rating Factor	
Speed	35 mph

Element 241 **Truss_Rating**

Shear:

Only vertical plates are considered to contribute to shear resistance (i.e. angle legs are excluded)

Normal:

$F_r = 0.35*Fy =$ 10.5 ksi

$P_r =$ 215.3 kips

Controlling Value:	Group I:	Group II:
	$RF_{Normal} = \frac{(215 - 0)}{(0)}$	$RF_{Normal} = \frac{(1.25*215 - 0)}{(0)}$
$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00	$RF_{Normal} =$ 999.00

Maximum:

K = 0.80

0.75*K = 0.60

$F_r = 0.75*K*Fy$ 18.0 ksi

$P_r =$ 369.0 kips

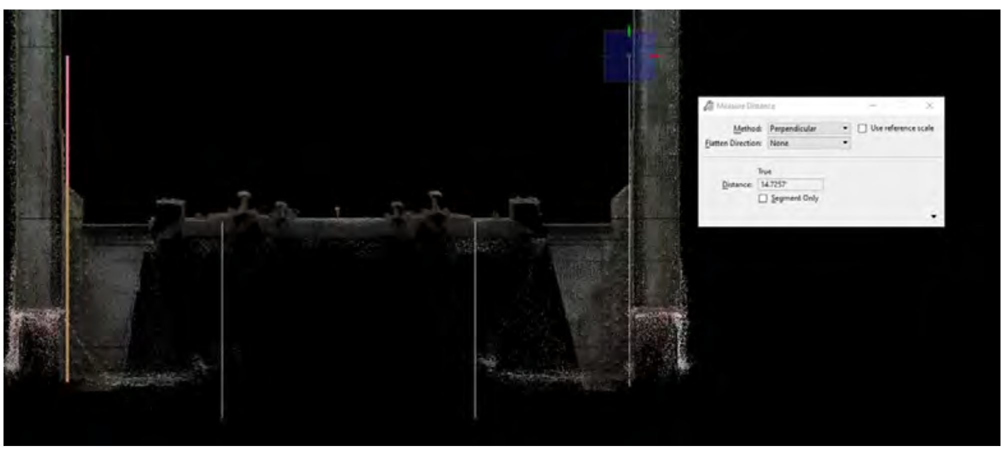
Controlling Value:	Group I:	Group II:
	$RF_{Maximum} = \frac{(369 - 0)}{(0)}$	$RF_{Maximum} = \frac{(1.25*369 - 0)}{(0)}$
$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00	$RF_{Maximum} =$ 999.00

TRUSS RATING FOR SPAN 3

RATING CALCULATIONS
for
FLOORBEAM

Asset 5104 Span 3 Floorbeam Section
Properties

Flange: L6x6x0.64
Web: 47.25X0.5



Length: 14.7257'

Stringer Spacing: 6.5367'

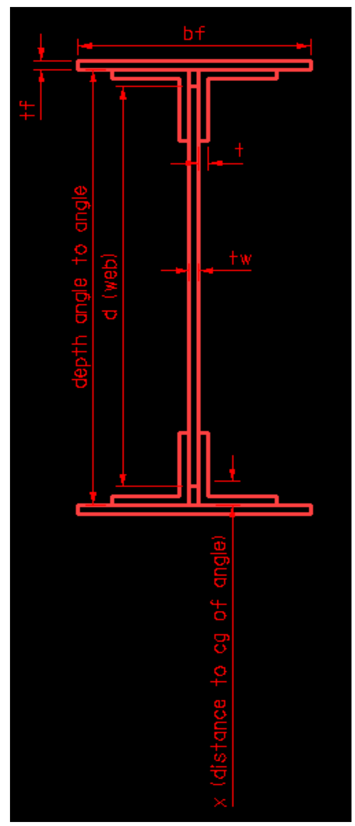
Assume similar rivet spacing as Span2/4 (Span 2/4 in photo):
Gage 3"
Pitch 2.5"

Task

This worksheet is configured to perform load rating for floorbeams supporting two stringers each in the back and ahead spans feeding into the floorbeam. A single track situated midway between the stringers is assumed. The floorbeam must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall floorbeam section property calculations. The spreadsheet does not calculate the dead load or wind load acting on the stringers. Rather, the stringer reactions due to these loads are direct inputs, taken from the spreadsheet used to rate the stringers. These loads, along with live load are assumed to be transmitted to the floorbeam via the stringers. Live load is interpolated herein from AREMA Table 15-1-15 as a pier reaction using the average length of the back and ahead spans feeding into the floorbeam. The E80 pier reactions from Table 15-1-15 are adjusted to represent 286k and 315k live load cases using conversion factors supplied by Norfolk Southern. Span imbalance is atypical and expected to be minor when present. Torsional effects of minor span imbalance, when present, are not considered in the section capacity calculations. Fatigue is not assessed.

Floorbeam Section Details (Note: Floorbeam & Stringer spans and stringer reactions addressed separately on worksheet *Rating Calculations*)

Floorbeam Type	**fastened**	rolled, welded, or fastened
Fy	**30,000**	psi (AREMA Table 15-7-2, MBE Table 6A.6.2.1-1)
Capacity Reduction	**1%**	due to section loss (geometry inputs below account for section loss, see Narrative)



Fastened Section Details (0 if not fastened)

Depth angle to angle	**47.250**	in	
Effective Rivet/Bolt hole diameter	**0.94**	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	**0.000**	in
t_f	**0.000**	in

Top Flange Angles (0 if they don't exist)

x	**6.000**	in	
y	**6.000**	in	
t	**0.640**	in	
A (each angle)	7.27	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	49.30	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.74	in	(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	106.62	in4	(ref. wksht. TF_Angle_Pair)

Holes Through Top Flange (0 if does not exist OR in compression at Section Location)

Rows	**0.00**	
Gage	**0.00**	in
Pitch	**0.00**	in

Pitch = distance btwn centers of adjacent fasteners, measured along one or more lines of fasteners. Gage = dist. btwn adjacent lines of fasteners, or dist from the back of angle or other shape to 1st line of fasteners.

Holes Through Top Flange Angles and Web (0 if does not exist OR in compression at Section Location)

Rows	**0**	
Gage 1	**0.00**	in
Gage 2	**0.00**	in
Pitch	**0.00**	in

Web

d	**47.250**	in
tw	**0.500**	in

Holes Through Web at Stringer to FB Connection

Total # of Holes	**13.00**	
# of Holes in long row	**7.00**	
Gage	**2.00**	in
Pitch	**2.00**	in

SUMMARY

Bottom Flange or Cover Plate (0 if does not exist)

b_f	0.000	in
t_f	0.000	in

Bottom Flange Angles (0 if they don't exist)

x	6.000	in	
y	6.000	in	
t	0.640	in	
A (each angle)	7.27	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	49.30	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.74	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	106.62	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR in compression at Section Location)

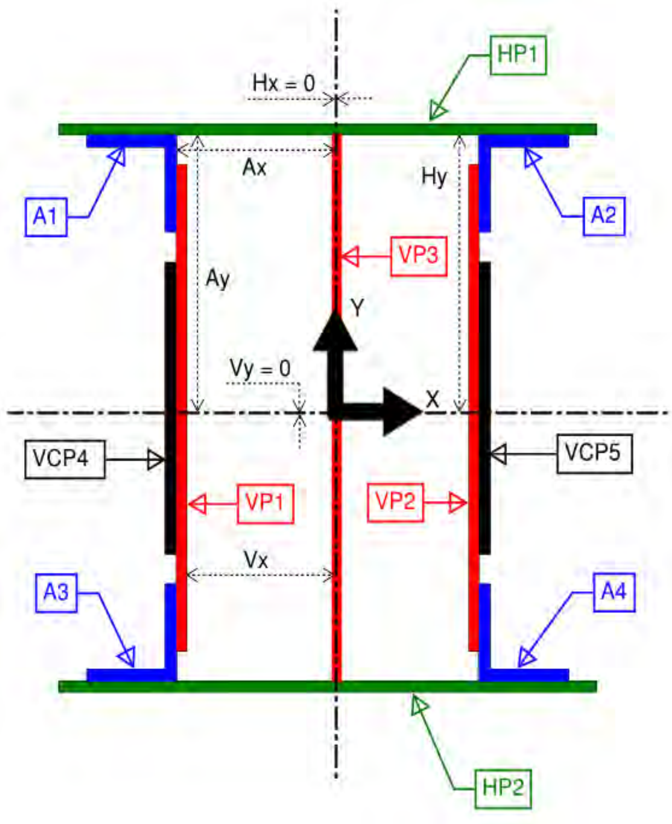
Rows	0.00	
Gage	1.00	in
Pitch	1.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR in compression at Section Location)

Rows	2	
Gage 1	3.00	in
Gage 2	3.00	in
Pitch	2.50	in

Project: VDOT Shenandoah Valley Asset 5104			Michael Baker INTERNATIONAL
Task: Span 3 Floorbeam Rating		Project No:	
Subject: Span 3 Floorbeam Rating			
Calculated By: DS	Date: 2/19/2025	Checked By: JBT	Date: 3/20/2025

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	6.00	0.64	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	6.00	0.64	-	-	-	-	-0.25	-	out		
A2 (Horiz. Leg)	yes	6.00	0.64	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	6.00	0.64	-	-	-	-	0.25	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)
HP1	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
HP2	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
VP1	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
VP2	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
VP3	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
A1 (Horiz. Leg)	3.84	0.32	1.23	0.13	-1.42	7.69	7.82
A1 (Vert. Leg)	3.43	3.32	11.39	8.21	1.58	8.61	16.83
A2 (Horiz. Leg)	3.84	0.32	1.23	0.13	-1.42	7.69	7.82
A2 (Vert. Leg)	3.43	3.32	11.39	8.21	1.58	8.61	16.83
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.74	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.74	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.74	0.00	0.00
Σ	**14.54**		**25.24**	**16.69**		**32.61**	**49.30**

	A_{net} (in^2)
HP1	0.00
HP2	0.00
VP1	0.00
VP2	0.00
VP3	0.00
VCP4	0.00
VCP5	0.00
A1 (Horiz. Leg)	3.84
A1 (Vert. Leg)	3.43
A2 (Horiz. Leg)	3.84
A2 (Vert. Leg)	3.43
A3 (Horiz. Leg)	0.00
A3 (Vert. Leg)	0.00
A4 (Horiz. Leg)	0.00
A4 (Vert. Leg)	0.00
Σ	**14.54**

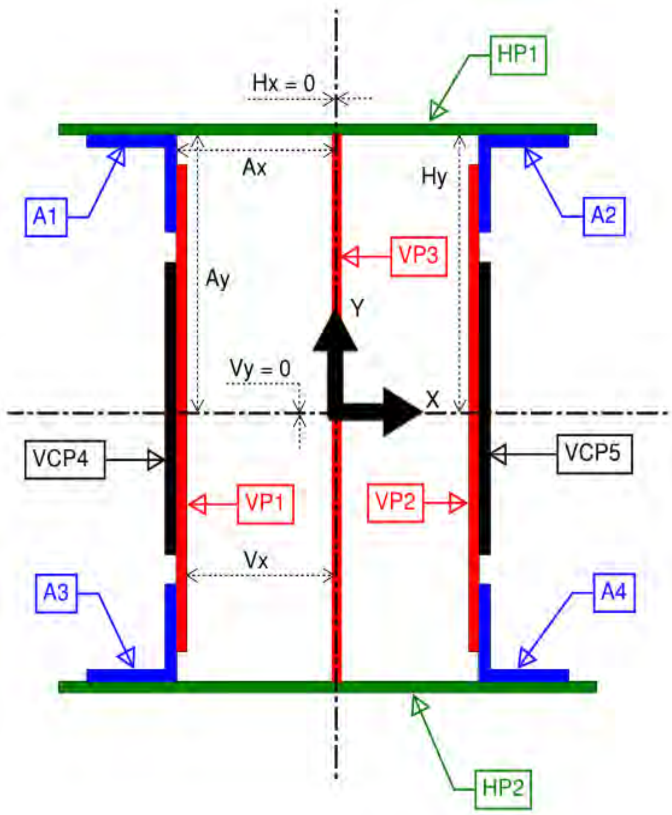
y_{bar} =	1.74	in	c_{top}=	1.26	in
I_x =	49.30	in^4	c_{bottom}=	4.74	in
A =	14.54	in^2	S_{top} =	38.99	in^3
r_x =	1.84	in	S_{bottom} =	10.41	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	3.84	-3.25	-12.48	11.52	-3.25	40.56	52.08
A1 (Vert. Leg)	3.43	-0.57	-1.96	0.12	-0.57	1.11	1.23
A2 (Horiz. Leg)	3.84	3.25	12.48	11.52	3.25	40.56	52.08
A2 (Vert. Leg)	3.43	0.57	1.96	0.12	0.57	1.11	1.23
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**14.54**		**0.00**	**23.27**		**83.35**	**106.62**

y_{bar} =	0.00	in	c_{left}=	6.25	in
I_y =	106.62	in^4	c_{right}=	6.25	in
A =	14.54	in^2	S_{left} =	17.06	in^3
r_y =	2.71	in	S_{right} =	17.06	in^3

BF_Angle_Pair

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	no			-	-	-	-	-		out		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	yes	6.00	0.64	-	-	-	-	-	0	out		
A3 (Vert. Leg)	yes	6.00	0.64	-	-	-	-	-0.25	-	out		
A4 (Horiz. Leg)	yes	6.00	0.64	-	-	-	-	-	0	out		
A4 (Vert. Leg)	yes	6.00	0.64	-	-	-	-	0.25	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.74	0.00	0.00		0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.74	0.00	0.00		0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.74	0.00	0.00		0.00
A3 (Horiz. Leg)	3.84	0.32	1.23	0.13	-1.42	7.69	7.82		3.84
A3 (Vert. Leg)	3.43	3.32	11.39	8.21	1.58	8.61	16.83		3.43
A4 (Horiz. Leg)	3.84	0.32	1.23	0.13	-1.42	7.69	7.82		3.84
A4 (Vert. Leg)	3.43	3.32	11.39	8.21	1.58	8.61	16.83		3.43
Σ	**14.54**		**25.24**	**16.69**		**32.61**	**49.30**	**Σ**	**14.54**

y_{bar} =	1.74	in	c_{top}=	1.26	in	
I_x =	49.30	in^4	c_{bottom}=	4.74	in	
A =	14.54	in^2	S_{top} =	38.99	in^3	10.41
r_x =	1.84	in	S_{bottom} =	10.41	in^3	38.99

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	3.84	-3.25	-12.48	11.52	-3.25	40.56	52.08
A3 (Vert. Leg)	3.43	-0.57	-1.96	0.12	-0.57	1.11	1.23
A4 (Horiz. Leg)	3.84	3.25	12.48	11.52	3.25	40.56	52.08
A4 (Vert. Leg)	3.43	0.57	1.96	0.12	0.57	1.11	1.23
Σ	**14.54**		**0.00**	**23.27**		**83.35**	**106.62**

y_{bar} =	0.00	in	c_{left}=	6.25	in
I_y =	106.62	in^4	c_{right}=	6.25	in
A =	14.54	in^2	S_{left} =	17.06	in^3
r_y =	2.71	in	S_{right} =	17.06	in^3

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	47.25	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		0	in
tf		0	in
A	0 x 0 =	0	in2
x	47.25 - (0.5 x 0) =	47.25	in
Ax	0 x 47.25 =	0	in3
d	47.25 - 24.68 =	22.57	in
Ad2	0 x 22.57^2 =	0	in4

Top Flange Angles

x		6	in
t		0.64	in
A (angle)		7.2704	in2
Ixxo, Double Angles		49.30077	in4
A	2 x 7.2704 =	14.5408	in2
y.bar		1.74	in
x	47.25 - 0 - 1.74 =	45.51	in
Ax	14.5408 x 45.51 =	661.75	in3
d	45.51 - 24.68 =	20.83	in
Ad2	14.5408 x 20.83^2 =	6309	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.64 =	0.64	in
A*	0	0.0000	in^2
x	47.25 - 0.64 / 2 =	46.93	in
Ax	0 x 46.93 =	0	in^3
d	46.93 - 24.68 =	22.25	in
Ad^2	0 x 22.25^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.64 + 0.5 =	1.78	in
A*	0	0.0000	in^2
x	47.25 - 0 - (0 +0)/2 =	47.25	in
Ax	0 x 47.25 =	0	in^3
d	47.25 - 24.68 =	22.57	in
Ad^2	0 x 22.57^2 =	0	in^4

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NET SECTION

Web			
d		47.25	in
t_w		0.50	in
A	0.5 x 47.25 =	23.6250	in^2
x	0 + 0 + (0.5 x 47.25) =	23.625	in
Ax	23.625 x 23.625 =	558.14	in^3
d	24.68 - 23.625 =	1.055	in
Ad^2	23.625 x 1.055^2 =	26.3	in^4
I_{web}	(0.5) x (47.25)^3 / 12 =	4395	in^4
Supplemental Web Cover Plate in End Zones			
x.tw'	Input	0.000	in
y.tw'	47.25 - 6 - 6 =	35.25	in
A'	23.625+0 x 35.25 =	23.625	in^2

Holes Through Web at Diaphragm Connection			
Total # of Holes		13.00	
# of Holes in long row		7.00	
Gage		2.00	in
Pitch		2.00	in
Grip	0.5 =	0.5	in
A*	7 x 0.9375 x 0.5 =	3.2813	in^2
x	centered on web =	23.625	in
Ax	3.2813 x 23.625 =	78	in^3
d	max =	12.00	in
Ad^2	Total for all holes =	106.01	in^4
I_{holes}	13 x 0.5 x 0.9375^3/12 =	0.45	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		3.00	in
Gage 2		3.00	in
Pitch		2.50	in
Grip	2 x 0.64 + 0.5 =	1.78	in
A*	x 2.5^2 / (4 x 3) x 1.78 =	2.4104	in^2
x	+ (3 + 3) / 2 =	3	in
Ax	2.4104 x 3 =	7	in^3
d	24.68 - 3 =	21.68	in
Ad^2	2.4104 x 21.68^2 =	1133	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		1.00	in
Pitch		1.00	in
Grip	0 + 0.64 =	0.64	in
A	2 x 0.9375 x 0.64 =	0.0000	in^2
x	0.5 x 0.64 =	0.32	in
Ax	0 x 0.32 =	0	in^3
d	24.68 - 0.32 =	24.36	in
Ad^2	0 x 24.36^2 =	0	in^4

Bottom Flange Angles			
x		6.00	in
t		0.64	in
A (angle)		7.27	in^2
Ixxo, Double Angles		49.30	in^4
A	2 x 7.2704 =	14.5408	in^2
y.bar		1.74	in
Ax	14.5408 x 1.74 =	25.30	in^3
d	24.68 - 1.74 =	22.94	in
Ad^2	14.5408 x 22.94^2 =	7652	in^4

Bottom Cover Plates			
b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	24.68 - 0 =	24.68	in
Ad^2	0 x 24.68^2 =	0	in^4

PROJECT : *VDOT Shenandoah Valley Asset 5104*		
TASK : *Span 3 Floorbeam Rating*	**PROJECT NO :**	
SUBJECT : *Span 3 Floorbeam Rating*		
CALCULATED BY : *DS* **DATE :** *2/19/2025*	**CHECKED BY :** *JBT*	**DATE :** 3/20/2025

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NET SECTION

Girder Properties

Girder d	0 + 0 + 47.25 + 0 + 0 =	47.25	in
ΣA	0 + 14.5408 - 0 - 0 + 23.625 - 3.2813 - 2.4104 - 0 + 14.5408 + 0 =	47.01	in^2
ΣAx	0 + 661.75 - 0 - 0 + 558.14 - 78 - 7 - 0 + 25.3 + 0 =	1160.19	in^3
Xcg	= ΣAx / ΣA =	24.68	in
ΣAd^2	0 + 6309 - 0 - 0 + 26.3 -106.011230769231 - 1133 - 0 + 7652 + 0 =	12748.29	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	17241.44	in^4
S_{BOTTOM}	17241.44 / 24.68 =	699	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	47.25	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	47.25 - (0.5 x 0) =	47.25	in
Ax	0 x 47.25 =	0	in^3
d	47.25 - 23.62 =	23.63	in
Ad^2	0 x 23.63^2 =	0	in^4

Top Flange Angles

x		6.00	in
t		0.64	in^2
A (each angle)		7.27	in^4
A	2 x 7.2704 =	14.5408	in^2
Ixx, double angles		49.30	in^4
y.bar		1.74	in
x	47.25 - 0 - 1.74 =	45.51	in
Ax	14.5408 x 45.51 =	661.75	in^3
d	45.51 - 23.62 =	21.89	in
Ad^2	14.5408 x 21.89^2 =	6967.55	in^4

Web

d		47.25	in
t_w		0.50	in
A	0.5 x 47.25 =	23.625	in^2
x	47.25 / 2 +0+0	23.625	in
Ax	23.625 x 23.625 =	558.14	in^3
d	23.62 - 23.625 =	0.005	in
Ad^2	23.625 x 0.005^2 =	0	in^4
I_{web}	(0.5) x (47.25)^3 / 12 =	4395.36	in^4

Bottom Flange Angles

x (angle)		6.00	in
t		0.64	in
A (angle)		7.27	in
A	2 x 7.2704 =	14.5408	in^2
Ixx, double angles		49.30	in^4
y.bar		1.74	in
Ax	14.5408 x 1.74 =	25.3	in^3
d	23.62 - 1.74 =	21.88	in
Ad^2	14.5408 x 21.88^2 =	6961.18	in^4

Bottom Cover Plate

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	23.62 - 0 =	23.62	in
Ad^2	0 x 23.62^2 =	0	in^4

GROSS SECTION

Girder Properties

Girder d	0 + 47.25 + 0 + 2 x 0 =	47.25	in
ΣA	0 + 14.5408 + 23.625 + 14.5408 + 0 =	52.707	in^2
ΣAx	0 + 661.75 + 558.14 + 25.3 + 0 =	1245.2	in^3
Xcg	= ΣAx / ΣA =	23.62	in
$ΣAd^2$	0 + 6967.55 + 0 + 6961.18 + 0 =	13,929	in^4
I	$ΣAd^2 + I_{web} + I_{flanges}$ =	18,423	in^4
S_{TOP}	18423 / (47.25 - 23.62) =	780	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)(set equal to Stringer Gage)		78	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	0 * 0^3/12="	0	in^4
Iyy.2A (for top flange double angle)		106.62	in
Iyy (compression flange)	0 + 106.62 =	106.60	in^4
A (compression flange & web)	0 + 14.5408 + 23.625 / 2 =	26.3533	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	2.01	in
A_f	0 + 14.5408 =	14.5408	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (78 / 2.01)^2 =	16,087	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((78 x 47.25 x √1+0.3) / (14.5408)) =	41,299	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	16.09	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (78 / 2.01)^2 =	23,398	psi
			23.4	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (78 x 47.25 / 14.5408) =	60,257	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.40	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

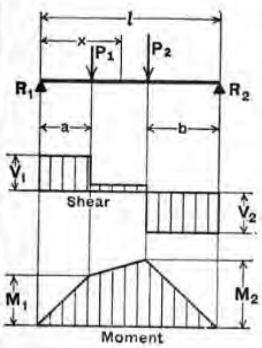
REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

Calculate point loads acting on the floorbeam at the stringer locations. Referencing Figure 11, P1 on the left is reduced while P2 on the right is increased consistent with directing rocking effect and wind in the clockwise direction.

11. SIMPLE BEAM—TWO UNEQUAL CONCENTRATED LOADS UNSYMMETRICALLY PLACED



$R_1 = V_1 \ldots = \frac{P_1(l-a)+P_2 b}{l}$

$R_2 = V_2 \ldots = \frac{P_1 a + P_2(l-b)}{l}$

$V_x \quad \left(\text{when } x > a \text{ and } < (l-b)\right) \ldots = R_1 - P_1$

$M_1 \quad \left(\text{max. when } R_1 < P_1\right) \ldots = R_1 a$

$M_2 \quad \left(\text{max. when } R_2 < P_2\right) \ldots = R_2 b$

$M_x \quad \left(\text{when } x < a\right) \ldots = R_1 x$

$M_x \quad \left(\text{when } x > a \text{ and } < (l-b)\right) \ldots = R_1 x - P_1(x-a)$

Stringer Rating File:

Number of Stringers	2		(recall from Stringer Rating)
Number of Tracks	1		
Deck Type	**open**		
Back Span Length	**25.50**	ft	(recall from End Stringer Rating)
Back Span DL Rxn	**6.12**	k	
Back Span WS+WLL Rxn (+ & -)	**4.08**	k	
Ahead Span Length	**25.50**	ft	(recall from Interior Stringer Rating)
Ahead Span DL Rxn	**6.12**	k	
Ahead Span WS+WLL Rxn (+ & -)	**4.08**	k	
Average Span Length, L.s =	25.50	ft	
Total DL Rxn	12.24	k	
Total WS Rx	8.16	k	

RATING CALCULATIONS

Floorbeam Span, L.f =	**16.17**	ft
Stringer Gage = L - a - b =	**6.50**	ft
a =	**4.84**	ft
b =	4.84	ft

(Without Vertical LL) Solve for P1 and P2 for Case without Wind:

P1.dl =	12.24	k
P2.dl =	12.24	k

(Without Vertical LL) Solve for P1 and P2 for Case with Wind causing Clockwise Rotation:

P1.dl-ws =	4.08	k
P2.dl+ws =	20.40	k

Recall Live Load per Rail reactions from attached worksheets for E80, 286k and 315k Live Loads. For 2-stringer arrangement centered below the track, each stringer delivers the per Rail reaction. Apply IM & RE for calibrated Pi

Pi.E80 =	154.2	k
Pi.286 =	119.0	k
Pi.315 =	130.1	k

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL.s)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects (using Avg Stringer Span)	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d

Rocking Effects (percentage of wheel load)	20.00%
RE = Wheel Percentage * Rail Spacing/L.F = 100/L.F =	6.18%

Speed (mph)	SRF	Impact Vert. Eff.	+RE	+RE Impact	-RE	-RE Impact %
35	0.80	31.02%	6.18%	37.2	-6.18%	24.8
35	0.80	31.02%	6.18%	37.2	-6.18%	24.8
30	0.71	27.61%	6.18%	33.8	-6.18%	21.4
25	0.61	23.58%	6.18%	29.8	-6.18%	17.4
20	0.49	18.93%	6.18%	25.1	-6.18%	12.7
15	0.35	13.65%	6.18%	19.8	-6.18%	7.5
10	0.20	7.76%	6.18%	13.9	-6.18%	1.6

Speed (mph)	P1.E80 (k)	P2.E80 (k)	P1.286 (k)	P2.286 (k)	P1.315 (k)	P1.315 (k)
35	192	212	149	163	162	178
35	192	212	149	163	162	178
30	187	206	145	159	158	174
25	181	200	140	154	153	169
20	174	193	134	149	147	163
15	166	185	128	143	140	156
10	157	176	121	136	132	148

By inspection, maximum moment and maximum shear due to stringer introducted load occurs AT Load P2. The maximum shear due to stringer introduced load is uniform from P2 over to R2.

Dead Load only via stringers:

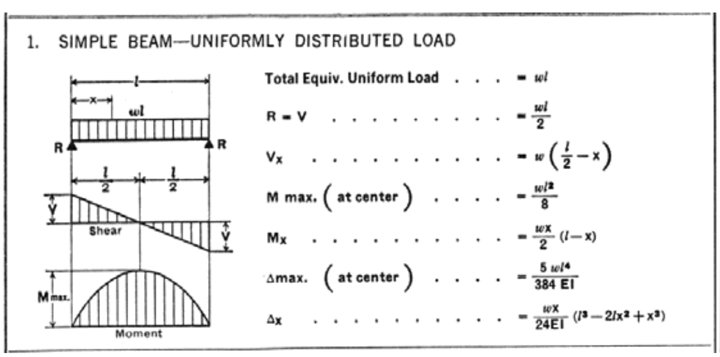
R2.DL = V2 = 12.24 k
M2.DL = 59.1804 k-ft

Dead Load + Wind Load via stringers:

R2.DL+W = V2 = 15.52 k
M2.DL+W = 75.04 k-ft

Proportionally, moment due to floorbeam self weight is trivial in comparison with moments due to stringer introduced loads. Solve for floorbeam self-weight moment occuring AT load P2 to superimpose this demand onto the stringer-introduced moments. Also, solve for maximum self-weight shear at the reaction location R2 to superimpose onto the stringer-introduced shear.

Recall, L.f = 16.17 ft
Recall, b = 4.84 ft
x = L.f - b = 11.34 ft



Recall, FB Area = 52.71 in2
w = 0.18 k/ft

R2.self = 1.45 k
M.x at P2 = M2.self = 4.91 k-t

RATING CALCULATIONS

Summarize Dead and Dead+Wind Loading Effects

V.DL = R2.DL + R2.self = 13.69 k
M.DL = M2.DL + M2.self = 64.09 k-ft

V.DL+W = R2.DL+W + R2.self = 16.97 k
M.DL+W = M2.DL+W + M2.self = 79.95 k-ft

Summarize Live Load Effects

Speed (mph)	V.E80 (k)	M.E80 (k-ft)	V.286 (k)	M.286 (k-ft)	V.315 (k)	M.315 (k-ft)
35	206	995	159	768	174	840
35	206	995	159	768	174	840
30	201	970	155	749	169	818
25	194	940	150	725	164	793
20	187	905	145	699	158	764
15	179	866	138	668	151	730
10	170	822	131	634	143	693

Existing Properties (from Net Section and Gross Section Calculations)

Recall: Fy = 30000 psi

S_{BOTTOM} (Tension - Net Section)				699	in^3
S_{TOP} (Compression - Gross Section)				780	in^3
A_{web} --- NOTE, for LE-88.74 ONLY, redirect Aweb from Nominal between stringers to A' in outside bays with cover plate				23.625	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				16.09	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.40	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 1.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(699 x 16.5 / 12) x (1 - CRF) =	952	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(699 x 24 / 12) x (1 - CRF) =	1384	k-ft
Maximum Compression Stress Capacity - Normal Rating	(780 x 16.087 / 12) x (1 - CRF) =	1035	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(780 x 23.4 / 12) x (1 - CRF) =	1506	k-ft
Maximum Shear Stress Capacity - Normal Rating	(23.625 x 10.5) x (1 - CRF) =	246	k
Maximum Shear Stress Capacity - Maximum Rating	(23.625 x 18) x (1 - CRF) =	421	k

PROJECT : *VDOT Shenandoah Valley Asset 5104*		Michael Baker INTERNATIONAL	
TASK : *Span 3 Floorbeam Rating*		PROJECT NO :	
SUBJECT : *Span 3 Floorbeam Rating*			
CALCULATED BY : *DS*	DATE : *2/19/2025*	CHECKED BY : *JBT*	DATE : 3/20/2025

RATING CALCULATIONS

Group I Girder Ratings for Tension Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E71	E106	E92	E137	E85	E126
35	E71	E106	E92	E137	E85	E126
30	E73	E109	E95	E141	E87	E129
25	E76	E112	E98	E146	E90	E133
20	E78	E117	E102	E151	E93	E138
15	E82	E122	E106	E158	E97	E145
10	E86	E128	E112	E166	E102	E152

Group I Girder Ratings for Compression Stress in Bending

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E78	E116	E101	E150	E93	E137
35	E78	E116	E101	E150	E93	E137
30	E80	E119	E104	E154	E95	E141
25	E83	E123	E107	E159	E98	E146
20	E86	E127	E111	E165	E102	E151
15	E90	E133	E116	E173	E106	E158
10	E95	E140	E122	E182	E112	E166

Group I Girder Ratings for Shear Stress

Speed	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	Normal	Max	Normal	Max	Normal	Max
35	E90	E158	E117	E205	E107	E188
35	E90	E158	E117	E205	E107	E188
30	E93	E162	E120	E210	E110	E193
25	E96	E168	E124	E217	E113	E199
20	E99	E174	E129	E225	E118	E206
15	E104	E182	E134	E236	E123	E216
10	E109	E192	E142	E248	E130	E227

Group I Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E71	E92	E85
Maximum	E106	E137	E126

RATING CALCULATIONS

Group II Allowable Stress Factor = 1.25

Group II Girder Ratings for Tension Stress in Bending

Speed (mph)	Cooper E80 Rating		286k Car Rating		315k Car Rating	
	Normal	Max	Normal	Max	Normal	Max
35	E89	E133	E116	E172	E106	E157
35	E89	E133	E116	E172	E106	E157
30	E92	E136	E119	E176	E109	E161
25	E95	E140	E122	E182	E112	E167
20	E98	E146	E127	E189	E116	E173
15	E103	E152	E133	E198	E122	E181
10	E108	E161	E140	E208	E128	E190

Group II Girder Ratings for Compression Stress in Bending

Speed (mph)	Cooper E80 Rating		286k Car Rating		315k Car Rating	
	Normal	Max	Normal	Max	Normal	Max
35	E98	E145	E126	E188	E116	E172
35	E98	E145	E126	E188	E116	E172
30	E100	E149	E130	E193	E119	E176
25	E103	E153	E134	E199	E122	E182
20	E107	E159	E139	E206	E127	E189
15	E112	E167	E145	E216	E133	E197
10	E118	E175	E153	E227	E140	E208

Group II Girder Ratings for Shear Stress

Speed (mph)	Cooper E80 Rating		286k Car Rating		315k Car Rating	
	Normal	Max	Normal	Max	Normal	Max
35	E113	E198	E146	E256	E134	E235
35	E113	E198	E146	E256	E134	E235
30	E116	E203	E150	E263	E137	E241
25	E120	E210	E155	E272	E142	E248
20	E124	E218	E161	E282	E147	E258
15	E130	E228	E168	E295	E154	E270
10	E137	E240	E177	E310	E162	E284

Group II Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E89	E116	E106
Maximum	E133	E172	E157

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E71	E92	E85
Maximum	E106	E137	E126

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

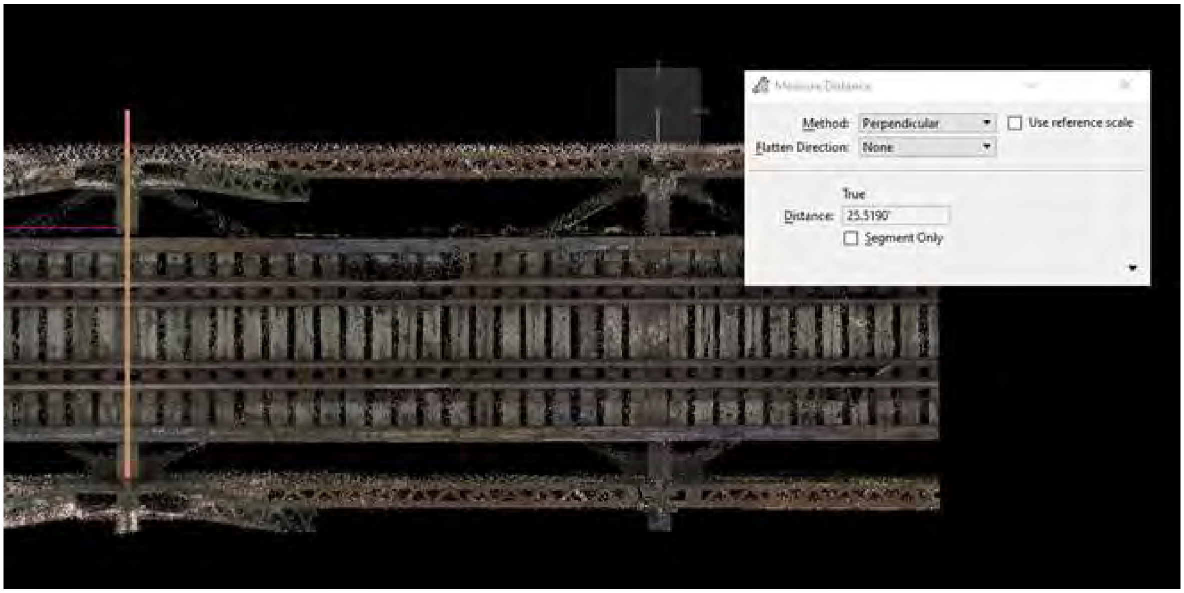
Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E71	E62	E67
Maximum	E106	-	-

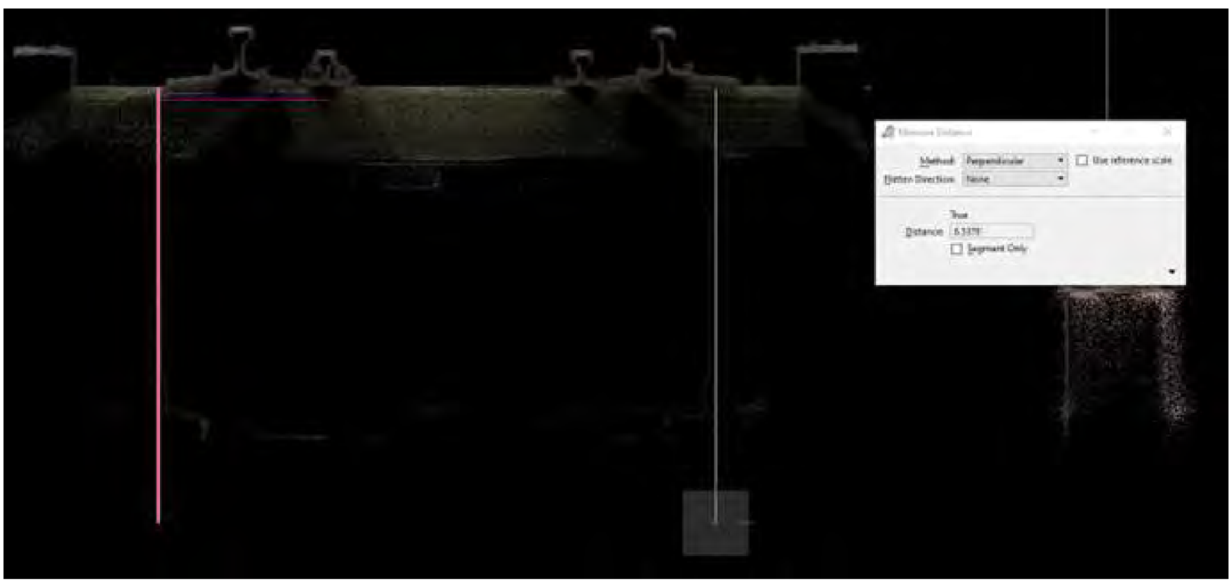
TRUSS RATING FOR SPAN 3

RATING CALCULATIONS
for
STRINGER

Asset 5104 Span 3 Stringer Section Properties



Span Length = 25.5'



Stringer Spacing = 6.5'

Stringer Flange: L6x6x0.9

Stringer Web: D = 37.25"
t = 0.5"

Lateral Bracing Distance:
5.4806'

SUMMARY

Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**25.50**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**6.50**	ft	
Girder Type	**fastened**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**1%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**65.77**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.25**	ft	
Tie Height	**10.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**10.00**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)

Girder Geometry

Depth angle to angle	**37.250**	in	
Effective Rivet/Bolt hole diameter	**0.94**	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	**0.00**	in
t_f	**0.000**	in

Top Flange Angles (0 if they don't exist)

x	**6.00**	in	
y	**6.00**	in	
t	**0.900**	in	
A (each angle)	9.99	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	65.29	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.83		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	151.59	in4	(ref. wksht. TF_Angle_Pair)

Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	**0.00**		This is an assumption based off of photos (photo 014)
Gage	**0.00**	in	
Pitch	**0.00**	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

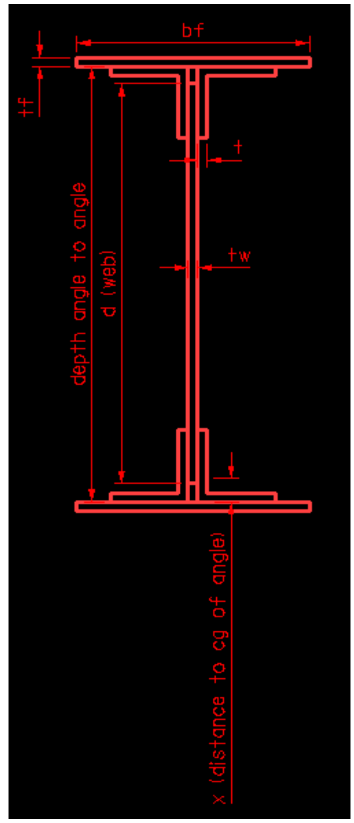
Rows	**0**	
Gage 1	**0.00**	in
Gage 2	**0.00**	in
Pitch	**0.00**	in

Web

d	**37.250**	in
tw	**0.500**	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	**0.00**	
# of Holes in long row	**0.00**	
Gage	**0.00**	in
Pitch	**0.00**	in



Bottom Flange or Cover Plate (0 if does not exist)

b_f	0.00	in	
t_f	0.000	in	

Bottom Flange Angles (0 if they don't exist)

x	6.00	in	
y	6.00	in	
t	0.900	in	
A (each angle)	9.99	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	65.29	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.83	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	151.59	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

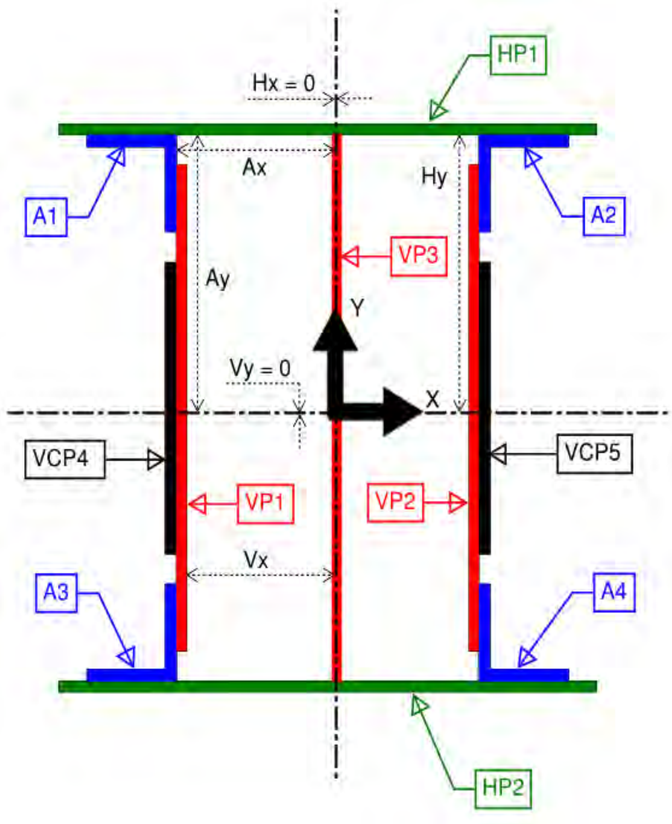
Rows	0.00	in
Gage	0.00	in
Pitch	0.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	2	
Gage 1	3.00	in
Gage 2	3.00	in
Pitch	2.50	in

TF_Angle_Pair

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	6.00	0.9	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	6.00	0.9	-	-	-	-	-0.25	-	out		
A2 (Horiz. Leg)	yes	6.00	0.9	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	6.00	0.9	-	-	-	-	0.25	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)
HP1	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
HP2	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP1	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP2	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP3	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A1 (Horiz. Leg)	5.40	0.45	2.43	0.36	-1.38	10.26	10.62
A1 (Vert. Leg)	4.59	3.45	15.84	9.95	1.62	12.07	22.02
A2 (Horiz. Leg)	5.40	0.45	2.43	0.36	-1.38	10.26	10.62
A2 (Vert. Leg)	4.59	3.45	15.84	9.95	1.62	12.07	22.02
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.83	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.83	0.00	0.00
Σ	**19.98**		**36.53**	**20.63**		**44.66**	**65.29**

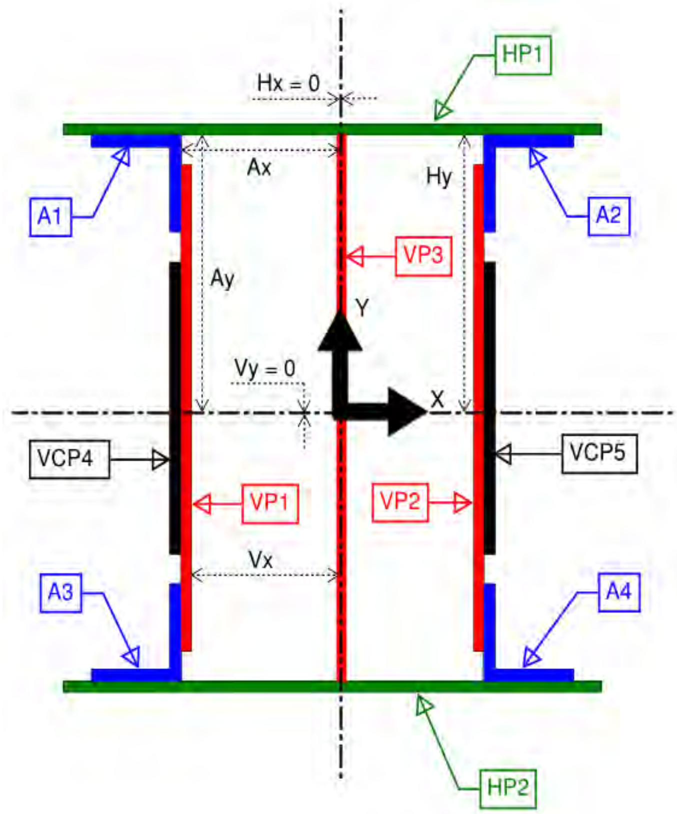
	A_{net} (in^2)
HP1	0.00
HP2	0.00
VP1	0.00
VP2	0.00
VP3	0.00
VCP4	0.00
VCP5	0.00
A1 (Horiz. Leg)	5.40
A1 (Vert. Leg)	4.59
A2 (Horiz. Leg)	5.40
A2 (Vert. Leg)	4.59
A3 (Horiz. Leg)	0.00
A3 (Vert. Leg)	0.00
A4 (Horiz. Leg)	0.00
A4 (Vert. Leg)	0.00
Σ	**19.98**

y_{bar} =	1.83	in	c_{top}=	1.17	in
I_x =	65.29	in^4	c_{bottom}=	4.83	in
A =	19.98	in^2	S_{top} =	55.72	in^3
r_x =	1.81	in	S_{bottom} =	13.52	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	5.40	-3.25	-17.55	16.20	-3.25	57.04	73.24
A1 (Vert. Leg)	4.59	-0.70	-3.21	0.31	-0.70	2.25	2.56
A2 (Horiz. Leg)	5.40	3.25	17.55	16.20	3.25	57.04	73.24
A2 (Vert. Leg)	4.59	0.70	3.21	0.31	0.70	2.25	2.56
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**19.98**		**0.00**	**33.02**		**118.57**	**151.59**

y_{bar} =	0.00	in	c_{left}=	6.25	in
I_y =	151.59	in^4	c_{right}=	6.25	in
A =	19.98	in^2	S_{left} =	24.25	in^3
r_y =	2.75	in	S_{right} =	24.25	in^3

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	no			-	-	-	-	-		out		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	yes	6.00	0.9	-	-	-	-	-	0	out		
A3 (Vert. Leg)	yes	6.00	0.9	-	-	-	-	-0.25	-	out		
A4 (Horiz. Leg)	yes	6.00	0.9	-	-	-	-	-	0	out		
A4 (Vert. Leg)	yes	6.00	0.9	-	-	-	-	0.25	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **12.5** in

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	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)
HP1	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
HP2	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP1	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP2	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VP3	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.83	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.83	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.83	0.00	0.00
A3 (Horiz. Leg)	5.40	0.45	2.43	0.36	-1.38	10.26	10.62
A3 (Vert. Leg)	4.59	3.45	15.84	9.95	1.62	12.07	22.02
A4 (Horiz. Leg)	5.40	0.45	2.43	0.36	-1.38	10.26	10.62
A4 (Vert. Leg)	4.59	3.45	15.84	9.95	1.62	12.07	22.02
Σ	**19.98**		**36.53**	**20.63**		**44.66**	**65.29**

A_{net} (in^2)
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
5.40
4.59
5.40
4.59
Σ 19.98

y_{bar} =	1.83	in	c_{top}=	1.17	in
I_x =	65.29	in^4	c_{bottom}=	4.83	in
A =	19.98	in^2	S_{top} =	55.72	in^3
r_x =	1.81	in	S_{bottom} =	13.52	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	5.40	-3.25	-17.55	16.20	-3.25	57.04	73.24
A3 (Vert. Leg)	4.59	-0.70	-3.21	0.31	-0.70	2.25	2.56
A4 (Horiz. Leg)	5.40	3.25	17.55	16.20	3.25	57.04	73.24
A4 (Vert. Leg)	4.59	0.70	3.21	0.31	0.70	2.25	2.56
Σ	**19.98**		**0.00**	**33.02**		**118.57**	**151.59**

y_{bar} =	0.00	in	c_{left}=	6.25	in
I_y =	151.59	in^4	c_{right}=	6.25	in
A =	19.98	in^2	S_{left} =	24.25	in^3
r_y =	2.75	in	S_{right} =	24.25	in^3

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	37.25	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		0	in
tf		0	in
A	0 x 0 =	0	in2
x	37.25 - (0.5 x 0) =	37.25	in
Ax	0 x 37.25 =	0	in3
d	37.25 - 19.51 =	17.74	in
Ad2	0 x 17.74^2 =	0	in4

Top Flange Angles

x		6	in
t		0.9	in
A (angle)		9.99	in2
Ixxo, Double Angles		65.28611	in4
A	2 x 9.99 =	19.98	in2
y.bar		1.83	in
x	37.25 - 0 - 1.83 =	35.42	in
Ax	19.98 x 35.42 =	707.69	in3
d	35.42 - 19.51 =	15.91	in
Ad2	19.98 x 15.91^2 =	5057	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.9 =	0.9	in
A*	2 x 0.9375 x 0.9 =	0.0000	in^2
x	37.25 - 0.9 / 2 =	36.8	in
Ax	0 x 36.8 =	0	in^3
d	36.8 - 19.51 =	17.29	in
Ad^2	0 x 17.29^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.9 + 0.5 =	2.3	in
A*	0	0.0000	in^2
x	37.25 - 0 - (0 +0)/2 =	37.25	in
Ax	0 x 37.25 =	0	in^3
d	37.25 - 19.51 =	17.74	in
Ad^2	0 x 17.74^2 =	0	in^4

NET SECTION

Web			
d		37.25	in
t_w		0.50	in
A	0.5 x 37.25 =	18.625	in^2
x	0 + 0 + (0.5 x 37.25) =	18.625	in
Ax	18.625 x 18.625 =	346.89	in^3
d	19.51 - 18.625 =	0.885	in
Ad^2	18.625 x 0.885^2 =	14.59	in^4
I_{web}	(0.5) x (37.25)^3 / 12 =	2154	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		0.00	
# of Holes in long row		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0.5 =	0.5	in
A*	0	0.0000	in^2
x	centered on web =	18.625	in
Ax	0 x 18.625 =	0	in^3
d	max =	0.00	in
Ad^2	Total for all holes =	0.00	in^4
I_{holes}	0 x 0.5 x 0.9375^3/12 =	0	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		3.00	in
Gage 2		3.00	in
Pitch		2.50	in
Grip	2 x 0.9 + 0.5 =	2.3	in
A*	2 x 2.5^2 / (4 x 3) x 2.3 =	3.1146	in^2
x	+ (3 + 3) / 2 =	3	in
Ax	3.1146 x 3 =	9	in^3
d	19.51 - 3 =	16.51	in
Ad^2	3.1146 x 16.51^2 =	849	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0 + 0.9 =	0.9	in
A	#DIV/0!	0.0000	in^2
x	0.5 x 0.9 =	0.45	in
Ax	0 x 0.45 =	0	in^3
d	19.51 - 0.45 =	19.06	in
Ad^2	0 x 19.06^2 =	0	in^4

Bottom Flange Angles			
x		6.00	in
t		0.90	in
A (angle)		9.99	in^2
Ixxo, Double Angles		65.29	in^4
A	2 x 9.99 =	19.98	in^2
y.bar		1.83	in
Ax	19.98 x 1.83 =	36.56	in^3
d	19.51 - 1.83 =	17.68	in
Ad^2	19.98 x 17.68^2 =	6245.4	in^4

Bottom Cover Plates			
b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	19.51 - 0 =	19.51	in
Ad^2	0 x 19.51^2 =	0	in^4

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NET SECTION

Girder Properties

Girder d	0 + 0 + 37.25 + 0 + 0 =	37.25	in
ΣA	0 + 19.98 - 0 - 0 + 18.625 - 0 - 3.1146 - 0 + 19.98 + 0 =	55.47	in^2
ΣAx	0 + 707.69 - 0 - 0 + 346.89 - 0 - 9 - 0 + 36.56 + 0 =	1082.14	in^3
Xcg	= ΣAx / ΣA =	19.51	in
ΣAd^2	0 + 5057 - 0 - 0 + 14.59 -0 - 849 - 0 + 6245.4 + 0 =	10467.99	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	12752.56	in^4
S_{BOTTOM}	12752.56 / 19.51 =	654	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	37.25	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	37.25 - (0.5 x 0) =	37.25	in
Ax	0 x 37.25 =	0	in^3
d	37.25 - 18.62 =	18.63	in
Ad^2	0 x 18.63^2 =	0	in^4

Top Flange Angles

x		6.00	in
t		0.90	in^2
A (each angle)		9.99	in^4
A	2 x 9.99 =	19.98	in^2
Ixx, double angles		65.29	in^4
y.bar		1.83	in
x	37.25 - 0 - 1.83 =	35.42	in
Ax	19.98 x 35.42 =	707.69	in^3
d	35.42 - 18.62 =	16.80	in
Ad^2	19.98 x 16.8^2 =	5639.16	in^4

Web

d		37.25	in
t_w		0.50	in
A	0.5 x 37.25 =	18.625	in^2
x	37.25 / 2 +0+0	18.625	in
Ax	18.625 x 18.625 =	346.89	in^3
d	18.62 - 18.625 =	0.005	in
Ad^2	18.625 x 0.005^2 =	0	in^4
I_{web}	(0.5) x (37.25)^3 / 12 =	2153.61	in^4

Bottom Flange Angles

x (angle)		6.00	in
t		0.90	in
A (angle)		9.99	in
A	2 x 9.99 =	19.98	in^2
Ixx, double angles		65.29	in^4
y.bar		1.83	in
Ax	19.98 x 1.83 =	36.56	in^3
d	18.62 - 1.83 =	16.79	in
Ad^2	19.98 x 16.79^2 =	5632.44	in^4

Bottom Cover Plate

b_f		0.00	in
t_f		0.00	in
A	0 x 0 =	0	in^2
x	0.5 x 0 =	0	in
Ax	0 x 0 =	0	in^3
d	18.62 - 0 =	18.62	in
Ad^2	0 x 18.62^2 =	0	in^4

GROSS SECTION

Girder Properties

Girder d	0 + 37.25 + 0 + 2 x 0 =	37.25	in
ΣA	0 + 19.98 + 18.625 + 19.98 + 0 =	58.585	in^2
ΣAx	0 + 707.69 + 346.89 + 36.56 + 0 =	1091.1	in^3
Xcg	= ΣAx / ΣA =	18.62	in
$ΣAd^2$	0 + 5639.16 + 0 + 5632.44 + 0 =	11,272	in^4
I	$ΣAd^2 + I_{web} + I_{flanges}$ =	13,556	in^4
S_{TOP}	13556 / (37.25 - 18.62) =	728	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		65.7672	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	0 * 0^3/12="	0	in^4
Iyy.2A (for top flange double angle)		151.59	in
Iyy (compression flange)	0 + 151.59 =	151.60	in^4
A (compression flange & web)	0 + 19.98 + 18.625 / 2 =	29.2925	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	2.27	in
A_f	0 + 19.98 =	19.98	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (65.7672 / 2.27)^2 =	16,270	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((65.7672 x 37.25 x √1+0.3) / (19.98)) =	85,370	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	16.27	ksi

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GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (65.7672 / 2.27)^2 =	23,664	psi
			23.66	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (65.7672 x 37.25 / 19.98) =	124,559	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.66	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

25.5	Span Length (ft)	6.5	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.25	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
10.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
10.00	Tie Length (ft)			fastened	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**630.63**	k-ft
E80 Shear	**114.59**	k

286k Car

286k Car Moment	**486.89**	k-ft
286k Car Shear	**114.59**	k

315k Car

315k Car Moment	**532.06**	k-ft
315k Car Shear	**100.68**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	25.50	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	26.01	k-ft
Wind on Live Load Shear	4.08	k

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2) Percentage of wheel load taken by one beam	15.38%

Dead Load on One Girder

Girder	58.585/144*490="	199.4	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 5% for Connections		x1.05	
Total Steel Load	1.05 x (199.4 + 0) =	209	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	10/12 x 10/12 x 10 x 60 =	417	lb
Number of ties	25.5 ft / 1.25 ft =	20.4	ties
Number of Beams		2	
Tie Weight/ LF of beam		167	lb / ft

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RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		6.95	ft^3
Ties per LF of Bridge		0.8	ties
Average Area of Ties per LF of Bridge		5.56	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**0.00**	lb / ft
Total Dead Load		**476**	**lb / ft**
		0.48	k / ft
Moment	**0.48 x 25.5^2 / 8 =**	**39.02**	**k-ft**
Shear	**0.48 x 25.5 / 2 =**	**6.12**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)			654	in^3
S_{TOP} (Compression - Gross Section)			728	in^3
A_{web}			18.625	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500 =	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)			16.27	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500 =	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000 =	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)			23.66	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000 =	18	ksi

PROJECT : *VDOT Shenandoah Valley Asset 5104*

TASK : *Span 3 Stringer Rating* PROJECT NO :

SUBJECT : *Span 3 Stringer Rating*

CALCULATED BY : *DS* DATE : *2/19/2025* CHECKED BY : *JBT* DATE : 3/20/2025

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RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 1.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(654 x 16.5 / 12) x (1 - CRF) =	890	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(654 x 24 / 12) x (1 - CRF) =	1295	k-ft
Maximum Compression Stress Capacity - Normal Rating	(728 x 16.27 / 12) x (1 - CRF) =	977	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(728 x 23.66 / 12) x (1 - CRF) =	1421	k-ft
Maximum Shear Stress Capacity - Normal Rating	(18.625 x 10.5) x (1 - CRF) =	194	k
Maximum Shear Stress Capacity - Maximum Rating	(18.625 x 18) x (1 - CRF) =	332	k

Girder Ratings for Tension Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	15.38%	46.4	E71	E107	E93	E138	E85	E126
35	0.80	31.02%	15.38%	46.4	E71	E107	E93	E138	E85	E126
30	0.71	27.61%	15.38%	43.0	E73	E109	E95	E141	E87	E129
25	0.61	23.58%	15.38%	39.0	E75	E112	E98	E145	E89	E133
20	0.49	18.93%	15.38%	34.3	E78	E116	E101	E150	E92	E138
15	0.35	13.65%	15.38%	29.0	E81	E121	E105	E157	E96	E143
10	0.20	7.76%	15.38%	23.1	E85	E127	E110	E164	E101	E150

Girder Ratings for Compression Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	15.38%	46.4	E79	E117	E102	E152	E94	E139
35	0.80	31.02%	15.38%	46.4	E79	E117	E102	E152	E94	E139
30	0.71	27.61%	15.38%	43.0	E81	E120	E105	E156	E96	E143
25	0.61	23.58%	15.38%	39.0	E83	E124	E108	E160	E99	E147
20	0.49	18.93%	15.38%	34.3	E86	E128	E112	E166	E102	E152
15	0.35	13.65%	15.38%	29.0	E90	E133	E116	E173	E106	E158
10	0.20	7.76%	15.38%	23.1	E94	E140	E122	E181	E111	E166

Girder Ratings for Shear Stress

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
35	0.80	31.02%	15.38%	46.4	E88	E153	E88	E153	E100	E175
35	0.80	31.02%	15.38%	46.4	E88	E153	E88	E153	E100	E175
30	0.71	27.61%	15.38%	43.0	E90	E157	E90	E157	E102	E179
25	0.61	23.58%	15.38%	39.0	E92	E162	E92	E162	E105	E184
20	0.49	18.93%	15.38%	34.3	E96	E167	E96	E167	E109	E190
15	0.35	13.65%	15.38%	29.0	E99	E174	E99	E174	E113	E198
10	0.20	7.76%	15.38%	23.1	E104	E183	E104	E183	E119	E208

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E71	E88	E85
Maximum	E107	E138	E126

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E71	E65	E67
Maximum	E107	-	-

Submittal ______ Date 03/21/2025
CHECK PRINT
Made By DS Date 12/04/2024
Checked By MSF Date 12/04/2024
Backchecked By DS Date 12/05/2024
Corrected By DS Date 12/05/2024
Verified By MF Date 12/05/2024

ASSET 6141 ROLLED BEAM

RATING CALCULATIONS

SUMMARY

STRUCTURE INFORMATION

Number of Spans	1.00		
Span Length	43.75	ft	
Fascia CL to Fascia CL	6.90	ft	
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Fy	30,000	psi	Assumed
Floorbeam Spacing	0.00	ft	
Ballast Depth (top of tie	0.00	in	
Tie Spacing	1.08	ft	(assumed)
Tie Height	9.50	in	
Tide Width	9.75	in	
Tie Length	10.00	ft	
Girder Type	rolled		
		rolled, welded, or fastened	

Number of Tracks	1.00		
Number of Girders	4.00		
Lateral Bracing Distance	45.00	in	(field verified)
Number of Diaphragms	10		
Diaphragm Weight/LF	73.00	lb/lf	
Ballast Width	0.00	ft	
Deck Material	steel	(steel or concrete)	
Deck Width	0.00	ft	
Deck Thickness	0.00	in	

Girder Measurements

Depth angle to angle	33.36	in	
Effective Rivet/Bolt hole diameter	1.00	in	AREMA 1.5.8. e

Top Flange or Cover Plate

b_f	16.66	in
t_f	1.680	in

Top Flange Angles (0 if they don't exist)

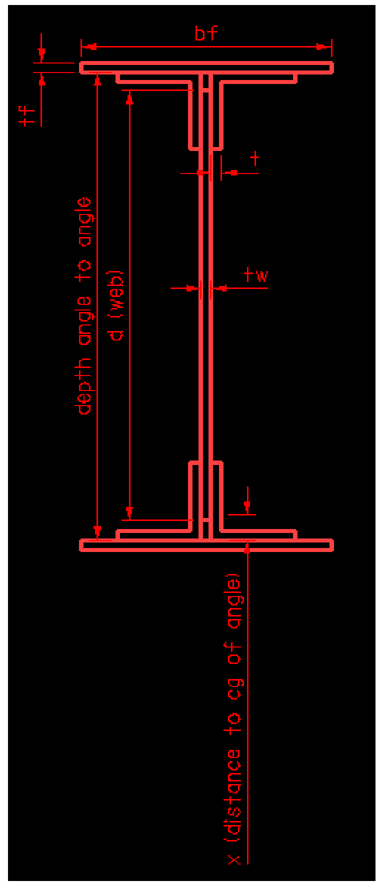
x	0.00	in
t	0.000	in
A (angle)	0.00	in2
Ixx, Double Angles	0.00	in4
y	0.00	in
Iyy, Single Angle	0.00	in4

Holes Through Top cover plates and top flange angles

Rows	0.00	
Gage	0.00	in
Pitch	0.00	in

Holes Through Top Flange Angles and Web

Rows	0.00	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in



SUMMARY

Web

d	**33.36**	in
tw	**0.9450**	in

Holes Through Web at Diaphragm Connection

Total # of Holes	**7.00**	
# of Holes in long row	**7.00**	
Gage	**5.00**	in
Pitch	**0.00**	in

Bottom Flange or Cover Plate

b_f	**16.66**	in
t_f	**1.680**	in

Bottom Flange Angles (0 if they don't exist)

x	**0.00**	in
t	**0.000**	in
A (angle)	**0.00**	in2
I, Double Angles	**0.00**	in4

Holes Through Bottom cover plates and bottom flange angles

Rows	**0.00**	
Gage	**0.00**	in
Pitch	**0.00**	in

Holes Through Bottom Flange Angles and Web

Rows	**0.00**	
Gage 1	**0.00**	in
Gage 2	**0.00**	in
Pitch	**0.00**	in

Capacity Reduction Calculation

Girder Measurements

Cover Plate Dimensions		
Width (wcp)	**16.7**	in
Thickness (tcp)	**1.680**	in
Flange Dimensions		
Width (wf)	**17**	in
Height (hf)	**0**	in
Thickness (tf)	**1.760**	in
Web Dimensions		
Thickness (tw)	**0.9450**	in
Depth (d)	**33.3600**	in

Section Loss

			Formula for Loss
Top Flange		in^2	
Exterior	**1.03750**	in^2	=(1/16)*tf
Interior	**0.00000**	in^2	#N/A
Web	**0.25000**	in^2	=2*1/8
Bottom Flange		in^2	
Exterior	**2.25000**	in^2	=0.75*3
Interior	**0.00000**	in^2	#N/A
Total Loss	3.54	in^2	=SUM(C28:C34)
Net Area of Girder	80.88	in^2	='Net Section'!H84
% Reduction	4.37%		

PROJECT : *VDOT Shenandoah Valley Asset 6141*		Michael Baker INTERNATIONAL
TASK : *Girder Load Rating*	PROJECT NO :	
SUBJECT : -		
CALCULATED BY : *DS* DATE : *12/3/2024*	CHECKED BY : *MSF*	DATE : *12/6/2024*

CAPACITY REDUCTION

typical - minor SL 1"-2" on web
1/16"-1/8" (conserv)
1/16" fl & 1/8" @ web
start on CAS   to flanges and webs
between paired beams

3/4" inward SL 3" wd NF B4 5' w of a bF

Centrifugal Force

Rail Gauge:	5.00	ft (see email with track measurements & location)
Superelevation:	1.50	in (see track chart)
Design Speed:	25.00	mph (see track chart)
Degree of Curvature:	3.00	degrees (see track chart)
Span Length:	43.75	ft
Superstructure Depth:	36.72	ft (deepest girder section)
Top of Rail to T/Girder:	1.38	ft (tie + rail height)
Girder Spacing:	3.23	ft
Tie Height:	9.50	in (see tie plans)
Tie Width:	9.75	in (see tie plans)
Tie Length:	10.00	ft (see tie plans)
Tie Spacing:	1.08	ft (estimated)

15-1.3.6 Centrifugal Force:

Dcf (Height above rail) =	8.00	ft
C =	0.02	(Superstructure)
Theta:	0.29	
Hcf (Height above low rail):	8.41	
Couple (Moment arm of CF):	1.68	
CF Factor:	0.02	

Superelevation Effects

offset:	2.30	in
Ratio(inner):	1.08	
Ratio(outer):	0.92	

CE + Super., Inner Girder:	1.10	M_{LL+I} factor for Inner Girder (See Ex. 4.7b)
CE + Super., Outer Girder:	0.94	M_{LL+I} factor for Outer Girder (See Ex. 4.7b)
Max Factor:	1.10	

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	33.36	in	
Effective rivet hole diameter	1	in	7/8" dia. Rivets
Clear Distance Web to Flange Angle	0	in	

Top Cover Plates

bf		16.655	in
tf		1.68	in
A	1.68 x 16.655 =	27.9804	in2
x	36.72 - (0.5 x 1.68) =	35.88	in
Ax	27.9804 x 35.88 =	1004	in3
d	35.88 - 18.37 =	17.51	in
Ad2	27.9804 x 17.51^2 =	8579	in4

Top Flange Angles

x		0	in
t		0	in
A (angle)		0	in2
I, Double Angles		0	in4
A	2 x 0 =	0	in2
x	36.72 - 1.68 - 0 =	35.04	in
Ax	0 x 35.04 =	0	in3
d	35.04 - 18.37 =	16.67	in
Ad2	0 x 16.67^2 =	0	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1.68 + 0 =	1.68	in
A*	2 x 1 x 1.68 =	0.0000	in^2
x	36.72 - 1.68 / 2 =	35.88	in
Ax	0 x 35.88 =	0	in^3
d	35.88 - 18.37 =	17.51	in
Ad^2	0 x 17.51^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.945 =	0.945	in
A*	1 x 1 x 0.945 =	0.0000	in^2
x	6.72 - 1.68 - (0.001 +0.001)/2 =	35.039	in
Ax	0 x 35.039 =	0	in^3
d	35.039 - 18.37 =	16.669	in
Ad^2	0 x 16.669^2 =	0	in^4

NET SECTION

Web			
d		33.36	in
t_w		0.95	in
A	0.945 x 33.36 =	31.5252	in^2
x	1.68 + 0 + (0.5 x 33.36) =	18.36	in
Ax	31.5252 x 18.36 =	579	in^3
d	18.37 - 18.36 =	0.01	in
Ad^2	31.5252 x 0.01^2 =	0	in^4
I_{web}	).945) x (33.36)^3 / 12 =	2924	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		7.00	
# of Holes in long row		7.00	
Gage		5.00	in
Pitch		0.00	in
Grip	0.945 =	0.945	in
A*	7 x 1 x 0.945 =	6.6150	in^2
x	centered on web =	18.36	in
Ax	6.615 x 18.36 =	121	in^3
d	max =	15.00	in
Ad^2	Total for all holes =	661.50	in^4
I_{holes}	7 x 0.945 x 1^3/12 =	0.55	in^4

Holes Through Bottom Flange L's and Web			
Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.945 =	0.945	in
A*	1 x 1 x 0.945 =	0.0000	in^2
x	+ (0.001 + 0.001) / 2 =	1.681	in
Ax	0 x 1.681 =	0	in^3
d	18.37 - 1.681 =	16.689	in
Ad^2	0 x 16.689^2 =	0	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1.68 + 0 =	1.68	in
A	2 x 1 x 1.68 =	0.0000	in^2
x	0.5 x 1.68 =	0.84	in
Ax	0 x 0.84 =	0	in^3
d	18.37 - 0.84 =	17.53	in
Ad^2	0 x 17.53^2 =	0	in^4

Bottom Flange Angles			
x		0.00	in
t		0.00	in
A (angle)		0.00	in^2
I, Double Angles		0.00	in^4
A	2 x 0 =	0	in^2
x	1.68 + 0 =	1.68	in
Ax	0 x 1.68 =	0	in^3
d	18.37 - 1.68 =	16.69	in
Ad^2	0 x 16.69^2 =	0	in^4

Bottom Cover Plates			
b_f		16.66	in
t_f		1.68	in
A	1.68 x 16.66 =	27.9888	in^2
x	0.5 x 1.68 =	0.84	in
Ax	27.9888 x 0.84 =	24	in^3
d	18.37 - 0.84 =	17.53	in
Ad^2	27.9888 x 17.53^2 =	8601	in^4

NET SECTION

Girder Properties

Girder d	1.68 + 0 + 33.36 + 0 + 1.68 =	36.72	in
ΣA	27.9804 + 0 - 0 - 0 + 31.5252 - 6.615 - 0 - 0 + 0 + 27.9888 =	80.88	in^2
ΣAx	1004 + 0 - 0 - 0 + 579 - 121 - 0 - 0 + 0 + 24 =	1486	in^3
Xcg	= ΣAx / ΣA =	18.37	in
ΣAd^2	8579 + 0 - 0 - 0 + 0 -661.5 - 0 - 0 + 0 + 8601 =	16518.5	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	19442.00	in^4
S_{BOTTOM}	19442 / (36.72 - 18.37) =	1060	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Top Cover Plates

b_f		16.66	in
t_f		1.68	in
A	1.68 x 16.655 =	27.9804	in^2
x	36.72 - (0.5 x 1.68) =	35.88	in
Ax	27.9804 x 35.88 =	1004	in^3
d	35.88 - 18.36 =	17.52	in
Ad^2	27.9804 x 17.52^2 =	8589	in^4

Top Flange Angles

x		0.00	in
t		0.00	in^2
A (angle)		0.00	in^4
A	2 x 0 =	0	in^2
I, double angles		0.00	in^4
x	36.72 - 1.68 - 0 =	35.04	in
Ax	0 x 35.04 =	0	in^3
d	35.04 - 18.36 =	16.68	in
Ad^2	0 x 16.68^2 =	0	in^4

Web

d		33.36	in
t_w		0.95	in
A	0.945 x 33.36 =	31.5252	in^2
x	1.125 + + (0.5 x 23) =	18.36	in
Ax	31.5252 x 18.36 =	578.8	in^3
d	18.36 - 18.36 =	0	in
Ad^2	31.5252 x 0^2 =	0	in^4
I_{web}	).945) x (33.36)^3 / 12 =	2924	in^4

Bottom Flange Angles

x (angle)		0.00	in
t		0.00	in
A (angle)		0.00	in
A	2 x 0 =	0	in^2
I, double angles		0.00	in^4
x	1.68 + 0 =	1.68	in
Ax	0 x 1.68 =	0	in^3
d	18.36 - 1.68 =	16.68	in
Ad^2	0 x 16.68^2 =	0	in^4

Bottom Cover Plate

b_f		16.66	in
t_f		1.68	in
A	1.68 x 16.66 =	27.9888	in^2
x	0.5 x 1.68 =	0.84	in
Ax	27.9888 x 0.84 =	24	in^3
d	18.36 - 0.84 =	17.52	in
Ad^2	27.9888 x 17.52^2 =	8591	in^4

GROSS SECTION

Girder Properties

Girder d	1.68 + 33.36 + 1.68 + 2 x 0 =	36.72	in
ΣA	27.9804 + 0 + 31.5252 + 0 + 27.9888 =	87.494	in^2
ΣAx	1004 + 0 + 578.8 + 0 + 24 =	1606.8	in^3
Xcg	= ΣAx / ΣA =	18.36	in
ΣAd^2	8589 + 0 + 0 + 0 + 8591 =	17,180	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	20,104	in^4
S_{TOP}	20104 / (36.72 - 18.36) =	1,095	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		45	in
y (for top flange angle)		0	in
Iyy (for top flange single angle)		0	in
Iyy (compression flange & web)	1.68 x 16.655^3 / 12 + 2 x 0 + 2 x 0 x (0.945 / 2 + 0)^2 =	646.8	in^4
A (compression flange & web)	27.9804 + 0 + 31.5252 / 2 =	43.743	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	3.85	in
A_f	27.9804 + 0 =	27.9804	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (45 / 3.85)^2 =	16,462	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((45 x 36.72 x √1+0.3) / 27.9804) =	177,250	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	rolled	
	Allowable Stress =	16.50	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (45 / 3.85)^2 =	23,945	psi
			23.95	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (45 x 36.72 / 27.9804) =	258,616	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	rolled	
		Allowable Stress =	24.00	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

LOAD CALCULATIONS:

43.75	Span Length (ft)	6.90	CL Fascia to CL Fascia (ft)	steel	Deck
5	Rail Spacing (ft)	4	Number of Girders	0.00	Deck Width (ft)
1.08	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
9.50	Tie Height (in)			10	Number of Diaphragms
9.75	Tie Width (in)	0	Floorbeam Spacing (ft)	73.00	Weight of Diaphragm (LB/FT)
10.00	Tie Length (ft)			rolled	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment (factored for CF)	**837.04**	k-ft
E80 Shear (Factored for CF)	**87.74**	k

286k Car

286k Car Moment	**621.76**	k-ft
286k Car Shear	**65.44**	k

315k Car

315k Car Moment	**682.71**	k-ft
315k Car Shear	**68.05**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	43.75	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	2	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.16	k/ft
Wind on Live Load Moment	38.28	k-ft
Wind on Live Load Shear	3.50	k

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	1 - (0.8 / 2500) x (60 - SL)^2
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	2
*Rocking distributed among half the beams since it acts downwards on only one rail	
Percentage of wheel load taken by one beam	10.00%

Dead Load on One Girder

Girder	87.4944 / 144 x 490 =	297.7	lb / ft
Diaphragms			
Number		10	
Total Length		68.95833	
Weight per foot		73.00	lb / ft
Total Weight		5033.958	lbs
Number of girders		4	
Weight per foot of beam		28.8	lb / ft
Add 5% for Connections		x1.15	
Total Steel Load	1.05 x (297.7 + 28.8) =	375	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		4	
Rail Weight/LF of beam		50	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	9.5/12 x 9.75/12 x 10 x 60 =	386	lb
Number of ties	43.75 ft / 1.08333333333333 ft =	40.38462	ties
Number of Beams		4	
Tie Weight/ LF of beam		89	lb / ft

PROJECT : *VDOT Shenandoah Valley Asset 6141*			
TASK : *Girder Load Rating*		PROJECT NO :	
SUBJECT : -			
CALCULATED BY : *DS*	DATE : *12/3/2024*	CHECKED BY : *MSF*	DATE : *12/6/2024*

Michael Baker INTERNATIONAL

RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		6.433333	ft^3
Ties per LF of Bridge		0.923077	ties
Average Area of Ties per LF of Bridge		5.938462	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		4	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		steel	
Unit weight of deck per AREMA 15.1.3.2.a -		490	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		4	
Weight of Deck per LF of Beam		0	lb / ft
Total Dead Load		**514**	**lb / ft**
		0.51	k / ft
Moment	**0.51 x 43.75^2 / 8 =**	**122**	**k-ft**
Shear	**0.51 x 43.75 / 2 =**	**11**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				1060	in^3
S_{TOP} (Compression - Gross Section)				1,095	in^3
A_{web}				31.5252	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				16.5	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				24.00	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 4.4%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(1060 x 16.5 / 12) x (1 - CRF) =	1394	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(1060 x 24 / 12) x (1 - CRF) =	2027	k-ft
Maximum Compression Stress Capacity - Normal Rating	(1095 x 16.5 / 12) x (1 - CRF) =	1440	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(1095 x 24 / 12) x (1 - CRF) =	2094	k-ft
Maximum Shear Stress Capacity - Normal Rating	(31.5252 x 10.5) x (1 - CRF) =	317	k
Maximum Shear Stress Capacity - Maximum Rating	(31.5252 x 18) x (1 - CRF) =	543	k

Girder Ratings for Tension Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
25	0.61	22.14%	10.00%	32.1	E89	E135	E120	E182	E109	E166

Girder Ratings for Compression Stress in Bending

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
25	0.61	22.14%	10.00%	32.1	E93	E140	E125	E188	E113	E171

Girder Ratings for Shear Stress

Speed (mph)	SRF	Impact Vert. Eff.	RE	Impact %	Cooper E80 Rating		286k Car Rating		315k Car Rating	
					Normal	Max	Normal	Max	Normal	Max
25	0.61	22.14%	10.00%	32.1	E209	E365	E280	E489	E269	E470

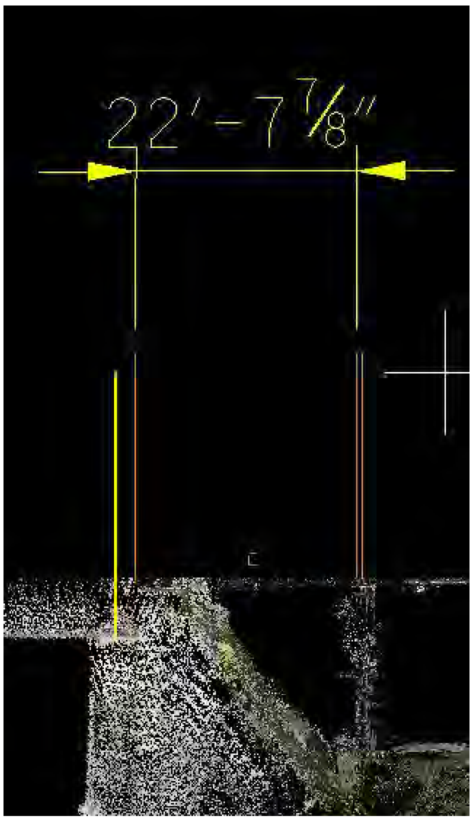
Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E89	E120	E109
Maximum	E135	E182	E166

ASSET 7643 ROLLED BEAM
SPAN 5 JUMP SPAN
RATING CALCULATIONS

VDOT Shenandoah Valley Asset 7643 Span Jump Span Load Rating

- Superstructure rating considers dead load (bridge and walkway self-weight), live load (E-80, 286k and 315k live loads) and wind on loaded bridge.
- Due to lack of record drawings the dimensions used to develop the span geometry and section properties were taken from field measurements and survey.
- An additional 5% was added to the steel weight to account for connections and the top lateral bracing between the beams.
- Span length was taken from the point cloud data provided and can be seen in the image below. The multiple jump spans vary in span length, with span 5 being the longer span.



- Tie dimensions were taken from the inspection notes provided. See image below.

- Lateral bracing could not be clearly identified from the point cloud data. Therefore, the lateral bracing of an adjacent span that was more clear was used to define lateral bracing distance.

- Beam dimensions were taken from the field notes, see the image below.

- Section loss was taken as an assumed percentage of section loss for the member. Section loss in the measured in the field was minor. A conservative assumption of 2% capacity reduction was assumed.
- The steel walkway connected to the structure was calculated based on the image below. The total dead load of the walkway was calculated to be 165 LB/FT.

Walkway channel
d=10 1/8"
flange width = 3 1/8"
flange thickness = 0.52"
web thickness = 0.84"

Posts L3x3x3/8

Walkway stringer
d=8 1/4"
flange width = 8 1/8"
flange thickness = .46"
web thickness = 0.32"

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	22.75	-	-	1820
WALKWAY CHANNEL (C10x30)	-	30	-	15.75	11.04167	3.0	1417.5
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	3	108
STEEL GRATING	7.4	-	4	22.75	-	-	673.4
						TOTAL:	4018.9
						LB/FT	176.6549451
						ADD 5%	186

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	22.75	-	-	1820
WALKWAY BEAM (W6x25)	-	25	-	15.75	11.04167	3.0	1181.25
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	3	108
STEEL GRATING	7.4	-	4	22.75	-	-	673.4
						TOTAL:	3782.65
						LB/FT	166.2703297
						ADD 5%	175

- The jump spans were added to the bridge at an unknown date, likely to reduce demand on the abutments, and therefore have an unknown Fy. Below are results based on the varying yield strength values. For the structure to rate (E80) an Fy of 50 ksi would be needed. It is suggested that steel coupon testing be performed to confirm the yield strength of the steel.

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E60	E78	E71
Maximum	E91	E118	E108

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E60	E62	E68
Maximum	E91	-	-

Fy = 30 ksi

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E74	E95	E87
Maximum	E111	E143	E131

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E74	E62	E68
Maximum	E111	-	-

Fy = 36 ksi

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E105	E137	E125
Maximum	E157	E203	E185

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E105	E62	E68
Maximum	E157	-	-

Fy = 50 ksi

Historical Listing of Selected Structural Steels

CSA Standards

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
A16	1924	½ F_u	½ F_u	55 - 65	380 - 450
S39	1935	30	210	55 - 65	380 - 450
S40	1935	33	230	60 - 72	410 - 500
G40.4	1950	33	230	60 - 72	410 - 500
G40.5	1950	33	230	60 - 72	410 - 500
G40.6	1950	45 [1]	310	80 - 95	550 - 650
G40.8	1960	40 [3]	280	65 - 85	450 - 590
G40.12	1964 *	44 [2]	300	65	450
G40.21	1973 **	Replaced all previous Standards, see CISC Handbook			

* Introduced in May 1962 by the Algoma Steel Corporation as "Algoma 44"
** In May 1997, grade 350W became the only grade for W and HP shapes produced by Algoma Steel Inc.
[1] Silicon steel
[2] Yield reduces when thickness exceeds 1½ inches (40 mm).
[3] Yield reduces when thickness exceeds ⅝ inches (16 mm).

Rivet Steel

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
G40.2	1950	28	190	52 - 62	360 - 430

ASTM Specifications

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
A7 (bridges) A9 (buildings)	1914*	½ F_u	½ F_u	55 - 65	380 - 450
	1924	½ $F_u \geq 30$	½ $F_u \geq 210$	55 - 65	380 - 450
	1934	½ $F_u \geq 33$	½ $F_u \geq 230$	60 - 72	410 - 500
A373	1954	32	220	58 - 75	400 - 520
A242	1955	50 [1]	350	70 [1]	480
A36	1960	36	250	60 - 80	410 - 550
A440	1959	50 [1]	350	70 [1]	480
A441	1960	50 [1]	350	70 [1]	480
A572 grade 50	1966	50	345	65	450
A588	1968	50 [1]	345	70 [1]	485
A992	1998	50 min. to 65 max.	345 min. to 450 max.	65	450

[1] Reduces with increasing thickness
* Between 1900 and 1909, medium steel in A7 and A9 had a tensile strength 5 ksi higher than that adopted in 1914.

Reference: Handbook of Steel Construction, 8th Edition, CISC, 2004.

Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**22.75**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**8.00**	ft	
Girder Type	**rolled**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**2%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**75.75**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.25**	ft	
Tie Height	**14.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**11.99**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)

SUMMARY

Girder Geometry

Depth angle to angle	27.630	in	
Effective Rivet/Bolt hole diameter	0.00	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	14.00	in
t_f	1.000	in

Top Flange Angles (0 if they don't exist)

x	0.00	in	
y	0.00	in	
t	0.000	in	
A (each angle)	0.00	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	0.00	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	0.00		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	0.00	in4	(ref. wksht. TF_Angle_Pair)

Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00		This is an assumption based off of photos
Gage	0.00	in	(photo 014)
Pitch	0.00	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

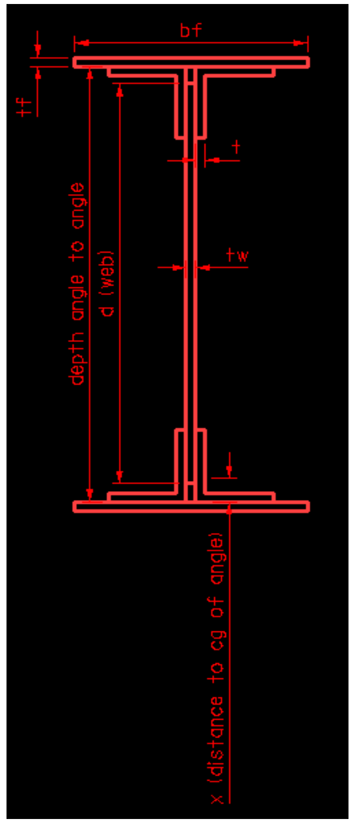
Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web

d	25.630	in
tw	0.620	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	0.00	
# of Holes in long row	0.00	
Gage	0.00	in
Pitch	0.00	in



Bottom Flange or Cover Plate (0 if does not exist)

b_f	14.00	in
t_f	1.000	in

Bottom Flange Angles (0 if they don't exist)

x	0.00	in	
y	0.00	in	
t	0.000	in	
A (each angle)	0.00	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	0.00	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	0.00	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	0.00	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00	in
Gage	0.00	in
Pitch	0.00	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	27.63	in
Effective rivet hole diameter	0	in
Clear Distance Web to Flange Angle	1	in

Top Cover Plates

bf		14	in
tf		1	in
A	1 x 14 =	14	in2
x	29.63 - (0.5 x 1) =	29.13	in
Ax	14 x 29.13 =	407.82	in3
d	29.13 - 14.82 =	14.31	in
Ad2	14 x 14.31^2 =	2866.87	in4

Top Flange Angles

x		0	in
t		0	in
A (angle)		0	in2
Ixxo, Double Angles		0	in4
A	2 x 0 =	0	in2
y.bar		0.00	in
x	29.63 - 1 - 0 =	28.63	in
Ax	0 x 28.63 =	0	in3
d	28.63 - 14.82 =	13.81	in
Ad2	0 x 13.81^2 =	0	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1 + 0 =	1	in
A*	2 x 0 x 1 =	0.0000	in^2
x	29.63 - 1 / 2 =	29.13	in
Ax	0 x 29.13 =	0	in^3
d	29.13 - 14.82 =	14.31	in
Ad^2	0 x 14.31^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.62 =	0.62	in
A*	0	0.0000	in^2
x	).63 - 1 - (0.00001 +0.0001)/2 =	28.62995	in
Ax	0 x 28.629945 =	0	in^3
d	28.629945 - 14.82 =	13.8099	in
Ad^2	0 x 13.8099^2 =	0	in^4

NET SECTION

Web			
d		25.63	in
t_w		0.62	in
A	0.62 x 25.63 =	15.8906	in^2
x	1 + 1 + (0.5 x 25.63) =	14.815	in
Ax	15.8906 x 14.815 =	235.42	in^3
d	14.82 - 14.815 =	0.005	in
Ad^2	15.8906 x 0.005^2 =	0	in^4
I_{web}	(0.62) x (25.63)^3 / 12 =	870	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		0.00	
# of Holes in long row		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	0.62 =	0.62	in
A*	0	0.0000	in^2
x	centered on web =	14.815	in
Ax	0 x 14.815 =	0	in^3
d	max =	0.00	in
Ad^2	Total for all holes =	0.00	in^4
I_{holes}	0 x 0.62 x 0^3/12 =	0	in^4

Holes Through Bottom Flange L's and Web			
Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0 + 0.62 =	0.62	in
A*	#DIV/0!	0.0000	in^2
x	+ (0 + 0) / 2 =	1	in
Ax	0 x 1 =	0	in^3
d	14.82 - 1 =	13.82	in
Ad^2	0 x 13.82^2 =	0	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1 + 0 =	1	in
A	#DIV/0!	0.0000	in^2
x	0.5 x 1 =	0.5	in
Ax	0 x 0.5 =	0	in^3
d	14.82 - 0.5 =	14.32	in
Ad^2	0 x 14.32^2 =	0	in^4

Bottom Flange Angles			
x		0.00	in
t		0.00	in
A (angle)		0.00	in^2
Ixxo, Double Angles		0.00	in^4
A	2 x 0 =	0	in^2
y.bar		0.00	in
Ax	0 x 0 =	0.00	in^3
d	14.82 - 0 =	14.82	in
Ad^2	0 x 14.82^2 =	0	in^4

Bottom Cover Plates			
b_f		14.00	in
t_f		1.00	in
A	1 x 14 =	14	in^2
x	0.5 x 1 =	0.5	in
Ax	14 x 0.5 =	7	in^3
d	14.82 - 0.5 =	14.32	in
Ad^2	14 x 14.32^2 =	2870.87	in^4

NET SECTION

Girder Properties

Girder d	1 + 1 + 25.63 + 1 + 1 =	29.63	in
ΣA	14 + 0 - 0 - 0 + 15.8906 - 0 - 0 - 0 + 0 + 14 =	43.89	in^2
ΣAx	407.82 + 0 - 0 - 0 + 235.42 - 0 - 0 - 0 + 0 + 7 =	650.24	in^3
Xcg	= ΣAx / ΣA =	14.82	in
ΣAd^2	2866.87 + 0 - 0 - 0 + 0 -0 - 0 - 0 + 0 + 2870.87 =	5737.74	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	6607.74	in^4
S_{BOTTOM}	6607.74 / 14.82 =	446	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	27.63	in
Clear Distance Web to Flange Angle	1	in

Top Cover Plates

b_f		14.00	in
t_f		1.00	in
A	1 x 14 =	14	in^2
x	29.63 - (0.5 x 1) =	29.13	in
Ax	14 x 29.13 =	407.82	in^3
d	29.13 - 14.82 =	14.31	in
Ad^2	14 x 14.31^2 =	2866.87	in^4

Top Flange Angles

x		0.00	in
t		0.00	in^2
A (each angle)		0.00	in^4
A	2 x 0 =	0	in^2
Ixx, double angles		0.00	in^4
y.bar		0.00	in
x	29.63 - 1 - 0 =	28.63	in
Ax	0 x 28.63 =	0	in^3
d	28.63 - 14.82 =	13.81	in
Ad^2	0 x 13.81^2 =	0	in^4

Web

d		25.63	in
t_w		0.62	in
A	0.62 x 25.63 =	15.8906	in^2
x	25.63 / 2 +1+1	14.815	in
Ax	15.8906 x 14.815 =	235.42	in^3
d	14.82 - 14.815 =	0.005	in
Ad^2	15.8906 x 0.005^2 =	0	in^4
I_{web}	(0.62) x (25.63)^3 / 12 =	869.87	in^4

Bottom Flange Angles

x (angle)		0.00	in
t		0.00	in
A (angle)		0.00	in
A	2 x 0 =	0	in^2
Ixx, double angles		0.00	in^4
y.bar		0.00	in
Ax	0 x 0 =	0	in^3
d	14.82 - 0 =	14.82	in
Ad^2	0 x 14.82^2 =	0	in^4

Bottom Cover Plate

b_f		14.00	in
t_f		1.00	in
A	1 x 14 =	14	in^2
x	0.5 x 1 =	0.5	in
Ax	14 x 0.5 =	7	in^3
d	14.82 - 0.5 =	14.32	in
Ad^2	14 x 14.32^2 =	2870.87	in^4

GROSS SECTION

Girder Properties

Girder d	1 + 25.63 + 1 + 2 x 1 =	29.63	in
ΣA	14 + 0 + 15.8906 + 0 + 14 =	43.891	in^2
ΣAx	407.82 + 0 + 235.42 + 0 + 7 =	650.2	in^3
Xcg	= ΣAx / ΣA =	14.82	in
ΣAd^2	2866.87 + 0 + 0 + 0 + 2870.87 =	5,738	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	6,608	in^4
S_{TOP}	6608 / (29.63 - 14.82) =	446	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		75.75	in
y (for top flange angle)		0	in
Iyy.pl (for top flange plate, or cover plate)	1 * 14^3/12="	228.7	in^4
Iyy.2A (for top flange double angle)		0.00	in
Iyy (compression flange)	228.7 + 0 =	228.70	in^4
A (compression flange & web)	14 + 0 + 15.8906 / 2 =	21.9453	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	3.23	in
A_f	14 + 0 =	14	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (75.75 / 3.23)^2 =	16,349	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((75.75 x 29.63 x √1+0.3) / (14)) =	65,292	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	rolled	
	Allowable Stress =	16.50	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (75.75 / 3.23)^2 =	23,780	psi
			23.78	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (75.75 x 29.63 / 14) =	95,264	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	rolled	
		Allowable Stress =	24.00	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

22.75	Span Length (ft)	8	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.25	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
14.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
11.99	Tie Length (ft)			rolled	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**521.07**	k-ft
E80 Shear	**107.45**	k

286k Car

286k Car Moment	**402.10**	k-ft
286k Car Shear	**107.45**	k

315k Car

315k Car Moment	**440.10**	k-ft
315k Car Shear	**93.10**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	22.75	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	20.70	k-ft
Wind on Live Load Shear	3.64	k

PROJECT : VDOT Shenandoah Valley Asset 7643			Michael Baker INTERNATIONAL
TASK : Deck Plate Girder Load Rating		PROJECT NO :	
SUBJECT : Span 5 Load Rating			
CALCULATED BY : DS	DATE : 1/15/2025	CHECKED BY : JBT	DATE : 1/22/2025

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	$1 - (0.8 / 2500) \times (60 - SL)^2$
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2)	
Percentage of wheel load taken by one beam	12.50%

Dead Load on One Girder

Girder	43.8906/144*490="	149.3	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 5% for Connections		x1.05	
Total Steel Load	1.05 x (149.3 + 0) =	157	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	14/12 x 10/12 x 11.9895833333333 x 60 =	699	lb
Number of ties	22.75 ft / 1.25 ft =	18.2	ties
Number of Beams		2	
Tie Weight/ LF of beam		280	lb / ft

PROJECT : *VDOT Shenandoah Valley Asset 7643*			Michael Baker INTERNATIONAL
TASK : *Deck Plate Girder Load Rating*		**PROJECT NO :**	
SUBJECT : *Span 5 Load Rating*			
CALCULATED BY : *DS*	**DATE :** *1/15/2025*	**CHECKED BY :** *JBT*	**DATE :** 1/22/2025

RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		11.65	ft^3
Ties per LF of Bridge		0.8	ties
Average Area of Ties per LF of Bridge		9.32	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**186.00**	lb / ft
Total Dead Load		**723**	**lb / ft**
		0.72	k / ft
Moment	**0.72 x 22.75^2 / 8 =**	**46.58**	**k-ft**
Shear	**0.72 x 22.75 / 2 =**	**8.19**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)			446	in^3
S_{TOP} (Compression - Gross Section)			446	in^3
A_{web}			15.8906	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500 =	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)			16.50	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500 =	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000 =	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)			24.00	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000 =	18	ksi

PROJECT : *VDOT Shenandoah Valley Asset 7643*		Michael Baker INTERNATIONAL	
TASK : *Deck Plate Girder Load Rating*		PROJECT NO :	
SUBJECT : *Span 5 Load Rating*			
CALCULATED BY : *DS*	DATE : *1/15/2025*	CHECKED BY : *JBT*	DATE : 1/22/2025

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 2.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(446 x 16.5 / 12) x (1 - CRF) =	601	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(446 x 24 / 12) x (1 - CRF) =	874	k-ft
Maximum Compression Stress Capacity - Normal Rating	(446 x 16.5 / 12) x (1 - CRF) =	601	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(446 x 24 / 12) x (1 - CRF) =	874	k-ft
Maximum Shear Stress Capacity - Normal Rating	(15.8906 x 10.5) x (1 - CRF) =	164	k
Maximum Shear Stress Capacity - Maximum Rating	(15.8906 x 18) x (1 - CRF) =	280	k

Girder Ratings for Tension Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108

Girder Ratings for Compression Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108
25	0.61	23.73%	12.50%	36.2	E60	E91	E78	E118	E71	E108

Girder Ratings for Shear Stress

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169
25	0.61	23.73%	12.50%	36.2	E83	E147	E83	E147	E96	E169

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E60	E78	E71
Maximum	E91	E118	E108

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

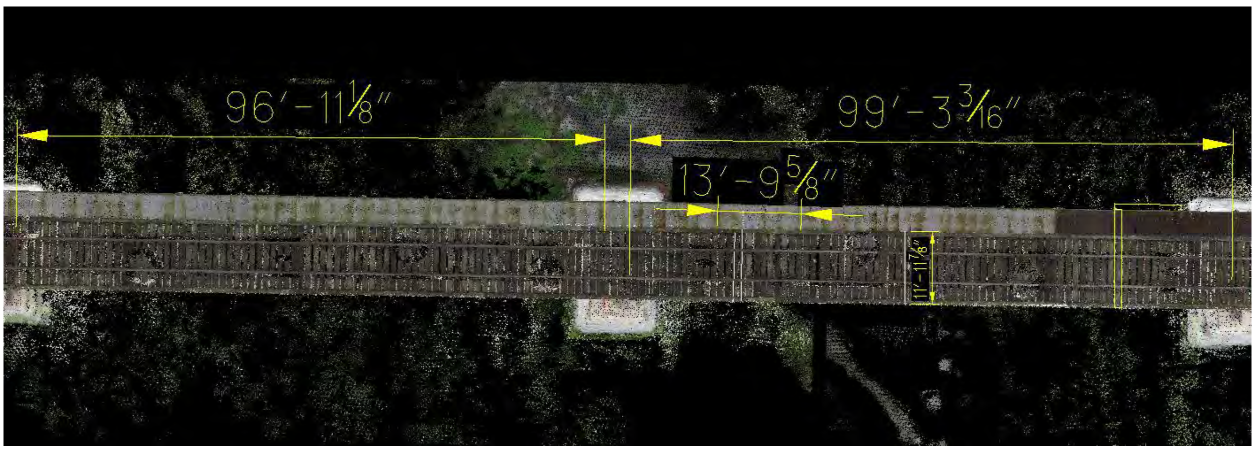
Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E60	E62	E68
Maximum	E91	-	-

ASSET 7643 DECK PLATE GIRDER
SPAN 8-9
RATING CALCULATIONS

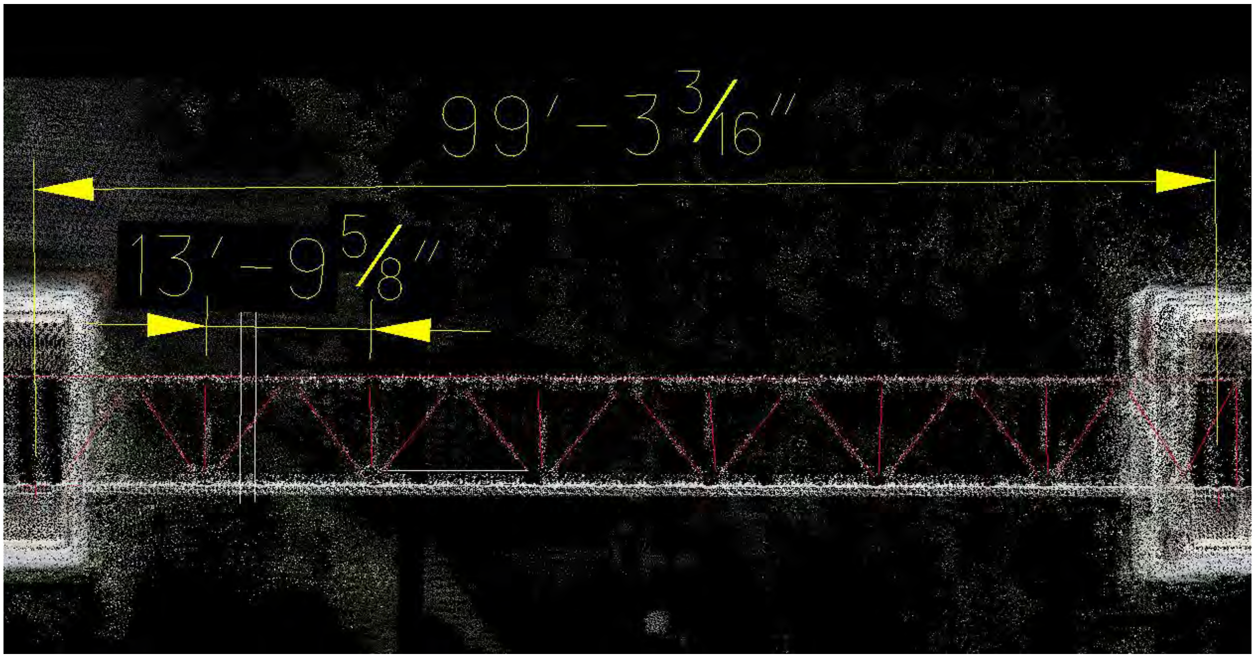
VDOT Shenandoah Valley Asset 7643 Span 8-9 Load Rating

- Superstructure rating considers dead load (bridge and walkway self-weight), live load (E-80, 286k and 315k live loads) and wind on loaded bridge.
- Due to lack of record drawings the dimensions used to develop the span geometry and section properties were taken from field measurements and survey.
- The bridge age is unknown. It is assumed to have been constructed prior to 1935, and fabricated using open hearth or ASTM A7 steel with Fy = 30 ksi (Ref AREMA Table 7.3.3.3)
- An additional 10% was added to the steel weight to account for connections and the top lateral bracing and cross frames between the girders.
- Span length was taken from the point cloud data provided and can be seen in the image below. Span 8 and Span 9 vary in span length. The longer span length of the two spans was used.



- Tie dimensions were taken from the inspection notes provided. See image below.

- Lateral bracing distance was measured using the point cloud data provided. See image below.



- Girder dimensions were taken from the field notes, due to the lack of record drawings and the limited data of the point cloud cover plate cutoff points could not be determined and have not been verified at this time.

Girders:
L8x8x.66
web thickness = dmeter - .595
top cp = 18wx5/8 (all 4 top)
bot cp 4plates = 2 7/8"
b2b Ls - 115 1/4"

Top cover plate cutoffs match bottom
(no cps at ends)

SOURCE: INSPECTOR NOTES

Asset 7643 Over Narrows Passage Ceek

Top lateral bracing
b2b Ls
L3 1/2x 3 1/2x.46

Span 9
Dimensions

Girders:
L8x8x.66
web thickness = dmeter - .595
top cp = 18wx5/8 (all 4 top)
bot cp 4plates = 2 7/8"
b2b Ls - 115 1/4"

Bot lateral bracing
typical 75% SL to rivet heads above top
of bottom flange
gusset plates 50% SL near connection
(75% at ends)

bottom flange OK

N

Top cover plate cutoffs match bottom
(no cps at ends)

Girder 1 (G1)

Girder 2 (G2)

Main Spans Built up Girders

X frame b2b Ls L4x4x3/8

bot lateral L4x4x3/8

Increasing Mile Post

masonry piers have voids and spacing
at seams

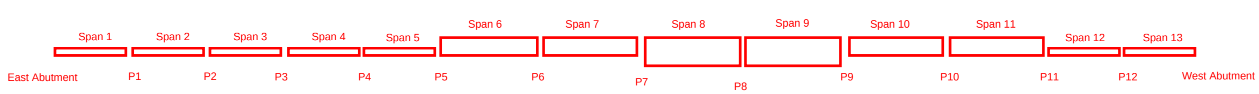
concrete caps are cracking on masonry
piers

13 Spans

Jump Spans

N

Jump Spans



Steel Pier

Deeper
Girders

Steel Pier

- Holes through the web and flange have been taken from photo 15. Measurements were not taken for the spacing of rivets, therefore, an assumption was made for the spacing of the rivets for both the web and flanges.

- Section loss was taken as an assumed percentage of section loss for the member. Section loss in the measured in the field was minor. A conservative assumption of 2% capacity reduction was assumed.

Span 9
Dimensions

Bot lateral bracing
typical 75% SL to rivet heads above top of bottom flange
gusset plates 50% SL near connection (75% at ends)

bottom flange OK

- The steel walkway connected to the structure was calculated based on the image below. The total dead load of the walkway was calculated to be 165 LB/FT.

Walkway channel
d=10 1/8"
flange width = 3 1/8"
flange thickness = 0.52"
web thickness = 0.84"

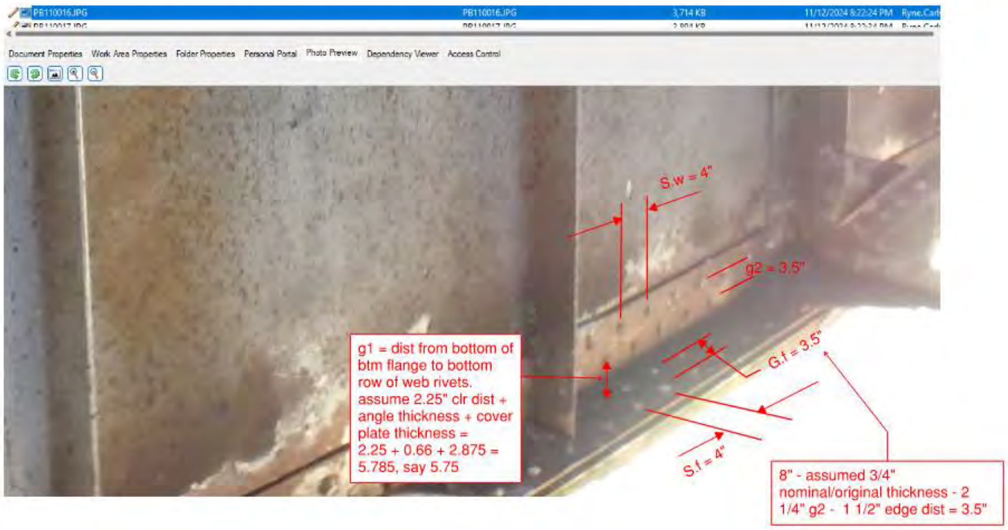
Posts L3x3x3/8

Walkway stringer
d=8 1/4"
flange width = 8 1/8"
flange thickness = .46"
web thickness = 0.32"

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	99.33	-	-	7946.4
WALKWAY CHANNEL (C10x30)	-	30	-	16.28646	11.04167	9.0	4397.34375
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	9	324
STEEL GRATING	7.4	-	4	99.33	-	-	2940.168
						TOTAL:	15607.91175
						LB/FT	157.1319012
						ADD 5%	165

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	99.33	-	-	7946.4
WALKWAY BEAM (W6x25)	-	25	-	16.28646	11.04167	9.0	3664.453125
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	9	324
STEEL GRATING	7.4	-	4	99.33	-	-	2940.168
						TOTAL:	14875.02113
						LB/FT	149.7535601
						ADD 5%	158

BOTTOM FLANGE & BOTTOM ANGLE GAGE (G) & PITCH (S)

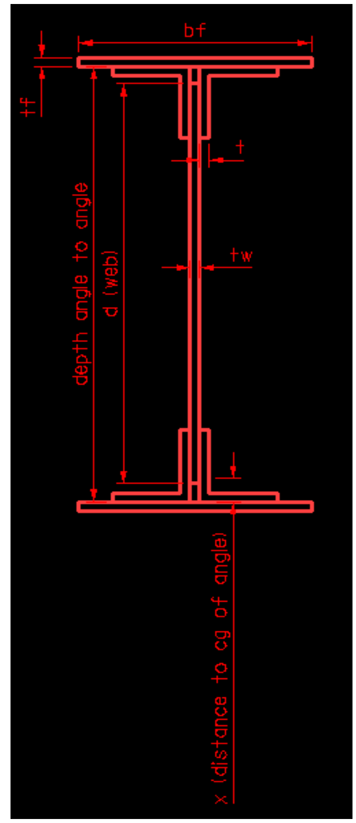


Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**99.33**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**9.00**	ft	
Girder Type	**fastened**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**2%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**165.60**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.04**	ft	
Tie Height	**14.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**11.99**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)



Girder Geometry

Depth angle to angle	115.250	in	
Effective Rivet/Bolt hole diameter	0.94	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	18.00	in
t_f	2.500	in

Top Flange Angles (0 if they don't exist)

x	8.00	in	
y	8.00	in	
t	0.660	in	
A (each angle)	10.12	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	124.73	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	2.24		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	255.51	in4	(ref. wksht. TF_Angle_Pair)

Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00		This is an assumption based off of photos (photo 014)
Gage	0.00	in	
Pitch	0.00	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web

d	115.250	in
tw	0.595	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	17.00	
# of Holes in long row	17.00	
Gage	6.00	in
Pitch	0.00	in

Bottom Flange or Cover Plate (0 if does not exist)

b_f	18.00	in
t_f	2.875	in

Bottom Flange Angles (0 if they don't exist)

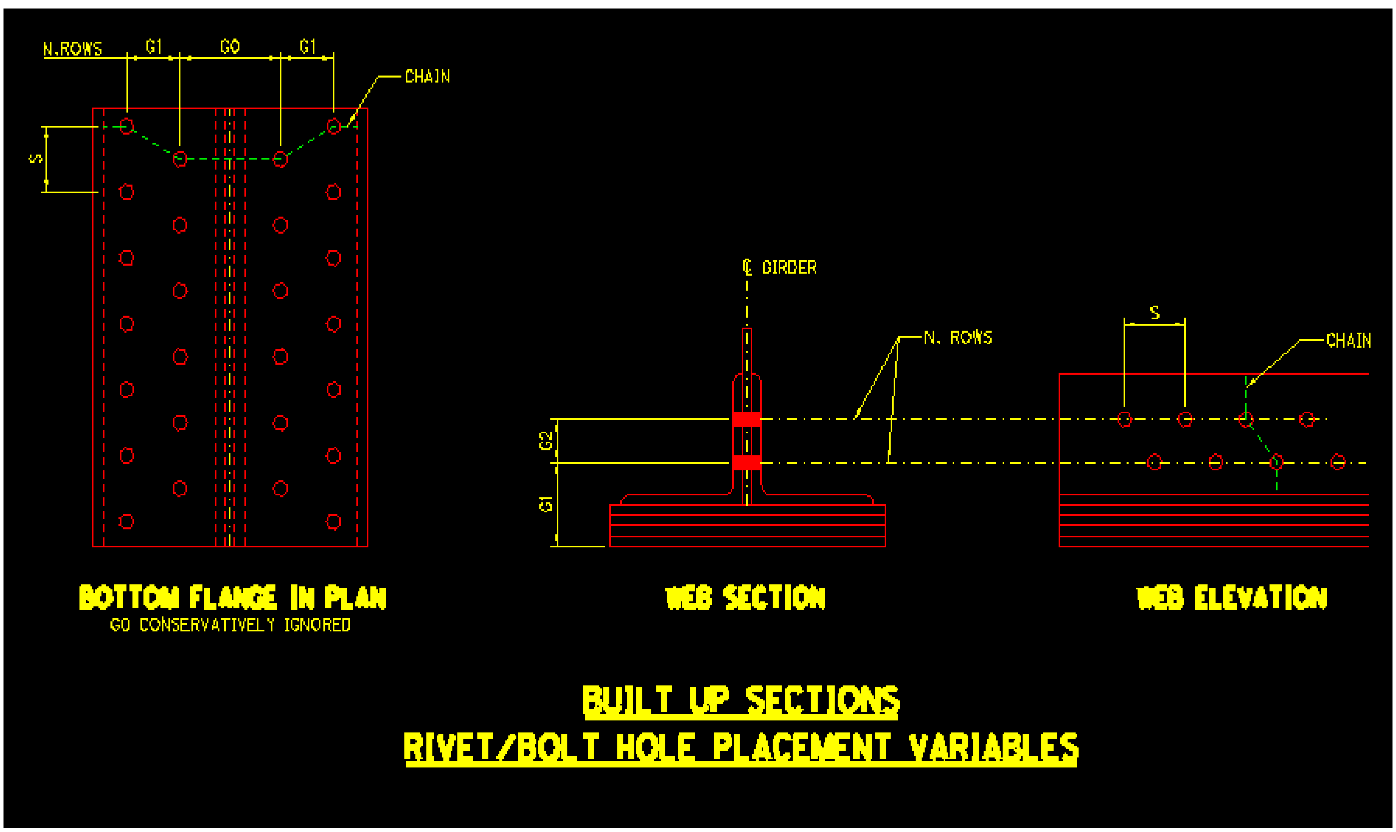
x	8.00	in	
y	8.00	in	
t	0.660	in	
A (each angle)	10.12	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	124.73	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	2.24	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	255.51	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

Rows	4.00	in
Gage	3.50	in
Pitch	4.00	in

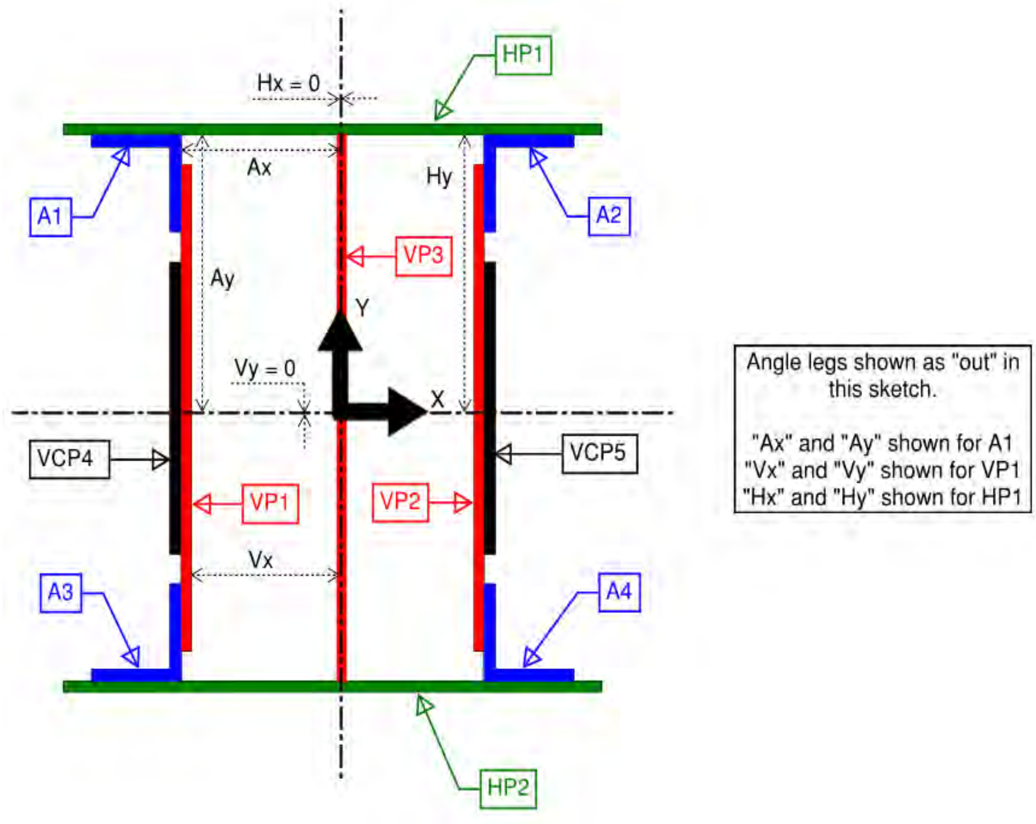
Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	2	
Gage 1	5.75	in
Gage 2	3.50	in
Pitch	4.00	in



TF_Angle_Pair

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	yes	8.00	0.66	-	-	-	-	-	0	out		
A1 (Vert. Leg)	yes	8.00	0.66	-	-	-	-	-0.2975	-	out		
A2 (Horiz. Leg)	yes	8.00	0.66	-	-	-	-	-	0	out		
A2 (Vert. Leg)	yes	8.00	0.66	-	-	-	-	0.2975	-	out		
A3 (Horiz. Leg)	no			-	-	-	-	-		out		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **8.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **16.595** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{x\text{-}x}$ (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A1 (Horiz. Leg)	5.28	0.33	1.74	0.19	-1.91	19.34	19.53		5.28
A1 (Vert. Leg)	4.84	4.33	20.98	21.75	2.09	21.08	42.83		4.84
A2 (Horiz. Leg)	5.28	0.33	1.74	0.19	-1.91	19.34	19.53		5.28
A2 (Vert. Leg)	4.84	4.33	20.98	21.75	2.09	21.08	42.83		4.84
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-2.24	0.00	0.00		0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-2.24	0.00	0.00		0.00
Σ	**20.25**		**45.44**	**43.88**		**80.85**	**124.73**	**Σ**	**20.25**

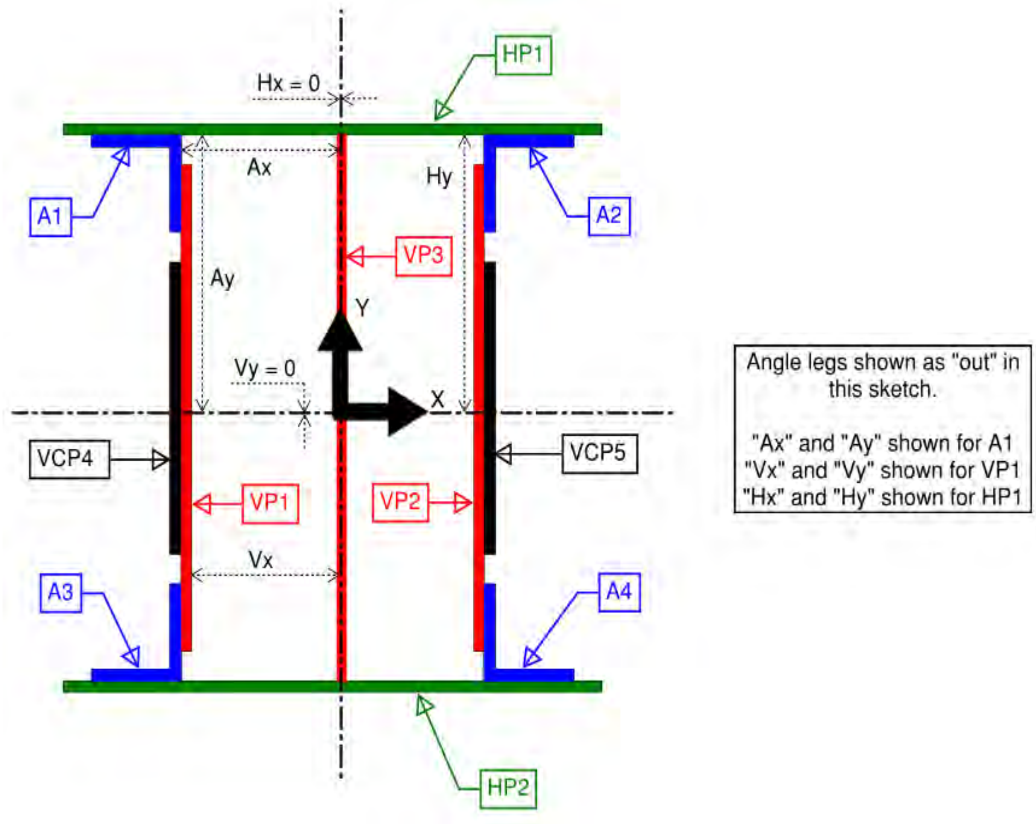
y_{bar} =	2.24	in	c_{top}=	1.76	in
I_x =	124.73	in^4	c_{bottom}=	6.24	in
A =	20.25	in^2	S_{top} =	71.03	in^3
r_x =	2.48	in	S_{bottom} =	19.98	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	$I_{y\text{-}y}$ (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	5.28	-4.30	-22.69	28.16	-4.30	97.51	125.67
A1 (Vert. Leg)	4.84	-0.63	-3.04	0.18	-0.63	1.91	2.08
A2 (Horiz. Leg)	5.28	4.30	22.69	28.16	4.30	97.51	125.67
A2 (Vert. Leg)	4.84	0.63	3.04	0.18	0.63	1.91	2.08
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**20.25**		**0.00**	**56.67**		**198.84**	**255.51**

y_{bar} =	0.00	in	c_{left}=	8.30	in
I_y =	255.51	in^4	c_{right}=	8.30	in
A =	20.25	in^2	S_{left} =	30.79	in^3
r_y =	3.55	in	S_{right} =	30.79	in^3

BF_Angle_Pair

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	no			-	-			-	-	-		
HP2	no			-	-			-	-	-		
VP1	no					-	-	-	-	-		
VP2	no					-	-	-	-	-		
VP3	no					-	-	-	-	-		
VCP4	no					-	-	-	-	-		
VCP5	no					-	-	-	-	-		
A1 (Horiz. Leg)	no			-	-	-	-	-		out		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	no			-	-	-	-	-	0	out		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	yes	8.00	0.66	-	-	-	-	-	0	out		
A3 (Vert. Leg)	yes	8.00	0.66	-	-	-	-	-0.2975	-	out		
A4 (Horiz. Leg)	yes	8.00	0.66	-	-	-	-	-	0	out		
A4 (Vert. Leg)	yes	8.00	0.66	-	-	-	-	0.2975	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **8.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **16.595** in

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	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-2.24	0.00	0.00		0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-2.24	0.00	0.00		0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-2.24	0.00	0.00		0.00
A3 (Horiz. Leg)	5.28	0.33	1.74	0.19	-1.91	19.34	19.53		5.28
A3 (Vert. Leg)	4.84	4.33	20.98	21.75	2.09	21.08	42.83		4.84
A4 (Horiz. Leg)	5.28	0.33	1.74	0.19	-1.91	19.34	19.53		5.28
A4 (Vert. Leg)	4.84	4.33	20.98	21.75	2.09	21.08	42.83		4.84
∑	**20.25**		**45.44**	**43.88**		**80.85**	**124.73**	∑	**20.25**

y_{bar} =	2.24	in	c_{top}=	1.76	in
I_x =	124.73	in^4	c_{bottom}=	6.24	in
A =	20.25	in^2	S_{top} =	71.03	in^3
r_x =	2.48	in	S_{bottom} =	19.98	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	5.28	-4.30	-22.69	28.16	-4.30	97.51	125.67
A3 (Vert. Leg)	4.84	-0.63	-3.04	0.18	-0.63	1.91	2.08
A4 (Horiz. Leg)	5.28	4.30	22.69	28.16	4.30	97.51	125.67
A4 (Vert. Leg)	4.84	0.63	3.04	0.18	0.63	1.91	2.08
∑	**20.25**		**0.00**	**56.67**		**198.84**	**255.51**

y_{bar} =	0.00	in	c_{left}=	8.30	in
I_y =	255.51	in^4	c_{right}=	8.30	in
A =	20.25	in^2	S_{left} =	30.79	in^3
r_y =	3.55	in	S_{right} =	30.79	in^3

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	115.25	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		18	in
tf		2.5	in
A	2.5 x 18 =	45	in2
x	120.625 - (0.5 x 2.5) =	119.375	in
Ax	45 x 119.375 =	5371.88	in3
d	119.375 - 60.61 =	58.765	in
Ad2	45 x 58.765^2 =	155399.6	in4

Top Flange Angles

x		8	in
t		0.66	in
A (angle)		10.1244	in2
Ixxo, Double Angles		124.7278	in4
A	2 x 10.1244 =	20.2488	in2
y.bar		2.24	in
x	120.625 - 2.5 - 2.24 =	115.89	in
Ax	20.2488 x 115.885 =	2346.53	in3
d	115.885 - 60.61 =	55.275	in
Ad2	20.2488 x 55.275^2 =	61867	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	2.5 + 0.66 =	3.16	in
A*	2 x 0.9375 x 3.16 =	0.0000	in^2
x	120.625 - 3.16 / 2 =	119.045	in
Ax	0 x 119.045 =	0	in^3
d	119.045 - 60.61 =	58.435	in
Ad^2	0 x 58.435^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.66 + 0.595 =	1.915	in
A*	0	0.0000	in^2
x	120.625 - 2.5 - (0 +0)/2 =	118.125	in
Ax	0 x 118.125 =	0	in^3
d	118.125 - 60.61 =	57.515	in
Ad^2	0 x 57.515^2 =	0	in^4

PROJECT : *VDOT Shenandoah Valley Asset 7643*	
TASK : *Deck Plate Girder Load Rating*	**PROJECT NO :**
SUBJECT : *Span 8 Load Rating*	
CALCULATED BY : *DS* **DATE :** *1/15/2025*	**CHECKED BY :** *JBT* **DATE :** 1/22/2025

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NET SECTION

Web			
d		115.25	in
t_w		0.60	in
A	0.595 x 115.25 =	68.57375	in^2
x	2.875 + 0 + (0.5 x 115.25) =	60.5	in
Ax	68.57375 x 60.5 =	4148.71	in^3
d	60.61 - 60.5 =	0.11	in
Ad^2	68.57375 x 0.11^2 =	0.83	in^4
I_{web}	595) x (115.25)^3 / 12 =	75903	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		17.00	
# of Holes in long row		17.00	
Gage		6.00	in
Pitch		0.00	in
Grip	0.595 =	0.595	in
A*	17 x 0.9375 x 0.595 =	9.4828	in^2
x	centered on web =	60.3125	in
Ax	9.4828 x 60.3125 =	572	in^3
d	max =	48.00	in
Ad^2	Total for all holes =	8193.14	in^4
I_{holes}	17 x 0.595 x 0.9375^3/12 =	0.69	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		5.75	in
Gage 2		3.50	in
Pitch		4.00	in
Grip	2 x 0.66 + 0.595 =	1.915	in
A*	1 x 0.9375 x 1.915 =	1.7953	in^2
x	+ (5.75 + 3.5) / 2 =	7.5	in
Ax	1.7953 x 7.5 =	13	in^3
d	60.61 - 7.5 =	53.11	in
Ad^2	1.7953 x 53.11^2 =	5064	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		4.00	
Gage		3.50	in
Pitch		4.00	in
Grip	2.875 + 0.66 =	3.535	in
A	2 x 0.9375 x 3.535 =	6.6281	in^2
x	0.5 x 3.535 =	1.7675	in
Ax	6.6281 x 1.7675 =	12	in^3
d	60.61 - 1.7675 =	58.8425	in
Ad^2	6.6281 x 58.8425^2 =	22949	in^4

Bottom Flange Angles			
x		8.00	in
t		0.66	in
A (angle)		10.12	in^2
Ixxo, Double Angles		124.73	in^4
A	2 x 10.1244 =	20.2488	in^2
y.bar		2.24	in
Ax	20.2488 x 2.24 =	45.36	in^3
d	60.61 - 2.24 =	58.37	in
Ad^2	20.2488 x 58.37^2 =	68988.81	in^4

Bottom Cover Plates			
b_f		18.00	in
t_f		2.88	in
A	2.875 x 18 =	51.75	in^2
x	0.5 x 2.875 =	1.4375	in
Ax	51.75 x 1.4375 =	74.39	in^3
d	60.61 - 1.4375 =	59.1725	in
Ad^2	51.75 x 59.1725^2 =	181196.7	in^4

NET SECTION

Girder Properties

Girder d	2.875 + 0 + 115.25 + 0 + 2.5 =	120.625	in
ΣA	45 + 20.2488 - 0 - 0 + 68.57375 - 9.4828 - 1.7953 - 6.6281 + 20.2488 + 51.75 =	187.92	in^2
ΣAx	5371.88 + 2346.53 - 0 - 0 + 4148.71 - 572 - 13 - 12 + 45.36 + 74.39 =	11389.87	in^3
Xcg	= ΣAx / ΣA =	60.61	in
ΣAd^2	155399.64 + 61867 - 0 - 0 + 0.83 -8193.1392 - 5064 - 22949 + 68988.81 + 181196.66 =	431246.8	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes} =$	507398.57	in^4
S_{BOTTOM}	507398.57 / 60.61 =	8372	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

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GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	115.25	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		18.00	in
t_f		2.50	in
A	2.5 x 18 =	45	in^2
x	120.625 - (0.5 x 2.5) =	119.375	in
Ax	45 x 119.375 =	5371.88	in^3
d	119.375 - 58.24 =	61.135	in
Ad^2	45 x 61.135^2 =	168187	in^4

Top Flange Angles

x		8.00	in
t		0.66	in^2
A (each angle)		10.12	in^4
A	2 x 10.1244 =	20.2488	in^2
Ixx, double angles		124.73	in^4
y.bar		2.24	in
x	120.625 - 2.5 - 2.24 =	115.89	in
Ax	20.2488 x 115.885 =	2346.53	in^3
d	115.885 - 58.24 =	57.65	in
Ad^2	20.2488 x 57.645^2 =	67285.67	in^4

Web

d		115.25	in
t_w		0.60	in
A	0.595 x 115.25 =	68.5738	in^2
x	115.25 / 2 +2.875+0	60.5	in
Ax	68.5738 x 60.5 =	4148.71	in^3
d	58.24 - 60.5 =	2.26	in
Ad^2	68.5738 x 2.26^2 =	350.25	in^4
I_{web}	(0.595) x (115.25)^3 / 12 =	75902.93	in^4

Bottom Flange Angles

x (angle)		8.00	in
t		0.66	in
A (angle)		10.12	in
A	2 x 10.1244 =	20.2488	in^2
Ixx, double angles		124.73	in^4
y.bar		2.24	in
Ax	20.2488 x 2.24 =	45.36	in^3
d	58.24 - 2.24 =	56	in
Ad^2	20.2488 x 56^2 =	63500.24	in^4

Bottom Cover Plate

b_f		18.00	in
t_f		2.88	in
A	2.875 x 18 =	51.75	in^2
x	0.5 x 2.875 =	1.4375	in
Ax	51.75 x 1.4375 =	74.39	in^3
d	58.24 - 1.4375 =	56.8025	in
Ad^2	51.75 x 56.8025^2 =	166972.6	in^4

GROSS SECTION

Girder Properties

Girder d	2.5 + 115.25 + 2.875 + 2 x 0 =	120.625	in
ΣA	45 + 20.2488 + 68.5738 + 20.2488 + 51.75 =	205.821	in^2
ΣAx	5371.88 + 2346.53 + 4148.71 + 45.36 + 74.39 =	11986.9	in^3
Xcg	= ΣAx / ΣA =	58.24	in
$ΣAd^2$	168186.97 + 67285.67 + 350.25 + 63500.24 + 166972.62 =	466,296	in^4
I	$ΣAd^2 + I_{web} + I_{flanges}$ =	542,448	in^4
S_{TOP}	542448 / (120.625 - 58.24) =	8,695	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		165.6	in
y (for top flange angle)		8	in
Iyy.pl (for top flange plate, or cover plate)	2.5 * 18^3/12="	1215	in^4
Iyy.2A (for top flange double angle)		255.51	in
Iyy (compression flange)	1215 + 255.51 =	1,470.50	in^4
A (compression flange & web)	45 + 20.2488 + 68.5738 / 2 =	99.5357	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	3.84	in
A_f	45 + 20.2488 =	65.2488	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (165.6 / 3.84)^2 =	15,989	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((165.6 x 120.625 x √1+0.3) / (65.2488)) =	34,192	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	15.99	ksi

PROJECT : *VDOT Shenandoah Valley Asset 7643*		
TASK : *Deck Plate Girder Load Rating*	PROJECT NO :	
SUBJECT : *Span 8 Load Rating*		
CALCULATED BY : *DS*	DATE : *1/15/2025*	CHECKED BY : *JBT* DATE : 1/22/2025

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GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2				
	K	0.8 x 30000 =	24,000	psi
	If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
	If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$			
		24000 - (24000 x 30000) / (1.8 x 10^9) x (165.6 / 3.84)^2 =	23,256	psi
			23.26	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K			
		(24000/0.55 x 30000) x (10,500,000/ (165.6 x 120.625 / 65.2488) =	49,887	psi
		Result of Eq. 2 not to exceed K =	24.00	ksi
		Girder Type =	fastened	
		Allowable Stress =	23.26	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

99.333333	Span Length (ft)	9	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.04	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
14.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
11.99	Tie Length (ft)			fastened	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**6,372.49**	k-ft
E80 Shear	**298.30**	k

286k Car

286k Car Moment	**4,856.43**	k-ft
286k Car Shear	**298.30**	k

315k Car

315k Car Moment	**4,146.39**	k-ft
315k Car Shear	**208.46**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	99.33	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	394.68	k-ft
Wind on Live Load Shear	15.89	k

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	1 - (0.8 / 2500) x (60 - SL)^2
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x { 16 + 600 / (99.3333333333333 - 30) }

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2)	
Percentage of wheel load taken by one beam	11.11%

Dead Load on One Girder

Girder	205.8214/144*490="	700.4	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 10% for Connections		x1.10	
Total Steel Load	1.10 x (700.4 + 0) =	770	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	14/12 x 10/12 x 11.9895833333333 x 60 =	699	lb
Number of ties	99.3333333333333 ft / 1.04166666666667 ft =	95.36	ties
Number of Beams		2	
Tie Weight/ LF of beam		336	lb / ft

PROJECT : *VDOT Shenandoah Valley Asset 7643*			
TASK : *Deck Plate Girder Load Rating*		PROJECT NO :	
SUBJECT : *Span 8 Load Rating*			
CALCULATED BY : *DS*	DATE : *1/15/2025*	CHECKED BY : *JBT*	DATE : 1/22/2025

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RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		11.65	ft^3
Ties per LF of Bridge		0.96	ties
Average Area of Ties per LF of Bridge		11.184	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**165.00**	lb / ft
Total Dead Load		**1371**	**lb / ft**
		1.37	k / ft
Moment	**1.37 x 99.3333333333333^2 / 8 =**	**1689.74**	**k-ft**
Shear	**1.37 x 99.3333333333333 / 2 =**	**68.04**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				8372	in^3
S_{TOP} (Compression - Gross Section)				8,695	in^3
A_{web}				68.57375	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				15.99	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.26	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

PROJECT : *VDOT Shenandoah Valley Asset 7643*

TASK : *Deck Plate Girder Load Rating* PROJECT NO :

SUBJECT : *Span 8 Load Rating*

CALCULATED BY : *DS* DATE : *1/15/2025* CHECKED BY : *JBT* DATE : 1/22/2025

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RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 2.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(8372 x 16.5 / 12) x (1 - CRF) =	11281	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(8372 x 24 / 12) x (1 - CRF) =	16409	k-ft
Maximum Compression Stress Capacity - Normal Rating	(8695 x 15.989 / 12) x (1 - CRF) =	11354	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(8695 x 23.26 / 12) x (1 - CRF) =	16517	k-ft
Maximum Shear Stress Capacity - Normal Rating	(68.57375 x 10.5) x (1 - CRF) =	706	k
Maximum Shear Stress Capacity - Maximum Rating	(68.57375 x 18) x (1 - CRF) =	1210	k

Girder Ratings for Tension Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219
25	0.61	14.99%	11.11%	26.1	E92	E143	E120	E187	E141	E219

Girder Ratings for Compression Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221
25	0.61	14.99%	11.11%	26.1	E92	E144	E121	E189	E142	E221

Girder Ratings for Shear Stress

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343
25	0.61	14.99%	11.11%	26.1	E132	E239	E132	E239	E189	E343

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E92	E120	E141
Maximum	E143	E187	E219

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

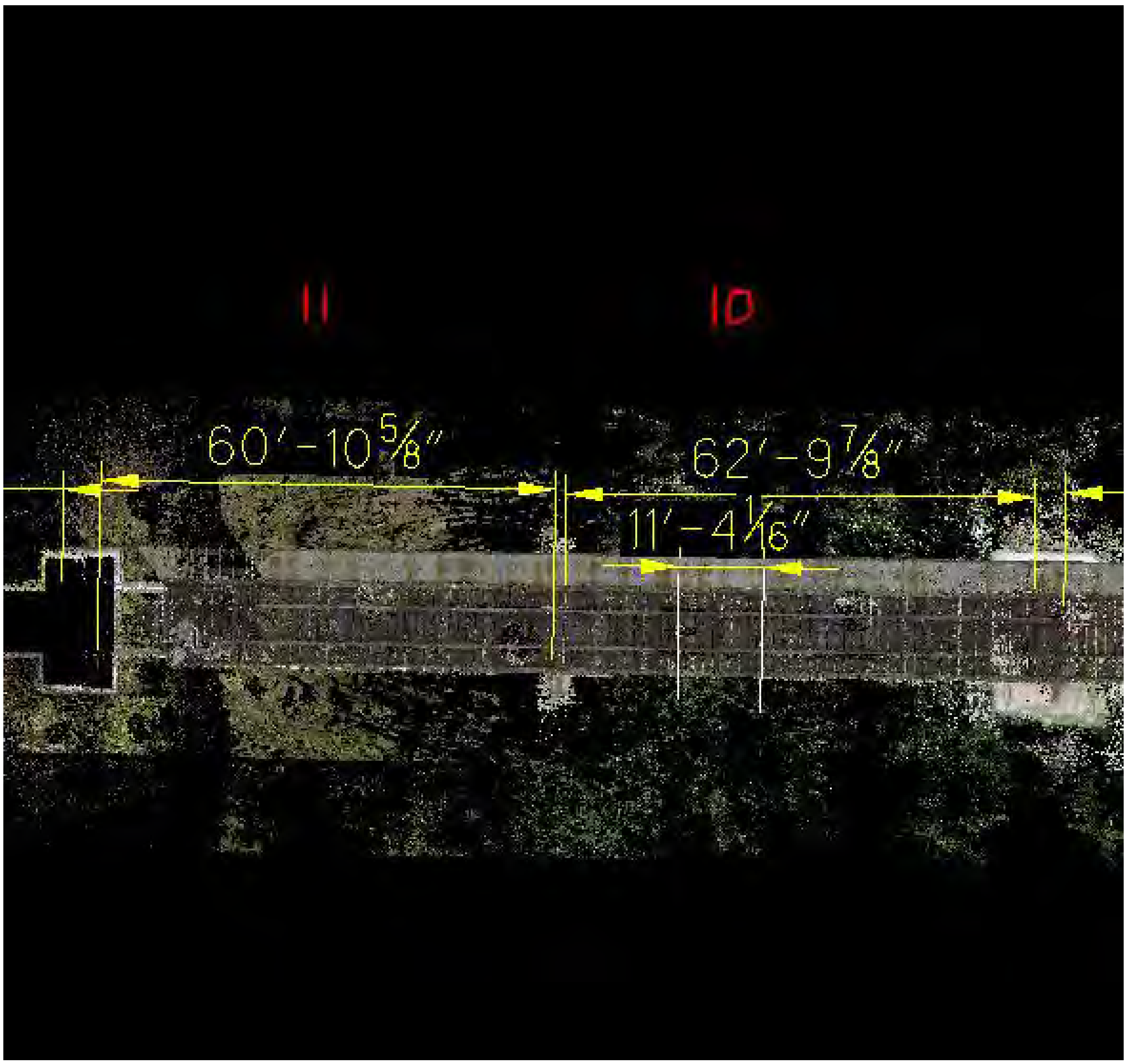
Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E92	E61	E52
Maximum	E143	-	-

ASSET 7643 DECK PLATE GIRDER
SPAN 10-11
RATING CALCULATIONS

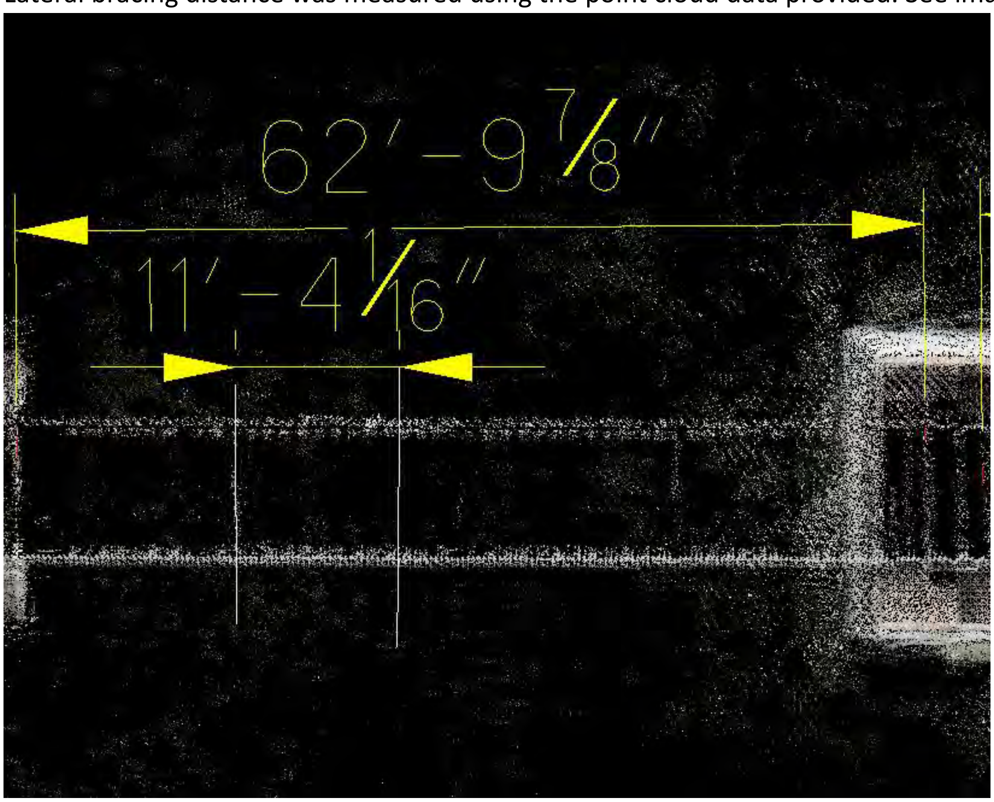
VDOT Shenandoah Valley Asset 7643 Span 10-11 Load Rating

- Superstructure rating considers dead load (bridge and walkway self-weight), live load (E-80, 286k and 315k live loads) and wind on loaded bridge.
- Due to lack of record drawings the dimensions used to develop the span geometry and section properties were taken from field measurements and survey.
- The bridge age is unknown. It is assumed to have been constructed prior to 1935, and fabricated using open hearth or ASTM A7 steel with Fy = 30 ksi (Ref AREMA Table 7.3.3.3)
- An additional 8% was added to the steel weight to account for connections and the top lateral bracing and cross frames between the girders.
- Span length was taken from the point cloud data provided and can be seen in the image below. Span 10 and Span 11 vary in span length. The longer span length of the two spans was used.



- Tie dimensions were taken from the inspection notes provided. See image below.

- Lateral bracing distance was measured using the point cloud data provided. See image below.



SOURCE: INSPECTOR NOTES

Asset 7643 Over Narrows Passage Ceek

Span 10/11
Dimensions

N

Walkway channel
d=10 1/8"
flange width = 3 1/8"
flange thickness = 0.52"
web thickness = 0.84"

Posts L3x3x3/8

Walkway stringer
d=8 1/4"
flange width = 8 1/8"
flange thickness = .46"
web thickness = 0.32"

Top lateral bracing
b2b Ls
L3 1/2x 3 1/2x.46

Top gussets .44"t

brg stiff .54"t
int stiff .44"t

X-frame are single Ls

Beam 1 (B1)

Beam 2 (B2)

General Notes:
SL minor throughout
isolated pitting along top flange at ties
(conservatively 1/32 full width)

Jumps Spans Rolled Beams

Girders:
L6 1/2 (h)x6vx.67
web gap = 7/16 dmeter - .509
top cp = 14 1/8wx.63 (all 3 top)
b2b Ls - 84 1/2"

Top cover plate cutoffs match bottom
(no cps at ends)

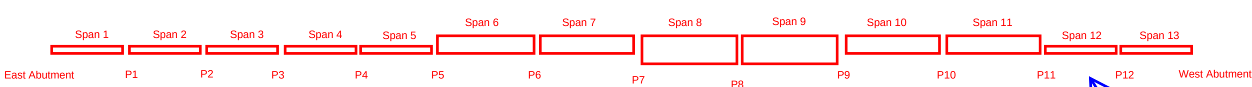
Increasing Mile Post

13 Spans

Jump Spans

N

Jump Spans



Steel Pier

Deeper
Girders

Steel Pier

Spans is mostly supported

- Girder dimensions were taken from the field notes, due to the lack of record drawings and the limited data of the point cloud cover plate cutoff points could not be determined and have not been verified at this time.

Girders:
L6 1/2 (h)x6vx.67
web gap = 7/16 dmeter - .509
top cp = 14 1/8wx.63 (all 3 top)
b2b Ls - 84 1/2"

Top cover plate cutoffs match bottom
(no cps at ends)

- Holes through the web and flange have been taken from photo 10. Measurements were not taken for the spacing of rivets, therefore, an assumption was made for the spacing of the rivets for both the web and flanges.

- Section loss was taken as a assumed percentage of section loss for the member. Section loss in the measured in the field was minor, 1/32" across the full width. A conservative assumption of 2% capacity reduction was assumed.

General Notes:
SL minor throughout
isolated pitting along top flange at ties
(conservatively 1/32 full width)

- The steel walkway connected to the structure was calculated based on the image below. The total dead load of the walkway was calculated to be 165 LB/FT.

Walkway channel
d=10 1/8"
flange width = 3 1/8"
flange thickness = 0.52"
web thickness = 0.84"

Posts L3x3x3/8

Walkway stringer
d=8 1/4"
flange width = 8 1/8"
flange thickness = .46"
web thickness = 0.32"

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	99.33	-	-	7946.4
WALKWAY CHANNEL (C10x30)	-	30	-	16.28646	11.04167	9.0	4397.34375
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	9	324
STEEL GRATING	7.4	-	4	99.33	-	-	2940.168
						TOTAL:	15607.91175
						LB/FT	157.1319012
						ADD 5%	165

ELEMENT	LB/SF	LB/FT	WIDTH	LENGTH	SPACING	QTY	TOTAL WEIGHT
WALKWAY STRINGER (W8x40)	-	40	-	99.33	-	-	7946.4
WALKWAY BEAM (W6x25)	-	25	-	16.28646	11.04167	9.0	3664.453125
WALKWAY POSTS (L3x3x3/8)	-	7.2	-	5	11.04167	9	324
STEEL GRATING	7.4	-	4	99.33	-	-	2940.168
						TOTAL:	14875.02113
						LB/FT	149.7535601
						ADD 5%	158

Task

This worksheet is configured to perform load rating for girders essentially parallel to the track for steel deck, concrete deck or open deck configurations. Girders must be I-shaped. If built-up sections are present, angles with or without cover plates can be modeled. Supplemental worksheets are provided to calculate angle section properties as inputs to the overall girder section property calculations. Loads assessed include dead loads with option to add walkway dead load, live loads (E80, 286k, 315k), and wind resolved into UDL acting along the girder. Girder fatigue is not assessed. Longitudinal force is assumed to be effectively carried by the span deck (where provided) or by span lateral bracing system (where provided) without imposing significant axial demand into the girders. The deck (where provided) or intra-girder lateral bracing (where provided) is also assumed to effectively carry lateral demands due to wind and equipment loads.

Span Geometry

Deck Type	**open**		(steel or concrete or open for ties only)
Deck Width	**0.00**	ft	(set to zero for open deck)
Deck Thickness	**0.00**	in	(set to zero for open deck)
Span Length	**62.83**	ft	
Number of Girders	**2**		
Fascia CL to Fascia CL	**9.00**	ft	
Girder Type	**fastened**	rolled, welded, or fastened	
Fy	**30,000**	psi	(MBE Table 6A.6.2.1-1)
Capacity Reduction	**2%**	due to section loss (geometry inputs below account for section loss, see Narrative)	
Number of Diaphragms	**0**		(No. of Diaph. LINES normal to girder webs, subsequently converted to UDL)
Diaphragm Weight/LF	**0.00**	lb/lf	
Lateral Bracing Distance	**136.06**	in	(top flange lateral brace point spacing, set to zero for steel or concrete deck)
Number of Tracks	**1.00**		
Rail Spacing	5.00	ft	AREMA 1.2.7.a
Ballast Depth (top of tie	**0.00**	in	(set to zero for open deck)
Ballast Width	**0.00**	ft	(set to zero for open deck)
Tie Spacing	**1.04**	ft	
Tie Height	**14.00**	in	(Typ. 7" on ballast, Typ. 10" on Open Deck)
Tie Width	**10.00**	in	(Typ. 8" on ballast, Typ. 10" on Open Deck)
Tie Length	**11.99**	ft	(Typ. 8.5' on ballast, Typ. 10' on Open Deck)

Girder Geometry

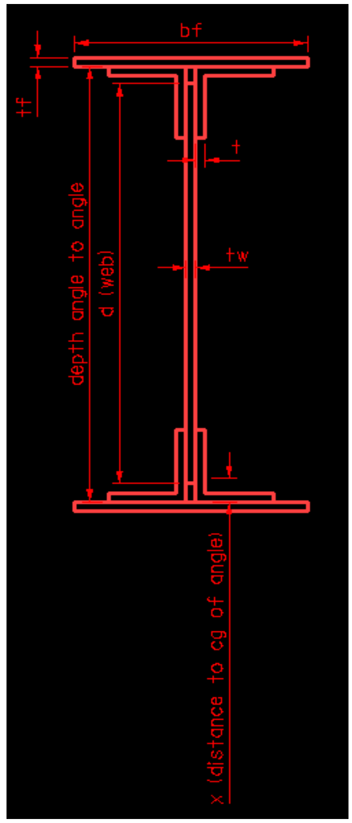
Depth angle to angle	84.500	in	
Effective Rivet/Bolt hole diameter	0.94	in	7/8" Rivet + 1/16"

Top Flange or Cover Plate (0 if does not exist)

b_f	14.13	in
t_f	1.875	in

Top Flange Angles (0 if they don't exist)

x	6.50	in	
y	6.00	in	
t	0.670	in	
A (each angle)	7.93	in2	(ref. wksht. TF_Angle_Pair)
Ixxo, Double Angles	52.55	in4	(ref. wksht. TF_Angle_Pair)
y.bar (wrt X)	1.69		(ref. wksht. TF_Angle_Pair)
Iyyo, Double Angles	140.39	in4	(ref. wksht. TF_Angle_Pair)



Holes Through Top Flange (0 if does not exist OR is in compression at Section Location)

Rows	0.00		This is an assumption based off of photos (photo 010)
Gage	0.00	in	
Pitch	0.00	in	

Holes Through Top Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	0	
Gage 1	0.00	in
Gage 2	0.00	in
Pitch	0.00	in

Web

d	84.500	in
tw	0.509	in

Holes Through Web at Diaphragm Connection (0 if does not exist)

Total # of Holes	12.00		Shown on photo 0010
# of Holes in long row	12.00		
Gage	6.00	in	approximate from photo 0010
Pitch	0.00	in	

Bottom Flange or Cover Plate (0 if does not exist)

b_f	**14.13**	in
t_f	**1.875**	in

Bottom Flange Angles (0 if they don't exist)

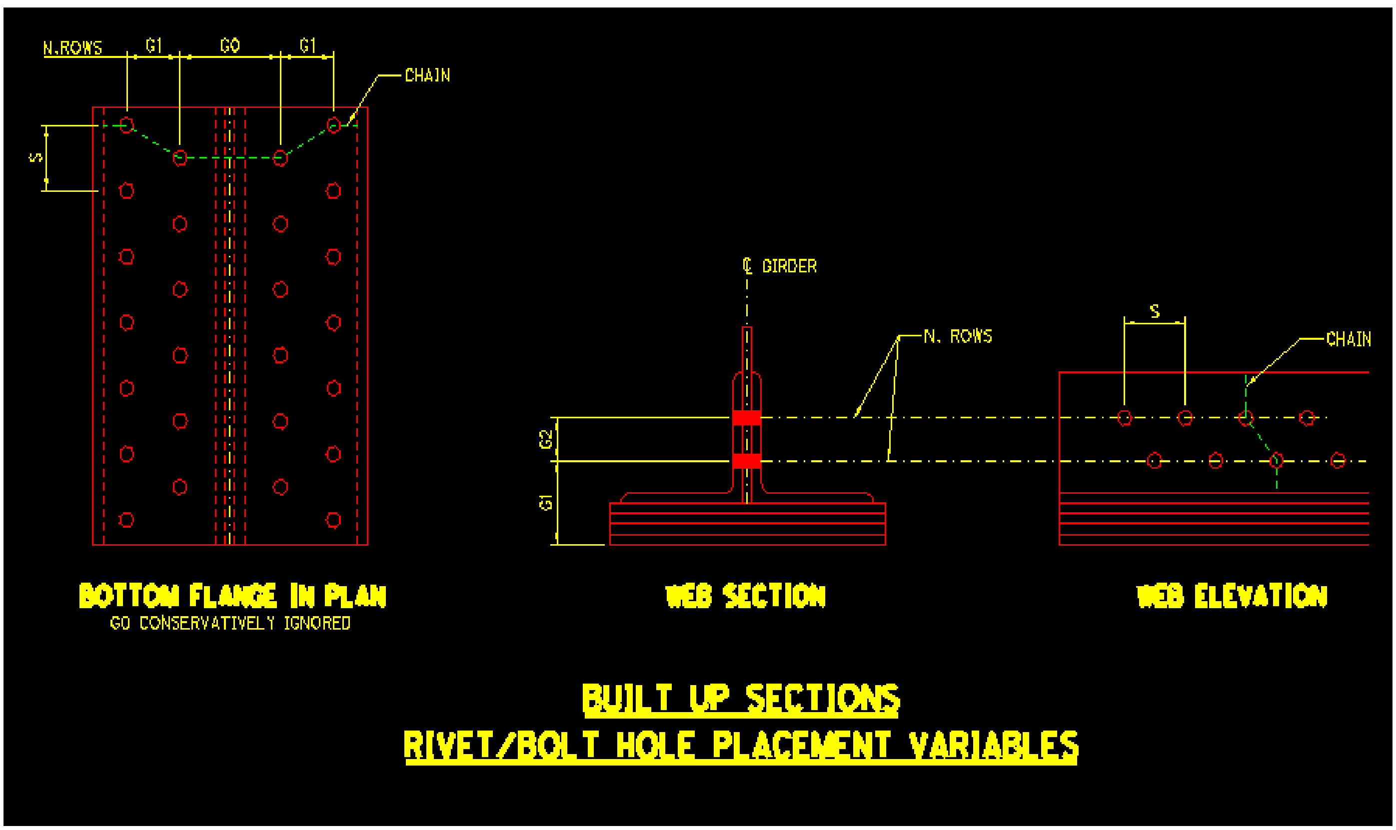
x	**6.50**	in	
y	**6.00**	in	
t	**0.670**	in	
A (each angle)	7.93	in2	(ref. wksht. BF_Angle_Pair)
Ixxo, Double Angles	52.55	in4	(ref. wksht. BF_Angle_Pair)
y.bar (wrt X)	1.69	in	(ref. wksht. BF_Angle_Pair)
Iyyo, Double Angles	140.39	in4	(ref. wksht. BF_Angle_Pair)

Holes Through Bottom Flange (0 if does not exist OR is in compression at Section Location)

Rows	**4.00**	
Gage	**3.00**	in
Pitch	**4.00**	in

Holes Through Bottom Flange Angles and Web (0 if does not exist OR is in compression at Section Location)

Rows	**2**	
Gage 1	**4.00**	in
Gage 2	**3.00**	in
Pitch	**4.00**	in



Project: *VDOT Shenandoah Valley Asset 7643*

Michael Baker INTERNATIONAL

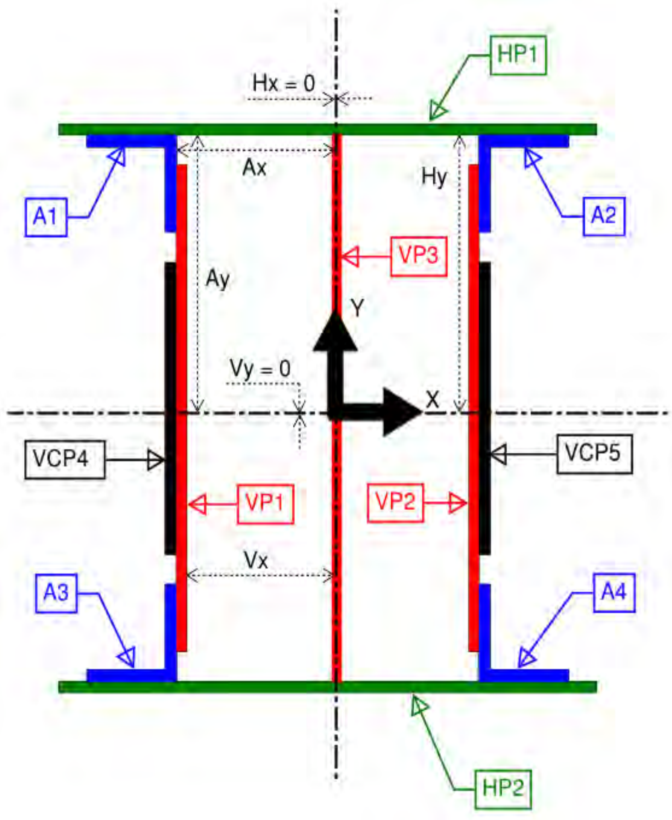
Task: *Deck Plate Girder Load Rating* **Project No:**

Subject: *Span 10 Load Rating*

Calculated By: *DS* **Date:** *1/15/2025* **Checked By:** *JBT* **Date:** 1/22/2025

TF_Angle_Pair

Member Section Properties



Angle legs shown as "out" in this sketch.

"Ax" and "Ay" shown for A1
"Vx" and "Vy" shown for VP1
"Hx" and "Hy" shown for HP1

	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	**no**			-	-			-	-	-		
HP2	**no**			-	-			-	-	-		
VP1	**no**					-	-	-	-	-		
VP2	**no**					-	-	-	-	-		
VP3	**no**					-	-	-	-	-		
VCP4	**no**					-	-	-	-	-		
VCP5	**no**					-	-	-	-	-		
A1 (Horiz. Leg)	**yes**	**6.50**	**0.67**	-	-	-	-	-	**0**	**out**		
A1 (Vert. Leg)	yes	**6.00**	**0.67**	-	-	-	-	**-0.2545**	-	out		
A2 (Horiz. Leg)	**yes**	**6.50**	**0.67**	-	-	-	-	-	0	**out**		
A2 (Vert. Leg)	yes	**6.00**	**0.67**	-	-	-	-	0.2545	-	out		
A3 (Horiz. Leg)	**no**			-	-	-	-	-		**out**		
A3 (Vert. Leg)	no			-	-	-	-		-	out		
A4 (Horiz. Leg)	**no**			-	-	-	-	-	0	**out**		
A4 (Vert. Leg)	no			-	-	-	-	0	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.509** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A1 (Horiz. Leg)	4.36	0.34	1.46	0.16	-1.35	7.96	8.12		4.36
A1 (Vert. Leg)	3.57	3.34	11.91	8.45	1.65	9.70	18.16		3.57
A2 (Horiz. Leg)	4.36	0.34	1.46	0.16	-1.35	7.96	8.12		4.36
A2 (Vert. Leg)	3.57	3.34	11.91	8.45	1.65	9.70	18.16		3.57
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.69	0.00	0.00		0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.69	0.00	0.00		0.00
Σ	**15.85**		**26.74**	**17.23**		**35.32**	**52.55**	**Σ**	**15.85**

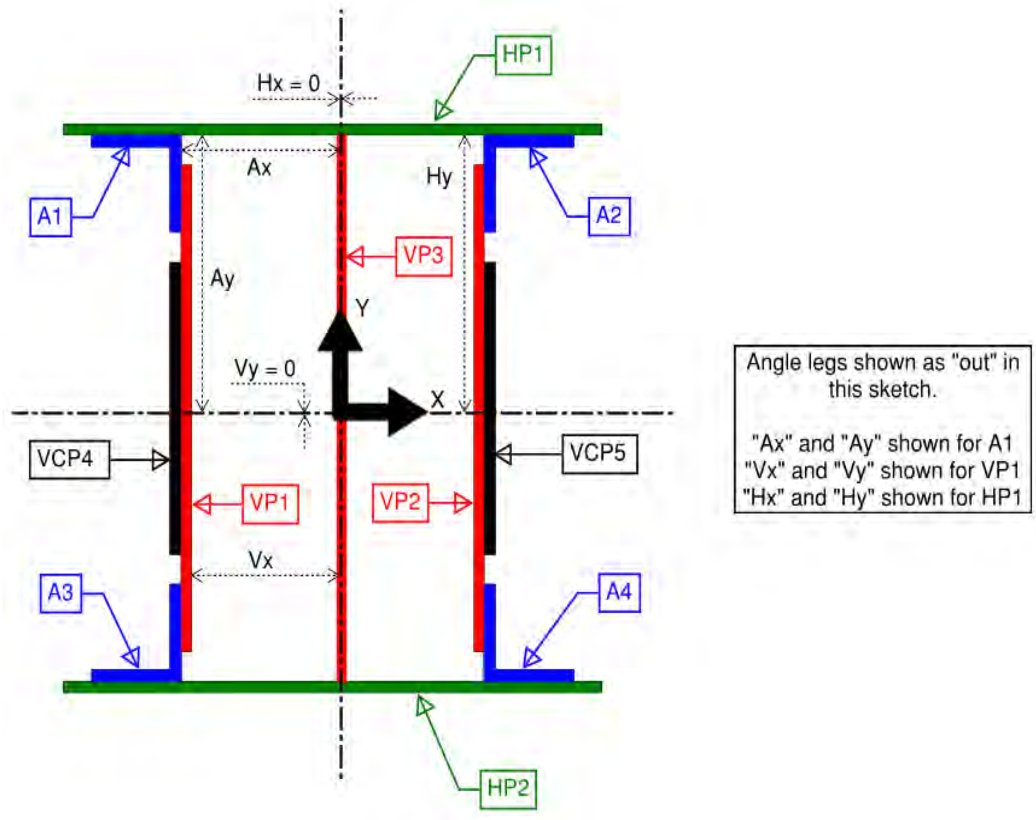
y_{bar} =	1.69	in	c_{top}=	1.31	in
I_x =	52.55	in^4	c_{bottom}=	4.69	in
A =	15.85	in^2	S_{top} =	40.01	in^3
r_x =	1.82	in	S_{bottom} =	11.21	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	4.36	-3.50	-15.26	15.33	-3.50	53.49	68.82
A1 (Vert. Leg)	3.57	-0.59	-2.11	0.13	-0.59	1.24	1.37
A2 (Horiz. Leg)	4.36	3.50	15.26	15.33	3.50	53.49	68.82
A2 (Vert. Leg)	3.57	0.59	2.11	0.13	0.59	1.24	1.37
A3 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A4 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
Σ	**15.85**		**0.00**	**30.93**		**109.45**	**140.39**

y_{bar} =	0.00	in	c_{left}=	6.75	in
I_y =	140.39	in^4	c_{right}=	6.75	in
A =	15.85	in^2	S_{left} =	20.78	in^3
r_y =	2.98	in	S_{right} =	20.78	in^3

BF_Angle_Pair

Member Section Properties



	Included?	Width (in.)	Thickness (in.)	"Vx", Horiz. Dist. from center to edge of plate	"Vy", Vert. offset of plate from X-X axis	"Hx", Horiz. offset of plate from Y-Y axis	"Hy", Vert. Dist. from center to edge of plate	"Ax", Horiz. Dist. from center to back face of angle leg	"Ay", Vert. Dist. from center to back face of angle leg	Angle Leg Orientation	Number of Holes	Dia. of Hole (in.)
HP1	**no**			-	-			-	-	-		
HP2	**no**			-	-			-	-	-		
VP1	**no**					-	-	-	-	-		
VP2	**no**					-	-	-	-	-		
VP3	**no**					-	-	-	-	-		
VCP4	**no**					-	-	-	-	-		
VCP5	**no**					-	-	-	-	-		
A1 (Horiz. Leg)	**no**			-	-	-	-	-		**out**		
A1 (Vert. Leg)	no			-	-	-	-		-	out		
A2 (Horiz. Leg)	**no**			-	-	-	-	-	0	**out**		
A2 (Vert. Leg)	no			-	-	-	-	0	-	out		
A3 (Horiz. Leg)	**yes**	**6.50**	**0.67**	-	-	-	-	-	**0**	**out**		
A3 (Vert. Leg)	yes	**6.00**	**0.67**	-	-	-	-	**-0.2545**	-	out		
A4 (Horiz. Leg)	**yes**	**6.50**	**0.67**	-	-	-	-	-	0	**out**		
A4 (Vert. Leg)	yes	**6.00**	**0.67**	-	-	-	-	0.2545	-	out		

X-X Axis Section Properties:

Total height of section (along y-y axis) = **6.00** in

Y-Y Axis Section Properties:

Total width of section (along x-x axis) = **13.509** in

	A (in^2)	y (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{x-x} (in^4)		A_{net} (in^2)
HP1	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
HP2	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP1	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP2	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VP3	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VCP4	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
VCP5	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.69	0.00	0.00		0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	-1.69	0.00	0.00		0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	-1.69	0.00	0.00		0.00
A3 (Horiz. Leg)	4.36	0.34	1.46	0.16	-1.35	7.96	8.12		4.36
A3 (Vert. Leg)	3.57	3.34	11.91	8.45	1.65	9.70	18.16		3.57
A4 (Horiz. Leg)	4.36	0.34	1.46	0.16	-1.35	7.96	8.12		4.36
A4 (Vert. Leg)	3.57	3.34	11.91	8.45	1.65	9.70	18.16		3.57
Σ	**15.85**		**26.74**	**17.23**		**35.32**	**52.55**	**Σ**	**15.85**

y_{bar} =	1.69	in	c_{top}=	1.31	in
I_x =	52.55	in^4	c_{bottom}=	4.69	in
A =	15.85	in^2	S_{top} =	40.01	in^3
r_x =	1.82	in	S_{bottom} =	11.21	in^3

	A (in^2)	x (in)	Ay (in^3)	Io (in^4)	d (in)	Ad^2 (in4)	I_{y-y} (in^4)
HP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VP3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VCP5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A1 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A2 (Horiz. Leg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2 (Vert. Leg)	0.00	0.00	0.00	FALSE	0.00	0.00	0.00
A3 (Horiz. Leg)	4.36	-3.50	-15.26	15.33	-3.50	53.49	68.82
A3 (Vert. Leg)	3.57	-0.59	-2.11	0.13	-0.59	1.24	1.37
A4 (Horiz. Leg)	4.36	3.50	15.26	15.33	3.50	53.49	68.82
A4 (Vert. Leg)	3.57	0.59	2.11	0.13	0.59	1.24	1.37
Σ	**15.85**		**0.00**	**30.93**		**109.45**	**140.39**

y_{bar} =	0.00	in	c_{left}=	6.75	in
I_y =	140.39	in^4	c_{right}=	6.75	in
A =	15.85	in^2	S_{left} =	20.78	in^3
r_y =	2.98	in	S_{right} =	20.78	in^3

NET SECTION

DESCRIPTION:

Net Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	84.5	in
Effective rivet hole diameter	0.9375	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

bf		14.125	in
tf		1.875	in
A	1.875 x 14.125 =	26.48438	in2
x	88.25 - (0.5 x 1.875) =	87.3125	in
Ax	26.484375 x 87.3125 =	2312.42	in3
d	87.3125 - 46.22 =	41.0925	in
Ad2	26.484375 x 41.0925^2 =	44721.34	in4

Top Flange Angles

x		6.5	in
t		0.67	in
A (angle)		7.9261	in2
Ixxo, Double Angles		52.5529	in4
A	2 x 7.9261 =	15.8522	in2
y.bar		1.69	in
x	88.25 - 1.875 - 1.69 =	84.69	in
Ax	15.8522 x 84.685 =	1342.44	in3
d	84.685 - 46.22 =	38.465	in
Ad2	15.8522 x 38.465^2 =	23454	in4

Holes Through Top Cover Plates and Top Flange Angles

Rows		0.00	
Gage		0.00	in
Pitch		0.00	in
Grip	1.875 + 0.67 =	2.545	in
A*	2 x 0.9375 x 2.545 =	0.0000	in^2
x	88.25 - 2.545 / 2 =	86.9775	in
Ax	0 x 86.9775 =	0	in^3
d	86.9775 - 46.22 =	40.7575	in
Ad^2	0 x 40.7575^2 =	0	in^4

Holes Through Top Flange Angles and Web

Rows		0.00	
Gage 1		0.00	in
Gage 2		0.00	in
Pitch		0.00	in
Grip	2 x 0.67 + 0.509 =	1.849	in
A*	0	0.0000	in^2
x	88.25 - 1.875 - (0 +0)/2 =	86.375	in
Ax	0 x 86.375 =	0	in^3
d	86.375 - 46.22 =	40.155	in
Ad^2	0 x 40.155^2 =	0	in^4

NET SECTION

Web			
d		84.50	in
t_w		0.51	in
A	0.509 x 84.5 =	43.0105	in^2
x	1.875 + 0 + (0.5 x 84.5) =	44.125	in
Ax	43.0105 x 44.125 =	1897.84	in^3
d	46.22 - 44.125 =	2.095	in
Ad^2	43.0105 x 2.095^2 =	188.77	in^4
I_{web}	(0.509) x (84.5)^3 / 12 =	25592	in^4

Holes Through Web at Diaphragm Connection			
Total # of Holes		12.00	
# of Holes in long row		12.00	
Gage		6.00	in
Pitch		0.00	in
Grip	0.509 =	0.509	in
A*	12 x 0.9375 x 0.509 =	5.7263	in^2
x	centered on web =	44.125	in
Ax	5.7263 x 44.125 =	253	in^3
d	max =	33.00	in
Ad^2	Total for all holes =	1589.05	in^4
I_{holes}	12 x 0.509 x 0.9375^3/12 =	0.42	in^4

Holes Through Bottom Flange L's and Web			
Rows		2.00	
Gage 1		4.00	in
Gage 2		3.00	in
Pitch		4.00	in
Grip	2 x 0.67 + 0.509 =	1.849	in
A*	1 x 0.9375 x 1.849 =	1.7334	in^2
x	+ (4 + 3) / 2 =	5.375	in
Ax	1.7334 x 5.375 =	9	in^3
d	46.22 - 5.375 =	40.845	in
Ad^2	1.7334 x 40.845^2 =	2892	in^4

Holes Through Bot. Cover Plates and Bot. Flange L's			
Rows		4.00	
Gage		3.00	in
Pitch		4.00	in
Grip	1.875 + 0.67 =	2.545	in
A	2 x 0.9375 x 2.545 =	4.7719	in^2
x	0.5 x 2.545 =	1.2725	in
Ax	4.7719 x 1.2725 =	6	in^3
d	46.22 - 1.2725 =	44.9475	in
Ad^2	4.7719 x 44.9475^2 =	9641	in^4

Bottom Flange Angles			
x		6.50	in
t		0.67	in
A (angle)		7.93	in^2
Ixxo, Double Angles		52.55	in^4
A	2 x 7.9261 =	15.8522	in^2
y.bar		1.69	in
Ax	15.8522 x 1.69 =	26.79	in^3
d	46.22 - 1.69 =	44.53	in
Ad^2	15.8522 x 44.53^2 =	31433.66	in^4

Bottom Cover Plates			
b_f		14.13	in
t_f		1.88	in
A	1.875 x 14.13 =	26.49375	in^2
x	0.5 x 1.875 =	0.9375	in
Ax	26.49375 x 0.9375 =	24.84	in^3
d	46.22 - 0.9375 =	45.2825	in
Ad^2	26.49375 x 45.2825^2 =	54325.56	in^4

Michael Baker INTERNATIONAL

NET SECTION

Girder Properties

Girder d	1.875 + 0 + 84.5 + 0 + 1.875 =	88.25	in
ΣA	26.484375 + 15.8522 - 0 - 0 + 43.0105 - 5.7263 - 1.7334 - 4.7719 + 15.8522 + 26.49375 =	115.46	in^2
ΣAx	2312.42 + 1342.44 - 0 - 0 + 1897.84 - 253 - 9 - 6 + 26.79 + 24.84 =	5336.33	in^3
Xcg	= ΣAx / ΣA =	46.22	in
ΣAd^2	44721.34 + 23454 - 0 - 0 + 188.77 -1589.04825 - 2892 - 9641 + 31433.66 + 54325.56 =	140001.3	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges} - I_{holes}$ =	165697.97	in^4
S_{BOTTOM}	165697.97 / 46.22 =	3585	in^3

* Area to be deducted for bolt holes calculated for multiple failure paths.

GROSS SECTION

DESCRIPTION:

Gross Section Calculation of Built Up Girder

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2020

GIRDER GROSS SECTION CALCULATION:

Depth Bk. To Bk. Of Angles	84.5	in
Clear Distance Web to Flange Angle	0	in

Top Cover Plates

b_f		14.13	in
t_f		1.88	in
A	1.875 x 14.125 =	26.48438	in^2
x	88.25 - (0.5 x 1.875) =	87.3125	in
Ax	26.484375 x 87.3125 =	2312.42	in^3
d	87.3125 - 43.89 =	43.4225	in
Ad^2	6.484375 x 43.4225^2 =	49936.65	in^4

Top Flange Angles

x		6.50	in
t		0.67	in^2
A (each angle)		7.93	in^4
A	2 x 7.9261 =	15.8522	in^2
Ixx, double angles		52.55	in^4
y.bar		1.69	in
x	88.25 - 1.875 - 1.69 =	84.69	in
Ax	15.8522 x 84.685 =	1342.44	in^3
d	84.685 - 43.89 =	40.80	in
Ad^2	15.8522 x 40.795^2 =	26381.74	in^4

Web

d		84.50	in
t_w		0.51	in
A	0.509 x 84.5 =	43.0105	in^2
x	84.5 / 2 +1.875+0	44.125	in
Ax	43.0105 x 44.125 =	1897.84	in^3
d	43.89 - 44.125 =	0.235	in
Ad^2	43.0105 x 0.235^2 =	2.38	in^4
I_{web}	(0.509) x (84.5)^3 / 12 =	25592.14	in^4

Bottom Flange Angles

x (angle)		6.50	in
t		0.67	in
A (angle)		7.93	in
A	2 x 7.9261 =	15.8522	in^2
Ixx, double angles		52.55	in^4
y.bar		1.69	in
Ax	15.8522 x 1.69 =	26.79	in^3
d	43.89 - 1.69 =	42.2	in
Ad^2	15.8522 x 42.2^2 =	28230.23	in^4

Bottom Cover Plate

b_f		14.13	in
t_f		1.88	in
A	1.875 x 14.13 =	26.49375	in^2
x	0.5 x 1.875 =	0.9375	in
Ax	26.49375 x 0.9375 =	24.84	in^3
d	43.89 - 0.9375 =	42.9525	in
Ad^2	26.49375 x 42.9525^2 =	48878.78	in^4

GROSS SECTION

Girder Properties

Girder d	1.875 + 84.5 + 1.875 + 2 x 0 =	88.25	in
ΣA	26.484375 + 15.8522 + 43.0105 + 15.8522 + 26.49375 =	127.693	in^2
ΣAx	2312.42 + 1342.44 + 1897.84 + 26.79 + 24.84 =	5604.3	in^3
Xcg	= ΣAx / ΣA =	43.89	in
ΣAd^2	49936.65 + 26381.74 + 2.38 + 28230.23 + 48878.78 =	153,430	in^4
I	$\Sigma Ad^2 + I_{web} + I_{flanges}$ =	179,127	in^4
S_{TOP}	179127 / (88.25 - 43.89) =	4,038	in^3

Allowable Compression in Bending

L (dist. Btwn pts. of lateral support for compr. flange)		136.0625	in
y (for top flange angle)		6	in
Iyy.pl (for top flange plate, or cover plate)	1.875 * 14.125^3/12="	440.3	in^4
Iyy.2A (for top flange double angle)		140.39	in
Iyy (compression flange)	440.3 + 140.39 =	580.70	in^4
A (compression flange & web)	26.484375 + 15.8522 + 43.0105 / 2 =	63.841825	in^2
r_Y (compression flange & web)	SQRT (Iyy / A) =	3.02	in
A_f	26.484375 + 15.8522 =	42.336575	in^2
F_y (psi)		30000	psi
Normal Rating - Refer to AREMA Section 15.1.4.1 - Table 15-1-11			
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed $0.55F_y$			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1 $0.55 \times F_Y - 0.55 (F_Y)^2 / (6.3 \times \pi^2 \times E) \times (L/ ry)^2$			
	0.55 x 30000 - 0.55 (30000)^2 / (6.3 x π^2 x E) x (136.0625 / 3.02)^2 =	15,943	psi
Eq. 2 $(0.131\pi E) / (ld \sqrt{(1+\mu)} / A_f)$			
	(0.131π x 29,000,000) / ((136.0625 x 88.25 x √1+0.3) / (42.336575)) =	36,907	psi
	But not to exceed 0.55 x 30000 =	16,500	psi
	Girder Type =	fastened	
	Allowable Stress =	15.94	ksi

GROSS SECTION

Maximum Rating - Refer to AREMA Section 15.7.3.3.4 - Table 15-7-2			
K 0.8 x 30000 =		24,000	psi
If Section is Rolled or Welded use larger of Eq. 1 and Eq. 2, not to exceed K			
If Section is fastened (bolts or rivets) use Eq. 1			
Eq. 1	$K - KF_Y / (1.8 \times 10^9) \times (L / ry)^2$		
	24000 - (24000 x 30000) / (1.8 x 10^9) x (136.0625 / 3.02)^2 =	23,188	psi
		23.19	ksi
Eq. 2	$(K / 0.55F_y) \times (10{,}500{,}000 / (Ld/A_f))$, not to exceed K		
	(24000/0.55 x 30000) x (10,500,000/ (136.0625 x 88.25 / 42.336575) =	53,849	psi
	Result of Eq. 2 not to exceed K =	24.00	ksi
	Girder Type =	fastened	
	Allowable Stress =	23.19	ksi

RATING CALCULATIONS

DESCRIPTION:

Calculations for Loads, capacities, and ratings

REFERENCES:

(1) AREMA Manual for Railway Engineering, 2024

LOAD CALCULATIONS:

62.833333	Span Length (ft)	9	CL Fascia to CL Fascia (ft)	open	Deck
5	Rail Spacing (ft)	2	Number of Girders	0.00	Deck Width (ft)
1.04	Tie Spacing (ft)	1	Number of Tracks	0.00	Deck Thickness (in)
14.00	Tie Height (in)			0	Number of Diaphragms
10.00	Tie Width (in)			0.00	Weight of Diaphragm (LB/FT)
11.99	Tie Length (ft)			fastened	Girder Type
0.00	Ballast Depth (in)	30000	F_y (psi)		
0.00	Ballast Width (ft)				

Cooper E80

E80 Moment	**2,829.34**	k-ft
E80 Shear	**203.09**	k

286k Car

286k Car Moment	**1,990.10**	k-ft
286k Car Shear	**203.09**	k

315k Car

315k Car Moment	**2,005.11**	k-ft
315k Car Shear	**149.05**	k

Wind on Live Load - Refer to AREMA Articles 15-7.3.2.5a

Span Length	62.83	ft
Rail Spacing	5.00	ft
Number of Beams Resisting Wind on Live Load Vertical Reaction	1	beams
Vertical Force on Beam Resulting from Wind on Live Load, Applied 8' above Track	0.32	k/ft
Wind on Live Load Moment	157.92	k-ft
Wind on Live Load Shear	10.05	k

PROJECT : *VDOT Shenandoah Valley Asset 7643*			
TASK : *Deck Plate Girder Load Rating*		PROJECT NO :	
SUBJECT : *Span 10 Load Rating*			
CALCULATED BY : *DS*	DATE : *1/15/2025*	CHECKED BY : *JBT*	DATE : 1/22/2025

RATING CALCULATIONS

Vertical Effects Impact Load - Refer to AREMA Articles 15.1.3.5.c.1 and 15.7.3.3.3.a

Speed Reduction Factor (SRF)	1 - (0.8 / 2500) x (60 - SL)^2
SFF = 1.0 For Open Deck, 0.9 For Ballasted Deck	1
Impact due to Vertical Effects	= SFF x SRF x [40 - 3L^2 / 1600]

Rocking Effects Impact Load - Refer to AREMA Articles 15.1.3.5.d **& 15.9.1.3.5.d**

Rocking Effects (percentage of wheel load)	20.00%
Number of Beams/2*	1
*Rocking distributed among half the beams since it acts downwards on only one rail	
Note: If Number of beams = 2, RE = 100 / Girder Spacing . If Number of beams > 2, Use RE = 20% (No. of Beams / 2)	
Percentage of wheel load taken by one beam	11.11%

Dead Load on One Girder

Girder	127.693025/144*490="	434.5	lb / ft
Diaphragms			
Number		0	
Total Length		0	
Weight per foot		0.00	lb / ft
Total Weight		0	lbs
Number of girders		2	
Weight per foot of beam		0.0	lb / ft
Add 8% for Connections		x1.08	
Total Steel Load	1.08 x (434.5 + 0) =	469	lb / ft
Rail - Use 200 lb / ft for rail, guard rails and rail fastenings per AREMA 15.1.3.2.b		200	lb / ft
Number of Rails		2	
Number of Beams		2	
Rail Weight/LF of beam		100	lb / ft
Ties - Unit Weight of Timber per AREMA 15.1.3.2.a -		60	lb / ft^3
Weight of one tie	14/12 x 10/12 x 11.99 x 60 =	699	lb
Number of ties	62.8333333333333 ft / 1.04166666666667 ft =	60.32	ties
Number of Beams		2	
Tie Weight/ LF of beam		336	lb / ft

Michael Baker INTERNATIONAL

RATING CALCULATIONS

Ballast -			
Unit weight of ballast per AREMA 15.1.3.2.a -		120	lb / ft^3
Volume of One Tie		11.65	ft^3
Ties per LF of Bridge		0.96	ties
Average Area of Ties per LF of Bridge		11.184	SF
Area of Ballast per LF of bridge		0	SF
Number of Beams		2	
Weight of Ballast per LF of Beam (subtract out volume of ties)		0	lb / ft
Deck -			
Deck Material		open	
Unit weight of deck per AREMA 15.1.3.2.a -		0	lb / ft^3
Area of deck per LF of Bridge		0	SF
Number of Beams		2	
Weight of Deck per LF of Beam		0	lb / ft
Walkway - See estimated unit weight calc in Narrative			
Unit Weight per LF of Beam		**165.00**	lb / ft
Total Dead Load		**1070**	**lb / ft**
		1.07	k / ft
Moment	**1.07 x 62.8333333333333^2 / 8 =**	**528.05**	**k-ft**
Shear	**1.07 x 62.8333333333333 / 2 =**	**33.62**	**k**

Existing Properties (from Net Section and Gross Section Calculations)

S_{BOTTOM} (Tension - Net Section)				3585	in^3
S_{TOP} (Compression - Gross Section)				4,038	in^3
A_{web}				43.0105	in^2
Allowable Tension Stress in Bending (Normal Rating)	0.55 x 30000 =	16500	=	16.5	ksi
Allowable Compression Stress in Bending (Normal Rating)				15.94	ksi
Allowable Shear Stress (Normal Rating)	0.35 x 30000 =	10500	=	10.5	ksi
Allowable Tension Stress in Bending (Maximum Rating)	K = 0.8 x 30000 =	24000	=	24	ksi
Allowable Compression Stress in Bending (Maximum Rating)				23.19	ksi
Allowable Shear Stress (Maximum Rating)	0.75K = 0.75 x 24000 =	18000	=	18	ksi

RATING CALCULATIONS

Capacity Reduction (Due to Section Loss, 0 for as-built condition) CRF = 2.0%

Maximum Capacity

Maximum Tension Stress Capacity - Normal Rating	(3585 x 16.5 / 12) x (1 - CRF) =	4831	k-ft
Maximum Tension Stress Capacity - Maximum Rating	(3585 x 24 / 12) x (1 - CRF) =	7027	k-ft
Maximum Compression Stress Capacity - Normal Rating	(4038 x 15.943 / 12) x (1 - CRF) =	5258	k-ft
Maximum Compression Stress Capacity - Maximum Rating	(4038 x 23.19 / 12) x (1 - CRF) =	7647	k-ft
Maximum Shear Stress Capacity - Normal Rating	(43.0105 x 10.5) x (1 - CRF) =	443	k
Maximum Shear Stress Capacity - Maximum Rating	(43.0105 x 18) x (1 - CRF) =	759	k

Girder Ratings for Tension Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193
25	0.61	19.82%	11.11%	30.9	E90	E137	E127	E195	E126	E193

Girder Ratings for Compression Stress in Bending

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212
25	0.61	19.82%	11.11%	30.9	E99	E150	E140	E214	E139	E212

Girder Ratings for Shear Stress

Speed		Impact		Impact	Cooper E80 Rating		286k Car Rating		315k Car Rating	
(mph)	SRF	Vert. Eff.	RE	%	Normal	Max	Normal	Max	Normal	Max
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293
25	0.61	19.82%	11.11%	30.9	E120	E215	E120	E215	E164	E293

RATING CALCULATIONS

Governing Ratings

Type	Cooper E80	286k Car	315k Car
Normal	E90	E120	E126
Maximum	E137	E195	E193

Note for Governing Ratings at the Alternative Live Loads (286k. 315k): An E-rating greater than the corresponding Cooper E80 member E-rating signifies that the Alternative Load is less demanding than the E80 load.

Convert the above normal ratings to show Equivalent 286k and Equivalent 315k ratings, where:

Eq. 286k Rating = 80 * (Member E80 Rating / Member 286k Rating normalized to E80 expression)

Eq. 315k Rating = 80 * (Member E80 Rating / Member 315k Rating normalized to E80 expression)

An Equivalent Rating value for the Alternative Loads less than the corresponding Cooper E80 member rating signifies that the Alternative Load is less demanding than the E80 load.

Governing Ratings including E-80 Equivalents for 286k and 315k loads

Type	Cooper E80	EQ 286k Car	EQ 315k Car
Normal	E90	E60	E57
Maximum	E137	-	-

Appendix D-2: Photo Log

Photo 01: Asset 5104 Elevation

Photo 02: Asset 5104 Track Level

Photo 03: Asset 5104 Span 3 End Post

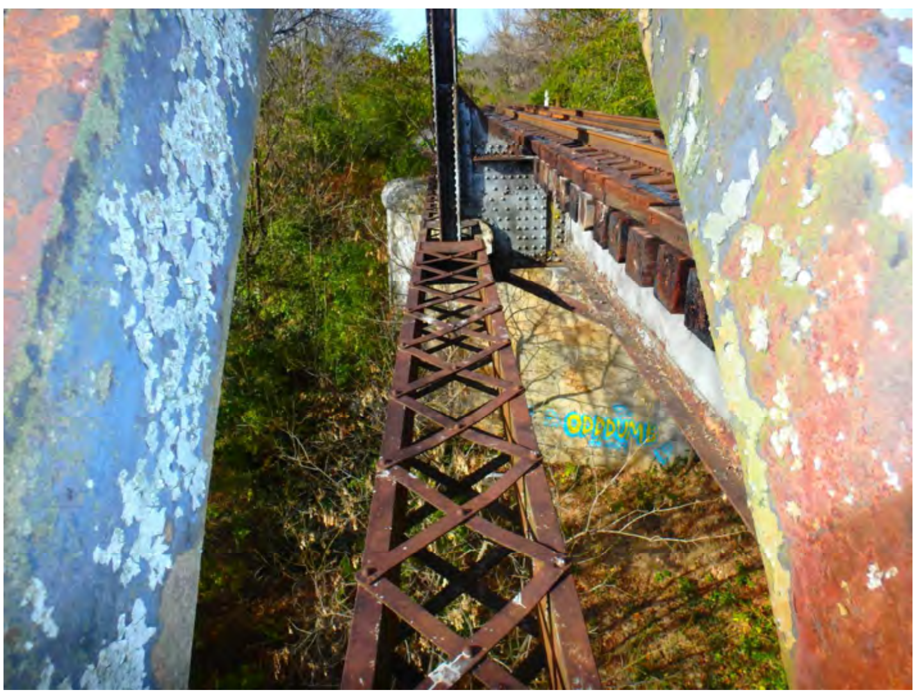


Photo 04: Asset 5104 Span 2/4 Bottom Chord

Photo 05: Asset 5104 Span 2/4 Eye-bar Diagnals

Photo 06: Asset 5104 Span 2/4 Eye-bar Bottom Chord

Photo 07: Asset 5104 Span 2/4 Upper Chord

Photo 08: Asset 5104 Span 2/4 Eye-bar Section Loss

Photo 09: Asset 5104 Typical Eye-bar Section Loss at Connection

Photo 10: Asset 5104 Span 4 Bearing

Photo 11: Asset 5104 Span 3 Bottom Chord Section Loss to Interior Angles

Photo 12: Aset 5104 Span 3 Section Loss at Portal Brace Connection

Photo 13: Asset 6141 Overall

Photo 14: Asset 6141 Diaphragms and Top Lateral Bracing

Photo 15: Asset 6141 Diaphragm Connection at Interior Beams

Photo 16: Asset 6141 Impact Damage Bottom Flange

Photo 17: Asset 6141 Diaphragm Connection

Photo 18: Asset 7643 Span 11 South Face

Photo 19: Asset 7643 Span 10 Upper Laterals and Inside Face

Photo 20: Asset 7643 Span 7 Cross Frames

Photo 21: Pier 6 North Face

Photo 22: Asset 7643 Jump Span West End

Photo 23: Asset 7643 Pier 7 East Face

Photo 24: Asset 7643 Track Level

Appendix D-3: Structure Inventory

MBI Asset No.	Superstructure Type	Structure Type	Feature Crossed	Deck Type	No. Spans	Bridge Length/ Culvert Opening (ft)	Deck Width/ Culvert Length (ft)	Existing Width Viable for Track & Trail (> 30ft)	Structure Viable for Cantilever	
5104	Steel Through Truss & Steel Deck Beams	Bridge	South Fork Shenandoah River	Open	5	522'-0"	16'-0"	No	No	Through truss is not condusive to resisting local torsional effects. The chords consists of eye-bars (2 of 3 trusses are pin connected) which makes retrofit nearly impossible.
5157	18" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	1'-6"	25'-0"	No	No	Trail must be accomodated through culvert lengthening.
5320	18" CMP	Culvert	Unnamed Drainage	N/A	1	1'-6"	20'-0"	No	No	Trail must be accomodated through culvert lengthening.
5321	18" CMP	Culvert	Unnamed Drainage	N/A	1	1'-6"	20'-0"	No	No	Trail must be accomodated through culvert lengthening.
5326	48" CMP	Culvert	Unnamed Drainage	N/A	1	4'-0"	45'-0"	Yes	No	Trail may fit in existing track bed.
5355	18" CMP	Culvert	Unnamed Drainage	N/A	1	1'-6"	24'-0"	No	No	Trail must be accomodated through culvert lengthening.
5382	24" CMP	Culvert	Unnamed Drainage	N/A	1	2'-0"	24'-0"	No	No	Trail must be accomodated through culvert lengthening.
5387	36" CMP	Culvert	Unnamed Drainage	N/A	1	3'-0"	38'-0"	Yes	No	Trail may fit in existing track bed.
5389	36" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	3'-0"	30'-0"	Yes	No	Trail may fit in existing track bed.
5518	36" Steel Pipe	Culvert	Unnamed Drainage	N/A	1	3'-0"	60'-0"	Yes	No	Trail may fit in existing track bed.
5523	Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	1	1'-8"	60'-0"	Yes	No	Trail may fit in existing track bed.

MBI Asset No.	Superstructure Type	Structure Type	Feature Crossed	Deck Type	No. Spans	Bridge Length/ Culvert Opening (ft)	Deck Width/ Culvert Length (ft)	Existing Width Viable for Track & Trail (> 30ft)	Structure Viable for Cantilever	
5565	Steel Deck Girder & Beams	Bridge	Passage Creek	Open	4	128'-6"	10'-0"	No	No	Depth of existing girders insufficient to support cantilever walkway.
5612	18" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	1'-6"	32'-0"	Yes	No	Trail may fit in existing track bed.
5618	Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	1	2'-0"	50'-0"	Yes	No	Trail may fit in existing track bed.
5636	60" CMP	Culvert	Unnamed Drainage	N/A	1	5'-0"	40'-0"	Yes	No	Trail may fit in existing track bed.
5671	4-30" Concrete Pipes	Culvert	Unnamed Drainage	N/A	4	4'x2'-6"	40'-0"	Yes	No	Trail may fit in existing track bed.
5695	36" Concrete Pipe & Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	2	3' & 1'-6"	26'-0"	No	No	Trail must be accomodated through culvert lengthening.
5705	20" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	1'-8"	34'-3"	Yes	No	Trail may fit in existing track bed.
5734	18" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	1'-6"	21'-0"	No	No	Trail must be accomodated through culvert lengthening.
5740	24" Concrete Pipe	Culvert	Unnamed Drainage	N/A	1	2'-0"	26'-6"	No	No	Trail must be accomodated through culvert lengthening.
5791	Concrete Box Culvert	Culvert	Unnamed Drainage	N/A	1	5'-0"	26'-0"	No	No	Trail must be accomodated through culvert lengthening.
5944	Pin Connected Deck Truss	Bridge	North Fork Shenandoah River	Open	2	290'-0"	16'-8"	No	No	Pin connected truss is not condusive to resisting local torsional effects. The structure consists of eye-bar construction which makes retrofit nearly impossible.

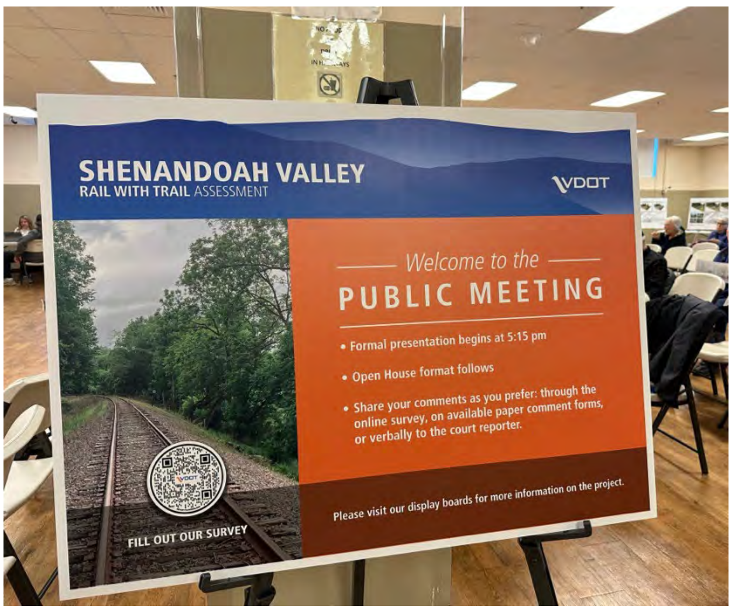
MBI Asset No.	Superstructure Type	Structure Type	Feature Crossed	Deck Type	No. Spans	Bridge Length/ Culvert Opening (ft)	Deck Width/ Culvert Length (ft)	Existing Width Viable for Track & Trail (> 30ft)	Structure Viable for Cantilever	
6141	Steel Deck Beams	Bridge	N. Massanutten Street	Open	1	45'-6"	10'-2"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
6148	Steel Deck Beams	Bridge	Town Run Stream	Open	5	105'-0"	11'-0"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
6280	Timber Deck Culvert	Culvert	Unnamed Drainage	Timber Ballasted	1	11'-0"	35'-0"	Yes	No	Trail may fit in existing track bed.
6391	Steel Deck Girder	Bridge	South Fork Run Tumbling Run & Battlefield Road	Open	4	262'-0"	10'-0"	No	Yes	
6540	Stone Masonry Arch	Culvert	Snapps Run	N/A	1	10'-0"	60'-0"	Yes	No	Trail may fit in existing track bed.
6669	Steel Deck Girders & Beams	Bridge	Hwy 651	Concrete Ballasted	3	127'-0"	26'-0"	No	Yes*	*Existing approach span beams too shallow for cantilever.
6765	Steel Deck Girder	Bridge	Toms Brook & Private Road	Open	12	510'-0"	10'-0"	No	Yes	
6824	Steel Deck Beams	Bridge	Jordan Run	Open	1	19'-1"	10'-0"	No	No	Depth of existing rolled beams insufficient to support cantilevered walkway.
6858	48" CMP	Culvert	Unnamed Drainage	N/A	1	3'-9"	40'-6"	Yes	No	Trail may fit in existing track bed.
7164	Steel Deck Girder	Bridge	Pugh's Run	Open	9	380'-0"	10'-0"	No	Yes	
7400	Stone Masonry Arch	Culvert	Unnamed Drainage	N/A	1	12'-0"	75'-0"	Yes	No	Trail may fit in existing track bed.

MBI Asset No.	Superstructure Type	Structure Type	Feature Crossed	Deck Type	No. Spans	Bridge Length/ Culvert Opening (ft)	Deck Width/ Culvert Length (ft)	Existing Width Viable for Track & Trail (> 30ft)	Structure Viable for Cantilever	
7500	Timber Deck Culvert	Culvert	Unnamed Drainage	Timber Ballasted	1	8'-6"	15'-0"	No	No	Trail must be accomodated through culvert lengthening.
7643	Steel Deck Girders & Beams	Bridge	Narrow Passage Run	Open	13	630'-0"	15'-2"	No	Yes	
7860	Stone Masonry Arch	Culvert	Unnamed Drainage	N/A	1	10'-0"	100'-0"	Yes	No	Trail may fit in existing track bed.
7902	Steel Deck Girder	Bridge	Stoney Creek & Massie Farm Lane	Open	7	375'-0"	12'-0"	No	Yes	
8438	Timber Deck Culvert	Culvert	Unnamed Drainage	Timber Ballasted	1	5'-0"	16'-6"	No	No	Trail must be accomodated through culvert lengthening.
8452	Timber Deck Bridge	Bridge	Unnamed Drainage	Timber Ballasted	1	6'-4"	17'-0"	No	No	Trail must be accomodated through culvert lengthening.
8620	Steel Deck Beams	Bridge	Bank Street	Open	1	20'-10"	11'-0"	No	No	Depth of existing girders insufficient to support a cantilever walkway.
8627	Steel Deck Girder	Bridge	Mill Creek (North Fork Shenandoah River) & Bryce Boulevard	Open	3	425'-0" MBI	12'-6"	No	Yes	
8763	Timber Deck Bridge	Bridge	Unnamed Drainage	Timber Ballasted	1	8'-6"	15'-0"	No	No	Trail must be accomodated through culvert lengthening.
8790	Timber Deck Culvert	Culvert	Unnamed Drainage	Timber Ballasted	1	13'-5"	32'-0"	Yes	No	Trail may fit in existing track bed.

MBI Asset No.	Superstructure Type	Structure Type	Feature Crossed	Deck Type	No. Spans	Bridge Length/ Culvert Opening (ft)	Deck Width/ Culvert Length (ft)	Existing Width Viable for Track & Trail (> 30ft)	Structure Viable for Cantilever	
8984	Steel Deck Girder	Bridge	Holmans Creek & Farm Road	Open	6	310'-0"	10'-1"	No	Yes	
9199	Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	2	2'-10" & 2'-11"	49'-0"	Yes	No	Trail may fit in existing track bed.
9213	Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	1	2'-9.5"	43'-0"	Yes	No	Trail may fit in existing track bed.
9224	Masonry Box Culvert	Culvert	Unnamed Drainage	Concrete Ballasted	1	6'-6"	16'-6"	No	No	Trail must be accomodated through culvert lengthening.
9286	Masonry Box Culvert	Culvert	Unnamed Drainage	N/A	1	3'-3"	20'-0"	No	No	Trail must be accomodated through culvert lengthening.
9430	Steel Deck Beams	Bridge	Unnamed Drainage	Open	7	140'-4"	10'-0"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
9435	Steel Deck Beams	Bridge	Unnamed Drainage	Open	2	40'-4"	11'-0"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
9540	Concrete Box Culvert	Culvert	Unnamed Drainage	N/A	1	12'-0"	41'-0"	Yes	No	Trail may fit in existing track bed.
9571	Steel Deck Beams	Bridge	Unnamed Drainage	Open	1	19'-8"	10'-0"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
9736	Steel Deck Girder	Bridge	Honey Run Creek	Open	2	90'-0"	10'-0"	No	No	Depth of existing girders insufficient to support cantilever walkway.
9901	Steel Deck Beams	Bridge	North Fork Shenandoah River	Open	1	28'-0"	11'-0"	No	No	Depth of existing rolled beams insufficient to support cantilever walkway.
9970	Steel Deck Girder	Bridge	North Fork Shenandoah River	Open	4	184'-0"	10'-1"	No	Yes	

APPENDIX E: PUBLIC ENGAGEMENT SUMMARY

Shenandoah Valley Rail-with-Trail Assessment
Public Information Meetings Comment Summary



June 2025

SUMMARY

The Virginia Department of Transportation (VDOT) hosted a series of Public Information Meetings for the public to learn more and provide input on the Shenandoah Valley Rail-with-Trail Assessment.

Meeting materials, including brochure, boards and survey were available on the project website at vdot.virginia.gov/shenandoahrailwithtrail.

In-person meetings were held from 5:00 to 7:00 pm at the following dates and locations:

Timberville
Tuesday April 8, at the Plains District Community Center, Large multi-purpose room
233 McCauley Ave, Timberville, VA 22853

Front Royal
Thursday April 10, at the Warren County Government Center, Board of Supervisors room
220 N Commerce Ave # 100, Front Royal, VA 22630

Woodstock
Tuesday April 15, at the Peter Muhlenberg Middle School, Cafeteria
1251 Susan Ave, Woodstock, VA 22664

A formal presentation was given at 5:15 at each meeting, followed by an open house style format.

A comment period was held from Thursday, March 27 until Friday, April 25, 2025.

Comments could be provided via survey forms at the meeting, submitted online or be sent via email or mail to the following:

Email: Brad.Reed@VDOT.virginia.gov

Mail:
Brad Reed, AICP
District Planner / Staunton
Virginia Dept. of Transportation
811 Commerce Road
Staunton, VA 24401

5,039 surveys were taken during the comment period.

3 Public Meetings

526 Total Attendees

5,039 Surveys Taken

Photos taken at the Shenandoah Rail-with-Trail meetings.

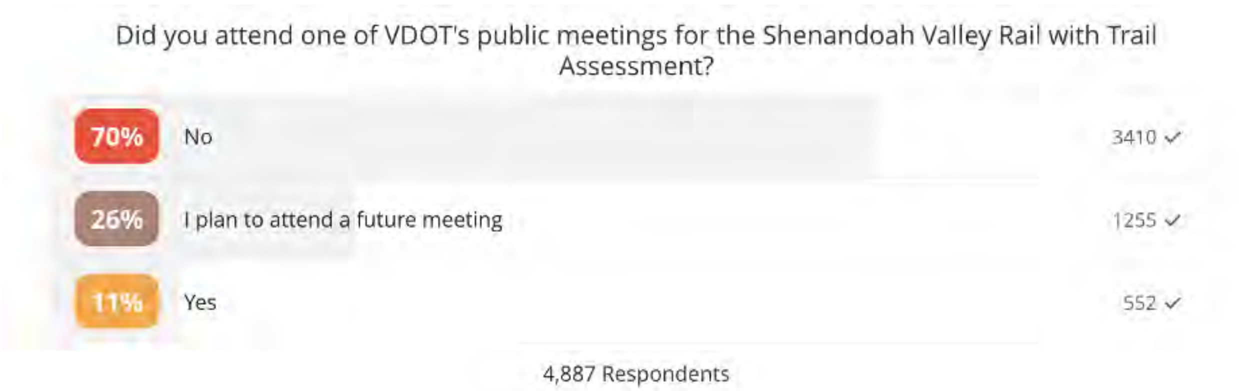
MEDIA

- Earned media coverage:
    - **VDOT study finds trail fits within rail corridor, schedules 3 public meetings for April** | The Winchester Star | March 24, 2025
    - **VDOT invites public feedback on Shenandoah Valley Rail-with-Trail Assessment** | Rocktown Now | March 27, 2025
    - **VDOT requests public feedback on phase 1 of Shenandoah Valley Rail-with-Trail** | Augusta Free Press | March 27, 2025
    - **VDOT seeks public opinion on Shenandoah rail trail** | WHSV3 | April 4, 2025
    - **Working on the rail trail: VDOT hosts informational meeting in Front Royal** | The Northern Virginia Daily | April 12, 2025
    - **Residents split over future of rail corridor at Woodstock meeting** | Daily News Record | April 17, 2025

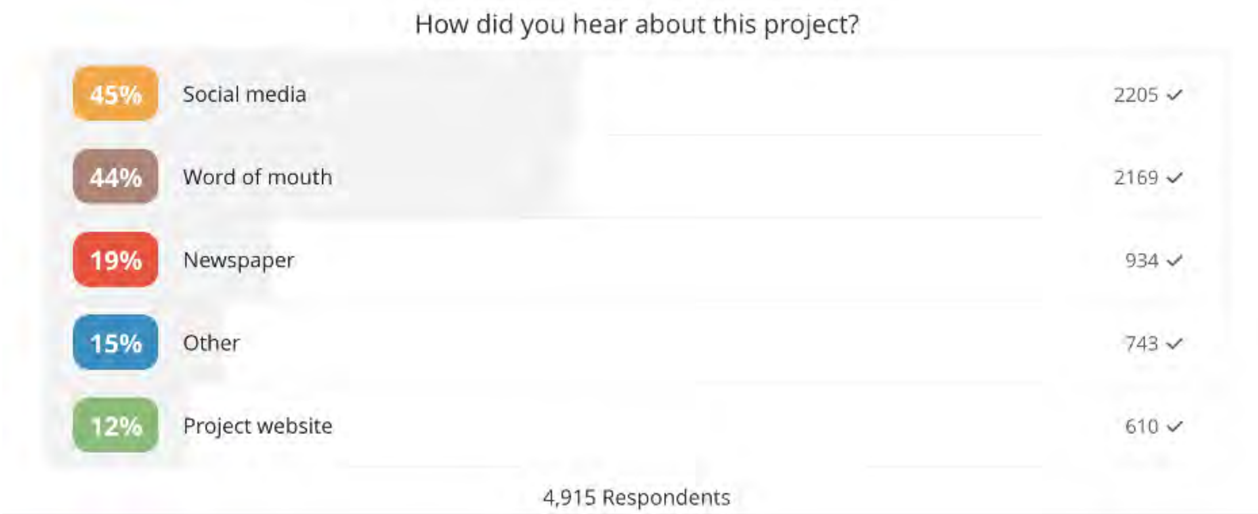
SURVEY RESULTS

Were you familiar with the Shenandoah Valley Rail Trail project prior to accessing this survey?
4,770 respondents

Did you attend one of VDOT's public meetings for the Shenandoah Valley Rail-with-Trail Assessment
4,887 respondents

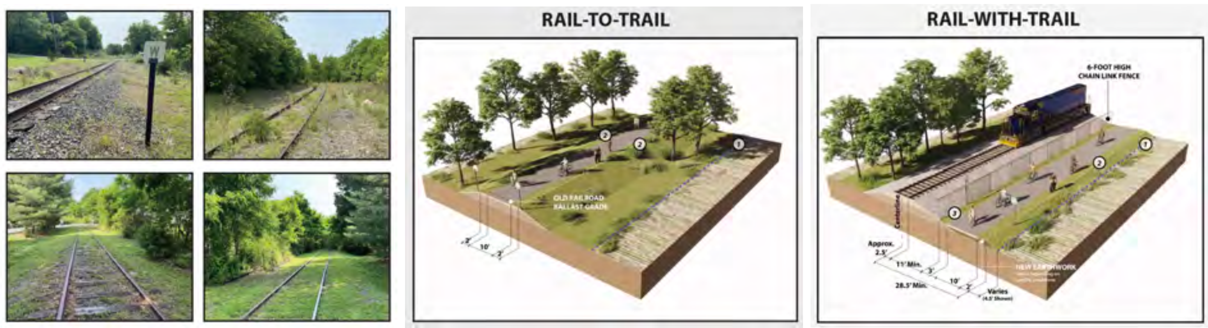


How did you hear about this project?
4,915 respondents



The following illustrations depict typical land conditions along the Shenandoah Valley Rail Corridor and how they would be developed with either a 'Rail-to-Trail' or a 'Rail-with-Trail' option. Please select the statement that best describes your view of these options.

4,875 Respondents



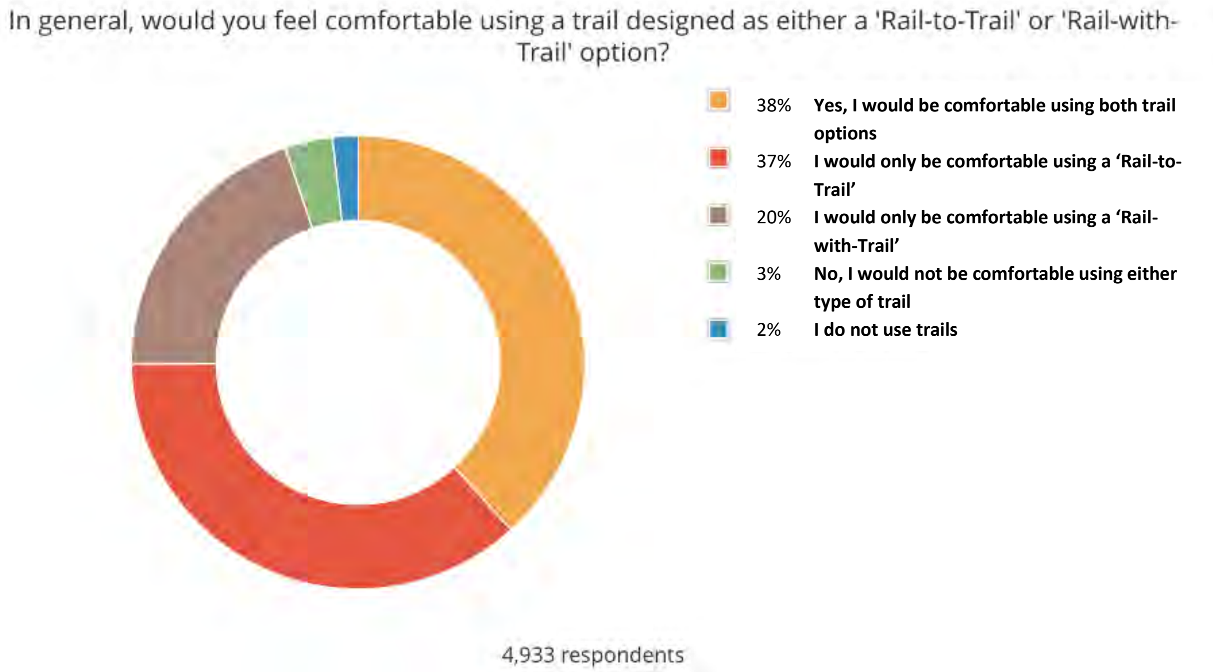
The following illustrations depict typical land conditions along the Shenandoah Valley Rail Corridor and how they would be developed with either a 'Rail-to-Trail' or a 'Rail-with-Trail' option. Please select the statement that best describes your view of these options.

54%	I prefer the Rail-to-Trail option	2615 ✓
31%	I prefer the Rail-with-Trail option	1489 ✓
13%	I am supportive of both options	655 ✓
5%	I am not supportive of changing the corridor from its current condition	235 ✓

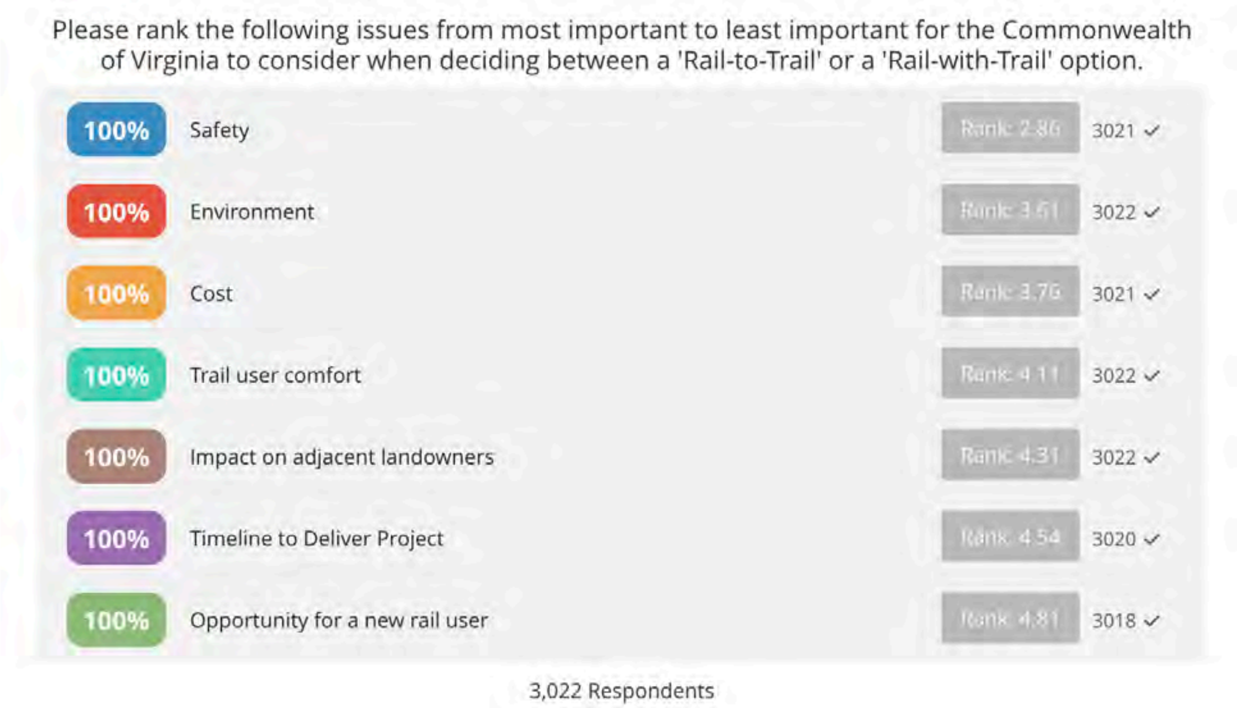
4,875 Respondents

In general, would you feel comfortable using a trail designed as either a "Rail-to-Trail' or 'Rail-with-Trail' option?

4,933 respondents

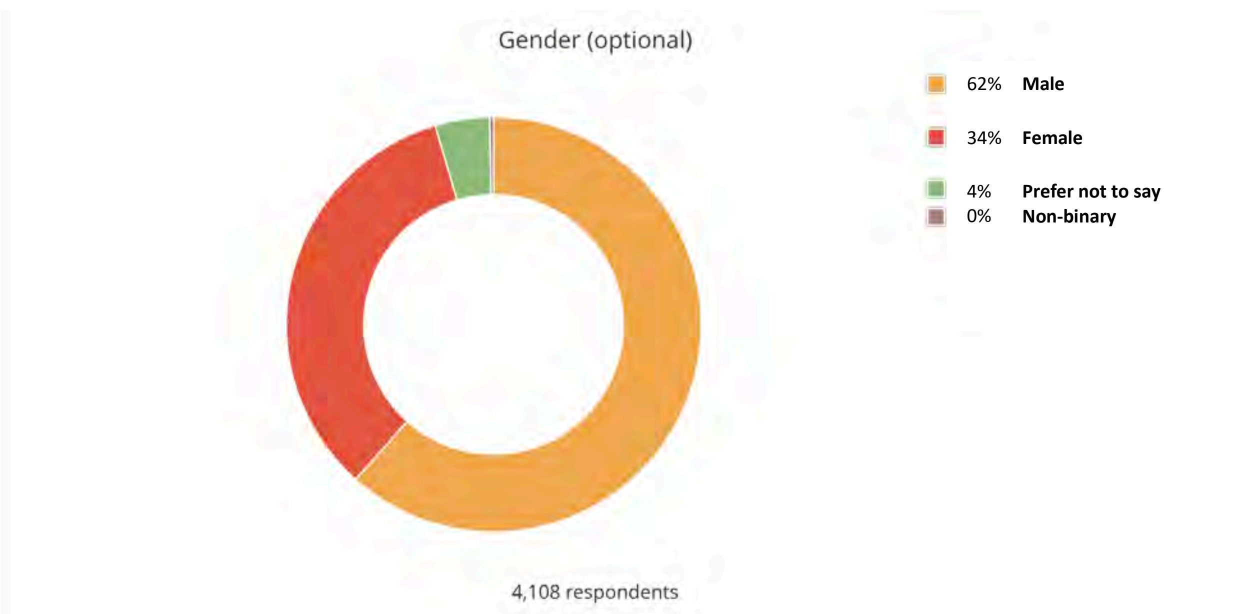


Please rank the following issues from most important to least important for the Commonwealth of Virginia to consider when deciding between a 'Rail-to-Trail' and a 'Rail-with-Trail' option. (Please note the lower the rank number, the higher the ranking)

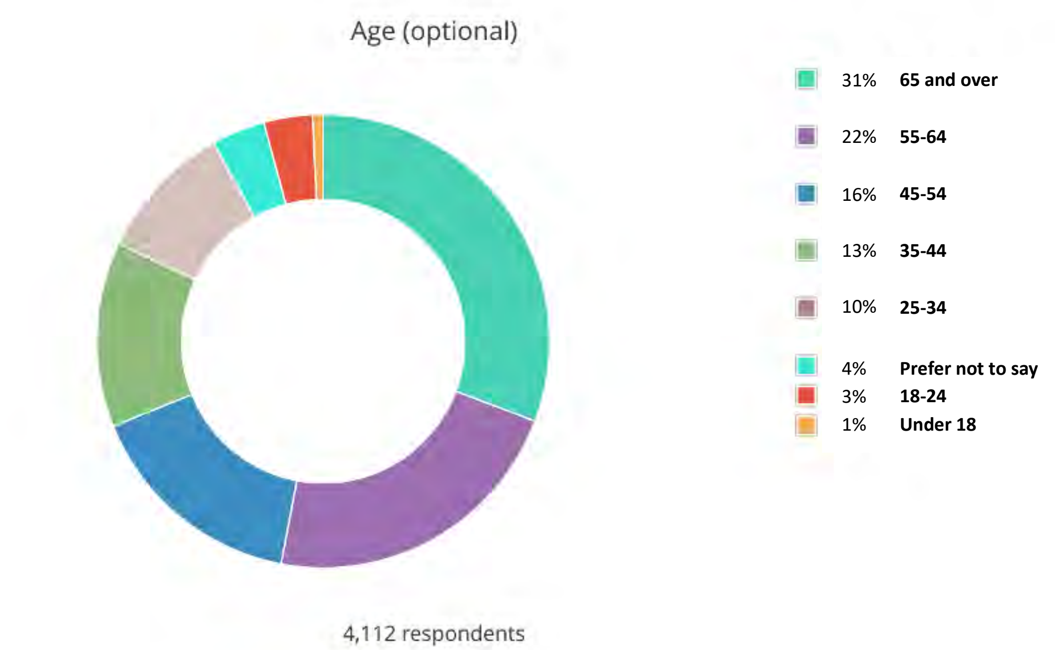


Gender (optional)

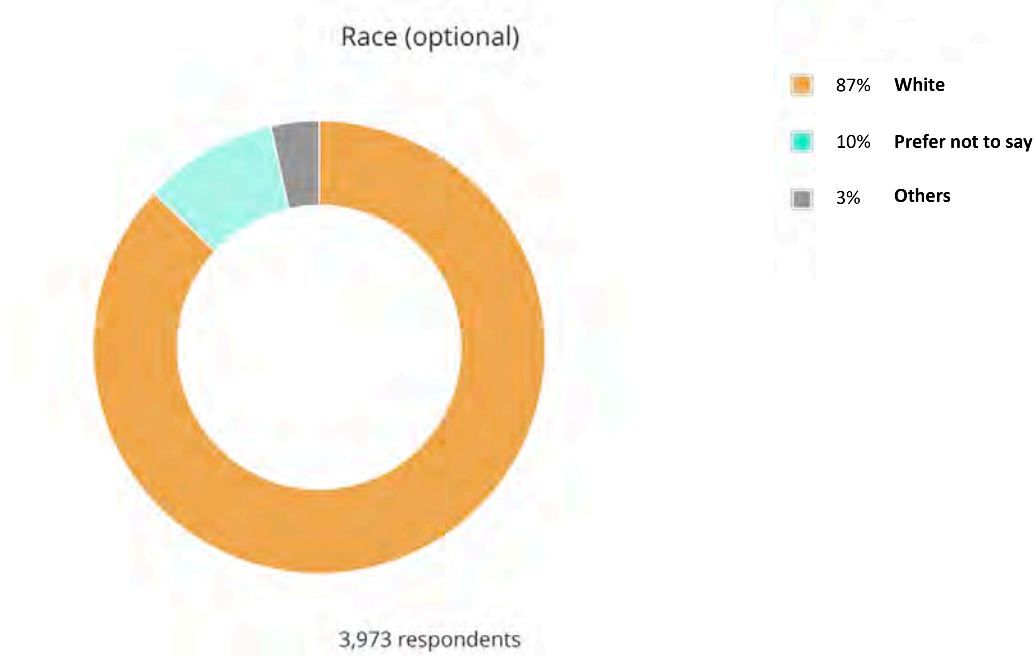
4,108 respondents



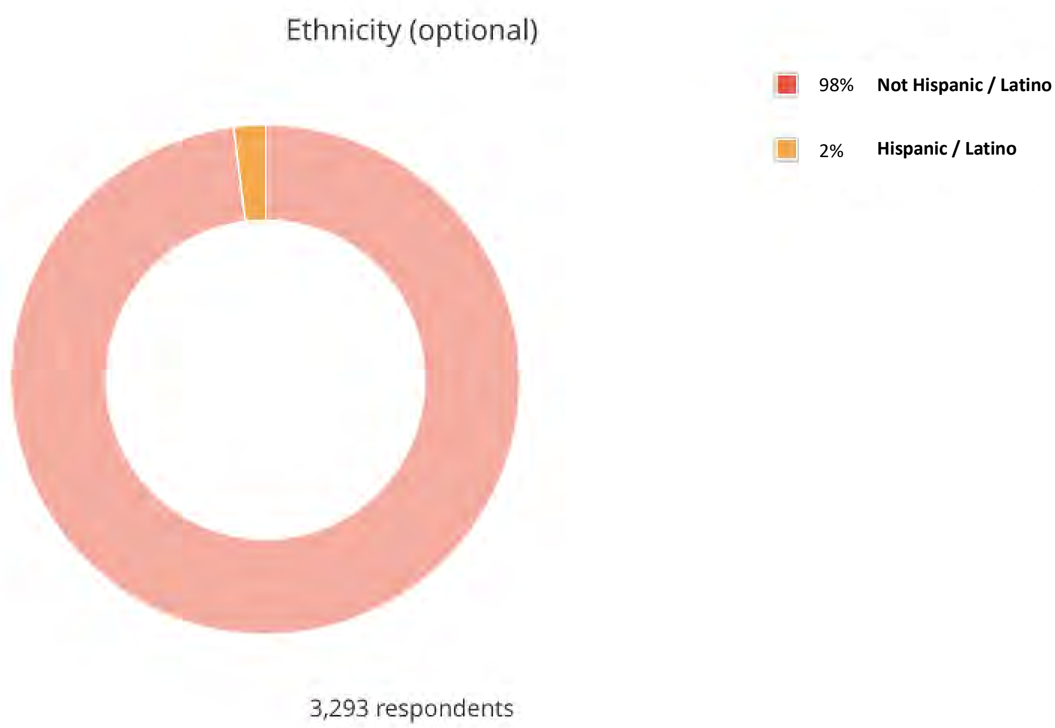
Age (optional)
4,112 respondents



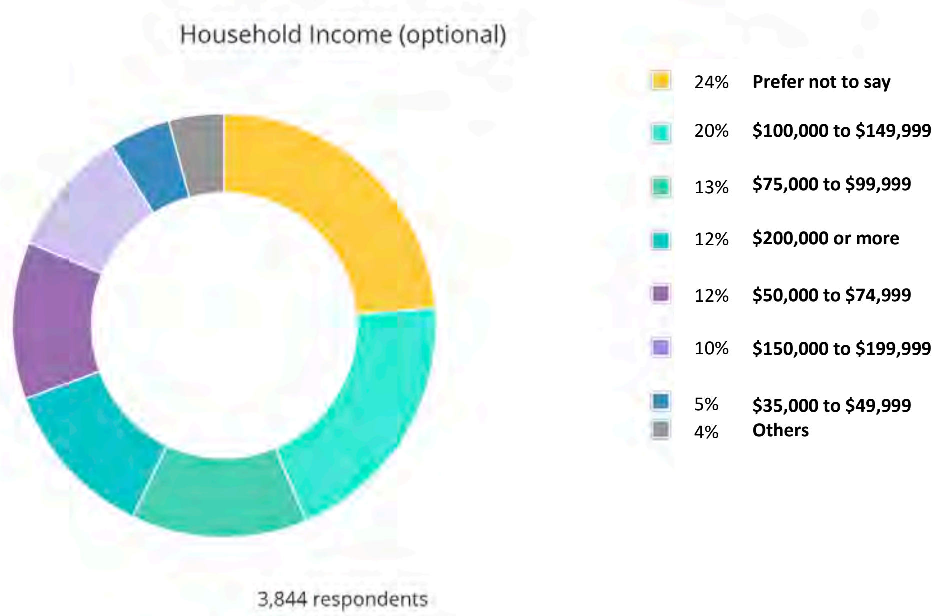
Race (optional)
3,973 respondents



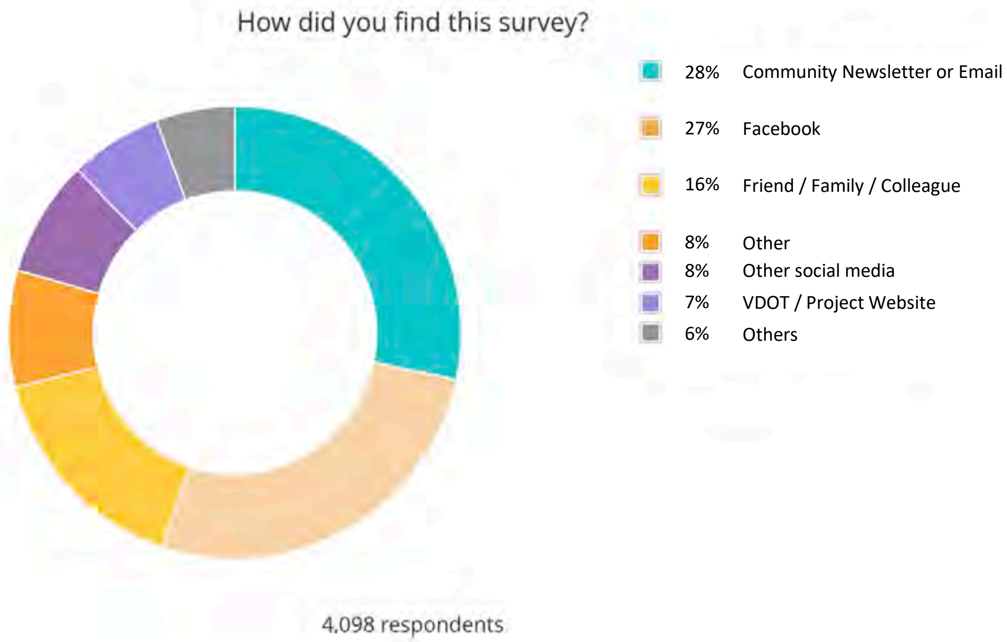
Ethnicity
3,293 respondents



Household Income (Optional)
3,844 respondents



How did you find this survey?
4,098 respondents



ANALYSIS OF OPEN-ENDED COMMENTS

There were three open-ended questions:

- Please provide us with any information that you believe will assist VDOT in studying the Shenandoah Valley Rail Corridor.
- What other information would you like to see released, if any?
- Please provide any other comments you may have on the study area.

A category-based comment classification was performed to summarize the information quantitatively and minimize potential issues related to human error and/or judgement.

Of the 5,039 survey responses received during the comment period, more than 2,000 individual respondents submitted open-ended comments. All comments were analyzed except those that were blank or with a "NA" or "Nothing at this time" or similar commentary. Comments were first cross-tabulated based on a respondent's selection of a given development option in the preference question (I am supportive of both options, I prefer the Rail-to-Trail option, I prefer the Rail-with-Trail option, I am not supportive of changing the corridor from its current condition). The comments were then systematically evaluated to uncover prevalent themes using a classification system. Comments were also categorized into two general groups: rationale for the option(s) they selected and aspirations for the future development of a trail system. This approach allowed the team to assess and quantify the qualitative data received.

From an initial review of the comments, the following themes emerged:

Development Option: I am not supportive of changing the corridor from its current condition
- Landowner Impacts
  - Crime, Noise and Pollution
- Cost
  - Building Trail
  - Maintenance of Trail
- Preserve Rail
  - Job Creation
  - Alternative Transportation – Freight
  - Alternative Transportation - Amenities
  - Historic Preservation

Development Option: I am supportive of both options
- Recreation
  - Design/Aesthetics
  - Amenities
  - Equestrian
- Economic Benefits
  - Tourism
  - Jobs
- Preserve Rail
  - Alternative Transportation – Freight
  - Alternative Transportation - Passenger
  - Historic Preservation
- Cost
  - Restoring Rail
  - Perform Cost/Benefit Analysis
- Landowner Impacts
- Environmental
  - Wildlife Impacts
- Safety
  - Rail
  - Trail Security

Development Option: I prefer the Rail-to-Trail option
- Environmental
  - Wildlife Impacts
- Safety
  - Rail
- Recreation
  - Design/Aesthetics
  - Amenities
  - Equestrian
- Cost
  - Added cost to Restore Rail
  - Cost/Benefit Analysis
- Timing

- Build Project Now
- Rail Time Delays
- Economic Benefits
    - Tourism

Development Option: I prefer the Rail-with-Trail option

- Economic Benefits
    - Tourism
    - Jobs
- Preserve Rail
    - Job Creation
    - Alternative Transportation – Freight
    - Alternative Transportation - Passenger
    - Historic Preservation
- Recreation
    - Design/Aesthetics
    - Amenities
    - Equestrian

These themes and their respective distribution of comments were adapted into a sunburst diagram for visualization. Note that some responses identified more than one option or theme, which resulted in some totals being greater than 100 percent for a given question or category.

Survey results are rounded, so they may not add up to 100 percent. Please note that some respondents selected more than one option, which resulted in a total greater than 100 percent for the questions.