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North Carolina Department of Transportation Division 14



I-40 CMGC Technical Study

Haywood County, North Carolina

WBS 44593.1.1



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Table of Contents

	EXECUTIVE SUMMARY	4
SECTION 1	PROJECT UNDERSTANDING	8
1.1	Purpose and Need	8
1.2	Study Scope	8
1.3	Project Area	8
1.4	Existing Bridge Conditions	11
1.5	Environmental Overview	16
SECTION 2	VALUE PLANNING	17
2.1	Background	17
2.2	Projects Owners, Users & Stakeholders	18
2.3	Constraints, Needs & Desires	19
SECTION 3	SEASONAL LIMITATIONS / MoT	21
SECTION 4	BRIDGE 430057	23
4.1	Alternate Development	23
4.2	Alternate Evaluation	24
4.3	Proposed Alternates	25
4.4	Cost Estimate	29
SECTION 5	BRIDGE 430124	30
5.1	Alternate Development	30
5.2	Alternate Evaluation	30
5.3	Proposed Alternates	31
5.4	Cost Estimate	33
SECTION 6	BRIDGE 430142	34
6.1	Alternate Development	34
6.2	Alternate Evaluation	35
6.3	Proposed Alternates	36
6.4	Cost Estimate	40
SECTION 7	BRIDGE 430159	41
7.1	Alternate Development	41
7.2	Alternate Evaluation	41
7.3	Proposed Alternates	42
7.4	Cost Estimate	44
SECTION 8	BRIDGE 430171	45
8.1	Alternate Development	45
8.2	Alternate Evaluation	46



Table of Contents (cont.)

8.3	Proposed Alternates	47
8.4	Cost Estimate.....	51
SECTION 9	ACCELERATED BRIDGE CONSTRUCTION.....	52
SECTION 10	ADDITIONAL DESIGN CONSIDERATIONS.....	54
SECTION 11	USER IMPACTS.....	56
SECTION 12	CONCLUSION.....	58
FIGURES		
1	Project Location Map	10
2	Owners, Users & Stakeholder Descriptions	18
3	Constraints, Needs & Desires Descriptions.....	19
4	Construction Season Scheduling.....	21
APPENDIX		60
	<i>Cost Estimate Justification / Supporting Information</i>	
	<i>Span Configurations</i>	
	<i>Value Planning Session Supporting Information</i>	
	<i>Environmental Project Boundaries</i>	



PURPOSE & NEED

The purpose of this project is to replace the following five (5) bridges along Interstate 40 in Haywood County, North Carolina:

- Bridge 430057 over US Forest Service Road / Cold Springs Creek Road at Harmon's Den
- Bridge 430124 over State Route 1338 (White Oak Road) at Fines Creek
- Bridge 430142 over Pigeon River
- Bridge 430159 over State Route 1338 (White Oak Road)
- Bridge 430171 over State Route 1338 (White Oak Road) & Jonathan Creek

The need for this project is to improve the reliability of the bridges on I-40 which is a major east-west corridor connecting Tennessee to North Carolina through the Pigeon River Gorge of the Appalachian Mountains. All of these bridges were constructed during the 1960s, are nearing the end of their service life, and have required multiple repairs over the past 50 years. Each repair not only has a monetary cost, but also a user cost for the motorists traveling through the corridor, as there are very few viable alternate routes in the area. By improving the reliability of these structures, the potential for repair cost and user impacts will be drastically reduced.

VALUE PLANNING

Value Planning (VP) was a vital part of this study. VP develops a range of design solutions for a project and then evaluates those alternatives to arrive at a preferred design that meets engineering performance measures, satisfies the project stakeholders and provides the most value for the anticipated cost. One of the primary advantages of utilizing the value planning process is the efficient vetting of a wide range of solutions that will stand up to the scrutiny of decision makers and the public. A multi-disciplinary team works together to:

- Identify the project's owners, users and stakeholders
- Identify the constraints, needs and desires
- Distill the project down to basic functions
- Propose design ideas to accomplish the project functions
- Assemble ideas into alternates
- Evaluate the alternates based on performance (engineering measures), acceptance (by the stakeholders) and relative cost

SCHEDULE CONSTRAINTS

For the purposes of this study, a five (5) month construction season (December through April), with I-40 reduced to one (1) travel lane in each direction, was the baseline used for development of alternates for each structure. Any work that does not impact the travel lanes of I-40 can occur year-round. Unique to the bridge over Cold Springs Creek Road (Bridge 430057) is the ability to detour traffic down the existing ramps to provide an opportunity to explore

accelerated replacement options that can occur in a timeframe shorter than five (5) months. The NCDOT can further refine this information during the advertisement for the contractor.

This corridor has been identified to support various wildlife habitat and animal movements. As the bridges are upgraded, the impacts of the construction efforts and final conditions on the local wildlife should be considered during the planning and design phases as much as practical by NCDOT. The potential presence of certain bats (Gray, Northern Long-Eared & Indiana) will require specific construction schedule restrictions to minimize impacts to the bat habitats. Other environmental related constraints may be identified in the future that will also need to be accommodated.

MAINTENANCE OF TRAFFIC

As these five (5) bridge locations are spread out along approximately 12.5 miles of I-40, three (3) separate work zones were defined:

- Work Zone 1 – Bridge 430057
- Work Zone 2 – Bridges 430124 & 430142
- Work Zone 3 – Bridges 430159 & 430171

As mentioned previously, the baseline traffic control plan is to maintain two (2) lanes of traffic on I-40 in each direction from May through November and then reduce, as needed, to one (1) lane in each direction from December to April. There is potential for other, more specialized, traffic control measures that could be determined during the design process.

PROPOSED ALTERNATES:

This study evaluated each of the five (5) bridges within the project limits, developed multiple alternates to replace each structure and selected a set of proposed options to move forward through for additional evaluation.

Bridge 430057 over USFS Road / Cold Spring Creek	Construction Seasons	Cost
Alternate 1: 255-foot, two-span steel beam superstructure	1	\$7.1 million
Alternate 2: 210-foot, two-span steel beam superstructure	1	\$9.8 million
Alternate 3: 210-foot, two-span concrete beam superstructure	1	\$9.7 million
Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek		Cost
Alternate 1: 76-foot, one-span concrete beam superstructure	2	\$4.9 million
Alternate 2: 43-foot, one-span concrete beam superstructure	2	\$4.4 million
Bridge 430142 over Pigeon River		Cost
Alternate 1: 304-foot, three-span concrete beam superstructure	2	\$21.1 million
Alternate 2: 347-foot, two-span steel beam superstructure	2	\$18 million
Alternate 3: 400-foot, two-span steel beam superstructure	2	\$13.4 million
Bridge 430159 over SR 1338 (White Oak Road)		Cost
Alternate 1: 78-foot, one-span concrete beam superstructure	2	\$5.4 million
Alternate 2: 47-foot, one-span concrete beam superstructure	2	\$4.9 million
Bridge 430171 over SR 1338 (White Oak Road) / Jonathan Creek		Cost
Alternate 1: 640-foot, three-span steel beam superstructure	2	\$20.9 million
Alternate 2: 560-foot, three-span steel beam superstructure	2	\$28.9 million
Alternate 3: 620-foot, five-span concrete beam superstructure	2	\$22.5 million

The costs on the previous page include approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, HP piles and/or micropiles, reinforced concrete for end bents, wingwalls, and interior bent, removal of existing structure, civil sitework, and mobilization. The costs for causeways, temporary structure support and lowering underpass roads are included when necessary.

Additional costs can be expected due to maintenance of traffic and final construction details such as: milling and resurfacing I-40, replacing barrier rail removed for MoT (installing crossovers) and final pavement markings. These costs were evaluated based on three (3) assumed Work Zones for the project. These estimated costs, per zone, are summarized in the table below:

Work Zone 1: Bridge 430057	Cost
Maintenance of Traffic	\$1,180,000
Replacement of Median Barrier removed for MoT	\$750,000
Milling & Resurfacing	\$240,000
Pavement Markings	\$70,000
Total Work Zone Cost (Roadway)	\$2,240,000
Work Zone 2: Bridges 430124 & 430142	Cost
Maintenance of Traffic	\$1,620,000
Replacement of Median Barrier removed for MoT	\$1,030,000
Milling & Resurfacing	\$330,000
Pavement Markings	\$90,000
Total Work Zone Cost (Roadway)	\$3,070,000
Work Zone 3: Bridges 430159 & 430171	Cost
Maintenance of Traffic	\$1,910,000
Replacement of Median Barrier removed for MoT	\$1,220,000
Milling & Resurfacing	\$390,000
Pavement Markings	\$110,000
Total Work Zone Cost (Roadway)	\$3,630,000

To determine an estimated cost for the entire project, the lowest priced alternates were combined and then the highest priced alternates were combined. These combined totals provided a range of estimated project costs of **\$59,390,000 to \$78,820,000**.

As this project continues forward in the CMGC process, the following steps will need to occur:

- Approve/sign off on Technical Study
- Begin Preliminary Design (set alignments, grades, etc.)
- Finalize Environmental Analysis / NEPA
- Develop Scope & Constraints for Construction Manager (CM) Advertisement
- Advertise & Select CM
- Design Team Kickoff Meeting

- Select Independent Cost Estimator (ICE) – at 30% Plans
- Finalize Design Plans
- NCDOT and CM agree on Guaranteed Maximum Price (GMP)
- Award Contract and Begin Construction

While this study covered multiple alternates for each structure, it is important to note that additional discussion and coordination will be required throughout the design phase. The continuous exchange of information and ideas will allow this project to be designed and constructed efficiently and to encompass as many issues or concerns as possible. It is important to note that this study is considered the first step in developing the project through the CMGC delivery method. This report is not intended to be the final answer for how the bridges will be replaced but rather a starting point to begin the design process once a contractor has been chosen by NCDOT.

1.1 PURPOSE AND NEED

The purpose of this project is to replace the following five (5) bridges along Interstate 40 in Haywood County, North Carolina:

- Bridge 430057 over US Forest Service Road / Cold Springs Creek Road
- Bridge 430124 over State Route 1338 (White Oak Road) at Fines Creek
- Bridge 430142 over Pigeon River
- Bridge 430159 over State Route 1338 (White Oak Road)
- Bridge 430171 over State Route 1338 (White Oak Road) & Jonathan Creek

The need for this project is to improve the reliability of the bridges on I-40 which is a major east-west corridor connecting Tennessee to North Carolina through the Pigeon River Gorge of the Appalachian Mountains. All of these bridges were constructed during the 1960s, are nearing the end of their service life, and have required multiple repairs over the past 50 years. Each repair not only has a monetary cost, but also a user cost for the motorists traveling through the corridor, as there are very few viable alternate routes in the area. By improving the reliability of these structures, the potential for repair cost and user impacts will be drastically reduced.

1.2 STUDY SCOPE

The purpose of this study is to explore potential replacement options to be developed through the Construction Manager General Contractor (CMGC) delivery method. Based on the unique project locations that will be discussed in further detail in this report, the five (5) bridges pose unique challenges for replacement while minimizing the impacts to the corridor users and stakeholders.

The scope of this Technical Study is to develop and evaluate potential alternatives to replace the five (5) existing bridges in Haywood County (Division 14). The study will also identify potential impacts and constraints related to the replacement of the bridges and provide construction cost estimates to be utilized for project budgeting and programming purposes. Location and Survey Office provided the QL2, which is the best available topographic information, for use in this study. Advanced survey efforts and static LIDAR have been contracted through the NCDOT LSC and are expected to be completed this summer for all five (5) bridge locations.

Throughout the report there are many methods discussed to accelerate bridge construction and minimize lane closure time. Accelerated methods will be considered but the project will also balance those construction methods and details with others to enhance durability and minimize long-term maintenance. The balancing of these methods and details will be developed as part of the CMGC process.

This report is the first step in developing the project through the CMGC delivery method. This report is not intended to be the final answer for how the bridges will be replaced, but rather a starting point to begin the design process once a contractor has been chosen by NCDOT.

1.3 PROJECT AREA

I-40 is a major east-west facility that stretches from California to North Carolina, providing connections for commuters, tourists and commercial vehicles across the country. Within North Carolina, starting at the Tennessee State Line and extending to the US-276 interchange (Exit 20) near Waynesville, this portion of I-40 travels through the mountainous terrain of the Pigeon River Gorge. I-40 is a four (4) lane, median barrier divided interstate with two (2) twelve (12) foot travel lanes in each direction. Inside shoulders are approximately three (3) feet wide and outside shoulders are approximately ten (10) feet wide, with narrower inside and outside shoulders at many of the bridge locations. These five (5) bridges represent all the bridges in North Carolina through the gorge.

Horizontal and vertical alignments for I-40 vary drastically within the project as compared to the surrounding areas. The roadway is situated between the Pigeon River on one side and steep mountainous slopes on the other side for much of the project length. This necessitates a curvy alignment and steep grades to minimize impacts on the surrounding area. This combination results in potential line of sight and stopping sight distance issues whenever traffic delays occur (weather conditions, construction, vehicular crashes, rock slides, etc.).

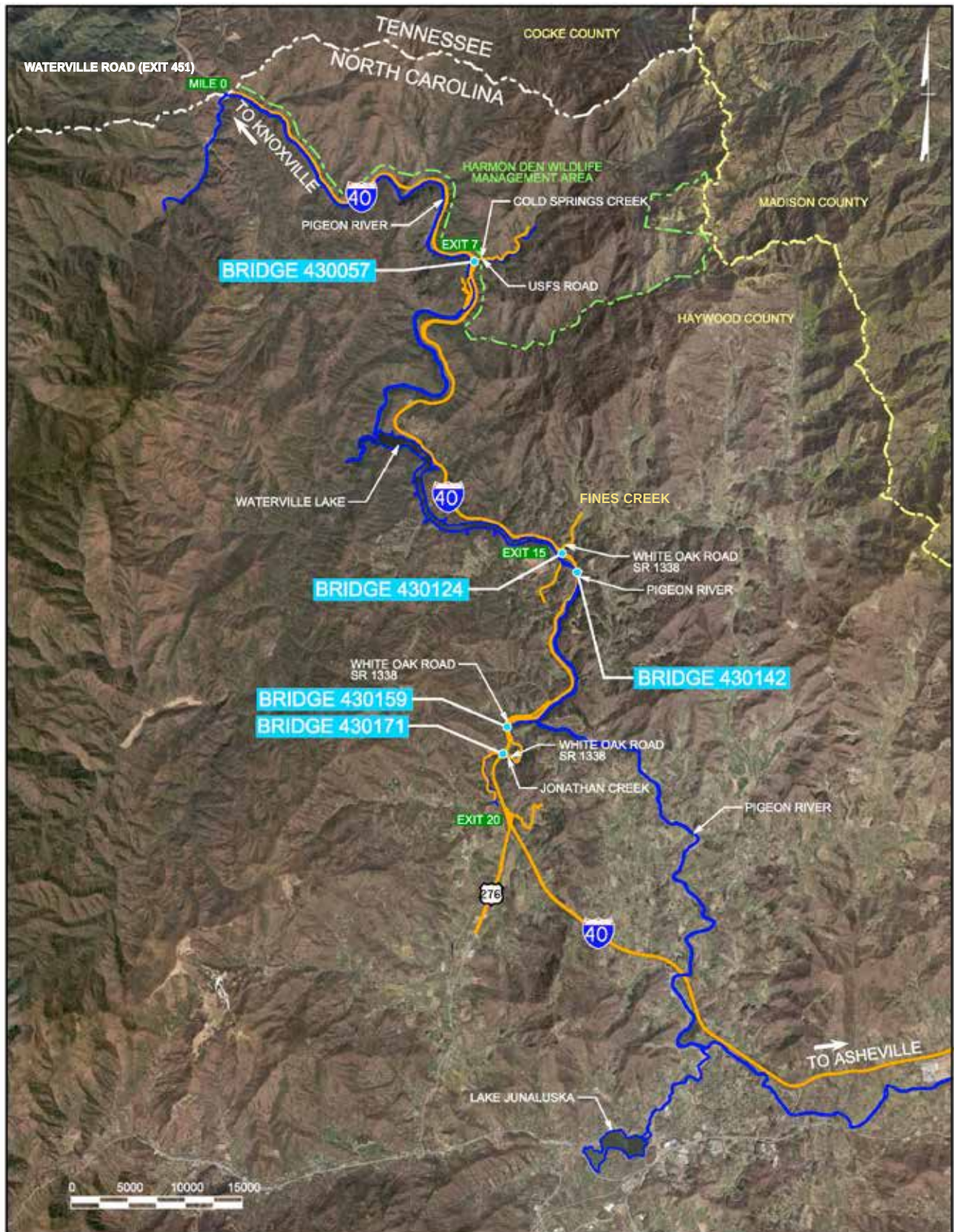
The section of I-40 within the study area carries between 26,000 and 27,000 vehicles per day. As I-40 is a primary east-west interstate, the volume of trucks is very high, ranging from 6,410 to 6,690 per day. There are no nearby alternative parallel routes available for interstate traffic along this section of I-40. If I-40 is shut down, interstate traffic is detoured along I-81 and I-26 between Dandridge, TN, and Asheville, NC. Local traffic, including school buses, is provided access on a network of secondary routes. The Waterville Road Exit just across the Tennessee State Line is a bus pickup location for North Carolina students being transported back to the Waynesville area.

Public access to the Smoky Mountains throughout the year for outdoor activities such as hiking, watersports, wildlife viewing etc. are very important to the area. In Eastern Tennessee and Western North Carolina, I-40 runs across the Smoky Mountains and the bridge over Cold Springs Creek Road is located near the Harmon Den Wildlife Management Area and within the Cherokee National Forest. The presence of large mammals such as elk and black bear have been documented throughout the entire route. Elk, and other large animals, are known to cross under the interstate in the area near Bridge 430057 over Cold Springs Creek Road and will need to be considered during the development of proposed improvements. Jonathan Creek, which contains trout and is a popular spot for anglers, is located at Bridge 430171.

The White Oak Landfill (WOLF) is located southwest of I-40 at Exit 15 and is the only landfill in Haywood County, NC. The facility operates Monday through Saturday 7:30 AM to 3:00 PM and has been in operation since October 8, 1993.

Figure 1- Project Location Map can be found on the following page.

Figure 1 - Project Location Map



1.4 EXISTING BRIDGE CONDITIONS

Bridge 430057 over US Forest Service Road / Cold Spring Creek



Looking West at Bridge 430057

Constructed in 1965, the I-40 bridge over USFS Road and Cold Spring Creek carries two (2) eastbound lanes and two (2) westbound lanes separated by a concrete median. The four (4) span steel beam bridge is approximately 245-feet long, 63'-7" wide, and is on a curve with a radius of approximately 1000-ft. The superstructure consists of 36-inch steel beams in Spans 1-3 and 33-inch steel beams in Span 4. The bridge crosses over Cold Spring Creek (Span 2) and USFS Road (Span 3), providing a 14'-3" minimum vertical clearance. There is approximately 57'-7" minimum horizontal clearance measured between bent columns and 33'-6" minimum horizontal clearance measured between inside faces of guardrail perpendicular to the roadway. Emergency repairs were done to the bridge this past winter (2018-2019). Prior to that, the bridge was last rehabbed in 2011. The bridge deck, superstructure and substructure were rated as FAIR in the 2019 NCDOT inspection report with an overall sufficiency rating of 53.87. The deck has been patched in multiple locations and continues to crack and spall. There are areas of corrosion on the steel beams with some section loss near the bearings. The concrete caps and columns have significant spalling with exposed rebar.

The bridge is located on an easement granted by the U.S. Forest Service and natural wildlife habitats surround the bridge. Exit 7 from I-40 to Cold Springs Creek Road, carried an AADT of 180 in 2017. Cold Springs Creek Road gives access to Pisgah National Forest Tourist Information Center and multiple overlooks and hiking entrances in the Great Smoky Mountains National Park, such as Buzzard's Roost Overlook.



Looking east at Bridge 430057



Existing Bents 1 & 2



Looking north at Bridge 430124

Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek

Constructed in 1966, the I-40 bridge over White Oak Road at Fines Creek carries two (2) eastbound lanes and two (2) westbound lanes separated by a concrete median. The three (3) span steel beam bridge is approximately 164-feet long, 76'-2" wide, and is on a curve with a radius of approximate 2600-ft. The superstructure consists of 35-inch steel beams. The bridge provides a 15'-1" minimum vertical clearance over White Oak Road. There is approximately 41'-7" minimum horizontal clearance measured between bent columns and 39'-0" minimum horizontal clearance measured between inside faces of guardrail perpendicular to the roadway. The bridge was last rehabbed in 2012. The bridge deck and substructure were rated as FAIR and the superstructure was rated as SATISFACTORY in the 2019 NCDOT inspection report with an overall sufficiency rating of 80. The deck has been patched in multiple locations and is delaminating and spalling over the travel lanes on White Oak Road. The concrete caps and columns have multiple locations with hairline cracks and delamination.

The bridge is located at Exit 15 leading from I-40 to White Oak Road, leading to White Oak Sanitary Landfill and local residences and businesses such as Fines Creek Farm Events. White Oak Road at Fines Creek carried an AADT of 640 in 2017. Bridge 430124 is located less than 0.5 miles west of Bridge 430142 on I-40.



Existing Bent 2

Bridge 430142 over Pigeon River



Looking east at Bridge 430142

Constructed in 1966, the I-40 bridge over Pigeon River carries two (2) eastbound lanes and two (2) westbound lanes separated by a concrete median. The five (5) span steel beam bridge is approximately 380-feet long, and 63'-4" wide. The superstructure consists of 36-inch steel beams. The bridge was last rehabbed in 2012. The bridge deck was rated as FAIR, the superstructure was rated as SATISFACTORY, and the substructure was rated as POOR in the 2019 NCDOT inspection report with an overall sufficiency rating of 40.09. The deck has been patched in multiple locations and continues to crack and spall. The steel beams have surface corrosion throughout their length. The concrete caps, columns and wing walls have significant spalling with exposed rebar with section loss. The deterioration of the caps has also resulted in undermining at some of the bearings. The large wingwall at End Bent 1 is in satisfactory condition with no major defects.

Pigeon River is approximately 200-ft wide and up to 8-feet deep at Bridge 430142. There is a vertical distance of approximately 40-feet from the bottom of the beams to the surface of the Pigeon River. West of the bridge, the river follows along the south-side of I-40. The river then crosses under I-40, makes a 30 degree turn and follows the north-side of I-40 east of the bridge. There is a large rock formation under Span 1 which reduces accessibility to End Bent 1 and Bent 1. An informal NCDOT storage yard is located near the bridge and could be used for material storage during construction. Bridge 430142 is located less than 0.5 miles east of Bridge 430124 on I-40.



Looking south at Bent 2



Looking east at Existing Span 1

Bridge 430159 over SR 1338



Looking northwest at Bridge 430159

Constructed in 1966, the I-40 bridge over White Oak Road carries two (2) eastbound lanes and two (2) westbound lanes separated by a concrete median. The three (3) span steel beam bridge is approximately 172-feet long, 76'-4" wide, and is on approximately 1000-ft curve. The superstructure consists of 33-inch and 36-inch steel beams. The bridge provides a 15'-4" minimum vertical clearance over White Oak Road. There is approximately 41'-10" minimum horizontal clearance measured between bent columns perpendicular to the roadway. The bridge was last rehabbed in 1987. The bridge deck and superstructure were rated as FAIR, and the substructure was rated as POOR in the 2019 NCDOT inspection report with an overall sufficiency rating of 54.98. The wearing surface has been patched and continues to spall. The steel beams have surface corrosion throughout their length. The concrete caps, columns and wing walls have significant spalling with exposed rebar with section loss.

There are no exit ramps located at the bridge, the closest access to White Oak Road from I-40 is approximately 1.5 miles east of the bridge on I-40 at exit 20. Bridge 430159 is located approximately 0.5 miles west of Bridge 430171 on I-40.



Looking southeast under Bridge 430159

Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek



Looking north at Bridge 430171

Constructed in 1966, the I-40 bridge over White Oak Road & Jonathans Creek carries two (2) eastbound lanes and two (2) westbound lanes separated by a concrete median. The six (6) span steel beam bridge is approximately 610-feet long, and 63'-4" wide. The superstructure consists of 36-inch steel beams (Spans 1, 5 & 6) and variable depth beams ranging from 72-inches to 96-inches deep (Spans 2-4). The bridge provides a minimum vertical clearance of 90-feet over White Oak Road. The bridge was last rehabbed in 2012. The bridge deck and superstructure were rated as FAIR, and the substructure was rated as POOR in the 2019 NCDOT inspection report with an overall sufficiency rating of 38. The deck has been patched and continues to crack and spall. The steel beams exhibit surface corrosion with some section loss scattered throughout the spans. The concrete caps and columns have significant delamination and spalling with exposed rebar.

There are no exit ramps located at the bridge, the closest access to White Oak Road from I-40 is approximately 1 mile east of the bridge on I-40 at exit 20. Bridge 430171 is located approximately 0.5 miles east of Bridge 430159 on I-40. The top of the bridge rail is approximately 125-feet above the streambed of Jonathan Creek, resulting in relatively tall interior bents.



Looking east at Bridge 430171



Looking west at Existing Bent 2

1.5 ENVIRONMENTAL OVERVIEW

The estimated limits of this project are determined by the potential impacts during construction and maintenance of traffic at each bridge location. These limits are then utilized for environmental studies prior to design and construction. Potential environmental boundaries were determined prior to this study and used to start environmental analysis efforts. It is anticipated that all proposed work developed in this study will remain within those boundaries.

Initial environmental coordination and evaluation has been undertaken by NCDOT staff. Anticipated impacts and likely project commitments that have been identified have been included in this section. However, a full environmental analysis will be required as part of Categorical Exclusions (CE) efforts coordinated with the NCDOT Environmental Analysis Unit (EAU) and as the project progresses. A kick-off meeting with anticipated agencies was held on May 6, 2019. The meeting was hosted by NCDOT to inform the local agencies of the projects that will be delivered under an alternative delivery method and potentially expedited schedule. Potential construction activity constraints are listed below. The environmental analysis will need to be developed for these five (5) bridge locations regardless of the project delivery method.

In general, tree removal is to be completed between October 15th and April 15th (over the winter) to accommodate protection of Indiana bats and other forest dwelling bat species.

If the Grey Bat or other federally listed bats are identified at any of the bridge locations, this will require that no night work be performed. NCDOT staff is currently performing a bat survey at each bridge to determine any impacts. The survey will be completed this summer before August 15th. To date, it has been determined that gray bats use Bridge 430142 (Bridge over the Pigeon River).

Bridges 430057, 430142 and 430171 all involve watercourses. NCDOT will continue to identify avoidance and minimization measures to all Waters of the U.S. and ensure that major hydraulic structures associated with the project are designed and installed to minimize negative impacts to stream stability (and therefore, water quality) to the greatest extent practical. Appropriate hydraulic study evaluation shall be coordinated with the NC Floodplain Mapping Program to determine the impacts of the proposed project and the status of the project with regard to the applicability of NCDOT's Memorandum of Agreement or approval of a Conditional Letter of Map Revision (CLOMR) and subsequent final Letter of Map Revision (LOMR). Specific attention and construction detailing shall be used for drainage structures and roadway embankments that are located within 100-year floodplains.

For Bridge 430057 and Bridge 430171, a Trout Moratorium has been identified. Active work is not allowed in stream from January 1st to April 15th.

The NCDOT Human Environment Unit assessed the bridge project areas and determined that under federal standards (Section 106) there was no need to survey the project areas for cultural resources as resources are absent or unlikely to be affected."

Project Boundaries for each bridge location can be found in the Appendix.

2.1 BACKGROUND

There are a myriad of potential design solutions to address the purpose and need for this project and meet the required roadway, structural and environmental needs identified for the project. Ensuring that the design solution is the right solution requires a structured process to identify, develop and evaluate potential solutions to ensure that the significant capital investment required for this project will not only meet the project requirements, but also represent a high-value and prudent investment of those funds. To meet this objective, the Value Planning process was utilized as part of this technical study.



Value Planning Session

Value Planning (VP) develops a range of design solutions for a project and then evaluates those alternatives to arrive at a preferred design that meets engineering performance measures, satisfies the project stakeholders and provides the most value for the anticipated cost. One of the primary advantages of utilizing the value planning process is the efficient vetting of a wide range of solutions that will stand up to the scrutiny of decision makers and the public. VP is based on the same process that has been utilized in the private sector for decades to improve product design and delivery. A multi-disciplinary team works together to:

- Identify the project's stakeholders and the constraints, needs and desires
- Distill the project down to basic functions
- Propose design ideas to accomplish the project functions
- Assemble ideas into alternatives
- Evaluate the alternatives based on performance (engineering measures), acceptance (by the stakeholders) and relative cost

On June 4th and 5th of 2019, the Benesch design team met with NCDOT staff to discuss the project and implement the first few phases of the VP process. Attendees included representatives from NCDOT Division 14 Design and Construction staff, Structures Management Unit (SMU) and Benesch. During this meeting, the team identified the Project Owners, Users and Stakeholders, the Constraints, Needs and Desires of the project and developed alternatives for each bridge. After this meeting, Benesch completed the evaluation phase for inclusion in this report.

2.2 PROJECT OWNERS, USERS & STAKEHOLDERS

In order to develop high-value solutions that meet the Purpose and Need of the project, the VP team needs to understand who the project's owners, users and stakeholders are and what they expect. Collectively, this group determines if the project is a success or a failure. Below is the initial list developed by the team during the first day of the Value Planning meeting:

Figure 2 – Owners, Users & Stakeholder Descriptions

OWNERS Those who:	USERS Those who:	Stakeholders Those who are:
- Own the project - Fund the project - Share in the funding - Represent the owner's interests - Manage the project for the owner	- Use the project - Operate the project - Maintain the project	- Financially effected by the project - Environmentally concerned about the project - Disturbed by a required change in habits or recreation
OWNERS		
- North Carolina Department of Transportation - Federal Highway Administration		
USERS		
- Eastbound I-40 Traffic - Westbound I-40 Traffic - Freight Traffic - Tourists - Minor Road Traffic - Exiting Traffic - NCDOT Maintenance Crews - NCDOT Bridge Inspectors - Contractors - Cold Springs Creek Road Traffic - Fines Creek Road Traffic - White Oak Road Traffic - NCDOT IMAP - I-40 Seasonal traffic - School Traffic - AT&T (Bell South) - Haywood EMC - Duke Electric - Utilities (Bridge 430057, 430124, 430159 & 430171) - Landfill Users (Bridge 430124) - Landfill Operators (Bridge 430124) - Anglers (Bridge 430171)		
STAKEHOLDERS		
- US Forest Service - NC DENR - NC Wildlife Resources Commission - US Fish & Wildlife - Wildlands Network - National Parks Conservation Association - Hunters - Nearby Residents - US Army Corps of Engineers - National Parks Users - Anglers - Campground (accommodate horses) - Kayak/Canoe Boater - Historical structures/property - Archeological Agencies - First Responders / Emergency Responders - Highway Patrol / Sheriff - FERC - Landfill - Haywood County - State of Tennessee - Cocke County - TDOT - TN Highway Patrol - TDOT Help Trucks - University – Research - Adjacent Homeowner (Bridge 430142 & 430171) - Private Bridge Owner (Bridge 430171) - Trout Restrictions (Bridge 430171)		

2.3 CONSTRAINTS, NEEDS & DESIRES

Each of the above Owners, Users & Stakeholders have expectations for the project and they can be grouped into constraints, needs and desires. These terms are defined as follows:

Figure 3 – Constraints, Needs & Desires Descriptions

CONSTRAINTS	NEEDS	DESIRES
1. Legal requirements 2. Standards of the owner 3. Physical site conditions 4. Stakeholder commitments	1. Expectations that must be fulfilled if constraints are not violated 2. Limitations or restrictions that are imposed by Stakeholders but which can be violated (the degree of violations will be considered in the evaluation of Alternatives)	1. Financially effected by the project 2. Environmentally concerned about the project 3. Disturbed by a required change in habits or recreation

There are several points to keep in mind in identifying the stakeholder constraints, needs, and desires. First, the majority of constraints are prescribed by law, applicable codes and standards. These constraints are too numerous to be listed for each study. Constraints listed are those imposed by an owner, user or stakeholder, or by a code or standard that applies strictly to this project. Secondly, design criteria can be described as a constraint, need or desire. Where a range of design criteria is acceptable, the more stringent design criteria is expressed as a Constraint, typical design expectations are expressed as a Need, and criteria that can be used if cost is not a factor is considered a Desire. Lastly, needs and desires are generally not executable. They are generally visions of what the project should do.

The VP team assembled an initial list of constraints, needs and desires for this project, which are shown below.

CONSTRAINTS	
• No work in streams between Jan 1 and April 15 during trout moratorium • Protect streams from debris during removal and construction • Observe work restrictions and moratoriums for T&E species • Comply with requirements associated with funding from other sources • Maintain two lanes of traffic in both directions on I-40 during construction between Memorial Day and Labor Day • Cannot block more than 50% of waterways during construction • Tree Removal limited to between October 15th and April 15 (Indiana bat) • Provide 10' shoulders • No changes to profile or alignment on Interstate (Bridge 430057)	• Comply with moratorium schedules (Bridge 430057 & 430171) • US Forest Service (Bridge/Roadway must remain on easement) (Bridge 430057) • Maintain Existing underclearance (Bridge 430057, 430124 & 430159)) • Do not enclose creek (i.e. no culvert) (Bridge 430057) • Maintain existing opening width beneath bridge (Bridge 430124) • Protect adjacent residence (Bridge 430142) • No MSE walls in area of flowing water (Bridge 430142) • Comply with moratorium schedules (Bridge 430171)
NEEDS	
• Maintain one lane of traffic on I-40 in both directions during construction • Follow NCDOT policy for detours • Provide "jump outs" for elk within corridor • Provide barriers to discourage large animals from entering roadway • Wider shoulders for wildlife on streets below • Minimize maintenance • Extend bridge life • Minimize bridge joints • Provide corrosion resistant details • No closed system for drains	• Complete all work by 2023 • Utilize concrete over steel • Provide for elk passage (Bridge 430057) • Discourage elk from entering road/ramps (Bridge 430057) • Wider shoulders for wildlife on minor road (Bridge 430057) • Follow NCDOT policy for detours (Bridge 430057) • Discourage animal grazing in median (Bridge 430057) • Increase opening width beneath bridge (Bridge 430124) • Coordinate replacement with other bridges (Bridge 430124) • No change in profile on Interstate (Bridge 430159) • Coordinate lane closures with Bridge 430171 (Bridge 430159)

DESIRES

- Start construction in 12 to 18 months
- Complete Bridge 430057 in 2020
- Complete all work by 2022
- Work done within existing R/W
- Categorical Exclusion
- Accelerated Bridge Construction
- Reduce large animal impacts in the corridor
- Make I-40 corridor ecologically friendly
- Minimize the amount of time traffic is impacted
- Maintain two lanes of traffic in both directions on I-40 during construction from Easter through Memorial Day
- Maintain two lanes of traffic in both directions on I-40 during construction from Labor Day through Thanksgiving
- Maintain two lanes of traffic in both directions on I-40 during construction from Thanksgiving through Christmas
- Accommodate Wide/oversize/overweight loads
- Avoid cold weather concrete pours
- Improve durability of structural elements
- Implement/Utilize ITS
- Accommodate Historical/Architectural resources
- Provide 12' shoulders
- Utilize incentives
- Minimize User cost
- Use FHWA Everyday Counts Funding
- Avoid work in Creek (Bridge 430057)
- Increase vertical Clearance (Bridge 430057)
- Single span (Bridge 430124)
- Increase vertical Clearance (Bridge 430124)
- Maximize span lengths (Bridge 430142)
- Avoid joints at abutments (Bridge 430142)
- No night work (Bridge 430142)
- Minimal Tree Clearing (Bridge 430142)
- No lights (Bridge 430142)
- Bench for wildlife (Bridge 430142)
- Single barrel culvert (Bridge 430159)
- 17-foot vertical clearance (Bridge 430159)
- Utilize bench for wildlife passage (Bridge 430171)
- Minimize number of piers (Bridge 430171)
- Lengthen spans (Bridge 430171)
- Complete Reconstruction (Bridge 430171)
- Protect hellbender (Bridge 430171)
- Avoid work in Creek (Bridge 430171)
- No night work (Bridge 430171)
- Minimal Tree Clearing (Bridge 430171)
- No lights (Bridge 430171)

Section 3 | Seasonal Limitations / Maintenance of Traffic (MoT)

This portion of I-40 through the Pigeon River Gorge has some unique seasonal and physical constraints that necessitate the need for accelerated construction to minimize impacts to the corridor. One of the initial goals of the NCDOT was to maintain two (2) lanes of travel in each direction between the heavier vacation season of Memorial Day to Labor Day. During the Value Planning Session this was further refined by the District 14 staff to include the seasonal changes for fall foliage as well as Spring Break season when hikers and campers return to the Smoky Mountains. The results of the Value Planning Session defined three (3) potential seasons, depicted below, to explore when lane reductions are allowed.

Figure 4 - Construction Season Scheduling

	Each Year												
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
I-40 - 2 Lanes EW (3 mo constr.)				Maintain 2 lanes Each Way on I-40									Notes - 2 lanes each direction should be maintained during this time frame: Spring break through Christmas/New Years Holiday
I-40 - 2 Lanes EW (5 mo constr.)					Maintain 2 lanes EW								May through end of Nov (leaf season) - exact dates to be determined
I-40 - 2 Lanes EW (8/9 mo constr.)						Maintain 2 lanes EW							Memorial Day through Labor Day

For the purposes of this study the five (5) month construction season was the baseline used for development of options. The NCDOT can further refine this information during the advertisement for the contractor. Variations of work to accommodate the schedule constraints are discussed with each respective alternative and this will be further refined through the design phase based on the contractor's input.

Although there are many methods of accelerated bridge construction for different structure elements discussed in this document, the desire is for high-quality replacement structures with construction methods and details to minimize long-term maintenance. It is not the intent of the project to accelerate the cure times of the deck/concrete pours if future maintenance costs increase and the longevity of the deck is decreased as a result of those accelerated cure times.

Various methods for accelerated bridge construction are discussed to minimize lane closure time and environmental impacts. Accelerated bridge construction methods will be considered but the project will also balance those construction methods and details with others to enhance durability and minimize long-term maintenance. The balancing of these methods and details will be developed as part of the CMGC process.

Unique to the bridge over Cold Springs Creek Road (Bridge 430057) is the ability to detour traffic down the existing ramps to provide an opportunity to explore accelerated replacement options that can occur in a timeframe shorter than five (5) months. The other work zones involve the construction of Bridges 430142 and 430171, which are large structures with challenging terrain and therefore, for the purpose of this report, the five (5) month season will remain the baseline. Once the contractor is onboard, opportunities for reducing this schedule will be explored.

During this study, short term, complete closures of I-40 were not explored due to the lack of alternate routes. Typical traffic control like temporary nighttime lane reductions and rolling roadblocks should be anticipated. Any work that does not impact the travel lanes of I-40 can occur year-round. The underpass roadways can be potentially reduced to signal controlled sixteen (16) feet wide one (1) lane roadways for the duration of construction. For the contractor's advertisement NCDOT will need to define the number and types of closures that will be acceptable.

Section 3 | Seasonal Limitations / Maintenance of Traffic (MoT)

It was noted by the team that modular homes with a width of sixteen (16) feet (and other wide loads) are routinely transported through the project area. During the design phase, it will be important to evaluate whether adequate lane widths, given the roadway geometry, can be maintained during construction to allow for these wide loads to travel through the project area. It is anticipated that Wide Load Permits will need to be limited by NCDOT during the construction phase to reduce the potential for issues to occur.

None of the proposed alternates being carried forward require major alignment shifts due to the challenges and high cost of permanent shifts. For constructability purposes, there are some minor lane shifts required to provide adequate working room while still maintaining traffic. These shifts will not be permanent but rather result in slightly wider shoulders on one side of the bridge.

Due to the existing geometry of I-40 in the project area, it will be important to consider the types of delays anticipated during construction. Lane closures, lane shifts, and overall posted speed reductions are likely to cause delays for motorists traveling through the project area. Depending on the reaction of each driver, there is potential for these delays to establish queuing in either direction along the interstate. With the existing roadway curvature, the ability to see these queues may be minimal and additional warning measures should be considered above and beyond the typical traffic control standards. The implementation of a Smart Work Zone System (SWZ) would be beneficial to the overall safety of the project. Through the design phase a SWZ will be developed to allow for real time traffic flow detection and alert motorists well in advance of the queue. In addition to the SWZ, advance warning signs on I-40 in Tennessee before the I-40/81 split and near Asheville will be considered to warn drivers of the potential delay.

The above information was utilized to develop an overall conceptual plan for Maintenance of Traffic (MoT). As these five (5) bridge locations are spread out along approximately 12.5 miles of I-40, three (3) separate work zones were defined:

- Work Zone 1 – Bridge 430057
- Work Zone 2 – Bridges 430124 & 430142
- Work Zone 3 – Bridges 430159 & 430171

For each of the work zones, possible traffic control plans to meet the phased construction needs of each structure were discussed and evaluated. Items used in the development of MoT costs included: advance warning signs, lane reductions, median barrier removal, temporary median crossovers, portable concrete barrier, temporary pavement markings, and portable smart work zone equipment. Costs for each work zone is summarized in the table below:

Maintenance of Traffic	Cost
Work Zone 1: Bridge 430057	\$1,180,000
Work Zone 2: Bridges 430124 & 430142	\$1,620,000
Work Zone 3: Bridges 430159 & 430171	\$1,910,000

Table 9-1: Maintenance of Traffic Cost per Work Zone

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

4.1 ALTERNATE DEVELOPMENT

During the speculation phase multiple ideas and concepts were identified for the replacement of this bridge. These ideas and concepts included such items as: various span arrangements, reusing existing bents, concrete girders, steel girders, alignment shifts, accelerated bridge construction techniques, new bent construction challenges, and wildlife accommodations. These elements were then combined in various ways to develop potential alternates for replacing the bridge. See Bridge 430057 Span Configuration Memorandum in Appendix for additional information regarding the alternates developed during the speculation phase, summaries are listed below:

- Three (3) span steel or concrete beam superstructure ($118' + 82' + 55' = 255'$), new eastern and western end bents constructed in I-40 approaches behind existing end bents, new bent constructed between existing Bent 2 and Cold Springs Creek, rehabilitate and reuse existing Bent 3
- Four (4) span concrete beam superstructure ($69' + 66' + 65' + 55' = 255'$), new eastern and western end bents constructed in I-40 approaches behind existing end bents, rehabilitate and reuse existing Bents 1, 2, & 3
- Two (2) span concrete beam superstructure ($80' + 60' = 140'$), new western end bent constructed in advance under existing Span 1 near existing Bent 1, new eastern end bent constructed in advance under existing Span 4 near existing Bent 3, new bent constructed between existing Bent 2 and Cold Springs Creek Road
- Two (2) span concrete beam superstructure ($60' + 80' = 140'$), new western end bent constructed in advance under existing Span 1 near existing Bent 1, new eastern end bent constructed in advance under existing Span 4 near existing Bent 3, new bent constructed between existing Bent 2 and Cold Springs Creek
- Two (2) span steel beam superstructure ($105' + 105' = 210'$), new western end bent constructed in advance under existing Span 1 near existing the existing end bent, new eastern end bent constructed in advance in the middle of existing Span 4, new bent constructed between existing Bent 2 and Cold Springs Creek
- Two (2) span steel beam superstructure ($124' + 131' = 255'$), new eastern and western end bents constructed in I-40 approaches behind existing end bents, new bent constructed between existing Bent 2 and Cold Springs Creek
- Two (2) span steel beam superstructure ($105' + 105' = 210'$), new western end bent constructed in I-40 approaches behind existing end bent, new eastern end bent constructed in advance in the middle of existing Span 4, new bent constructed between existing Bent 2 and Cold Springs Creek

Discussions regarding Bridge 430057 during the value planning session revealed some additional constraints specific to this bridge. Constraints must be met for the successful completion of the project. Bridge specific constraints identified for all options included the following items:

- No changes to the vertical profile or horizontal alignment of I-40 would be allowed due to concerns regarding the easement for I-40 through the Pisgah National Forest – project shall stay within the existing easement
- Comply with trout moratorium schedule between January 1st and April 15th
- At a minimum, the existing vertical clearance to the roadway below must be maintained
- Additional encapsulation of Cold Springs Creek would not be permitted due to wildlife concerns
- Additional needs specific to this project location were also identified. Project needs are expectations that must be met if constraints are not violated or limitations imposed by project stakeholders that can be violated. The needs identified included:
 - » Provide for elk passage under the new structure
 - » Discourage elk from entering I-40 or the ramps
 - » Wider shoulders for Cold Springs Creek Road for wildlife passage
 - » Follow NCDOT policy for detours
 - » Discourage animal grazing in medians

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

Additional desires were expressed for this location which reflect goals that should be accomplished if cost or impact are not a significant factor. The desires expressed included:

- Avoid work in Cold Springs Creek
- Increase the vertical clearance above Cold Springs Creek Road

The value planning group also identified that this structure was in the worst present condition. There is a strong desire to proceed with construction for this bridge as soon as possible to alleviate the continuity risk to the corridor due this structure's frequent need for emergency repairs.

4.2 ALTERNATE EVALUATION

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward for further consideration. Alternates that reused existing substructures were rejected due to condition and feasibility concerns.

Each alternate considered needed to provide a new I-40 width that included a minimum ten (10) foot outside shoulder. The existing bridge has roadway shoulders that are 2'-0" wide or less and provides a total roadway width of 28' between barriers in each direction.

Emergency repairs in the past have resulted in eastbound and westbound I-40 traffic being diverted to the Exit 7 ramps for varying lengths of time. Because of this historical precedent, there is a willingness to perform a rapid, complete replacement of this bridge utilizing the ramp diversion and accelerated bridge construction techniques.

Phased replacement of the bridge was also considered for this structure. In this scenario, east and westbound I-40 traffic will be reduced to one lane in each direction and shifted to one half of the existing superstructure. The existing bridge is a ten (10) girder, steel beam superstructure, and the median barrier is supported by the center two girders. This study reviewed phasing options to construct a Phase 1 superstructure that would provide a similar width for traffic during phased operations in all seasons. One option initially removed four (4) girders from the existing superstructure allowing the existing median barrier to continue to be supported by the middle two (2) girders. Phase 1 would then construct an over-widened Phase 1 superstructure that provided sufficient roadway width during between-phase operation (May-November) and during Phase 2 construction. This study estimated that over-widening produced an approximate 14' outside shoulder for the completed superstructure on the Phase 1 side of the bridge. Small alignment shifts were studied to eliminate the construction of this additional bridge width, but it was determined that the cost for the additional bridge width would be much less than costs associated with a similar width alignment shift of I-40.

Some alternates were developed that dramatically shortened the proposed structure for the purpose of reducing new girder depths (gaining vertical clearance) and also as a practical solution. These alternates were rejected based upon discussions with Forest Services and wildlife agencies who conveyed concerns regarding animal access under the structure. New bridge alternatives must accommodate animal passage to minimize the desire for wildlife to access I-40 lanes.

A few of the proposed alternates investigated the advanced construction of a new western end bent under the existing Span 1. Concerns quickly arose regarding this concept due to access challenges related to the steep nature of the terrain, disturbance to the adjacent stream, and shoring requirements in the embankment that likely contains mixed boulder fill. The options that contained the advanced built western abutments were eliminated.

Both steel girder and concrete girder superstructures were considered in the alternatives. Steel girder superstructures have the advantage of providing longer spans, similar girder depths to the existing superstructure, and a greater suitability for accommodating the curved geometry of I-40 in this area.

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

There is a desire to increase the vertical clearance above the roadway beneath the bridge. This study did identify the possibility of lowering the existing roadway grade to improve the vertical clearance, with consideration given to roadway drainage and potential ramp impacts.

Some alternates were rejected for the reasons mentioned above. These rejected alternates were not carried forward as part of this study. Two (2) alternates for the replacement of this bridge were accepted as viable and further evaluation is provided below. Additional information about all the potential alternates can be found in the Appendix.

4.3 PROPOSED ALTERNATES

The baseline global project assumption for superstructure construction work is that a reduction in travel lanes for I-40, from two (2) lanes each direction to one (1) lane each direction, would only be allowed between the end of November and the end of April. For a complete replacement using ramp diversion and accelerated bridge construction techniques, the closure of I-40 across the bridge would also occur for a portion of the same time frame. All alternates in either a complete closure or phasing scenario would require construction of a new bent ahead of the first I-40 disruption, and one alternate requires construction of an end bent in advance as well. Both proposed alternatives would, at a minimum, maintain the existing vertical clearance of 14'-3".

Both proposed alternates require the construction of a new end bent(s) behind the existing end bent(s) in the I-40 approach. These end bents would either be constructed part width during a phased replacement or in a rapid manner during a complete closure of I-40 across the bridge. Based on the available information, these new end bents would be supported by driven H-piles.

Both proposed alternates would construct a new bent between the existing Bent 2 and Cold Springs Creek. The existing Bent 2 utilizes spread footings cast against bedrock at an elevation that is similar to the bottom of Cold Springs Creek. The advance construction of this bent in either alternate would require excavation of the slope adjacent to the creek. The vertical clearance beneath the bridge measured from the low girder to bedrock elevation is approximately 35 feet.

Alternate 1: Two (2) Span, Curved Steel Girders, $124 + 131 = 255'$



Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

This proposed alternate would replace the existing four (4) span, steel beam superstructure with a two (2) span, steel beam superstructure. The construction project would likely need to begin in February through March, eight (8) to ten (10) months prior to the beginning of December when the disruption of I-40 could commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and preparations, and then beginning construction of the new bent. This alternate would construct new end bents behind the existing end bents in the I-40 approaches

Closure and Ramp Diversion Scenario

The contractor would construct the new end bents concurrently with bridge demolition activities. Construction of the new end bents would require five (5) to seven (7) days utilizing rapid curing, cast-in-place concrete. This duration could be further shortened by utilizing precast concrete sections with UHPC materials for H-pile incorporation. In a phased replacement scenario, the construction of a part width end bent would require one (1) to two (2) weeks and would be concurrent with bridge demolition activities.

Once new end bent construction was complete, the construction of the new superstructure would proceed. New steel girders and full-depth precast concrete deck panels could be utilized to construct the new superstructure in seven (7) to ten (10) days. This time frame also accommodates closure pours for deck panel joints, construction of new barriers and bridge rails, and the installation of either a polyester polymer concrete or latex modified concrete overlay. Based on this, it is estimated that a complete closure scenario of Bridge 430057 would require approximately three weeks before opening the new bridge to traffic.

Phased Construction Scenario

Two (2) options exist for the phased installation of the new bridge superstructure. One option would be spread over two (2) concurrent December-to-April construction seasons. During the first construction season, install new Phase 1 steel girders and then provide a cast-in-place bridge deck over an eight (8) to twelve (12) week time frame. A second December-to-April construction season would be required to construct the second phase of the end bents and the new superstructure.

In the second option, accelerated bridge construction techniques would be employed to replace both phases of the bridge within a single December-to-April season. The Phase 1 steel girders and full-depth precast concrete deck panels could be installed in a three (3) week time frame. New barriers, bridge rails and an overlay could be installed in an additional week. Traffic could then be switched to the new Phase 1 superstructure allowing another five to six weeks to complete second phase end bent construction and superstructure construction. In this phased, accelerated bridge construction scenario, Bridge 430057 could be replaced in an approximate ten to 12 week duration for impacts to I-40.

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

Alternate 2: Two (2) Span, Curved Steel Girders, $105 + 105 = 210'$



This proposed alternate would replace the existing four span, steel beam superstructure with a two span, steel beam superstructure. This alternate is similar to Alternate 1 with the exception of the approach to the eastern end bent. In this alternate, the eastern end bent would be constructed in advance underneath the existing Span 4. Excavation and shoring using a temporary soil nail wall would be required adjacent to the existing eastern end bent. This would then allow the installation of a micropile foundation, the cast-in-place construction of the new end bent, and for the completion of the majority of backfill in advance of the disruption of I-40 traffic.

The construction project would likely need to also begin in February through March, eight (8) to ten (10) months prior to the beginning of December when the disruption of I-40 could commence. In the advance work period, the contractor would be mobilizing to the site, performing initial clearing and preparations, and then beginning construction of the new bent and eastern end bent.

Closure and Ramp Diversion Scenario

The scenarios for a three (3) week total closure with ramp diversion or a rapid, one-season, ten (10) to twelve (12) week accelerated phased replacement are similar to Alternate 1.

Phased Construction Scenario

The advance construction of the eastern end bent in this alternate is to provide a slight time advantage to the accelerated construction scenarios. Therefore, this alternate would not require a two (2) season phased replacement as described in Alternate 1. Having only one (1) end bent to construct during the I-40 disruption should reduce the risk to the overall schedule. From a scheduling perspective, there would be no practical advantage to pre-building the eastern end bent if the remaining construction was extended to two (2) seasons.

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

Alternate 3: Two (2) Span, Concrete Girders, $105' + 105' = 210'$



Like Alternate 2, this proposed alternate would utilize two (2) spans, each at approximately 105' in length. However, this structure would replace the existing four (4) span, steel beam superstructure with a two (2) span, prestressed concrete girder superstructure. As with Alternate 2, the eastern end bent would be constructed in advance underneath the existing Span 4. Excavation and shoring using a temporary soil nail wall would be required adjacent to the existing eastern end bent. This would then allow the installation of a micropile foundation, the cast-in-place construction of the new end bent, and for the completion of the majority of backfill in advance of the disruption of I-40 traffic.

The construction project would likely need to also begin in February through March, eight (8) to ten (10) months prior to the beginning of December when the disruption of I-40 could commence. In the advance work period, the contractor would be mobilizing to the site, performing initial clearing and preparations, and then beginning construction of the new bent and eastern end bent.

Since vertical clearance is relatively low (14'-3") under the structure, the proposed prestressed concrete beam type is a 45" Florida I-Beam (FIB), which is shallower than the AASHTO Type IV girder (54" depth) or any other standard NCDOT concrete girders that could accommodate the required span lengths. The existing superstructure depth is equal to 3'-7" (36" deep beam, 7" thick deck slab). Assuming no changes will be made to the vertical profile of I-40, the 45" FIB (assuming a 9" thick deck and 3" thick buildup) would add approximately 14" to the total depth of the superstructure when compared to existing. As a result, the vertical profile of the roadway under the bridge will need to be lowered a minimum of 14" just to maintain existing vertical clearance.

Unlike steel girder alternates, which are typically curved to match the roadway geometry and alignment, prestressed concrete girders on curved bridges are usually built on a chorded alignment, with overhang widths that vary along the span length. However, the combination of the relatively tightly curved alignment (curve radius is approximately 1000') and the span lengths do not allow for chorded girders, as either the maximum overhang widths exceed the NCDOT suggested maximums at points along the span length, or the top flange of the exterior girder sticks out past

Section 4 | Bridge 430057 over USFS Road / Cold Spring Creek

the edge of the deck due to the 48" wide top flange width of the FIBs. Therefore, the edges of this bridge will be set tangent in order to eliminate the restrictions of the curved alignment. The proposed width of the tangent bridge is approximately 6'-6" wider than the width of the Alternate 2 bridge to accommodate the curved alignment and utilize prestressed concrete girders without curving the edges of the deck.

Closure and Ramp Diversion Scenario

The scenarios for a three week total closure with ramp diversion or a rapid, one-season, ten (10) to twelve (12) week accelerated phased replacement are similar to Alternates 1 & 2.

Phased Construction Scenario

As mentioned with Alternate 2, the advance construction of the eastern end bent in this alternate is to provide a slight time advantage to the accelerated construction scenarios. Therefore, this alternate would not require a two (2) season phased replacement as described in Alternate 1. Having only one (1) end bent to construct during the I-40 disruption should reduce the risk to the overall schedule. From a scheduling perspective, there would be no practical advantage to pre-building the eastern end bent if the remaining construction was extended to two (2) seasons.

4.4 COST ESTIMATES

Bridge 430057 over USFS Road / Cold Spring Creek	Construction Seasons	Cost
Alternate 1: 255-foot, two-span steel beam superstructure*	1	\$7.1 million
Alternate 2: 210-foot, two-span steel beam superstructure*	1	\$9.8 million
Alternate 3: 210-foot, two-span concrete beam superstructure*	1	\$9.7 million

Cost Estimate includes: removal of existing structure, approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, HP piles & micropiles, reinforced concrete for end bents, wingwalls, and interior bent, civil sitework, mobilization, causeways, and the underpass adjustment

Section 5 | Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek

5.1 ALTERNATE DEVELOPMENT

During the speculation phase multiple ideas and concepts were identified for the replacement of this bridge. These ideas and concepts included: various span arrangements, reusing existing bents, concrete girders, steel girders, alignment shifts, accelerated bridge construction techniques, and a complete closure of I-40. These elements were then combined in various ways to develop potential alternates for replacing the bridge. See Bridge 430124 Span Configuration Memorandum in Appendix for additional information regarding the alternates developed during the speculation phase, summaries are listed below:

- Three (3) span concrete or steel beam superstructure ($56' + 53' + 64' = 173'$), reuse Bents 1 & 2, new end bents behind existing end bents
- Single span, concrete or steel beam superstructure, reuse Bents 1 & 2 with earth retention improvement
- Single span 65', new end bents close behind existing Bents 1 & 2, steel or concrete girders
- Single span 76', new end bents behind existing Bents 1 & 2, steel or concrete girders, 68' horizontal clearance for roadway below
- Single span 43', new end bents in front of existing Bents 1 & 2, steel or concrete girders, 38' horizontal clearance for roadway below

Discussions regarding Bridge 430124 during the value planning session revealed some additional constraints, needs and desires specific to this bridge:

- Vertical clearance: The primary goal for the new structure is to maintain or preferably improve the existing vertical clearance of 15'-1", as the bridge has been hit in the past.
- Horizontal clearance: At a minimum, maintain the existing horizontal clearance of approximately 41'-7" between bent columns and approximately 39'-0" between inside faces of guardrail, improve if possible.
- Span Configuration: Members participating in the value planning session expressed a desire for the bridge to be single span.
- Construction timeline: Coordinate construction activities for this bridge concurrently with work associated with the adjacent Bridge 430142 over the Pigeon River. Concurrent work specifically would facilitate a linking of traffic control and phasing associated with impacts to I-40.

5.2 ALTERNATE EVALUATION

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward for further consideration. Alternates that reused existing substructures were rejected due to condition and feasibility concerns. The use of steel beams was rejected for alternates as the preference is to use concrete beams where possible. Single span bridges with concrete beam superstructures were preferred. A superstructure consisting of only a thickened, reinforced concrete slab was also considered acceptable.

Improving the vertical clearance was a major desire for the new structure. A vertical change to the profile of I-40 was not considered feasible. Acceptable options considered for improving the vertical clearance consisted of providing a shallower depth superstructure or by lowering the grade of the road below.

Each alternate considered needed to provide a new I-40 width that included a minimum ten (10) foot outside shoulder. Because this location exists at Exit 15, consideration was given to short term closure options that diverted I-40 traffic to the exit ramps. Because construction of a new bridge would most likely be concurrent with Bridge 430142 reconstruction, the most practical solution appeared to be the replacement of Bridge 430124 using phased construction. Permanent horizontal alignment shifts appeared to provide a low benefit.

Section 5 | Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek

Some alternates were rejected for the reasons mentioned above. These rejected alternates were not carried forward as part of this study. Two alternates for the replacement of this bridge were accepted as viable and further evaluation is provided below. Additional information about all the potential alternates can be found in the Appendix.

5.3 PROPOSED ALTERNATES

The understanding of this project is that the construction of this bridge would be aligned with construction work associated with Bridge 430142 over the Pigeon River. Therefore, Bridges 430124 and 430142 would have concurrent advance substructure construction work and concurrent phasing for I-40 traffic control during installations of bridge superstructures. Both proposed alternates are similar from a construction schedule and phasing standpoint.

The baseline project assumption for superstructure construction work is that a reduction in travel lanes for I-40, from two lanes each direction to one lane each direction, would only be allowed between the end of November and the end of April. Both alternates would require construction of the new end bents ahead of the first I-40 disruption, and that the new superstructure would be constructed in two (2) phases that aligned with work on Bridge 430142. For the advance construction of the end bents, all work associated with the construction of these substructures would occur without disrupting traffic on I-40 and with minimal disruption to traffic on White Oak Road. All work associated with excavation, foundation and wall construction, and the majority of the backfill installation could be completed with the existing bridge in operation overhead.

Alternate 1: Single Span (76')



This proposed alternate would replace the existing three (3) span, steel beam superstructure with a single span, concrete beam superstructure. New end bents would be constructed in advance approximately ten (10) feet behind existing Bents 1 and 2 under the end spans. These would be either taller cast-in-place concrete end bents or standard cast-in-place concrete end bent caps constructed behind wrap around MSE walls for earth retention. The new end bents would most likely be founded upon the shallow, competent bedrock that supports the existing bridge. New end bent construction could be significantly advanced or mostly completed prior to disruptions to I-40 lanes.

Section 5 | Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek

This proposed alternate has a total bridge length of 76 feet relative to the centerline of I-40. The proposed single span bridge would provide a roadway width of approximately 68 feet measured perpendicular across the centerline of White Oak Road below. To meet the desire of utilizing concrete beams for the new superstructure, it is anticipated that the new superstructure depth will be similar to the existing superstructure depth. In order to improve the vertical clearance, the roadway below could be lowered, with consideration given to roadway drainage and potential ramp tie-in impacts.

Because the timeline for the superstructure installation is governed by the phasing of adjacent Bridge 430142, it is possible to erect girders and install the new bridge deck for each phase conventionally during two (2), five (5) month baseline time frames. Accelerated bridge construction could be utilized to speed up superstructure construction utilizing full-depth precast concrete deck panels. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Alternate 2: Single Span (43')



Figure 4.2 - Bridge 430124 Alternate 2 Layout

This proposed alternate would replace the existing three span, steel beam superstructure with a single span, concrete beam superstructure. New end bents would be constructed in advance approximately five feet in front of existing Bents 1 and 2, in the existing center span. The end bents would be either taller cast-in-place concrete end bents or standard cast-in-place concrete end bent caps constructed behind wrap around MSE walls for earth retention. The new end bents would most likely be founded upon the shallow, competent bedrock that supports the existing bridge. The design of the new abutment foundations would need to accommodate the existing bent foundation locations. New end bent construction could be significantly advanced or mostly completed prior to disruptions to I-40 lanes.

This proposed alternate has a total bridge length of 43 feet relative to the centerline of I-40. The proposed single span bridge would provide a reduced total horizontal roadway width of approximately 38 feet measured perpendicular across the centerline of White Oak Road below. To meet the desire of utilizing concrete beams for the new superstructure, it is anticipated that the new superstructure depth will be similar to the existing superstructure depth. In order to improve the vertical clearance, White Oak Road could be lowered, with consideration given to roadway drainage and potential ramp tie-in impacts.

Section 5 | Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek

Because the timeline for the superstructure installation is governed by the phasing of adjacent Bridge 430142, it is possible to erect girders and install the new bridge deck conventionally during two, five (5) month baseline time frame. Accelerated bridge construction could be utilized to speed up superstructure construction utilizing full-depth precast concrete deck panels. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek	Approximate Proposed Vertical Clearance	Approximate Proposed Horizontal Clearance
Alternate 1: 76-foot, one-span concrete beam superstructure	15'-1"	65'-0"
Alternate 2: 43-foot, one-span concrete beam superstructure	15'-10"	35'-0"

Note the proposed vertical clearance assumes the existing vertical clearance is 15'-1", the existing superstructure depth is equal to 3'-6" (35" deep beam, 7" thick deck slab) and that no changes will be made to the vertical profile of I-40. For both proposed alternates, a deck thickness of 9" and a buildup thickness of 3" are assumed. For Alternate 1, the assumed beam depth is 45" (AASHTO Type III beam), and for Alternate 2, the assumed beam depth is 36" (AASHTO Type II beam). Both alternates assume SR 1338 (White Oak Road) will be lowered approximately 15" to at least maintain the existing vertical clearance.

Note the proposed horizontal clearance assumes 1'-6" width for proposed barrier and guardrail in front of front face of both end bents.

5.4 COST ESTIMATES

Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek	Construction Seasons	Cost
Alternate 1: 76-foot, one-span concrete beam superstructure*	2	\$4.9 million
Alternate 2: 43-foot, one-span concrete beam superstructure*	2	\$4.4 million

Cost Estimate includes: removal of existing structure, approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, reinforced concrete for end bents and wingwalls, civil sitework, mobilization, and the underpass adjustment.

6.1 ALTERNATE DEVELOPMENT

During the speculation phase multiple ideas and concepts were identified for the replacement of this bridge. These ideas and concepts included: various span arrangements, reusing existing bents, concrete girders, steel girders, alignment shifts, accelerated bridge construction techniques, new bent construction challenges, and causeway installations. These elements were then combined in various ways to develop potential alternates for replacing the bridge. See Bridge 430142 Span Configuration memorandum in Appendix for additional information regarding the alternatives developed during the speculation phase, summaries are listed below:

- Three (3) span concrete beam superstructure ($98' + 130' + 46' = 304'$), new end bents constructed in advance in existing Spans 1 & 5, two new bents constructed in advance to west side of existing Bent 2 and in the middle of existing Span 4.
- Five (5) span concrete girder superstructure ($76' + 76' + 76' + 76' + 76' = 387'$), new eastern end bent constructed in I-40 approach behind existing end bent during phased construction, new western end bent constructed in advance in existing Span 1, rehabilitate and reuse all existing bents.
- Two (2) span steel beam superstructure ($187' + 160' = 347'$), new eastern end bent constructed in I-40 approach behind existing end bent during phased construction, new western end bent constructed in advance in existing Span 1, rehabilitate and reuse existing Bent 3
- Two (2) span steel beam superstructure ($202' + 145' = 347'$), new eastern end bent constructed in I-40 approach behind existing end bent during phased construction, new western end bent constructed in advance in existing Span 1, new bent constructed in advance to the eastern side of existing Bent 3 near the low bank
- Two (2) span steel beam superstructure ($145' + 200' = 345'$), new eastern end bent constructed in advance in existing Span 5, widen and reuse existing End Bent 1, new bent constructed in advance to the western side of existing Bent 2 near the low bank
- Two (2) span concrete beam superstructure ($152' + 152' = 304'$), new end bents constructed in advance in existing Spans 1 & 5, new bent constructed in advance in the middle of existing Span 4
- Two (2) span steel beam superstructure ($200' + 200' = 400'$), new end bents constructed in I-40 approach behind existing end bents during phased construction, new bent constructed in advance in the middle of existing Span 4
- Two (2) span steel beam superstructure ($180' + 180' = 360'$), new western end bent constructed in I-40 approach behind existing end bent during phased construction, new eastern end bent constructed in advance in Span 5, new bent constructed in advance to the western side of existing Bent 2
- Three (3) span concrete beam superstructure ($134' + 134' + 134' = 402'$), new end bents constructed in I-40 approach behind existing end bents during phased construction, two (2) new bents constructed in advance to western side of existing Bent 2 and to eastern side of existing Bent 3.
- Three (3) span concrete beam superstructure ($120' + 120' + 120' = 360'$), new western end bent constructed in I-40 approach behind existing end bent during phased construction, new eastern end bent constructed in advance in existing Span 5, two (2) new bents constructed in advance to eastern side of existing Bent 1 and to western side of existing Bent 3
- Two (2) span steel beam superstructure ($180' + 220' = 400'$), new end bents constructed in I-40 approach behind existing end bents during phased construction, new bent constructed in advance to eastern side of existing Bent 2

Discussions regarding Bridge 430142 during the value planning session revealed some additional constraints and desires specific to this bridge. Bridge specific constraints identified for all options included:

- Minimizing or eliminating encroachment on the residence adjacent to the eastern approach (southwest corner)
- MSE walls should not be used for earth retention within the influence of the Pigeon River.

Section 6 | Bridge 430142 over Pigeon River

Additional desires were expressed for this location which reflect goals that should be accomplished if cost or impact are not a significant factor. The desires expressed included:

- Construct slope benches for wildlife passage under the new structure
- Minimize the number of piers and lengthen spans
- Provide a complete reconstruction – no reuse of existing superstructure or substructures
- Avoid expansion joints at end bents
- Avoid nighttime work and minimize tree clearing to accommodate wildlife concerns

The value planning group also identified the need to coordinate construction activities for this bridge concurrently with work associated with the adjacent Bridge 430124 over White Oak Road (Fines Creek). Concurrent work specifically would facilitate a linking of traffic control and phasing associated with impacts to I-40.

6.2 ALTERNATE EVALUATION

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward for further consideration. Alternates that reused existing substructures were rejected due to condition and feasibility concerns.

Each alternate considered needed to provide a new I-40 width that included a minimum ten (10) foot outside shoulder. The existing bridge has roadway shoulders that are 2' wide or less and provides a total roadway width of 28' between barriers in each direction. During phased replacement of the bridge, east and westbound I-40 traffic will be reduced to one lane in each direction and shifted to one half of the existing superstructure. The existing bridge is an eight (8) girder, steel beam superstructure, and the median barrier is supported by the center two (2) girders. This study reviewed phasing options to construct a Phase 1 superstructure that would provide a similar width for traffic during phased operations in all seasons. One option initially removed three (3) girders from the existing superstructure allowing the existing median barrier to continue to be supported by the middle two (2) girders. Phase 1 would then construct an over-widened Phase 1 superstructure that provided sufficient roadway width during between-phase operation (May-November) and during Phase 2 construction. This study estimated that over-widening produced an approximate 14' outside shoulder for the completed superstructure on the Phase 1 side of the bridge. Small alignment shifts were studied to eliminate the construction of this additional bridge width, but it was determined that the cost for the additional bridge width would be much less than costs associated with a similar width alignment shift of I-40.

Construction of the end bent at the western approach will be a significant task for the new bridge construction. The existing end bent is very tall at one end, varying from five (5) feet to more than 30 feet in height from one side to the other. The end bent is founded on spread footings on rock, and the height varies significantly to follow the rock profile in this location. At the corner of the existing end bent where it is tallest, a large retaining wall ties into the existing end bent. This retaining wall is over 100 feet long, over 30 feet tall, and runs adjacent and parallel to the eastbound lanes of I-40 west of the existing bridge.

Because of the nature of the existing rock outcropping under Span 1 and information regarding the flows of the Pigeon River, the existing Span 1 does not appear to contribute to the hydraulic capacity of the Pigeon River through the structure. Therefore, alternates are considered that construct the new west approach end bent both behind the existing end bent and in front of it under existing Span 1.

With an overall bridge widening of nearly twenty (20) feet, the new structure will need to fit through a narrow corridor that is bounded by tight I-40 curve geometry, steep terrain, and the Pigeon River paralleling one side of the eastern approach. Widening impacts to the eastern approach slope down to the Pigeon River must be balanced

with modifications or accommodations necessary to the existing retaining wall along the western approach. Partial demolition will be required to the upper sections of the wall to facilitate the widening of the roadway. The advance construction of a new western end bent under the existing Span 1 will require a new wingwall that must balance challenges between proximity to the existing retaining wall versus a more accommodating geometry that may limit access under the bridge at the western approach.

Construction of the other substructure units will also pose challenges. At the eastern approach, advance construction of an end bent under existing Span 5 will require excavation and shoring. The advance construction of bents within the flow of the Pigeon River will require the installation of construction access roads, or causeways. Causeways installed in the Pigeon River are not permitted to restrict more than 50% of the normal flow.

Access for cranes to erect girders will be limited. Steep terrain on the eastern side (inlet side) of the bridge will pose challenges for cranes to access the Pigeon River directly. Because the clearance under the bridge is approximately 40 feet, cranes may have potential to gain access to the Pigeon River down the western side (outlet side) and then access the eastern side via a causeway under the bridge. Innovative girder erection techniques, such as beam launching, may be employed where crane access is a less feasible alternative. The site constraints and challenges at this bridge site in particular will require contractor ingenuity to erect the girders for the superstructure, regardless of whether a steel or a concrete alternate is ultimately selected.

Options for the construction of new end bents were considered. Advanced construction of end bents under existing Spans 1 and 5 were compared to phased, part-width construction in the I-40 approaches behind the existing end bents. Considerations were given to the construction of a new western end bent behind the tall existing substructure. Modifications to the western retaining wall for I-40 widening would need to be advanced prior to phased disruption. Part width construction during phased disruption of a new western end bent means there would be ample time to also construct a new part width eastern end bent. Because of this, alternatives were rejected that pre-built eastern end bents under Span 5 while also constructing part width western end bents in the I-40 approach during phased disruption.

Steel girder and concrete girder superstructures were considered in the alternatives. Steel girder superstructures have the advantage of providing longer spans with fewer total substructure units and a greater flexibility for locating those substructure units. Concrete girder bridges are more desirable to NCDOT because of a higher corrosion resistance to deicing salts frequently used in this corridor. These concrete girder superstructure configurations do require additional substructure units versus steel girder superstructures. Concrete girders would also require heavier pick weights for cranes versus the steel girder options.

Some alternates were rejected for the reasons mentioned above. These rejected alternates were not carried forward as part of this study. Three (3) alternates for the replacement of this bridge were accepted as viable and further evaluation is provided below. Additional information about all the potential alternates can be found in the Appendix.

6.3 PROPOSED ALTERNATES

As previously stated, Bridges 430124 and 430142 would have concurrent advance substructure construction work and concurrent phasing for I-40 traffic control during installations of bridge superstructures. Bridge 430142 would require the most effort and therefore governs the schedule for the two bridge reconstructions.

The baseline project assumption for superstructure construction work is that a reduction in travel lanes for I-40, from two (2) lanes each direction to one (1) lane each direction, would only be allowed between the end of November and the end of April. All alternates would require construction of new bents ahead of the first I-40 disruption, and some require construction of end bents in advance as well. The advance construction of substructures controls the schedule for time required ahead of the first I-40 disruption window (December – April).

Section 6 | Bridge 430142 over Pigeon River

The existing bridge girders are steel beams with a 36-inch depth. For all alternates considered, new girder depths would likely be deeper than 36 inches. The installation of girders during Phase 1 erection may require partial demolition of the existing bents for new girders to clear existing top of bent elevations. All existing bents are five (5) column structures. Design details and construction strategies will need to consider temporary support needs to ensure the existing bents provide sufficient support for the remaining superstructure during Phase 1.

Alternate 1: Three Span (3), Concrete Girders, 98+130+76 = 304'



This proposed alternate would replace the existing five (5) span, steel beam superstructure with a three (3) span, concrete beam superstructure. Two (2) new bents would be constructed in advance of Phase 1 disruption of I-40. New end bents would be constructed under the existing Spans 1 and 5.

The two (2) new bents would be constructed to the western side of existing Bent 2 and approximately in the middle of existing Span 4. Both new bents would be constructed adjacent to the low bank of the Pigeon River which would minimize the causeway installation required. The advance construction of the western end bent would require rock excavation and a significant amount of backfill between the new end bent and the front face of the existing western end bent. The advance construction of the eastern end bent under Span 5 would likely require shoring and the use of micropiles to install the substructure foundation.

The construction project would likely need to begin 16 to 18 months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and causeway preparations, and constructing four new substructures. During this same 16-18 month period, the contractor would also be performing the advance work for Bridge 430124 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three girder lines) would require approximately two (2) to four (4) weeks. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one (1) month to complete. Deck form work and rebar installation would require two (2) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four lane conveyance at the beginning of May.

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through the end of April. This accommodates a cast-in-place bridge deck; however, full-depth precast

Section 6 | Bridge 430142 over Pigeon River

concrete deck panels could be utilized to shorten the disruption duration of I-40. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

Alternate 2: Two (2) Span, Steel Girders, 202+145 = 347'



This proposed alternate would replace the existing five (5) span, steel beam superstructure with a two (2) span, steel beam superstructure. One new bent would be constructed in advance of Phase 1 disruption of I-40. The new western end bent would be constructed under existing Span 1. The eastern end bent would be constructed part width during phased work behind the existing eastern end bent in the I-40 approach.

The new bent would be constructed between the eastern side of existing Bent 3 and the low bank of the Pigeon River. Causeway installation would be required to construct this new bent. The advance construction of the western end bent would require rock excavation and a significant amount of backfill between the new end bent and the front face of the existing western end bent. The new eastern end bent would be a standard end bent cap supported by driven H-piles.

The construction project would likely need to begin 12 to 14 months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and causeway preparations, and constructing two new substructures. During this same 12-14 month period, the contractor would also be performing the advance work for Bridge 430124 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three girder lines) and part width construction of the new eastern end bent would require approximately two (2) to four (4) weeks. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one month to complete. Deck formwork and rebar installation would require two (2) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four (4) lane conveyance at the beginning of May.

Section 6 | Bridge 430142 over Pigeon River

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through the end of April. This accommodates a cast-in-place bridge deck; however, full-depth precast concrete deck panels could be utilized to shorten the disruption duration of I-40. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

Alternate 3: Two (2) Span, Steel Girders, 180 + 220 = 400'



This proposed alternate would replace the existing five (5) span, steel beam superstructure with a two (2) span, steel beam superstructure. One (1) new bent would be constructed in advance of Phase 1 disruption of I-40. The new western and eastern end bents would be constructed part width during phased work behind the existing end bents in the I-40 approaches.

The new bent would be constructed to the western side of existing Bent 2 in the Pigeon River. Causeway installation would be required to construct this new bent. Advance planning for the layout of this causeway would be required to ensure that less than 50% of the waterway is blocked when the causeway is in place. For the part-width, phased construction of the western end bent behind the existing end bent, foundation types may vary between spread footings on rock and driven H-piles from one side to the other. This new western end bent would also need to incorporate a design that modified the existing large retaining wall to accommodate the widening of I-40. The new eastern end bent would be a standard end bent cap constructed part width during phasing and supported by driven H-piles.

The construction project would likely need to begin ten (10) to twelve (12) months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and causeway preparations, constructing a new bent, and making modifications to the large western wall for end bent construction during phasing. During this same 10-12 month period, the contractor would also be performing the advance work for Bridge 430124 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three (3) girder lines) and part width construction of the new end bents would require

Section 6 | Bridge 430142 over Pigeon River

approximately two (2) to four (4) weeks. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one (1) month to complete. Deck formwork and rebar installation would require two (2) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four (4) lane conveyance at the beginning of May.

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through the end of April. This accommodates a cast-in-place bridge deck; however, precast concrete deck panels could be utilized to shorten the disruption duration of I-40. If full-depth precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

6.4 COST ESTIMATES

Bridge 430142 over Pigeon River	Construction Seasons	Cost
Alternate 1: 304-foot, three-span concrete beam superstructure*	2	\$21.1 million
Alternate 2: 347-foot, two-span steel beam superstructure*	2	\$18 million
Alternate 3: 400-foot, two-span steel beam superstructure*	2	\$13.4 million

Cost Estimate includes: removal of existing structure, approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, HP piles & micropiles, reinforced concrete for end bents, wingwalls, and interior bent, temporary supports at existing bents, civil sitework, mobilization, and causeways

7.1 ALTERNATE DEVELOPMENT

During the speculation phase multiple ideas and concepts were identified for the replacement of this bridge. These ideas and concepts included: various span arrangements, reusing existing bents, concrete girders, steel girders, alignment shifts, accelerated bridge construction techniques, and Controlled Low Strength Material (CLSM) backfill material. These elements were then combined in various ways to develop potential alternates for replacing the bridge. See Bridge 430159 Span Configuration Memorandum in Appendix for additional information regarding the alternates developed during the speculation phase, summaries are listed below:

- Three (3) span concrete or steel beam superstructure ($43' + 61' + 77' = 181'$), reuse Bents 1 & 2, new end bents behind existing end bents
- Single span, concrete or steel beam superstructure, reuse Bents 1 & 2 with earth retention improvement
- Single span 72', new end bents close behind existing Bents 1 & 2, steel or concrete girders
- Single span 78', new end bents behind existing Bents 1 & 2, steel or concrete girders, 63' horizontal clearance for roadway below
- Single span 47', new end bents in front of existing Bents 1 & 2, steel or concrete girders, 38' horizontal clearance for roadway below

Discussions regarding Bridge 430159 during the value planning session revealed some additional constraints, needs and desires specific to this bridge:

- Horizontal clearance: At a minimum, maintain the existing horizontal clearance, improve if possible.
- Vertical clearance: At a minimum, maintain the existing vertical clearance, improve if possible.
- Span Configuration: Members participating in the value planning session expressed a desire for the bridge to be single span.
- Construction timeline: Coordinate construction activities for this bridge concurrently with work associated with the adjacent Bridge 430171 over White Oak Road and Jonathan Creek. Concurrent work specifically would facilitate a linking of traffic control and phasing associated with impacts to I-40.

7.2 ALTERNATE EVALUATION

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward for further consideration. Alternates that reused existing substructures were rejected due to condition and feasibility concerns. The use of steel beams was rejected for alternates as the preference is to use concrete beams where possible. Single span bridges with concrete beam superstructures were preferred. A superstructure consisting of only a thickened, reinforced concrete slab was also considered acceptable.

Improving the vertical clearance was a desire for the new structure. A vertical change to the profile of I-40 was not considered feasible. Acceptable options considered for improving the vertical clearance consisted of providing a shallower depth superstructure or lowering the grade of the road below.

Each alternate considered needed to provide a new I-40 width that included a minimum ten (10) foot outside shoulder. Because construction of a new bridge would most likely be concurrent with Bridge 430171 reconstruction, the most practical solution appeared to be the replacement of Bridge 430159 using phased construction. Permanent horizontal alignment shifts appeared to provide a low benefit.

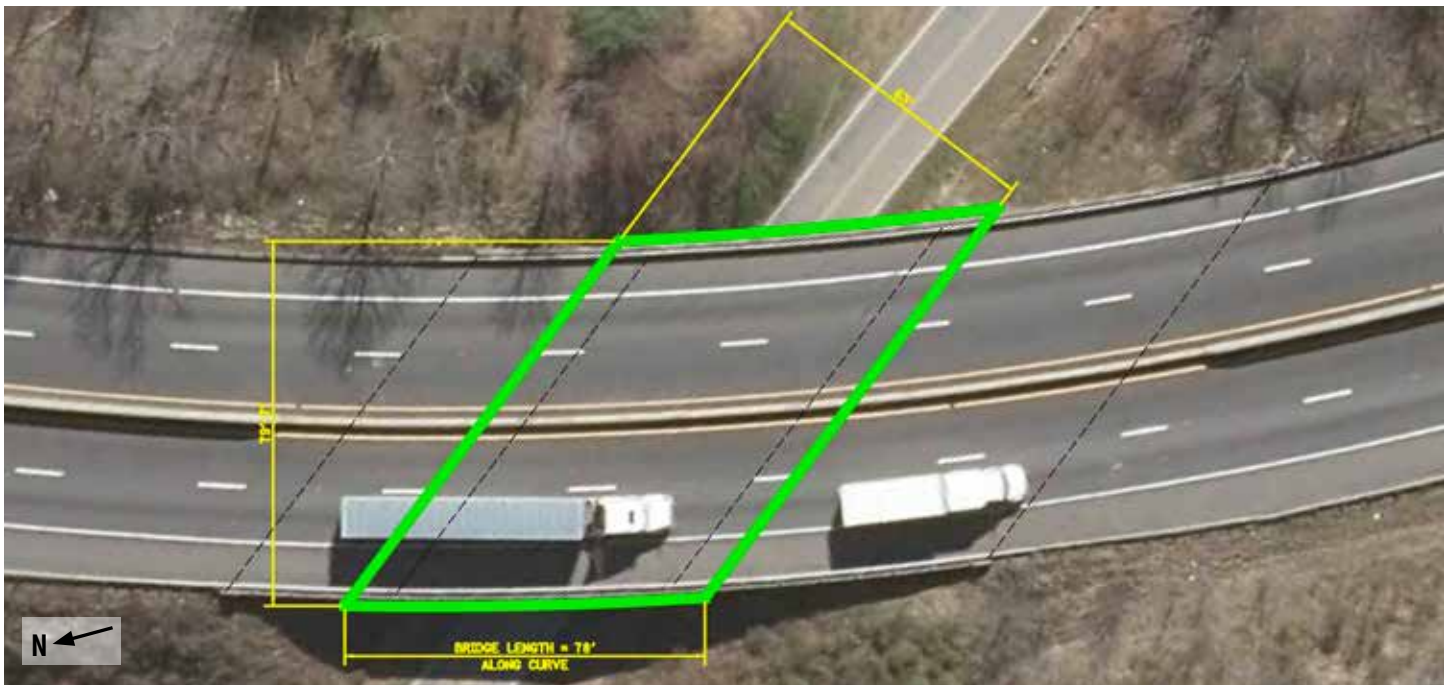
Some alternates were rejected for the reasons mentioned above. These rejected alternates were not carried forward as part of this study. Two (2) alternates for the replacement of this bridge were accepted as viable and further evaluation is provided below. Additional information about all the potential alternates can be found in the Appendix.

7.3 PROPOSED ALTERNATES

The understanding of this project is that the construction of this bridge would be aligned with construction work associated with Bridge 430171 over the White Oak Road and Jonathan Creek. Therefore Bridges 430159 and 430171 would have concurrent advance substructure construction work and concurrent phasing for I-40 traffic control during installations of bridge superstructures. Both proposed alternates are similar from a construction schedule and phasing standpoint. Note that since neither Bridge 430159 nor Bridge 430171 is part of an interchange, the schedule for both these bridges will be more critical than the other I-40 bridges due to access. Additionally, the limits of lane closure and maintenance of traffic for these two bridges should take construction access into consideration.

The baseline project assumption for superstructure construction work is that a reduction in travel lanes for I-40, from two lanes each direction to one lane each direction, would only be allowed between the end of November and the end of April. Both alternates would require construction of the new end bents ahead of the first I-40 disruption, and that the new superstructure would be constructed in two phases that aligned with work on Bridge 430171. For the advance construction of the end bents, all work associated with the construction of these substructures would occur without disrupting traffic on I-40 and with minimal disruption to traffic on White Oak Road. All work associated with excavation, foundation and wall construction, and the majority of the backfill installation could be completed with the existing bridge in operation overhead.

Alternate 1: Single Span (78')



This proposed alternate would replace the existing three span, steel beam superstructure with a single span, concrete beam superstructure. New end bents would be constructed in advance approximately ten feet behind existing Bents 1 and 2 under the end spans. These would be either taller cast-in-place concrete end bents or standard cast-in-place concrete end bent caps constructed behind wrap around MSE walls for earth retention. The new end bents would most likely be founded upon the shallow, competent bedrock that supports the existing bridge. New end bent construction could be significantly advanced or mostly completed prior to disruptions to I-40 lanes.

This proposed alternate has a total bridge length of 78 feet relative to the centerline of I-40. The proposed single span bridge would provide a roadway width of approximately 63 feet measured perpendicular across the centerline

of White Oak Road below. To meet the desire of utilizing concrete beams for the new superstructure, it is anticipated that the new superstructure depth will be similar to the existing superstructure depth. In order to improve the vertical clearance, the roadway below could be lowered, with consideration given to roadway drainage.

Because the timeline for the superstructure installation is governed by the phasing of adjacent Bridge 430171, it is possible to erect girders and install the new bridge deck conventionally during two, five month baseline time frame. Accelerated bridge construction could be utilized to speed up superstructure construction utilizing full-depth precast concrete deck panels. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Alternate 2: Single Span (47')



This proposed alternate would replace the existing three span, steel beam superstructure with a single span, concrete beam superstructure. New end bents would be constructed in advance approximately five feet in front of existing Bents 1 and 2. These would be either taller cast-in-place concrete end bents or standard cast-in-place concrete end bent caps constructed behind wrap around MSE walls for earth retention. The new end bents would most likely be founded upon the shallow, competent bedrock that supports the existing bridge. New end bent construction could be significantly advanced or mostly completed prior to disruptions to I-40 lanes.

This proposed alternate has a total bridge length of 47 feet relative to the centerline of I-40. The proposed single span bridge would provide a reduced total horizontal roadway width of approximately 38 feet measured perpendicular across the centerline of White Oak Road below. To meet the desire of utilizing concrete beams for the new superstructure, it is anticipated that the new superstructure depth will be similar to the existing superstructure depth. In order to improve the vertical clearance, White Oak Road could be lowered, with consideration given to roadway drainage.

Because the timeline for the superstructure installation is governed by the phasing of adjacent Bridge 430171, it is possible to erect girders and install the new bridge deck conventionally during two, five month baseline time frames. Accelerated bridge construction could be utilized to speed up superstructure construction utilizing full-depth precast concrete deck panels. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Bridge 430159 over SR 1338 (White Oak Road)	Approximate Proposed Vertical Clearance	Approximately Proposed Horizontal Clearance
Alternate 1: 78-foot, one-span concrete beam superstructure	15'-4"	60'-0"
Alternate 2: 47-foot, one-span concrete beam superstructure	16'-1"	35'-0"

Note the proposed vertical clearance assumes the existing vertical clearance is 15'-4", the existing superstructure depth is equal to 3'-6" (35" deep beam, 7" thick deck slab) and that no changes will be made to the vertical profile of I-40. For both proposed alternates, a deck thickness of 9" and a buildup thickness of 3" are assumed. For Alternate 1, the assumed beam depth is 45" (AASHTO Type III beam), and for Alternate 2, the assumed beam depth is 36" (AASHTO Type II beam). Both alternates assume SR 1338 (White Oak Road) will be lowered approximately 15" to at least maintain the existing vertical clearance.

Note the proposed horizontal clearance assumes 1'-6" width for proposed barrier and guardrail in front of front face of both end bents.

7.4 COST ESTIMATES

Bridge 430159 over SR 1338 (White Oak Road)	Construction Seasons	Cost
Alternate 1: 78-foot, one-span concrete beam superstructure*	2	\$5.4 million
Alternate 2: 47-foot, one-span concrete beam superstructure*	2	\$4.9 million

Cost Estimate includes: removal of existing structure, approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, reinforced concrete for end bents and wingwalls, civil sitework, mobilization, and the underpass adjustment.

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

8.1 ALTERNATE DEVELOPMENT

During the speculation phase multiple ideas and concepts were identified for the replacement of this bridge. These ideas and concepts included: various span arrangements, reusing existing bents, concrete girders, steel girders, alignment shifts, accelerated bridge construction techniques, and new bent construction challenges. These elements were then combined in various ways to develop potential alternates for replacing the bridge. See Bridge 430159 Span Configuration Memorandum in Appendix for additional information regarding the alternates developed during the speculation phase, summaries are listed below:

- Three (3) span steel beam superstructure ($100' + 200' + 150' = 450'$), new end bents constructed in advance in existing Spans 2 & 5, two new bents constructed in advance to west side of existing Bent 2 and eastern side of existing Bent 3
- Three (3) span steel beam superstructure ($150' + 200' + 150' = 500'$), new end bents constructed in advance in existing Spans 1 & 5, two new bents constructed in advance to west side of existing Bent 2 and eastern side of existing Bent 3
- Three (3) span steel beam superstructure ($150' + 160' + 150' = 460'$), new end bents constructed in advance in existing Spans 1 & 5, rehabilitate and reuse existing Bents 2 & 3
- Four (4) span steel or concrete beam superstructure ($120' + 160' + 140' + 85' = 505'$), new end bents constructed in advance in existing Spans 2 & 6, rehabilitate and reuse existing Bents 2, 3, and 4
- Five (5) span concrete beam superstructure ($100' + 110' + 110' + 110' + 95' = 525'$), new end bents constructed in advance in existing Spans 1 & 6, four new bents constructed in advance
- Five (5) span concrete beam superstructure ($85' + 110' + 110' + 110' + 95' = 510'$), new end bents constructed in advance in existing Spans 2 & 6, four new bents constructed in advance
- Permanent I-40 alignment shift of approximately 32 feet to facilitate the construction of one phase superstructure without disruption to I-40 lanes, Three span steel beam superstructure ($150' + 200' + 150' = 500'$), new end bents constructed in advance in existing Spans 1 & 5, two new bents constructed in advance to west side of existing Bent 2 and eastern side of existing Bent 3
- Three (3) span steel beam superstructure ($200' + 240' + 200' = 640'$), new end bents constructed in I-40 approach behind existing end bents during phased construction, new bent constructed in advance to west side of existing Bent 2, new bent constructed in advance in middle of existing Span 4
- Four (4) span concrete beam superstructure ($140' + 160' + 140' + 100' = 540'$), new end bents constructed in advance in existing Spans 1 & 6, three new bents constructed in advance, new middle bent would be large diameter single column hammerhead constructed between Jonathan Creek and existing Bent 3
- Five (5) span concrete beam superstructure ($120' + 140' + 140' + 130' + 90' = 620'$), new end bents constructed in I-40 approach behind existing end bents during phased construction, four new bents constructed in advance, new Bent 2 would be smaller diameter multi column bent at opposing skew to other substructures and constructed between White Oak Road and Jonathan Creek
- Three (3) span steel beam superstructure ($160' + 240' + 160' = 560'$), new end bents constructed in advance in existing Spans 1 & 6, new bent constructed in advance to west side of existing Bent 2, new bent constructed in advance in middle of existing Span 4

Discussions regarding Bridge 430171 during the value planning session revealed some additional constraints and desires specific to this bridge. Bridge specific constraints identified for all options were that construction must not actively impact Jonathan Creek from January 1st to April 15th due to a trout moratorium restriction. Additional desires were expressed for this location which reflect goals that should be accomplished if cost or impact are not a significant factor. The desires expressed included:

- Construct slope benches for wildlife passage under the new structure
- Minimize the number of piers and lengthen spans
- Provide a complete reconstruction – no reuse of existing superstructure or substructures

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

- Avoid work in Jonathan Creek due to permit requirements and presence of Hellbender Salamanders
- Avoid nighttime work and minimize tree clearing to accommodate wildlife concerns

The value planning group also identified the need to coordinate construction activities for this bridge concurrently with work associated with the adjacent Bridge 430159 over White Oak Road. Concurrent work specifically would facilitate a linking of traffic control and phasing associated with impacts to I-40.

8.2 ALTERNATE EVALUATION

Each of the initial alternates developed were evaluated to determine if they should be eliminated or carried forward for further consideration. Alternates that reused existing substructures were rejected due to condition and feasibility concerns.

Each alternate considered needed to provide a new I-40 width that included a minimum ten (10) foot outside shoulder. The existing bridge has roadway shoulders that are 2' wide or less and provides a total roadway width of 28' between barriers in each direction. During phased replacement of the bridge, east and westbound I-40 traffic will be reduced to one lane in each direction and shifted to one half of the existing superstructure. The existing bridge is an eight (8) girder, steel beam superstructure, and the median barrier is supported by the center two (2) girders. This study reviewed phasing options to construct a Phase 1 superstructure that would provide a similar width for traffic during phased operations in all seasons. One option initially removed three (3) girders from the existing superstructure allowing the existing median barrier to continue to be supported by the middle two (2) girders. Phase 1 would then construct an over-widened Phase 1 superstructure that provided sufficient roadway width during between-phase operation (May-November) and during Phase 2 construction. This study estimated that over-widening produced an approximate 14' outside shoulder for the completed superstructure on the Phase 1 side of the bridge. Small alignment shifts were studied to eliminate the construction of this additional bridge width, but it was determined that the cost for the additional bridge width would be much less than costs associated with a similar width alignment shift of I-40. This study also reviewed a larger 32-foot alignment shift that would facilitate the construction of Phase 1 superstructure without impacting the existing bridge. This study concluded that I-40 costs associated with a large alignment shift outweighed the benefits of this concept.

Construction of new substructures in advance of I-40 traffic disruption will be a significant task for the new bridge construction. The existing bridge Bents 1, 3, and 4 are founded completely upon bedrock. One of the large column foundations for existing Bent 2 appears to have been partially switched to H-Piles during construction due to a bedrock anomaly. Discussions with members of the technical study team concluded that substructure construction impacting Jonathan Creek should be avoided due to permitting concerns. Some of the span configuration options looked at the possibility of installing new bents between the creek and either White Oak Road or existing Bent 3. The construction of spread footings on rock would likely impact the waters of Jonathan Creek in these locations, however, drilled shaft supported bents appeared to be a better solution. Due to the high clearance under the existing bridge, drilled shaft installation appeared to be a feasible alternative where spread footing excavation was not possible.

Options for the construction of new end bents were considered. Two (2) strategies were developed: construct new end bents in advance of I-40 disruption or construct part-width end bents behind the existing bridge ends during the phasing of I-40. Construction of end bents in advance of I-40 disruption have the advantage of simplifying the phased scheduling required, however these new end bents appeared to be most cost effective only when pre-built under the end spans of the existing bridge. Part-width construction of end bents during I-40 disruption would add to the schedule complexity of the phasing operations, but these end bents would likely be much easier to construct.

The height of this structure poses several constructability challenges. As previously mentioned, the top of the existing bridge rail is approximately 125-feet above the streambed of Jonathan Creek. To erect the girders, large or multiple

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

crane pads will be required. Innovative girder erection techniques, such as beam launching, may be employed where crane access is a less feasible alternative. In addition, construction of the tall interior bent columns underneath the existing structure will pose some challenges. These more challenging constraints will require the design team and contractor to have in depth discussion on the means and methods to develop the design and scope.

Steel girder and concrete girder superstructures were considered in the alternatives. Steel girder superstructures have the advantage of providing longer spans with fewer total substructure units and a greater flexibility for locating those substructure units. Concrete girder bridges are more desirable to NCDOT because of a higher corrosion resistance to deicing salts frequently used in this corridor. Span configurations that utilized higher efficiency prestressed girder sections, such as Florida I-Beams (FIBs), appeared most practical. These concrete girder superstructure configurations do require additional substructures versus steel girder superstructures. Concrete girders would also require heavier pick weights for cranes versus steel girder options.

Some alternates were rejected for the reasons mentioned above. These rejected alternates were not carried forward as part of this study. Three alternates for the replacement of this bridge were accepted as viable and further evaluation is provided below. Additional information about all the potential alternates can be found in the Appendix.

8.3 PROPOSED ALTERNATES

As previously stated, Bridges 430159 and 430171 would have concurrent advance substructure construction work and concurrent phasing for I-40 traffic control during installations of bridge superstructures. Bridge 430171 would require the most effort and therefore governs the schedule for the two (2) bridge reconstructions.

The baseline project assumption for superstructure construction work is that a reduction in travel lanes for I-40, from two lanes each direction to one lane each direction, would only be allowed between the end of November and the end of April. All alternates would require construction of new bents ahead of the first I-40 disruption, and some require construction of end bents in advance as well. The advance construction of substructures controls the schedule for time required ahead of the first I-40 disruption window (December – April).

The existing bridge girders vary in depth between the longer and shorter spans. The longer span girders have a six foot depth for most of their length, including at Bents 1 & 4. These long span girders increase in depth to eight feet at Bents 2 & 3. Existing Spans 1, 5, & 6 utilize three foot deep girders. For all alternates considered, girder depths are likely to be a minimum of six (6) feet. The installation of girders during Phase 1 erection will likely require partial demolition of some of the existing bents for new girders to clear existing top of bent elevations. Existing Bents 1 and 5 are four column bents, and existing Bents 2, 3, & 4 are large two column bents. It appears that new superstructure girder depths can be designed such that clearance over Bents 2 & 3 can be achieved without partial demolition, however, partial demolition is likely required at Bents 1, 4, & 5. Design details and construction strategies will need to consider temporary support needs to ensure the existing bents provide sufficient support for the remaining superstructure during Phase 1.

Bridges 430159 and 430171 would be constructed during the same time frames with the efforts to construct Bridge 430171 having longer lead times and durations. Because both bridges are active simultaneously, this would afford the contractor the opportunity to provide efficient work balancing of labor.

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

Alternate 1: Three (3) Span, Steel Girders, 200+240+200 = 640'



This proposed alternate would replace the existing six (6) span, steel beam superstructure with a three (3) span, steel beam superstructure. Two (2) new bents would be constructed in advance of Phase 1 disruption of I-40. New end bents would be constructed part-width behind existing end bents during phasing. The western end bent would likely be founded upon bedrock, and the eastern end bent on driven H-piles.

The construction project would likely need to begin ten (10) to twelve (12) months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and preparations, and then beginning construction of the two (2) new large bents with heights of approximately 90 feet. During this same 10-12 month period, the contractor would also be performing the advance work for Bridge 430159 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three (3) girder lines) and construction of the end bents would require approximately two (2) to four (4) weeks. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one month to complete. Deck formwork and rebar installation would require two (2) to four (4) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four lane conveyance at the beginning of May.

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through the end of April. This accommodates a cast-in-place bridge deck; however, full-depth precast concrete deck panels could be utilized to shorten the disruption duration of I-40. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

Alternate 2: Three (3) Span, Steel Girders, $160+240+160 = 560'$



This proposed alternate has a lot of similarities to Alternate 1. It would also replace the existing six (6) span, steel beam superstructure with a three (3) span, steel beam superstructure. Two (2) new bents would be constructed in advance of Phase 1 disruption of I-40. In this alternate however, new end bents would be constructed in advance of I-40 phase disruption under existing Spans 1 and 6. The western end bent would likely be founded upon bedrock, and the eastern end bent on micropiles.

The construction project would likely need to begin twelve (12) to fourteen (14) months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. Mobilization, clearing, and preparations would be the first steps in this alternate which would prepare for the construction of the new end bents and the construction of the two new large bents with heights of approximately 90 feet. During this same twelve (12) - fourteen (14) month period, the contractor would also be performing the advance work for Bridge 430159 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three girder lines) could immediately be followed by the erection of girders since the end bents are already constructed in this alternate. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one month to complete. Deck formwork and rebar installation would require two (2) to four (4) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four (4) lane conveyance by the middle of April.

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through April. This accommodates a cast-in-place bridge deck; however, full-depth precast concrete deck panels could be utilized to shorten the disruption duration of I-40. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

Alternate 3: Five Span, Concrete Girders, 120 + 140 + 140 + 130 + 90 = 620'



This proposed alternate would replace the existing six (6) span, steel beam superstructure with a five (5) span, concrete beam superstructure. Even with the use of efficient prestressed concrete beam sections, such as FIBs, span configuration options are more challenging with concrete girders due to the layout of existing Bents 2 and 3 relative to White Oak Road and Jonathan Creek. Longer spans are possible with deeper concrete girder sections; however, this might require partial demolition of the Bent 2 and 3 caps as the existing girders are eight feet deep at these locations.

For this alternate, four (4) new bents would be constructed in advance of Phase 1 disruption of I-40. New end bents would be constructed part-width behind existing end bents during phasing. The western end bent would likely be founded upon bedrock, and the eastern end bent on driven H-piles.

In the previous alternates, all proposed substructures were at a 90-degree skew relative to the centerline of I-40 as is the case with the existing substructures. In this proposed alternate, new Bent 2 would be at a 75-degree skew to allow it to fit between White Oak Road and Jonathan Creek. Smaller diameter columns could be utilized along with drilled shafts to avoid entering the waters of Jonathan Creek. Minor adjustment to the alignment of White Oak Road may also be required to fit the new bent in this location.

The construction project would likely need to begin 15 to 18 months prior to the beginning of December when the Phase 1 disruption of I-40 would commence. In the first advance work period, the contractor would be mobilizing to the site, performing initial clearing and preparations, and then beginning construction of the four new bents. During this same 15-18 month period, the contractor would also be performing the advance work for Bridge 430159 and procuring girders for both bridges.

At the beginning of December, the first lane reduction disruption of I-40 would commence. Demolition of the first portion of the superstructure (three (3) girder lines) and construction of the end bents would require approximately two (2) to four (4) weeks. The new Phase 1 superstructure would require the erection of four (4) or five (5) girder lines and would need approximately one (1) month to complete. The erection of concrete girders would require multiple and/or larger cranes and additional crane pad preparation in advance due to the larger pick weights required versus the steel girder segments in Alternates 1 & 2. Deck formwork and rebar installation would require two (2)

Section 8 | Bridge 430171 over SR 1338 (White Oak Road) & Jonathan Creek

to four (4) weeks. Approximately six (6) to eight (8) weeks would be required to complete the bridge deck concrete placement, parapet installation, and traffic control preparation to return I-40 to a four-lane conveyance at the beginning of May.

The timeline described above would encompass the allowable I-40 disruption duration from the beginning of December through the end of April. This accommodates a cast-in-place bridge deck; however, full-depth precast concrete deck panels could be utilized to shorten the disruption duration of I-40. If precast deck panels are utilized, the bridge deck would receive an overlay to provide proper seal and improved rideability using either polyester polymer concrete or latex modified concrete.

Phase 2 installation of the superstructure would follow a similar path. Once the last half of the superstructure was installed, final demolition of the existing substructures would be completed.

8.4 COST ESTIMATES

Bridge 430171 over SR 1338 (White Oak Road) / Jonathan Creek	Construction Seasons	Cost
Alternate 1: 640-foot, three-span steel beam superstructure**	2	\$20.9 million
Alternate 2: 560-foot, three-span steel beam superstructure**	2	\$28.9 million
Alternate 3: 620-foot, five-span concrete beam superstructure**	2	\$22.5 million

Cost Estimate includes: removal of existing structure, approach slabs, cast-in-place reinforced concrete deck slab, superstructure girders, concrete barrier rail, HP piles & micropiles, reinforced concrete for end bents, wingwalls, and interior bents, temporary supports at existing bents, civil sitework, mobilization, and causeways.

Section 9 | Accelerated Bridge Construction (ABC)

Accelerated bridge construction techniques are an effective tool to help minimize traffic impacts and to keep construction progress moving forward. Many of the proposed alternates for these five (5) bridges noted the possibility of utilizing ABC methods to reduce the required construction time frame and minimize impacts to Interstate 40. Such methods include, but are not limited to:

- Advance construction of new substructures
- Advance foundation installation using micropiles
- Modular steel girder bridge units
- Precast beam and deck units
- Precast full-depth deck panels
- Precast substructure units

Construction of new bridge substructures in advance of superstructure replacements are an effective ABC tool that has been implemented on many projects. Constructing new end bents and interior bents between existing substructures allows traffic to remain open on the existing structure at the same time.

The use of modular steel girder bridge units or precast beam and deck units are efficient ways to construct bridge superstructures in a short amount of time. Where girders can be erected conventionally, precast full depth deck panels can significantly accelerate superstructure construction versus the time and labor intensive installation of a cast-in-place bridge deck. The use of precast units or deck panels requires the installation of a final overlay, such as PCC, to produce a final product with a satisfactory ride and corrosion resistance. Precast substructure units can be used to accelerate substructure construction and can provide a higher quality and more durable final product.

Many of the bridges on this project present mobilization and staging challenges due to terrain, bridge height and limited right-of-way. Once a contractor has been selected and included in the overall team, ideas such as girder launching, complex girder erection plans and other unique solutions can be considered to maximize design and cost efficiency as well as minimize overall impacts to the project area.

Bridge slides and roll-ins using self-propelled modular transports (SPMTs) can even further accelerate

Modular Unit Closure Pours



Complex Girder Erection



Large Cranes Install Superstructure Units



Section 9 | Accelerated Bridge Construction (ABC)

superstructure replacements. Slides and roll-ins allow for large sections of the superstructure to be built 'offline' and then moved into place, minimizing the length of impact to interstate traffic. These options were studied for each of the bridge locations. Bridge slides appeared to provide a low benefit given the curved geometry of some structures, high costs of temporary superstructure supports, and schedules being governed by the larger structure construction durations. Roll-ins of large superstructure units using SPMTs also appeared to provide a low benefit or little opportunity given the challenges of the terrain.

Advance Construction of New Substructures



Micropile Installation



Maximizing Construction Opportunities During Scheduled Closures



Beam Launching



Accelerated Demolition



Section 10 | Additional Design Considerations

While this study is focused mainly on the structure replacement costs and maintenance of traffic during construction, it is important to remember that there are many other components that should be considered as the project moves forward, such as: future maintenance, resurfacing and restriping, drainage design, ITS, autonomous vehicles, erosion control, new utilities, utility relocation, construction access, construction easements, inspection access, and wildlife related measures.

- Ease of future maintenance is a major consideration for the replacement of these bridges along I-40. All the existing structures have narrow shoulders, necessitating a lane closure when performing any sort of maintenance. It is important that the new structures have adequate shoulder widths to minimize the need for lane closures when performing routine maintenance. Additionally, because of the remote and challenging terrain and site constraints at some of these bridges, it is recommended that the structures are constructed durably and of high-quality materials to reduce maintenance costs. It is important to note that oftentimes the most cost-effective design or materials is not necessarily the cheapest, as future maintenance costs can far exceed any savings upfront. As such, the desire is for minimal maintenance for the first few years after construction is complete. The following steps should be taken to minimize maintenance:
 - » Design/construct all concrete decks using methods to reduce cracking.
 - » Ensure rideability standards when considering overlays. Latex overlays have been found to have better ride quality results. If PPC overlays are used, consideration should be given to including a rideability specification.
 - » If full-depth precast concrete deck panels are used, ensure the rideability with the PPC overlay is adequate. Partial-depth concrete deck panels should be avoided if possible.
 - » Consideration should be given to coating the substructure units with either a silane or epoxy coating.
- Due to construction activities and traffic control measures, a portion of I-40 will likely need to be milled and resurfaced to put forth a complete project. Lane closures and shifts in traffic often cause damage to the existing pavement surface or create potential confusion because of temporary striping changes. Resurfacing and restriping the project area reduces the chance of confusion and presents a more finished product to those traveling along I-40. Moving forward, the NCDOT will need to determine the extent of the resurfacing and whether each work zone is completed separately or if the entire corridor is repaved. Note that a portion of I-40 in this corridor was resurfaced during the summer of 2019.
- Drainage design is another factor that should be considered, especially during the various construction phases of the project. Typically, storm drainage is considered for the final product but not always evaluated in the interim stages of construction. As the existing bridges are removed and the new structures are built, designers will need to review the work zones to determine if there are any potential ponding issues. There are also likely to be special drainage design requirements for the proposed structures over the various watercourses in the project area. Special attention to these will be necessary to ensure adequate inclusion of drainage details in the construction plans.
- Intelligent Transportation Systems (ITS) are a growing sector of transportation projects. Particularly along a major interstate corridor such as I-40 through mountainous terrain subject to hazardous weather, rockslides, and other traffic, ITS plays an important role in alerting drivers traveling through the corridor of impending delays. Consideration should be given to the use of ITS and the future potential of autonomous vehicles through this well-traveled corridor.
- Construction access and erosion control will also play a vital role in the overall design of this project. As many of these structures are in remote areas with steep terrain, adequate access to complete the necessary work will be very important. Access roads may require additional vegetative clearing that would need to be replaced or

Section 10 | Additional Design Considerations

possibly extend beyond the existing right of way limits along I-40. If these access roads need to extend into the Pigeon River or other streams, special permitting may be required. Erosion control methods will also need to be completed in detail to ensure construction related activities do not encroach on the surrounding areas.

- As mentioned above, once construction methods are determined, it may be necessary to acquire construction easements outside of the existing right of way. These easements should be kept to the minimum wherever possible and agreements reached with the property owners to return the area, as close as possible, to its original state.
- Consideration should be given to the accommodation of future utilities through the corridor. As this stretch of I-40 is a major thoroughfare between North Carolina and Tennessee, it is reasonable to expect that future utilities will run along this corridor, and accommodation of those utilities across the proposed bridges should be considered. Utility relocation may also be required at many of these structures. Coordination with the utility owners on potential impacts is imperative to ensure minimal disruption in utility service as well as the development of adequate and cost-effective solutions.
- Since all these proposed bridges carry both eastbound and westbound traffic on a single structure, all the proposed bridges are relatively wide. For the bridges spanning high above waterways, particularly Bridges 430142 and 430171, inspection access needs to be a consideration. Underbridge access equipment such as snoopers can only reach a certain length from the edge of the bridge, so a series of catwalks or other bridge access facilities should be considered during design.
- It has been noted in this study that there are certain constraints, needs and desires for this project related to wildlife control. During the design process, NCDOT, the US Forest Service, US Fish & Wildlife, and the design team will need to discuss what measures need to be included as part of this project. The group will then need to determine the best way to implement those measures while still accomplishing the overall purpose and need of the project.

As discussed previously in the report, this portion of the I-40 corridor has limited alternative routes and is highly susceptible to natural events which can impact users of the interstate corridor. As recently as the rockslide events, which occurred in February and June of 2019, NCDOT is keenly aware of how vital the project corridor is to the whole of transportation between North Carolina and the surrounding states. As part of this study, user costs associated with work zone delays and a full closure of the roadway were developed.

Cost/Person-hour

To calculate the monetary value of time the methods employed in Chapter 2 of FHWA's publication "Work Zone Road User Costs – Concepts and Applications" were utilized. The methods were defensible and provided a straightforward approach to applying cost to user delay.

The hourly value of personal travel time per person was calculated by taking 50-percent of the median annual household income divided by 2,080 hours. To determine the median household income, the US Census Bureau's document "Household Income: 2016" authored by Gloria G. Guzman, was referenced. In this document, the median household income in the surrounding states (North Carolina, South Carolina, and Tennessee) was approximately \$50,000. This value was then adjusted for inflation (2% assumed) to ascertain the approximate 2019 value of \$53,000. Using this method, the monetary value of travel time related to person travel is equal to \$12.74/person-hr.

The hourly value of business travel was calculated by taking 100-percent of median hourly wages plus benefits. The median hourly value of a person's time was found by utilizing information from the Bureau of Labor Statistics. The total wages and benefits of all civilian workers reported in March 2019 from the Bureau of Labor Statistics (BLS) Employer Costs for Employee Compensation (ECEC) was \$36.77/person-hr.

Average Vehicle Occupancy (AVO) factors were then applied to complete the total monetary value of time. FHWA completed a study in April 2018 titled, "Average Vehicle Occupancy Factors for Computing Travel Time Reliability Measures and Total Peak Hour Excessive Delay Metrics". In this document, they concluded that for passenger vehicles, the AVO is equal to 1.7, and for truck traffic the AVO is equal to 1.0.

Work Zone Delay

This calculation assumes the bridges are phase constructed, which will result in traffic being reduced to one (1) travel lane in each direction. For purposes of this calculation the assumption is that all five (5) bridge locations are under construction at the same time. Based on these assumptions, the cumulative length of the work zone delay will be approximately 13.5 miles long.

To determine the delay within the work zone, the posted speed limit along this portion of I-40, which is 55mph for cars and 50mph for trucks, was used as the existing free flow speed. The existing free flow speed was then compared to a free flow speed of 35mph for the work zone. This value was selected by analyzing several factors regarding the corridor. First, the work zone speed limit will likely be posted at 45mph. The Highway Capacity Manual, Volume 2, Chapters 10 and 11 were then used to determine the demand flow rate under base conditions within the corridor. This manual also contained information regarding the capacity for a freeway in a work zone, which was listed as 1690 pc/ln/hr. This information was attributed to, "Capacity for North Carolina Freeway Work Zone", published in the Transportation Research Record 1529 by the Transportation Research Board. The actual flow rate of the corridor was derived using Equation 11-2, and was found to be 1685 pc/ln/hr. We utilized the following variables:

AADT: 28,000; K: 0.11; D:0.50

ET: 4.5; PT: 0.25

PHF: 0.88; Lanes: 2; fp: 0.975

The factor for heavy vehicle was calculated to be fHV: 0.533, using equation 11-3.

Based on our calculations, the flow rate of the corridor is very close to capacity and would likely impact the speed of vehicles as they merge into one lane. Also, the preliminary discussions regarding how construction would be accomplished has involved the possibility of utilizing ramps as thru-lanes. Said ramps have been designed for stop control conditions and could likely only accommodate a free-flow speed of 20mph.

Once all of the above factors were analyzed, the approximately delay and user cost was determined and is summarized in the table below. Additional calculations and cost details can be found in the appendix of this report.

Passenger Car Volume	Passenger Car Delay	Truck Volume	Truck Delay	Approx. User Cost per Day
21,000	0.14 hrs.	7,000	0.12 hrs.	\$93,600

Full Closure Delay

To accommodate a full closure, the preferred Interstate detour route in the area of Exit 7 through Exit 20 encompasses a route beginning near Dandridge, TN. This detour directs motorists to connect to I-81 then I-26 then I-240 and finally connect back to I-40 in Asheville, NC. The direct distance along I-40 from the interchange near Dandridge, TN, with I-81 and I-40 to the interchange in Asheville, NC with I-240 and I-40 is approximately 76.5 miles. The distance along the detour route to the same point is approximately 134 miles, a difference of 57.5 miles. Other, non-interstate detour routes were also considered, most notably US 25, but were not seen as viable alternatives. Therefore, they were disregarded during this phase of planning.

For planning purposes, sections of both corridors were reviewed, and the most frequently posted speed limit was chosen to calculate travel time within the corridors. The I-40 corridor was found to have a posted speed limit of 55mph for cars and 50mph for trucks within the project limits. The detour route was found to have a posted speed limit of 65mph for cars and 55mph for trucks at multiple locations along the route.

The AADT data for this segment of the I-40 corridor was provided by NCDOT, with a 2017 total of approximately 27,000 vehicles per day. The data identified that 30% of the traffic appears to be related to trucks. The traffic data included years 2002 to 2017 and the rate of change was calculated to be 1.70% per year. This data was extrapolated to year 2019 using the same rate of change which provides us with a total AADT of 28,000.

By utilizing this methodology, it was determined that a full closure of I-40 will result in an approximate delay of 40 minutes for a passenger car and 54 minutes for trucks, which has an impact to users approximately equal to \$540,000 per day.

Passenger Car Volume	Passenger Car Delay	Truck Volume	Truck Delay	Approx. User Cost per Day
21,000	0.67 hrs.	7,000	0.91 hrs.	\$540,000

While the difficulty of valuing user cost has been noted in many publications, the FHWA still considers this information valid for review when looking at a total cost analysis of the project. It is important to determine the impacts of the various alternates, methods of construction, and maintenance of traffic options to users of the corridor. Throughout this section we have identified delays due to lane and road closures and the reduction in posted speed limits as we view these as the primary impacts to motorists along this portion of I-40. As delays increase, the motorists time meant for other uses (commuting, vacationing, and commercial transportation) is reduced. This impact can lead to frustration and potentially unsafe conditions. Therefore, this data should be utilized to compare the available options as the project proceeds.

This study evaluated each of the five (5) bridges within the project limits, developed multiple alternates to replace each structure and selected a set of proposed options to move forward through for additional evaluation.

The proposed alternates selected to be carried forward will replace the existing structures, improve their reliability, and decrease maintenance costs over the upcoming years, accomplishing the purpose and need of this project. A summary of these alternates and the estimated costs is below:

Bridge 430057 over USFS Road / Cold Spring Creek	Construction Seasons	Cost
Alternate 1: 255-foot, two-span steel beam superstructure	1	\$7.1 million
Alternate 2: 210-foot, two-span steel beam superstructure	1	\$9.8 million
Alternate 3: 210-foot, two-span concrete beam superstructure	1	\$9.7 million
Bridge 430124 over SR 1338 (White Oak Road) at Fines Creek		Cost
Alternate 1: 76-foot, one-span concrete beam superstructure	2	\$4.9 million
Alternate 2: 43-foot, one-span concrete beam superstructure	2	\$4.4 million
Bridge 430142 over Pigeon River		Cost
Alternate 1: 304-foot, three-span concrete beam superstructure	2	\$21.1 million
Alternate 2: 347-foot, two-span steel beam superstructure	2	\$18 million
Alternate 3: 400-foot, two-span steel beam superstructure	2	\$13.4 million
Bridge 430159 over SR 1338 (White Oak Road)		Cost
Alternate 1: 78-foot, one-span concrete beam superstructure	2	\$5.4 million
Alternate 2: 47-foot, one-span concrete beam superstructure	2	\$4.9 million
Bridge 430171 over SR 1338 (White Oak Road) / Jonathan Creek		Cost
Alternate 1: 640-foot, three-span steel beam superstructure	2	\$20.9 million
Alternate 2: 560-foot, three-span steel beam superstructure	2	\$28.9 million
Alternate 3: 620-foot, five-span concrete beam superstructure	2	\$22.5 million

The costs above include items that are directly related to the construction of each structure, as well as storm drainage, construction access, guardrail replacement, underpass roadway work and erosion control. Additional costs can be expected due to maintenance of traffic and final construction details such as: milling and resurfacing I-40, replacing barrier rail removed for MoT and final pavement markings. These costs were evaluated, as discussed in Section 9 of this report, based on three (3) assumed Work Zones for the project. These estimated costs, per zone, are summarized in the table on the following page.

Work Zone 1: Bridge 430057	Cost
Maintenance of Traffic	\$1,180,000
Replacement of Median Barrier removed for MoT	\$750,000
Milling & Resurfacing	\$240,000
Pavement Markings	\$70,000
Total Work Zone Cost (Roadway)	\$2,240,000
Work Zone 2: Bridges 430124 & 430142	Cost
Maintenance of Traffic	\$1,620,000
Replacement of Median Barrier removed for MoT	\$1,030,000
Milling & Resurfacing	\$330,000
Pavement Markings	\$90,000
Total Work Zone Cost (Roadway)	\$3,070,000
Work Zone 3: Bridges 430159 & 430171	Cost
Maintenance of Traffic	\$1,910,000
Replacement of Median Barrier removed for MoT	\$1,220,000
Milling & Resurfacing	\$390,000
Pavement Markings	\$110,000
Total Work Zone Cost (Roadway)	\$3,630,000

To determine an estimated cost for the entire project, the lowest priced alternates were combined and then the highest priced alternates were combined. These combined totals provided a range of estimated project costs of **\$59,390,000 to \$78,820,000**.

As this project continues forward in the CMGC process, the following steps will need to occur:

- Approve/sign off on Technical Study
- Begin Preliminary Design (set alignments, grades, etc.)
- Finalize Environmental Analysis / NEPA
- Develop Scope & Constraints for Construction Manager (CM) Advertisement
- Advertise & Select CM
- Design Team Kickoff Meeting
- Select Independent Cost Estimator (ICE) – at 30% Plans
- Finalize Design Plans
- NCDOT and CM agree on Guaranteed Maximum Price (GMP)
- Award Contract and Begin Construction

While this study covered multiple alternates for each structure, it is important to note that additional discussion and coordination will be required throughout the design phase. The continuous exchange of information and ideas will allow this project to be designed and constructed efficiently and to encompass as many issues or concerns as possible. As mentioned previously in this report, this study is considered the first step in developing the project through the CMGC delivery method. This report is not intended to be the final answer for how the bridges will be replaced but rather a starting point to begin the design process once a contractor has been chosen by NCDOT.



Appendix

Cost Estimate Justification / Supporting Information
Span Configurations
Value Planning Session Supporting Information
Environmental Project Boundaries

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430057; Alternate 1; Configuration F
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	2
Total Bridge Length	255 FT
Out-to-Out Width	77.167 FT
Deck Area	19678 SF
Skew	76 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON PILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	36 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$533,000.00	\$533,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$53,000.00	\$106,000.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	19678	SF	\$48.00	\$944,524.08
STEEL PLATE GIRDERS	19678	SF	\$163.00	\$3,207,446.36
CONCRETE BARRIER RAIL	915	LF	\$140.00	\$128,100.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	1800	LF	\$60.00	\$108,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	105	CY	\$1,640.00	\$172,241.46
END BENT 2, CLASS A REINFORCED CONCRETE	105	CY	\$1,640.00	\$172,241.46
BENT 1, CLASS A REINFORCED CONCRETE	296	CY	\$1,640.00	\$485,151.19

Structure Cost/SF	\$298.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$300,000.00	\$300,000.00
MOBILIZATION	1	LS	\$590,000.00	\$590,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$200,000.00	\$200,000.00

Total Cost	\$7,100,000.00
Total Cost/SF	\$361.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430057; Alternate 2; Configuration G
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	2
Total Bridge Length	210 FT
Out-to-Out Width	77.167 FT
Deck Area	16205 SF
Skew	78 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON PILES & MICROPILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	42 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$533,000.00	\$533,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$53,000.00	\$106,000.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	16205	SF	\$48.00	\$777,843.36
STEEL PLATE GIRDERS	16205	SF	\$163.00	\$2,641,426.41
CONCRETE BARRIER RAIL	780	LF	\$140.00	\$109,200.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	900	LF	\$60.00	\$54,000.00
MICROPILES	9300	LF	\$200.00	\$1,860,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	104	CY	\$1,640.00	\$171,175.76
END BENT 2, CLASS A REINFORCED CONCRETE	711	CY	\$1,910.00	\$1,357,471.49
BENT 1, CLASS A REINFORCED CONCRETE	313	CY	\$1,640.00	\$512,852.74

Structure Cost/SF	\$502.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$410,000.00	\$410,000.00
MOBILIZATION	1	LS	\$820,000.00	\$820,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$200,000.00	\$200,000.00

Total Cost	\$9,710,000.00
Total Cost/SF	\$600.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430057; Alternate 3
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	2
Total Bridge Length	210 FT
Out-to-Out Width	83.667 FT
Deck Area	17570 SF
Skew	78 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON PILES & MICROPILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	42 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$533,000.00	\$533,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$53,000.00	\$106,000.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	17570	SF	\$48.00	\$843,363.36
CONCRETE I-BEAM OR BULB T	17570	SF	\$126.00	\$2,213,828.82
CONCRETE BARRIER RAIL	780	LF	\$140.00	\$109,200.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	950	LF	\$60.00	\$57,000.00
MICROPILES	9450	LF	\$200.00	\$1,890,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	111	CY	\$1,640.00	\$181,468.46
END BENT 2, CLASS A REINFORCED CONCRETE	742	CY	\$1,910.00	\$1,416,467.45
BENT 1, CLASS A REINFORCED CONCRETE	321	CY	\$1,640.00	\$526,172.70

Structure Cost/SF	\$449.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$400,000.00	\$400,000.00
MOBILIZATION	1	LS	\$790,000.00	\$790,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$400,000.00	\$400,000.00

Total Cost	\$9,620,000.00
Total Cost/SF	\$548.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430124; Alternate 1; Configuration D
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	1
Total Bridge Length	76 FT
Out-to-Out Width	79.583 FT
Deck Area	6048 SF
Skew	64 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG.
Interior Bent Type	N/A
Average Interior Bent Ht	N/A

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$248,000.00	\$248,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	6048	SF	\$50.00	\$302,415.40
CONCRETE I-BEAM OR BULB T	6048	SF	\$115.00	\$695,555.42
CONCRETE BARRIER RAIL	378	LF	\$150.00	\$56,700.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
END BENT 1, CLASS A REINFORCED CONCRETE	664	CY	\$2,035.00	\$1,351,919.33
END BENT 2, CLASS A REINFORCED CONCRETE	664	CY	\$2,035.00	\$1,351,919.33

Structure Cost/SF	\$681.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$210,000.00	\$210,000.00
MOBILIZATION	1	LS	\$420,000.00	\$420,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$145,000.00	\$145,000.00

Total Cost	\$4,895,000.00
Total Cost/SF	\$810.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430124; Alternate 2; Configuration E
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	1
Total Bridge Length	43 FT
Out-to-Out Width	79.583 FT
Deck Area	3422 SF
Skew	64 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG.
Interior Bent Type	N/A
Average Interior Bent Ht	N/A

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$248,000.00	\$248,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	3422	SF	\$50.00	\$171,103.45
CONCRETE I-BEAM OR BULB T	3422	SF	\$107.00	\$366,161.38
CONCRETE BARRIER RAIL	279	LF	\$150.00	\$41,850.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
END BENT 1, CLASS A REINFORCED CONCRETE	664	CY	\$2,035.00	\$1,351,919.33
END BENT 2, CLASS A REINFORCED CONCRETE	664	CY	\$2,035.00	\$1,351,919.33

Structure Cost/SF	\$1,065.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$190,000.00	\$190,000.00
MOBILIZATION	1	LS	\$370,000.00	\$370,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$145,000.00	\$145,000.00

Total Cost	\$4,355,000.00
Total Cost/SF	\$1,273.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430142; Alternate 1; Configuration A
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	3
Total Bridge Length	304 FT
Out-to-Out Width	81.08 FT
Deck Area	24648 SF
Skew	135 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG. & MICROPILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	50 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$1,428,000.00	\$1,428,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	24648	SF	\$50.00	\$1,232,416.00
CONCRETE I-BEAM OR BULB T	24648	SF	\$129.00	\$3,179,633.28
CONCRETE BARRIER RAIL	1062	LF	\$150.00	\$159,300.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
MICROPILES	11150	LF	\$200.00	\$2,230,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	2855	CY	\$2,035.00	\$5,809,896.78
END BENT 2, CLASS A REINFORCED CONCRETE	1003	CY	\$2,035.00	\$2,040,401.17
BENT 1, CLASS A REINFORCED CONCRETE	476	CY	\$1,705.00	\$811,481.23
BENT 2, CLASS A REINFORCED CONCRETE	476	CY	\$1,705.00	\$811,481.23

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3 & 4	4	LS	\$60,000.00	\$240,000.00

Structure Cost/SF	\$733.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$910,000.00	\$910,000.00
MOBILIZATION	1	LS	\$1,810,000.00	\$1,810,000.00
CAUSEWAYS	1	LS	\$300,000.00	\$300,000.00

Total Cost	\$21,080,000.00
Total Cost/SF	\$856.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430142; Alternate 2; Configuration D
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	2
Total Bridge Length	347 FT
Out-to-Out Width	81.08 FT
Deck Area	28135 SF
Skew	135 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON SPREAD FTG. & PILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	50 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$1,428,000.00	\$1,428,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	28135	SF	\$50.00	\$1,406,738.00
STEEL PLATE GIRDERS	28135	SF	\$169.00	\$4,754,774.44
CONCRETE BARRIER RAIL	1191	LF	\$150.00	\$178,650.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	1250	LF	\$70.00	\$87,500.00
END BENT 1, CLASS A REINFORCED CONCRETE	2976	CY	\$2,035.00	\$6,056,996.62
END BENT 2, CLASS A REINFORCED CONCRETE	159	CY	\$1,705.00	\$271,271.33
BENT 1, CLASS A REINFORCED CONCRETE	476	CY	\$1,705.00	\$811,481.23

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3 & 4	4	LS	\$60,000.00	\$240,000.00

Structure Cost/SF	\$546.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$770,000.00	\$770,000.00
MOBILIZATION	1	LS	\$1,540,000.00	\$1,540,000.00
CAUSEWAYS	1	LS	\$300,000.00	\$300,000.00

Total Cost	\$17,960,000.00
Total Cost/SF	\$639.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430142; Alternate 3; Configuration K
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	2
Total Bridge Length	400 FT
Out-to-Out Width	81.08 FT
Deck Area	32432 SF
Skew	135 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON PILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	56 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$1,428,000.00	\$1,428,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	32432	SF	\$50.00	\$1,621,600.00
STEEL PLATE GIRDERS	32432	SF	\$169.00	\$5,481,008.00
CONCRETE BARRIER RAIL	1350	LF	\$150.00	\$202,500.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	1900	LF	\$70.00	\$133,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	584	CY	\$1,705.00	\$995,168.25
END BENT 2, CLASS A REINFORCED CONCRETE	147	CY	\$1,705.00	\$251,439.65
BENT 1, CLASS A REINFORCED CONCRETE	508	CY	\$1,705.00	\$866,725.02

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3 & 4	4	LS	\$60,000.00	\$240,000.00

Structure Cost/SF	\$350.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$570,000.00	\$570,000.00
MOBILIZATION	1	LS	\$1,140,000.00	\$1,140,000.00
CAUSEWAYS	1	LS	\$300,000.00	\$300,000.00

Total Cost	\$13,340,000.00
Total Cost/SF	\$412.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430159; Alternate 1; Configuration D
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	1
Total Bridge Length	78 FT
Out-to-Out Width	79.583 FT
Deck Area	6207 SF
Skew	130 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG.
Interior Bent Type	N/A
Average Interior Bent Ht	N/A

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$258,000.00	\$258,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	6207	SF	\$50.00	\$310,373.70
CONCRETE I-BEAM OR BULB T	6207	SF	\$116.00	\$720,066.98
CONCRETE BARRIER RAIL	384	LF	\$150.00	\$57,600.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
END BENT 1, CLASS A REINFORCED CONCRETE	735	CY	\$2,035.00	\$1,495,563.90
END BENT 2, CLASS A REINFORCED CONCRETE	735	CY	\$2,035.00	\$1,495,563.90

Structure Cost/SF	\$717.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$230,000.00	\$230,000.00
MOBILIZATION	1	LS	\$450,000.00	\$450,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$225,000.00	\$225,000.00

Total Cost	\$5,355,000.00
Total Cost/SF	\$863.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430159; Alternate 2; Configuration E
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	1
Total Bridge Length	47 FT
Out-to-Out Width	79.583 FT
Deck Area	3740 SF
Skew	130 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG.
Interior Bent Type	N/A
Average Interior Bent Ht	N/A

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$258,000.00	\$258,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	3740	SF	\$50.00	\$187,020.05
CONCRETE I-BEAM OR BULB T	3740	SF	\$108.00	\$403,963.31
CONCRETE BARRIER RAIL	291	LF	\$150.00	\$43,650.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
END BENT 1, CLASS A REINFORCED CONCRETE	735	CY	\$2,035.00	\$1,495,563.90
END BENT 2, CLASS A REINFORCED CONCRETE	735	CY	\$2,035.00	\$1,495,563.90

Structure Cost/SF	\$1,068.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$200,000.00	\$200,000.00
MOBILIZATION	1	LS	\$400,000.00	\$400,000.00

Underpass Adjustment	Quantities	Unit	Unit Cost	Total Cost
ADJUST GRADE OF UNDERPASS	1	LS	\$225,000.00	\$225,000.00

Total Cost	\$4,825,000.00
Total Cost/SF	\$1,290.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430171; Alternate 1; Configuration H
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	3
Total Bridge Length	640 FT
Out-to-Out Width	81.08 FT
Deck Area	51891 SF
Skew	90 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON SPREAD FTG. & PILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	90 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$2,364,000.00	\$2,364,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	51891	SF	\$50.00	\$2,594,560.00
STEEL PLATE GIRDERS	51891	SF	\$169.00	\$8,769,612.80
CONCRETE BARRIER RAIL	2070	LF	\$150.00	\$310,500.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	1440	LF	\$70.00	\$100,800.00
END BENT 1, CLASS A REINFORCED CONCRETE	178	CY	\$1,705.00	\$304,279.67
END BENT 2, CLASS A REINFORCED CONCRETE	111	CY	\$1,705.00	\$188,801.91
BENT 1, CLASS A REINFORCED CONCRETE	859	CY	\$1,705.00	\$1,464,442.41
BENT 2, CLASS A REINFORCED CONCRETE	859	CY	\$1,705.00	\$1,464,442.41

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3,4 &5	5	LS	\$60,000.00	\$300,000.00

Structure Cost/SF	\$347.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$900,000.00	\$900,000.00
MOBILIZATION	1	LS	\$1,800,000.00	\$1,800,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Total Cost	\$20,830,000.00
Total Cost/SF	\$402.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430171; Alternate 2; Configuration K
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	3
Total Bridge Length	560 FT
Out-to-Out Width	81.08 FT
Deck Area	45405 SF
Skew	90 DEG
Superstructure Type	STEEL PLATE GIRDERS
End Bent Type	RC CAP ON SPREAD FTG. & MICROPILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	90 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$2,364,000.00	\$2,364,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	45405	SF	\$50.00	\$2,270,240.00
STEEL PLATE GIRDERS	45405	SF	\$169.00	\$7,673,411.20
CONCRETE BARRIER RAIL	1830	LF	\$150.00	\$274,500.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	0	LF	\$70.00	\$0.00
MICROPILES	22240	LF	\$200.00	\$4,448,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	624	CY	\$2,035.00	\$1,270,666.06
END BENT 2, CLASS A REINFORCED CONCRETE	1620	CY	\$2,035.00	\$3,296,840.19
BENT 1, CLASS A REINFORCED CONCRETE	859	CY	\$1,705.00	\$1,464,442.41
BENT 2, CLASS A REINFORCED CONCRETE	859	CY	\$1,705.00	\$1,464,442.41

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3,4 & 5	5	LS	\$60,000.00	\$300,000.00

Structure Cost/SF	\$550.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$1,250,000.00	\$1,250,000.00
MOBILIZATION	1	LS	\$2,500,000.00	\$2,500,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Total Cost	\$28,840,000.00
Total Cost/SF	\$636.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
BR430171; Alternate 3; Configuration J
August 07, 2019

COST ESTIMATE

Proposed Bridge Configuration

No. Spans	5
Total Bridge Length	620 FT
Out-to-Out Width	81.08 FT
Deck Area	50270 SF
Skew	90 DEG
Superstructure Type	CONCRETE I-BEAM OR BULB T
End Bent Type	RC CAP ON SPREAD FTG. & PILES
Interior Bent Type	RC MULTI-COLUMN PIER ON SPREAD FTG.
Average Interior Bent Ht	78.75 FT

Existing Structure	Quantities	Unit	Unit Cost	Total Cost
REMOVAL OF EXISTING STRUCTURE	1	LS	\$2,364,000.00	\$2,364,000.00

Approach Slab	Quantities	Unit	Unit Cost	Total Cost
BRG APPR SLAB	2	LS	\$55,120.00	\$110,240.00

Superstructure	Quantities	Unit	Unit Cost	Total Cost
REINF CONCRETE DECK SLAB	50270	SF	\$50.00	\$2,513,480.00
CONCRETE I-BEAM OR BULB T	50270	SF	\$140.00	\$7,037,744.00
CONCRETE BARRIER RAIL	2010	LF	\$150.00	\$301,500.00

Substructure	Quantities	Unit	Unit Cost	Total Cost
HP PILES	2640	LF	\$70.00	\$184,800.00
DRILLED PIERS IN SOIL	280	LF	\$3,300.00	\$924,000.00
END BENT 1, CLASS A REINFORCED CONCRETE	175	CY	\$1,705.00	\$298,333.32
END BENT 2, CLASS A REINFORCED CONCRETE	107	CY	\$1,705.00	\$182,855.57
BENT 1, CLASS A REINFORCED CONCRETE	610	CY	\$1,705.00	\$1,040,574.04
BENT 2, CLASS A REINFORCED CONCRETE	948	CY	\$1,705.00	\$1,615,993.69
BENT 3, CLASS A REINFORCED CONCRETE	1015	CY	\$1,705.00	\$1,730,712.00
BENT 4, CLASS A REINFORCED CONCRETE	441	CY	\$1,705.00	\$752,353.26

Temporary Support	Quantities	Unit	Unit Cost	Total Cost
CONSTRUCTION, MAINTENANCE, & REMOVAL OF TEMP STRUCTURE AT BENTS 1,2,3,4 & 5	5	LS	\$60,000.00	\$300,000.00

Structure Cost/SF	\$386.00
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Sitework	Quantities	Unit	Unit Cost	Total Cost
CIVIL SITE WORK	1	LS	\$970,000.00	\$970,000.00
MOBILIZATION	1	LS	\$1,940,000.00	\$1,940,000.00
CAUSEWAYS	1	LS	\$150,000.00	\$150,000.00

Total Cost	\$22,420,000.00
Total Cost/SF	\$446.00

COST ESTIMATE

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
Workzone 1
July 11, 2019

Work Zone 1

Maintenance of Traffic	Quantities	Unit	Unit Cost	Total Cost
PORTABLE SAFE WORK ZONE	1	EA	\$100,000.00	\$125,000.00
REMOVE MEDIAN BARRIER RAIL	4,092	LFT	\$25.00	\$102,300.00
WORK ZONE ADV/GEN WARN SIGN	480	SFT	\$13.27	\$6,369.60
FLASHING ARROW BOARD	12	EA	\$2,475.68	\$29,708.16
PORTABLE CHANGE MSG SIGN	3	EA	\$7,648.63	\$22,945.89
DRUMS	508	EA	\$53.85	\$27,328.88
BARRICADES (TYPE III)	108	LFT	\$29.95	\$3,234.60
TEMP CRASH CUSHIONS	3	EA	\$4,946.70	\$14,840.10
PORT CONC BARRIER	16,368	LFT	\$31.85	\$521,320.80
LAW ENFORCEMENT	780	H	\$50.54	\$39,421.20
PAINT PVMT MARKINGS 8"	8,448	LFT	\$1.32	\$11,151.36
			CONTINGENCY (30%) =	\$272,000.00
			TOTAL =	\$1,180,000.00

Pavement Markings	Quantities	Unit	Unit Cost	Total Cost
THERMO PVT MKG LINES 8" 90MILS	19,008	LFT	\$2.24	\$42,577.92
			CONTINGENCY (50%) =	\$25,000.00
			TOTAL =	\$70,000.00

Milling & Resurfacing	Quantities	Unit	Unit Cost	Total Cost
MILL ASP PVMT (1.5")	25,344	SYD	\$2.85	\$72,230.40
MILLED RUMBLE STRIPS	6,336	LFT	\$0.13	\$823.68
ASP CONC SURF CRS S9.5B	2,100	TON	\$77.47	\$162,687.00
			TOTAL =	\$240,000.00

Replacement of Median Barrier removed for MoT	Quantities	Unit	Unit Cost	Total Cost
VERT CONC BARRIER RAIL	4,092	LFT	\$182.00	\$744,744.00
			TOTAL =	\$750,000.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
Workzone 2
July 11, 2019

COST ESTIMATE

Work Zone 2

Maintenance of Traffic	Quantities	Unit	Unit Cost	Total Cost
PORTABLE SAFE WORK ZONE	2	EA	\$100,000.00	\$171,875.00
REMOVE MEDIAN BARRIER RAIL	5,627	LFT	\$25.00	\$140,662.50
WORK ZONE ADV/GEN WARN SIGN	660	SFT	\$13.27	\$8,758.20
FLASHING ARROW BOARD	17	EA	\$2,475.68	\$40,848.72
PORTABLE CHANGE MSG SIGN	4	EA	\$7,648.63	\$31,550.60
DRUMS	698	EA	\$53.85	\$37,577.20
BARRICADES (TYPE III)	149	LFT	\$29.95	\$4,447.58
TEMP CRASH CUSHIONS	4	EA	\$4,946.70	\$20,405.14
PORT CONC BARRIER	22,506	LFT	\$31.85	\$716,816.10
LAW ENFORCEMENT	1,073	H	\$50.54	\$54,204.15
PAINT PVMT MARKINGS 8"	11,616	LFT	\$1.32	\$15,333.12
			CONTINGENCY (30%) =	\$373,000.00
			TOTAL =	\$1,620,000.00

Pavement Markings	Quantities	Unit	Unit Cost	Total Cost
THERMO PVT MKG LINES 8" 90MILS	26,136	LFT	\$2.24	\$58,544.64
			CONTINGENCY (50%) =	\$30,000.00
			TOTAL =	\$90,000.00

Milling & Resurfacing	Quantities	Unit	Unit Cost	Total Cost
MILL ASP PVMT (1.5")	34,848	SYD	\$2.85	\$99,316.80
MILLED RUMBLE STRIPS	8,712	LFT	\$0.13	\$1,132.56
ASP CONC SURF CRS S9.5B	2,888	TON	\$77.47	\$223,694.63
			TOTAL =	\$330,000.00

Replacement of Median Barrier removed for MoT	Quantities	Unit	Unit Cost	Total Cost
VERT CONC BARRIER RAIL	5,627	LFT	\$182.00	\$1,024,023.00
			TOTAL =	\$1,030,000.00

I-40 CMGC Project-5 Bridge Replacements
Haywood County, Division 14
Workzone 3
July 11, 2019

COST ESTIMATE

Work Zone 3

Maintenance of Traffic	Quantities	Unit	Unit Cost	Total Cost
PORTABLE SAFE WORK ZONE	2	EA	\$100,000.00	\$203,125.00
REMOVE MEDIAN BARRIER RAIL	6,650	LFT	\$25.00	\$166,237.50
WORK ZONE ADV/GEN WARN SIGN	780	SFT	\$13.27	\$10,350.60
FLASHING ARROW BOARD	20	EA	\$2,475.68	\$48,275.76
PORTABLE CHANGE MSG SIGN	5	EA	\$7,648.63	\$37,287.07
DRUMS	825	EA	\$53.85	\$44,409.42
BARRICADES (TYPE III)	176	LFT	\$29.95	\$5,256.23
TEMP CRASH CUSHIONS	5	EA	\$4,946.70	\$24,115.16
PORT CONC BARRIER	26,598	LFT	\$31.85	\$847,146.30
LAW ENFORCEMENT	1,268	H	\$50.54	\$64,059.45
PAINT PVMT MARKINGS 8"	13,728	LFT	\$1.32	\$18,120.96
			CONTINGENCY (30%) =	\$441,000.00
			TOTAL =	\$1,910,000.00

Pavement Markings	Quantities	Unit	Unit Cost	Total Cost
THERMO PVT MKG LINES 8" 90MILS	30,888	LFT	\$2.24	\$69,189.12
			CONTINGENCY (50%) =	\$35,000.00
			TOTAL =	\$110,000.00

Milling & Resurfacing	Quantities	Unit	Unit Cost	Total Cost
MILL ASP PVMT (1.5")	41,184	SYD	\$2.85	\$117,374.40
MILLED RUMBLE STRIPS	10,296	LFT	\$0.13	\$1,338.48
ASP CONC SURF CRS S9.5B	3,413	TON	\$77.47	\$264,366.38
			TOTAL =	\$390,000.00

Replacement of Median Barrier removed for MoT	Quantities	Unit	Unit Cost	Total Cost
VERT CONC BARRIER RAIL	6,650	LFT	\$182.00	\$1,210,209.00
			TOTAL =	\$1,220,000.00

Work Zone User cost calculations

7/11/2019

One lane closure cost calculation procedure

	Passenger Car (75%)	Truck (25%)
Cost per hour:	\$12.74	\$36.77
Length of Work zone in miles:	13.5	13.5
Free flow speed in mph:	55	50
Work zone speed in mph:	35	35
Average AADT of full section:	21000	7000
Duration of Partial Closure in days	1	1
Calculated values:		
Travel time in free flow (secs):	884	972
Travel Time in work zone (secs):	1389	1389
Delay (secs):	505	417
Delay (hours):	0.14025974	0.115714286
Cost per Vehicle:	\$1.787	\$4.255
[1]Cost per day per Road User per work zone:	\$63,792.65	\$29,783.70
Total Cost for closure duration:	\$63,792.65	\$29,783.70
Total Cost for all vehicles:	\$93,576.35	
Total Cost per day	\$93,600.00	

[1] Assumes 1.7 persons per passenger car and 1.0 persons per truck.

Work Zone User Cost Calculations

7/11/2019

I-40 Closure Detour [2]

Detour cost calculation procedure

	Passenger Car (75%)	Truck (25%)
Cost per hour:	\$12.74	\$36.77
Length of Non-Detoured Traffic miles:	76.5	76.5
Length of Detour in miles:	134	134
Free flow speed in mph:	55	50
Detour zone speed in mph:	65	55
Average AADT of full section:	21000	7000
Duration of Closure in days	1.000	1.000
Calculated values:		
Travel time in free flow (secs):	5007	5508
Travel Time in detour (secs):	7422	8771
Delay (secs):	2414	3263
Delay (hours):	0.6706	0.9064
Cost per Vehicle:	\$8.54	\$33.33
[1]Cost per day per Road User per closure:	\$305,014.31	\$233,288.94
Total Cost for closure duration:	\$305,014.31	\$233,288.94
Total Cost for all vehicles:	\$538,303.25	
Total Cost per day	\$540,000.00	

[1] Assumes 1.7 persons per passenger car and 1.0 persons per truck.

[2] Assumes a detour route beginning in Dandridge, TN of I-40 to I-81 to I-26 to I-240 back to I-40 in Asheville, NC.

TO: Josh Deyton, P.E. and NCDOT Project Staff

FROM: Greg Stewart, P.E; Sammie McCoy, P.E; Jake Williams, P.E.

Project: WBS 44593.11 / Benesch Project 17000306.00
I-40 CMGC Project -5 Bridge Replacements – Haywood County (Division 14)

SUBJECT: Span Configuration Rating Memorandum
Bridge 430057 over USFS Road / Cold Spring Creek

DATE: 6-17-2019

The information below is a summary of span configurations developed prior to, during and following the Value Planning Session conducted on June 4th and 5th at the Division 14 Office. These options were developed to capture various ideas, site condition accommodations, and compatibility with Constraints, Needs, and Desires developed during the session.

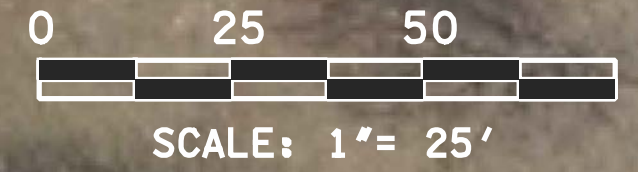
The baseline replacement in the report will be developed to fit within a 5 month I-40 disruption window where traffic can be reduced to one lane in each direction. Two lanes would be maintained in each direction between May and November with exact date ranges to be determined. Unique to Bridge 430057 the remote area and ability to detour traffic down the existing ramps will provide the opportunity to explore an accelerated replacement that can occur in a much shorter timeframe. Advance work and Accelerated Bridge Construction techniques are considered to meet project schedule goals. Alternative construction efforts may be applied where schedule adjustments can be allowed or where needed.

The information below will be used to further develop the Technical Study for this project and is offered for review and comment.

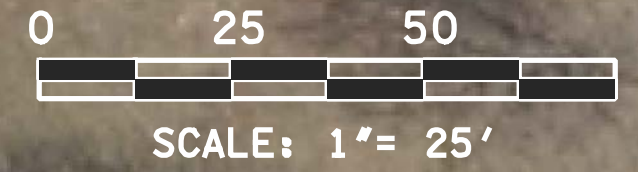
- Span Configuration A
 - o Three Span: $118+82+55=255'$
 - o New end bents behind existing end bents in approaches constructed either during staged construction or during short term I-40 closure with traffic diverted to ramps
 - o New bent constructed in advance between existing Bent 2 and Cold Springs Creek
 - o Reuse Bent 3 - work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bent
- Span Configuration B
 - o Four Span: $69+66+65+55=255'$
 - o New end bents behind existing end bents in approaches constructed either during staged construction or during short term I-40 closure with traffic diverted to ramps
 - o Reuse Bents 1, 2, & 3 – work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bents

- Span Configuration C
 - o Two Span: $80+60=140'$
 - o New western end bent constructed in advance close behind existing bent 1
 - o New middle bent constructed in advance between existing bent 2 and roadway
 - o New eastern end bent constructed in advance under eastern span 4 adjacent to existing bent 3
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Anticipated low acceptance by Forest Service
 - Concerns regarding western end bent construction
- Span Configuration D
 - o Two Span: $60+80=140'$
 - o New western end bent constructed in advance close behind existing bent 1
 - o New middle bent constructed in advance between existing bent 2 and Cold Springs Creek
 - o New eastern end bent constructed in advance under eastern span 4 adjacent to existing bent 3
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Anticipated low acceptance by Forest Service
 - Concerns regarding western end bent construction
- Span Configuration E
 - o Two Span: $105+105=210'$
 - o New western end bent constructed in advance in front of existing western end bent
 - o New eastern end bent constructed in advance under span 4 (mid span)
 - o New bent constructed in advance between existing Bent 2 and Cold Springs Creek
 - o Steel girders with similar or slightly less depth than existing girders
 - o Propose to **reject** for the following reasons:
 - Concerns regarding western end bent construction
- Span Configuration F
 - o Two Span: $124+131=255'$
 - o New end bents behind existing end bents in approaches constructed either during staged construction or during short term I-40 closure with traffic diverted to ramps
 - o New bent constructed in advance between existing Bent 2 and Cold Springs Creek
 - o Steel girders with similar depth as existing girders
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Anticipated acceptance by Forest Service
 - Efficient end bent for staged construction or closure
 - Maintains existing vertical clearance with opportunity to improve by lowering roadway
- Span Configuration G
 - o Two Span: $105+105=210'$
 - o New western end bent behind existing end bent in approach constructed either during staged construction or during short term I-40 closure with traffic diverted to ramps
 - o New eastern end bent constructed in advance under span 4 (mid span)
 - o New bent constructed in advance between existing Bent 2 and Cold Springs Creek
 - o Steel girders with same or less depth as existing girders
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Anticipated acceptance by Forest Service
 - Efficient western end bent for staged construction or closure
 - Efficient eastern end bent construction in advance allows shortening of bridge and opportunity to reduce span/girder depth.
 - Maintains existing vertical clearance with opportunity to improve by lowering roadway and/or reduction in girder depth

BRIDGE 057
SPAN CONFIG. A

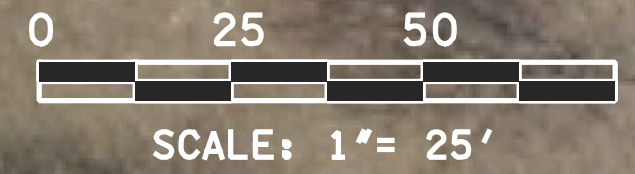


BRIDGE 057
SPAN CONFIG. B

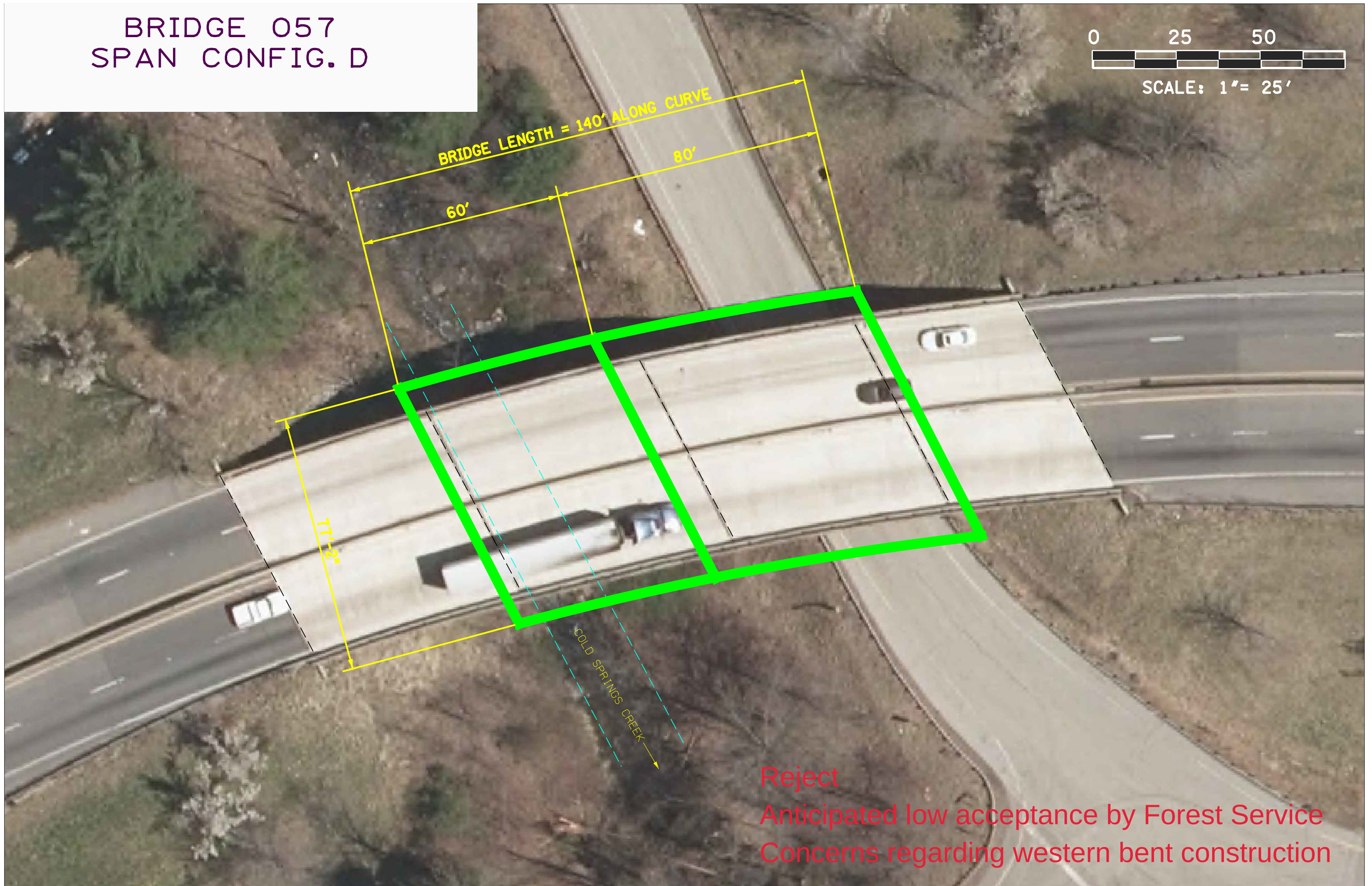
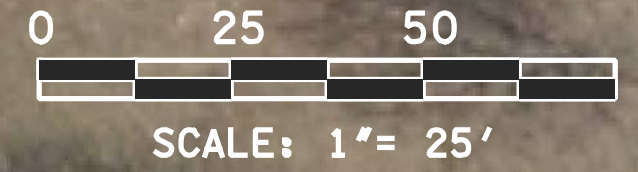


Reject
Reuse of Bent

BRIDGE 057
SPAN CONFIG. C

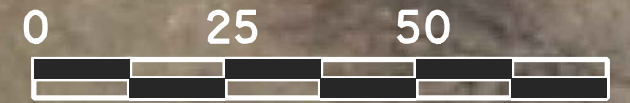


BRIDGE 057 SPAN CONFIG. D

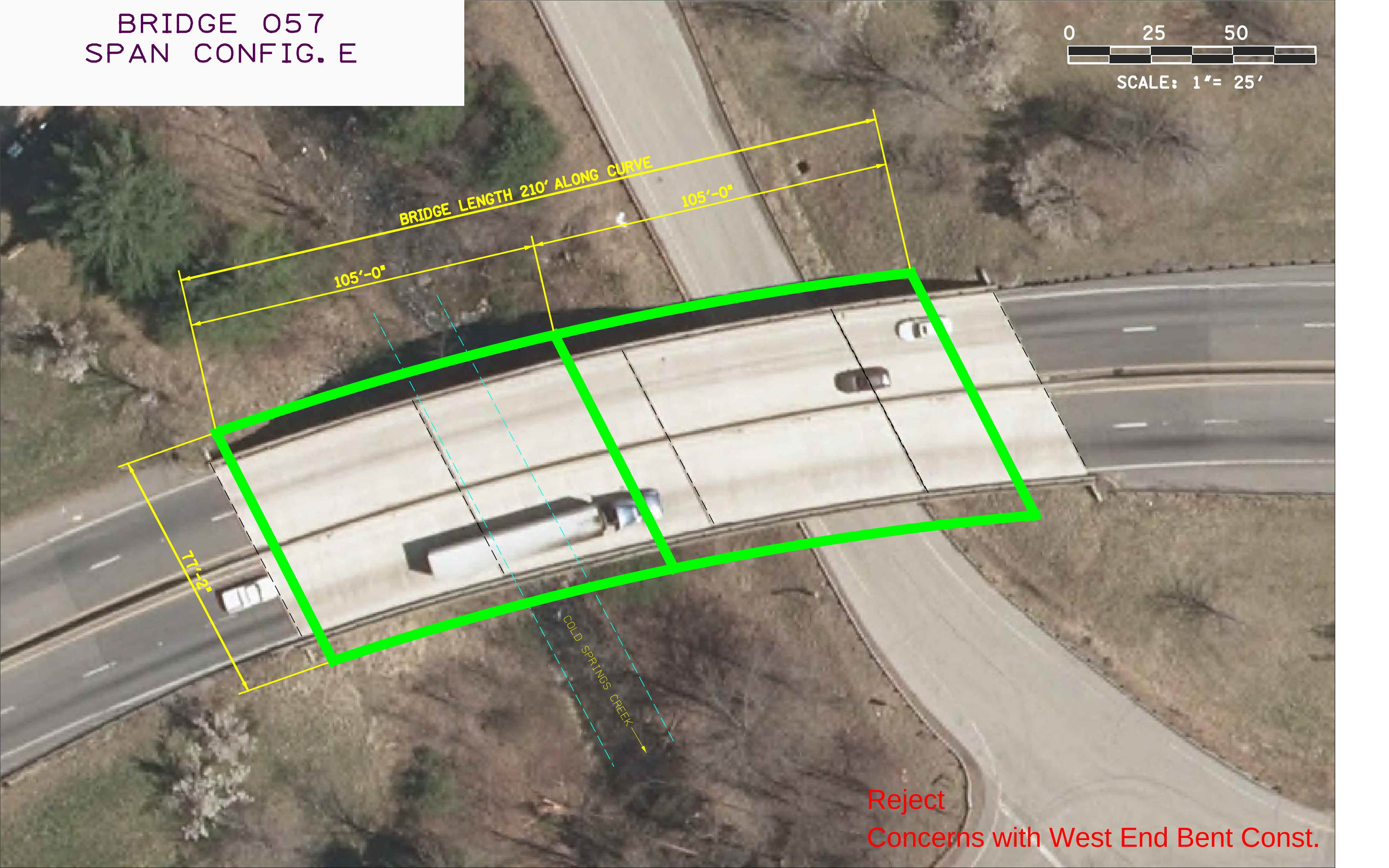


Reject
Anticipated low acceptance by Forest Service
Concerns regarding western bent construction

BRIDGE 057
SPAN CONFIG. E

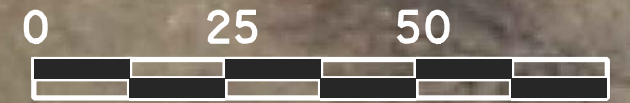


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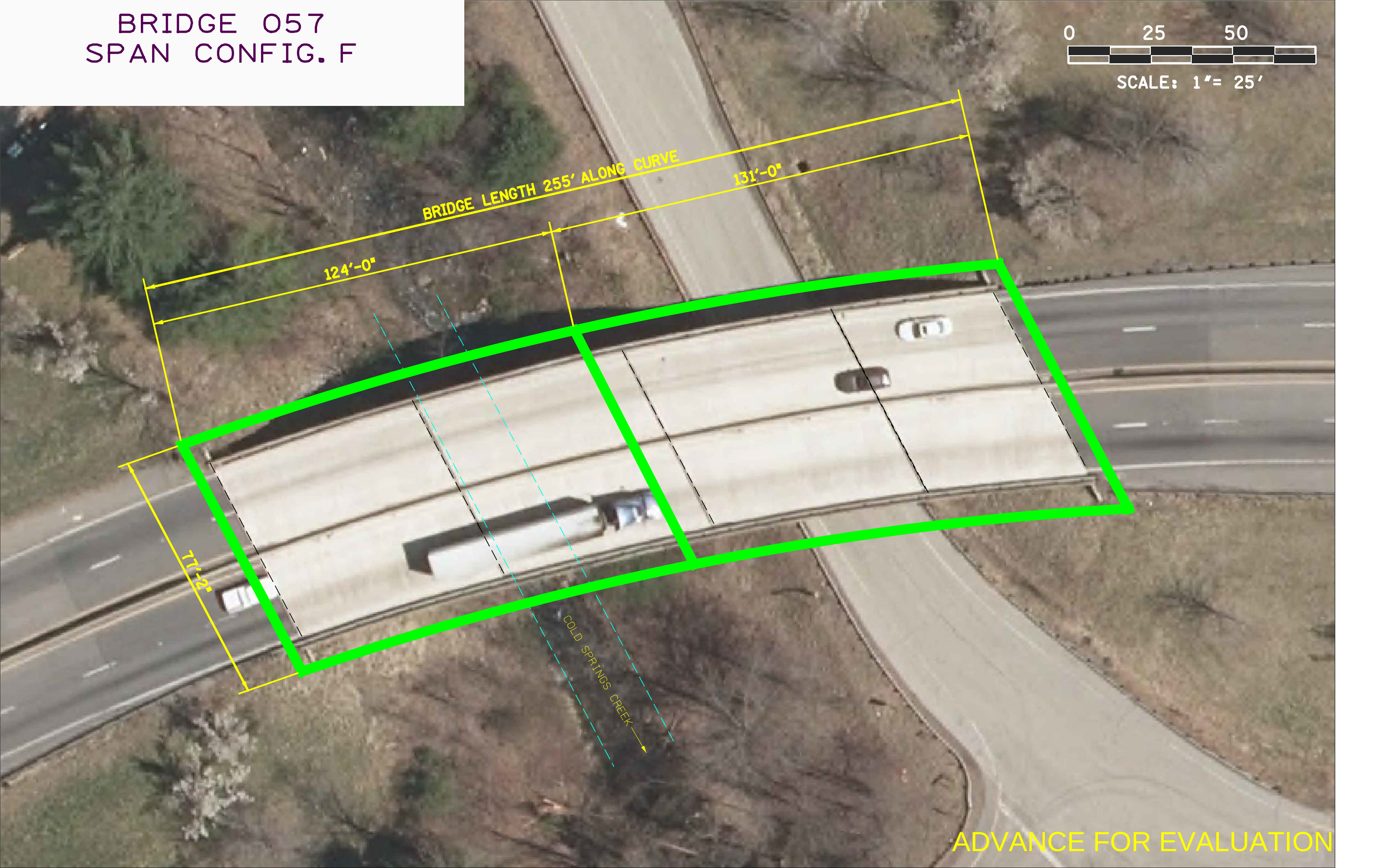


Reject
Concerns with West End Bent Const.

BRIDGE 057
SPAN CONFIG. F

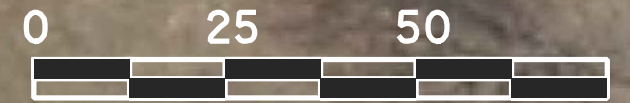


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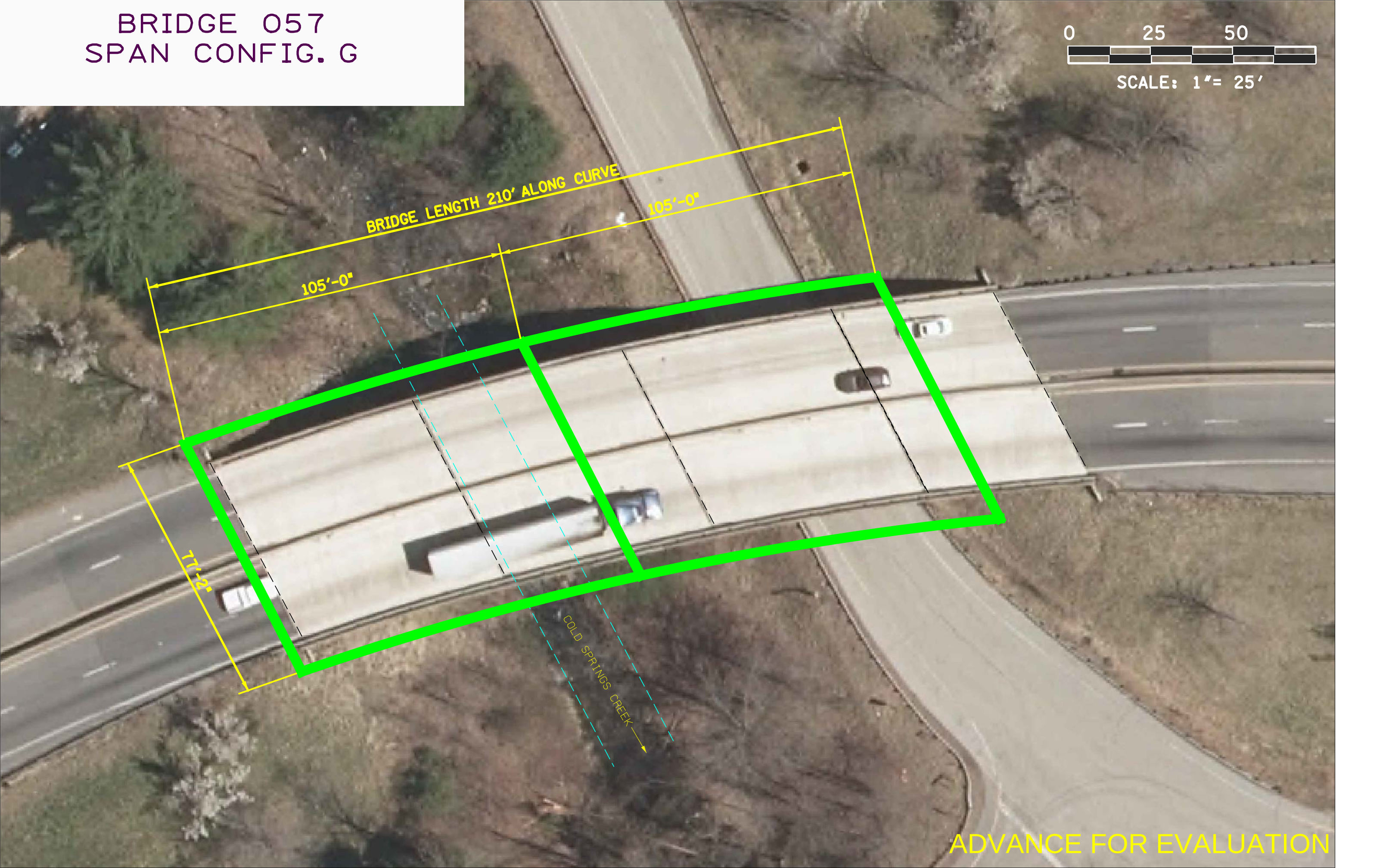


ADVANCE FOR EVALUATION

BRIDGE 057
SPAN CONFIG. G



SCALE: 1" = 25'



ADVANCE FOR EVALUATION

TO: Josh Deyton, P.E. and NCDOT Project Staff
FROM: Greg Stewart, P.E; Sammie McCoy, P.E; Jake Williams, P.E.
Project: WBS 44593.11 / Benesch Project 17000306.00
I-40 CMGC Project -5 Bridge Replacements – Haywood County (Division 14)
SUBJECT: Span Configuration Rating Memorandum
Bridge 430124 over SR1338 (White Oak Road) at Fines Creek
DATE: 6-17-2019

The information below is a summary of span configurations developed prior to, during and following the Value Planning Session conducted on June 4th and 5th at the Division 14 Office. These options were developed to capture various ideas, site condition accommodations, and compatibility with Constraints, Needs, and Desires developed during the session.

These bridge replacements are intended to fit within a 5 month I-40 disruption window where traffic can be reduced to one lane in each direction. Two lanes would be maintained in each direction between May and November with exact date ranges to be determined. Advance work and Accelerated Bridge Construction techniques are considered to meet project schedule goals. Alternative construction efforts may be applied where schedule adjustments can be allowed or where needed.

The information below will be used to further develop the Technical Study for this project and is offered for review and comment.

- Span Configuration A
 - o Three Span: 56+53+64=173'
 - o New end bents behind existing end bents in approaches constructed either during staged construction or during short term I-40 closure with traffic diverted to ramps
 - o Reuse Bents 1 & 2 - work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bent
- Span Configuration B
 - o One Span: 53'
 - o Reuse Bents 1 & 2 with earth retention improvement- work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bents
- Span Configuration C
 - o One Span: 65'
 - o New end bents behind existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - New end bents may conflict with existing bents due to proximity

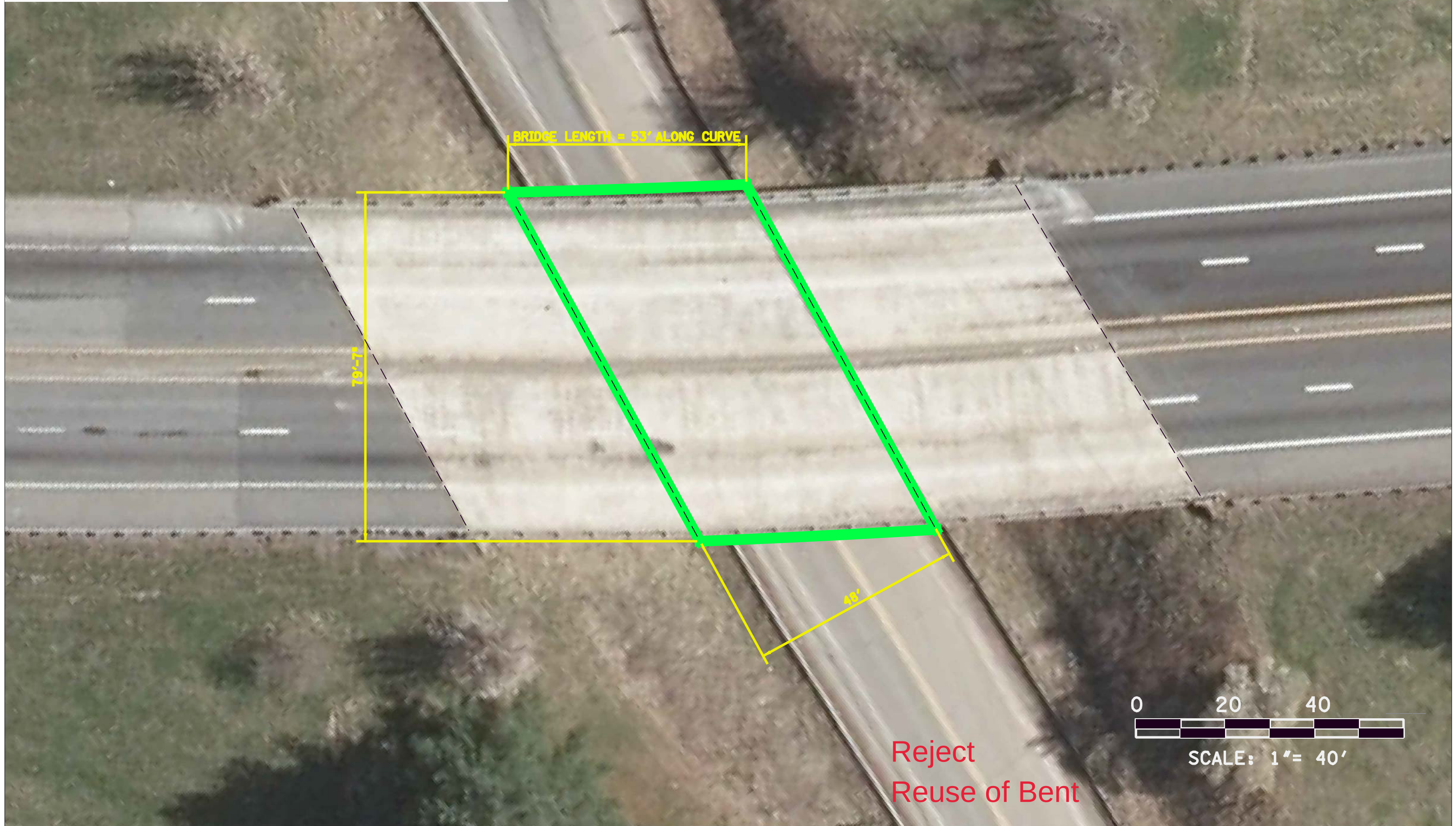
- Span Configuration D
 - o One Span: 76'
 - o New end bents behind existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Accommodates staged part width construction
 - Provides 68' horizontal clearance for roadway below
 - Provides opportunity to improve vertical clearance by lowering road or reduced steel girder depth

- Span Configuration E
 - o One Span: 43'
 - o New end bents in front of existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Could be post tensioned slab with reduced depth
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Accommodates staged part width construction
 - Provides shortest bridge with 38' horizontal clearance for roadway below
 - Provides opportunity to improve vertical clearance by lowering road or reduced superstructure depth

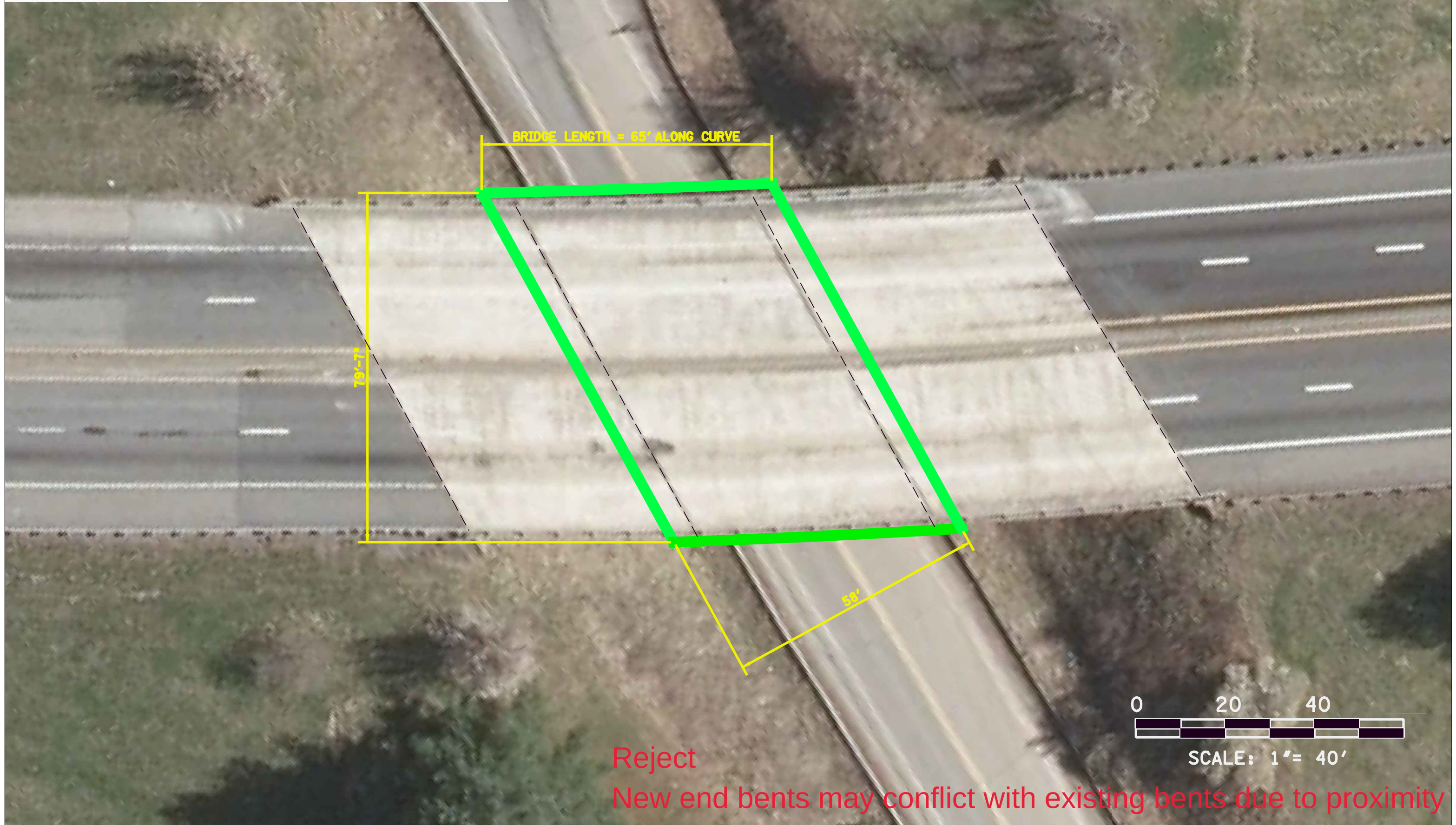
BRIDGE 124 SPAN CONFIG. A



BRIDGE 124
SPAN CONFIG. B



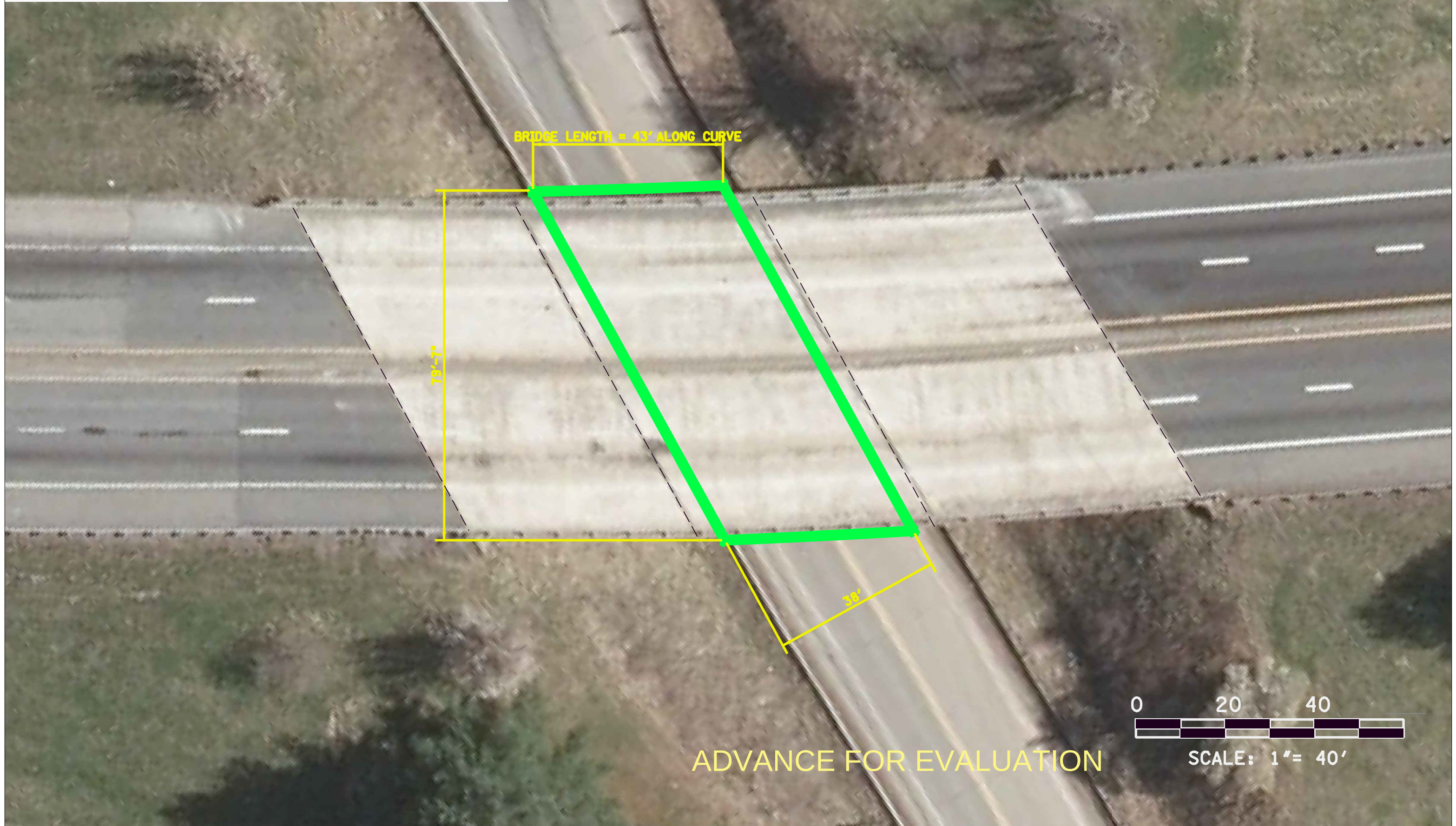
BRIDGE 124 SPAN CONFIG. C



BRIDGE 124
SPAN CONFIG. D



BRIDGE 124
SPAN CONFIG. E



TO: Josh Deyton, P.E. and NCDOT Project Staff
FROM: Greg Stewart, P.E; Sammie McCoy, P.E; Jake Williams, P.E.
Project: WBS 44593.11 / Benesch Project 17000306.00
I-40 CMGC Project -5 Bridge Replacements – Haywood County (Division 14)
SUBJECT: Span Configuration Rating Memorandum
Bridge 430142 over Pigeon River
DATE: 6-17-2019

The information below is a summary of span configurations developed prior to, during and following the Value Planning Session conducted on June 4th and 5th at the Division 14 Office. These options were developed to capture various ideas, site condition accommodations, and compatibility with Constraints, Needs, and Desires developed during the session.

These bridge replacements are intended to fit within a 5 month I-40 disruption window where traffic can be reduced to one lane in each direction. Two lanes would be maintained in each direction between May and November with exact date ranges to be determined. Advance work and Accelerated Bridge Construction techniques are considered to meet project schedule goals. Alternative construction efforts may be applied where schedule adjustments can be allowed or where needed.

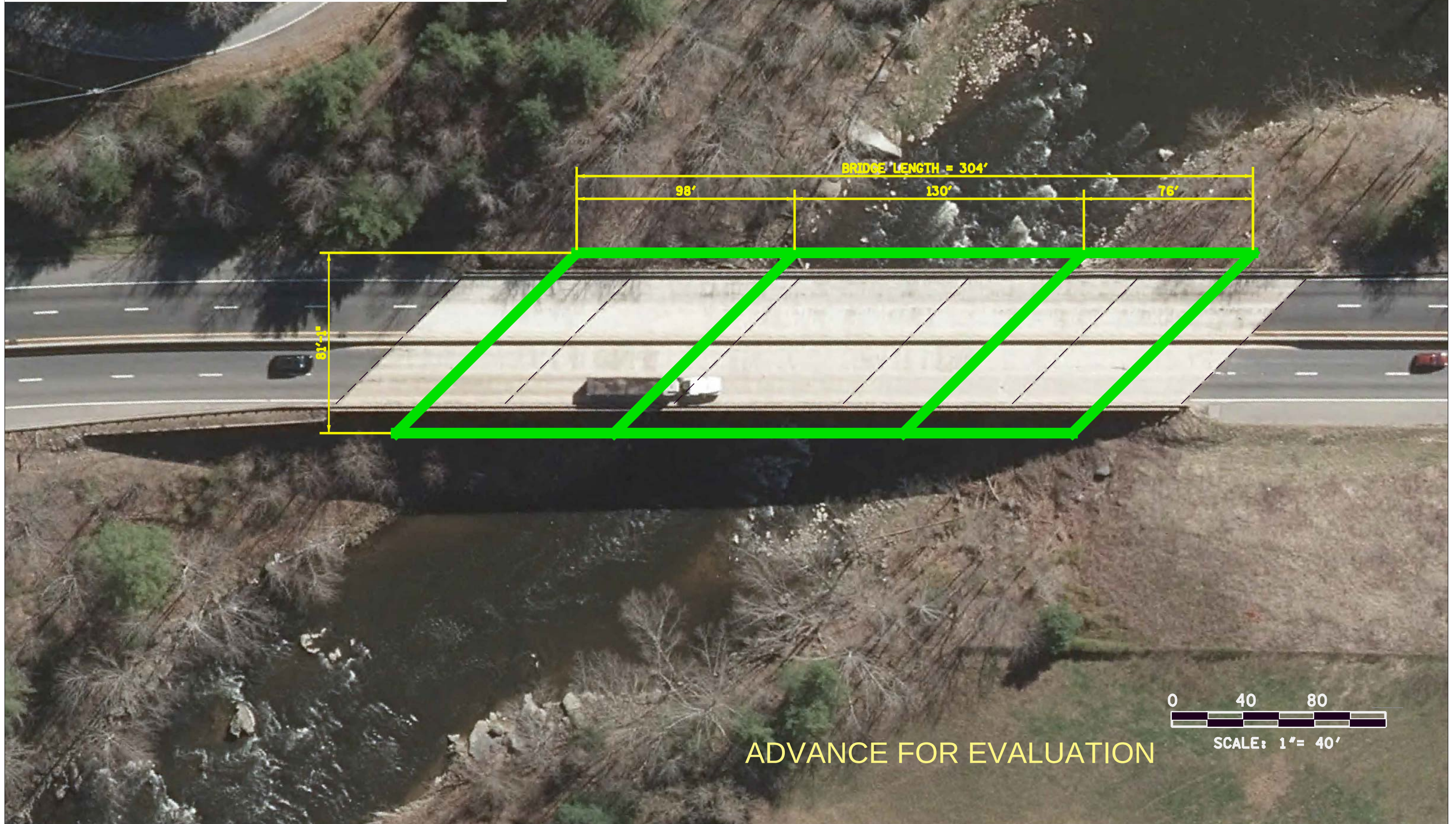
The information below will be used to further develop the Technical Study for this project and is offered for review and comment.

- Span Configuration A
 - o Three Span: $98+130+76=304'$
 - o New end bents constructed in advance of I-40 disruption in existing end spans (mid span)
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2 near western low bank
 - o New bent constructed in advance of I-40 disruption near eastern low bank between existing Bents 3 & 4
 - o Concrete girders with approximate 63" depth (Modified BT63 or FIB)
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Provides complete advance substructure work prior to I-40 disruption
 - Provides concrete girder option
 - Accommodates 50% hydraulic blockage restriction for new bent construction
- Span Configuration B
 - o 5 Span: $76+76+76+76+83=387'$
 - o Reuse Bents 1, 2, 3, 4 and West Abutment 1 – work performed in advance of I-40 disruption
 - o New eastern end bent behind existing end bent in approach constructed during staged construction
 - o Concrete girders with similar depth as existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Reuse of substructures

- Span Configuration C
 - o 2 Span: $187+160=347'$
 - o Reuse Bent 3 - work performed in advance of I-40 disruption
 - o New western abutment constructed in advance under span 1 (mid span)
 - o New eastern end bent behind existing end bent in approach constructed during staged construction
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Reuse of substructures
- Span Configuration D
 - o 2 Span: $202+145=347'$
 - o New bent constructed in advance of I-40 disruption near eastern low bank between existing Bents 3 & 4
 - o New western abutment constructed in advance under span 1 (mid span)
 - o New eastern end bent behind existing end bent in approach constructed during staged construction
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Provides west abutment construction in advance of I-40 disruption
 - Efficient eastern end bent for part width staged construction
 - Accommodates 50% hydraulic blockage restriction for new bent construction
- Span Configuration E
 - o 2 Span: $145+200=345'$
 - o Reuse West Abutment 1 – work performed in advance of I-40 disruption
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2 near western low bank
 - o New eastern end bent constructed in advance of I-40 disruption in existing end span (mid span)
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Reuse of substructures
- Span Configuration F
 - o 2 Span: $152+152=304'$
 - o New end bents constructed in advance of I-40 disruption in existing end spans (mid span)
 - o New bent constructed in advance of I-40 disruption between existing Bents 2 and 3
 - o Steel or concrete girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Does not accommodate 50% hydraulic blockage restriction
- Span Configuration G
 - o 2 Span: $200+200=400'$
 - o New end bents behind existing end bents in approaches constructed during staged construction
 - o New bent constructed in advance of I-40 disruption between existing Bents 2 and 3
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Does not accommodate 50% hydraulic blockage restriction
- Span Configuration H
 - o 2 Span: $180+180=360'$
 - o New western end bent behind existing abutment in approach constructed during staged construction
 - o New eastern end bent constructed in advance of I-40 disruption in existing end span (mid span)
 - o New bent constructed in advance of I-40 disruption adjacent to eastern side of existing Bent 2
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Provides no advantage compared to Config K – Western end bent construction allows time to construct new eastern end bent behind existing end bent

- Span Configuration I
 - o 3 Span: $134+134+134=402'$
 - o New end bents behind existing end bents in approaches constructed during staged construction
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2 near western low bank
 - o New bent constructed in advance of I-40 disruption near eastern low bank between existing Bents 3 & 4
 - o Concrete girders with approximate 63" depth (Modified BT63 or FIB)
 - o Propose to **reject** for the following reasons:
 - Steel girder options does not provide advantage vs other configurations
 - Concrete girder option does not provide advantage vs Config A
- Span Configuration J
 - o 3 Span: $120+120+120=360'$
 - o New western end bent behind existing abutment in approach constructed during staged construction
 - o New eastern end bent constructed in advance of I-40 disruption in existing end span (mid span)
 - o New bent constructed in advance of I-40 disruption between existing Bents 1 and 2
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 3
 - o Concrete girders with increased depth vs existing girders (36")
 - o Propose to **reject** for the following reasons:
 - Steel girder options does not provide advantage vs other configurations
 - Concrete girder option does not provide advantage vs Config A
 - Western end bent construction allows time to construct new eastern end bent behind existing end bent
 - May not accommodate 50% hydraulic blockage restriction
- Span Configuration K
 - o 2 Span: $180+220=400'$
 - o New western end bent behind existing abutment in approach constructed during staged construction
 - o New eastern end bent behind existing end bent in approach constructed during staged construction
 - o New bent constructed in advance of I-40 disruption adjacent to western side of existing Bent 2
 - o Steel girders with increased depth vs existing girders (36")
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Accommodates western and eastern end bent for part width staged construction
 - Accommodates 50% hydraulic blockage restriction for new bent construction

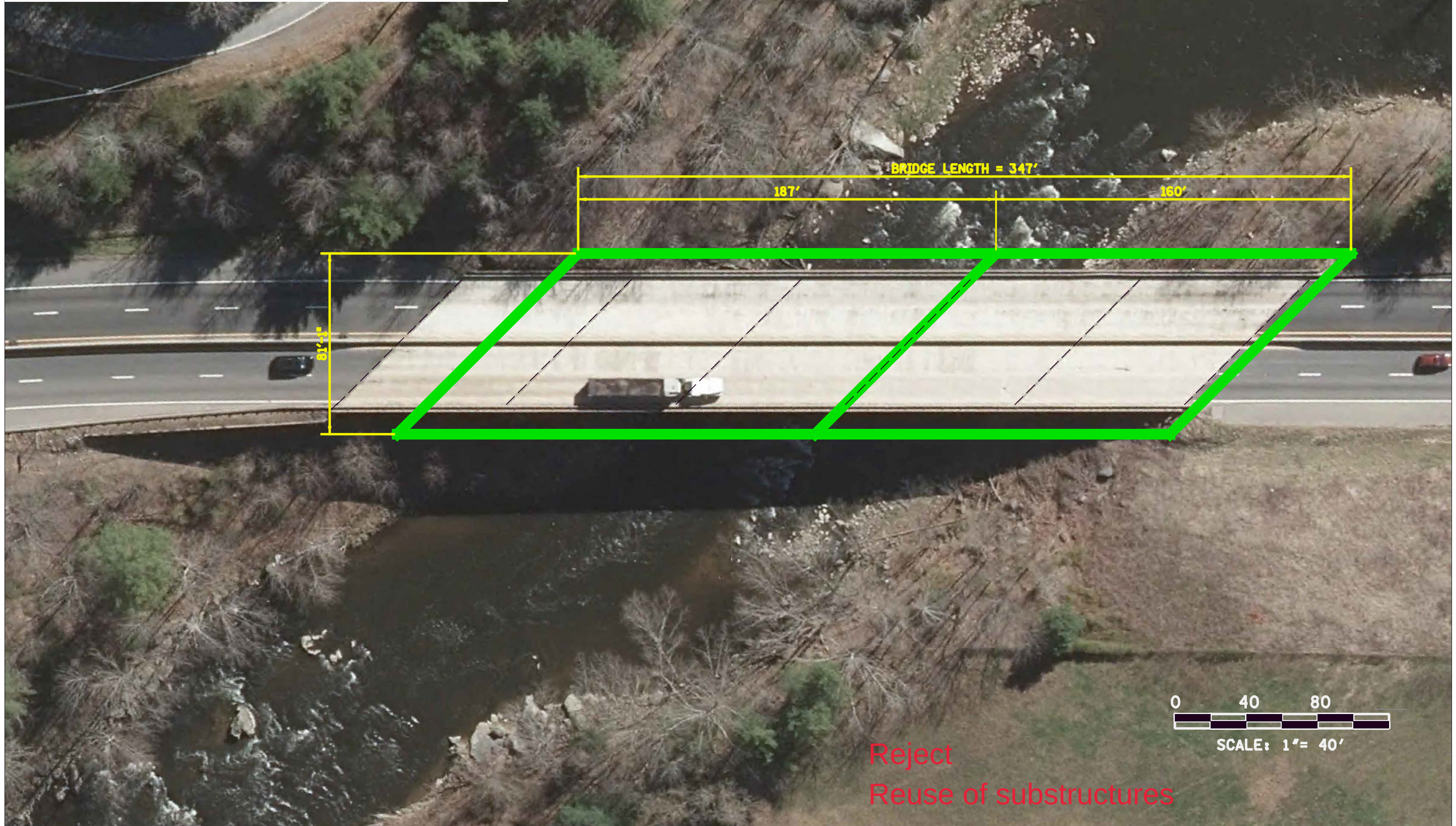
BRIDGE 142
SPAN CONFIG. A



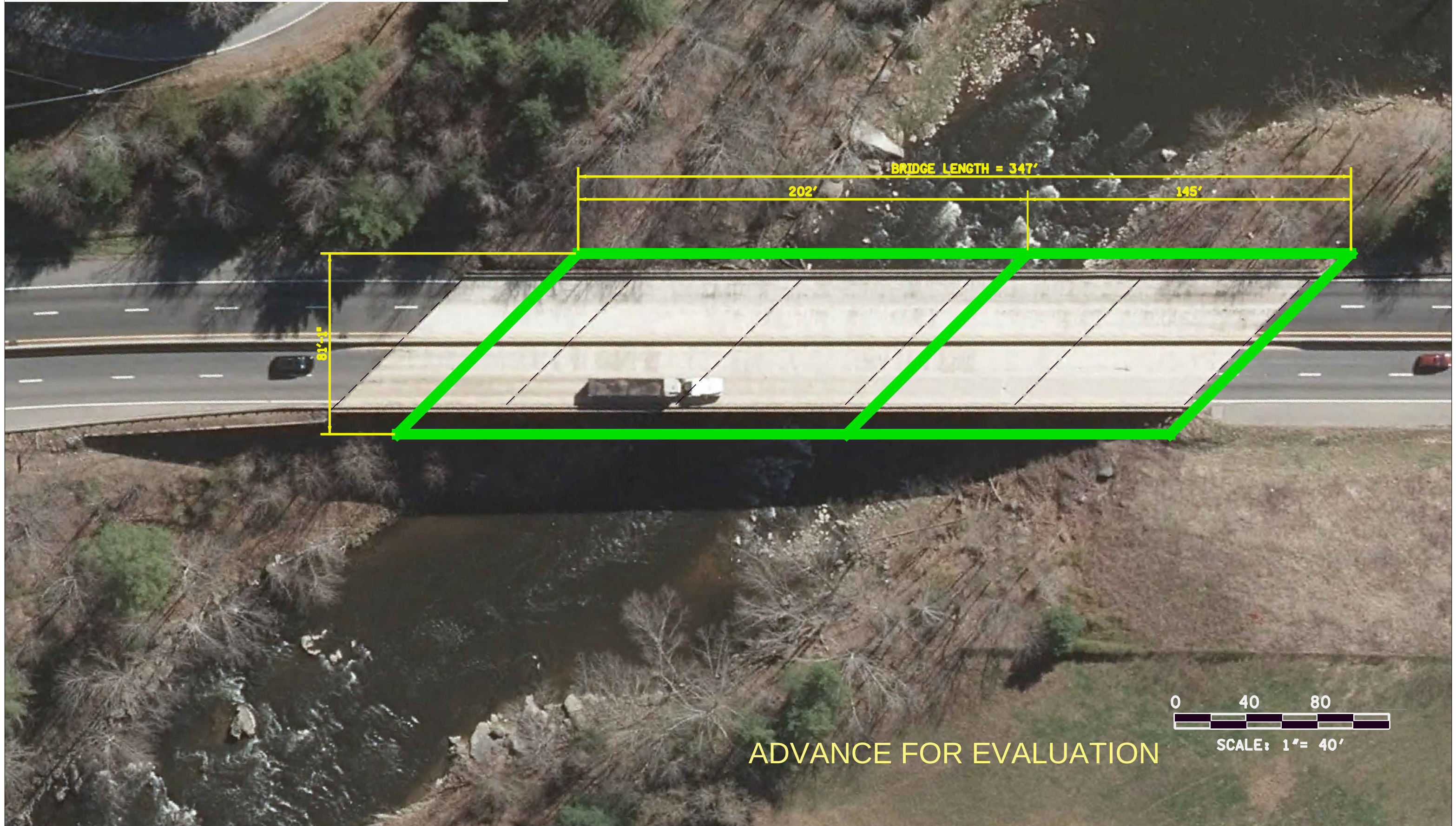
BRIDGE 142 SPAN CONFIG. B



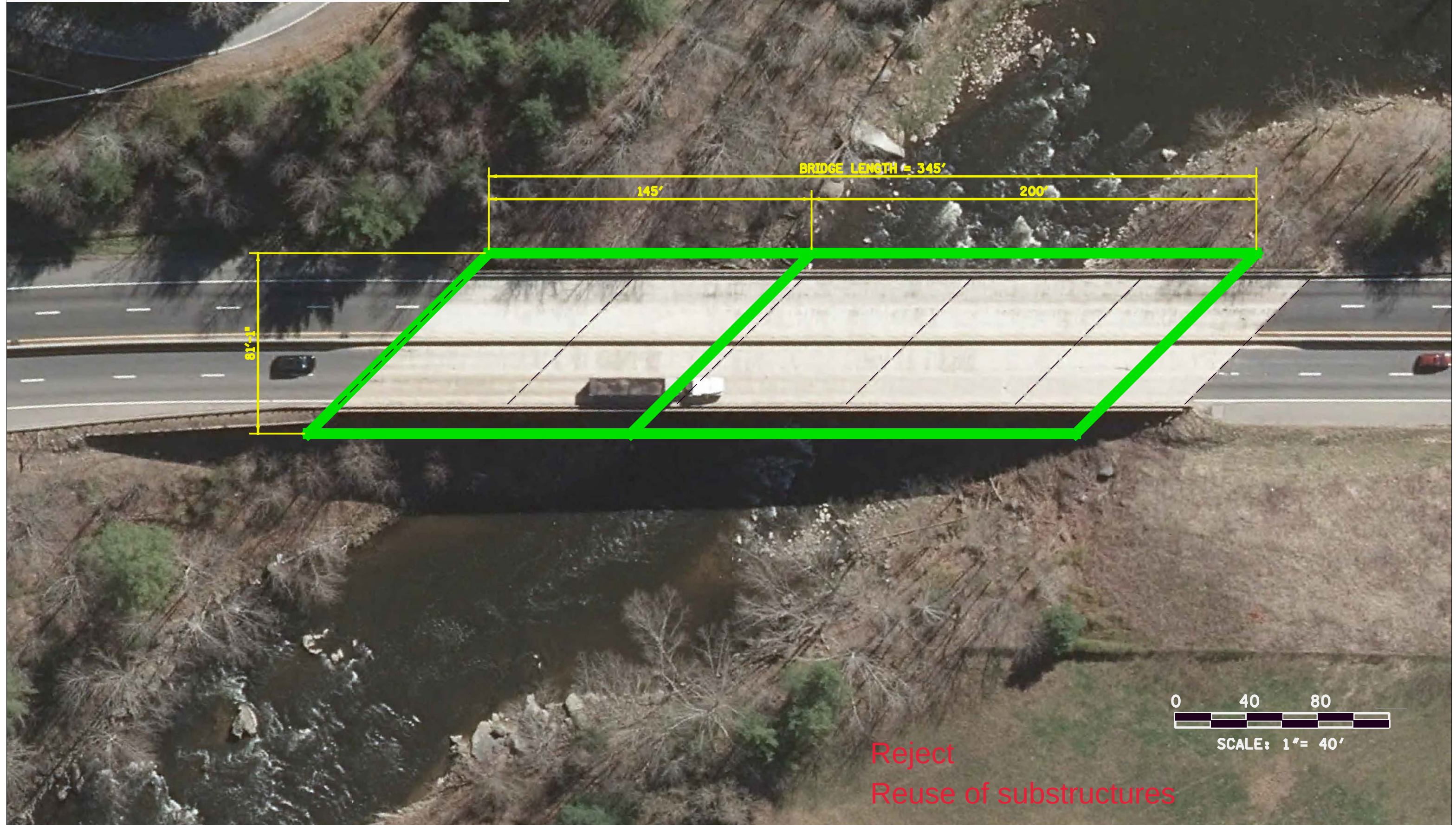
BRIDGE 142
SPAN CONFIG. C



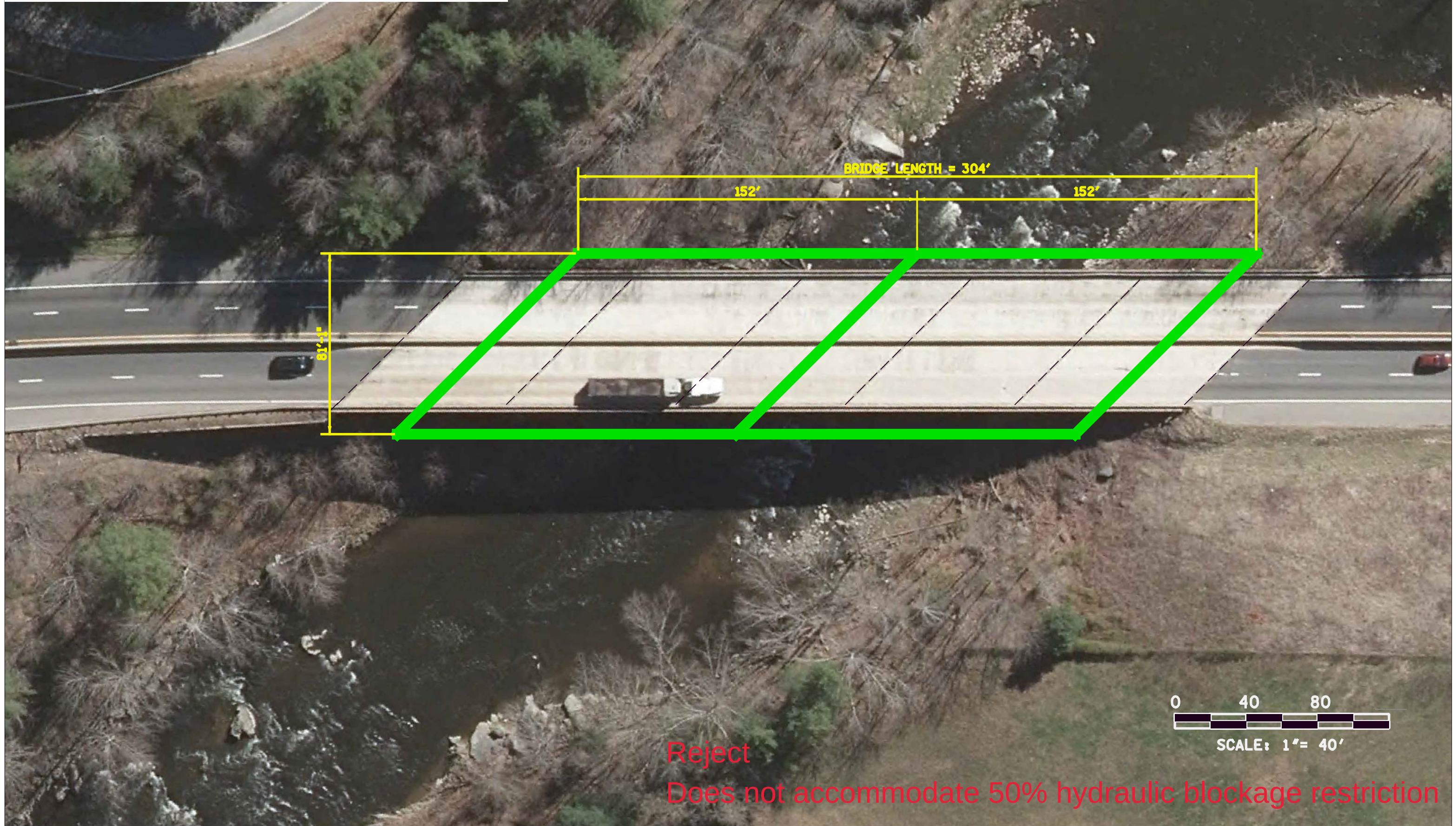
BRIDGE 142 SPAN CONFIG. D



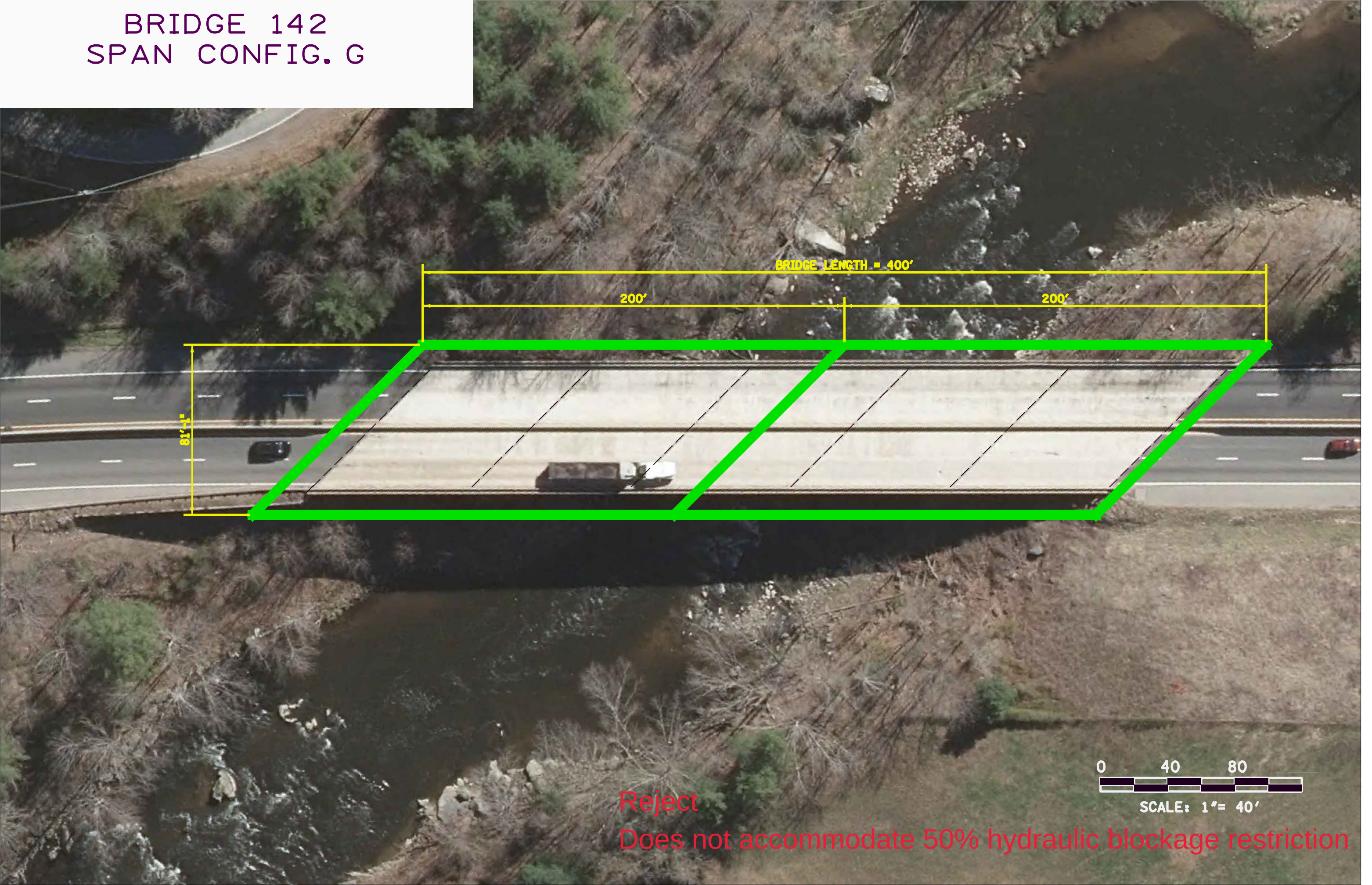
BRIDGE 142 SPAN CONFIG. E



BRIDGE 142
SPAN CONFIG. F

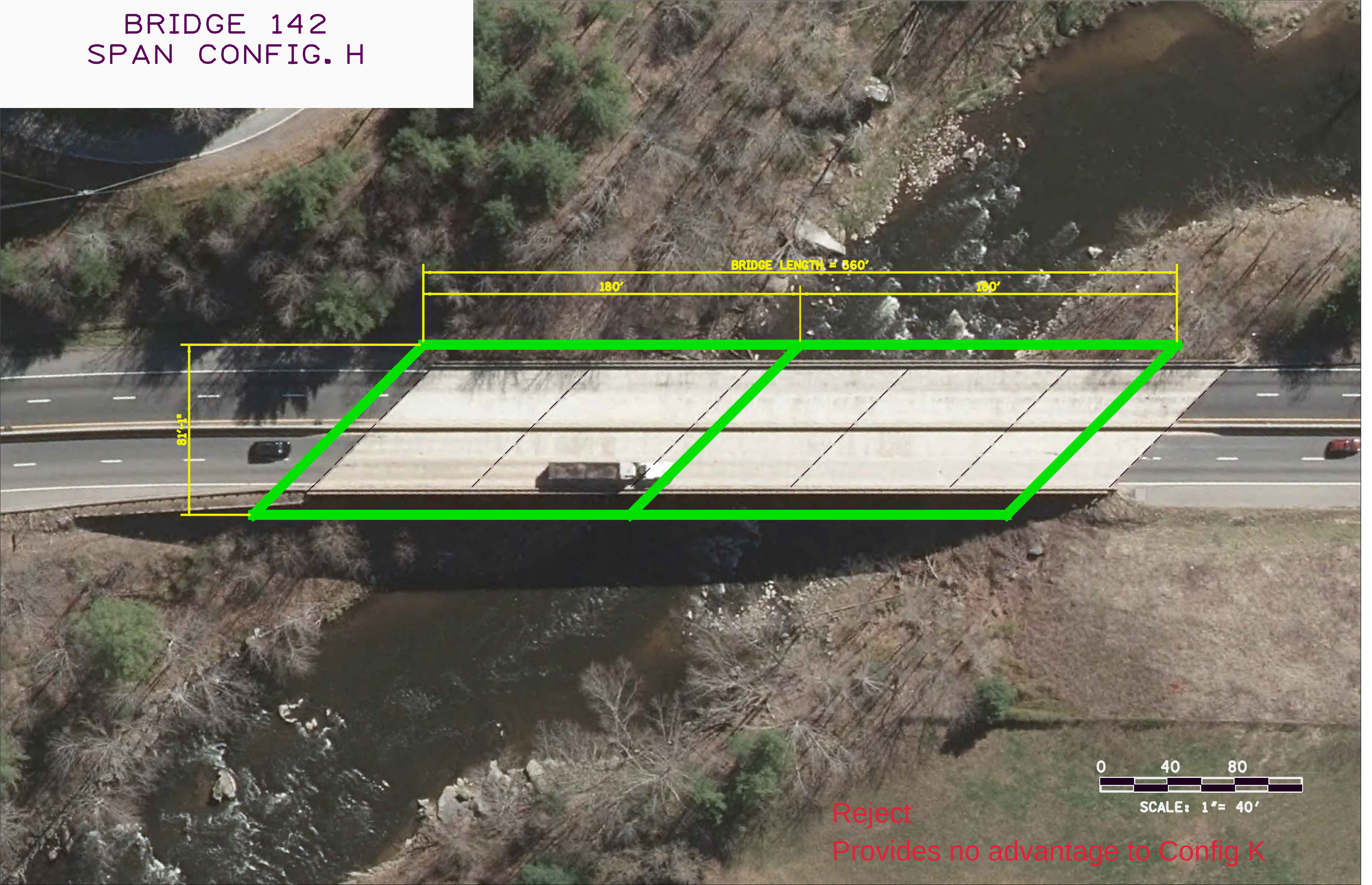


BRIDGE 142
SPAN CONFIG. G



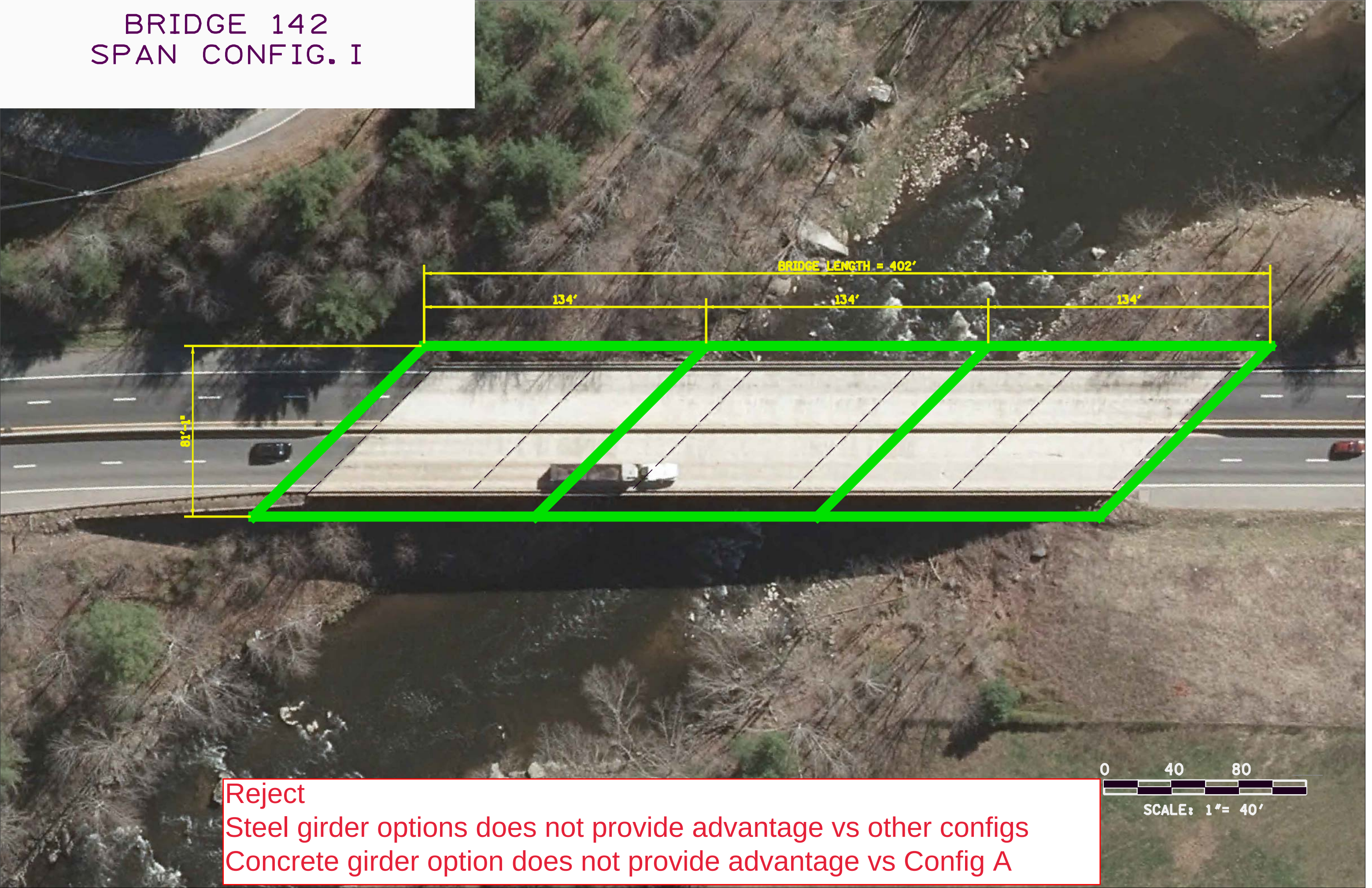
Reject
Does not accommodate 50% hydraulic blockage restriction

BRIDGE 142 SPAN CONFIG. H



Reject
Provides no advantage to Config K

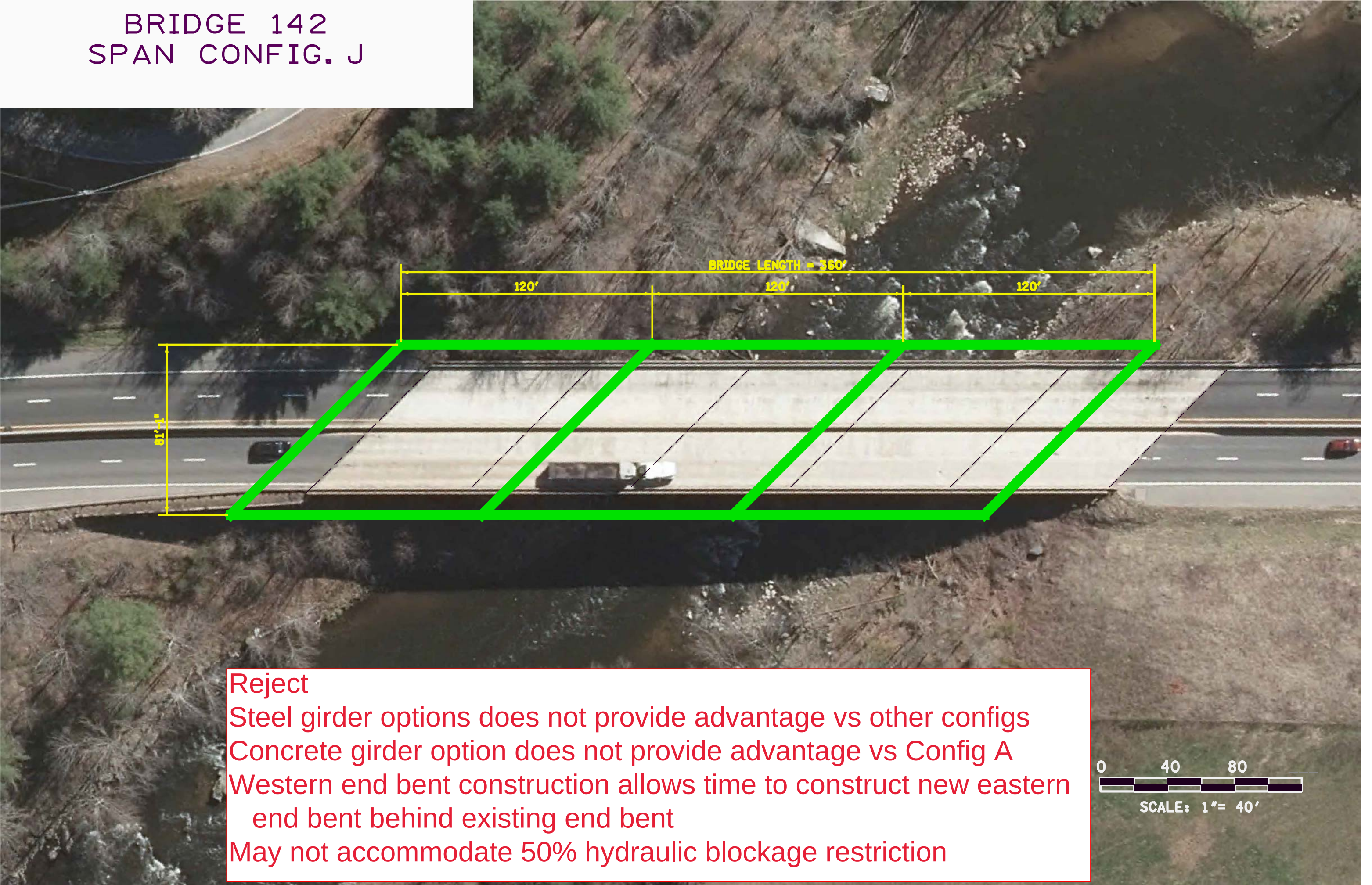
BRIDGE 142 SPAN CONFIG. I



Reject

Steel girder options does not provide advantage vs other configs
Concrete girder option does not provide advantage vs Config A

BRIDGE 142 SPAN CONFIG. J



Reject

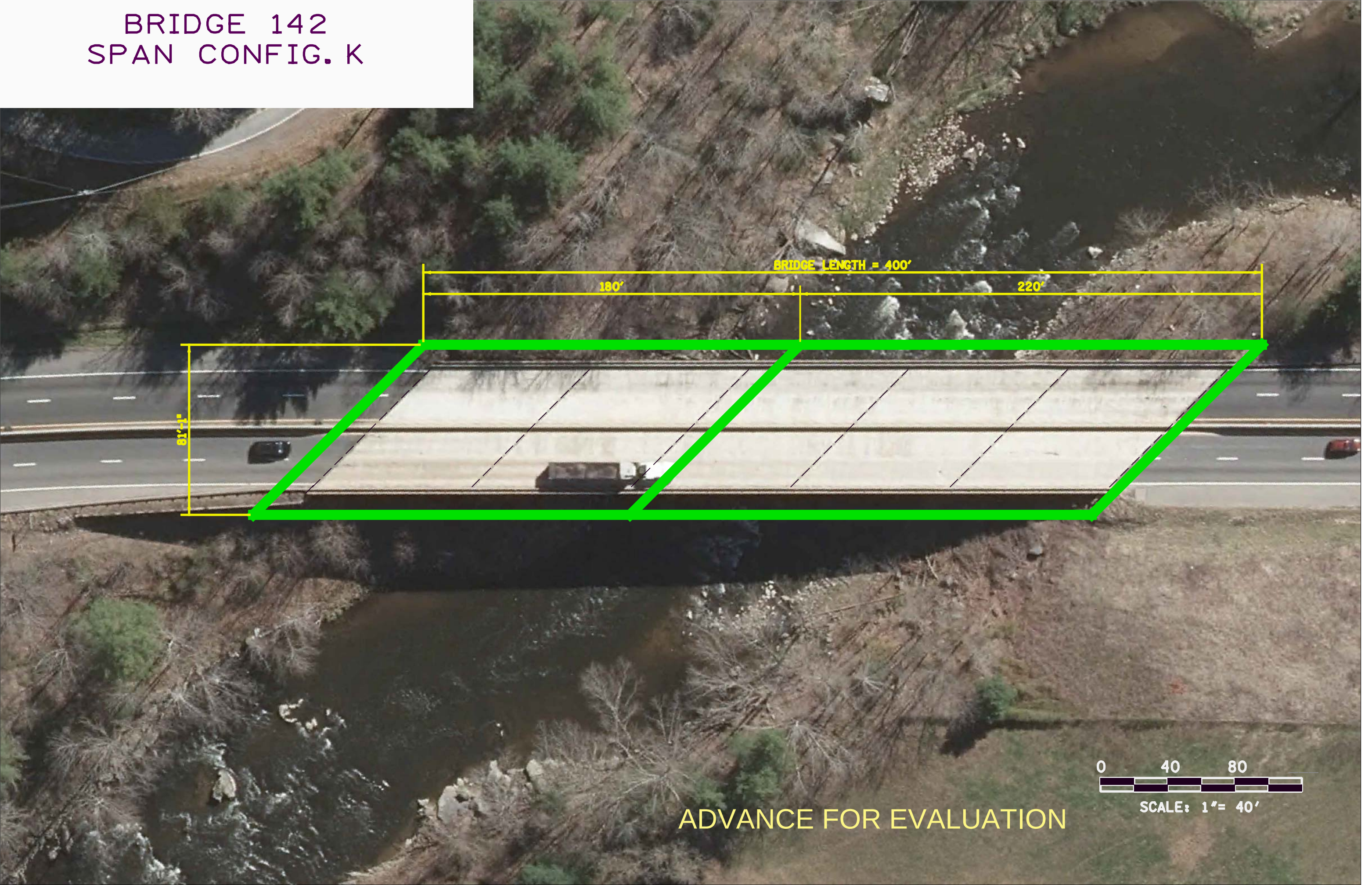
Steel girder options does not provide advantage vs other configs

Concrete girder option does not provide advantage vs Config A

Western end bent construction allows time to construct new eastern end bent behind existing end bent

May not accommodate 50% hydraulic blockage restriction

BRIDGE 142
SPAN CONFIG. K



TO: Josh Deyton, P.E. and NCDOT Project Staff
FROM: Greg Stewart, P.E; Sammie McCoy, P.E; Jake Williams, P.E.
Project: WBS 44593.11 / Benesch Project 17000306.00
I-40 CMGC Project -5 Bridge Replacements – Haywood County (Division 14)
SUBJECT: Span Configuration Rating Memorandum
Bridge 430159 over SR1338 (White Oak Road)
DATE: 6-17-2019

The information below is a summary of span configurations developed prior to, during and following the Value Planning Session conducted on June 4th and 5th at the Division 14 Office. These options were developed to capture various ideas, site condition accommodations, and compatibility with Constraints, Needs, and Desires developed during the session.

These bridge replacements are intended to fit within a 5 month I-40 disruption window where traffic can be reduced to one lane in each direction. Two lanes would be maintained in each direction between May and November with exact date ranges to be determined. Advance work and Accelerated Bridge Construction techniques are considered to meet project schedule goals. Alternative construction efforts may be applied where schedule adjustments can be allowed or where needed.

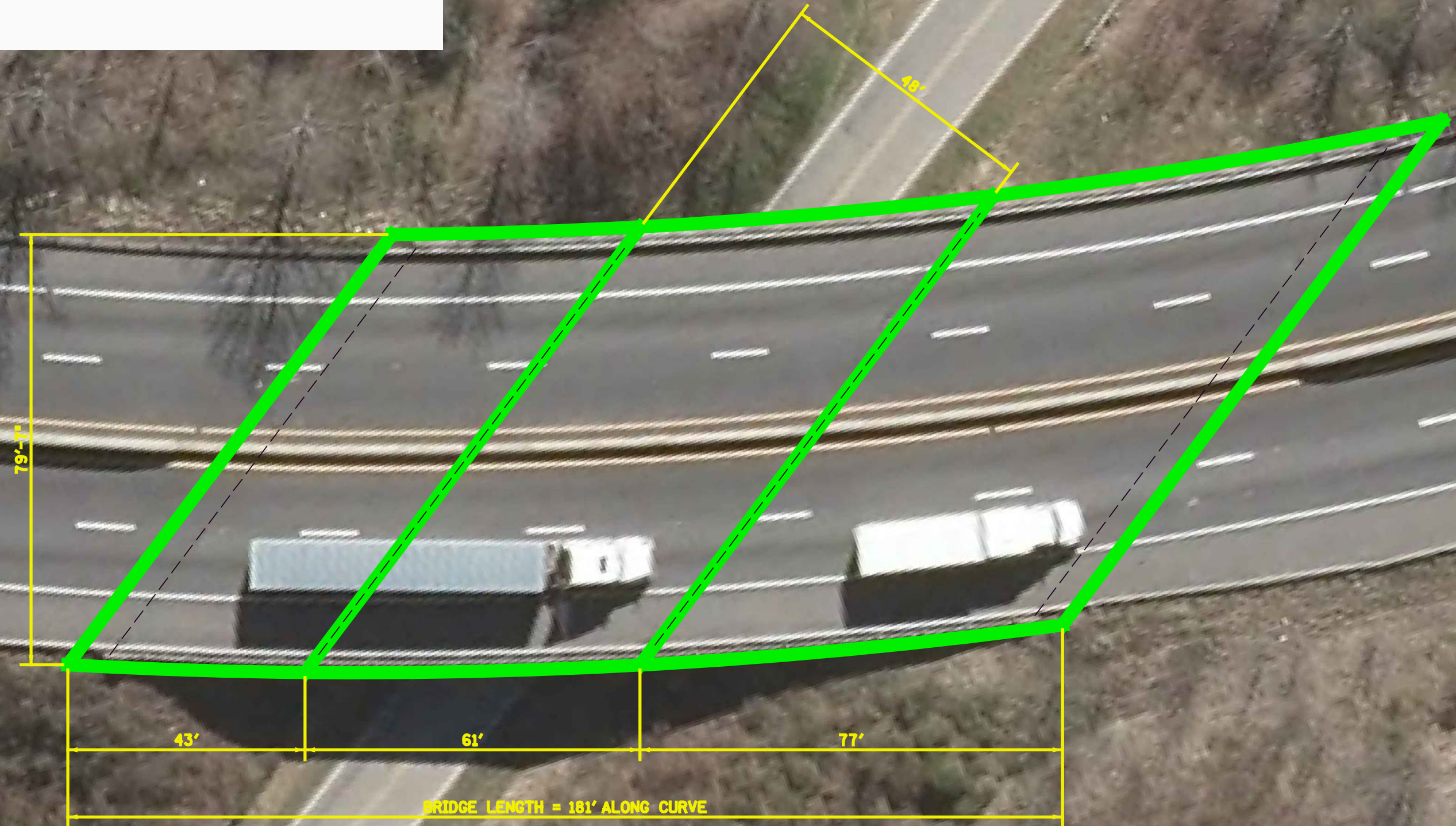
The information below will be used to further develop the Technical Study for this project and is offered for review and comment.

- Span Configuration A
 - o Three Span: 43+61+77=181'
 - o New end bents behind existing end bents in approaches constructed during staged construction
 - o Reuse Bents 1 & 2 - work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bents
- Span Configuration B
 - o One Span: 61'
 - o Reuse Bents 1 & 2 with earth retention improvement- work performed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - Reuse of Bents
- Span Configuration C
 - o One Span: 72'
 - o New end bents behind existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **reject** for the following reasons:
 - New end bents may conflict with existing bents due to proximity

- Span Configuration D
 - o One Span: 78'
 - o New end bents behind existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Accommodates staged part width construction
 - Provides 63' horizontal clearance for roadway below
 - Provides opportunity to improve vertical clearance by lowering road or reduced steel girder depth

- Span Configuration E
 - o One Span: 47'
 - o New end bents in front of existing Bents 1 & 2 constructed in advance of I-40 disruption
 - o Could be concrete girders with same depth as existing girders
 - o Could be steel girders with same or less depth as existing girders
 - o Could be post tensioned slab with reduced depth
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Accommodates staged part width construction
 - Provides shortest bridge with 38' horizontal clearance for roadway below
 - Provides opportunity to improve vertical clearance by lowering road or reduced superstructure depth

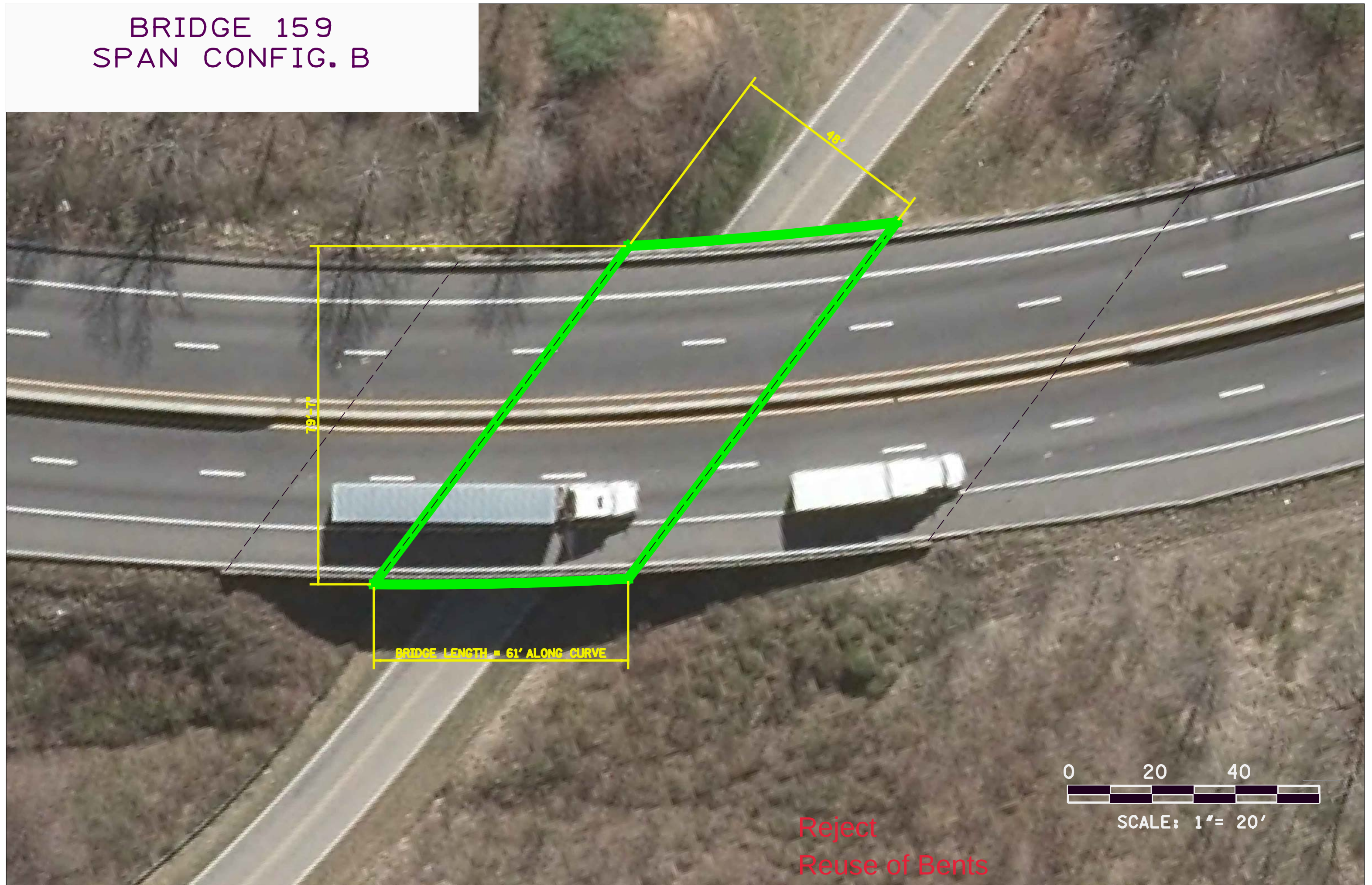
BRIDGE 159 SPAN CONFIG. A



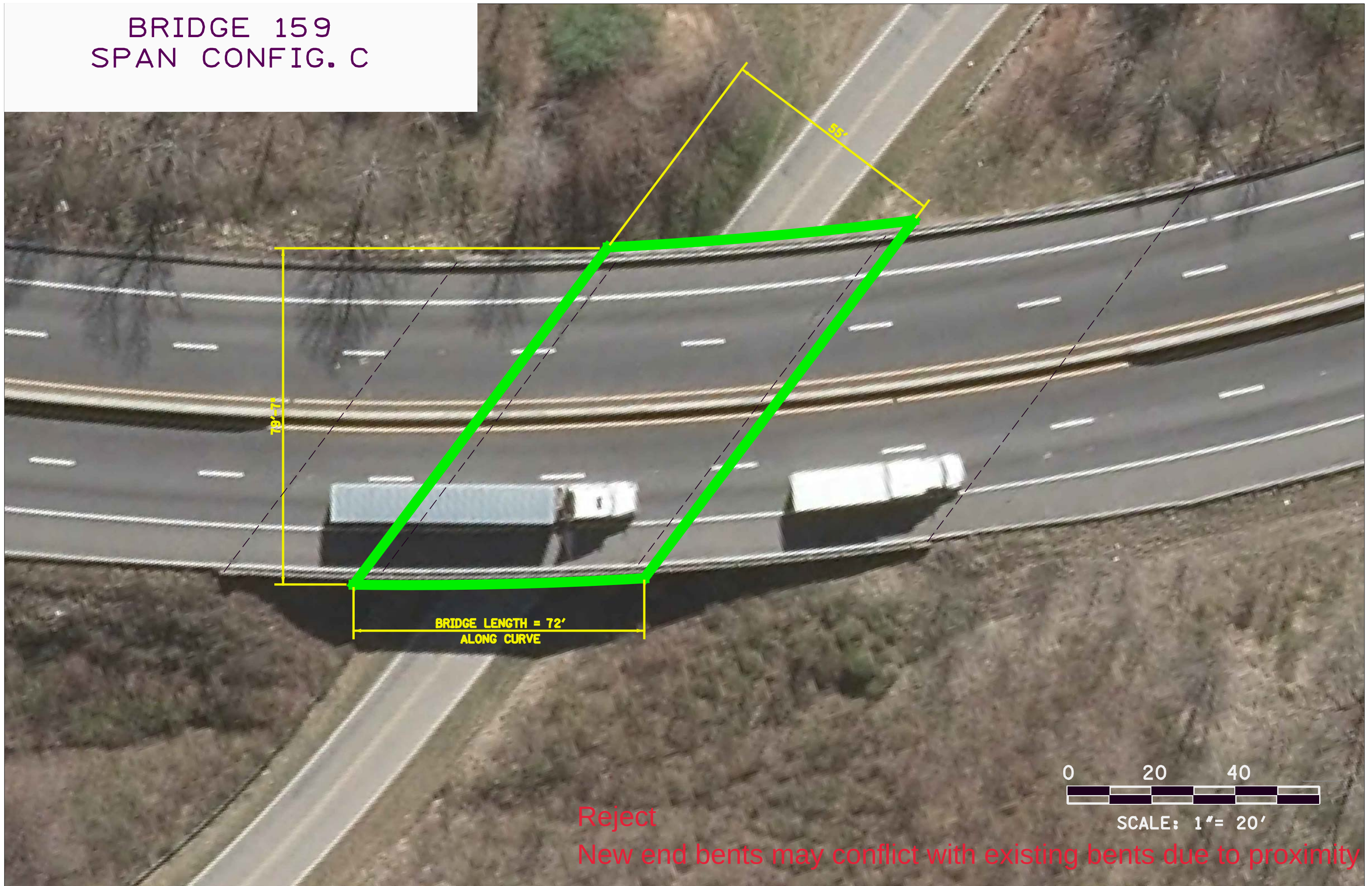
SCALE: 1" = 20'

Reject
Reuse of Bents

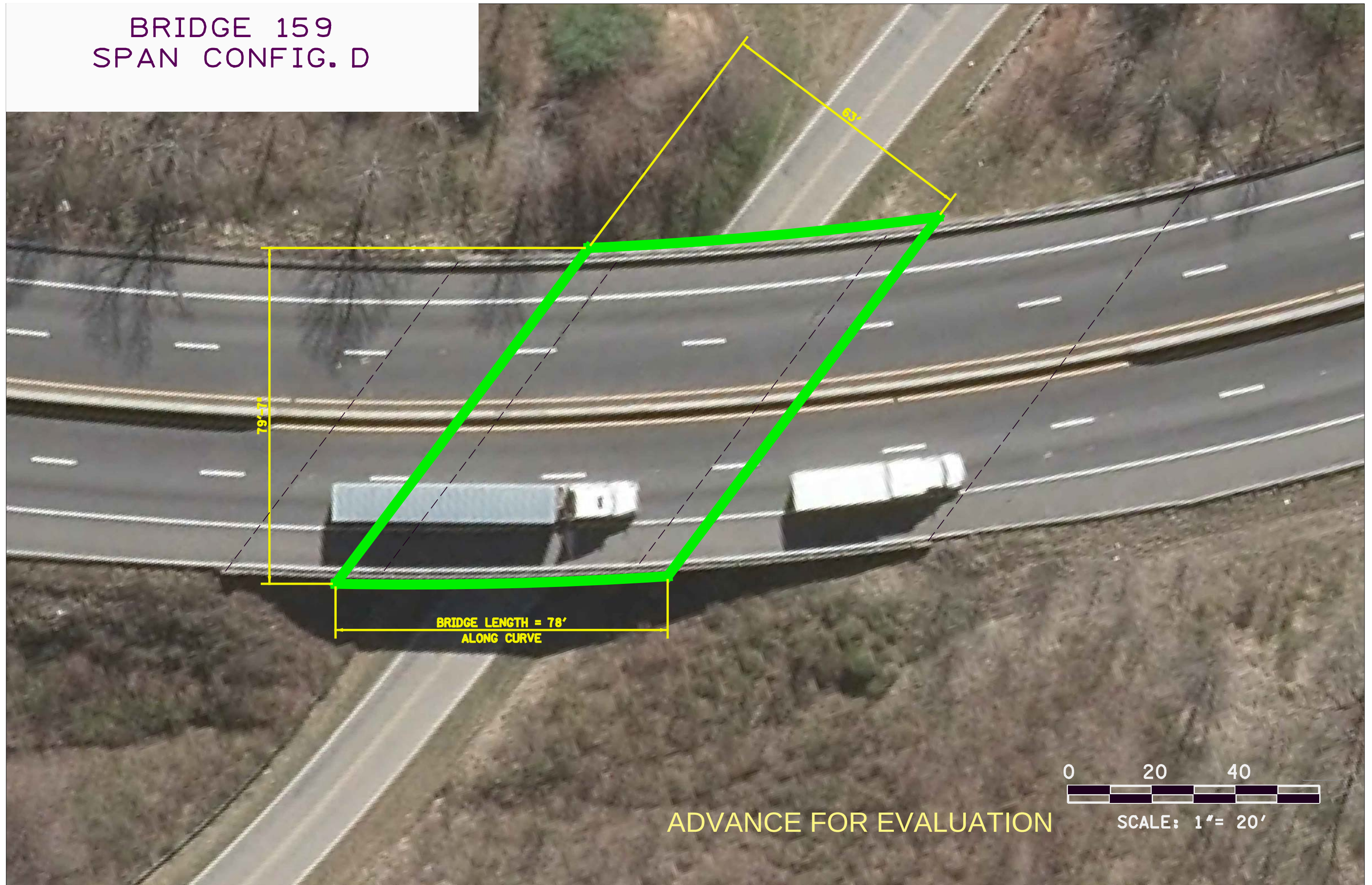
BRIDGE 159
SPAN CONFIG. B



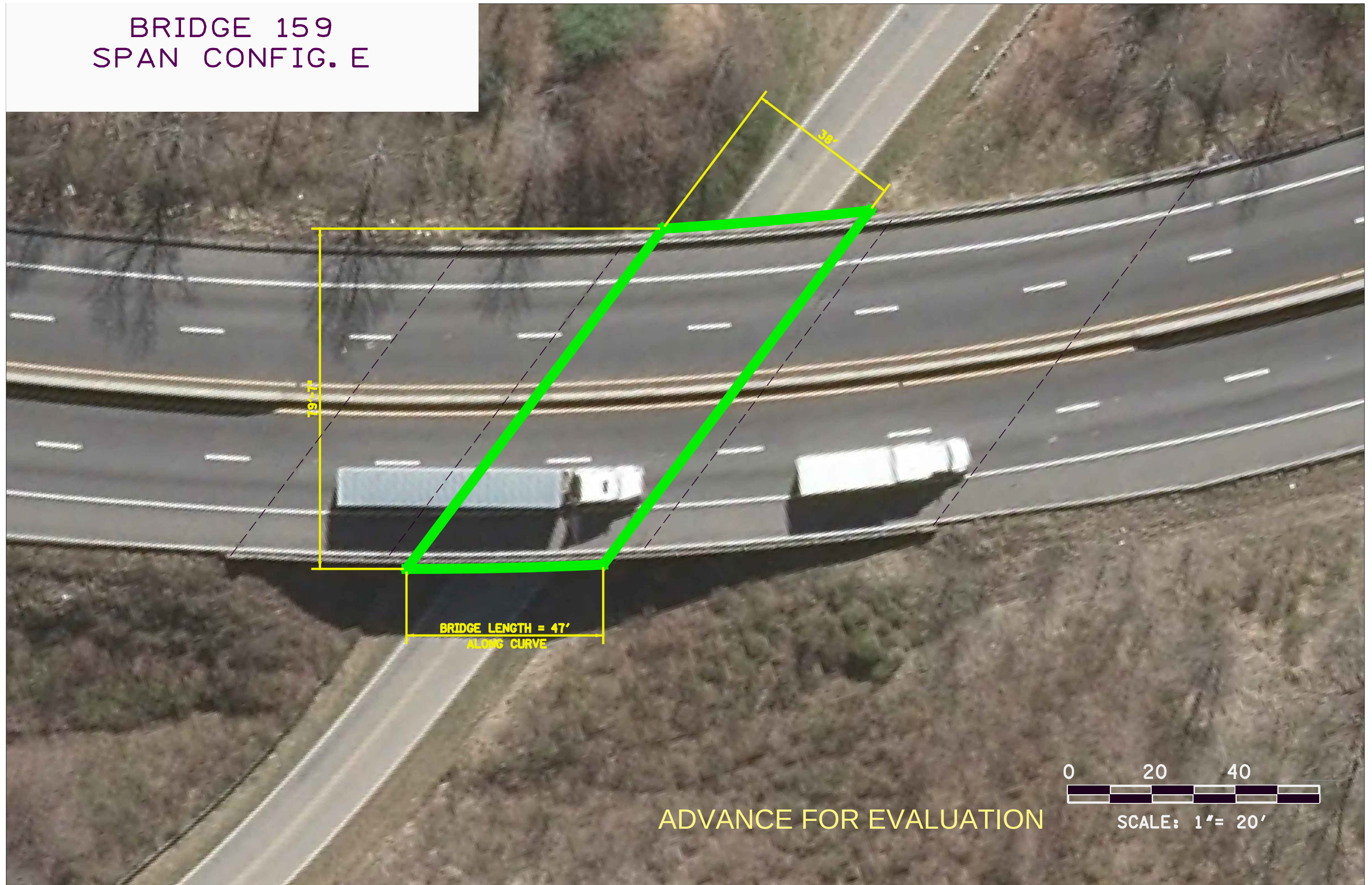
BRIDGE 159
SPAN CONFIG. C



BRIDGE 159
SPAN CONFIG. D



BRIDGE 159
SPAN CONFIG. E



TO: Josh Deyton, P.E. and NCDOT Project Staff
FROM: Greg Stewart, P.E; Sammie McCoy, P.E; Jake Williams, P.E.
Project: WBS 44593.11 / Benesch Project 17000306.00
I-40 CMGC Project -5 Bridge Replacements – Haywood County (Division 14)
SUBJECT: Span Configuration Rating Memorandum
Bridge 430171 over SR 1338 (White Oak Road) / Jonathan Creek
DATE: 6-17-2019

The information below is a summary of span configurations developed prior to, during and following the Value Planning Session conducted on June 4th and 5th at the Division 14 Office. These options were developed to capture various ideas, site condition accommodations, and compatibility with Constraints, Needs, and Desires developed during the session.

These bridge replacements are intended to fit within a 5 month I-40 disruption window where traffic can be reduced to one lane in each direction. Two lanes would be maintained in each direction between May and November with exact date ranges to be determined. Advance work and Accelerated Bridge Construction techniques are considered to meet project schedule goals. Alternative construction efforts may be applied where schedule adjustments can be allowed or where needed.

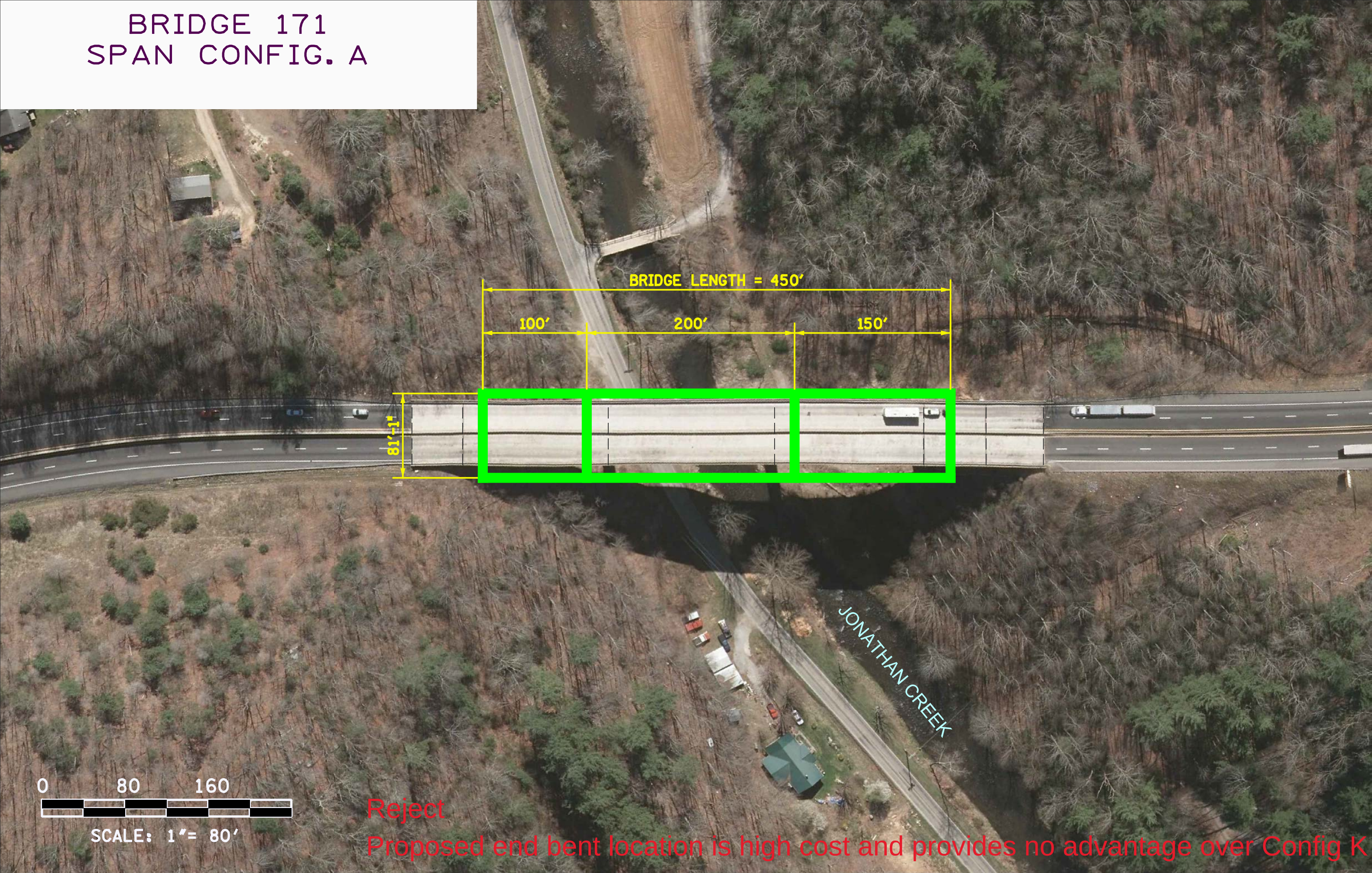
The information below will be used to further develop the Technical Study for this project and is offered for review and comment.

- Span Configuration A
 - o Three Span: $100+200+150=450'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 2 & 5
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2
 - o New bent constructed in advance of I-40 disruption near eastern side of Bent 3
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Proposed end bent locations are high cost and provide no advantage over Config K
- Span Configuration B
 - o Three Span: $150+200+150=500'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 5
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2
 - o New bent constructed in advance of I-40 disruption near eastern side of Bent 3
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Proposed eastern end bent location is high cost and provides no advantage over Config K
- Span Configuration C
 - o Three Span: $150+160+150=500'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 5
 - o Reuse Bents 2 & 3 - work performed in advance of I-40 disruption
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Reuse of bents

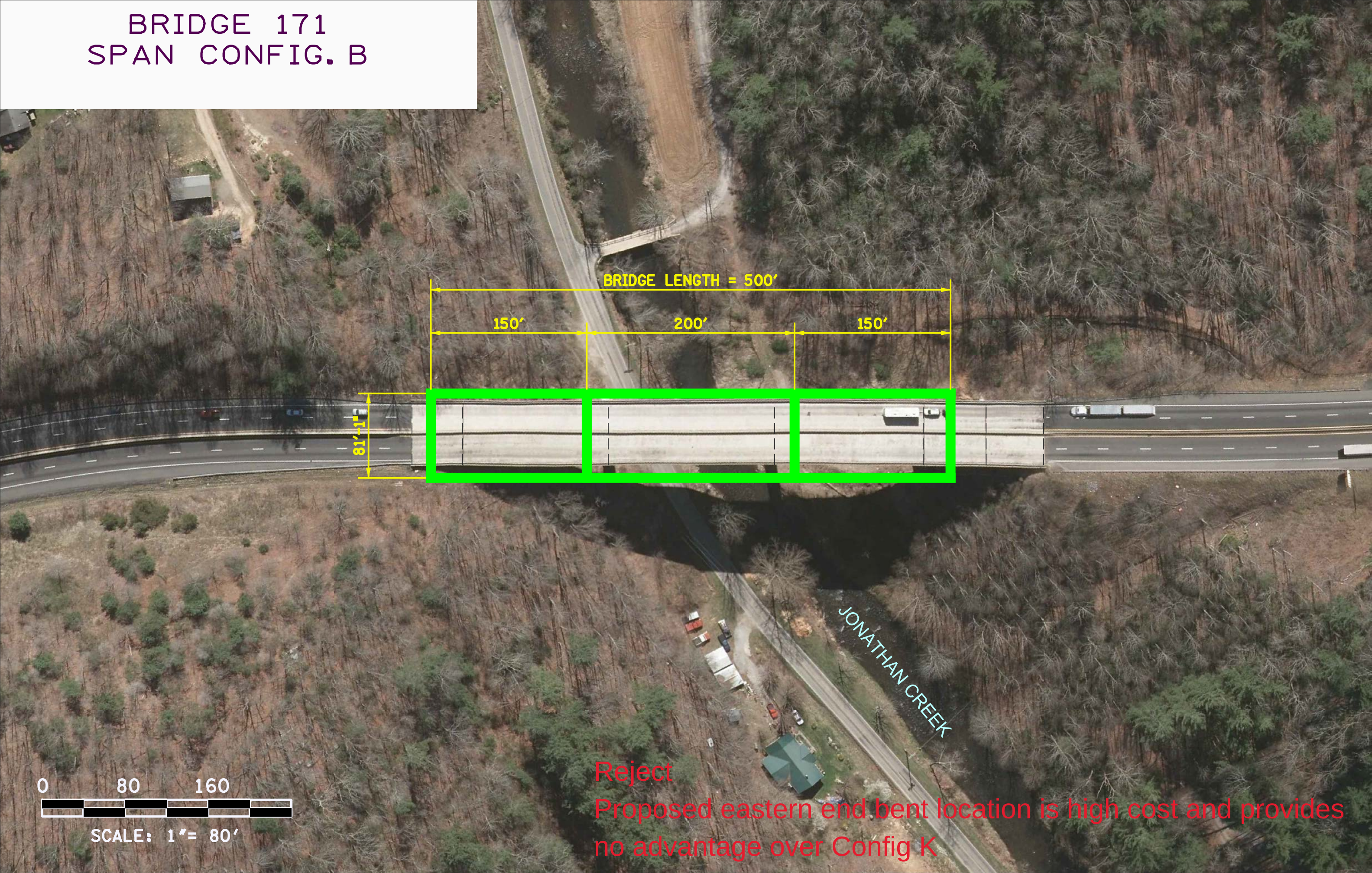
- Span Configuration D
 - o Four Span: $120+160+140+85=505'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 2 & 6
 - o Reuse Bents 2, 3 & 4 - work performed in advance of I-40 disruption
 - o Could be Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Could be Concrete Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Reuse of bents
- Span Configuration E
 - o Five Span: $100+110+110+110+95=525'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 6
 - o Four new bents constructed in advance of I-40 disruption
 - o Could be Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Could be Concrete Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Provides no advantage over other steel beam Configs
 - Proposed Bent 2 between road and creek likely large diameter column with hammerhead – constructability and permit concerns
- Span Configuration F
 - o Five Span: $85+110+110+110+95=510'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 2 & 6
 - o Four new bents constructed in advance of I-40 disruption
 - o Could be Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Could be Concrete Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Provides no advantage over other steel beam Configs
 - Proposed Bent 2 between road and creek likely large diameter column with hammerhead – constructability and permit concerns
 - Proposed western end bent location is high cost
- Span Configuration G
 - o Three Span: $150+200+150=500'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 5
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2
 - o New bent constructed in advance of I-40 disruption near eastern side of Bent 3
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Phase 1 (Westbound) superstructure constructed without disruption to I-40
 - o Phase 2 (Eastbound) superstructure phased constructed during disruption of I-40
 - o Propose to **reject** for the following reasons:
 - Permanent alignment shift required – low benefit versus cost
- Span Configuration H
 - o Three Span: $200+240+200=640'$
 - o New end bents behind existing end bents in approaches constructed during staged construction
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2
 - o New bent constructed in advance of I-40 disruption in existing Span 4 (mid span)
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Efficient end bents for part width staged construction
 - New tall bents constructed in advance of I-40 disruption
 - Efficient steel girder configuration

- Span Configuration I
 - o Four Span: $140+160+140+100=540'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 6
 - o Three new bents constructed in advance of I-40 disruption
 - o Could be Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Could be Concrete Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **reject** for the following reasons:
 - Provides no advantage over other steel beam Configs
 - Proposed Bent 2 between creek and existing Bent 3 likely large diameter column with hammerhead – constructability and permit concerns
- Span Configuration J
 - o Five Span: $120+140+140+130+90=620'$
 - o New end bents behind existing end bents in approaches constructed during staged construction
 - o Four new bents constructed in advance of I-40 disruption
 - o New Bent 2 at different skew vs other substructures
 - o Could be Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Could be Concrete Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - Provides concrete girder option
 - Efficient end bents for part width staged construction
 - New tall bents constructed in advance of I-40 disruption
 - New skewed Bent 2 can be multi-column with constructible diameters that fit between road and creek
- Span Configuration K
 - o Three Span: $160+240+160=560'$
 - o New end bents constructed in advance of I-40 disruption in existing Spans 1 & 6
 - o New bent constructed in advance of I-40 disruption adjacent to west side of existing Bent 2
 - o New bent constructed in advance of I-40 disruption in existing Span 4 (mid span)
 - o Steel Girders with depth less than Spans 2, 3, & 4 but greater than Spans 1, 5, & 6
 - o Propose to **advance as alternate for evaluation** for the following reasons:
 - End bents constructed in advance of I-40 disruption
 - New tall bents constructed in advance of I-40 disruption

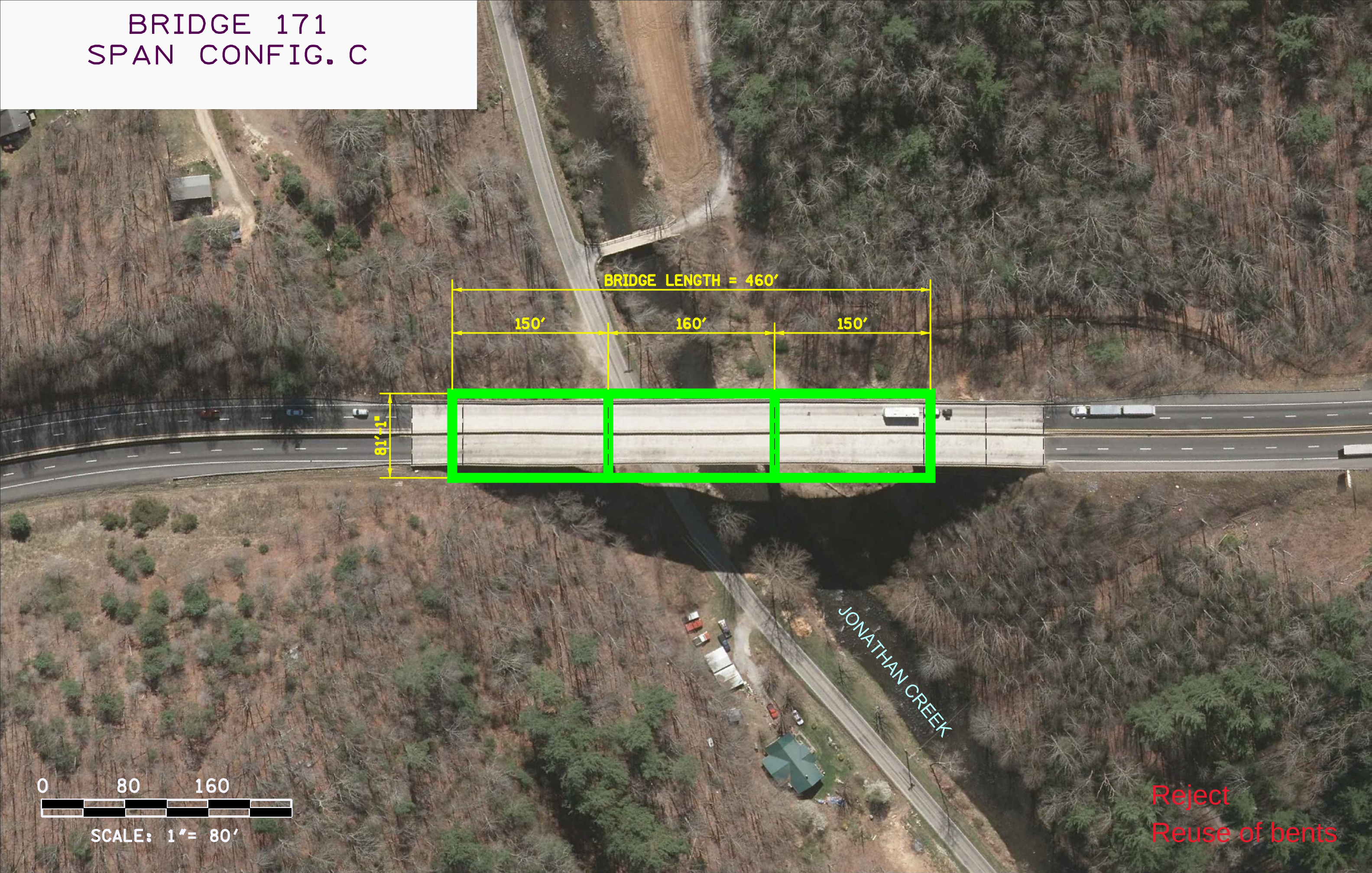
BRIDGE 171
SPAN CONFIG. A



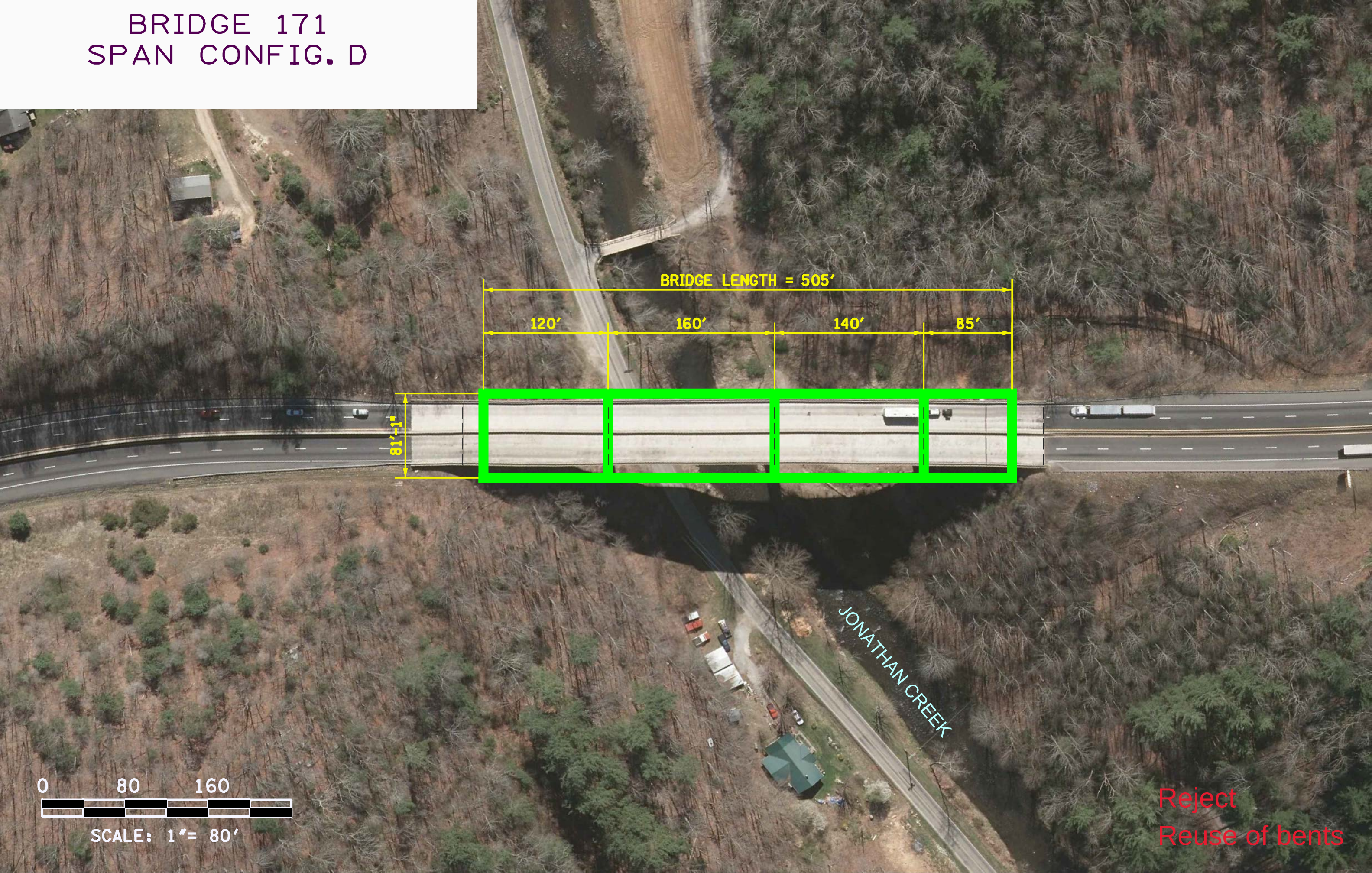
BRIDGE 171
SPAN CONFIG. B



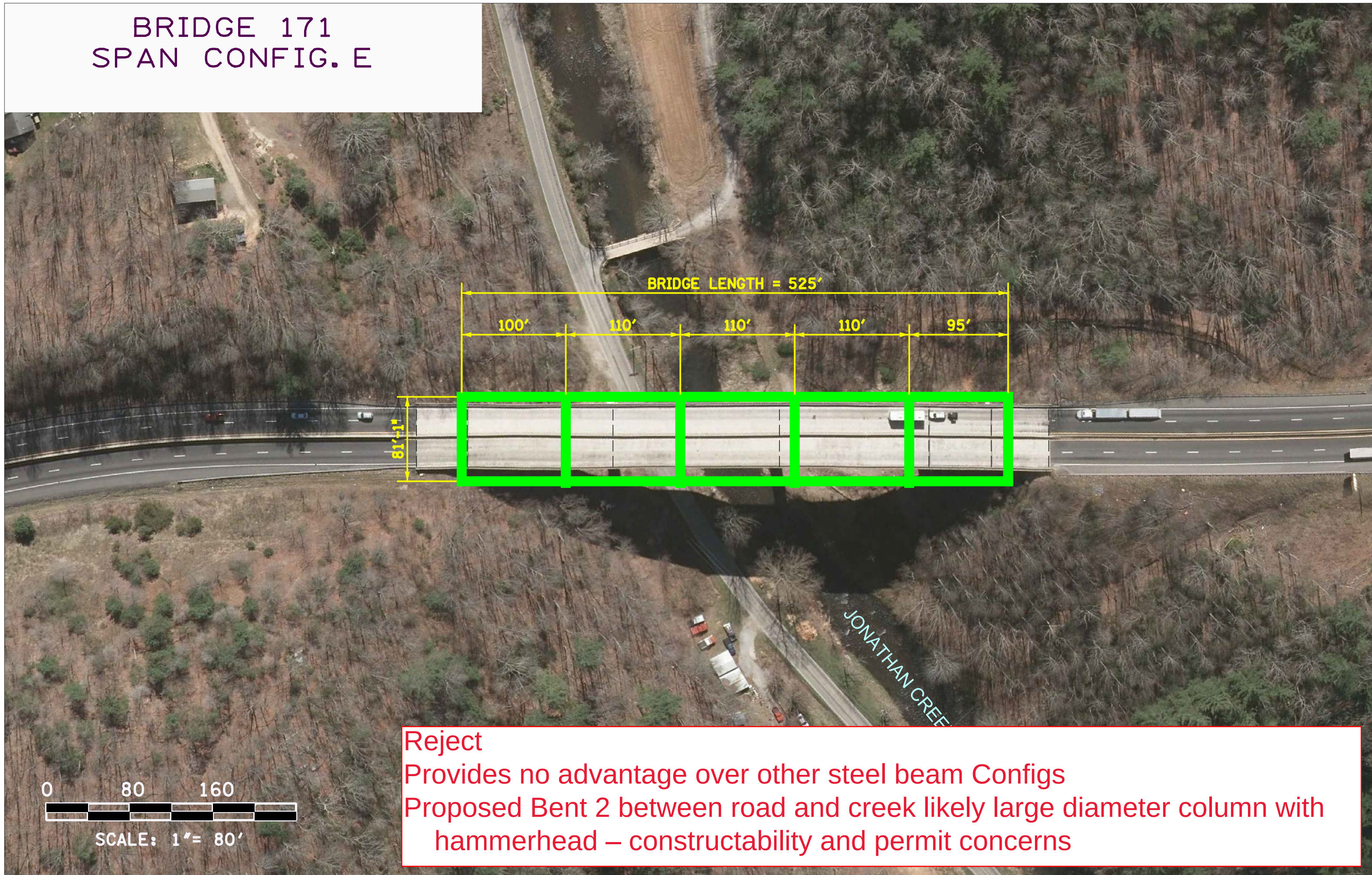
BRIDGE 171
SPAN CONFIG. C



BRIDGE 171
SPAN CONFIG. D



BRIDGE 171 SPAN CONFIG. E

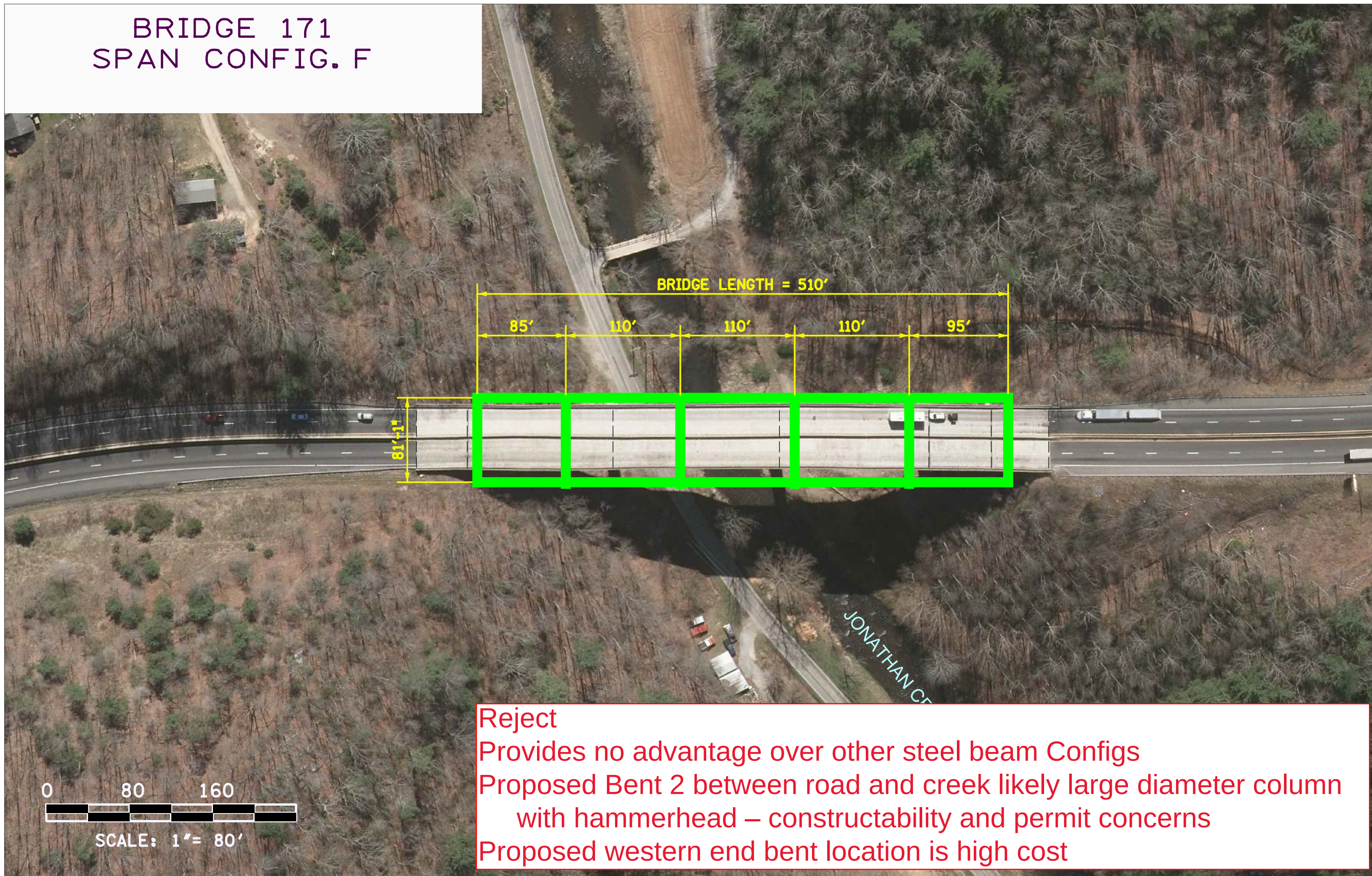


Reject

Provides no advantage over other steel beam Configs

Proposed Bent 2 between road and creek likely large diameter column with hammerhead – constructability and permit concerns

BRIDGE 171 SPAN CONFIG. F



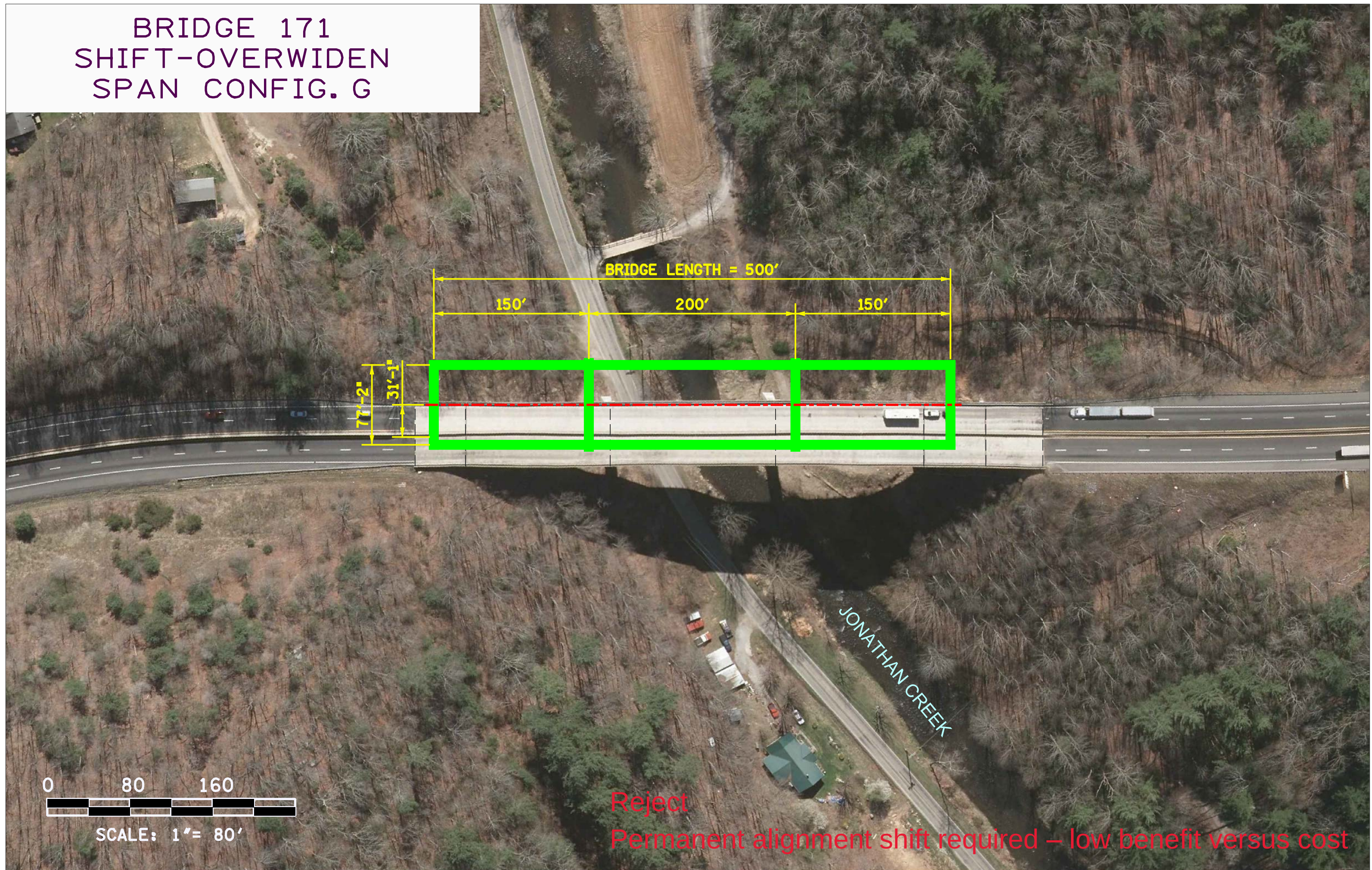
Reject

Provides no advantage over other steel beam Configs

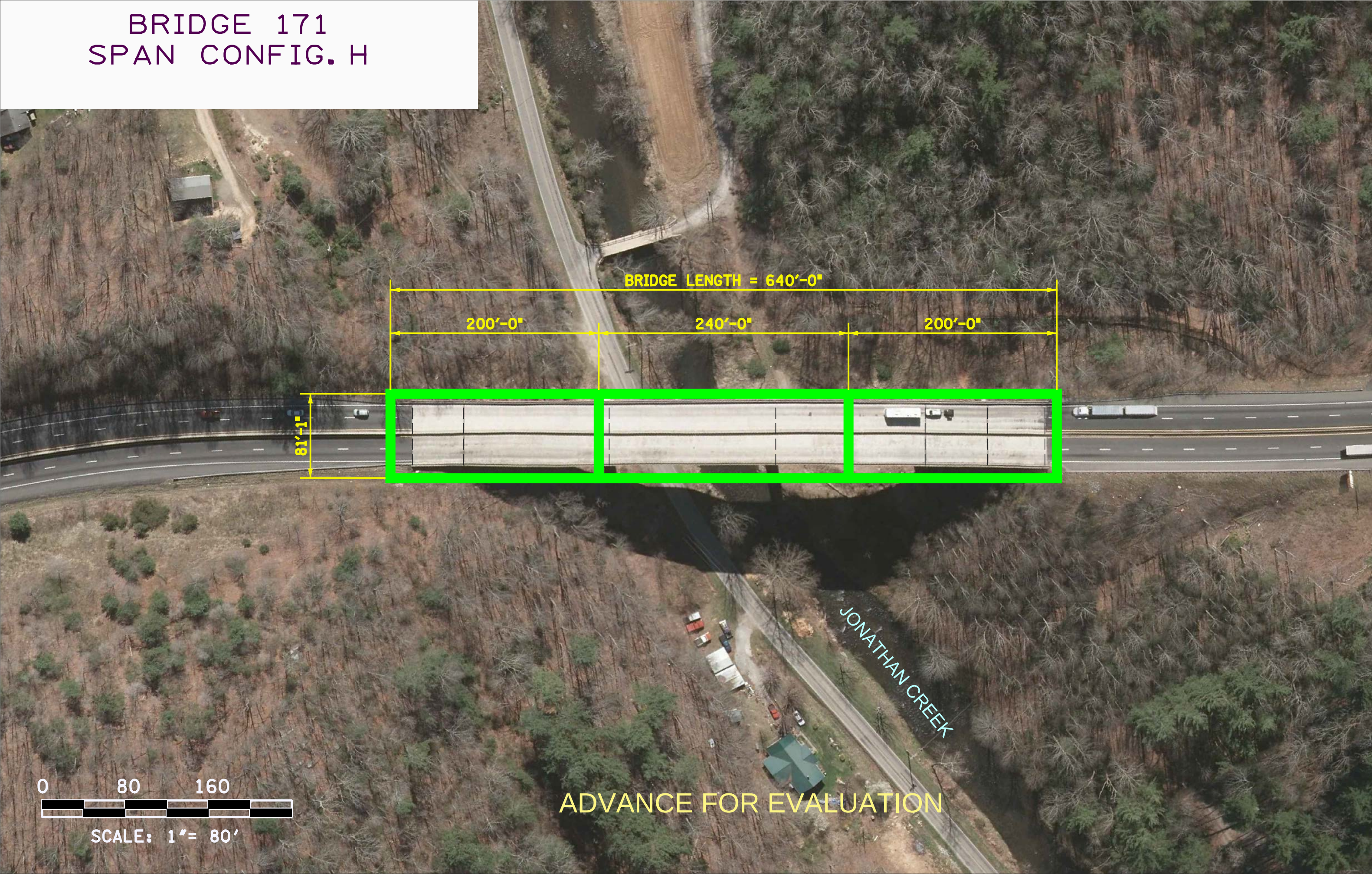
Proposed Bent 2 between road and creek likely large diameter column with hammerhead – constructability and permit concerns

Proposed western end bent location is high cost

BRIDGE 171
SHIFT-OVERWIDEN
SPAN CONFIG. G



BRIDGE 171
SPAN CONFIG. H



BRIDGE LENGTH = 640'-0"

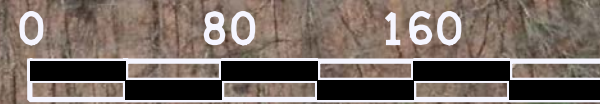
200'-0"

240'-0"

200'-0"

81'-11"

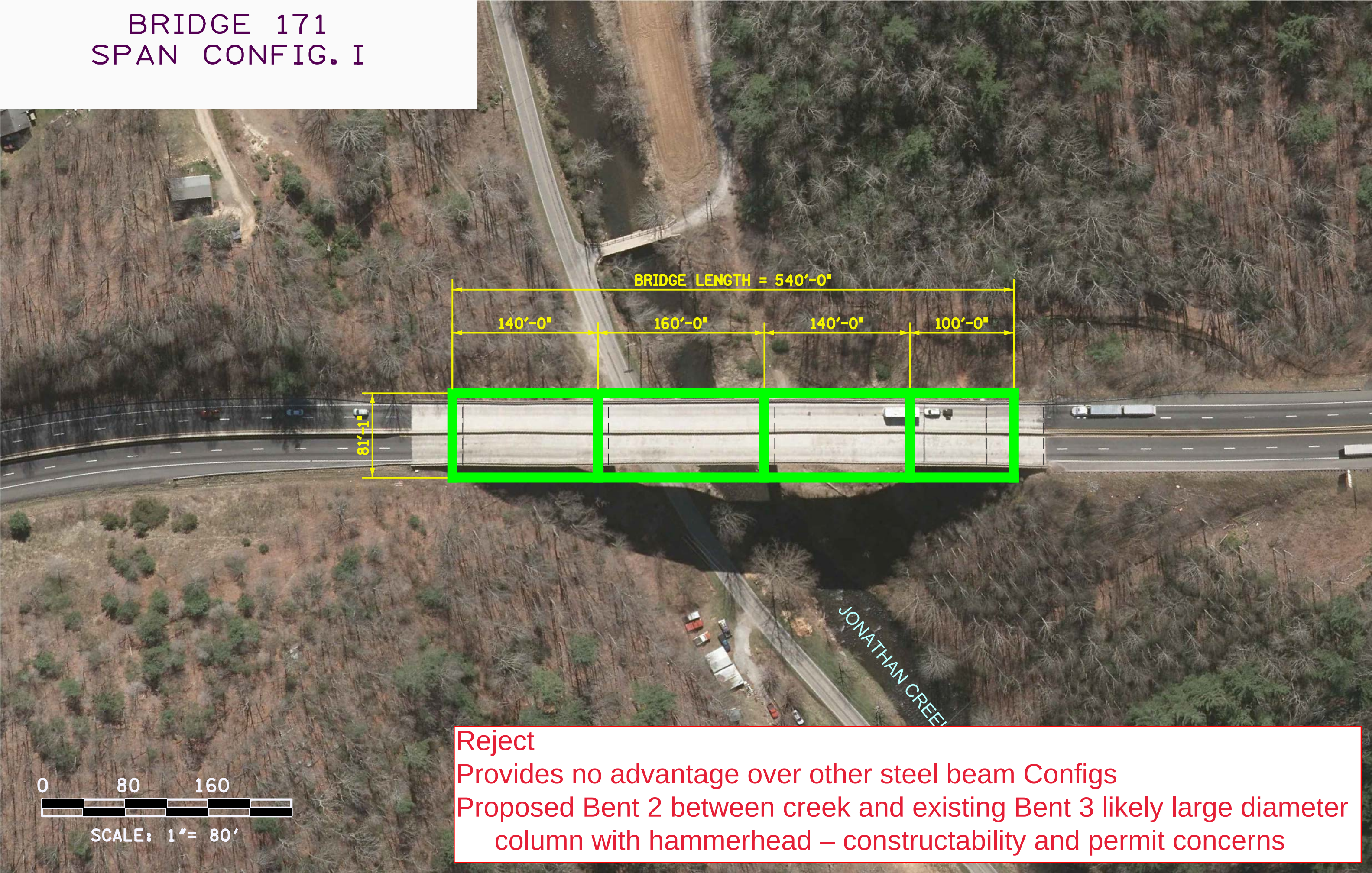
JONATHAN CREEK



SCALE: 1"= 80'

ADVANCE FOR EVALUATION

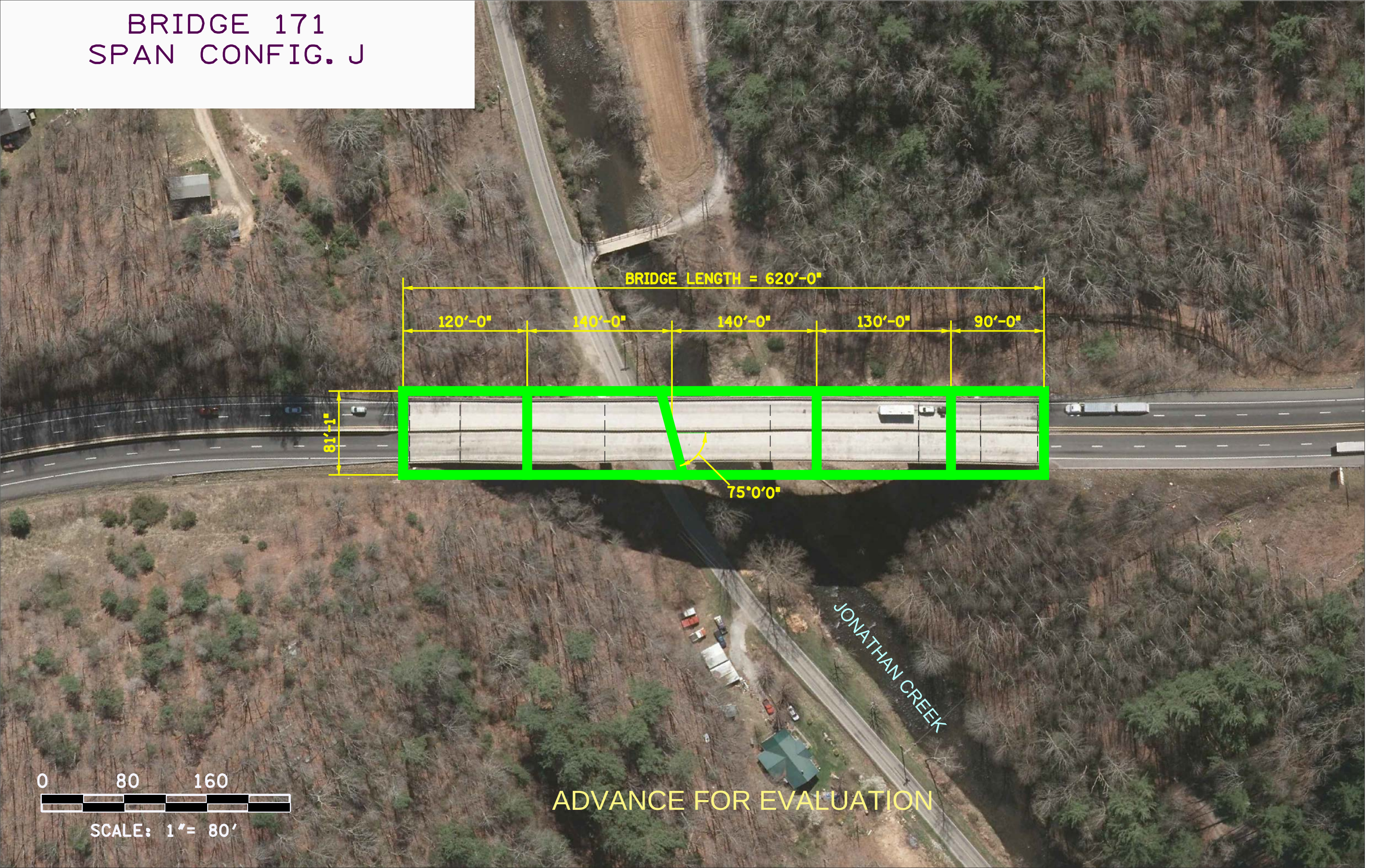
BRIDGE 171
SPAN CONFIG. I



Reject

Provides no advantage over other steel beam Configs
Proposed Bent 2 between creek and existing Bent 3 likely large diameter column with hammerhead – constructability and permit concerns

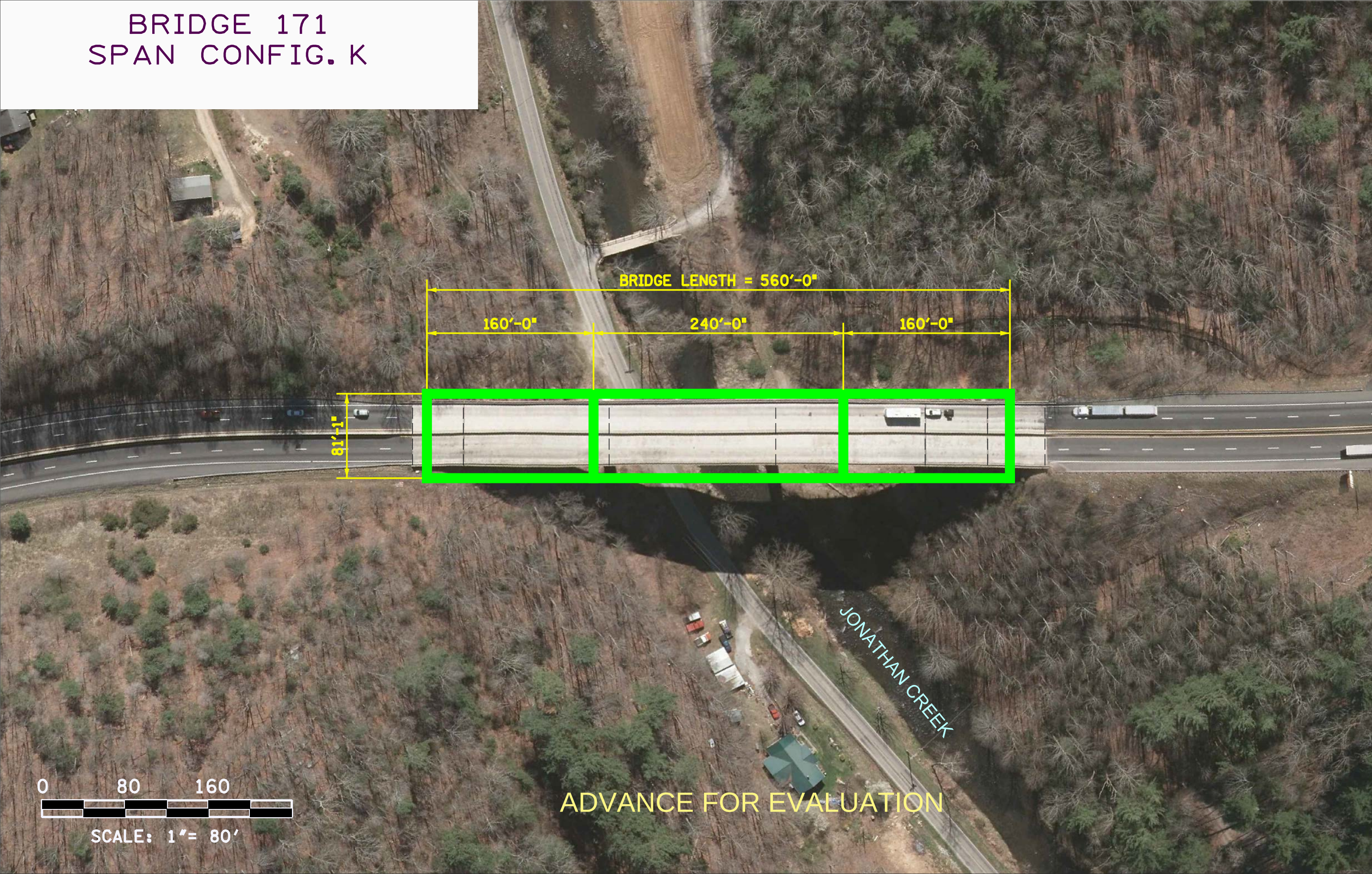
BRIDGE 171
SPAN CONFIG. J



SCALE: 1"= 80'

ADVANCE FOR EVALUATION

BRIDGE 171
SPAN CONFIG. K



VALUE ENGINEERING / PLANNING PROCESS

The ultimate goal of a VE study is to carefully transform the needs and desires for a project into functions. The team then speculates ideas for all functions and develops a solution that scores high on performance with a reasonable acceptance and cost. At the end, VE efforts result in a solution that satisfies owners, users and stakeholders. The VE team keeps the following three principles in mind when determining value:

1. Every action is required or desired by someone (Stakeholders)
2. Every action has a reason or purpose (Function)
3. The cost of each action must be justified within the limits of constraints (Function Cost)

INFORMATION PHASE

The purpose of the Information Phase is to gain an understanding of the project and the stakeholders who will be affected. The information phase can be summarized as follows:

- Review all relevant project information, including description and scope of work
- Identify owners, users and stakeholders
- Identify needs, desires and constraints of owners, users and stakeholders

FUNCTION ANALYSIS PHASE

- Using stakeholder needs, desires and constraints, develop project related functions
- Determine the task, basic function(s) and supporting functions
- Estimate the cost of project elements and each critical function
- Analyze owner and stakeholder attitudes toward each function

SPECULATION PHASE

The purpose of the Speculation Phase is to identify ideas that will perform the project functions or will enhance performance or acceptance at a reasonable cost.

EVALUATION PHASE

The purpose of the Evaluation Phase is to identify the most outstanding alternatives for further development. This identification is accomplished through a series of screening processes that sort ideas by comparison and combination. Using these ideas, alternatives are developed. These alternatives are then rated for performance, acceptance and cost.

DEVELOPMENT PHASE

The purpose of the Development Phase is to add information that facilitates selection of a preferred alternative. This is accomplished by comparing the remaining alternatives. The following rules are considered during the Development Phase:

- Recognize ideas that may be unique
 - Conduct research, as required, to provide additional information
 - Analyze weaknesses of selected alternatives and provide improvements
-

INFORMATION PHASE**DESCRIPTION OF OWNERS, USERS AND STAKEHOLDERS**

In general, everyone involved in a project is a stakeholder. However, during this part of the Information Phase, they are grouped separately as owners, users and stakeholders, as defined below:

OWNERS THOSE WHO:

1. Own the project
2. Fund the project
3. Share in the funding
4. Represent the owner's interests
5. Manage the project for the owner

USERS THOSE WHO:

1. Use the project
2. Operate the project
3. Maintain the project

STAKEHOLDERS THOSE WHO ARE:

1. Financially affected by the project
2. Environmentally concerned about the project
3. Disturbed by a required change in habits or recreation

These groupings help the VE Team better understand what the project does and what it should do. In subsequent sections, the owners, users and stakeholders will be referred to only as stakeholders.

DESCRIPTION OF CONSTRAINTS, NEEDS AND DESIRES

Each stakeholder expects something from the project. Stakeholder expectations were then grouped into constraints, needs and desires, as defined below:

CONSTRAINTS

1. Legal requirements
2. Standards of the owner
3. Physical site conditions
4. Stakeholder commitments

NEEDS

1. Expectations that must be fulfilled if constraints are not violated
2. Limitations or restrictions that are imposed by stakeholders but which can be violated (the degree of violations will be considered in the evaluation of alternatives)

DESIRES

1. Expectations that should be fulfilled if cost is not a factor

North Carolina DOT I-40 CMGC Bridge Improvements

Haywood County, North Carolina

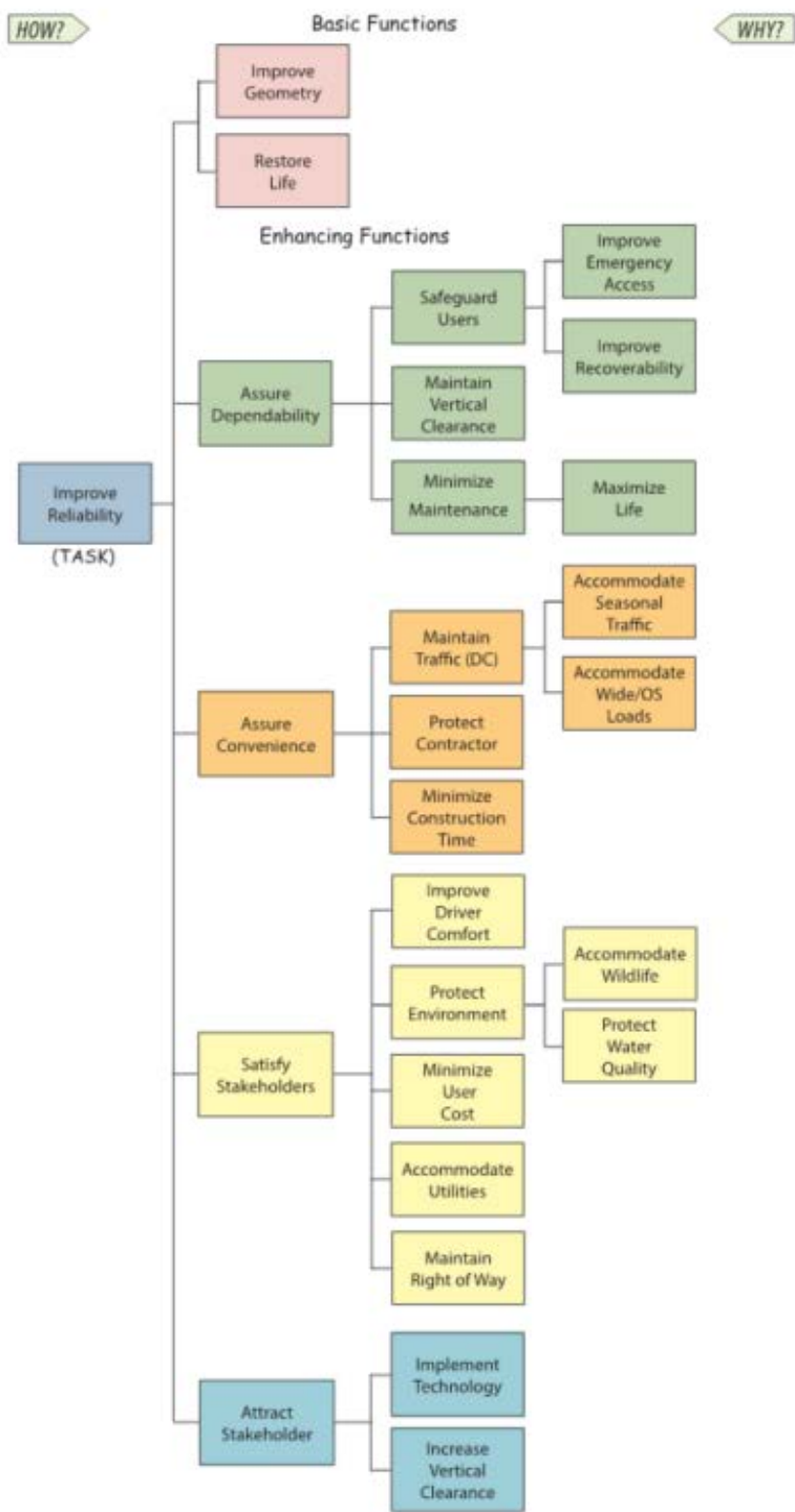
Owners	Users	Stakeholders
<i>Financially Responsible for funding the project</i>		<i>Financially affected by the project</i>
<i>Shares in the funding</i>	<i>Actively uses or maintains the project</i>	<i>Environmentally concerned about the project</i>
<i>Represents the Owner's Interests</i>		<i>Disturbed by a required change in habits or recreation</i>
North Carolina DOT	Eastbound I-40 Traffic	US Forest Service
FHWA	Westbound I-40 Traffic	NC DENR
	Freight Traffic	NC Wildlife Resources Commission
	Tourists	US Fish & Wildlife
	Minor Road Traffic	US Forest Service
	Exiting Traffic	NC DENR
	Landfill Traffic	NC Wildlife Resources Commission
	NCDOT Maintenance Crews	US Fish & Wildlife
	NCDOT Bridge Inspectors	Wildlands Network
	Contractors	National Parks Conservation Association
	Cold Springs Creek Road Traffic	Hunters
	Fines Creek Road Traffic	Nearby Residents
	White Oak Road Traffic	US Army Corps of Engineers
	NCDOT IMAP	National Parks Users
	I-40 Seasonal traffic	Anglers
	School Traffic	Campground (accommodate horses)
	AT&T (Bell South) - verify	Kayak/Canoe Boater
	Frontier (Verizon) - verify	Historical structures/property
	Haywood EMC	Archaeological Agencies
	Duke Elec - verify	First Responders / Emergency Responders
		Highway Patrol / Sheriff
		FERC
		Landfill
		Haywood County
		State of Tennessee
		Cocke County
		TDOT
		TN Highway Patrol
		TDOT Help Trucks
		University - Research
Bridge 057		
	Utilities	US Forest Service
Bridge 124		
	Utilities	
	Landfill Users	
	Landfill Operators	
Bridge 142 - Pigeon River		
		Adjacent Homeowner
Bridge 159		
	Utilities	
Bridge 171 - Jonathan Creek		
	Utilities (under bridge)	Adjacent Homeowner
	Anglers	Private bridge owner
		Trout restrictions

North Carolina DOT I-40 CMGC Bridge Improvements

Haywood County, North Carolina

Constraints	Needs	Desires
Legal Requirement Standards of the Owner Physical conditions of the site Commitments to stakeholders	Expectations that must be fulfilled by the project if constraints are not violated Limitations or restrictions that are imposed by stakeholders but which can be violated	Expectations that should be fulfilled if cost is not a factor
No work in streams between Jan 1 and April 15 during trout moratorium	Maintain one lane of traffic on I-40 in both directions during construction	Start construction in 12 to 18 months
Protect streams from debris during removal and construction	Follow NCDOT policy for detours	Complete Bridge 57 in 2020
Observe work restrictions and moratoriums for T&E species	Provide "jump outs" for elk within corridor	Complete all work by 2022
Comply with requirements associated with funding from other sources.	Provide barriers to discourage large animals from entering roadway	Work done within existing R/W
Maintain two lanes of traffic in both directions on I-40 during construction between Memorial Day and Labor Day	Wider shoulders for wildlife on streets below	Categorical Exclusion
Cannot block more than 50% of waterways	Minimize maintenance	Accelerated Bridge Construction
Tree Removal limited to between October 15th and April 15 (Indiana bat)	Extend bridge life	Reduce large animal impacts in the corridor
Provide 10' shoulders	Minimize joints	Make I-40 corridor ecologically friendly
	Provide corrosion resistant details	Minimize the amount of time traffic is impacted
	No closed system for drains	Maintain two lanes of traffic in both directions on I-40 during construction from Easter through Memorial Day
	Complete all work by 2023	Maintain two lanes of traffic in both directions on I-40 during construction from Labor Day through Thanksgiving
	Utilize concrete over steel	Maintain two lanes of traffic in both directions on I-40 during construction from Thanksgiving through Christmas
		Accommodate Wide/oversize/overweight loads
		Avoid cold weather concrete pours
		Improve durability of structural elements
		Implement/Utilize ITS
		Accommodate Historical/Architectural resources
		Provide 12' shoulders
		Utilize incentives
		Minimize User cost
		Use FHWA Everyday Counts Funding??
Bridge 057		
No changes to profile or alignment on Interstate	Provide for elk passage	Avoid work in Creek
Comply with moratorium schedules	Discourage elk from entering road/ramps	Increase vertical Clearance
US Forest Service (Bridge/Roadway must remain on easement)	Wider shoulders for wildlife on minor road	
Maintain Existing underclearance	Follow NCDOT policy for detours	
Do not enclose creek (i.e. no culvert)	Discourage animal grazing in median	
Bridge 124		
Maintain existing opening width beneath bridge	Increase opening width beneath bridge	Single span
Maintain Existing underclearance	Coordinate replacement with other bridges	Increase vertical Clearance
Bridge 142		
Protect adjacent residence		Maximize span lengths
No MSE walls in area of flowing water		Avoid joints at abutments
		No night work
		Minimal Tree Clearing
		No lights
		Bench for wildlife
Bridge 159		
Maintain Existing underclearance	No change in profile on Interstate	Single barrel culvert
	Coordinate lane closures with bridge 171	17-foot vertical clearance
Bridge 171		
Comply with moratorium schedules		Utilize bench for wildlife passage
		Minimize number of piers
		Lengthen spans
		Complete Reconstruction
		Protect hellbender
		Avoid work in Creek
		No night work
		Minimal Tree Clearing
		No lights

No.	Function	Dependability	Convenience	Satisfy Stakeholders	Attract Stakeholders	Basic Function	Task				
							057	124	142	159	171
1	Maintain connectivity										
2	Improve driver comfort										
3	Improve reliability						X	X	X	X	X
4	Minimize user cost										
5	Minimize construction time										
6	Maintain underpass vert. clearance										
7	Increase underpass vert. clearance										
8	Protect environment										
9	Accommodate wildlife										
10	Minimize future maint.										
11	Inform user DC										
12	Accommodate seasonal traffic										
13	Maintain ROW										
14	Accommodate wide/OS loads										
15	Improve emergency access										
16	Protect contractor										
17	Improve geometry										
18	Restore life										
19	Safeguard users										
20	Improve recoverability										
21	Maximize life										
22	Protect Water Quality										
23	Accommodate Utilities										
24	Implement Technology										



Rejection Reasoning
R1 Violates Constraint
R2 Not Feasible
R3 Too Expensive
R4 Low Public Acceptance
R5 Low Benefit
R6 Duplicate Idea
R7 High Cost/Low Benefit
R8 Outside Scope/Beyond Study Area
R9 Environmental Complications
R10 Combine with another idea
S = Selected for further consideration

	SR 57 - Harmons Den	Comments
1	Single Span	S
2	Single Span - Curved Girder	R7
3	Two Span	S
4	Three Span	S
5	Four Span	S
6	Use wraparound soil nail wall at abutment	R5
7	Use wraparound soldier pile wall at abutment	R5
8	Utilize existing western end bent	R5
9	Utilize existing eastern end bent	R5
10	Utilize existing piers	R5
11	lengthen bridge to West	S
12	lengthen bridge to East	S
13	Shorten bridge to West	S
14	shorten bridge to East	S
15	Maintain Vertical Clearance (14' - 3")	S
16	Increase vertical clearance	S
17	Lower roadway below (USFS / Old Spring Creek)	S
18	Tow Contract	S
19	Steel Bridge	R7
20	Concrete Bridge	S
21	Florida I Beams	S
22	Crane Erection	S
23	Integral Abutments (End Bents)	S
24	Weathering steel	R7
25	Precast deck panels	R7
26	Expansion joints at End Bents	S
27	Black rebar	S
28	Epoxy rebar	S
29	Stainless steel rebar	R3
30	GFRP Reinforcement	R3
31	Sealing sub structure units	S
32	Widen bridge	S
33	Offset bridge to North	R5
34	Offset bridge to South	R5
35	6 ft shoulder	R1
36	10 ft shoulder	S

	SR 57 - Harmons Den	Comments
37	12 ft shoulder	S
38	Reduce drains / scuppers	S
39	Closed drainage system	R7
40	Gutter drainage system	R7
41	No drains	S
42	De-icing system	S
43	ITS during construction	S
44	ITS permanent	S
45	Bury Utilities (power lines)	
46	Maintain Utilities	A
47	Relocate Utilities	A
48	Asphalt overlay	R5
49	Latex overlay	S
50	Deck sealer	S
51	PPC overlay	S
52	Independent structures (dual structures)	R5
53	On alignment replacement	S
54	Offset alignment replacement	R5
55	Do not demolish existing piers during staged construction	
56	Use wraparound MSE wall at abutment	S
57	Drilled shaft	S
58	Driven pile foundations	S
59	Carry micropile contingency	S
60	Spread footing	S
61	Hammerhead pier	R2
62	Multi-column pier	S
63	Solid wall pier	R7
64	Spread box	R5
65	Spliced bulb beams	S
66	Segmental box	R2
67	MSE Walls	R1
68	CIP concrete walls	S
69	Maintain residential access	S
70	Stream through culvert (temp pipe)	R1
71	Crane matting / shield over creek	S
72	Partial width staged reconstruction with crossover	S
73	Counter flow on westbound	S
74	Variable message boards during construction	S
75	Complete I-40 closure (duration of all construction)	R1
76	Complete I-40 closure (short term)	S
77	Eliminate spans / fill in I-40 part way	S
78	Advanced sub-structure construction	S
79	Use I-26 detour	R10
80	Use other local detour	R2
81	Rock slide contingency plan	R1
82	Temporary bridge	R7
83	Bridge Slide (built adjacent and slide into place)	R7
84	Meet 3 month window for single lane operations	S
85	Meet 5 month window for single lane operations	S
86	Meet 8 month window for single lane operations	R4

	SR 57 - Harmons Den	Comments
87	Combine Construction with adjacent bridge (171)	S
88	Construct bridge as a separate project	S
89	Link slabs	S
90	Prefabricated deck/slab (modular unit)	S
91	Slip Form barriers	S
92	Zipper barrier	R5
93	Cross Over gates (permanent)	R7
94	Inspection walkway	R7
95	Utility conduit on bridge	S
96	Bat boxes	S
97	Decorative rail	S
98	Form liners	S
99	Bridge lighting	R7
100	Autonomous Vehicle accommadation	S
101	Benching for wildlife	S
102	Causeway	S
103	Piers in waterway	R9
104	Piers out of waterway	S
105	Full Depth, full width, Precast panels with UHPC joints	R7
106	Full depth, full width Precast without transverse construction joints or overlay	R7
107	Partial Depth Precast Panels	R7
108	SIP Metal Decking	S
109	Deeper Superstructures	
110	Micropiles for abutments	S
111	Span Configuration A - 3 span	R7
112	Span Configuration B - 4 span (Existing Bents)	R7
113	Span Configuration C - 2 span (behind existing bents)	S
114	Span Configuration D - 2 span (center pier closer to stream)	S
115	Span Configuration E - Two span (105, 105) - within existing end bents	S
116	Span Configuration F - Two span (124, 131) - beyond existing end bents	S
117	Maintain 13' (min.) lanes (toe to toe) during construction	S
118	Run all traffic on shoulders	R2
119	Run Wide loads on shoulders	R2
120	Advance notification for wide load permits	S
121	Reconfigure roadway below	S
122	Temp signal/flagger on road below	S
123	Close roadway below	S
124	Maintain stability of existing piers during substructure construction	R2
125	Use existing piers to support girders during erection	R2

Rejection Reasoning
R1 Violates Constraint
R2 Not Feasible
R3 Too Expensive
R4 Low Public Acceptance
R5 Low Benefit
R6 Duplicate Idea
R7 High Cost/Low Benefit
R8 Outside Scope/Beyond Study Area
R9 Environmental Complications
R10 Combine with another idea
S = Selected for further consideration

	Fines Creek - Br 124	Comments
1	Single Span	S
2	Single Span 43' - (Inside piers)	S
3	Single Span 58' - (Just Outside piers)	S
4	Two Span	R5
5	Three Span	S
6	Deck Slab Bridge (post tensioned)	R7
7	Wraparound wall around existing piers to create single span	R10
8	Use wraparound soil nail wall at abutment	R2
9	Use wraparound soldier pile wall at abutment	R5
10	Utilize existing western end bent	R5
11	Utilize existing eastern end bent	R5
12	Utilize existing piers	R5
13	Lengthen bridge to west	S
14	Lengthen bridge to east	S
15	Shorten bridge to west	S
16	Shorten bridge to east	S
17	Maintain Vertical Clearance	S
18	Increase vertical clearance to 16'	S
19	Increase vertical clearance to 17' (desirable)	S
20	Lower roadway below (Fines Creek)	S
21	Tow Contract	S
22	"Car culvert"	S
23	Precast Culvert top slab	S
24	CLSM fill for culvert option	S
25	Steel Bridge	R7
26	Concrete Bridge	S
27	Florida I Beams	S
28	Crane Erection	S
29	Integral Abutments (End Bents)	S
30	Weathering steel	R7
31	Precast deck panels	R7
32	Expansion joints at End Bents	S
33	Black rebar	S
34	Epoxy rebar	S
35	Stainless steel rebar	R3
36	GFRP Reinforcement	R3

	Fines Creek - Br 124	Comments
37	Sealing sub structure units	S
38	Re-deck bridge and save piers/beams	R5
39	Use chloride resistant concrete	S
40	Use added cover for durability	S
41	Space rebar for increased crack control	S
42	Eliminate joints	S
43	Widen bridge	S
44	Offset bridge to North	R5
45	Offset bridge to South	R5
46	6 ft shoulder	R1
47	10 ft shoulder	S
48	12 ft shoulder	S
49	Reduce drains / scuppers	S
50	Closed drainage system	R7
51	Gutter drainage system	R7
52	No drains	S
53	De-icing system	S
54	ITS during construction	S
55	ITS permanent	S
56	Bury Utilities (power lines)	R7
57	Maintain Utilities	S
58	Relocate Utilities	S
59	Asphalt overlay	R5
60	Latex overlay	S
61	Deck sealer	S
62	PPC overlay	S
63	Independent structures (dual structures)	R5
64	On alignment replacement	S
65	Offset alignment replacement	R5
66	Do not demolish existing piers during staged construction	
67	Use wraparound MSE wall at abutment	S
68	Drilled shaft	S
69	Driven pile foundations	S
70	Carry micropile contingency	S
71	Spread footing	S
72	Hammerhead pier	R2
73	Multi-column pier	S
74	Solid wall pier	R7
75	Spread box	R5
76	Spliced bulb beams	R2
77	Segmental box	R2
78	MSE Walls	S
79	CIP concrete walls	S
80	Soldier Pile wall with CLSM fill	S
81	Maintain local access	S
82	Temp bridge over creek for crane/contractor access	
83	Partial width staged reconstruction with crossover	S
84	Counter flow on westbound	S

	Fines Creek - Br 124	Comments
85	Variable message boards during construction	S
86	Complete I-40 closure (duration of all construction)	R1
87	Complete I-40 closure With I-26 Detour (short term)	S
88	Eliminate spans / fill in I-40 part way	R10
89	Advanced sub-structure construction	S
90	Use I-26 detour	R10
91	Use other local detour	R2
92	Rock slide contingency plan	R1
93	Temporary bridge	R7
94	Bridge Slide (built adjacent and slide into place)	R7
95	Meet 3 month window for single lane operations	S
96	Meet 5 month window for single lane operations	S
97	Meet 8 month window for single lane operations	R4
98	Combine Construction with adjacent bridge (142)	S
99	Link slabs	S
100	Prefabricated deck/slab (modular unit)	S
101	Slip Form barriers	S
102	Zipper barrier	R5
103	Cross Over gates (permanent)	R7
104	Inspection walkway	R7
105	Utility conduit on bridge	S
106	Bat boxes	R5
107	Decorative rail	R7
108	Form liners	R7
109	Bridge lighting	R7
110	Autonomous Vehicle accommodation	S
111	Benching for wildlife	S
112	Causeway	
113	Piers in waterway	
114	Piers out of waterway	
115	Full Depth, full width, Precast panels with UHPC joints	R7
116	Full depth, full width Precast without transverse construction joints or overlay	R7
117	Partial Depth Precast Panels	R7
118	SIP Metal Decking	S
119	Deeper Superstructures	
120	Micropiles for abutments	S
121	Span Configuration A	R5
122	Span Configuration B	R5
123	Span Configuration C	S
124	Span Configuration D	S
125	Span Configuration E	S
126	Three span (200, 240, 200)	
127	Maintain 13' (min.) lanes (toe to toe) during construction	S
128	Advance notification for wide load permits	S
129	Reconfigure roadway below	R5
130	Temp signal/flagger on road below	S
131	Close roadway below	R4
132	Maintain stability of existing piers during substructure construction	S

Rejection Reasoning
R1 Violates Constraint
R2 Not Feasible
R3 Too Expensive
R4 Low Public Acceptance
R5 Low Benefit
R6 Duplicate Idea
R7 High Cost/Low Benefit
R8 Outside Scope/Beyond Study Area
R9 Environmental Complications
R10 Combine with another idea
S = Selected for further consideration

	Pigeon River - Br 142	Comments
1	Two Span	S
2	Three Span	S
3	Four Span	S
4	Steel Bridge	S
5	Concrete Bridge	S
6	Florida I Beams	S
7	Launched girder erection	S
8	Crane erection	S
9	Integral Abutments (End Bents)	S
10	Weathering steel	S
11	Precast deck panels	S
12	Expansion joints at End Bents	S
13	Black rebar	S
14	Epoxy rebar	S
15	Stainless steel rebar	R7
16	GFRP Reinforcement	R7
17	Sealing substructure units	S
18	Lengthen bridge to west	S
19	Lengthen bridge to east	S
20	Shorten bridge to west	S
21	Shorten bridge to east	S
22	Widen bridge	S
23	Offset bridge to North	Do not believe so - R7
24	Offset bridge to South	Do not believe so - R7
25	6 ft shoulder	R1
26	10 ft shoulder	S
27	12 ft shoulder	S
28	Reduce drains / scuppers	S
29	Closed drainage system	R7
30	Gutter drainage system	S
31	No drains	S
32	De-icing system	S
33	ITS during construction	S
34	ITS permanent	S
35	Simple layout / eliminate geometry	
36	Elimination of skew	

	Pigeon River - Br 142	Comments
37	Reduce skew	
38	Elimination of spiral	
39	Elimination of vertical curve (crown)	
40	Asphalt overlay	R5
41	Latex overlay	S
42	Deck sealer	S
43	PPC overlay	S
44	Independent structures (dual structures)	S
45	On alignment replacement	S
46	Offset alignment replacement	R7
47	Closed abutment (encapsulate rock)	
48	Remove rock outcrop	
49	Utilize existing western end bent	R5
50	Utilize existing eastern end bent	R5
51	Utilize existing piers	R5
52	Drilled shaft	S
53	Driven pile foundations	S
54	Spread footing	S
55	Hammerhead pier	R7
56	Multi-column pier	S
57	Solid wall pier	S - possibly for river
58	Spread box	R3
59	Spliced bulb beams	R7
60	Segmental box	R3
61	MSE Walls	S
62	CIP concrete walls	S
63	Soldier Pile wall with CLSM fill	S
64	Soldier Pile wall attached to existing wall	S
65	Maintain/re-use existing wall	S
66	Overwiden south for better ramp acceleration	S
67	Partial width staged reconstruction with crossover	S
68	Counter flow on westbound	S
69	Variable message boards during construction	S
70	Complete I-40 closure (duration of all construction)	R1
71	Complete I-40 closure (short term)	S
72	Eliminate bridges / fill in I-40	R1
73	Advanced sub-structure construction	S
74	Use I-26 detour	R10
75	Use other local detour	R2
76	Rock slide contingency plan	R2
77	Temporary bridge	R3
78	Bridge Slide (built adjacent and slide into place)	R3
79	Meet 3 month window for single lane operations	S
80	Meet 5 month window for single lane operations	S
81	Meet 8 month window for single lane operations	R4
82	Combine Construction with adjacent bridge (124)	S
83	Link slabs	R5
84	Prefabricated deck/slab (modular unit)	R7

	Pigeon River - Br 142	Comments
85	Slip Form barriers	S
86	Zipper barrier	S
87	Cross Over gates (permanent)	S
88	Inspection walkway	S
89	Utility conduit on bridge	S
90	Bat boxes	S
91	Decorative rail	R7
92	Form liners	R7
93	Bridge lighting	R7
94	Autonomous Vehicle accommodation	S
95	Benching for wildlife	S
96	Causeway	S
97	Piers in waterway	S
98	Piers out of waterway	S
99	Full Depth, full width, Precast panels with UHPC joints	S
100	Full depth, full width Precast without transverse construction joints or overlay	S
101	Partial Depth Precast Panels	R5
102	SIP Metal Decking	S
103	Deeper Superstructures	R5
104	Micropiles for abutments	S
105	Span Configuration A - Shorten Overall w/ 3 span	S
106	Span Configuration B - 5 span -reuse existing	R7
107	Span Configuration C - 2 Span; re-use existing	R7
108	Span Configuration D - 2 span (202 - 145)	S
109	Span Configuration E - 2 span (145-200)	S
110	Span Configuration F (152-152)	S
111	Span Configuration G (2 span)- overall longer spans; new end bents behind existing end bents (200 - 200)	S
112	Span Configuration H (2 span)- keep west end abut (& wall); at east - new end bent in front (180-180)	S
113	Span Configuration I (3 span)- overall longer length; 3 equal spans; piers in water (134-134-134)	S
114	Span Configuration J (3 span)- keep west end abut (& wall); at east - new end bent in front (120 -120 -120)	S
115	Maintain 13' (min.) lanes (toe to toe) during construction	S
116	Advance notification for wide load permits	S
117	Maintain stability of existing piers during substructure construction	S
118	Use existing piers to support girders during erection	S

Rejection Reasoning
R1 Violates Constraint
R2 Not Feasible
R3 Too Expensive
R4 Low Public Acceptance
R5 Low Benefit
R6 Duplicate Idea
R7 High Cost/Low Benefit
R8 Outside Scope/Beyond Study Area
R9 Environmental Complications
R10 Combine with another idea
S = Selected for further consideration

	SR 1338 - Br 159	Comments
1	Single Span	S
2	Single Span 47' - (Inside piers)	S
3	Single Span 72' - (Just outside piers)	S
4	Single Span 78'	S
5	Two Span	R5
6	Three Span	S
7	Deck Slab Bridge (post tensioned)	R7
8	Use wraparound soil nail wall at abutment	R2
9	Use wraparound soldier pile wall at abutment	R5
10	Utilize existing western end bent	R5
11	Utilize existing eastern end bent	R5
12	Utilize existing piers	R5
13	Lengthen bridge to west	S
14	Lengthen bridge to east	S
15	Shorten bridge to west	S
16	Shorten bridge to east	S
17	Maintain Vertical Clearance	S
18	Increase vertical clearance	S
19	Lower roadway below (White Oak)	S
20	Tow Contract	S
21	"Car culvert"	S
22	Precast Culvert top slab	S
23	CLSM fill for culvert option	S
24	Steel Bridge	R7
25	Concrete Bridge	S
26	Florida I Beams	S
27	Crane Erection	S
28	Integral Abutments (End Bents)	S
29	Weathering steel	R7
30	Precast deck panels	R7
31	Expansion joints at End Bents	S
32	Black rebar	S
33	Epoxy rebar	S
34	Stainless steel rebar	R3
35	GFRP Reinforcement	R3
36	Sealing sub structure units	S

	SR 1338 - Br 159	Comments
37	Widen bridge	S
38	Offset bridge to North	R5
39	Offset bridge to South	R5
40	6 ft shoulder	R1
41	10 ft shoulder	S
42	12 ft shoulder	S
43	Reduce drains / scuppers	S
44	Closed drainage system	R7
45	Gutter drainage system	R7
46	No drains	S
47	De-icing system	S
48	ITS during construction	S
49	ITS permanent	S
50	Bury Utilities (power lines)	Strikethrough
51	Maintain Utilities	S
52	Relocate Utilities	S
53	Asphalt overlay	R5
54	Latex overlay	S
55	Deck sealer	S
56	PPC overlay	S
57	Independent structures (dual structures)	R5
58	On alignment replacement	S
59	Offset alignment replacement	R5
60	Do not demolish existing piers during staged construction	Strike through
61	Use wraparound MSE wall at abutment	S
62	Drilled shaft	S
63	Driven pile foundations	S
64	Carry micropile contingency	S
65	Spread footing	S
66	Hammerhead pier	R2
67	Multi-column pier	S
68	Solid wall pier	S
69	Spread box	R5
70	Spliced bulb beams	R2
71	Segmental box	R2
72	MSE Walls	S
73	CIP concrete walls	S
74	Soldier Pile wall with CLSM fill	S
75	Maintain residential access	S - change to local access
76	Temp bridge over creek for crane/contractor access	
77	Partial width staged reconstruction with crossover	S
78	Counter flow on westbound	S
79	Variable message boards during construction	S
80	Complete I-40 closure (duration of all construction)	R1
81	Complete I-40 closure (short term)	S
82	Eliminate spans / fill in I-40 part way	R10
83	Advanced sub-structure construction	S
84	Use I-26 detour	R10

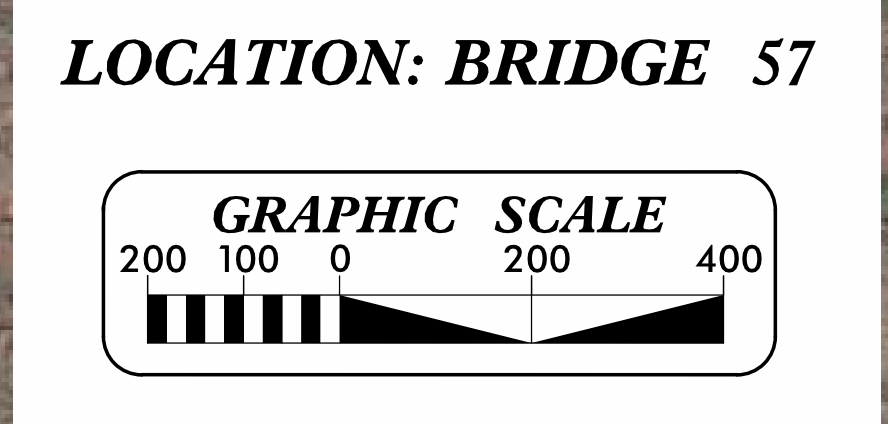
	SR 1338 - Br 159	Comments
85	Use other local detour	R2
86	Rock slide contingency plan	R1
87	Temporary bridge	R7
88	Bridge Slide (built adjacent and slide into place)	R7
89	Meet 3 month window for single lane operations	S
90	Meet 5 month window for single lane operations	S
91	Meet 8 month window for single lane operations	R4
92	Combine Construction with adjacent bridge (171)	S
93	Construct bridge as a separate project	?
94	Link slabs	S
95	Prefabricated deck/slab (modular unit)	S
96	Slip Form barriers	S
97	Zipper barrier	R5
98	Cross Over gates (permanent)	R7
99	Inspection walkway	R7
100	Utility conduit on bridge	S
101	Bat boxes	R5
102	Decorative rail	R7
103	form liners	R7
104	bridge lighting	R7
105	Autonomous Vehicle accommodation	S
106	Benching for wildlife	S
107	Causeway	
108	Piers in waterway	
109	Piers out of waterway	
110	Full Depth, full width, Precast panels with UHPC joints	R7
111	Full depth, full width Precast without transverse construction joints or overlay	R7
112	Partial Depth Precast Panels	R7
113	SIP Metal Decking	S
114	Deeper Superstructures	
115	Micropiles for abutments	S
116	Span Configuration A	R7
117	Span Configuration B	R7
118	Span Configuration C	S
119	Span Configuration D	S
120	Span Configuration E	S
121	Three span (200, 240, 200)	
122	Maintain 13' (min.) lanes (toe to toe) during construction	S
123	Advance notification for wide load permits	S
124	Reconfigure roadway below	S
125	Temp signal/flagger on road below	S
126	Close roadway below	S
127	Maintain stability of existing piers during substructure construction	S
128	Use existing piers to support girders during erection	S

Rejection Reasoning
R1 Violates Constraint
R2 Not Feasible
R3 Too Expensive
R4 Low Public Acceptance
R5 Low Benefit
R6 Duplicate Idea
R7 High Cost/Low Benefit
R8 Outside Scope/Beyond Study Area
R9 Environmental Complications
R10 Combine with another idea
S = Selected for further consideration

	Jonathan Creek - Br 171	Comments
1	Two Span	S
2	Three Span	S
3	Four Span	S
4	Five Span	S
5	Steel Bridge	S
6	Concrete Bridge	S
7	Florida I Beams	S
8	Launched girder erection	S
9	Crane erection	S
10	Integral Abutments (End Bents)	S
11	Open Joints at end bents	S
12	Weathering steel	S
13	Precast deck panels	S
14	Expansion joints at End Bents	S
15	Black rebar	S
16	Epoxy rebar	S
17	Stainless steel rebar	R7
18	GFRP Reinforcement	R7
19	Sealing sub structure units	S
20	Lengthen bridge to west	S
21	Lengthen bridge to east	S
22	Shorten bridge to west	S
23	Shorten bridge to east	S
24	Widen bridge	S
25	Offset bridge to North	R7
26	Offset bridge to South	R7
27	6 ft shoulder	R1
28	10 ft shoulder	S
29	12 ft shoulder	S
30	Reduce drains / scuppers	S
31	Closed drainage system	R7
32	Gutter drainage system	S
33	No drains	S
34	De-icing system	S
35	ITS during construction	S
36	ITS permanent	S

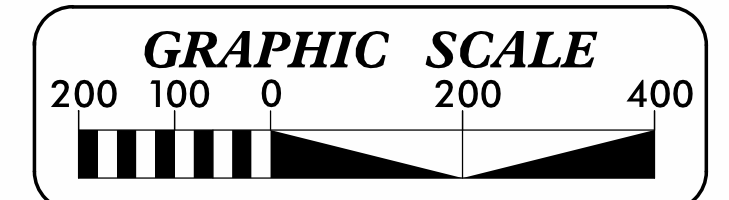
	Jonathan Creek - Br 171	Comments
37	Bury Utilities (power lines)	S
38	Maintain Utilities	S
39	Relocate Utilities	S
40	Asphalt overlay	R5
41	Latex overlay	S
42	Fiber Reinforced Concrete for Bridge Deck	S
43	Deck sealer	S
44	PPC overlay	S
45	Independent structures (dual structures)	S
46	On alignment replacement	S
47	Offset alignment replacement	R7
48	Do not demolish existing piers during staged construction	S
49	Use wraparound MSE wall at abutment	S
50	Use wraparound soil nail wall at abutment	R2
51	Use wraparound soldier pile wall at abutment	R7
52	Utilize existing western end bent	R5
53	Utilize existing eastern end bent	R5
54	Utilize existing piers	R5!
55	Drilled shaft	S
56	Driven pile foundations	S
57	Spread footing	S
58	Hammerhead pier	R3
59	Multi-column pier	S
60	Solid wall pier	R3
61	Spread box	R2
62	Spliced bulb beams	R7
63	Segmental box	R3
64	MSE Walls	S
65	CIP concrete walls	S
66	Soldier Pile wingwall with CLSM fill	S
67	Maintain residential access	S
68	Temp bridge over creek for crane/contractor access	S
69	Partial width staged reconstruction with crossover	S
70	Use counterflow to facilitate staged construction	S
71	Variable message boards during construction	S
72	Complete I-40 closure (duration of all construction)	R1
73	Complete I-40 closure With I-26 Detour (short term)	S
74	Eliminate bridges / fill in I-40 part way	R10
75	Advanced sub-structure construction	S
76	Use I-26 detour	R10
77	Use other local detour	R2
78	Rock slide contingency plan	R2
79	Temporary bridge	R3
80	Bridge Slide (built adjacent and slide into place)	R3
81	Meet 3 month window for single lane operations	S
82	Meet 5 month window for single lane operations	S
83	Meet 8 month window for single lane operations	R4
84	Combine Construction with adjacent bridge (159)	S

	Jonathan Creek - Br 171	Comments
85	Link slabs	R5
86	Prefabricated deck/slab (modular unit)	R7
87	Slip Form barriers	S
88	Zipper barrier	R5
89	Cross Over gates (permanent)	S
90	Inspection walkway	S
91	Utility conduit on bridge	S
92	Bat boxes	S
93	Decorative rail	R7
94	Form liners	R7
95	Bridge lighting	R7
96	Autonomous Vehicle accommodation	S
97	Benching for wildlife	S
98	Causeway	S
99	Piers in waterway	R5
100	Piers out of waterway	S
101	Full Depth, full width, Precast panels with UHPC joints	S
102	Full depth, full width Precast without transverse construction joints or overlay	S
103	Partial Depth Precast Panels	R5
104	SIP Metal Decking	S
105	Deeper Superstructures	R5
106	Micropiles for abutments	S
107	Span Configuration A - 3 span (100 -200 -150)	S
108	Span Configuration B - 3 Span (150-200-150)	S
109	Span Configuration C - 3 Span (150-160-150) - using existing piers	R7
110	Span Configuration D - 4 span (120-160-140-85) - using existing Piers	R7
111	Span Configuration E - 5 span (100-110-110-110-95)	S
112	Span Configuration F - (85-110-110-110-95)	S
113	Span Configuration G - 3 span (offset bridge)	R7
114	Span Configuration H - Three span (200, 240, 200) - End Bents behind existing	S
115	Span Configuration I - Four span - End Bents in front of existing (140-160-140-100)	S
116	Span Configuration J - Four span - End Bents behind existing & skewed Pier - (120-140-140-130-90)	S
117	Span Configuration K (Modified B) end bents in front of existing - (160-240-160)	S
118	Maintain 13' (min.) lanes (toe to toe) during construction	S
119	Advance notification for wide load permits	S
120	Reconfigure roadway below	S
121	Temp signal/flagger on road below	S
122	Close roadway below	S
123	Maintain stability of existing piers during substructure construction	S
124	Use existing piers to support girders during erection	S





**LOCATION: BRIDGE 124
AND BRIDGE 142**





**LOCATION: BRIDGE 159
AND BRIDGE 171**

GRAPHIC SCALE

200 100 0 200 400