Whitewater State Park Culverts
Bridges 8592, 8593, 8594 & 8595
TH 74 over Drainage Channels
Condition and Rehabilitation Study
July 2018

Bridge 8592

Bridge 8593

Bridge 8594

Bridge 8595

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION
AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

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LHB Project No. 160986.00
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I. EXECUTIVE SUMMARY

The Minnesota Department of Transportation (MnDOT) is evaluating options for rehabilitating or replacing six culverts that carry TH 74 over a drainage channel in Whitewater State Park under State Project 8508-38. This report studies rehabilitation alternatives for the southern four of the six culverts carrying Trunk Highway (TH) 74 over drainage channels in Whitewater State Park. The northern two culverts lie outside of the boundaries of the Whitewater State Park Historic District and will be studied separately.

The four culverts were designed by the National Park Service, Minnesota Department of Highways and the Minnesota Department of Conservation and constructed by a WPA Transient Camp located in the park. The culverts (Bridges 8592, 8593, 8594 & 8595) are contributing resources in the Whitewater State Park Historic District and construction was completed in the fall of 1936. The Whitewater State Park Historic District is listed in the National Register of Historic Places. All four culverts are currently in fair to poor condition.

This rehabilitation study report: summarizes the information gathered regarding the structures’ condition and history; outlines the process undertaken to develop and assess rehabilitation alternatives; details the scope of each alternative, including its compatibility with the Secretary of the Interior’s Standards for Rehabilitation; and concludes with the selection of rehabilitation alternatives to be carried forward to the NEPA document.

Multiple alternatives for each bridge site were studied and compared to inform the selection of rehabilitation alternatives to be carried forward to the NEPA document. For all bridges, Alternative 1 proposes to do nothing to the structure and Alternative 2 proposes to perform a basic rehabilitation. All additional alternatives studied (Alternative 2A, 2B, 2C, etc.) propose a scope that satisfies the evaluation criteria beyond a basic rehabilitation.

The “Rehabilitation with Soil Reinforcement” alternatives for each bridge have been chosen to be carried forward to the NEPA document. These alternatives comprehensively meet the project need of a structurally sound crossing and preserves the integrity of the historic structure while also being an economical rehabilitation solution. The Soil Reinforcement alternative does not result in an adverse effect to the historic district as a result of the rehabilitation scope for the individual contributing elements, under Section 106 of the National Historic Preservation Act. See Section XIII for details of the selection of alternatives to be carried forward for each culvert.
II. PROJECT LOCATION
III. PROJECT OVERVIEW

Study Objectives
The Minnesota Department of Transportation (MnDOT) is evaluating options for rehabilitating or replacing six culverts (Bridges 8592, 8593, 8594, 8595, 5836 & 5835) that carry TH 74 over a drainage channel in Whitewater State Park under SP 8508-38. The state park is located in southeastern Minnesota’s Winona County. The northern two culverts (Bridges 5836 & 5835) lie outside of the historic district boundaries and will be evaluated within a separated study/report. The purpose of this study is to investigate the feasibility of rehabilitation of Bridges 8592, 8593, 8594 & 8595 and to explore alternatives that may satisfy Section 106 of the National Historic Preservation Act and Section 4(f) of the Department of Transportation Act of 1966 (as amended). The key steps in this process include:

- Assessment of the current condition of the structure
- Updating the load capacity rating for the current state of the structure
- Development of evaluation criteria for rehabilitation alternatives
- Development of rehabilitation alternatives and evaluation matrix
- Selection of rehabilitation alternative(s) to be carried forward to the NEPA Document

Study Participants
A series of meetings were held with a core group of individuals from various agencies to ensure that the project was coordinated with all interested parties from the start of the study. These agencies and firms include:

- MnDOT Bridge Office
  - Angel Staples
- MnDOT District 6
  - Richard Augustin
  - Steve Kirsch
  - Kyle Lake
  - Nathan Gregor
  - Craig Lenz
  - Gary Lovelace
  - Tony Wagner
  - Jake Gasper
- MnDOT Cultural Resources Unit
  - Kristen Zschomler
  - Linda Pate
- Minnesota State Historic Preservation Office (SHPO)
  - Kelly Gragg-Johnson
- FHWA
  - Phil Forst
  - Abbi Ginsberg
- Minnesota DNR
  - Miranda VanVleet
  - Brent Anderson
  - Nick Schwaegerl
  - Stacy Smith
  - Gretchen Miller
  - Jeremy Darst
- LHB (Consulting Engineer)
  - Joe Litman
  - Lisa Karlgaard
- Gemini Research (Consulting Historian)
  - Sue Granger
  - Scott Kelly
Historic Review

Bridges 8592, 8593, 8594, and 8595 are contributing elements in the Whitewater State Park historic district which is listed in the National Register of Historic Places. Properties that are listed in, or eligible for, the National Register meet the definition of “historic” properties under Section 106 of the National Historic Preservation Act of 1966. Section 106 requires that federally-funded, -permitted, and -licensed undertakings take historic properties into consideration during project planning and implementation. Section 106 also requires that government agencies and interested parties consult on ways to avoid, reduce, and/or mitigate negative impacts to historic properties caused by the undertaking.

Under Section 106, a project is deemed to have an adverse effect if it proposes to “alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register, in a manner that would diminish the integrity of the property’s location, design, setting, materials, workmanship, feeling, or association.” The Act also states that, to avoid an adverse effect, the “alteration of a [historic] property, including restoration, rehabilitation, repair, maintenance, stabilization” must be “consistent with the Secretary of the Interior’s Standards for the Treatment of Historic Properties (36 CFR part 68) [SOI Standards] and applicable guidelines.” The project must also avoid diminishing the integrity of other historic properties in the project area.

Because the culverts are located within a National Register-listed historic district, they also fall within the purview of the Minnesota Historic Sites Act of 1966. This statute directs state agencies to consult with the Minnesota Historical Society if projects they undertake will impact properties listed in the National Register and/or in the State Register of Historic Places. MnDOT, through its Cultural Resources Unit, determines whether an undertaking meets the SOI Standards and consults with the State Historic Preservation Office on ways to avoid, reduce, and mitigate potential adverse effects.

According to MnDOT’s Management Plan for Historic Bridges (2015), the preferred option for the treatment of a historic bridge is rehabilitation for continued vehicular use on-site, with the rehabilitation following the SOI Standards. MnDOT’s historic bridge program also encourages historic bridge projects to explore context-sensitive solutions during project planning, including the use of tools such as design exceptions, where practical, to help preserve a bridge’s historic integrity.

National Register-listed and -eligible properties also fall within the purview of Section 4(f) of the Transportation Act of 1966. Under Section 4(f), a federally-funded transportation project cannot “use” a historic property unless there is no prudent and feasible alternative to the use and the undertaking includes all possible planning to minimize harm.
Purpose and Need Statement

A purpose and need statement was prepared by the Study Participants and is the basis of the study. This report focuses on the southern 4 bridges within the historic district, but the overall project includes 6 structures (5835 and 5836 are not eligible for the national register and are not contributing resources to the Whitewater State Park Historic District). The final purpose and need statement is as follows:

The purpose of the project is to provide six (6) structurally sound bridge crossings to carry Trunk Highway (TH) 74 over dry runs through Whitewater State Park.

Bridges 8592, 8593, 8594, 8595, 5835 and 5836 were constructed between 1936 and 1938 as part of an overall project to reconstruct TH 74 and to further protect it from ongoing erosion. Bridges 8592, 8593, 8594 and 8595 lie within the Whitewater State Park Historic District and are contributing resources. Bridges 5835 and 5836 lie outside of the Historic District and they are not individually eligible for the National Register.

Need – Bridge Condition

All six structures feature corrugated, multi-plate, metal arches with some experiencing noticeable deformations. Current sufficiency ratings for the structures range from 48.6 to 93.8 with 5 of the 6 structures currently classified as Structurally Deficient. The stone masonry headwalls, wingwalls and knee walls are in varying stages of deterioration with the stones and mortared joints either cracked, damaged or missing. Due to deterioration of the culvert concrete floors, water is flowing beneath the inverts, leading to undetected erosion and distress to the arch knee wall foundations. Since the original construction of these structures, the roadway has been widened and the profile has been raised at most of the structures. This has resulted in the roadway inslopes becoming too steep and prone to erosion above many of the headwalls and has increased surcharge loading to the headwalls/wingwalls leading to their accelerated deterioration. The profile grade raise was significant enough to require the addition of steel shoring beams at the tops of the original stone headwalls at two locations and these beams are currently severely corroded and failing.

Available Data

The following reports and studies were utilized as sources of historic background, structure condition and proposed rehabilitation alternatives.

- 2016 MnDOT Bridge Inspection Reports
- 2017 Structure Inventory Reports
- Bridge Inspection and Maintenance Files (MnDOT Archive Files)
- Bridges 8592 (No. 1), 8593 (No. 2), 8594 (No. 3) & 8595 (No. 4) – 1936 Original Layout Plan
- 2008 Bituminous Mill & Overlay, Culvert Lining, Culvert Replacement, Guardrail Replacement & Stone Wall Restoration Plans
- 1935 Roadway Alignment Plan
- Evaluation of the National Register Eligibility of Stone Culverts on T.H. 74, Whitewater State Park, Winona County, Minnesota (Prepared by Gemini Research, 2000)
IV. HISTORIC BACKGROUND AND SIGNIFICANCE

History and Significance of the Whitewater State Park Culverts
Bridges 8592, 8593, 8594, and 8595 were built in 1936.

The culverts were designed by the National Park Service (NPS) and the Minnesota Department of Conservation (now MnDNR) working in cooperation with the Minnesota Department of Highways (MHD). The NPS and Department of Conservation also designed the rest of the New Deal-built resources in Whitewater State Park.

The culverts were built by enrollees of a Works Progress Administration (WPA) transient or homeless persons camp that operated in Whitewater State Park from early 1936 through 1941.

The culverts are associated with: a) the primary effort to develop Whitewater State Park, b) the establishment of TH 74 through the park, c) a broad campaign to improve erosion control in southeastern Minnesota, and d) federal New Deal programs created to counter the Great Depression by providing jobs and housing to the poor while at the same time building needed public infrastructure. They are important examples of the National Park Service Rustic Style and of metal multi-plate arch bridges. The set of four culverts as a drainage system is unique in the state park system.

New Deal Development of Whitewater State Park
The culverts were built as part of the New Deal development of Whitewater State Park.

The park was established by the legislature in 1919 and land acquisition began in 1921. Whitewater was one of the first five state parks established in Minnesota and for many years was the only state park in the southeastern part of the state. Historically, Whitewater has been one of Minnesota’s most popular state parks.

In 1937 the park comprised about 668 acres; today it is 2,733 acres. The park landscape is dominated by steep bluffs, dolomite cliffs, trout streams, conifers, and hardwood forests. TH 74 bisects the park.

For the first 15 years, Whitewater State Park saw relatively few improvements. Then, in the 1930s and early 1940s, the park was extensively developed with an infusion of federal funds and manpower. The improvements were designed by the NPS and the Minnesota Department of Conservation. Labor was provided by the Civilian Conservation Corps (CCC), which operated camps in the park in 1934-1935, and by the WPA, which operated a camp in the park from 1936-1941.

Most of the WPA enrollees who worked on the culverts were homeless men who lived in a WPA transient camp that occupied the preexisting CCC camp. The WPA was established by President Roosevelt in May 1935 near the depth of the Great Depression. The WPA was the New Deal’s largest work relief program in terms of both funding and scope. In Minnesota, 600,000 people worked for the
WPA between 1935 and 1943. While most WPA workers lived at home and reported to a job site, the WPA also operated about 25 work camps to provide room, board, and work for homeless men. Whitewater was one of five state parks to host a WPA transient camp.

The CCC and WPA built Whitewater State Park’s extensive collection of buildings and structures, in addition to building the park roads, trails, campgrounds, parking areas, swimming beach, and other resources. Most of the structures were designed in the National Park Service Rustic Style and most were built of native limestone and rough-sawn timber.

**Reconstruction of TH 74 Through Whitewater State Park**

The culverts were built as part of a project to construct TH 74 through Whitewater State Park. The segment of TH 74 that runs through the park was added to the trunk highway system in 1934. This existing gravel road was realigned and reconstructed to state standards by the MHD in cooperation with the NPS and state Department of Conservation in 1936-1941, at the same time the rest of the park was being developed. The highway project extended between the towns of St. Charles and Elba. Much of the labor was provided by the WPA workers stationed in the park. WPA workers assisted the MHD with bridge and culvert construction, grading, sloping, crushed rock surfacing, installing guardrail, landscaping, and other tasks.

An undated WPA progress report indicates “A road building project has been carried on jointly by the National Park Service and the state highway department along State Highway #74. This work included both common labor and the work of constructing multi-plate steel [sic] arch culverts, and the preliminary work in the construction of the bridge crossing the Whitewater River.” A report for the month of August 1936 indicates “Roadside sloping has been continued along the park road [TH 74] and considerable time has been spent on the retaining walls [flumes] at the ends of the culverts which drain the road ditches. These retaining walls will prevent erosion at the ends of the culverts.” A May 1937 report indicates “Work has continued on the highway sloping and thousands of native trees and shrubs have been planted to blend the sloping into the surrounding landscaping.” Reports for July and August 1937 indicate the WPA was applying crushed rock to the highway surface and installing guardrail. A June 1938 WPA report estimates the highway relocation within the park to be 75 percent complete, and highway construction between the park and Elba to be 15 percent complete. According to the progress reports, reconstruction of the highway both north and south of the park was considered important to increasing the number of visitors to the park.

TH 74 within Whitewater State Park was first paved with bituminous in 1939 as part of the construction project.

**Erosion Control**

The culverts were also built as part of a broad effort to mitigate flooding and soil erosion in the area. Whitewater State Park had been plagued since its establishment by severe erosion and flooding. Soil erosion in hilly southeastern Minnesota was exacerbated at the turn of the century as steep bluff lands...
were cleared for farming. By the time of the Great Depression, repeated flooding and erosion were destroying farmland, washing out roads, and threatening the viability of small towns. The small town of Beaver a few miles north of the park was reportedly flooded more than two dozen times in 1938 alone.

During the New Deal, southeastern Minnesota and west central Wisconsin became the testing grounds for cutting-edge conservation practices developed by scientists and engineers employed by new state and federal conservation agencies and associated universities. The CCC established several camps in southeastern Minnesota targeted specifically to erosion control. These men, including some crews stationed in Whitewater State Park, built diversion channels, flumes, check dams, and drop structures; riprapped streambanks and ditches; and planted large quantities of trees and shrubs to hold the soil in place. Structures were built on both public and private land. Many were built of local stone. The culverts and associated drainage ditches built to protect TH 74 were designed and built as part of this effort, as were additional culverts north and south of the park.

**National Park Service Rustic Style**
The culverts are excellent examples of the National Park Service Rustic Style. The NPS Rustic Style originated in the 1910s-1920s but spread across the country during the Depression thanks to National Park Service construction projects. The style is based on the premise that all manmade structures are intrusive in natural settings and their use should be minimized. When such structures are necessary, they should blend with their environment through the use of native materials, muted colors, low silhouettes, careful massing, rugged textures, hand-built or “primitive” construction methods, and naturalistic plantings. Low construction costs, durability, and minimal maintenance were also important. NPS Rustic Style construction often involved labor-intensive methods that were feasible because of the large labor force available through New Deal work programs.

An influential NPS publication that helped disseminate the style was *Park and Recreation Structures*, a heavily-illustrated style guide published in three volumes in 1938 after being distributed in smaller pieces during previous years. The manual’s advice on culverts and bridges includes:

- “Materials and workmanship should be such that [both the] facing and culvert itself, once constructed, make no demands whatever upon maintenance appropriations.”

- “The headwall . . . should avoid disclosing that it is a mere veneer. Natural rock is certainly the preferred material.”

- “Quite as much care should be given to the design and execution of the culvert headwalls as [to] other park structures. Usual mistakes [to be avoided] are insufficient care in the handling of mortar resulting in sloppy joints, stone of trivial size, and lack of variety in sizes leading to monotony and formality of surface pattern.”
- The “new-born nakedness” of the headwalls will “benefit greatly from the toning influence of a return of natural vegetative growth.”

- “In outward appearance, the bridge calls most importantly for visible assurance of strength and stability.”

- “Overemphasis of the structural elements of the bridge is usually necessary in order to maintain a good scale relationship with the natural elements of the more or less rugged landscape.”

- “Only those [materials] which are native to the area and predominate near the bridge site will constitute a convincingly appropriate and harmonious medium of structural interpretation.”

- “Rugged and informal simplicity in use is the indisputable specification for [masonry’s] proper employment.”

**Local Stone**
The culverts, like the rest of the CCC- and WPA-built resources in Whitewater State Park, are built of stone that was quarried within the park.

The stone is Oneota Dolomite, a hard carbonate rock that ranges in color from tan to gray. This bedrock forms most of the steep cliff exposures in the park and surrounding region. Rather than slowly weathering like some rock, Oneota Dolomite tends to break off in large blocks along vertical fractures. Smaller, angled blocks also fall from the cliffs when loosened during freeze-thaw cycles. Oneota Dolomite in Minnesota was historically quarried for buildings, paving blocks, curbing, riprap, crushed rock, and for the production of lime used in agriculture and construction.

The quarry in Whitewater State Park was operated by CCC and WPA crews. The quarry is still evident along Trout Run Creek Trail in the southern part of the park. (Note on this report’s Project Location map that the historic district’s south boundary has a semicircular projection that encompasses the former quarry.)

**Multi-Plate Metal Arch Bridges**
The culverts are good examples of metal multi-plate arch bridges. The Armco Multi-plate arch was introduced in 1931 by the Armco Culvert Manufacturers Association. The product consisted of curved, thick gauge, galvanized, corrugated iron sheets that could be bolted together to form strong, durable arches mounted on low masonry abutments or knee walls. Armco Multi-plates were cheaper to ship to a site than prefabricated culverts and were aggressively marketed just as New Deal federal dollars were pouring into the nation’s highway system. Armco Multi-plates were widely used in the construction of New Deal-sponsored bridges and culverts. Like the culverts in Whitewater State Park, multi-plate arch bridges usually have headwalls designed in the National Park Service Rustic Style and built of local stone. According to a historic context study of iron and steel bridges in Minnesota, metal multi-plate arch
bridges are almost exclusively associated with Depression-era New Deal construction (Quivik and Martin 1988). The context study explains that after World War II metal multi-plate arches declined in popularity as culvert systems that did not require masonry abutments or headwalls were developed. In 1988 the context study identified about 35 multi-plate arch bridges in Minnesota. Today the number of surviving multi-plate arch structures is believed to be relatively low.

**Description of Bridges 8592, 8593, 8594, and 8595**

The four culverts, built in 1936, are located on the segment of TH 74 that winds through steep, hilly terrain in the southwest part of the park. The land flanking the highway is steep, rocky, and forested. The highway has been paved with bituminous since 1939.

The four culverts are closely spaced and connected by a rock-lined dry run drainage ditch that switches back and forth under the highway through the culverts. An approximately 100-foot segment of the dry-stacked stone walls that are believed to have lined the sides of the ditches is extant at the southeast end of Bridge 8594. The flow drains into the Middle Fork of the Whitewater River.

The culverts are multi-plate arch bridges with stone headwalls and low stone abutments or knee walls. The culverts are designed in the National Park Service Rustic Style.

Each culvert is 10 feet wide. The culverts are skewed. The barrels range in length from 85 to 115 feet. The culverts have no railings or other elements that project above the roadway and therefore are not visible to highway traffic.

Most of the headwalls are accompanied by angled wing walls. Bridges 8593, 8594, and 8595 have limestone flumes at one or both ends designed to guide fast-moving water into or out of the culverts. (See historic plan sheet in this report’s appendices.) The flumes, integral with the culverts, are 10-foot wide, open channels with vertical walls 6 to 12 feet tall. The longest flume is about 40 feet long. The flumes incorporate stepped limestone drop structures designed to slow the speed of the water. The flume at the west end of Bridge 8595 also has an unusual semicircular alcove-like drop structure.

The culvert headwalls, abutments or knee walls, wingwalls, and flumes are built of random ashlar, roughly-squared, limestone (Oneota Dolomite) blocks. In some areas, the stone is nearly coursed. The stones are split- and rock-faced. (None of the blocks have concave faces.) Mortar joints range from .5 to 1.25 inches wide with most joints being between .75 and 1-inch wide. It is believed that the culverts have been repointed at least once.

One original plan sheet has been located. The culverts were largely built to this plan, with some adjustments made for topography and hydrology (see sketch in Appendix D). For example, Bridge 8592 was not built with a planned flume at the west headwall. Also, this bridge’s east wingwalls are angled less acutely than planned. Similarly, Bridge 8594 was built with a flume at the east end that has a
somewhat different shape than drawn on the plan. In addition, the plan sheet shows the culverts with ring stones lining the arches; the four culverts were built without ring stones.

**Alterations**
The stone floors have been covered with poured concrete. Concrete caps have been added to the top of the knee walls. The upper portion of the roadbed has been widened and raised in elevation by several inches. To help support the widened roadbed, the east headwalls of Bridges 8593 and 8594 were supplemented with steel beams around the 1970s. All culverts have deteriorating masonry and some stone loss. A portion of the southwest flume wall of Bridge 8594 is missing. Modern guardrail has been installed. Some of the bridges likely had post and cable guardrail originally.

**National Register Eligibility of Bridges 8592, 8593, 8594, and 8595**
The four culverts are contributing elements within Whitewater State Park CCC/WPA/Rustic Style Historic Resources, a 563-acre historic district that was listed in the National Register of Historic Places in 1989.

The district was listed under National Register Criterion A (broad patterns of history) and Criterion C (design and construction). The areas of significance are Architecture, Landscape Architecture, Recreation, and Politics/Government. The period of significance is 1934-1941.

According to the National Register nomination (Anderson “Whitewater” 1988):

Whitewater State Park CCC/WPA/Rustic Style Historic Resources are historically significant for their association with the social, political and economic impact of the Great Depression and the subsequent development of the various Federal Relief programs which were responsible for their construction. The park was developed by both the Civilian Conservation Corps and the Works Progress Administration, two of the most popular and successful programs from the period. Whitewater State Park Historic Resources are also significant for their association with the development of the Minnesota state park system by providing the only state owned recreational facility in southeastern Minnesota.

Whitewater State Park CCC/WPA/Rustic Style Historic Resources are architecturally significant as an outstanding collection of rustic style buildings and structures featuring native limestone construction. . . . . The park is also architecturally significant for its ability to represent a particularly well developed and diverse collection of rustic style resources. The landscape design for Whitewater State Park is a notable achievement in master planning which successfully located the various functional areas of the park on a problematic site which included land on both sides of State Highway 74.
Character-Defining Features of Bridges 8592, 8593, 8594, and 8595

Character-defining features are prominent or distinctive qualities or elements of a historic property that contribute significantly to its physical character, historic integrity, and significance. A list of character-defining features does not identify all important aspects of an historic property – each contains additional elements of location, design, setting, materials, workmanship, feeling, and association that, together with character-defining features, comprise its historic character and authenticity.

Character-defining features of Bridges 8592, 8593, 8594, and 8595 include:

- Designed in the National Park Service Rustic Style to blend with the natural environment and match other Whitewater State Park structures
- Moderate size (10-foot spans; 85- to 115-foot skewed barrels)
- Oneota Dolomite limestone; split- and rock-faced stones; mostly random ashlar bonding pattern with some coursing
- Armco Multi-Plate metal arches above low concrete and stone abutments or knee walls
- Simple aesthetic treatment
- Flumes and drop structures to guide and slow water
- Closely spaced and interconnected by a stone-lined dry run drainage channel
- Located in a narrow road cut flanked by steep forested bluffs

Character-defining features of the Whitewater State Park CCC/WPA/Rustic Style Historic Resources historic district include, but are not limited to:

- Large collection of resources (buildings, structures, objects, sites, and landscape features) designed by the National Park Service and Minnesota Departments of Conservation and Highways and built by CCC and WPA crews
- Compared to other state parks, an unusually well-developed and diverse set of resources from the period
- Resources developed and sited in response to a physically challenging site
- Resources designed, developed, and sited following NPS Rustic Style precepts
- Resources built of local Oneota Dolomite limestone and rough-cut timber
- Resources developed with labor-intensive methods
- Use areas concentrated in the north half of the historic district with few buildings and structures in the south half or in outlying areas
- Landscape dominated by steep hillsides, stone cliffs, streams, conifers, and hardwood forests
References


V. CONDITION ASSESSMENT

Field Assessment Methodology
To gather information for the existing structures, a comprehensive field assessment was performed on May 3 and May 4 of 2017 by LHB, Gemini Research, MnDOT District 6 (Engineering and Bridge Maintenance), and the MnDOT Bridge Office. The purpose was to define the overall condition of the structures as well as to define the specific condition of individual elements. The assessment included hands-on and visual inspection. No aerial equipment was used to assist in the inspection.

Traffic and Roadway Data
In addition to the condition of the structure, the condition of the roadway, guardrails, and roadway embankments were also assessed. Roadway and guardrail needs relate to the current traffic and accident data as well as the current roadway geometrics. Prior to field assessment all existing traffic and roadway data was reviewed.

In general, the roadway section where the four bridges lie is on a slope and on a curve. The roadway grade moves downward from south to north with an average grade of 5 percent and two vertical curves of 120 feet and 240 feet. The bridges also lie within a horizontal curve in the roadway with a radius of approximately 760 feet.

Trunk Highway 74 (TH 74) is a two-lane undivided highway in the location of the four bridges, with one lane of traffic in each direction. Each lane is 12 feet wide. The shoulder widths vary at each bridge, but average approximately 5 feet wide and consist of either a fully paved surface or a combination of bituminous pavement and gravel. The roadway inslopes are steepest above the culvert inlets and vary between approximately 1:1 and 1:4.

New guardrail was placed on TH 74 in 2008. There is currently standard w-beam guardrail located at the inlet and outlets of Bridges 8592 and 8593 and the inlet of Bridge 8594. There is no guardrail in the vicinity of Bridge 8595.

TH 74 is classified as a rural major collector. The annual average daily traffic count (AADT) on record for this portion of TH 74 is 1558 vehicles per day and was recorded in 2008 with a heavy commercial annual average daily traffic (HCAADT) count of 63, or 4 percent. Heavy commercial vehicles are all trucks with at least three axles and six tires. The speed through the park on this portion of TH 74 is 40 miles per hour. This reduced speed zone begins between bridges 8592 and 8593 and ends just north of bridge 5835. The speed limit outside of the park on TH 74 is 55 miles per hour.

There are 3 recorded accidents within 500 feet of the four bridges. All three accidents occurred near bridge 8592. None of the accidents were fatal and all three involved a singular vehicle. One accident was a collision with a deer. The other two involved the vehicle running off the road with the contributing factors on the report listed as illegal speed, distraction, and skidding.
Bridge 8592 General Description and Findings

Bridge 8592 is a single-span, 10-foot-by-6-foot corrugated metal, multi-plate arch structure carrying TH 74 over an established drainage channel. The upper portion of the arch knee walls are constructed of cast-in-place concrete and the lower portions are stone masonry, however the stone masonry knee walls are currently hidden by the non-historic concrete floor. The headwalls and wingwalls are constructed of mortared stone masonry. A concrete floor has been placed atop the original stone masonry floor.

The bridge is in generally fair condition with some elements in poor condition. Overall, the concrete floor is in poor condition with severe cracking and holes observed in the floor, with settlement at the outlet. The multi-plate arch and its knee walls are in fair condition except for a short length of missing knee wall concrete. The condition of the headwalls and wingwalls is poor with deficient pointing mortar, missing or deteriorated stones, and some displacement noted at the outlet headwall. The roadway inslopes appear to be stable, however erosion is occurring where the headwall stones are missing.

Photos (8592)

Photo 1: Inlet (East) Elevation

Photo 2: Outlet (West) Elevation
Bridge 8592 Condition by Element

Concrete Floor (8592)

Description
- Originally constructed of mortared stone paving with assumed concrete weirs (energy dissipaters)
- New concrete floor poured over the stone floor at an unknown date
- Jointing on either side of buried original weir visible (Photo 5)

Existing Condition & Deficiencies
- Rubble fill obstructing inlet (Photo 3); extends 7 feet into culvert by approximately 3 feet deep
- Surface deterioration of concrete over entire floor (Photo 4)
- Severe cracking and many holes in concrete floor
- Appears heaved at one-third point nearest outlet
- Water observed to be flowing under concrete
- Floor settled/tipped at outlet end (settled 6 inches at northwest corner and lifted 2 inches on southeast corner) (Photo 6)

Photos (8592)

Photo 3: Rubble Fill at Inlet

Photo 4: Culvert Floor General Condition

Photo 5: Jointing in Floor at Assumed Weir

Photo 6: Northwest Corner of Floor (settled)
Knee Walls (8592)

Description

- The walls anchor the multi-plate arch (Photo 10)
- Top of wall constructed of cast-in-place concrete (no reinforcing observed)
- Typical projection from arch face is 5-1/2 inches
- Typical height is 10 inches from concrete floor
- Based on condition at northwest corner where floor has settled, wall stones are missing, and additional knee wall is visible, it is assumed that the knee walls are constructed of a stone base with a concrete cap (Photo 9)
- No known previous repairs

Existing Condition & Deficiencies

- A 3-foot length of concrete is missing near the southeast corner, approximately 2 percent of the total area (Photos 7 and 8)

Photos (8592)

- Photo 7: Concrete Knee Walls
- Photo 8: Missing Knee Wall Concrete
- Photo 9: Knee Wall End (northwest)
- Photo 10: Knee Wall End (southwest)
Multi-Plate Arch (8592)

Description

- Constructed of galvanized, corrugated metal plates bolted together to form a 10-foot-by-5-foot multi-plate arch
- Barrel length is approximately 103 feet
- Plate corrugation pattern measures at a 6-inch width, 1-1/2-inch depth, and a 1/4-inch thickness
- Culvert is skewed to the roadway, 45 degrees, resulting in a span length of 14 feet

Existing Condition & Deficiencies

- No deformations were observed
- No significant corrosion was present
- By observations of sediment on all surfaces of the arch, it appears that the culvert flows full at times of high water/peak flow.

Photos (8592)

![Photo 11: Typical Arch Condition](image1)
![Photo 12: Typical Arch Condition (outlet)](image2)

Rating Summary

- The previous bridge rating (HS 16 inventory & HS 22 operating) was performed using a culvert rating form which was the standard practice for rating structures of this type. This form rates a structure based on its material and type (or shape) using tabulated values.
- The structure was re-rated during this study to arrive at an analytical rating value based on the current culvert condition, geometric/material properties, and current loading.
- The updated rating was performed using Load and Resistance Factor Rating (LRFR) methodology. Since traditional rating software cannot compute multi-plate arch ratings, the rating was computed using a spreadsheet developed by the Ohio DOT in 2016.
- Due to the age of the arches and the unknown condition of the buried face, a section loss of 10 percent was assumed for the entire structure.
- The resulting HL-93 rating factors are 17.30 inventory and 22.43 operating.
- The rating factors represent the current state of the arch and would not result in a load posting.
- Bridge 8592 has no measurable crown deflection, a short span, and deep cover (approximately 7 feet) which helps to dissipate the live load applied to the arch, resulting in a higher rating factor.
Masonry Headwalls and Wingwalls (8592)

Description

- Constructed of mortared stone masonry
- Headwalls extend 1 foot 6 inches above arch plate
- Wingwall geometry varies at all four corners of bridge
- Appears to have been previously repointed

Existing Condition & Deficiencies

Overall:

- The pointing mortar is deficient for all stone masonry
  - Cracked and missing in many locations
  - Appears to have been repointed with a mortar that is very hard and likely not compatible with the somewhat softer dolomite stone of the structure
- Much of the stone masonry which remains in place is severely deteriorated
  - Some stones heavily fractured, deeming them to be unsound
  - Mortar deteriorated to depths that would warrant removal and re-assembly instead of the less disruptive scope of repointing

Inlet Headwall (East):

- Missing stone over north half of arch, approximately 50 percent of total area
- Deteriorated masonry over south half of arch, approximately 50 percent of total area

Inlet Wingwalls:

- Southeast: deteriorated stone masonry continuing from headwall, approximately 25 percent of total area
- Northeast: missing stone at top of wingwall near headwall and deteriorated stone below stone masonry wedge along bottom of wingwall, approximately 25 percent of total area

Outlet Headwall (West):

- Headwall stones are displaced 2 inches outward compared to end of metal arch
- Stone missing above arch, approximately 50 percent of total area
- Deteriorated masonry over remaining headwall, approximately 50 percent of total area

Outlet Wingwalls:

- Northwest: end of wall is displaced, approximately 15 percent of total area
- Northwest: deteriorated stone masonry over remaining area of wingwall, approximately 85 percent of total area
- Southwest: stone at top of wingwall is missing, approximately 10 percent of total area
- Southwest: deteriorated stone masonry over remaining area of wingwall, approximately 90 percent of total area
Photos (8592)

Photo 13: Inlet (E) Headwall and SE Wingwall

Photo 14: Southeast Wingwall (Inlet)

Photo 15: Inlet (E) Headwall and NE Wingwall

Photo 16: Outlet (W) Headwall and Wingwalls

Photo 17: Northwest Wingwall (Outlet)

Photo 18: Outlet (W) Headwall and SE Wingwall
**Roadway, Inslopes & Guardrail (8592)**

**Description**
- Original roadbed was designed to be 30 feet wide (scaled from original plan)
- The current clear width from guardrail to guardrail is approximately 35 feet
- The speed limit is signed to 40 miles per hour through Park
- Roadway received a mill and overlay and new guardrail was placed in 2008
- Guardrail is present at both the inlet and outlet

**Existing Condition & Deficiencies**
- Roadway inslope at inlet is stable, except at the headwall where the slope steepens to 1:1 (Figure 1, Photo 20) where the headwall has failed
- Roadway inslope at outlet is stable with slopes greater than 1:3
- Three non-fatal accidents have been recorded near this bridge site since 2006

**Photos (8592)**

![Photo 19: Typical Roadway (looking north)](image1)

![Photo 20: Roadway Inslope at Inlet](image2)
Figure 1: Bridge 8592 Roadway Inslope at Inlet (looking north)

Figure 2: Bridge 8592 Roadway Inslope at Outlet (looking north)
Bridge 8593 General Description and Findings

Bridge 8593 is a single-span, 10-foot-by-6-foot corrugated metal, multi-plate arch structure carrying TH 74 over an established drainage channel. The upper portion of the arch knee walls are constructed of cast-in-place concrete and the lower portions are stone masonry, however the stone masonry knee walls are currently hidden by the non-historic concrete floor. The headwalls and wingwalls are constructed of mortared stone masonry. A concrete floor has been placed atop the original stone masonry culvert floor and inlet apron. There are masonry steps at the end of the inlet apron which act as an energy dissipater or a stepped drop structure.

The bridge is in generally fair condition with some elements in poor condition. Overall, the concrete floor is in poor condition with severe cracking and holes observed in the floor. The multi-plate arch and its knee walls are in fair condition except for a short length of cracked knee wall concrete and corrosion of the arch at the outlet. The condition of the inlet steps, headwalls and wingwalls is poor with deficient pointing mortar, and missing or deteriorated stones. The roadway inslopes appear to be stable at the inlet. At the outlet, steel I-beams have been placed atop the headwall to hold the roadway inslope. The steel beams are severely corroded and there is a washout on the slope above the outlet headwall.

Photos (8593)

Photo 21: Inlet (West) Elevation

Photo 22: Outlet (East) Elevation
Bridge 8593 Condition by Element

**Culvert Floor (Inlet Masonry Steps and Concrete Floor) (8593)**

**Description**
- Originally constructed of mortared stone paving with inlet steps and assumed concrete weirs (energy dissipaters)
- New concrete floor poured over the stone floor at an unknown date
- Jointing on either side of buried original weir visible

**Existing Condition & Deficiencies**
- The pointing mortar is deficient for the masonry steps (Photo 23)
- The inlet apron is in good condition except at the masonry steps there is a small area of deterioration (Photo 24)
- Severe cracking and many holes in the culvert concrete floor (Photo 25)
- Water observed to be flowing under the concrete floor near the outlet (Photo 26)

**Photos (8593)**

- Photo 23: Inlet Steps
- Photo 24: Inlet Apron
- Photo 25: Hole in Culvert Floor
- Photo 26: Culvert Floor at Outlet (flow under)
Knee Walls (8593)

Description
- The walls anchor the multi-plate arch
- Top of wall constructed of cast-in-place concrete (no reinforcing observed)
- Stone masonry knee wall beneath the concrete cap (currently hidden by concrete floor)
- Average projection from arch face is 5-1/2 inches
- Typical height is 12 inches from concrete floor
- No known previous repairs

Existing Condition & Deficiencies
- Generally good condition
- A 15-foot length of concrete is deteriorated with vertical cracking near the northeast corner

Photos (8593)

Photo 27: Typical Concrete Knee Wall

Photo 28: Typical Knee Wall Concrete
Multi-Plate Arch (8593)

Description
- Constructed of galvanized, corrugated metal plates bolted together to form a 10-foot-by-5-foot multi-plate arch
- Barrel length is approximately 85 feet
- Plate corrugation pattern measures at a 6-inch width, 1-1/2-inch depth, and a 1/4-inch thickness
- Culvert is skewed to the roadway, 45 degrees, resulting in a span length of 14 feet

Existing Condition & Deficiencies
- No deformations were observed
- Areas of corrosion identified at outlet end where headwall I-beam bracing is welded (Photo 30)
- By observations of sediment on all surfaces of the arch, it appears that the culvert flows full at times of high water/peak flow.

Photos (8593)

Rating Summary
- The previous bridge rating (HS 16 inventory & HS 22 operating) was performed using a culvert rating form which was the standard practice for rating structures of this type. This form rates a structure based on its material and type (or shape) using tabulated values.
- The structure was re-rated during this study to arrive at an analytical rating value based on the current culvert condition, geometric/material properties, and current loading.
- The updated rating was performed using Load and Resistance Factor Rating (LRFR) methodology. Since traditional rating software cannot compute multi-plate arch ratings, the rating was computed using a spreadsheet developed by the Ohio DOT in 2016.
- Due to the age of the arch and the unknown condition of the buried face, a section loss of 10 percent was assumed for the entire structure.
- The resulting HL-93 rating factors are 31.28 inventory and 40.55 operating.
- The rating factors represent the current state of the arch and would not result in a load posting.
- Bridge 8593 has minimal crown deflection, a short span and deep cover (approximately 9 feet) which helps to dissipate the live load applied to the arch, resulting in a higher rating factor.
Masonry Headwalls and Wingwalls (8593)

Description
- Constructed of mortared stone masonry
- Headwalls extend 2 feet 3 inches above arch plate at inlet and 1 foot 5 inches at outlet
- Steel I-beam placed at top of outlet headwall to extend its height
- Wingwall geometry varies at all four corners of bridge
- Appears to have been previously repointed

Existing Condition & Deficiencies

Overall:
- The pointing mortar is deficient for all stone masonry
  - Cracked and missing in many locations
  - Appears to have been repointed with a mortar that is very hard and likely not compatible with the somewhat softer dolomite stone of the structure
- Much of the stone masonry which remains in place is severely deteriorated
  - Some stones heavily fractured, deeming them to be unsound
  - Mortar deteriorated to depths that would warrant removal and re-assembly instead of the less disruptive scope of repointing

Inlet Headwall (West):
- South half of the headwall is deteriorated

Inlet Wingwalls:
- Southwest: deteriorated stone masonry continuing from headwall, approximately 50 percent of total area
- Southwest: erosion at end of wingwall
- Northwest: masonry in fair condition

Outlet Headwall (East):
- Deteriorated masonry over entire headwall
- I-beam above headwall increases the height of retained soil by approximately 1 foot 5 inches

Outlet Wingwalls
- Northeast: deteriorated stone masonry over entire area of wingwall
- Southeast: south half of wingwall displaced and would require reconstruction
- Southeast: deteriorated stone masonry over 60 percent of remaining area of wingwall, approximately 20 percent of total area in fair condition
Photos (8593)

Photo 31: Inlet (W) Headwall

Photo 32: Inlet (W) Headwall and SW Wingwall

Photo 33: SW Wingwall End Scour (Inlet)

Photo 34: Outlet and NE Wingwall

Photo 35: Outlet (E) Headwall and I-Beam

Photo 36: SE Wingwall (end displaced)
Roadway, Inslopes & Guardrail (8593)

Description

- Original roadbed was designed to be 30 feet wide (scaled from original plan)
- The current clear width from guardrail to guardrail is approximately 35 feet
- The speed limit is signed to 40 miles per hour through Park
- Roadway received a mill and overlay and new guardrail was placed in 2008
- Guardrail is present at both the inlet and outlet

Existing Condition & Deficiencies

- Roadway inslope at inlet is stable, with slopes approximately 1:2
- There is a washout at the outlet roadway inslope above the headwall
- Inslope at outlet is as steep as 1:1 (Figure 4, Photo 38)
- There are no accidents on record at this bridge site

Photos (8593)

Photo 37: Typical Roadway (looking north)  Photo 38: Roadway Inslope at Outlet
Figure 3: Bridge 8593 Roadway Inslope at Inlet (looking north)

Figure 4: Bridge 8593 Roadway Inslope at Outlet (looking north)
Bridge 8594 General Description and Findings

Bridge 8594 is a single-span, 10-foot-by-6-foot corrugated metal, multi-plate arch structure carrying TH 74 over an established drainage channel. The upper portion of the arch knee walls are constructed of cast-in-place concrete and the lower portions are stone masonry. The headwalls and wingwalls are constructed of mortared stone masonry. A concrete floor has been placed atop the original stone masonry culvert floor and inlet apron. There are masonry steps at the end of the inlet apron which act as an energy dissipater or a stepped drop structure.

The bridge is in generally fair condition with some elements in poor condition. Overall, the concrete floor is in poor condition with severe cracking throughout the interior of the culvert. The multi-plate arch is in fair condition except for the corrosion of the arch at the inlet and a noted deformed shape of the culvert at the crown. The knee walls are in fair condition with some cracking noted in the concrete cap and deteriorated mortar in the stone masonry. The condition of the inlet steps, headwalls and wingwalls is poor with deficient pointing mortar, and missing or deteriorated stones, especially at the headwalls. The roadway inslopes appear to be stable at the outlet. At the inlet, steel I-beams have been placed atop the headwall to hold the roadway inslope. The I-beams are severely corroded and there is a washout on the slope above the inlet headwall.

Photos (8594)

Photo 39: Inlet (East) Elevation

Photo 40: Outlet (West) Elevation
Bridge 8594 Condition by Element

**Culvert Floor (Inlet Masonry Steps and Concrete Floor) (8594)**

**Description**
- Originally constructed of mortared stone paving with inlet steps and assumed intermediate concrete weirs (energy dissipaters)
- New concrete floor poured over the stone floor at an unknown date
- Jointing on either side of buried original weir visible (Photo 42)

**Existing Condition & Deficiencies**
- Inlet masonry steps have deficient pointing mortar with some missing/spalled stone (Photo 41)
- Inlet concrete apron has cracking throughout, especially in downstream two-thirds
- Interior concrete floor has severe cracking in upstream third (Photos 42 & 43)
- Outlet concrete apron in fair condition (Photo 44)

**Photos (8594)**

![Photo 41: Inlet Steps](image1)
![Photo 42: Culvert Floor (at inlet)](image2)
![Photo 43: Culvert Floor (typical)](image3)
![Photo 44: Culvert Floor (at outlet)](image4)
Knee Walls (8594)

Description
- The walls anchor the multi-plate arch
- Top of wall constructed of cast-in-place concrete (no reinforcing observed)
- Stone masonry knee wall beneath the concrete cap
- Average projection from arch face is 6 inches
- Typical height is 1 foot 10 inches from concrete floor
- Stone masonry appears to be repointed
- No known previous repairs to concrete

Existing Condition & Deficiencies
- Stone masonry knee walls have deficient pointing mortar
- The knee wall concrete cap has some minor cracking

Photos (8594)

Photo 45: Typical Knee Wall  Photo 46: Typical Knee Wall
Multi-Plate Arch (8594)

Description
- Constructed of galvanized, corrugated metal plates bolted together to form a 10-foot-by-5-foot multi-plate arch
- Barrel length is approximately 102 feet
- Plate corrugation pattern measures at a 6-inch width, 1-1/2-inch depth, and a 1/4-inch thickness
- Culvert is skewed to the roadway, 45 degrees, resulting in a span length of approx. 14 feet

Existing Condition & Deficiencies
- Deformations were observed at the crown of the arch (measured to be approximately 5 inches)
- Areas of corrosion at inlet end where headwall I-beam bracing is welded (Photo 48)
- By observations of sediment on all surfaces of the arch, it appears that the culvert flows full at times of high water/peak flow.

Photos (8594)

Photo 47: Typical Arch Condition

Photo 48: Corrosion of Arch at Outlet

Rating Summary
- The previous bridge rating (HS 16 inventory & HS 22 operating) was performed using a culvert rating form which was the standard practice for rating structures of this type. This form rates a structure based on its material and type (or shape) using tabulated values.
- The structure was re-rated during this study to arrive at an analytical rating value based on the current culvert condition, geometric/material properties, and current loading.
- The updated rating was performed using Load and Resistance Factor Rating (LRFR) methodology. Since traditional rating software cannot compute multi-plate arch ratings, the rating was computed using a spreadsheet developed by the Ohio DOT in 2016.
- Due to the age of the arch, the unknown condition of the buried face, and the known deformation a section loss of 10 percent was assumed for the entire structure. A measured crown deflection of 9 percent was also used in the rating calculation.
- The resulting HL-93 rating factors are 1.32 inventory and 1.71 operating.
- The rating factors represent the current state of the arch and would not result in a load posting.
- Bridge 8594 has a short span and deep cover (approx. 12 feet) which helps to dissipate and distribute the live load applied to the arch. However, due to the crown deflection, the resulting rating factors are lower than Bridges 8592 and 8593 which have minimal crown deflection.
Masonry Headwalls and Wingwalls (8594)

Description
- Constructed of mortared stone masonry
- Headwalls extend 2 feet 5 inches above arch plate at inlet and 1 foot 6 inches at outlet
- Steel I-beams placed at top of outlet headwall to extend its height
- Wingwall geometry varies at all four corners of bridge
- Appears to have been previously repointed

Existing Condition & Deficiencies

Overall:
- The pointing mortar is deficient for all stone masonry
  - Cracked and missing in many locations
  - Appears to have been repointed with a mortar that is very hard and likely not compatible with the somewhat softer dolomite stone of the structure

Inlet Headwall (East) and Outlet Headwall (West):
- The stone masonry at and around the headwalls is severely deteriorated
  - Some stones heavily fractured, deeming them to be unsound
  - Mortar deteriorated to depths that would warrant removal and re-assembly instead of the less disruptive scope of repointing
- I-beams above inlet headwall increases the height of retained soil by approximately 4 feet 4 inches
- I-beams are severely deteriorated

Inlet Wingwalls:
- Northeast: deteriorated stone masonry near headwall, approximately 20 percent of total area
- Southeast: deteriorated stone masonry near headwall, approximately 25 percent of total area

Outlet Wingwalls
- Northwest: erosion at end of wingwall
- Northwest: deteriorated stone masonry near headwall, approximately 6 percent of total area
- Southwest: masonry in fair condition
Photos (8594)

Photo 49: Inlet (E) Headwall and I-Beams

Photo 50: Inlet NE Wingwall

Photo 51: Inlet I-Beams

Photo 52: Outlet Headwall (W)

Photo 53: Outlet SW Wingwall

Photo 54: Outlet NW Wingwall
Roadway, Inslopes & Guardrail (8594)

Description

- Original roadbed was designed to be 30 feet wide (scaled from original plan)
- The current width from guardrail to edge of shoulder is approximately 32 feet
- The speed limit is signed to 40 miles per hour through Park
- Roadway received a mill and overlay and new guardrail was placed in 2008
- Guardrail is present at the inlet only

Existing Condition & Deficiencies

- There is a washout at the inlet roadway inslope above the headwall which has also washed out the bituminous shoulder (Photo 56)
- Roadway inslope at outlet is stable, with slopes approximately 1:2
- Inslope at inlet is as steep as 1:1.5 (Figure 5, Photo 58)
- There are no accidents on record at this bridge site

Photos (8594)

Photo 55: Roadway looking North

Photo 56: Washout at Guardrail (inlet)

Photo 57: Washout above Inlet

Photo 58: Roadway Inslope at Inlet
Figure 5: Bridge 8594 Roadway Inslope at Inlet (looking north)

Figure 6: Bridge 8594 Roadway Inslope at Outlet (looking north)
Bridge 8595 General Description and Findings

Bridge 8595 is a single-span, 10-foot-by-6-foot corrugated metal, multi-plate arch structure carrying TH 74 over an established drainage channel. The upper portion of the arch knee walls are constructed of cast-in-place concrete and the lower portions are stone masonry. The headwalls and wingwalls are constructed of mortared stone masonry. A non-historic concrete floor has been placed atop the original stone masonry culvert floor and inlet apron. There are masonry steps at the end of the inlet apron which act as an energy dissipater or a stepped drop structure.

The bridge is in generally fair condition with some elements in poor condition. Overall, the concrete floor is in poor condition with severe cracking observed. The multi-plate arch and its knee walls are in fair condition except for a short length of displaced knee wall concrete and observed deformations in the arch crown. The condition of the inlet steps, headwalls and wingwalls is fair to poor with deficient pointing mortar and missing or deteriorated stones. The roadway inslopes appear to be stable at the inlet and the outlet.

Photos (8595)

Photo 59: Inlet (West) Elevation

Photo 60: Outlet (East) Elevation
Bridge 8595 Condition by Element

Culvert Floor (Inlet Masonry Steps and Concrete Floor) (8595)

Description
- Originally constructed of mortared stone paving with assumed concrete weirs (energy dissipaters)
- New concrete floor poured over the stone floor at an unknown date
- Jointing on either side of buried original weir visible

Existing Condition & Deficiencies
- Severe cracking throughout the interior concrete floor
- Deficient pointing mortar at the inlet masonry steps
- Spot regions of the inlet concrete floor deteriorated, approximately 50 percent of total area

Photos (8595)

Photo 61: Inlet Masonry Steps
Photo 62: Inlet Apron General Condition
Photo 63: Interior Culvert Floor
Photo 64: Culvert Floor at Outlet
Knee Walls (8595)

Description

- The walls anchor the multi-plate arch
- Constructed of cast-in-place concrete at top of wall (8 inches to 12 inches tall, no reinforcing observed) and stone masonry at remaining wall
- Typical projection from arch face is 6 inches and 2 feet 6 inches from concrete floor
- Stone masonry appears to be repointed
- No known previous repairs to concrete

Existing Condition & Deficiencies

- Stone masonry pointing mortar is smeared over the stone
  - Condition appears to be irreversible
  - Attempting to remove the hard mortar would likely severely damage the stone
- A 10-foot length of knee wall concrete cap is displaced at the northeast end of bridge, approximately 3 percent of the total area (Photo 67)
  - Crack through concrete cap in same location continues through the stone masonry

Photos (8595)

- Photo 65: Typical Knee Walls
- Photo 66: Typical Knee Walls
- Photo 67: Displaced Concrete Cap
- Photo 68: Typical Floor at Knee Wall
Multi-Plate Arch (8595)

Description
- Constructed of galvanized, corrugated metal plates bolted together to form a 10-foot-by-5-foot multi-plate arch
- Barrel length is approximately 116 feet
- Plate corrugation pattern measures at a 6-inch width, 1-1/2-inch depth, and a 1/4-inch thickness
- Culvert is skewed to the roadway, 45 degrees, resulting in a span length of 14 feet

Existing Condition & Deficiencies
- Deformations were observed at arch crown (measured to be approximately 5 inches, Photo 69)
- By observations of sediment on all surfaces of the arch, it appears that the culvert flows full at times of high water/peak flow.
- No significant corrosion was present

Photos (8595)

Photo 69: Deflection at Arch Crown

Photo 70: Bent Arch Plate (outlet)

Rating Summary
- The previous bridge rating (HS 16 inventory & HS 22 operating) was performed using a culvert rating form which was the standard practice for rating structures of this type. This form rates a structure based on its material and type (or shape) using tabulated values.
- The structure was re-rated during this study to arrive at an analytical rating value based on the current culvert condition, geometric/material properties, and current loading.
- The updated rating was performed using Load and Resistance Factor Rating (LRFR) methodology. Since traditional rating software cannot compute multi-plate arch ratings, the rating was computed using a spreadsheet developed by the Ohio DOT in 2016.
- Due to the age of the arch, the unknown condition of the buried face, and the known deformation a section loss of 10 percent was assumed for the entire structure. A measured crown deflection of 9 percent was also used in the rating calculation.
- The resulting HL-93 rating factors are 1.55 inventory and 2.00 operating.
- The rating factors represent the current state of the arch and would not result in a load posting.
- Bridge 8595 has a short span and deep cover (approx. 11 feet) which helps to dissipate and distribute the live load applied to the arch. However, due to the crown deflection, the resulting rating factors are lower than Bridges 8592 and 8593 which have minimal crown deflection.
Masonry Headwalls and Wingwalls (8595)

Description
- Constructed of mortared stone masonry
- Headwalls extend 1 foot 3 inches above arch plate
- Wingwall geometry varies at all four corners of bridge
- Appears to have been previously repointed

Existing Condition & Deficiencies

Overall:
- The pointing mortar is deficient for all stone masonry
  - Cracked and missing in many locations
  - Appears to have been repointed with a mortar that is very hard and likely not compatible with the somewhat softer dolomite stone of the structure
- Much of the stone masonry which remains in place is severely deteriorated
  - Some stones heavily fractured, deeming them to be unsound
  - Mortar deteriorated to depths that would warrant removal and re-assembly instead of the less disruptive scope of repointing

Inlet Headwall (West):
- Deteriorated masonry over entire headwall

Inlet Wingwalls:
- Northwest: in fair condition with no severely deteriorated areas
- Southwest: deteriorated stone masonry continuing from headwall, approximately 3 percent of total area
- Southwest: slope eroding at end of wingwall

Outlet Headwall (East):
- Several stones missing at top of headwall
- Entire headwall severely deteriorated
- Stone missing at end of knee wall in southeast corner

Outlet Wingwalls:
- Northeast: stones are displaced 1-inch outward per 1 foot vertically
- Stone missing above arch, approximately 20 square feet or 50 percent of total area
- Northeast: Deteriorated masonry over remaining top portion of wingwall, approximately 50 percent of total area
- Southeast: Deteriorated masonry over remaining top portion of wingwall, approximately 60 percent of total area
Photos (8595)

Photo 71: Inlet SW Wingwall End

Photo 72: SE Wingwall (Inlet Drop Stricture)

Photo 73: Inlet Headwall

Photo 74: Outlet (E) Headwall and Wingwalls

Photo 75: Outlet (E) Headwall

Photo 76: Outlet SE Wingwall
Roadway, Inslopes & Guardrail (8595)

Description
- Original roadbed was designed to be 30 feet wide (scaled from original plan)
- The current width from shoulder to shoulder is approximately 30 feet
- The speed limit is signed to 40 miles per hour through Park
- Roadway received a mill and overlay and new guardrail was placed in 2008
- There is no guardrail at this bridge

Existing Condition & Deficiencies
- Roadway inslope at inlet is stable, approximately 1:2 (Figure 7, Photo 77)
- Roadway inslope at outlet is stable, approximately 1:3 (Figure 8, Photo 78)
- There are no accidents on record at this bridge

Photos (8595)

Photo 77: Inlet Roadway Inslope

Photo 78: Outlet Roadway Inslope
Figure 7: Bridge 8595 Roadway Inslope at Inlet (looking north)

Figure 8: Bridge 8595 Roadway Inslope at Outlet (looking north)
VI. DEVELOPMENT OF EVALUATION CRITERIA

Both the evaluation criteria and the rehabilitation alternatives were developed as a collaborative effort between the key participants listed in Section II. The summaries below represent the results of the effort to define the parameters for evaluating and developing rehabilitation alternatives.

Development of Evaluation Criteria

Development of the evaluation criteria was done in advance of the development of rehabilitation alternatives. A workshop was held in May 2017 with key participants, to discuss and agree upon the evaluation criteria that would be used to assess the rehabilitation alternatives for all four culverts. Following the decision to use Federal dollars for rehabilitation efforts, an additional meeting was held with FHWA in October of 2017 to further refine the evaluation criteria. Development of evaluation criteria was based upon purpose and need based criteria, social, economic and environmental (SEE) issues, cost-based criteria, and design considerations. The primary criterion was developed to satisfy the purpose and need of the project. SEE impacts are regulatory and statutory laws that must be followed. Design considerations are criteria that are desirable to meet, although not critical to the selection of a particular alternative to be carried forward into the NEPA Document. See below for a summary and explanation of each criterion.

The following criteria were agreed upon during the collaborative process:

Purpose & Need (Primary Criteria)

- Bridge Condition
  - Condition of Multi-Plate Arch and Knee Wall Abutments
  - Condition of Headwalls & Wingwalls
  - Inslope Erosion Deficiencies
  - Headwall Surcharge/Overburden
  - Channel Erosion at Inlet/Outlet

Social, Economic & Environmental Impacts

- Section 106 of the National Historic Preservation Act Of 1966 (as amended)
  - Structure Historic Integrity
  - Historic District Integrity
- Endangered Species Act Of 1973
- Minnesota Natural Heritage Information System (NHIS) & Rare Species
- DNR – Public Waters
- Section 4(f) of the Transportation Act of 1966
  - Park Land or Wildlife Refuge
  - Historic District
- Section 404 of the Clean Water Act
- Construction Noise
- Impact to TH 74 Traffic
Cost Criteria
• Construction Cost of Alternative

Design Considerations
• Load Capacity
• Service Life

Evaluation Criteria

Purpose & Need (Primary)
• Bridge Condition
  o Due to the deteriorating condition of the culverts, the primary need of a rehabilitation would be to improve the bridge condition.
  o To evaluate for improvement of bridge condition, five elements/conditions will be measured including culvert, headwalls and wingwalls, channel, inslope, and headwall surcharge/overburden.
    ▪ Multi-Plate Arch and Knee Wall Abutments
      • The multi-plate arches and knee wall abutments are in varying states of condition with some of the multi-plate arches experiencing deformations and/or moderate corrosion.
      • The knee wall foundations are constructed of stone masonry with concrete caps and have several locations of cracked/missing concrete and/or deteriorated masonry.
      • The multi-plate arches and knee wall abutments will be evaluated based upon the rehabilitated condition of the multi-plate arch and arch knee wall foundations.
      • The current NBI rating codes will be used to estimate the resulting culvert condition for each alternative.
        o A rating of 5 is defined as ‘Fair’ in which the “culvert has moderate deterioration – repairs may be required, but the culvert is structurally sound and functioning as intended. Joints may have separation or misalignment (moderate leakage or backfill infiltration).” And the masonry has “extensive weathering, cracking or leaching.”
        o A rating of 6 is defined as ‘Satisfactory’ in which the “culvert has minor to moderate deterioration. Joints may have minor separation or misalignment (slight leakage or backfill infiltration).” And the masonry has “moderate weathering, cracking or leaching.”
        o A rating of 7 is defined as ‘Good’ in which the “culvert has minor (or isolated) deterioration. Joints are sound and properly
aligned (no leakage or backfill infiltration).” And the masonry has “minor weathering, cracking or leaching.”

- A rating of 8 is defined as ‘Very Good’ in which the “culvert has very minor (and isolated) deterioration.”
- A rating of 9 is defined as ‘Excellent’ in which the “culvert is in new condition (recently constructed).”

- It is desirable to improve upon the current NBI ratings to achieve a minimum rating of 6 (Satisfactory Condition).

### Headwalls and Wingwalls

- The stone masonry headwalls and wingwalls are in varying states of deterioration with much of the stones and mortared joints either cracked, damaged or missing.
- The headwalls and wingwalls will be evaluated based upon their rehabilitated condition.
- The current NBI rating code general descriptions will be used to estimate the resulting headwall/wingwall condition for each alternative.
  - See the rating code descriptions in the above Multi-Plate Arch and Knee Wall Abutments bullet.
- The estimated Condition Ratings upon completing rehabilitative work will be compared to the current NBI Culvert Condition Rating for each bridge.
- It is desirable to improve upon the current NBI ratings to achieve a minimum rating of 6 (Satisfactory Condition), especially ratings which classify the culvert in poor or serious condition (NBI ratings of 4 or 3).

### Inslope

- Through the raising of the roadway profile over time, the roadway inslopes have become increasingly steep at the culvert headwall locations. This steep slope has led to increased erosion and wash-outs of the roadway inslopes.
- Inslope condition will be measured based on how each alternative addresses the observed deficiencies in terms of no concern (concerning condition is not present), not addressed, partially addressed or addressed.

### Headwall Surcharge/Overburden

- Through the raising of the roadway profile over time, additional surcharge/overburden loading has been applied to the stone masonry headwalls, leading to their accelerated deterioration.
- The mitigation of this surcharge/overburden will be measured in terms of no concern (concerning condition is not present), not addressed and addressed.
Channel

- Water is flowing beneath the culvert concrete floors, leading to distress and potential undetected erosion of the arch knee wall foundations. At the outlets, channel flow has scoured the channel at the end of the concrete floor to varying levels. And, at some of the inlets, channel flow has scoured the channel banks at the ends of the wingwalls.

Channel condition will be measured based on how each alternative addresses the observed deficiencies in terms of no concern (concerning condition is not present), not addressed, partially addressed, or addressed.

Social, Economic & Environmental (SEE) Impacts

- Section 106 of the National Historic Preservation Act of 1966 (as amended)
  - The MnDNR Cultural Resources Manager has been consulted on the potential for archaeological sites in the vicinity of the four bridges.
    - The area within the roadway corridor and at the culvert locations has been previously disturbed, reducing the likelihood of encountering an archaeological site.
    - Because the four bridges are located within a steep ravine, it was determined that the steepness of the grade and past flash flooding has disturbed the soils in the bottom of the ravine.
    - Section 106 does not apply to the culverts in terms of archaeological sites.
  - Bridges 8592, 8593, 8594 and 8595 are contributing resources within the “Whitewater State Park CCC/WPA/Rustic Style Historic Resources” historic district which is listed in the National Register of Historic Places. See Section IV for the full description of historic significance.
  - Structure Historic Integrity
    - Each alternative will be evaluated for its impact on the historic integrity of the structure in terms of no impact, preserves, diminishes & significantly diminishes.
  - SOI Standards
    - Each alternative will be evaluated for its consistency with the SOI Standards for Rehabilitation in terms of consistent or not consistent.
  - Historic District Integrity
    - The effect on the historic district can only be determined once the effect on each individual resource has been evaluated.
    - The overall effect on the Historic District will not be evaluated for each proposed alternative, but rather for the proposed combination(s) of alternatives recommended to advance to the NEPA Document.
    - The effect on the integrity of the historic district will be evaluated in terms of no impact, preserves, diminishes, and significantly diminishes.
      - See Section XIII of this report for historic district integrity discussion.
- **Endangered Species Act of 1973**
  - There is a potential for the presence of the Northern Long-Eared Bat; however, there are no known roosts within a one-mile radius of the proposed project.
  - Bats roost under bark, in crevices or cavities of trees or in crevices under bridges during their active season (April – October).
    - Tree removal is prohibited during active season.
    - Although bats can roost under bridges, these structures are not designed in a fashion where there are crevices that bats would find appealing to roost in.
  - This criterion will be evaluated based on the risk of impacting the Northern Long Eared Bat in terms of low risk, moderate risk and higher risk.
    - No known roosts are present and best practices will be followed in timing of any tree clearing (if required).
      - Practices are in place to ensure the northern long-eared bat is minimally affected.
      - It is anticipated all alternatives will evaluate as low risk.

- **Minnesota Natural Heritage Information System (NHIS) and Rare Species**
  - A query of the NHIS database discovered that there are several rare animal species documented within a one-mile radius of all project sites. Due to the sensitivity of this information the species and their exact location will not be listed here.
    - Disturbance in the project area may require special erosion control as well as relocation of specific wildlife species.
    - Best practices will be followed to ensure the risk of impact to rare animal species is low for all alternatives.
  - This project area of Bridges 8593, 8594 & 8595 lie adjacent to or within a site of biodiversity of outstanding significance, which means the site contains excellent quality occurrences of the rarest species, high quality example of rare native plant communities and/or important functional landscapes.
    - The project area is listed as an “Area of Environmental Sensitivity” and will necessitate strict measures to ensure the protection and re-vegetation of the entire project area.
    - Bridge 8592 lies outside of the site of biodiversity.
  - This criterion is to be evaluated based upon the risk of impacting identified locations of rare species and vegetation in terms of low risk, moderate risk and higher risk.
    - Thresholds for determining the risk of impact have been set based on area of disturbed vegetation:
      - Low – less than 1,000 square feet
      - Moderate – between 1,000 and 10,000 square feet
      - Higher – greater than 10,000 square feet
• **DNR – Public Waters**
  - Because the drainage channels discharge into the Middle Fork of the Whitewater River, which is a designated Trout Stream, they have been determined to carry “Waters Contributing to Waters of the State.”
    - Work in the water or within ordinary high water will require a permit.
  - Permit restrictions for work within the Middle Fork of the Whitewater River typically do not allow work in the stream from October 15 to April 15 of the following year.
  - There are established means of minimizing impacts to protected waters during this type of work (known as best management practices) and the project special provisions will need to ensure extreme care is taken when performing the work and that best management practices are implemented.
  - This criterion will be evaluated based on the level of disturbance to the drainage channel in terms of acres disturbed, both temporary and permanent.

• **Section 4(f) of the Transportation Act of 1966**
  - **Park Land or Wildlife Refuge**
    - The park does not lie within a designated US Fish & Wildlife Game Refuge
    - There will be no US Fish and Wildlife Service involvement in the project.
    - MnDOT right-of-way extends 75 feet on either side of the TH 74 centerline for a total width of 150 feet through the park.
      - MnDOT has permanent easement through the park.
      - This easement gives MnDOT the right to work within the easement on things that are done for ‘highway purposes’ including maintenance or adding infrastructure
    - Although the project will occur within park land, there will be no Section 4(f) involvement if the project footprint remains within the existing MnDOT permanent easement.
      - Work outside of existing right-of-way is not anticipated.
    - None of the proposed alternatives would result in a ‘Take’ of Section 4(f) park land or wildlife refuge resources, thus will not be evaluated on this criterion within the alternatives evaluation matrix.
  - **Historic District**
    - Bridges 8592, 8593, 8594 and 8595 are contributing elements of the Whitewater State Park Historic District which is listed in the National Register of Historic Places and therefore are Section 4(f) resources.
    - This criterion will evaluate the risk of Section 4(f) use of (adverse impact to) the historic district.
    - The evaluation will occur after the recommended alternative(s) for each bridge is selected.
    - The criteria will be evaluated in terms of low risk, moderate risk and higher risk.
      - See Section XIII for discussion on impacts to the historic district.
• **Section 404 of the Clean Water Act**
  o Because the drainage channels discharge into the Middle Fork of the Whitewater River, they have been determined to carry “waters contributing to waters of the US.” Work in the water or within ordinary high water will require a Section 404 permit.
  o There are established means of minimizing impacts to protected waters during this type of work (known as best management practices) and the project special provisions will need to ensure extreme care is taken when performing the work and that best management practices are implemented.
  o This criterion will be evaluated based on the cubic yard volume of placement of fill into waters contributing to waters of the US, both temporary and permanent.

• **Construction Noise**
  o The culverts are all located within the boundaries of Whitewater State Park and are directly south of the Park’s campsites and hiking trails.
  o Whitewater State Park is the second most frequented state park in Minnesota for overnight visits.
  o Construction noise within the Park could cause disturbances to Park users and detract from the park setting.
    ▪ Although the bridges are not in the immediate vicinity of the Park’s campsites and trails, they are potentially in close enough proximity for construction noise to be heard from locations of the Park frequented by park users.
    ▪ The closure of the highway during construction will result in a decrease in the typical highway traffic noise heard by Park users at all hours of the day.
    ▪ The Park’s quiet hours are 10 p.m. to 8 a.m.
      • Standard practices for noise mitigation would be employed which could include restrictions on hours of the day and/or days of the week when construction activities are permitted, and maximum allowed noise levels of construction activities.
  o This criterion will be evaluated based on the level of impact of construction noise to the Park users in terms of low impact, moderate impact and higher impact.
    ▪ Level of impact will be determined based on duration of construction activities with thresholds as follows:
      • Low – less than 3 months
      • Low/Moderate – between 3 months and 6 months
      • Moderate – between 6 months and 9 months
      • Moderate/High – between 9 months and 1 year
      • Higher – greater than 1 year
• **Impact to TH 74 Traffic**
  o Closure or impedance of traffic will have impacts on both park users and local residents, due to the high volume of visitors to the Park and the 8-mile-long detour.
  o This criterion will be evaluated based on the level of impact to traffic in terms of low impact, moderate impact and higher impact.
    ▪ Thresholds for determining the level of impact have been set based on duration of required road closure and detour:
      • Low – less than 2 weeks
      • Moderate – between 2 weeks and 3 months
      • Higher – greater than 3 months

**Cost Criteria**

• **Construction Cost of Alternative**
  o Work scope and cost estimates have been prepared based on a limited level assessment of the existing structures.
    ▪ It is to be recognized that portions of the structure that are not currently accessible have been assigned preliminary scope that may change once further investigation is performed.
  o The opinion of probable construction cost range is presented in year 2020 dollars (estimated year of letting).
    ▪ Per the MnDOT Cost Estimate Inflation Conversion Factor Table (updated 10/24/207), inflation rates of 3 percent for 2018, 6 percent for 2019 and 4 percent for 2020 were used, equating to an overall inflation from 2017 to 2020 of 14 percent.
  o The estimated costs represent an opinion based on background knowledge of historic unit prices and comparable work performed on other structures.
  o The opinion of cost is intended to provide a programming level of estimated cost.
  o Cost ranges have been established using a variable contingency of 0 to 20 percent.
    ▪ A contingency of 25 percent is typical for project study report cost estimates, however the level of uncertainty within the scope is such that it was determined to use a 20 percent maximum contingency.
  o Cost estimates for each alternative can be found in Section XIV, Appendix B.
  o The construction cost estimates will be used as a comparison of the risk-based construction cost range for each alternative.
Design Considerations

- Load Capacity
  - The current load capacity ratings for each culvert are based upon a Physical Inspection Rating which is based only on the condition and construction type of the structure and is not based on a design analysis of the structure.
  - An analytical HL-93 load capacity rating will be calculated for each structure as a basis of existing condition.
  - This criterion will be evaluated based on the resulting HL-93 inventory and operating rating factors for each alternative and whether or not the bridge will require load posting.

- Service Life
  - This criterion is to be evaluated based upon the estimated service life until the next major repair following the completion of the scope of each alternative.
  - A 20-year service life will be considered the minimum acceptable timeframe.
VII. DEVELOPMENT OF REHABILITATION ALTERNATIVES

Development of Rehabilitation Alternatives
A workshop was held in May of 2017 with key participants to discuss and agree upon the rehabilitation alternatives to be studied.

Development of rehabilitation alternatives was based upon a collaborative discussion of rehabilitation scope for each element of the culvert that could potentially be considered compliant with the SOI Standards for the Treatment of Historic Properties and would fulfill the project purpose and need. The workshop concluded with the development of a range of rehabilitation scope items for each bridge element which are described below under ‘Rehabilitation Scope by Element.’

Using input from the workshop, potential scope to rehabilitate each bridge element was analyzed and combinations of scope were developed to create comprehensive alternatives pertaining to each culvert structure. Following the decision to use Federal dollars for rehabilitation efforts, an additional meeting was held with FHWA in October of 2017 to further refine the evaluation criteria and rehabilitation alternatives. The descriptions and evaluations of the alternatives for each bridge can be found in Sections VIII, IX, X and XI. Further details of the scope proposed in each alternative description can be found in this section (Section VII).

The comprehensive rehabilitation alternatives have been evaluated against the evaluation criteria. During this evaluation, any rehabilitation scope that was found infeasible upon initial review was removed from further consideration. See ‘Alternatives Not Further Studied’ below for more information.

The following design standards and guidelines are applicable to this study in the development of rehabilitation scope and the assessment of alternatives.

- MnDOT Bridge Preservation and Improvement Guidelines
- MnDOT LRFD Bridge Design Manual
- MnDOT Road Design Manual
- 2014 and current interim AASHTO LRFD Bridge Design Specifications
- AASHTO Manual for Bridge Evaluation
- MnDOT, FHWA Geometric and Design Criteria
- Secretary of the Interior’s (SOI) Standards for the Treatment of Historic Properties, specifically the Standards for Rehabilitation
Alternatives Not Further Studied

Inlet/Outlet Masonry Headwall & Wingwalls

- All Bridges – Lower Roadway Profile
  - Reducing the roadway profile to an elevation that allows a standard guardrail and a 1:3 slope to be placed to match the top of the stone masonry walls was investigated.
  - The depth of roadway profile change would vary from site to site (from 2 feet 6 inches to 5 feet 4 inches).
  - Lowering the roadway profile was deemed infeasible and removed from further consideration due to the inability to maintain proper ditching in select regions of the roadway due to current terrain.
    - Expansive retaining walls and/or extensive blasting of the rock bluffs would be required.

Rehabilitation Scope by Element

A ‘No Build’ option (Alternative 1) will be studied for each element along with the items listed below.

Culvert Floor

- All Bridges – Remove and Replace Concrete Floor (retain stone floor beneath)
  - Rehabilitation would involve removing and replacing the non-historic concrete floor in-kind where it is severely cracked or failed.
  - Removal of the concrete floor should be done with extra caution to not damage the existing stone masonry floor that is presumed to be beneath the concrete floor.
  - The replacement concrete material would be colored so it does not visually distract from the historic structure.

- All Bridges – Remove Concrete Floor and Rehabilitate Mortared Stone Masonry Floor
  - Rehabilitation restores the culvert floor to the original stone masonry floor.
  - After careful removal of the concrete floor, the existing stone floor would be documented prior to removing, in order to replace the stones in their original locations/configuration.
  - The culvert floor stones would be removed, cleaned, and re-laid on a newly placed aggregate bed.
  - Repointing mortar should be selected to match the original pointing mortar.
  - A mortar study should be performed to ensure selection of a mortar that is compatible in composition, strength, color, texture and tooling.
  - It will be necessary for the project construction details to fully define the stone setting and repointing requirements, including but not limited to such items as joint preparation, mortar finish and tooling, mortar curing, and preparation of test panels.
Stones found to be missing or heavily fractured and not structurally sound should be replaced in-kind. Stone replacements should be selected from replacement stone material that is matching in stone type, color, texture, graining, size and surface finish.

**Knee Walls - Stone Masonry**

- **Bridges 8594 & 8595 – Spot Pointing and Replace Deficient Stones**
  - The stone masonry knee walls would be repointed.
  - Repointing mortar should be selected to match the original pointing mortar.
  - A mortar study should be performed to ensure selection of a mortar that is compatible in composition, strength, color, texture and tooling.
  - It will be necessary for the project construction details to fully define the repointing requirements, including but not limited to such items as joint preparation, mortar finish and tooling, mortar curing, and preparation of repointing test panels.
  - Prior to conducting preservation work, a hands-on evaluation of the structural integrity of each stone should be performed. Every effort should be made to retain the existing headwall and wingwall stones.
  - Stones found to be heavily fractured and not competent should be replaced in-kind. Stone replacements should be selected from replacement stone material that is matching in stone type, color, texture, graining, size and surface finish.

**Knee Walls – Concrete/Concrete Cap**

- **All Bridges – Repair Spalled and Delaminated Areas**
  - The spalled and delaminated areas of the concrete knee wall cap would be repaired by selective removal of deteriorated concrete to sound concrete.
  - Following concrete removal, and to maintain historic integrity, the concrete should be replaced with concrete of color, composition, forming and finish to match the original concrete.

**Multi-Plate Arch**

- **Bridges 8593 & 8594 – Replace or Repair Deficient Arch Plates (to address areas of significant section loss)**
  - Rehabilitation proposes to repair select locations of deficient arch plates. Since the load capacity of the multi-plate arch is adequate for all structures, regardless of deformation, only areas of the culvert with advanced corrosion and section loss would be repaired.
  - Where the plates are experiencing moderate corrosion, the corroded portions of the plates would be blasted clean and re-coated with a zinc-rich paint system. The top coat of the paint system would be of a color that blends with the existing galvanized finish of the original culvert coating.
  - Where corrosion is severe, select multi-plate pieces would be removed and replaced with modern multi-plate arch components, or salvaged plates from previously removed culverts of like geometry.
Because multi-plates matching the historic shape of the culverts are no longer made, the option to use modern multi-plate arch components would require gap sealing at the joints between the new and old plates and casting a concrete collar around the outside (buried face) of the culvert at this joint.

The corrugation and radius of the plates of Bridge 5836, currently planned for replacement, could potentially be used for patching of Bridges 8593 and 8594. Additional research and/or testing is required to determine the composition of the existing arch plates and their compatibility with any proposed plates in terms of dissimilar metals and the potential risk of accelerated corrosion.

The areas of multi-plate corrosion appear to have been initiated by field drilling and welding to the culvert plates which destroyed the galvanizing and precipitated the rusting and corrosion loss. Because of the isolated nature of the welding and field drilling, additional regions of severe corrosion and inflation in estimated patch areas are not anticipated.

All Bridges – Waterproof Top Surface of Multi-Plate Arch
This rehabilitation scope would extend the life of the multi-plate arch by protecting the buried face with a waterproof coating. This would be accomplished by excavating the fill above the arch, which would require closure of and removal of the roadway. Once excavated, the arch surface would be prepared, and waterproofing membrane applied that would act as a barrier from moisture.

Inlet Masonry Steps
Bridges 8593, 8594, & 8595 – Repoint and Replace Deficient Stones
- The stone masonry inlet steps would be repointed.
- Repointing mortar should be selected to match the original pointing mortar.
- A mortar study should be performed to ensure selection of a mortar that is compatible in composition, strength, color, texture and tooling.
- It will be necessary for the project construction details to fully define the repointing requirements, including but not limited to such items as joint preparation, mortar finish and tooling, mortar curing, and preparation of repointing test panels.
- Prior to conducting preservation work, a hands-on evaluation of the structural integrity of each stone should be performed. Every effort should be made to retain the existing stones.
- Stones found to be heavily fractured and not structurally sound should be replaced in-kind. Stone replacements should be selected from replacement stone material that is matching in stone type, color, texture, graining, size and surface finish

Inlet/Outlet Masonry Headwall & Wingwalls
All Bridges – Repoint and Replace Deficient or Missing Stones (to original geometry)
- The stone masonry headwalls and wingwalls would be repointed.
- Repointing mortar should be selected to match the original pointing mortar.
- A mortar study should be performed to ensure selection of a mortar that is compatible in composition, strength, color, texture and tooling.
- It will be necessary for the project construction details to fully define the repointing requirements, including but not limited to such items as joint preparation, mortar finish and tooling, mortar curing, and preparation of repointing test panels.
- Prior to conducting preservation work, a hands-on evaluation of the structural integrity of individual stones should be performed. Every effort should be made to retain the existing headwall and wingwall stones.
- Stones found to be heavily fractured and not structurally sound should be replaced in-kind. Stone replacements should be selected from replacement stone material that is matching in stone type, color, texture, graining size and surface finish.

- Bridges 8592, 8593 & 8594 – Extend Height of Stone Headwalls with Stone Masonry (use compliant replacement stones and structural backing where necessary)
  - This rehabilitation scope would extend the height of the stone masonry headwall and wingwalls with additional stone to correct the slope stability issues at the inlet or outlet.
  - In cases where more than a few courses of stone are to be added, to maintain structural stability, the stone headwall will need to be removed, a new structural concrete wall built, then the concrete wall would be faced with the original stones.
  - The original stone locations would be documented and placed back as originally constructed.
  - To reduce the visual distraction of the addition, the new stone would be selected from replacement stone material that is matching the original in stone type, color, texture, graining, size and surface finish.
  - A mortar study should be performed to ensure selection of a mortar that is compatible in composition, strength, color, texture and tooling.
  - It will be necessary for the project construction details to fully define the repointing requirements, including but not limited to such items as joint preparation, mortar finish and tooling, mortar curing, and preparation of repointing test panels.
  - This work will require excavation behind the stone walls, which would encroach into the roadway and require partial replacement of the existing pavement and guardrail.

- Bridges 8592, 8593 & 8594 – Place Structural Concrete Retaining Wall (set back from the face of the stone masonry headwall)
  - An unornamented reinforced concrete retaining wall would be placed between the roadway and the stone masonry headwall and wingwalls in order to correct the steep roadway inslopes and retain the original geometry of the stone masonry walls.
  - The finished surface of the concrete wall would be stained a dark color in order to blend with its surroundings.
The concrete retaining wall would have a specially designed footing that reduces the length of the toe, in turn requiring a larger footing heel.

The retaining wall would be designed to span over the multi-plate arch.

This work will require excavation behind the stone walls, which would encroach into the roadway and require either partial or full replacement of the existing pavement and guardrail facilitate construction.

- **Bridges 8592, 8593 & 8594 – Reinforce Soil Slopes**
  - Those slopes that are steeper than 1:3 and are failing and/or causing the stone masonry walls to fail would be stabilized/mitigated by using a geogrid soil reinforcing.
  - Soil reinforcing will allow for a slope as steep as 1:1
  - This work will require excavation behind the stone walls, which would encroach into the roadway and require either partial or full replacement of the existing pavement and guardrail.

- **Bridge 8593, 8594, & 8595 – Extend or Revise Geometrics at Wingwall Ends**
  - This rehabilitation scope modifies the wingwall ends to mitigate scouring or hydraulic concerns.
    - Extension of Bridge 8594 wingwall would build the wall back to its original geometry.
    - Extension of Bridges 8593 & 8595 wingwalls would modify the original wingwall geometry.
  - The wingwall extensions, beyond original geometrics, would be modest in size and built of stone masonry construction.
  - The stones and mortar used to construct the wingwall additions would be selected to match the existing stone masonry wingwalls.

**Guardrail - Inlet/Outlet**

- **Bridges 8592, 8593 & 8594 – Remove and Replace with Type 31 through Corridor**
  - This rehabilitation scope replaces all guardrail with new guardrail that meets the new design standard of Type 31 guardrail.
  - It will be required to meet the current design standard for guardrail or obtain a design exception.
    - Due to the major scope of the rehabilitation project, it was determined to assume that the new design standard will be met.
  - The guardrail would need to be replaced for its entire length and not just where excavation of roadway occurs since the new standard guardrail is 3 inches taller than the existing guardrail.
Development of Structure Alternatives
Structure alternatives have been generated for Bridge 8592 based on a combination of element alternatives discussed during the development of alternatives workshop held in May of 2017. The element alternatives for Bridge 8592 are summarized in the following table:

<table>
<thead>
<tr>
<th>Element</th>
<th>Alternative 2 - Rehabilitate</th>
<th>Alternative 2 Variations</th>
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<tbody>
<tr>
<td>Culvert Floor</td>
<td>Remove and Replace Concrete Floor (retain stone floor beneath)</td>
<td>2A: Remove Concrete Floor and Rehabilitate Mortared Stone Masonry</td>
</tr>
<tr>
<td>Knee Walls - Stone Masonry</td>
<td>Spot Pointing and Replace Deficient Stones</td>
<td>2A: Additional Spot Pointing and Replace Deficient Stones</td>
</tr>
<tr>
<td>Knee Walls - Concrete Cap</td>
<td>Repair Spalled and Delaminated Areas</td>
<td></td>
</tr>
<tr>
<td>Multi-Plate Arch</td>
<td></td>
<td>2B: Waterproof Top Surface of Multi-Plate Arch</td>
</tr>
<tr>
<td>Inlet/Outlet Masonry Headwall &amp; Wingwalls</td>
<td>Repoint and Replace Deficient or Missing Stones &amp; Reconstruct Severely Deteriorated Regions (to original geometry)</td>
<td>2C: Extend Height of Inlet Stone Headwall with Structural Wall and Stone Masonry</td>
</tr>
<tr>
<td></td>
<td>Reconstruct Severely Deteriorated Regions (to original geometry)</td>
<td>2D: Place Structural Concrete Retaining Wall between Inlet Stone Headwall &amp; Roadway</td>
</tr>
<tr>
<td></td>
<td>Reinforce Soil Slope (Turf Reinforcement Mat)</td>
<td>2E: Reinforce Soil Slope (Geogrid)</td>
</tr>
<tr>
<td>Guardrail - Inlet/Outlet</td>
<td>Remove and Replace Guardrail with Type 31 through Corridor</td>
<td></td>
</tr>
</tbody>
</table>

1 A ‘No Build’ alternative (Alternative 1) will be studied along with the tabled rehabilitation alternatives. Alternative 1 is not shown in the table due to redundancy.

Structure alternatives, excluding the ‘No Build’ alternative, were developed based on a core rehabilitation scope for the structure with combinations of element alternatives resulting in the following alternatives:

- Alternative 1 – No Build
- Alternative 2 – Rehabilitate
- Alternative 2A – Rehabilitate and Restore Original Masonry Floor
• Alternative 2B – Rehabilitate and Waterproof Top of Multi-Plate Arch
• Alternative 2C – Rehabilitate and Extend Height of Inlet Walls with Structural Walls and Stone Masonry
• Alternative 2D – Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway
• Alternative 2E – Rehabilitate and Reinforce Soil Slope

Each alternative has been developed to detail the scope of the alternative and evaluation of the alternative per the chosen evaluation criteria.

**Alternative 1 (8592) – No Build**

**Scope of Alternative 1:**
Alternative 1 proposes to leave the current structure in place with no rehabilitation. Maintenance of the structure would be continued.

**Evaluation of Alternative 1:**
- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated culvert floor contributes to this rating. With this alternative, there is no improvement to the culvert floor, knee walls or arch and thus no improvement to the condition rating, therefore it does not meet the primary need for a structurally sound crossing.
- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated headwalls and wingwalls, and eroding roadway inslope at the inlet headwall (putting culvert end treatment at risk) all contribute to the current NBI condition rating. With this alternative, there is no improvement to the condition ratings, therefore it does not meet the primary need for a structurally sound crossing.
- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. Because this alternative proposes no work, the inslope erosion deficiencies are not addressed.
- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.
- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron. Because this alternative proposes no work, the channel erosion issue is not addressed.
- **Section 106 (SEE Impact):** Alternative 1 would not involve a federal undertaking (project, activity, or program), therefore the Section 106 process would not be initiated, and this evaluation criterion does not apply.
Deterioration of the bridge would continue under this alternative and further loss of historic fabric is likely. As the bridge’s condition worsens, integrity of materials and workmanship would diminish.

Consistency with the SOI Standards is not assessed because it is assumed no measures would be taken to sustain or repair historic materials and features.

- **Endangered Species Act (SEE Impact):** This alternative proposes no construction activities therefore it has **no risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes no construction activities, resulting in **no risk** of impact to rare species or features.

- **DNR Public Waters (SEE Impact):** This alternative proposes no work in the drainage channel bottom or banks, resulting in **0 acres** of disturbance.

- **Section 4(f) (SEE Impact):** Alternative 1 does not propose federal action therefore this evaluation criterion **does not apply.**

- **Section 404 of the Clean Water Act (SEE Impact):** This alternative does not propose to place any fill into Waters Contributing to Waters of the US, resulting in **0 cubic yards** of proposed fill.

- **Construction Noise (SEE Impact):** This alternative proposes no construction activities, resulting in **no impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes no construction activities, resulting in **no impact** to TH 74 traffic.

If nothing were done to the bridge in the near future, it would result in continued maintenance to the roadway slopes that would cause service interruptions such as lane closures. Over the long term, if no major construction work is to occur, closure of the roadway for emergency repairs is a probable outcome. Emergency repairs are assumed to be of moderate duration (between 2 weeks and 3 months), resulting in a moderate impact to TH 74 traffic.

- **Construction Cost:** The construction cost is estimated to be **$0** due to no work being proposed.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **17.30 inventory and 22.43 operating.** The rating factors are more than adequate to carry TH 74 and would not result in a load posting.

- **Service Life (Design Consideration):** If no repairs were undertaken, it is estimated that the structure has a **remaining service life of 5 to 10 years** until the next major rehabilitation would be required. With the headwalls and wingwalls already in poor condition, they are expected to continue to deteriorate but at an unknown rate. However, since some portions of the walls are already failing, it is anticipated that their condition will begin to rapidly deteriorate in the near future.
Alternative 2 (8592) – Rehabilitate

Scope of Alternative 2:
Alternative 2 proposes a basic rehabilitation to Bridge 8592. This alternative would involve removing and replacing the deteriorated and non-historic concrete floor with a new concrete floor, selectively repairing the spalled and delaminated areas of the concrete knee wall cap and reconstructing severely deteriorated regions and repointing and replacing deficient stones of the stone masonry headwalls and wingwalls. The stone masonry knee walls that will be exposed upon removal of the concrete floor will be repointed and any deficient stones replaced.

The existing guardrail would be removed and replaced with the new standard guardrail, MnDOT Type 31. The new standard requires 2 feet of a 1:10 slope behind the guardrail post before breaking the slope. This will result in a 1:2 slope from the slope break to the top of the headwall at the inlet (worst case). The maximum desired roadway incline is a 1:3 and it has been determined that a surface-applied turf reinforcement mat would be acceptable for stabilization of slopes between 1:2 and 1:3. Therefore, a surface-applied turf reinforcement mat would be placed on the inlet slope to add an erosion control measure. The outlet slope would not receive additional soil stabilization but would be re-graded and vegetation re-established by traditional methods of seed and erosion control blanket since the slope is greater than 1:3 (1:3.6). See Section VII for further details regarding the individual scope items for this alternative.

![Diagram of Type 31 Guardrail and Surface Soil Stabilization at Bridge 8292 Inlet (Alternative 2)](image-url)
Figure 10: Type 31 Guardrail at Bridge 8292 Outlet (Alternative 2)

Evaluation of Alternative 2:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through reconstruction and repointing. However, the steep slope at the inlet headwall would remain, leaving the stone masonry headwalls and wingwalls in a state where they are vulnerable to damage from future erosion and subject to overburden/surge pressure. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the inlet erosion deficiencies are **partially addressed**.
• **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are **not addressed**.

• **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is **addressed**.

• **Section 106 (SEE Impact):** Alternative 2 would generally preserve the bridge’s integrity of design, materials, workmanship, feeling, and association. Integrity of design and feeling would be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. Integrity of location and setting would not be affected.

  Alternative 2 would be **consistent with the SOI Standards for Rehabilitation**. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Alternative 2’s turf reinforcement mat would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. Together the two most obvious alterations – the concrete floor and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. Therefore, this alternative has a **low risk** of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a **low risk** of impact to rare features.

• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. This work would constitute a temporary disturbance.
This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be 0.03 acres temporary and 0.001 acres permanent.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. Riprap is proposed at the end of the outlet apron. This would result in 5 cubic yards of fill.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, and removal and driving of guardrail posts. The duration of the project is estimated to be relatively short (less than 3 months). The construction special provisions would ensure construction activities are limited to specific hours to minimize disruption to park users. Due to the proposed noise mitigation and the short duration of construction, this alternative would have a low impact to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will not require excavation of the roadway, however staging of the work will likely require road closure and detour of TH 74 traffic for up to 3 months. Because of the closure and duration of traffic detour, there will be a moderate impact to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated to be $351,100 to $422,100 for a basic rehabilitation. See Section XIV and App. B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of 17.30 inventory and 22.43 operating. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure would have a remaining service life of 25 to 35 years. Although the walls are being repaired in this alternative, erosion of the roadway inslope has not been addressed and could cause the need for an additional repair or rehabilitation project.
Alternative 2A (8592) – Rehabilitate and Restore Original Masonry Floor

Scope of Alternative 2A:
Alternative 2A proposes the basic rehabilitation scope to Bridge 8592 of Alternative 2, but instead of removing and replacing the concrete floor, the stone masonry culvert floor would be restored. It is assumed that the stone masonry knee walls will be exposed upon removal of the concrete floor. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2A:
- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through reconstruction and repointing. However, the steep slope at the inlet headwall would remain, leaving the stone masonry headwalls and wingwalls in a state where they are vulnerable to damage from future erosion and subject to overburden/surcharge pressures. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the inlet erosion deficiencies are partially addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is addressed.
Section 106 (SEE Impact): Alternative 2A would generally preserve the bridge’s integrity of design, materials, workmanship, feeling, and association. The alternative would reverse an alteration by uncovering the stone floor. Integrity of design and feeling would be somewhat reduced by reinstalling modern steel guardrail. Integrity of location and setting would not be affected.

Alternative 2A would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The turf reinforcement mat would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail would be the alternative’s most obvious alteration. It would not be so visually disruptive that it prevents the bridge from conveying its historic character and significance.

Endangered Species Act (SEE Impact): This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. Therefore, this alternative has a low risk of impact to endangered species.

NHIS (SEE Impact): This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There would also be construction access needed to complete the masonry work and the masonry floor restoration which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a low risk of impact to rare features.

DNR Public Waters (SEE Impact): This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be 0.03 acres temporary and 0.001 acres permanent.

Section 4(f) (SEE Impact): This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.
• **Section 404 of the Clean Water Act (SEE Impact):** The concrete floor will be removed. The stone masonry floor will have a lower finished elevation, which technically removes fill from Waters Contributing to Waters of the US, however since it is the concrete floor which was previously placed, it is not considered an impact. This activity will place no fill. Riprap is proposed at the end of the outlet apron. This would result in 5 cubic yards of fill.

• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, and removal and driving of guardrail posts. The duration of the project is estimated to be relatively short (less than 3 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the short duration of construction, this alternative would have a **low impact** to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will not require excavation of the roadway, however staging of the work will likely require road closure and detour of TH 74 traffic for up to 3 months. Because of the closure and duration of traffic detour, there will be a **moderate impact** to TH 74 traffic.

• **Construction Cost:** The risk-based construction cost is estimated by combining the cost range for Alternative 2 ($351,100 to $422,100) with the change in cost resulting from the modified scope of restoring the stone culvert floor instead of replacing the concrete floor in-kind ($92,600 to $111,600). The cost range for this alternative is **$443,700 to $533,700**. See Section XIV and Appendix B for a detailed cost summary.

• **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of 17.30 inventory and 22.43 operating. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, and restoring the masonry culvert floor, it is estimated that the structure has a remaining service life of **25 to 35 years**. Although the walls are being repaired in this alternative, erosion of the roadway inslope has not been addressed and could cause the need for an additional repair or rehabilitation project.
Alternative 2B (8592) – Rehabilitate and Waterproof Top of Multi-Plate Arch

Scope of Alternative 2B:
Alternative 2B proposes the basic rehabilitation scope to Bridge 8592 of Alternative 2 and proposes excavation and waterproofing of the buried surface of the multi-plate arch. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2B:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no corrosion and little-to-no section loss on both the buried and exposed faces, therefore it is assumed that waterproofing the buried face of the arch would not improve the arch condition rating. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through reconstruction and repointing. However, the steep slope at the inlet headwall would remain, leaving the stone masonry headwalls and wingwalls in a state where they are vulnerable to damage from future erosion and subject to overburden/surcharge pressures. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the inlet erosion deficiencies are **partially addressed**.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are **not addressed**.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is **addressed**.
• **Section 106 (SEE Impact):** Alternative 2B would generally *preserve the bridge’s integrity* of design, materials, workmanship, feeling, and association. Integrity of design and feeling would be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. Integrity of location and setting would not be affected.

Alternative 2B would be **consistent with the SOI Standards for Rehabilitation.** Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Alternative 2B’s arch waterproofing and turf reinforcement mat would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. Together the two most obvious alterations – the concrete floor and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to expose the buried face of the multi-plate arch. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. There is a *low risk* of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to expose the buried face of the multi-plate arch. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a *low risk* of impact to rare features.

• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The waterproofing of the multi-plate arch and the reinforcing of the roadway inlet and outlet would result in a large excavation. However, the majority of the excavation would occur above ordinary high water. This work would constitute a temporary disturbance.
This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.001 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. Riprap is proposed at the end of the outlet apron. This would result in **5 cubic yards** of fill.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris as well as excavation and fill material, and removal and driving of guardrail posts. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($351,100 to $422,100) with the change in cost resulting from the additional scope of excavating and waterproofing the multi-plate arch ($264,100 to $317,100). The cost range for this alternative is **$615,200 to $739,200**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **17.30 inventory and 22.43 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.
• **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, waterproofing the multi-plate arch, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 45 years**.

**Alternative 2C (8592) – Rehabilitate and Extend Height of Inlet Walls with Structural Walls and Stone Masonry**

**Scope of Alternative 2C:**
Alternative 2C proposes the basic rehabilitation scope to Bridge 8592 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls using stone masonry to increase the height of the existing stone walls.

Due to the resulting overall height of the stone wall extension, it will be required to place a concrete retaining wall behind the stone masonry wall to be assured of its structural stability. This alternative proposes to dismantle the existing stone masonry wall, construct a reinforced-concrete wall directly behind it and to use the original stones to place a thick veneer (or stone facing) in front of the new concrete wall. The new concrete wall will not be visible upon completion of the project. Figure 13 depicts the proposed wall geometry with the dark stone hatch representing new stone, the light hatch is existing stone and the area with no hatch represents areas where the original stone is missing and must be replaced. The overall height of the wall is proposed to be raised by 3 feet 6 inches. Figure 14 shows a section through the slope and proposed wall with a new roadway inslope of 1:3. See Section VII for further details regarding the individual scope items for this alternative.

![Figure 11 – Stone Masonry Wall Extension Elevation (Alternative 2C)](image-url)
Figure 12 – Stone Masonry Wall Extension Section (Alternative 2C)

Evaluation of Alternative 2C:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where
there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the outlet headwall and wingwalls are stabilized through reconstruction and repointing. The inlet headwall and wingwalls would be replaced with a new concrete wall faced with stone masonry veneer. Placement of the new concrete wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion**: There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to increase the wall height which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the inlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden**: There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to replace the existing inlet headwall and wingwalls with a new concrete wall, the inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion**: There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact)**: Alternative 2C would significantly diminish the bridge’s integrity of design, feeling, and association by substantially changing the design, massing, and proportions of the east headwall and wingwalls. Integrity of design and feeling would also be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. The alternative would have less effect on integrity of materials and workmanship. Integrity of location and setting would not be affected.

Alternative 2C would not be consistent with SOI Standards. The east elevation, an important component of the bridge, would be altered considerably. This elevation would increase in square area by about 100%. While some distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce the bridge’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the changes to the east elevation, several options were considered including placing the additional stonework back from the plane of the headwall; using contrasting stone, cast-in-place concrete, concrete block, or another material rather than
matching limestone; and including a course of contrasting stone to delineate the original dimensions of the headwall and wingwalls. None of the options would provide significantly less impact to historic integrity than the wall extension proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the outlet and major excavation to construct the extended height stone-faced wall at the inlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the outlet and major excavation to construct the extended height stone-faced wall at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a **low risk** of impact to rare features.

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the outlet headwall and wingwalls to reconstruct and repoint the stone masonry. The construction of the extended height stone-faced walls at the inlet would result in a large excavation that would cause additional disturbance within ordinary high water at the culvert inlet. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.05 acres temporary** and **0.001 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. Riprap is proposed at the end of the outlet apron. This would result in **5 cubic yards** of fill.
• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor and hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the inlet walls. The duration of the project is estimated to be of moderate length. The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction (between 3 months and 6 months), this alternative would have a low/moderate impact to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a higher impact to TH 74 traffic.

• **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($351,100 to $422,100) with the change in cost resulting from the additional scope of replacing the inlet walls with a stone-faced concrete retaining wall ($281,900 to $338,900). The cost range for this alternative is $633,000 to $761,000. See Section XIV and Appendix B for a detailed cost summary.

• **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of 17.30 inventory and 22.43 operating. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration):** By reconstructing and repointing the outlet headwall and wingwalls, replacing the inlet headwall and wingwalls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of 30 to 40 years.
Alternative 2D (8592) – Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway

Scope of Alternative 2D:
Alternative 2D proposes the basic rehabilitation scope to Bridge 8592 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls by placing an intermediate reinforced-concrete structural wall between the stone headwall and the roadway shoulder. See Section VII for further details regarding the individual scope items for this alternative.

Figure 13 – Intermediate Structural Wall Section at Inlet Headwall (Alternative 2D)

The proposed reinforced-concrete wall will be placed between the guardrail and the stone masonry headwall to achieve a 1:3 slope in all locations between the stone wall and guardrail. The original stone masonry walls would not be altered in geometry or materials. The proposed concrete wall would be about 58 feet long. It would be exposed at a maximum height of 3 feet 6 inches. Figure 13 shows a
Evaluation of Alternative 2D:

- **Bridge Condition (Primary) – Arch & Knee Walls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, an intermediate concrete wall would be constructed behind the inlet headwall and wingwalls. The new concrete wall would become the new load-carrying element for the roadway embankment, the new wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion**: There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place an intermediate wall behind the inlet headwall which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the inlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden**: There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place an intermediate wall behind the inlet headwall which will alleviate loading on the existing stone masonry headwall and wingwalls. The inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion**: There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact)**: Alternative 2D would add a large new structure to the property, **significantly diminishing its integrity** of design, feeling, and association. Integrity of design and feeling would also be somewhat reduced by reinstalling the bridge’s concrete floor and the modern guardrail. The alternative would not affect integrity of materials, workmanship, location, or setting.
Alternative 2D **would not be consistent with SOI Standards.** By virtue of its size and location, the new wall would visually compete with, and distract from, the east elevation. The visual impact would be compounded by the wall’s close proximity to the steel guardrail – also a substantial modern structure. The wall’s design and material would be inconsistent with NPS Rustic Style emphasis on careful siting, native materials, rugged textures, and hand-built construction. The wall would separate the east end of the bridge from the roadway, altering their spatial relationship. The wall would represent a new element in the historic landscape that would be visible from some distance away. While distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce Bridge 8592’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the new wall, various options were considered. They included creating a wall with either horizontal terraces or vertical segments in various planes; building the wall of timbers, concrete blocks, or another material; giving the wall a surface texture; and facing the wall with stone. Not all of these options were geometrically or structurally feasible, and none would provide significantly less impact to historic integrity than the wall proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to construct the intermediate concrete retaining wall at the inlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. There is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to construct the intermediate concrete retaining wall at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a **low risk** of impact to rare features.

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the intermediate concrete retaining wall at the inlet would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.
Also, this alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.001 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. Riprap is proposed at the end of the outlet apron. This would result in **5 cubic yards** of fill.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor and hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the intermediate inlet wall. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($351,100 to $422,100) with the change in cost resulting from the additional scope of constructing an intermediate inlet wall ($5261,700 to $314,700). The cost range for this alternative is **$612,800 to $736,800**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **17.30 inventory** and **22.43 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, placing an intermediate inlet wall, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2E (8592) – Rehabilitate and Reinforce Soil Slope

Scope of Alternative 2E:
Alternative 2E proposes the basic rehabilitation scope to Bridge 8592 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls by using an embedded geo-grid soil reinforcement system instead of the surface-applied turf reinforcement mat proposed in Alternative 2. The slopes above the headwalls will be reinforced to achieve a stable slope although it is steeper than the desired 1:3. In this case, the resulting roadway inslope would be approximately 1:2. Geogrid would also be placed behind the stone masonry walls to alleviate some loading on the walls caused by the additional soil on the slope behind the wall. The existing guardrail would be removed and replaced with the new standard guardrail, MnDOT Type 31. The new standard requires 2 feet of a 1:10 slope behind the guardrail post before breaking the slope. The use of geogrid in the guardrail zone is likely to necessitate the need for a buried moment slab or alternative anchoring scheme for the guardrail. Figure 14 shows a section through the slope and proposed soil reinforcing section. See Bridge 8594 Alternative 2 for a rendering produced to visually portray the use of reinforced soil slopes. See Section VII for further details regarding the individual scope items for this alternative.

Figure 14 – Soil Reinforcing Section at Inlet Headwall (Alternative 2E)
Evaluation of Alternative 2E:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the inlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place soil reinforcing on the inlet slope to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the inlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place soil reinforcing behind the inlet headwall which will alleviate loading on the existing stone masonry walls. The inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron. This alternative proposes to place riprap at the end of the outlet apron to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2E would preserve the bridge's integrity of design, materials, workmanship, feeling, and association. Integrity of design and feeling would be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. Integrity of location and setting would not be affected.

Alternative 2E would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be
replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Alternative 2E’s geogrid soil reinforcing would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. Together the two most obvious alterations – the concrete floor and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. There is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. The project area does not lie within a site of biodiversity and best management practices will be employed for any disturbances to rare plant or animal species. Therefore, this alternative has a **low risk** of impact to rare features.

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the inlet soil reinforcing would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.001 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.
• Section 404 of the Clean Water Act (SEE Impact): Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. Riprap is proposed at the end of the outlet apron. This would result in 5 cubic yards of fill.

• Construction Noise (SEE Impact): This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor and hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the inlet soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a low/moderate impact to Park users.

• Impact to TH 74 Traffic (SEE Impact): This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a higher impact to TH 74 traffic.

• Construction Cost: The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($351,100 to $422,100) with the change in cost resulting from the additional scope of reinforcing the soils at the inlet walls ($181,800 to $218,800). The cost range for this alternative is $532,900 to $640,900. See Section XIV and Appendix B for a detailed cost summary.

• Load Capacity (Design Consideration): The structure load rating was computed for this study and resulted in HL-93 rating factors of 17.30 inventory and 22.43 operating. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• Service Life (Design Consideration): By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet walls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of 30 to 40 years.
IX. BRIDGE 8593 STRUCTURE REHABILITATION ALTERNATIVES AND EVALUATION

Development of Structure Alternatives
Structure alternatives have been generated for Bridge 8593 based on a combination of element alternatives discussed during the development of alternatives workshop held in May of 2017. The element alternatives for Bridge 8593 are summarized in the following table:

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<thead>
<tr>
<th>Bridge 8593 Alternatives</th>
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<tbody>
<tr>
<td><strong>Element</strong></td>
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<tr>
<td>Culvert Floor</td>
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<tr>
<td>Inlet Masonry Steps</td>
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<tr>
<td>Knee Walls - Stone Masonry</td>
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<tr>
<td>Knee Walls - Concrete Cap</td>
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<td>Inlet/Outlet Masonry Headwall &amp; Wingwalls</td>
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<td>Inlet Masonry Wingwalls</td>
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1 A 'No Build' alternative (Alternative 1) will be studied along with the tabled rehabilitation alternatives. Alternative 1 is not shown in the table due to redundancy.
Structure alternatives, excluding the ‘No Build’ alternative, were developed based on a core rehabilitation scope for the structure with combinations of elements alternatives resulting in the following alternatives:

- Alternative 1 – No Build
- Alternative 2 – Rehabilitate and Reinforce Soil Slopes
- Alternative 2A – Rehabilitate and Restore Original Masonry Floor
- Alternative 2B – Rehabilitate and Waterproof Top of Multi-Plate Arch
- Alternative 2C – Rehabilitate and Extend Height of Outlet Walls with Structural Wall and Stone Masonry
- Alternative 2D – Rehabilitate and Place Structural Wall between Stone Headwall and Roadway

Each alternative has been developed to detail the scope of the alternative and evaluation of the alternative per the chosen evaluation criteria.

**Alternative 1 (8593) – No Build**

**Scope of Alternative 1:**
Alternative 1 proposes to leave the current structure in place with no rehabilitation. Maintenance of the structure would be continued.

**Evaluation of Alternative 1:**

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated culvert floor contributes to this rating. With this alternative, there is no improvement to the culvert floor, knee walls or arch and thus no improvement to the condition rating, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated headwalls and wingwalls, and eroding roadway inslope at the outlet headwall (putting culvert end treatment at risk) all contribute to the current NBI condition rating. With this alternative, there is no improvement to the condition ratings, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet and inlet. Because this alternative proposes no work, the inslope erosion deficiencies are not addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.
• **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron and erosion at the southwest wingwall end. Because this alternative proposes no work, the channel erosion issues are **not addressed**.

• **Section 106 (SEE Impact):** Alternative 1 would not involve a federal undertaking (project, activity, or program), therefore the Section 106 process would not be initiated, and this evaluation criterion **does not apply**.

  Deterioration of the bridge would continue under this alternative and further loss of historic fabric is likely. As the bridge’s condition worsens, integrity of materials and workmanship would diminish.

  Consistency with the SOI Standards is not assessed because it is assumed no measures would be taken to sustain or repair historic materials and features.

• **Endangered Species Act (SEE Impact):** This alternative proposes no construction activities therefore it has **no risk** of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes no construction activities, resulting in **no risk** of impact to rare species or features and the biodiversity site.

• **DNR Public Waters (SEE Impact):** This alternative proposes no work in the drainage channel bottom or banks, resulting in **0 acres** of disturbance.

• **Section 4(f) (SEE Impact):** Alternative 1 does not propose federal action therefore this evaluation criterion **does not apply**.

• **Section 404 of the Clean Water Act (SEE Impact):** This alternative does not propose to place any fill into Waters Contributing to Waters of the US, resulting in **0 cubic yards** of proposed fill.

• **Construction Noise (SEE Impact):** This alternative proposes no construction activities, resulting in **no impact** to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes no construction activities, resulting in **no impact** to TH 74 traffic.

  If nothing were done to the bridge in the near future, it would result in continued maintenance to the roadway slopes that would cause service interruptions such as lane closures. Over the long term, if no major construction work is to occur, closure of the roadway for emergency repairs is a probable outcome. Emergency repairs are assumed to be of moderate duration (between 2 weeks and 3 months), resulting in a moderate impact to TH 74 traffic.
• **Construction Cost:** The construction cost is estimated to be $0 due to no work being proposed.

• **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **31.28 inventory and 41.55 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting.

• **Service Life (Design Consideration):** If no repairs were undertaken, it is estimated that the structure has a **remaining service life of 5 to 10 years** until the next major rehabilitation would be required. With the headwalls and wingwalls already in poor condition, they are expected to continue to deteriorate but at an unknown rate. However, since some portions of the walls are already failing, it is anticipated that their condition will begin to rapidly deteriorate in the near future.
Alternative 2 (8593) – Rehabilitate and Reinforce Soil Slopes

Scope of Alternative 2:
Alternative 2 proposes a basic rehabilitation to Bridge 8593. This alternative would involve removing and replacing the deteriorated and non-historic concrete floor with a new concrete floor, selectively repairing the spalled, cracked, and delaminated areas of the concrete knee wall cap, selectively replacing corroded sections of multi-plate (at existing I-beam headwall extension), and reconstructing severely deteriorated regions and repointing and replacing deficient stones of the stone masonry steps, headwalls and wingwalls. The stone masonry knee walls that will be exposed upon removal of the concrete floor will be repointed and any deficient stones replaced. Additionally, Alternative 2 proposes to address the erosion at the southwest wingwall end by extending the length of the wingwall with stone masonry. This alternative would extend the wingwall length by a maximum of 10 feet. The extension would be set back about 3 inches from the existing wall to differentiate it. It would be about 5 feet tall, tapering to about 2 feet.

Because a basic rehabilitation must also include removal of the corroding non-historic I-beams, this alternative proposes to address the steep and eroding roadway inslopes above the outlet headwall and wingwalls by using a geo-grid soil reinforcement system. The slopes above the headwalls will be reinforced to achieve a stable slope although it is steeper than the desired 1:3. In this case, the resulting roadway inslope would be approximately 1:0.9. Geogrid would also be placed behind the stone masonry walls to alleviate some loading on the walls caused by the additional soil on the slope behind the wall. Because this alternative will require a large excavation, the guardrail will need to be removed and replaced. The existing guardrail would be removed and replaced with the new standard guardrail, MnDOT Type 31. The new standard requires 2 feet of a 1:10 slope behind the guardrail post before breaking the slope. The use of geogrid in the guardrail zone is likely to necessitate the need for a buried moment slab or alternative anchoring scheme for the guardrail. See Section VII for further details regarding the individual scope items for this alternative.
The inslope above the inlet headwall and wingwall will receive a similar soil reinforcing treatment as proposed for the outlet. Since the walls do not currently appear to be affected by the roadway inslope, the excavation and reinforcing at the inlet will not extend to behind the stone masonry walls. The resulting slope will be a 1:1.5. See Bridge 8594 Alternative 2 for a rendering produced to visually portray the use of reinforced soil slopes.
Evaluation of Alternative 2:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).
• **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the outlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

• **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are **addressed**.

• **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to place soil reinforcing behind the outlet headwall which will alleviate loading on the existing stone masonry walls. The outlet surcharge/overburden concerns are **addressed**.

• **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is **addressed**.

• **Section 106 (SEE Impact):** Alternative 2 would generally **preserve the bridge’s integrity** of design, materials, workmanship, feeling, and association. Removing the I-beam from the east headwall would reverse a conspicuous alteration. Integrity of design would be somewhat diminished by adding up to 10 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor and modern steel guardrail. The alternative would not affect integrity of location or setting.

Alternative 2 would be **consistent with the SOI Standards for Rehabilitation.** Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 10 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3
inches from the plane of the existing wall to differentiate it. The change would occur at a
distinctive part of the bridge near the step-like drop structure at the end of the flume. The
addition would be modest in size: a 10-foot-long, 35-square-foot addition would increase the
wall area of the flume by about 7%. Alternative 2’s geogrid soil reinforcing would be hidden.
The steel guardrail, while visually incompatible with the bridge, is a necessary and removable
safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible.
Together the three most obvious alterations – the concrete floor, wingwall addition, and metal
guardrail – would not be so visually disruptive that they prevent the bridge from conveying its
historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to
retain the slope would not be feasible given the steep grade. An addition of contrasting stone
or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most
important characteristics, the way it harmonizes with its setting.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform
the stone masonry repointing and reconstruction work and major excavation to place the
geogrid at the inlet and outlet. There are no known northern long-eared bat roost trees in the
vicinity of the project and the proposed activities do not intend to remove trees larger than 3
inches in diameter. There is a **low risk** of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry
repointing and reconstruction work and major excavation to place the geogrid at the inlet and
outlet. There would also be construction access needed to complete the masonry work and the
concrete floor replacement which would cause ground disturbances within the drainage
channel. There is currently no vegetation on the concrete culvert floor. Best management
practices will be employed for any disturbances to rare plant or animal species. Because specific
locations of rare native plant communities are currently unknown, the measure of risk is based
upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of
impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to
replace the concrete floor, minor repair to the concrete knee walls, and construction activity at
the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of
the inlet and outlet soil reinforcing would result in a large excavation, but the excavation would
be outside of ordinary high water since the stone masonry wall would remain in place. This
work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the
end of the outlet apron and the southwest wingwall extension. The project special provisions
would need to ensure extreme care is taken when performing the work and that best
management practices are implemented.
The total disturbance would be **0.03 acres temporary** and **0.004 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated to be **$767,100 to $921,100** which includes a basic rehabilitation as well as soil reinforcing. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **31.28 inventory and 41.55 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2A (8593) – Rehabilitate and Restore Original Masonry Floor

Scope of Alternative 2A:
Alternative 2A proposes the basic rehabilitation scope to Bridge 8593 of Alternative 2, but instead of removing and replacing the concrete floor, the stone masonry culvert floor would be restored. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2A:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the outlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to place soil reinforcing behind the outlet headwall which will alleviate loading on the existing stone masonry walls. The outlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.
• **Section 106 (SEE Impact):** Alternative 2A would generally preserve the bridge's integrity of design, materials, workmanship, feeling, and association. Uncovering the stone floor and removing the I-beam from the east headwall would reverse two alterations. Integrity of design would be somewhat diminished by adding up to 10 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling modern steel guardrail. The alternative would not affect integrity of location or setting.

Alternative 2A would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 10 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 10-foot-long, 35-square-foot addition would increase the wall area of the flume by about 7%. Alternative 2A’s geogrid soil reinforcing would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. Together the two most obvious alterations – the wingwall addition and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees larger than 3 inches in diameter. There is a low risk of impact to endangered species.
• **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to restore the culvert floor to stone masonry, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the inlet and outlet soil reinforcing would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance. This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.004 acres permanent**.

• **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

• **Section 404 of the Clean Water Act (SEE Impact):** The concrete floor will be removed. The stone masonry floor will have a lower finished elevation, which technically removes fill from Waters Contributing to Waters of the US, however since it is the concrete floor which was previously placed, it is not considered an impact. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption.
to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($767,100 to $921,100) with the change in cost resulting from the modified scope of restoring the stone culvert floor instead of replacing the concrete floor in-kind ($108,300 to $130,300). The cost range for this alternative is **$875,400 to $1,051,400**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **31.28 inventory and 41.55 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls, repairing the knee walls, and restoring the masonry culvert floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2B (8593) – Rehabilitate and Waterproof Top of Multi-Plate Arch

Scope of Alternative 2B:
Alternative 2B proposes the basic rehabilitation scope to Bridge 8593 of Alternative 2 and proposes excavation and waterproofing of the buried surface of the multi-plate arch. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2B:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no corrosion and little-to-no section loss on both the buried and exposed faces, therefore it is assumed that waterproofing the buried face of the arch would not improve the arch condition rating. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the outlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to place soil reinforcing behind the outlet headwall which will alleviate loading on the existing stone masonry walls. The outlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end
of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2B would generally **preserve the bridge's integrity** of design, materials, workmanship, feeling, and association. Removing the I-beam from the east headwall would reverse a conspicuous alteration. Integrity of design would be somewhat diminished by adding up to 10 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor and modern steel guardrail. The alternative would not affect integrity of location or setting.

Alternative 2B would be **consistent with the SOI Standards for Rehabilitation.** Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 10 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 10-foot-long, 35-square-foot addition would increase the wall area of the flume by about 7%. Alternative 2B’s arch waterproofing and geogrid reinforcing would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. Together the three most obvious alterations – the concrete floor, wingwall addition, and metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet and to expose the buried face of the multi-plate arch. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed
activities do not intend to remove trees larger than 3 inches in diameter. There is a \textit{low risk} of impact to endangered species.

- \textbf{NHIS (SEE Impact):} This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet and to expose the buried face of the multi-plate arch. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a \textit{moderate risk} of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- \textbf{DNR Public Waters (SEE Impact):} This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The waterproofing of the multi-plate arch and the reinforcing of the roadway inlet and outlet would result in a large excavation. However, the majority of the excavation would occur above ordinary high water. This work would constitute a temporary disturbance.

  This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

  The total disturbance would be \textbf{0.03 acres temporary and 0.004 acres permanent}. 

- \textbf{Section 4(f) (SEE Impact):} This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- \textbf{Section 404 of the Clean Water Act (SEE Impact):} Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place \textbf{approximately 15 cubic yards} of fill into Waters Contributing to Waters of the US.

- \textbf{Construction Noise (SEE Impact):} This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of
moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a low/moderate impact to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a higher impact to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($767,100 to $921,100) with the change in cost resulting from the additional scope of excavating and waterproofing the multi-plate arch ($138,200 to $166,200). The cost range for this alternative is $905,300 to $1,087,300. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of 31.28 inventory and 41.55 operating. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls and slopes, repairing the knee walls, waterproofing the multi-plate arch, and replacing the concrete floor, it is estimated that the structure has a remaining service life of 30 to 45 years.
Alternative 2C (8593) – Rehabilitate and Extend Height of Outlet Walls with Structural Wall and Stone Masonry

Scope of Alternative 2C:
Alternative 2C proposes the basic rehabilitation scope to Bridge 8593 of Alternative 2 and instead of reinforcing the roadway inslopes, it proposes to address the eroding roadway inslopes above the outlet headwall and wingwalls using stone masonry to increase the height of the existing stone walls.

Due to the resulting overall height of the stone wall extension, it will be required to place a concrete retaining wall behind the stone masonry wall to be assured of its structural stability. This alternative proposes to dismantle the existing stone masonry wall, construct a reinforced-concrete wall directly behind it and to use the original stones to place a thick veneer (or stone facing) in front of the new concrete wall. The new concrete wall will not be visible upon completion of the project. Figure 17 depicts the proposed wall geometry with the dark stone hatch representing new stone and the light hatch is existing stone. The overall height of the wall is proposed to be raised by 5 feet. Figure 18 shows a section through the slope and proposed wall with a new roadway inslope of 1:3. See Section VII for further details regarding the individual scope items for this alternative.

Figure 17 – Stone Masonry Wall Extension Elevation (Alternative 2C)
Figure 18 – Stone Masonry Wall Extension Section (Alternative 2C)
Evaluation of Alternative 2C:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet headwall and wingwalls are stabilized through reconstruction and repointing. The outlet headwall and wingwalls would be replaced with a new concrete wall faced with stone masonry veneer. Placement of the new concrete wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet but not the inlet. This alternative proposes to increase the wall height which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the outlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to replace the existing inlet headwall and wingwalls with a new concrete wall, the outlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2C would reverse an alteration by removing the I-beam from the east headwall. However, the alternative would significantly diminish the bridge’s integrity of design, feeling, and association by substantially changing the design, massing, and proportions of the east headwall and wingwalls. Integrity of design would be somewhat diminished by adding up to 10 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor and modern steel guardrail. The alternative would have less effect on integrity of materials and workmanship. The alternative would not affect integrity of location or setting. Alternative 2C would not be consistent with SOI Standards. The east elevation, an important component of the bridge, would be altered considerably. This elevation would increase in
square area by about 100%. While some distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce the bridge’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the changes to the east elevation, several options were considered including placing the additional stonework back from the plane of the headwall; using contrasting stone, cast-in-place concrete, concrete block, or another material rather than matching limestone; and including a course of contrasting stone to delineate the original dimensions of the headwall and wingwalls. None of the options would provide significantly less impact to historic integrity than the wall extension proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the inlet and major excavation to construct the extended height stone-faced wall at the outlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees larger than 3 inches in diameter. There is a low risk of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the inlet and major excavation to construct the extended height stone-faced wall at the outlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a moderate risk of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the inlet headwall and wingwalls to reconstruct and repoint the stone masonry. The construction of the extended height stone-faced walls at the outlet and the soil reinforcing at the inlet would result in a large excavation. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.05 acres temporary** and **0.004 acres permanent**.
• **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

• **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the outlet walls. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

• **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($767,100 to $921,100) with the change in cost resulting from the additional scope of replacing the outlet walls with a stone-faced concrete retaining wall instead of soil reinforcing ($193,100 to $232,100). The cost range for this alternative is **$960,200 to $1,153,200**. See Section XIV and Appendix B for a detailed cost summary.

• **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **31.28 inventory and 41.55 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration):** By reconstructing and repointing the outlet headwall and wingwalls, reinforcing the inlet roadway inslope, replacing the outlet headwall and wingwalls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2D (8593) – Rehabilitate and Place Structural Wall between Stone Headwall and Roadway

Scope of Alternative 2D:
Alternative 2D proposes the basic rehabilitation scope to Bridge 8593 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the outlet headwall and wingwalls by placing an intermediate reinforced-concrete structural wall between the stone headwall and the roadway shoulder instead of reinforcing the roadway inslope. See Section VII for further details regarding the individual scope items for this alternative.

Figure 19 – Intermediate Structural Wall Section at Outlet Headwall (Alternative 2D)

The proposed reinforced-concrete wall will be placed between the guardrail and the stone masonry headwall to achieve a 1:3 slope in all locations between the stone wall and guardrail. The original stone
masonry walls would not be altered in geometry or materials. The proposed concrete wall would be about 100 feet long and would be exposed at a maximum height of 6 feet 3 inches. Figure 19 shows a section through the slope and proposed wall with a new roadway inslope of 1:3. See Bridge 8594 Alternative 2D for a rendering produced to visually portray the insertion of an intermediate wall.

Evaluation of Alternative 2D:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, an intermediate concrete wall would be constructed behind the outlet headwall and wingwalls. The new concrete wall would become the new load-carrying element for the roadway embankment, the new wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet but not the inlet. This alternative proposes to place an intermediate wall behind the inlet headwall which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the outlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to place an intermediate wall behind the outlet headwall which will alleviate loading on the existing stone masonry headwall and wingwalls. The outlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2D would reverse an alteration by removing the I-beam from the east headwall. However, the alternative would add a large new structure to the
property, **significantly diminishing its integrity** of design, feeling, and association. Integrity of design and feeling would also be somewhat reduced by reinstalling the bridge’s concrete floor and the modern guardrail. The alternative would not affect integrity of materials, workmanship, location, or setting.

Alternative 2D **would not be consistent with SOI Standards**. By virtue of its size and location, the new wall would visually compete with, and distract from, the east elevation. The visual impact would be compounded by the wall’s close proximity to the steel guardrail – also a substantial modern structure. The wall’s design and material would be inconsistent with NPS Rustic Style emphasis on careful siting, native materials, rugged textures, and hand-built construction. The wall would separate the east end of the bridge from the roadway, altering their spatial relationship. The wall would represent a new element in the historic landscape that would be visible from some distance away. While distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce Bridge 8593’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the new wall, various options were considered. They included creating a wall with either horizontal terraces or vertical segments in various planes; building the wall of timbers, concrete blocks, or another material; giving the wall a surface texture; and facing the wall with stone. Not all of these options were geometrically or structurally feasible, and none would provide significantly less impact to historic integrity than the wall proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to construct the intermediate concrete retaining wall at the outlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees larger than 3 inches in diameter. There is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and construction work and major excavation to construct the intermediate concrete retaining wall at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).
- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the intermediate concrete retaining wall at the outlet would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.004 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the intermediate outlet wall. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($767,100 to $921,100) with the change in cost resulting from the additional scope of constructing an intermediate wall instead of soil reinforcing at the outlet ($357,000 to **$767,100** to **$921,100**).
$429,000). The cost range for this alternative is **$1,124,100 to $1,350,100**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** The structure load rating was computed for this study and resulted in HL-93 rating factors of **31.28 inventory and 41.55 operating**. The rating factors are more than adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the inlet roadway inslope, placing an intermediate outlet wall, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure will have a remaining service life of **30 to 40 years**.
X. BRIDGE 8594 STRUCTURE REHABILITATION ALTERNATIVES AND EVALUATION

Development of Structure Alternatives

Structure alternatives have been generated for Bridge 8594 based on a combination of element alternatives discussed during the development of alternatives workshop held in May of 2017. The element alternatives for Bridge 8594 are summarized in the following table:

<table>
<thead>
<tr>
<th>Bridge 8594 Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
</tr>
<tr>
<td>Culvert Floor</td>
</tr>
<tr>
<td>Inlet Masonry Steps</td>
</tr>
<tr>
<td>Knee Walls - Stone Masonry</td>
</tr>
<tr>
<td>Knee Walls - Concrete Cap</td>
</tr>
<tr>
<td>Multi-Plate Arch</td>
</tr>
<tr>
<td>Inlet/Outlet Masonry Headwall &amp; Wingwalls</td>
</tr>
<tr>
<td>Inlet Masonry Wingwalls</td>
</tr>
<tr>
<td>Guardrail - Inlet/Outlet</td>
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</tbody>
</table>

1 A 'No Build' alternative (Alternative 1) will be studied along with the tabled rehabilitation alternatives. Alternative 1 is not shown in the table due to redundancy.
Structure alternatives, excluding the ‘No Build’ alternative, were developed based on a core rehabilitation scope for the structure with combinations of elements alternatives resulting in the following alternatives:

- Alternative 1 – No Build
- Alternative 2 – Rehabilitate and Reinforce Soil Slopes
- Alternative 2A – Rehabilitate and Restore Original Masonry Floor
- Alternative 2B – Rehabilitate and Waterproof Top of Multi-Plate Arch
- Alternative 2C – Rehabilitate and Extend Height of Inlet Walls with Structural Wall and Stone Masonry
- Alternative 2D – Rehabilitate and Place Structural Wall between Stone Headwall and Roadway

Each alternative has been developed to detail the scope of the alternative and evaluation of the alternative per the chosen evaluation criteria.

**Alternative 1 (8594) – No Build**

**Scope of Alternative 1:**
Alternative 1 proposes to leave the current structure in place with no rehabilitation. Maintenance of the structure would be continued.

**Evaluation of Alternative 1:**

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated culvert floor contributes to this rating. With this alternative, there is no improvement to the culvert floor, knee walls or arch and thus no improvement to the condition rating, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated headwalls and wingwalls, and eroding roadway inslope at the inlet headwall (putting culvert end treatment at risk) all contribute to the current NBI condition rating. With this alternative, there is no improvement to the condition ratings, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. Because this alternative proposes no work, the inslope erosion deficiencies are not addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.
- **Bridge Condition (Primary) – Channel Erosion**: There is channel erosion at the end of the outlet apron and erosion at the southwest wingwall end. Because this alternative proposes no work, the channel erosion issues are **not addressed**.

- **Section 106 (SEE Impact)**: Alternative 1 would not involve a federal undertaking (project, activity, or program), therefore the Section 106 process would not be initiated, and this evaluation criterion **does not apply**.

  Deterioration of the bridge would continue under this alternative and further loss of historic fabric is likely. As the bridge’s condition worsens, integrity of materials and workmanship would diminish.

  Consistency with the SOI Standards is not assessed because it is assumed no measures would be taken to sustain or repair historic materials and features.

- **Endangered Species Act (SEE Impact)**: This alternative proposes no construction activities therefore it has **no risk** of impact to endangered species.

- **NHIS (SEE Impact)**: This alternative proposes no construction activities, resulting in **no risk** of impact to rare species or features and the biodiversity site.

- **DNR Public Waters (SEE Impact)**: This alternative proposes no work in the drainage channel bottom or banks, resulting in **0 acres** of disturbance.

- **Section 4(f) (SEE Impact)**: Alternative 1 does not propose federal action therefore this evaluation criterion **does not apply**.

- **Section 404 of the Clean Water Act (SEE Impact)**: This alternative does not propose to place any fill into Waters Contributing to Waters of the US, resulting in **0 cubic yards** of proposed fill.

- **Construction Noise (SEE Impact)**: This alternative proposes no construction activities, resulting in **no impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact)**: This alternative proposes no construction activities, resulting in **no impact** to TH 74 traffic.

  If nothing were done to the bridge in the near future, it would result in continued maintenance to the roadway slopes that would cause service interruptions such as lane closures. Over the long term, if no major construction work is to occur, closure of the roadway for emergency repairs is a probable outcome. Emergency repairs are assumed to be of moderate duration (between 2 weeks and 3 months), resulting in a moderate impact to TH 74 traffic.
• **Construction Cost:** The construction cost is estimated to be $0 due to no work being proposed.

• **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.32 inventory and 1.71 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting.

• **Service Life (Design Consideration):** If no repairs were undertaken, it is estimated that the structure has a **remaining service life of 5 to 10 years** until the next major rehabilitation would be required. With the headwalls and wingwalls already in poor condition, they are expected to continue to deteriorate but at an unknown rate. However, since some portions of the walls are already failing, it is anticipated that their condition will begin to rapidly deteriorate in the near future.
Alternative 2 (8594) – Rehabilitate and Reinforce Soil Slopes

Scope of Alternative 2:
Alternative 2 proposes a basic rehabilitation to Bridge 8594. This alternative would involve removing and replacing the deteriorated and non-historic concrete floor with a new concrete floor, selectively repairing the spalled and delaminated areas of the concrete knee wall cap, selectively replacing corroded sections of multi-plate (at existing I-beam headwall extension) and reconstructing severely deteriorated regions and repointing and replacing deficient stones of the stone masonry steps, headwalls and wingwalls. The stone masonry knee walls that will be exposed upon removal of the concrete floor will be repointed and any deficient stones replaced. Additionally, Alternative 2 proposes to address the erosion at the southwest wingwall end by reconstructing the missing portion of the wingwall with stone masonry back to its original geometry. The missing portion of wingwall is approximately 20 feet long. It would be approximately 6 feet in height, with the height at the end of the all matching the height of the northwest wingwall in order to construct the wall similar to original geometry. See Section VII for further details regarding the individual scope items for this alternative.

Figure 20 – Soil Reinforcing Section at Inlet Headwall (Alternative 2)
Because a basic rehabilitation must also include removal of the corroding non-historic I-beams, this alternative proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls by using a geo-grid soil reinforcement system. The slopes above the headwalls will be reinforced to achieve a stable slope although it is steeper than the desired 1:3. In this case, the resulting roadway inslope would be approximately 1:1.2. Geogrid would also be placed behind the stone masonry walls to alleviate some loading on the walls caused by the additional soil on the slope behind the wall. The existing guardrail would be removed and replaced with the new standard guardrail, MnDOT Type 31. The new standard requires 2 feet of a 1:10 slope behind the guardrail post before breaking the slope. The use of geogrid in the guardrail zone is likely to necessitate the need for a buried moment slab or alternative anchoring scheme for the guardrail.

The inslope above the outlet headwall and wingwall will receive a similar soil reinforcing treatment as proposed for the inlet. Since the walls do not currently appear to be affected by the roadway inslope, the excavation and reinforcing at the outlet will not extend to behind the stone masonry walls. The resulting slope will be a 1:1.8.

Figure 21 – Soil Reinforcing Section at Outlet Headwall (Alternative 2)
Rendering 1A: Bridge 8594 Inlet – Existing Condition

Rendering 1B: Bridge 8594 Inlet – Proposed Slope Reinforcing
Evaluation of Alternative 2:

- **Bridge Condition (Primary) – Arch & Knee Walls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the inlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

- **Bridge Condition (Primary) – Inslope Erosion**: There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden**: There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place soil reinforcing behind the inlet headwall which will alleviate loading on the existing stone masonry walls. The inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion**: There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact)**: Alternative 2 would generally preserve the bridge’s integrity of design, materials, workmanship, feeling, and association. Removing the three I-beams from the east headwall would reverse a conspicuous alteration. The alternative would reconstruct the missing 20-foot-long piece of the southwest wingwall/flume wall, also improving integrity. Integrity of design and feeling would be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. The alternative would not affect integrity of location or setting.
Alternative 2 would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Alternative 2’s geogrid soil reinforcing would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. Together the two most obvious alterations – the concrete floor and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There are no known northern long-eared bat roost trees in the vicinity of the project however the proposed activities have the potential to remove select large trees. Best management practices will be employed for any tree removal to ensure the northern long-eared bat is minimally affected. Through the use of best management practices, there is a low risk of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a moderate risk of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the inlet soil reinforcing would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions...
would need to ensure extreme care is taken when performing the work and that best
management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.003 acres permanent**

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for
each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to
its current elevation, this activity does not propose to place any fill into Waters Contributing to
Waters of the US. The extension of the southwest wingwall and the riprap at the end of the
outlet apron will, however, place approximately **25 cubic yards** of fill into Waters Contributing
to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would
utilize heavy equipment for removal of the concrete floor, hauling of the construction debris,
evacuation material and fill material, removal and driving of guardrail posts, and construction of
the soil reinforcing. The duration of the project is estimated to be of moderate length (between
than 3 months and 6 months). The construction special provisions would ensure construction
activities are limited to specific hours and that noise levels are controlled to minimize disruption
to park users. Due to the proposed noise mitigation and the moderate duration of construction,
this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will
require excavation and complete closure of the roadway. A road closure and detour of TH 74
traffic will be required in excess of 3 months. Because of the closure and duration of traffic
detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated to be **$ 906,300 to
$1,088,300** which includes a basic rehabilitation as well as soil reinforcing. See Section XIV and
Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing
structure for this study and resulted in HL-93 rating factors of **1.32 inventory and 1.71
operating**. The rating factors are adequate to carry TH 74 and would not result in a load
posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and
wingwalls, reinforcing the soils at the inlet and outlet walls, repairing the knee walls, and
replacing the concrete floor, it is estimated that the structure has a remaining service life of **30
to 40 years.**
Alternative 2A (8594) – Rehabilitate and Restore Original Masonry Floor

Scope of Alternative 2A:
Alternative 2A proposes the basic rehabilitation scope to Bridge 8594 of Alternative 2, but instead of removing and replacing the concrete floor, the stone masonry culvert floor would be restored. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2A:
- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the inlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place soil reinforcing behind the inlet headwall which will alleviate loading on the existing stone masonry walls. The inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end
of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is **addressed**.

- **Section 106 (SEE Impact):** Alternative 2A would generally **preserve the bridge's integrity** of design, materials, workmanship, feeling, and association. Uncovering the stone floor and removing the I-beams from the east headwall would reverse two alterations. The alternative would reconstruct the missing 20-foot-long piece of the southwest wingwall/flume wall, also improving integrity. Integrity of design and feeling would be somewhat reduced by reinstalling modern steel guardrail. The alternative would not affect integrity of location or setting.

Alternative 2A would be **consistent with the SOI Standards for Rehabilitation**. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden, as would the geogrid soil reinforcing. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. The guardrail would be the alternative’s most obvious alteration. It would not be so visually disruptive that it prevents the bridge from conveying its historic character and significance.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There are no known northern long-eared bat roost trees in the vicinity of the project however the proposed activities have the potential to remove select large trees. Best management practices will be employed for any tree removal to ensure the northern long-eared bat is minimally affected. Through the use of best management practices, there is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to restore the culvert floor to stone masonry, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone
masonry. The construction of the inlet and outlet soil reinforcing would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.003 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** The concrete floor will be removed. The stone masonry floor will have a lower finished elevation, which technically removes fill from Waters Contributing to Waters of the US, however since it is the concrete floor which was previously placed, it is not considered an impact. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **25 cubic yards** of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($906,300 to $1,088,300) with the change in cost resulting from the modified scope of restoring the stone culvert floor instead of replacing the concrete floor in-kind ($141,400 to $170,400). The cost range for this alternative is **$1,047,700 to $1,258,700**. See Section XIV and Appendix B for a detailed cost summary.
• **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.32 inventory and 1.71 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls, repairing the knee walls, and restoring the masonry culvert floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2B (8594) – Rehabilitate and Waterproof Top of Multi-Plate Arch

Scope of Alternative 2B:
Alternative 2B proposes the basic rehabilitation scope to Bridge 8594 of Alternative 2 and proposes excavation and waterproofing of the buried surface of the multi-plate arch. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2B:
• **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. It is assumed that waterproofing the buried face of the arch would not improve the arch condition rating. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no corrosion and little-to-no section loss on both the buried and exposed faces. This alternative would increase the culvert condition rating to 7 (good condition).

• **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the inlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).

• **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

• **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place soil reinforcing behind the inlet headwall which will alleviate loading on the existing stone masonry walls. The inlet surcharge/overburden concerns are addressed.
- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2B would generally preserve the bridge’s integrity of design, materials, workmanship, feeling, and association. Removing the three I-beams from the east headwall would reverse a conspicuous alteration. The alternative would reconstruct the missing 20-foot-long piece of the southwest wingwall/flume wall, also improving integrity. Integrity of design and feeling would be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. The alternative would not affect integrity of location or setting.

Alternative 2B would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. The concrete collar associated with the metal arch repairs would be hidden. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Alternative 2B’s arch waterproofing and geogrid reinforcing would be hidden. The steel guardrail, while visually incompatible with the bridge, is a necessary and removable safety feature. The guardrail moment slab, at or slightly below grade, would not be very visible. Together the two most obvious alterations – the concrete floor and the metal guardrail – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet and to expose the buried face of the multi-plate arch. There are no known northern long-eared bat roost trees in the vicinity of the project however the proposed activities have the potential to remove select large trees. Best management practices will be employed for any tree removal to ensure the northern long-eared bat is minimally affected. Through the use of best management practices, there is a low risk of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet and to expose the buried face of the multi-plate arch. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to
rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a moderate risk of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The waterproofing of the multi-plate arch and the reinforcing of the roadway inlet and outlet would result in a large excavation. However, the majority of the excavation would occur above ordinary high water. This work would constitute a temporary disturbance.

  This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

  The total disturbance would be 0.03 acres temporary and 0.003 acres permanent.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately 25 cubic yards of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a low/moderate impact to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a higher impact to TH 74 traffic.
• **Construction Cost**: The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($906,300 to $1,088,300) with the change in cost resulting from the additional scope of excavating and waterproofing the multi-plate arch ($144,100 to $173,100). The cost range for this alternative is **$1,050,400 to $1,261,400**. See Section XIV and Appendix B for a detailed cost summary.

• **Load Capacity (Design Consideration)**: A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.32 inventory and 1.71 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration)**: By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls and slopes, repairing the knee walls, waterproofing the multi-plate arch, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 45 years**.
**Alternative 2C (8594) – Rehabilitate and Extend Height of Inlet Walls with Structural Wall and Stone Masonry**

**Scope of Alternative 2C:**
Alternative 2C proposes the basic rehabilitation scope to Bridge 8594 of Alternative 2 and instead of reinforcing the roadway inslopes, it proposes to address the eroding roadway inslopes above the inlet headwall and wingwalls using stone masonry to increase the height of the existing stone walls.

Due to the resulting overall height of the stone wall extension, it will be required to place a concrete retaining wall behind the stone masonry wall to be assured of its structural stability. This alternative proposes to dismantle the existing stone masonry wall, construct a reinforced-concrete wall directly behind it and to use the original stones to place a thick veneer (or stone facing) in front of the new concrete wall. The new concrete wall will not be visible upon completion of the project. Figure 22 depicts the proposed wall geometry with the dark stone hatch representing new stone and the light hatch is existing stone. The overall height of the wall is proposed to be raised by 4 feet 6 inches. Figure 23 shows a section through the slope and proposed wall with a new roadway inslope of 1:3. See Section VII for further details regarding the individual scope items for this alternative.

![Figure 22 – Stone Masonry Wall Extension Elevation (Alternative 2C)](image-url)
Figure 23 – Stone Masonry Wall Extension Section (Alternative 2C)
Evaluation of Alternative 2C:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the outlet headwall and wingwalls are stabilized through reconstruction and repointing. The inlet headwall and wingwalls would be replaced with a new concrete wall faced with stone masonry veneer. Placement of the new concrete wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to increase the wall height which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the inlet erosion deficiencies are **addressed**.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to replace the existing inlet headwall and wingwalls with a new concrete wall, the inlet surcharge/overburden concerns are **addressed**.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is **addressed**.

- **Section 106 (SEE Impact):** Alternative 2C would improve integrity by removing the I-beams from the east headwall and by reconstructing the missing part of the southwest wingwall/flume wall. However, the alternative would **significantly diminish the bridge’s integrity** of design, feeling, and association by substantially changing the design, massing, and proportions of the east headwall and wingwalls. Integrity of design and feeling would also be somewhat reduced by reinstalling the concrete floor and modern steel guardrail. The alternative would have less effect on integrity of materials and workmanship. Integrity of location or setting would not be affected.
Alternative 2C **would not be consistent with SOI Standards.** The east elevation, an important component of the bridge, would be altered considerably. This elevation would increase in square area by more than 50%. While some distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce the bridge’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the changes to the east elevation, several options were considered including placing the additional stonework back from the plane of the headwall; using contrasting stone, cast-in-place concrete, concrete block, or another material rather than matching limestone; and including a course of contrasting stone to delineate the original dimensions of the headwall and wingwalls. None of the options provide significantly less impact to historic integrity than the wall extension proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the outlet and major excavation to construct the extended height stone-faced wall at the inlet. There are no known northern long-eared bat roost trees in the vicinity of the project however the proposed activities have the potential to remove select large trees. Best management practices will be employed for any tree removal to ensure the northern long-eared bat is minimally affected. Through the use of best management practices, there is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work at the outlet and major excavation to construct the extended height stone-faced wall at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the outlet headwall and wingwalls to reconstruct and repoint the stone masonry. The construction of the extended height stone-faced walls at the inlet would result in a large excavation. This work would constitute a temporary disturbance. This alternative would have a permanent impact to the channel with the riprap placed at the outlet apron end and at the southwest wingwall extension. The project special provisions would
need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.05 acres temporary** and **0.003 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **25 cubic yards** of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the inlet walls. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($906,300 to $1,088,300) with the change in cost resulting from the additional scope of replacing the inlet walls with a stone-faced concrete retaining wall instead of soil reinforcing ($325,900 to $391,900). The cost range for this alternative is **$1,232,200 to $1,480,200**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.32 inventory** and **1.71 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the outlet headwall and wingwalls, reinforcing the outlet roadway inslope, replacing the inlet headwall and wingwalls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
Alternative 2D (8594) – Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway

Scope of Alternative 2D:
Alternative 2D proposes the basic rehabilitation scope to Bridge 8594 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls by placing an intermediate reinforced-concrete structural wall between the stone headwall and the roadway shoulder instead of reinforcing the roadway inslope. See Section VII for further details regarding the individual scope items for this alternative.

The proposed reinforced-concrete wall will be placed between the guardrail and the stone masonry headwall to achieve a 1:3 slope in all locations between the stone wall and guardrail. The original stone masonry walls would not be altered in geometry or materials. The proposed concrete wall would be approximately 90 feet long and would be exposed at a maximum height of 6 feet 7 inches. Figure 24 shows a section through the slope and proposed wall with a new roadway inslope of 1:3.
Figure 24 – Intermediate Structural Wall Section at Inlet Headwall (Alternative 2D)
Evaluation of Alternative 2D:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has small areas of corrosion and section loss. The condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, an intermediate concrete wall would be constructed behind the inlet headwall and wingwalls. The new concrete wall would become the new load-carrying element for the roadway embankment, the new wall would increase the culvert condition rating to 9 (excellent condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet but not the outlet. This alternative proposes to place an intermediate wall behind the inlet headwall which will flatten the slope to 1:3 and mitigate erosion. Because this alternative flattens the steep slope, the inlet erosion deficiencies are addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert inlet but not the outlet. This alternative proposes to place an intermediate wall behind the inlet headwall which will alleviate loading on the existing stone masonry headwall and wingwalls. The inlet surcharge/overburden concerns are addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

- **Section 106 (SEE Impact):** Alternative 2D would improve integrity by removing the I-beams from the east headwall and reconstructing the missing portion of the southwest wingwall/flume wall. However, the alternative would add a large new structure to the property, significantly diminishing its integrity of design, feeling, and association. Integrity of design and feeling would
also be somewhat reduced by reinstalling the bridge’s concrete floor and the modern guardrail. The alternative would not affect integrity of materials, workmanship, location, or setting.

Alternative 2D **would not be consistent with SOI Standards.** By virtue of its size and location, the new wall would visually compete with, and distract from, the east elevation. The visual impact would be compounded by the wall’s close proximity to the steel guardrail – also a substantial modern structure. The wall’s design and material would be inconsistent with NPS Rustic Style emphasis on careful siting, native materials, rugged textures, and hand-built construction. The wall would separate the east end of the bridge from the roadway, altering their spatial relationship. The wall would represent a new element in the historic landscape that would be visible from some distance away. While distinctive materials, construction techniques, and craftsmanship would be preserved (including at the west elevation), the overall effect of the alternative would be to significantly reduce Bridge 8594’s ability to convey its historic character and significance.

In an attempt to reduce the impact of the new wall, various options were considered. They included creating a wall with either horizontal terraces or vertical segments in various planes; building the wall of timbers, concrete blocks, or another material; giving the wall a surface texture; and facing the wall with stone. Not all of these options were geometrically or structurally feasible, and none would provide significantly less impact to historic integrity than the wall proposed.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to construct the intermediate concrete retaining wall at the outlet. There are no known northern long-eared bat roost trees in the vicinity of the project however the proposed activities have the potential to remove select large trees. Best management practices will be employed for any tree removal to ensure the northern long-eared bat is minimally affected. Through the use of best management practices, there is a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to construct the intermediate concrete retaining wall at the inlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).
• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the intermediate concrete retaining wall at the inlet would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.03 acres temporary** and **0.003 acres permanent**.

• **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

• **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **25 cubic yards** of fill into Waters Contributing to Waters of the US.

• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for roadway reconstruction work, removal of the concrete floor, hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the intermediate inlet wall. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

• **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($906,300 to $1,088,300) with the change in cost resulting from the additional scope of constructing an intermediate wall instead of soil reinforcing at the inlet ($328,300 to
$394,300). The cost range for this alternative is **$1,234,600 to $1,482,600**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.32 inventory and 1.71 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the outlet roadway inslope, placing an intermediate inlet wall, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure will have a remaining service life of **30 to 40 years**.
XI. BRIDGE 8595 STRUCTURE REHABILITATION ALTERNATIVES AND EVALUATION

Development of Structure Alternatives
Structure alternatives have been generated for Bridge 8595 based on a combination of element alternatives discussed during the development of alternatives workshop held in May of 2017. The element alternatives for Bridge 8595 are summarized in the following table:

<table>
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<tr>
<th>Element</th>
<th>Alternative 2 - Rehabilitate</th>
<th>Alternative 2 Variations</th>
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<td>2A: Remove Concrete Floor and Rehabilitate Mortared Stone Masonry</td>
</tr>
<tr>
<td>Inlet Masonry Steps</td>
<td>Repoint and Replace Deficient Stones</td>
<td></td>
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<tr>
<td>Knee Walls - Stone Masonry</td>
<td>Spot Pointing and Replace Deficient Stones</td>
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<td>Multi-Plate Arch</td>
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<td>Inlet/Outlet Masonry Headwall &amp; Wingwalls</td>
<td>Repoint and Replace Deficient or Missing Stones &amp; Reconstruct Severely Deteriorated Regions (to original geometry)</td>
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<tr>
<td></td>
<td>Reconstruct Severely Deteriorated Regions (to original geometry)</td>
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</table>

1 A ‘No Build’ alternative (Alternative 1) will be studied along with the tabled rehabilitation alternatives. Alternative 1 is not shown in the table due to redundancy.

Structure alternatives, excluding the ‘No Build’ alternative, were developed based on a core rehabilitation scope for the structure with combinations of element alternatives resulting in the following alternatives:
Alternative 1 – No Build

Alternative 2 – Rehabilitate

Alternative 2A – Rehabilitate and Restore Original Masonry Floor

Alternative 2B – Rehabilitate and Waterproof Top of Multi-Plate Arch

Alternative 2C – Rehabilitate and Reinforce Soil Slopes

Each alternative has been developed to detail the scope of the alternative and evaluation of the alternative per the chosen evaluation criteria.

Alternative 1 (8595) – No Build

Scope of Alternative 1:
Alternative 1 proposes to leave the current structure in place with no rehabilitation. Maintenance of the structure would be continued.

Evaluation of Alternative 1:

- **Bridge Condition (Primary) – Arch & Knee Walls**: The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated culvert floor contributes to this rating. With this alternative, there is **no improvement** to the culvert floor, knee walls or arch and thus no improvement to the condition rating, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Headwalls & Wingwalls**: The NBI condition rating for the culvert is a 3 (serious condition). The severely deteriorated headwalls and wingwalls, and eroding roadway inslope at the outlet headwall (putting culvert end treatment at risk) all contribute to the current NBI condition rating. With this alternative, there is **no improvement** to the condition ratings, therefore it does not meet the primary need for a structurally sound crossing.

- **Bridge Condition (Primary) – Inslope Erosion**: There are inslope erosion deficiencies at the culvert outlet but not the inlet. Because this alternative proposes no work, the inslope erosion deficiencies are **not addressed**.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden**: There are surcharge/overburden concerns the culvert outlet but not the inlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are **not addressed**.

- **Bridge Condition (Primary) – Channel Erosion**: There is channel erosion at the end of the outlet apron and erosion at the southwest wingwall end. Because this alternative proposes no work, the channel erosion issues are **not addressed**.
• **Section 106 (SEE Impact):** Alternative 1 would not involve a federal undertaking (project, activity, or program), therefore the Section 106 process would not be initiated, and this evaluation criterion does not apply.

Deterioration of the bridge would continue under this alternative and further loss of historic fabric is likely. As the bridge’s condition worsens, integrity of materials and workmanship would diminish.

Consistency with the SOI Standards is not assessed because it is assumed no measures would be taken to sustain or repair historic materials and features.

• **Endangered Species Act (SEE Impact):** This alternative proposes no construction activities therefore it has no risk of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes no construction activities, resulting in no risk of impact to rare species or features and the biodiversity site.

• **DNR Public Waters (SEE Impact):** This alternative proposes no work in the drainage channel bottom or banks, resulting in 0 acres of disturbance.

• **Section 4(f) (SEE Impact):** Alternative 1 does not propose federal action therefore this evaluation criterion does not apply.

• **Section 404 of the Clean Water Act (SEE Impact):** This alternative does not propose to place any fill into Waters Contributing to Waters of the US, resulting in 0 cubic yards of proposed fill.

• **Construction Noise (SEE Impact):** This alternative proposes no construction activities, resulting in no impact to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes no construction activities, resulting in no impact to TH 74 traffic.

If nothing were done to the bridge in the near future, it would result in continued maintenance to the roadway slopes that would cause service interruptions such as lane closures. Over the long term, if no major construction work is to occur, closure of the roadway for emergency repairs is a probable outcome. Emergency repairs are assumed to be of moderate duration (between 2 weeks and 3 months), resulting in a moderate impact to TH 74 traffic.

• **Construction Cost:** The construction cost is estimated to be $0 due to no work being proposed.

• **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of 1.55 inventory and 2.00
operating. The rating factors are adequate to carry TH 74 and would not result in a load posting.

- **Service Life (Design Consideration):** If no repairs were undertaken, it is estimated that the structure has a **remaining service life of 5 to 10 years** until the next major rehabilitation would be required. With the headwalls and wingwalls already in poor condition, they are expected to continue to deteriorate but at an unknown rate. However, since some portions of the walls are already failing, it is anticipated that their condition will begin to rapidly deteriorate in the near future.
Alternative 2 (8595) – Rehabilitate

Scope of Alternative 2:
Alternative 2 proposes a basic rehabilitation to Bridge 8595. This alternative would involve removing and replacing the deteriorated and non-historic concrete floor with a new concrete floor, selectively repairing the spalled and delaminated areas of the concrete knee wall cap, and reconstructing severely deteriorated regions and repointing and replacing deficient stones of the stone masonry knee walls, headwalls and wingwalls. The stone masonry knee walls that will be exposed upon removal of the concrete floor will be repointed and any deficient stones replaced. This alternative would address the erosion at the southwest wingwall end by extending the length of the wingwall with stone masonry by a maximum of 6 feet. The extension would be set back from the existing wall about 3 inches to differentiate it. It would be about 4 feet tall, tapering to 2 feet. See Section VII for further details regarding the individual scope items for this alternative.

![Diagram of Surface Soil Stabilization at Bridge 8295 Inlet (Alternative 2)](image)

Figure 25: Surface Soil Stabilization at Bridge 8295 Inlet (Alternative 2)
The maximum desired roadway inslope is a 1:3 and it has been determined that a surface-applied turf reinforcement mat would be acceptable for stabilization of slopes between 1:2 and 1:3. Therefore, a surface-applied turf reinforcement mat would be placed on the inlet slope to add an erosion control measure. The outlet slope would not receive additional soil stabilization but would be re-graded and vegetation re-established by traditional methods of seed and erosion control blanket since the slope is greater than 1:3 (1:3.6).

Evaluation of Alternative 2:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through
reconstruction and repointing. However, the tall embankments remain, leaving the stone masonry headwalls and wingwalls in a state where they are subject to overburden/surcharge pressures. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet but not the inlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the outlet erosion deficiencies are **partially addressed**.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are **not addressed**.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is **addressed**.

- **Section 106 (SEE Impact):** Alternative 2 would generally **preserve the bridge’s integrity** of design, materials, workmanship, feeling, and association. The alternative would somewhat diminish integrity of design by adding up to 6 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor. The alternative would not affect integrity of location or setting. Alternative 2 would be **consistent with the SOI Standards for Rehabilitation**. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 6 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 6-foot-long, 18-square-foot addition would increase the wall area of the flume by about 2.5%. Together the two most obvious alterations – the concrete
floor and the wingwall addition – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. This alternative has a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. This work would constitute a temporary disturbance.

  This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

  The total disturbance would be **0.04 acres temporary** and **0.002 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the
outlet apron will, however, place approximately 15 cubic yards of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, and removal and driving of guardrail posts. The duration of the project is estimated to be relatively short (less than 3 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the short duration of construction, this alternative would have a low impact to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will not require excavation of the roadway, however staging of the work will likely require road closure and detour of TH 74 traffic for up to 3 months. Because of the closure and duration of traffic detour, there will be a moderate impact to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated to be $476,200 to $572,200 for a basic rehabilitation. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of 1.55 inventory and 2.00 operating. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure would have a remaining service life of 25 to 35 years. Although the walls are being repaired in this alternative, erosion of the roadway inslope has not been addressed and could cause the need for an additional repair or rehabilitation project.
Alternative 2A (8595) – Rehabilitate and Restore Original Masonry Floor

Scope of Alternative 2A:
Alternative 2A proposes the basic rehabilitation scope to Bridge 8595 of Alternative 2, but instead of removing and replacing the concrete floor, the stone masonry culvert floor would be restored. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2A:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through reconstruction and repointing. However, the tall embankments remain, leaving the stone masonry headwalls and wingwalls in a state where they are subject to overburden/surcharge pressures. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet but not the inlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the outlet erosion deficiencies are partially addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.

- **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.
• **Section 106 (SEE Impact):** Alternative 2A would generally *preserve the bridge's integrity* of design, materials, workmanship, feeling, and association. Uncovering the stone floor would reverse an alteration. Integrity of design would be somewhat diminished by adding up to 6 feet to the southwest wingwall/flume wall. The alternative would not affect integrity of location or setting.

Alternative 2A would be **consistent with the SOI Standards for Rehabilitation.** Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. Lengthening the southwest wingwall/flume wall by up to 6 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 6-foot-long, 18-square-foot addition would increase the wall area of the flume by about 2.5%. The wingwall addition would be the alternative’s most obvious alteration. It would not be so visually disruptive that it prevents the bridge from conveying its historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. This alternative has a **low risk** of impact to endangered species.

• **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work. There would also be construction access needed to complete the masonry work and the masonry floor restoration which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).
• **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.04 acres temporary** and **0.002 acres permanent**.

• **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

• **Section 404 of the Clean Water Act (SEE Impact):** The concrete floor will be removed. The stone masonry floor will have a lower finished elevation, which technically removes fill from Waters Contributing to Waters of the US, however since it is the concrete floor which was previously placed, it is not considered an impact. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

• **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris, and removal and driving of guardrail posts. The duration of the project is estimated to be relatively short (less than 3 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the short duration of construction, this alternative would have a **low impact** to Park users.

• **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will not require excavation of the roadway, however staging of the work will likely require road closure and detour of TH 74 traffic for up to 3 months. Because of the closure and duration of traffic detour, there will be a **moderate impact** to TH 74 traffic.

• **Construction Cost:** The risk-based construction cost is estimated by combining the cost range for Alternative 2 ($476,200 to $572,200) with the change in cost resulting from the modified scope of restoring the stone culvert floor instead of replacing the concrete floor in-kind ($155,100 to $187,100). The cost range for this alternative is **$631,300 to $759,300**. See Section XIV and Appendix B for a detailed cost summary.
• **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.55 inventory and 2.00 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

• **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, and restoring the masonry culvert floor, it is estimated that the structure has a remaining service life of **25 to 35 years**. Although the walls are being repaired in this alternative, erosion of the roadway inslope has not been addressed and could cause the need for an additional repair or rehabilitation project.
Alternative 2B (8595) – Rehabilitate and Waterproof Top of Multi-Plate Arch

Scope of Alternative 2B:
Alternative 2B proposes the basic rehabilitation scope to Bridge 8595 of Alternative 2 and proposes excavation and waterproofing of the buried surface of the multi-plate arch. Because this alternative will require a large excavation, the roadway within the excavation limits will need to be removed and replaced. See Section VII for further details regarding the individual scope items for this alternative.

Evaluation of Alternative 2B:

- **Bridge Condition (Primary) – Arch & Knee Walls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing the concrete overlay and restoring the masonry floor. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face present no evidence that advanced corrosion or section loss is occurring. It is assumed that waterproofing the buried face of the arch would not improve the arch condition rating. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no corrosion and little-to-no section loss on both the buried and exposed faces. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls:** The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the headwalls and wingwalls are stabilized through reconstruction and repointing. However, the tall embankments remain, leaving the stone masonry headwalls and wingwalls in a state where they are subject to overburden/surcharge pressures. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert outlet but not the inlet. This alternative proposes to place a turf reinforcing mat on the slopes to mitigate erosion. Because this alternative only applies a surface treatment to address the erosion issues and the steep slope remains, the outlet erosion deficiencies are partially addressed.

- **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. Because this alternative proposes no work, the inlet surcharge/overburden concerns are not addressed.
• **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is **addressed**.

• **Section 106 (SEE Impact):** Alternative 2B would generally **preserve the bridge’s integrity** of design, materials, workmanship, feeling, and association. The alternative would somewhat diminish integrity of design by adding up to 6 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor. The alternative would not affect integrity of location or setting.

Alternative 2B would be **consistent with the SOI Standards for Rehabilitation**. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 6 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 6-foot-long, 18-square-foot addition would increase the wall area of the flume by about 2.5%. Alternative 2B’s arch waterproofing would be hidden. Together the two most obvious alterations – the concrete floor and the wingwall addition – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.

Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

• **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to expose the buried face of the multi-plate arch. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. This alternative has a **low risk** of impact to endangered species.
NHIS (SEE Impact): This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to expose the buried face of the multi-plate arch. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel or on the roadway slopes. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a moderate risk of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

DNR Public Waters (SEE Impact): This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The waterproofing of the multi-plate arch and the reinforcing of the roadway inlet and outlet would result in a large excavation. However, the majority of the excavation would occur above ordinary high water. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be 0.04 acres temporary and 0.002 acres permanent.

Section 4(f) (SEE Impact): This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

Section 404 of the Clean Water Act (SEE Impact): Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the outlet apron will, however, place approximately 15 cubic yards of fill into Waters Contributing to Waters of the US.

Construction Noise (SEE Impact): This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor, hauling of the construction debris as well as excavation and fill material, and removal and driving of guardrail posts. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed
noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($476,200 to $572,200) with the change in cost resulting from the additional scope of excavating and waterproofing the multi-plate arch ($312,800 to $375,800). The cost range for this alternative is **$789,000 to $948,000**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.55 inventory and 2.00 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, repairing the knee walls, waterproofing the multi-plate arch, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 45 years**.
Alternative 2C (8595) – Rehabilitate and Reinforce Soil Slopes

Scope of Alternative 2C:
Alternative 2C proposes the basic rehabilitation scope to Bridge 8595 of Alternative 2 and proposes to address the steep and eroding roadway inslopes above the inlet headwall and wingwalls by using an embedded geo-grid soil reinforcement system instead of the surface-applied turf reinforcement mat proposed in Alternative 2. The slopes above the headwalls will be reinforced to achieve a stable slope although it is steeper than the desired 1:3. In this case, the resulting roadway inslope would be approximately 1:2 at the inlet and 1:2.8 at the outlet. Geogrid would also be placed behind the stone masonry walls at the outlet to alleviate some loading on the walls caused by the additional soil on the slope behind the wall. See Bridge 8594 Alternative 2 for a rendering produced to visually portray the use of reinforced soil slopes. See Section VII for further details regarding the individual scope items for this alternative.

Figure 27 – Soil Reinforcing Section at Inlet Headwall (Alternative 2C)
Evaluation of Alternative 2C:

- **Bridge Condition (Primary) – Arch & Knee Walls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the culvert floor is repaired to a stable condition by removing and replacing the concrete overlay. Any concrete and stone masonry would be rehabilitated to a condition where only minor weathering or cracking of the stone remains. The arch has very little exposed corrosion and although the condition of the buried face of the arch plates is unknown, observations of the exposed face presents no evidence that advanced corrosion or section loss is occurring. Deformations were observed at the arch crown; however, this condition has been observed for several decades with no change, therefore is not assumed to affect the overall condition of the structure. The arch would be rehabilitated to a condition where there is no exposed corrosion and little-to-no section loss. This alternative would increase the culvert condition rating to 7 (good condition).

- **Bridge Condition (Primary) – Headwalls & Wingwalls**: The NBI condition rating for the culvert is a 3 (serious condition). With this alternative, the inlet and outlet headwalls and wingwalls are stabilized through reconstruction and repointing. Additionally, the soil behind and above the outlet headwall and wingwalls would be reinforced to reduce the surcharge on the existing walls and mitigate erosion of the roadway inslope. The soil reinforcing would reduce the loading/surcharge on the stone masonry walls, thus improving their culvert condition rating to 8 (very good condition).
• **Bridge Condition (Primary) – Inslope Erosion:** There are inslope erosion deficiencies at the culvert inlet and outlet. This alternative proposes to place soil reinforcing on the inslopes to mitigate erosion. Although with this alternative the slopes remain steeper than desired, the slope reinforcing provides long-term stability and the erosion deficiencies are addressed.

• **Bridge Condition (Primary) – Headwall Surcharge/Overburden:** There are surcharge/overburden concerns the culvert outlet but not the inlet. This alternative proposes to place soil reinforcing behind the outlet headwall which will alleviate loading on the existing stone masonry walls. The outlet surcharge/overburden concerns are addressed.

• **Bridge Condition (Primary) – Channel Erosion:** There is channel erosion at the end of the outlet apron as well as at the southwest wingwall. This alternative proposes to place riprap at the end of the outlet apron and extend the southwest wingwall to mitigate channel erosion. The channel erosion issue is addressed.

• **Section 106 (SEE Impact):** Alternative 2C would generally preserve the bridge’s integrity of design, materials, workmanship, feeling, and association. The alternative would somewhat diminish integrity of design by adding up to 6 feet to the southwest wingwall/flume wall. Integrity of design and feeling would also be reduced to some degree by reinstalling the concrete floor. The alternative would not affect integrity of location or setting.

Alternative 2C would be consistent with the SOI Standards for Rehabilitation. Distinctive materials, features, finishes, construction techniques, and craftsmanship would be preserved. Deteriorated historic materials would be repaired where possible and, if unrepairable, would be replaced in-kind. While restoring the stone floor would be preferable (see Alternative 2A), covering the stone with concrete provides more durability. Soundness of the floor is essential to the bridge’s longevity, and the floor is an element especially vulnerable to scour and erosion from high velocity water during large rain events. Lengthening the southwest wingwall/flume wall by up to 6 feet would be necessary to protect the bridge from erosion. It is believed the roadway slope at this location was retained historically with a dry-stacked stone wall (similar to the existing wall at the east end of Bridge 8594). Reconstructing a dry-laid wall would not provide sufficient durability; mortared limestone is proposed. The addition would be set back about 3 inches from the plane of the existing wall to differentiate it. The change would occur at a distinctive part of the bridge near the step-like drop structure at the end of the flume. The addition would be modest in size: a 6-foot-long, 18-square-foot addition would increase the wall area of the flume by about 2.5%. Alternative 2C’s georgrid soil reinforcing would be hidden. Together the two most obvious alterations – the concrete floor and the wingwall addition – would not be so visually disruptive that they prevent the bridge from conveying its historic character and significance.
Several other options for the wingwall extension were considered. Using only loose riprap to retain the slope would not be feasible given the steep grade. An addition of contrasting stone or cast-in-place concrete would likely be distracting and detrimental to one of the bridge’s most important characteristics, the way it harmonizes with its setting.

- **Endangered Species Act (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There are no known northern long-eared bat roost trees in the vicinity of the project and the proposed activities do not intend to remove trees. This alternative has a **low risk** of impact to endangered species.

- **NHIS (SEE Impact):** This alternative proposes minor excavation to perform the stone masonry repointing and reconstruction work and major excavation to place the geogrid at the inlet and outlet. There would also be construction access needed to complete the masonry work and the concrete floor replacement which would cause ground disturbances within the drainage channel. There is currently no vegetation on the concrete culvert floor. Best management practices will be employed for any disturbances to rare plant or animal species. Because specific locations of rare native plant communities are currently unknown, the measure of risk is based upon the total estimated area of disturbed vegetation. This alternative has a **moderate risk** of impact to the biodiversity site (disturbance between 1,000 and 10,000 square feet).

- **DNR Public Waters (SEE Impact):** This alternative proposes work within the drainage channel to replace the concrete floor, minor repair to the concrete knee walls, and construction activity at the headwalls and wingwalls to reconstruct and repoint the stone masonry. The construction of the outlet soil reinforcing would result in a large excavation, but the excavation would be outside of ordinary high water since the stone masonry wall would remain in place. This work would constitute a temporary disturbance.

This alternative would have a permanent impact to the channel with the riprap placed at the end of the outlet apron and the southwest wingwall extension. The project special provisions would need to ensure extreme care is taken when performing the work and that best management practices are implemented.

The total disturbance would be **0.04 acres temporary** and **0.002 acres permanent**.

- **Section 4(f) (SEE Impact):** This evaluation will occur after the recommended alternative(s) for each bridge is selected. See Section XIII for discussion on impacts to the historic district.

- **Section 404 of the Clean Water Act (SEE Impact):** Since the concrete floor will be placed back to its current elevation, this activity does not propose to place any fill into Waters Contributing to Waters of the US. The extension of the southwest wingwall and the riprap at the end of the
outlet apron will, however, place approximately **15 cubic yards** of fill into Waters Contributing to Waters of the US.

- **Construction Noise (SEE Impact):** This alternative proposes construction activities that would utilize heavy equipment for removal of the concrete floor and hauling of the construction debris, excavation material and fill material, removal and driving of guardrail posts, and construction of the soil reinforcing. The duration of the project is estimated to be of moderate length (between 3 months and 6 months). The construction special provisions would ensure construction activities are limited to specific hours and that noise levels are controlled to minimize disruption to park users. Due to the proposed noise mitigation and the moderate duration of construction, this alternative would have a **low/moderate impact** to Park users.

- **Impact to TH 74 Traffic (SEE Impact):** This alternative proposes construction activities that will require excavation and complete closure of the roadway. A road closure and detour of TH 74 traffic will be required in excess of 3 months. Because of the closure and duration of traffic detour, there will be a **higher impact** to TH 74 traffic.

- **Construction Cost:** The risk-based construction cost range is estimated by combining the cost of Alternative 2 ($476,200 to $572,200) with the change in cost resulting from the additional scope of reinforcing the soils at the inlet and outlet walls ($417,700 to $501,700). The cost range for this alternative is **$893,900 to $1,073,900**. See Section XIV and Appendix B for a detailed cost summary.

- **Load Capacity (Design Consideration):** A load rating analysis was performed for the existing structure for this study and resulted in HL-93 rating factors of **1.55 inventory and 2.00 operating**. The rating factors are adequate to carry TH 74 and would not result in a load posting. The current load rating for the structure would not change with this alternative.

- **Service Life (Design Consideration):** By reconstructing and repointing the headwalls and wingwalls, reinforcing the soils at the inlet and outlet walls, repairing the knee walls, and replacing the concrete floor, it is estimated that the structure has a remaining service life of **30 to 40 years**.
XII. ALTERNATIVES MATRIX

An alternatives matrix has been developed as a tool to help evaluate each alternative against the selected evaluation criteria. Within the matrix, each alternative has been analyzed and summarized in regard to its conformance to the established criteria. The metrics agreed upon for criteria evaluation during the collaborative process are outlined in Section VI.
## Whitewater State Park Bridge 8592 Alternatives Evaluation Matrix

<table>
<thead>
<tr>
<th>EVALUATION CRITERIA</th>
<th>MEASUREMENT</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 2A</th>
<th>Alternative 2B</th>
<th>Alternative 2C</th>
<th>Alternative 2D</th>
<th>Alternative 2E</th>
</tr>
</thead>
<tbody>
<tr>
<td>PURPOSE &amp; NEED (PRIMARY)</td>
<td></td>
<td>No Build</td>
<td>Rehabilitate (includes \nSurface Slope Stabilization)</td>
<td>Rehabilitate w/ Masonry Floor Restoration</td>
<td>Rehabilitate + Waterproof Arch</td>
<td>Rehabilitate + Raise Stone Wall</td>
<td>Rehabilitate + Intermediate Wall</td>
<td>Rehabilitate + Reinforce Soil</td>
</tr>
<tr>
<td>Bridge Condition</td>
<td>Evaluate Multi-Plate Arch and Knee Wall Abutments with condition to be based on NBI Culvert Condition Rating guidelines, upon completion of rehab. \n(6 or better desired, no change = current culvert NBI)</td>
<td>5 Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls/ wingswalls) \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition</td>
<td>7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition</td>
<td>7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition \n7-Good Condition</td>
<td>7-Good Condition \n7-Good Condition</td>
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<td>7-Good Condition \n7-Good Condition</td>
<td>7-Good Condition \n7-Good Condition</td>
</tr>
<tr>
<td></td>
<td>Evaluate Headwalls &amp; Wingswalls with condition to be based on NBI Culvert Condition Rating guidelines, upon completion of rehab. \n(6 or better desired, no change = current culvert NBI)</td>
<td>5 Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls/ wingswalls) \n7-Good Condition \n7-Good Condition \n7-Good Condition</td>
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<td>7-Good Condition \n7-Good Condition</td>
<td>7-Good Condition \n7-Good Condition</td>
</tr>
<tr>
<td>To what level does the alternative address observed inslope erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Inlet - Not Addressed \nOutlet - No Concern</td>
<td>Inlet - Partially Addressed \nOutlet - No Concern</td>
<td>Inlet - Partially Addressed \nOutlet - No Concern</td>
<td>Inlet - Partially Addressed \nOutlet - No Concern</td>
<td>Inlet - Addressed \nOutlet - No Concern</td>
<td>Inlet - Addressed \nOutlet - No Concern</td>
<td>Inlet - Addressed \nOutlet - No Concern</td>
<td>Inlet - Addressed \nOutlet - No Concern</td>
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<tr>
<td></td>
<td>To what level does the alternative mitigate the additional headwall surcharge/overburden from the raised road and steep slope? (no concern, not addressed, partially addressed, addressed)</td>
<td>Inlet - Not Addressed \nOutlet - No Concern</td>
<td>Inlet - Not Addressed \nOutlet - No Concern</td>
<td>Inlet - Not Addressed \nOutlet - No Concern</td>
<td>Inlet - Not Addressed \nOutlet - No Concern</td>
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<td>Inlet - Addressed \nOutlet - No Concern</td>
</tr>
<tr>
<td>To what level does the alternative address observed channel and inlet/outlet erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Not Addressed</td>
<td>Addressed</td>
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### SOCIAL, ECONOMIC & ENVIRONMENTAL (SEE) IMPACTS

Section 106 of the National Historic Preservation Act of 1966

- Effect on Integrity of the Historic Structure (no impact, preserves, diminishes, significantly)

  - Not Applicable
  - Preserves Integrity
  - Preserves Integrity
  - Preserves Integrity
  - Significantly Diminishes Integrity
  - Preserves Integrity

Section 4(f) of the Transit Act of 1966

- Effect on historic district

  - Not Addressed
  - Addressed

### Endangered Species Act of 1973

- Risk of Impact to Northern Long-Eared Bat (low, moderate, higher)

  - No Risk
  - Low Risk
  - Low Risk
  - Low Risk
  - Low Risk
  - Low Risk

### Migratory Bird Convention Act

- Risk of Impact to Migratory Birds

  - No Risk
  - Low Risk
  - Low Risk
  - Low Risk
  - Low Risk

### Clean Water Act

- Temporary and Permanent Impact to Stream

  - 0 acres - temporary
  - 0.001 acres - permanent
  - 0.001 acres - permanent
  - 0.003 acres - temporary
  - 0.003 acres - permanent
  - 0.003 acres - permanent
  - 0.003 acres - permanent
  - 0.003 acres - permanent

### Section 404 of the Clean Water Act

- Temporary and Permanent Volume of Placement of Fill

  - 0 cu yd - temporary
  - 0 cu yd - permanent
  - 0 cu yd - temporary
  - 0 cu yd - permanent
  - 0 cu yd - temporary
  - 0 cu yd - permanent
  - 0 cu yd - temporary
  - 0 cu yd - permanent

### Section 404(f) Use of Historic District

- *See report Section XIII for determination of overall project effects (all bridges) to Historic District.*

### Design Considerations

#### Construction Cost

- **Risk-Based Construction Cost Range (in 2020 $)**
  - Alternative 1: $351,100 to $422,100
  - Alternative 2: $443,700 to $533,700
  - Alternative 2A: $615,200 to $739,200
  - Alternative 2B: $633,000 to $761,000
  - Alternative 2C: $532,900 to $640,900

#### Load Capacity

- **Resulting HL-93 Load Capacity Rating Factors (Inventory & Operating)**
  - RF 17.30 inventory
  - RF 22.43 operating
  - RF 22.43 operating
  - RF 22.43 operating
  - RF 22.43 operating
  - RF 22.43 operating
  - RF 22.43 operating

#### Service Life

- Estimated timeframe until major rehabilitation is required (20 years minimum) following 2020
  - Major rehab. is required w/in next 5-10 yrs
    - 25-35 years
    - 30-40 years
    - 40-40 years

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Whitewater State Park Culverts - TH 74 over Drainage Channel (SP 8508-38)
Condition and Rehabilitation Study – June 2018

Page 173
### Whitewater State Park Bridge 8593 Alternatives Evaluation Matrix

<table>
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<tr>
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<td>Evaluate Headwalls &amp; Wingwalls with condition to be based on NB Culvert Condition Rating guidelines, upon completion of rehab. (6 or better desired, no change = current culvert NBI)</td>
<td>3 Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls/ wingswalls)</td>
<td>5 Very Good Condition</td>
<td>8 Very Good Condition</td>
<td>8 Very Good Condition</td>
<td>9 Excellent</td>
<td>9 Excellent</td>
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<tr>
<td></td>
<td>To what level does the alternative address observed inslope erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Inlet - Not Addressed Outlet - Not Addressed</td>
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<tr>
<td></td>
<td>To what level does the alternative mitigate the additional headwall surcharge/overburden from the raised road and steep inslope? (no concern, not addressed, partially addressed, addressed)</td>
<td>Inlet - No Concern Outlet - No Concern</td>
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<td>Inlet - No Concern Outlet - No Concern</td>
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<tr>
<td></td>
<td>To what level does the alternative address observed channel and inlet/outlet erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Not Addressed Addressed Addressed Addressed</td>
<td>Addressed Addressed Addressed Addressed</td>
<td>Addressed Addressed Addressed Addressed</td>
<td></td>
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</tr>
<tr>
<td>SOCIAL, ECONOMIC &amp; ENVIRONMENTAL (SEE) IMPACTS</td>
<td>Effect on Integrity of the Historic Structure (no impact, preserves, diminishes, significantly diminishes)</td>
<td>Not Applicable</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
<td>Significantly Diminishes Integrity</td>
<td>Significantly Diminishes Integrity</td>
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<tr>
<td></td>
<td>Evaluate alternative scope based on consistency w/ SOI</td>
<td>Not Applicable</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Not Consistent w/ SOI Standards</td>
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*Effect on Integrity of the Historic District * See report Section XIII for determination of overall project effects (all bridges) to Historic District.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Endangered Species Act of 1973</td>
<td>No Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
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<tr>
<td>Risk of Impact to Northern Long-Eared Bat (low, moderate, higher)</td>
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<td></td>
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<tr>
<td>Risk of Impact to Rare Features &amp; Biodiversity Site Based on Disturbed Vegetated Area (low, moderate, higher)</td>
<td>No Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
</tr>
<tr>
<td>NDR – Public Waters</td>
<td>Temporary and Permanent Impact to Stream</td>
<td>0.03 acres - temporary</td>
<td>0.03 acres - temporary</td>
<td>0.03 acres - temporary</td>
<td>0.03 acres - temporary</td>
<td>0.03 acres - temporary</td>
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<tr>
<td>Disturbed area of waters contributing to public waters, (current rating includes condition of floor, knee walls, arch and headwalls/ wingswalls)</td>
<td>0.04 acres - permanent</td>
<td>0.04 acres - permanent</td>
<td>0.04 acres - permanent</td>
<td>0.04 acres - permanent</td>
<td>0.04 acres - permanent</td>
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<tr>
<td>Temporary and Permanent Volume of Placement of Fill into Waters Contributing to Waters of the U.S. (cubic yd)</td>
<td>0 cu yd - temporary</td>
<td>0 cu yd - temporary</td>
<td>0 cu yd - temporary</td>
<td>0 cu yd - temporary</td>
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<tr>
<td>8-Very Good Condition</td>
<td>7 Good Condition</td>
<td>7 Good Condition</td>
<td>7 Good Condition</td>
<td>7 Good Condition</td>
<td>7 Good Condition</td>
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<tr>
<td>7 Good Condition</td>
<td>6-Very Good Condition</td>
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<td>6-Very Good Condition</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact to TH 74 Traffic</th>
<th>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</th>
<th>None</th>
<th>Higher</th>
<th>Higher</th>
<th>Lower/Moderate</th>
<th>Lower/Moderate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
<tr>
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<tr>
<td>Impact to TH 74 Traffic</td>
<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
<tr>
<td>Impact to TH 74 Traffic</td>
<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
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<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
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<td>Lower/Moderate</td>
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<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<td>Construction Noise</td>
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<td>None</td>
<td>Higher</td>
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<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
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<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
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<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
</tr>
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<tr>
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<td>None</td>
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<td>Higher</td>
<td>Lower/Moderate</td>
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</tr>
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<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
<td>Construction Noise</td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
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<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
<td>Impact to TH 74 Traffic</td>
<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
<td>None</td>
<td>Higher</td>
<td>Higher</td>
<td>Lower/Moderate</td>
<td>Lower/Moderate</td>
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<tr>
<td>EVALUATION CRITERIA</td>
<td>MEASUREMENT</td>
<td>Alternative 1</td>
<td>Alternative 2</td>
<td>Alternative 2A</td>
<td>Alternative 2B</td>
<td>Alternative 2C</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>PURPOSE &amp; NEED (PRIMARY)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluate Multi-Plate Arch and Knee Wall Abutments with condition to be based on NB Culvert Condition Rating guidelines, upon completion of rehab.</td>
<td></td>
<td>3 Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls)</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
</tr>
<tr>
<td>Evaluate Headwalls &amp; Wingwalls with condition to be based on NB Culvert Condition Rating guidelines, upon completion of rehab.</td>
<td></td>
<td>3 Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls)</td>
<td>6-Very Good Condition</td>
<td>6-Very Good Condition</td>
<td>6-Very Good Condition</td>
<td>6-Very Good Condition</td>
</tr>
<tr>
<td>To what level does the alternative address observed inslope erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td></td>
<td>Inlet - Not Addressed</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
</tr>
<tr>
<td>To what level does the alternative mitigate the additional headwall surcharge/overburden from the raised road and steep inslope? (no concern, not addressed, partially addressed, addressed)</td>
<td></td>
<td>Inlet - No Concern</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
<td>Inlet - Addressed</td>
</tr>
<tr>
<td>To what level does the alternative address observed channel and inlet/outlet erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td></td>
<td>Not Addressed</td>
<td>Addressed</td>
<td>Addressed</td>
<td>Addressed</td>
<td>Addressed</td>
</tr>
<tr>
<td>SOCIAL, ECONOMIC &amp; ENVIRONMENTAL (SEE) IMPACTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 106 of the National Historic Preservation Act of 1966</td>
<td></td>
<td>Not Applicable</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
<td>Significantly Diminishes Integrity</td>
</tr>
<tr>
<td>*Effect on Integrity of the Historic District</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endangered Species Act of 1973</td>
<td></td>
<td>No Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>NPS &amp; Rare Species</td>
<td></td>
<td>No Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
</tr>
<tr>
<td>DNR – Public Waters</td>
<td></td>
<td>6 acres - temporary</td>
<td>0.03 acres - permanent</td>
<td>0.03 acres - permanent</td>
<td>0.03 acres - permanent</td>
<td>0.03 acres - permanent</td>
</tr>
<tr>
<td>*Effect on Integrity of the Historic District</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 4(f) of the Transp. Act of 1966</td>
<td></td>
<td>No Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td>Construction Noise</td>
<td></td>
<td>Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Low/Moderate</td>
<td>Low/Moderate</td>
<td>Low/Moderate</td>
</tr>
<tr>
<td>Cost Criteria</td>
<td></td>
<td>Construction Cost</td>
<td>$0</td>
<td>$1,060,300 to $1,088,300</td>
<td>$1,047,700 to $1,258,700</td>
<td>$1,050,400 to $1,261,400</td>
</tr>
<tr>
<td>Load Capacity</td>
<td></td>
<td>1.32 inventory</td>
<td>1.32 inventory</td>
<td>1.32 inventory</td>
<td>1.32 inventory</td>
<td>1.32 inventory</td>
</tr>
<tr>
<td>Service Life</td>
<td></td>
<td>Major rehab. is required w/in next 5-10 yrs</td>
<td>30-40 years</td>
<td>30-40 years</td>
<td>30-40 years</td>
<td>30-40 years</td>
</tr>
</tbody>
</table>

**Whitewater State Park Bridge 8594 Alternatives Evaluation Matrix**

**Condition and Rehabilitation Study – June 2018**

**Whitewater State Park Culverts - TH 74 over Drainage Channel (SP 8508-38)**

**GEMINI RESEARCH**

**Cultural Resource Consultants**

**PERFORMANCE DRIVEN DESIGN**

**LHB**
## Whitewater State Park 8595 Alternatives Evaluation Matrix

<table>
<thead>
<tr>
<th>EVALUATION CRITERIA</th>
<th>MEASUREMENT</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 2A</th>
<th>Alternative 2B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Build</td>
<td>Rehabilitate</td>
<td>Rehabilitate w/Masonry Floor</td>
<td>Rehabilitate + Waterproof Floor</td>
</tr>
<tr>
<td><strong>PURPOSE &amp; NEED (PRIMARY)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridge Condition</td>
<td>Evaluate Multi-Plate Arch and Knee Wall Abutments with condition to be based on NBi Culvert Condition Rating guidelines, upon completion of rehab. (6 or better desired, no change = current culvert NBi)</td>
<td>3-Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls/wingwalls)</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
</tr>
<tr>
<td></td>
<td>Evaluate Headwalls &amp; Wingwalls with condition to be based on NBi Culvert Condition Rating guidelines, upon completion of rehab. (6 or better desired, no change = current culvert NBi)</td>
<td>3-Serious Condition (current rating includes condition of floor, knee walls, arch and headwalls/wingwalls)</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
<td>7-Good Condition</td>
</tr>
<tr>
<td></td>
<td>To what level does the alternative address observed in-slope erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Inlet - Not Addressed Outlet - No Concern</td>
<td>Inlet - Partially Addressed Outlet - No Concern</td>
<td>Inlet - Partially Addressed Outlet - No Concern</td>
<td>Inlet - Addressed Outlet - No Concern</td>
</tr>
<tr>
<td></td>
<td>To what level does the alternative mitigate the additional headwall surcharge/overburden from the raised road and steep in-slope? (no concern, not</td>
<td>Inlet - No Concern Outlet - Not Addressed</td>
<td>Inlet - No Concern Outlet - Not Addressed</td>
<td>Inlet - No Concern Outlet - Not Addressed</td>
<td>Inlet - No Concern Outlet - Addressed</td>
</tr>
<tr>
<td></td>
<td>To what level does the alternative address observed channel and inlet/outlet erosion deficiencies? (no concern, not addressed, partially addressed, addressed)</td>
<td>Not Addressed</td>
<td>Addressed</td>
<td>Addressed</td>
<td>Addressed</td>
</tr>
<tr>
<td><strong>SOCIAL, ECONOMIC &amp; ENVIRONMENTAL (SEE) IMPACTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 106 of the National Historic Preservation Act of 1966</td>
<td>Effect on Integrity of the Historic Structure (no impact, preserves, diminishes, significantly affects)</td>
<td>Not Applicable</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
<td>Preserves Integrity</td>
</tr>
<tr>
<td></td>
<td>Evaluate alternative scope based on consistency w/ SOI Standards (consistent, not consistent)</td>
<td>Not Applicable</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
</tr>
<tr>
<td></td>
<td>*See Section XIII for determination of overall project effects (all bridges) to Historic District.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endangered Species Act of 1973</td>
<td>Risk of Impact to Northern Long-Eared Bat (low, moderate, higher)</td>
<td>No Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
<tr>
<td></td>
<td>Base of Impact to Rare Features &amp; Biodiversity Site Based on Disturbed Vegetated Area (low, moderate, higher)</td>
<td>No Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
<td>Moderate Risk</td>
</tr>
<tr>
<td>DNR – Public Waters</td>
<td>Temporary and Permanent Impact to Stream (disturbed area of waters contributing to public waters)</td>
<td>0.006 acres - temporary</td>
<td>0.04 acres - temporary</td>
<td>0.02 acres - permanent</td>
<td>0.002 acres - temporary</td>
</tr>
<tr>
<td></td>
<td>Evaluate multi-plate arch for potential bridge retrofit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 4(f) of the Transp. Act of 1966</td>
<td>Risk of Section 4(f) Use of Historic District</td>
<td>Not Applicable</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
<td>Consistent w/ SOI Rehab Standards</td>
</tr>
<tr>
<td></td>
<td>*See Section XIII for determination of overall project effects (all bridges) to Historic District.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 404 of the Clean Water Act</td>
<td>Temporary and Permanent Volume of Placement of Fill into Waters Contributing to Waters of the U.S. (cubic yards)</td>
<td>0 cu yd - temporary</td>
<td>0 cu yd - permanent</td>
<td>0 cu yd - temporary</td>
<td>0 cu yd - temporary</td>
</tr>
<tr>
<td>Construction Noise Impact to Park Users (none, low, moderate, higher)</td>
<td>None</td>
<td>Low</td>
<td>Low/Moderate</td>
<td>Low/Moderate</td>
<td>Low/Moderate</td>
</tr>
<tr>
<td>Impact to TH 74 Traffic</td>
<td>Impact to Traffic During Construction Based on Duration of Road Closure (none, low, moderate, higher)</td>
<td>None</td>
<td>Moderate</td>
<td>Higher</td>
<td>Higher</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>Risk-Based Construction Cost Range (in 2020$)</td>
<td>$0</td>
<td>$476,200 to $572,200</td>
<td>$631,300 to $759,300</td>
<td>$789,000 to $948,000</td>
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<tr>
<td><strong>DESIGN CONSIDERATIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Capacity</td>
<td>Resulting HL-93 Load Capacity Rating Factors (Inventory &amp; Operating)</td>
<td>RF 1.55 inventory</td>
<td>RF 2.00 operating</td>
<td>RF 1.55 inventory</td>
<td>RF 2.00 operating</td>
</tr>
<tr>
<td></td>
<td>Is Load Posting Required? (yes, no)</td>
<td>no posting</td>
<td>no posting</td>
<td>no posting</td>
<td>no posting</td>
</tr>
<tr>
<td>Service Life</td>
<td>Estimated timeframe until major rehabilitation is required (20 years minimum) following completion of rehab</td>
<td>Major rehab. is required w/in next 5-10 yrs.</td>
<td>25-35 years</td>
<td>25-35 years</td>
<td>30-40 years</td>
</tr>
</tbody>
</table>
XIII. REHABILITATION ALTERNATIVE(S) CARRIED FORWARD

This rehabilitation study for Bridges 8592, 8593, 8594 & 8595 concludes with selection of rehabilitation alternatives to be carried forward to the NEPA document. The Alternatives Evaluation Matrix for each culvert (see Section XII) summarizes how the alternatives rated within the individual evaluation criteria. This section provides a collective summary and analysis of the evaluation matrices as it applies to selection of alternatives to be carried forward.

Evaluation by Alternative Type

Although there are nuances between the culverts in terms of their condition and needs, the alternatives studied for each culvert are similar. Therefore, there are also similarities in evaluated criteria between alternatives studied for each culvert with similar scope. Grouping the alternatives for each culvert into alternative types results in seven alternatives (some of the alternatives do not apply to every culvert). The alternative types are:

- No Build
- Rehabilitate
- Rehabilitate and Restore Original Masonry Floor
- Rehabilitate and Waterproof Top of Multi-Plate Arch
- Rehabilitate and Extend Height of Inlet Walls with Structural Walls and Stone Masonry
- Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway
- Rehabilitate and Reinforce Soil Slopes

For an alternative to be carried forward to the NEPA document, it must meet the project’s primary needs of improving the condition of the culvert, as stated in the project Purpose & Need Statement (see Section II). Although not stated as a primary need for the project, the culverts lie within and are contributing resources to a National Register-listed historic district. Therefore, the ability for each alternative to preserve the historic integrity of the culverts with a scope consistent with the SOI Rehabilitation Standards will be weighed heavily within the decision to carry an alternative forward to the NEPA document. Each rehabilitation alternative type will be primarily evaluated below on its ability to meet the primary project need as well as preserve the historic integrity of the culvert. Evaluation criteria which have no variation from alternative to alternative will not be discussed here.

No Build

- No work proposed to the culverts, however routine maintenance would continue.
  - Alternative 1 – All Bridges
    - Although the project’s primary need (bridge condition) is not met with this alternative, it must be studied for each culvert within the NEPA document.
    - Carried Forward?
      - No – Although a ‘No Build’ alternative will be considered within the NEPA document, it will be a singular alternative for the entire project (6 bridges), not individual bridges.
Rehabilitate

- Rehabilitates culvert with no change/improvement to the strength of the headwalls or wingwalls or the steepness of roadway inslopes.
  - Alternative 2 – Bridges 8592 & 8595
  - This alternative is not applicable to Bridges 8593 & 8594 because a basic rehabilitation must also include removal of the corroding non-historic I-beam shoring, which is not possible without addressing the steep and eroding roadway inslopes above the outlet headwall and wingwalls.

- Project Primary Need (Bridge Condition)
  - This alternative succeeds in improving the condition of the culvert knee walls, floor, headwalls and wingwalls and would improve the NBI culvert condition rating from a 3 to a 7 (6 or better desired).
  - The erosion of the roadway inslopes is partially addressed through the placement of a surface-only erosion control treatment.
  - The headwall surcharge/overburden is not mitigated with this alternative
    - The project primary need is not met.

- Effect on Integrity of the Historic Structure
  - The scope of this alternative is consistent with the SOI Standards and preserves the historic integrity of the structure.

- Carried Forward?
  - No

Rehabilitate and Restore Original Masonry Floor

- For each culvert, Alternative 2 includes the removal and replacement of the concrete floor of the culvert. This alternative replaces that scope with the restoration of the original stone masonry culvert floor.
  - Alternative 2A – All Bridges

- Project Primary Need (Bridge Condition)
  - This alternative has a neutral effect on bridge condition compared to Alternative 2; placing a masonry floor in lieu of a concrete floor would neither increase or decrease the condition rating of the culvert.

- Effect on Integrity of the Historic Structure
  - Restoration of the original masonry floor would improve the integrity of the historic structure.
  - Restoration of the original floor within the basic rehabilitation (Alternative 2) is consistent with the SOI Standards.

- This alternative varies from Alternative 2 only in cost; other criteria remain the same.
  - Additional cost is $90K to $190K, depending on the culvert and its floor area.
  - A stone masonry floor would have less durability and service life compared to a new concrete floor.
Additional cost for culvert floor work is not justified.

- Carried Forward?
  - No

**Rehabilitate and Waterproof Top of Multi-Plate Arch**

- This alternative increases the scope of a basic rehabilitation by adding the waterproofing of the multi-plate arch.
  - Alternative 2B – All Bridges
- Project Primary Need (Bridge Condition)
  - This alternative has a neutral effect on bridge condition compared to Alternative 2; waterproofing would not increase the condition rating of the culvert.
- Effect on Integrity of the Historic Structure
  - The waterproofing would be hidden and would not diminish the integrity of the historic structure.
  - The overall scope of the alternative remains consistent with the SOI Standards.
- This alternative varies from Alternative 2 in cost, service life, and duration/area of disruption.
  - This added scope results in a large excavation and roadway replacement quantity.
  - Additional cost is $138K to $375K, depending on the culvert and its Alternative 2 scope
    - When Alternative 2 includes reinforced soil slopes (Bridges 8593 & 8594) the additional cost is less due to the larger excavation already included with the slope work.
  - 5 to 10 years of additional service life is anticipated
  - Additional cost for culvert waterproofing is not justified in comparison to the amount of additional service life expected.
- Carried Forward?
  - No

**Rehabilitate and Extend Height of Inlet Walls with Structural Walls and Stone Masonry**

- This alternative increases the scope of a basic rehabilitation by extending select east stone masonry headwall and wingwall heights to address the slope stability and headwall surcharge concerns.
  - Alternative 2C – Bridges 8592, 8593 & 8594
  - This alternative is not applicable to Bridge 8595 as there are no concerns with the steepness of the existing roadway inslopes.
- Project Primary Need (Bridge Condition)
  - This alternative succeeds in improving the condition of the culvert headwalls and wingwalls through the construction of a new reinforced concrete wall with a masonry veneer face in place of the stone masonry walls.
    - Headwall and wingwall condition would be considered new.
    - The NBI culvert condition rating would improve from a 3 to a 9 (6 or better desired).
The erosion of the roadway inslopes and headwall surcharge/overburden would be mitigated with this alternative.

- **Effect on Integrity of the Historic Structure**
  - Due to the geometric changes, this alternative is not consistent with the SOI Standards and significantly diminishes the historic integrity of the structure.

- **Carried Forward?**
  - No

**Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway**

- This alternative increases the scope of a basic rehabilitation by constructing an intermediate concrete wall between the east culvert headwall and the roadway guardrail to address the slope stability and headwall surcharge concerns.
  - Alternative 2D – Bridges 8592, 8593 & 8594
  - This alternative is not applicable to Bridge 8595 as there are no concerns with the steepness of the existing roadway inslopes

- **Project Primary Need (Bridge Condition)**
  - This alternative succeeds in improving the condition of the culvert headwalls and wingwalls through the construction of a new reinforced concrete wall behind the stone masonry walls.
    - Headwall and wingwall condition would be considered new.
    - The NBI culvert condition rating would improve from a 3 to a 9 (6 or better desired).
  - The erosion of the roadway inslopes and headwall surcharge/overburden would be mitigated with this alternative.

- **Effect on Integrity of the Historic Structure**
  - Because the intermediate concrete wall would be a significant addition to the structure and would visually distract from the east elevation, this alternative is not consistent with the SOI Standards and significantly diminishes the historic integrity of the structure.

- **Carried Forward?**
  - No

**Rehabilitate and Reinforce Soil Slopes**

- This alternative increases the scope of a basic rehabilitation by constructing a reinforced soil embankment to address the slope stability and headwall surcharge concerns.
  - Alternative 2E – Bridge 8592
  - Alternative 2C – Bridge 8595

- **Project Primary Need (Bridge Condition)**
  - The erosion of the roadway inslopes and headwall surcharge/overburden would be mitigated with this alternative.
Placement of a reinforced soil mass behind the walls would relieve the surcharge on the stone masonry walls.

Soil reinforcement would stabilize the existing steep slopes above the headwalls and wingwalls which would remain.

- The condition of the culvert headwalls and wingwalls would be improved.
  - Walls would be repointed and selectively reconstructed with most load removed.
  - The NBI culvert condition rating would improve from a 3 to a 8 (6 or better desired).

Effect on Integrity of the Historic Structure

- The soil reinforcement would be an addition to the historic structure but would be hidden.
- The scope of this alternative is consistent with the SOI Standards and preserves the historic integrity of the structure.

This is the **lowest cost alternative of those that meet the project primary need**.

- The other alternatives (raising of stone walls and placement of intermediate wall) do not meet historic integrity criteria.

Carried Forward?

- Yes

**Section 106 and Section 4(f) Review of Alternatives Carried Forward**

The effect on the historic district is best determined once the effect on each individual bridge has been evaluated. Therefore, the overall effect on the historic district will not be evaluated for each proposed alternative, but rather for the proposed combination(s) of alternatives. Since only one alternative has been selected for each culvert, ‘Rehabilitate and Reinforce Soil Slopes,’ there is only one combination of alternatives to review.

Taken together, the alternatives to be carried forward – Alternative 2E for Bridge 8592; Alternative 2 for Bridge 8593; Alternative 2 for Bridge 8594; and Alternative 2C for Bridge 8595 – would not diminish the integrity of the Whitewater State Park CCC/WPA/Rustic Style Historic Resources historic district and would be consistent with SOI Rehabilitation Standards. The historic character of the district would be retained and preserved, meeting Standard 1. The removal of distinctive materials and the alteration of characteristic features, spaces, and spatial relationships would be avoided. Per Standard 5, distinctive materials, features, finishes, construction techniques, and examples of craftsmanship that characterize the district would be preserved. Consistent with Standard 6, deteriorated historic features would be repaired rather than replaced, and, if unrepairable, the historic materials and features would be replaced in-kind. Per Standard 7, treatments that damage historic materials would not be used. Consistent with Standard 9, new additions would not destroy characteristic historic materials, features, and spatial relationships; would be differentiated from the old; and would be compatible with historic
materials and features in size, scale, proportion, and massing. Per Standard 10, if new additions were removed in the future the essential form and integrity of the historic property would be unimpaired.

Taken together, the effect of the alternatives would be to preserve the integrity of the historic district. It is recommended there would be no Adverse Effect under Section 106. The risk of Section 4(f) use of historic property under the alternatives carried forward, taken together, is low.

Summary of Alternatives Carried Forward
Only three alternative types fully meet the project’s primary need of improving the bridge condition. Those alternatives are ‘Rehabilitate and Extend Height of Inlet Walls with Structural Walls and Stone Masonry’, ‘Rehabilitate and Place Structural Wall between Inlet Stone Headwall and Roadway’, and ‘Rehabilitate and Reinforce Soil Slopes.’ Of these three alternative types, only ‘Rehabilitate and Reinforce Soil Slopes’ preserves the integrity of the historic structure. Although not a factor in alternative selection, the reinforced soil alternative is the lowest cost of the three above mentioned alternatives. This alternative for each culvert will move forward to the NEPA document. In summary, the alternatives moving forward for each culvert are:

- Bridge 8592 – Alternative 2E
- Bridge 8593 – Alternative 2
- Bridge 8594 – Alternative 2
- Bridge 8595 – Alternative 2C
XIV. APPENDICES

Appendix A – Secretary of the Interior’s Standards

Secretary of the Interior’s Standards for the Treatment of Historic Properties

The Secretary of the Interior’s Standards for the Treatment of Historic Properties were authorized by the National Historic Preservation Act of 1966. The Standards were revised in 1992 and the revisions codified in 1995 (36 CFR 68). The Standards are designed to be applied to all types of historic properties including buildings, sites, structures, districts, and objects. They are accompanied by a set of advisory guidelines. The Standards and Guidelines outline a hierarchy of four treatment approaches: Preservation, Rehabilitation, Restoration, and Reconstruction.

The first treatment, Preservation, places a high premium on the retention of all historic fabric through conservation, maintenance and repair. Rehabilitation, the second treatment, emphasizes the retention and repair of historic materials, but more latitude is provided for replacement because it is assumed the property is more deteriorated prior to work. Restoration, the third treatment, focuses on the retention of materials from the most significant time in a property’s history, while permitting the removal of materials from other periods. Reconstruction, the fourth treatment, establishes limited opportunities to recreate a building, structure, object, or landscape that has disappeared.

Rehabilitation is the treatment approach most applicable to the Whitewater State Park culverts project. The Standards and Guidelines for all four treatments, including Rehabilitation, emphasize that the most conservative treatments – retaining, preserving, and repairing historic materials and features – are the preferred approach for preserving the historic integrity of a property. The Standards and Guidelines begin with the recommendation that features important in defining the historic character of the property be identified, retained, preserved, protected, and maintained. If repair is necessary, it should begin with the least intervention possible. If parts of an element are extensively damaged or deteriorated, limited replacement of those parts in-kind is acceptable. Next in the hierarchy, if the entire feature or element has deteriorated beyond repair, the preferred option is replacement in-kind, with the same material. Removal and replacement of a historic feature that could reasonably be repaired (and thus preserved) is never recommended.

The Standards and Guidelines direct that when alterations are needed to assure continued use of a historic property – for example, improving a bridge’s load capacity and geometry – the alterations should not radically change, obscure, or destroy important materials, features, or finishes.

The Guidelines also advise that the effect of proposed changes be assessed within the overall context of the entire property, stating that “loss of [historic] character is just as often caused by the cumulative effect of a series of actions that would seem to be minor interventions” as by a single action.
Standards for Rehabilitation

1. A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.

2. The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.

3. Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.

4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.

6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.

7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

9. New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work will be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.

10. New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.
### Appendix B – Detailed Alternative Cost Estimates

#### Rehabilitation Construction Costs – Bridge 8592

**REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)**

**Bridge No. 8592**

April 2, 2018

<table>
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<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
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<th>UNIT</th>
<th>COST</th>
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**ALTERNATIVE 2A - Restore Masonry Floor**

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**ALTERNATIVE 2B - Waterproof Top of Multi-Plate Arch**

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| **ALTERNATIVE 2B COST RANGE** | **$615,200 TO $739,200** |...
### REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**Bridge No. 8592**  
April 2, 2018

<table>
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**ADDITIONAL COST TO ALTERNATIVE 2**  
$338,810

**ALTERNATIVE 2C COST RANGE**  
$633,000 TO $761,000

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**ADDITIONAL COST TO ALTERNATIVE 2**  
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**ALTERNATIVE 2D COST RANGE**  
$612,800 TO $736,800

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**ADDITIONAL COST TO ALTERNATIVE 2**  
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**ALTERNATIVE 2E COST RANGE**  
$532,900 TO $640,900
### REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**Bridge No. 8593**  
April 2, 2018

#### ALTERNATIVE 2 - Rehabilitate and Reinforce Soil Embankment

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<td>REINFORCED SOIL SLOPE (OUTLET)</td>
<td>SQ FT</td>
<td>1150</td>
<td>$57</td>
<td>$65,550</td>
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<tr>
<td>15</td>
<td>REINFORCED SOIL SLOPE (INLET)</td>
<td>SQ FT</td>
<td>675</td>
<td>$57</td>
<td>$38,475</td>
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<tr>
<td>16</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>4800</td>
<td>$11</td>
<td>$52,800</td>
</tr>
<tr>
<td>17</td>
<td>FURNISH ADDITIONAL WINGWALL STONE</td>
<td>SQ FT</td>
<td>90</td>
<td>$57</td>
<td>$5,130</td>
</tr>
<tr>
<td>18</td>
<td>CONSTRUCT WINGWALL EXTENSION</td>
<td>SQ FT</td>
<td>90</td>
<td>$342</td>
<td>$30,780</td>
</tr>
<tr>
<td>19</td>
<td>REMOVE AND REPLACE GUARDRAIL WITH TYPE 31</td>
<td>LIN FT</td>
<td>480</td>
<td>$57</td>
<td>$27,360</td>
</tr>
<tr>
<td>20</td>
<td>EROSION CONTROL</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$22,800</td>
<td>$22,800</td>
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</table>

20% CONTINGENCY  
LUMP SUM 1  | $154,000  | $154,000

ALTERNATIVE 2 SUBTOTAL  | $921,080

ALTERNATIVE 2 COST RANGE  | $767,100 TO $921,100

#### ALTERNATIVE 2A - Restore Masonry Floor

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$7,100</td>
<td>$7,100</td>
</tr>
<tr>
<td>1</td>
<td>REMOVE AND REPLACE CONCRETE FLOOR</td>
<td>SQ FT</td>
<td>(1100)</td>
<td>$114</td>
<td>($125,400)</td>
</tr>
<tr>
<td>2</td>
<td>REMOVE CONCRETE FLOOR AND RECONSTRUCT STONE FLOOR</td>
<td>SQ FT</td>
<td>1100</td>
<td>$206</td>
<td>$226,600</td>
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</tbody>
</table>

20% CONTINGENCY  
LUMP SUM 1  | $22,000  | $22,000

ADDITIONAL COST TO ALTERNATIVE 2  | $10,000

ALTERNATIVE 2A COST RANGE  | $875,400 TO $1,051,400

#### ALTERNATIVE 2B - Waterproof Top of Muti-Plate Arch

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$9,100</td>
<td>$9,100</td>
</tr>
<tr>
<td>1</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>(1100)</td>
<td>$69</td>
<td>($75,900)</td>
</tr>
<tr>
<td>2</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>1650</td>
<td>$67</td>
<td>$101,550</td>
</tr>
<tr>
<td>3</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>(4800)</td>
<td>$11</td>
<td>($52,800)</td>
</tr>
<tr>
<td>4</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>8750</td>
<td>$11</td>
<td>$96,250</td>
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<td>5</td>
<td>WATERPROOF MULTI-PLATE ARCH</td>
<td>SQ FT</td>
<td>1520</td>
<td>$26</td>
<td>$39,520</td>
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<tr>
<td>6</td>
<td>ADDITIONAL EROSION CONTROL</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$11,400</td>
<td>$11,400</td>
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20% CONTINGENCY  
LUMP SUM 1  | $28,000  | $28,000

ADDITIONAL COST TO ALTERNATIVE 2  | $166,120

ALTERNATIVE 2B COST RANGE  | $905,300 TO $1,087,300
Rehabilitation Construction Costs – Bridge 8593 (continued)

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REPOINT HEADWALLS AND WINGWALLS</td>
<td>SQ FT</td>
<td>(320)</td>
<td>$48</td>
<td>($15,360)</td>
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<tr>
<td>2</td>
<td>REPOINT HEADWALLS AND WINGWALLS</td>
<td>SQ FT</td>
<td>275</td>
<td>$48</td>
<td>($13,200)</td>
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<tr>
<td>3</td>
<td>REPLACE DEFICIENT HEADWALL AND WINGWALL STONE</td>
<td>SQ FT</td>
<td>(150)</td>
<td>$57</td>
<td>($8,550)</td>
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<tr>
<td>4</td>
<td>REPLACE DEFICIENT HEADWALL AND WINGWALL STONE</td>
<td>SQ FT</td>
<td>80</td>
<td>$456</td>
<td>$36,480</td>
</tr>
<tr>
<td>5</td>
<td>RECONSTRUCT HEADWALL AND WINGWALL</td>
<td>SQ FT</td>
<td>(420)</td>
<td>$513</td>
<td>($215,460)</td>
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<tr>
<td>6</td>
<td>RECONSTRUCT HEADWALL AND WINGWALL</td>
<td>SQ FT</td>
<td>125</td>
<td>$684</td>
<td>$85,500</td>
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<tr>
<td>7</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>(1100)</td>
<td>$69</td>
<td>($75,900)</td>
</tr>
<tr>
<td>8</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>1130</td>
<td>$61</td>
<td>$68,930</td>
</tr>
<tr>
<td>9</td>
<td>REINFORCED SOIL SLOPE (OUTLET)</td>
<td>SQ FT</td>
<td>(1150)</td>
<td>$57</td>
<td>($65,550)</td>
</tr>
<tr>
<td>10</td>
<td>CONSTRUCT STRUCTURAL RETAINING WALL</td>
<td>SQ FT</td>
<td>735</td>
<td>$228</td>
<td>$167,580</td>
</tr>
<tr>
<td>11</td>
<td>STONE MASONRY VENEER</td>
<td>SQ FT</td>
<td>625</td>
<td>$285</td>
<td>$178,125</td>
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<td>12</td>
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<td>LUMP SUM</td>
<td>1</td>
<td>$11,400</td>
<td>$11,400</td>
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<tr>
<td></td>
<td>20% CONTINGENCY</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$39,000</td>
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</table>

**ALTERNATIVE 2C COST RANGE**

$960,200 TO $1,153,200

**ALTERNATIVE 2D - Add Structural Wall Between Outlet Headwall and Road**

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>(1100)</td>
<td>$69</td>
<td>($75,900)</td>
</tr>
<tr>
<td>2</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>2050</td>
<td>$61</td>
<td>$125,050</td>
</tr>
<tr>
<td>3</td>
<td>REINFORCED SOIL SLOPE (OUTLET)</td>
<td>SQ FT</td>
<td>(1150)</td>
<td>$57</td>
<td>($65,550)</td>
</tr>
<tr>
<td>4</td>
<td>CONSTRUCT STRUCTURAL RETAINING WALL</td>
<td>SQ FT</td>
<td>1485</td>
<td>$228</td>
<td>$338,580</td>
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<tr>
<td>5</td>
<td>ADDITIONAL EROSION CONTROL</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$11,400</td>
<td>$11,400</td>
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<tr>
<td></td>
<td>20% CONTINGENCY</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$72,000</td>
<td>$72,000</td>
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**ALTERNATIVE 2D COST RANGE**

$1,124,100 TO $1,350,100
# Rehabilitation Construction Costs – Bridge 8594

## REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**Bridge No. 8594**  
April 2, 2018

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALTERNATIVE 2 - Rehabilitate and Reinforce Soil Embankment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$59,300</td>
<td>$59,300</td>
</tr>
<tr>
<td>1</td>
<td>REMOVE AND REPLACE CONCRETE FLOOR</td>
<td>SQ FT</td>
<td>1435</td>
<td>$114</td>
<td>$163,590</td>
</tr>
<tr>
<td>2</td>
<td>RIPRAP STREAM AT OUTLET</td>
<td>CU YD</td>
<td>5</td>
<td>$92</td>
<td>$460</td>
</tr>
<tr>
<td>3</td>
<td>REPOINT KNEE WALLS</td>
<td>SQ FT</td>
<td>260</td>
<td>$48</td>
<td>$12,480</td>
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<tr>
<td>4</td>
<td>FURNISH AND INSTALL KNEE WALL STONES</td>
<td>SQ FT</td>
<td>30</td>
<td>$228</td>
<td>$6,840</td>
</tr>
<tr>
<td>5</td>
<td>REPAIR ARCH PLATE (FROM INSIDE)</td>
<td>SQ FT</td>
<td>15</td>
<td>$228</td>
<td>$3,420</td>
</tr>
<tr>
<td>6</td>
<td>FURNISH AND INSTALL INLET MASONRY STEP STONES</td>
<td>SQ FT</td>
<td>10</td>
<td>$228</td>
<td>$2,280</td>
</tr>
<tr>
<td>7</td>
<td>REPOINT HEADWALLS AND WINGWALLS</td>
<td>SQ FT</td>
<td>720</td>
<td>$48</td>
<td>$34,560</td>
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<tr>
<td>8</td>
<td>REPLACE DEFICIENT HEADWALL AND WINGWALL STONE</td>
<td>SQ FT</td>
<td>190</td>
<td>$228</td>
<td>$43,320</td>
</tr>
<tr>
<td>9</td>
<td>RECONSTRUCT HEADWALL AND WINGWALL</td>
<td>SQ FT</td>
<td>235</td>
<td>$513</td>
<td>$120,555</td>
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<tr>
<td>10</td>
<td>FURNISH ADDITIONAL WINGWALL STONE</td>
<td>SQ FT</td>
<td>200</td>
<td>$57</td>
<td>$11,400</td>
</tr>
<tr>
<td>11</td>
<td>CONSTRUCT WINGWALL EXTENSION</td>
<td>SQ FT</td>
<td>200</td>
<td>$342</td>
<td>$68,400</td>
</tr>
<tr>
<td>12</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>1700</td>
<td>$63</td>
<td>$107,100</td>
</tr>
<tr>
<td>13</td>
<td>REINFORCED SOIL SLOPE (INLET)</td>
<td>SQ FT</td>
<td>2400</td>
<td>$52</td>
<td>$124,800</td>
</tr>
<tr>
<td>14</td>
<td>REINFORCED SOIL SLOPE (OUTLET)</td>
<td>SQ FT</td>
<td>1250</td>
<td>$52</td>
<td>$65,000</td>
</tr>
<tr>
<td>15</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>4800</td>
<td>$11</td>
<td>$52,800</td>
</tr>
<tr>
<td>16</td>
<td>REMOVE AND REPLACE GUARDRAIL WITH TYPE 31</td>
<td>LIN FT</td>
<td>250</td>
<td>$57</td>
<td>$14,250</td>
</tr>
<tr>
<td>17</td>
<td>EROSION CONTROL</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$11,400</td>
<td>$11,400</td>
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<tr>
<td></td>
<td>20% CONTINGENCY</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$182,000</td>
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</tr>
</tbody>
</table>

**ALTERNATIVE 2 COST RANGE**  
$906,300 TO $1,088,300

**ALTERNATIVE 2 SUBTOTAL**  
$1,088,275

## ALTERNATIVE 2A - Restore Masonry Floor

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$9,300</td>
<td>$9,300</td>
</tr>
<tr>
<td>1</td>
<td>REMOVE AND REPLACE CONCRETE FLOOR</td>
<td>SQ FT</td>
<td>(1435)</td>
<td>$114</td>
<td>($163,590)</td>
</tr>
<tr>
<td>2</td>
<td>REMOVE CONCRETE FLOOR AND RECONSTRUCT STONE FLOOR</td>
<td>SQ FT</td>
<td>1435</td>
<td>$206</td>
<td>$295,610</td>
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<tr>
<td></td>
<td>20% CONTINGENCY</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$29,000</td>
<td>$29,000</td>
</tr>
</tbody>
</table>

**ADDITIONAL COST TO ALTERNATIVE 2**  
$170,320

**ALTERNATIVE 2A COST RANGE**  
$1,047,700 TO $1,258,700

## ALTERNATIVE 2B - Waterproof Top of Multi-Plate Arch

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT COST</th>
<th>TOTAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$9,500</td>
<td>$9,500</td>
</tr>
<tr>
<td>1</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>(1700)</td>
<td>$63</td>
<td>($107,100)</td>
</tr>
<tr>
<td>2</td>
<td>STRUCTURE EXCAVATION AND BACKFILL</td>
<td>CU YD</td>
<td>2450</td>
<td>$61</td>
<td>$149,450</td>
</tr>
<tr>
<td>3</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>(4800)</td>
<td>$11</td>
<td>($52,800)</td>
</tr>
<tr>
<td>4</td>
<td>REMOVE AND REPLACE ROADWAY</td>
<td>SQ FT</td>
<td>8600</td>
<td>$11</td>
<td>$94,600</td>
</tr>
<tr>
<td>5</td>
<td>WATERPROOF MULTI-PLATE ARCH</td>
<td>SQ FT</td>
<td>1500</td>
<td>$26</td>
<td>$39,000</td>
</tr>
<tr>
<td>6</td>
<td>ADDITIONAL EROSION CONTROL</td>
<td>LUMP SUM</td>
<td>1</td>
<td>$11,400</td>
<td>$11,400</td>
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<td>LUMP SUM</td>
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<td>$29,000</td>
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</table>

**ADDITIONAL COST TO ALTERNATIVE 2**  
$173,050

**ALTERNATIVE 2B COST RANGE**  
$1,050,400 TO $1,261,400
### REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**Bridge No. 8594**  
**April 2, 2018**

<table>
<thead>
<tr>
<th>ESTIMATED QUANTITIES AND COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTERNATIVE 2C - Extend Height of Inlet Stone Headwall with Structural Wall and Stone Masonry Veneer</td>
</tr>
<tr>
<td>MOBILIZATION @ 7%</td>
</tr>
<tr>
<td>1 REPOINT HEADWALLS AND WINGWALLS</td>
</tr>
<tr>
<td>2 REPOINT HEADWALLS AND WINGWALLS</td>
</tr>
<tr>
<td>3 REPLACE DEFICIENT HEADWALL AND WINGWALL STONE</td>
</tr>
<tr>
<td>4 REPLACE DEFICIENT HEADWALL AND WINGWALL STONE</td>
</tr>
<tr>
<td>5 STRUCTURE EXCAVATION AND BACKFILL</td>
</tr>
<tr>
<td>6 STRUCTURE EXCAVATION AND BACKFILL</td>
</tr>
<tr>
<td>7 RECONSTRUCT HEADWALL AND WINGWALL</td>
</tr>
<tr>
<td>8 RECONSTRUCT HEADWALL AND WINGWALL</td>
</tr>
<tr>
<td>9 REINFORCED SOIL SLOPE (INLET)</td>
</tr>
<tr>
<td>10 CONSTRUCT STRUCTURAL RETAINING WALL</td>
</tr>
<tr>
<td>11 STONE MASONRY VENEER</td>
</tr>
<tr>
<td>12 ADDITIONAL EROSION CONTROL</td>
</tr>
<tr>
<td>20% CONTINGENCY</td>
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**ADDITIONAL COST TO ALTERNATIVE 2**  
$391,875  
$391,875 TO $493,875

**ALTERNATIVE 2D - Add Structural Wall Between Inlet Headwall and Road**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
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<td>$21,500</td>
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<td>(1700)</td>
<td>$63</td>
<td>($107,100)</td>
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<tr>
<td>2 STRUCTURE EXCAVATION AND BACKFILL</td>
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<td>2300</td>
<td>$61</td>
<td>$140,300</td>
</tr>
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<td>3 REINFORCED SOIL SLOPE (INLET)</td>
<td>SQ FT</td>
<td>(2400)</td>
<td>$52</td>
<td>($124,800)</td>
</tr>
<tr>
<td>4 CONSTRUCT STRUCTURAL RETAINING WALL</td>
<td>SQ FT</td>
<td>1620</td>
<td>$228</td>
<td>$369,360</td>
</tr>
<tr>
<td>5 REMOVE AND REPLACE ROADWAY</td>
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<td>$11</td>
<td>($52,800)</td>
</tr>
<tr>
<td>6 REMOVE AND REPLACE ROADWAY</td>
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**ADDITIONAL COST TO ALTERNATIVE 2**  
$394,260  
$394,260 TO $496,260

**ALTERNATIVE 2D COST RANGE**  
$1,234,600 TO $1,482,600
### REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**ALTERNATIVE 2 - Rehabilitate**  
Bridge No. 8595  
April 2, 2018

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QUANTITY</th>
<th>UNIT</th>
<th>COST</th>
<th>TOTAL ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOBILIZATION @ 7%</td>
<td>LUMP SUM</td>
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<td>$31,200</td>
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<td>FURNISH ADDITIONAL WINGWALL STONE</td>
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**20% CONTINGENCY**  
LUMP SUM | 1 | $96,000 | $96,000

**ALTERNATIVE 2 SUBTOTAL**  
$572,185

**ALTERNATIVE 2 COST RANGE**  
$476,200 TO $572,200

### ALTERNATIVE 2A - Restore Masonry Floor

**MOBILIZATION @ 7%**  
LUMP SUM | 1 | $10,200 | $10,200

**ADDITIONAL COST TO ALTERNATIVE 2**  
$187,100

**ALTERNATIVE 2A COST RANGE**  
$631,300 TO $759,300

### ALTERNATIVE 2B - Waterproof Top of Multi-Plate Arch

**MOBILIZATION @ 7%**  
LUMP SUM | 1 | $20,500 | $20,500

**ADDITIONAL COST TO ALTERNATIVE 2**  
$375,765

**ALTERNATIVE 2B COST RANGE**  
$789,000 TO $948,000
### REHABILITATION CONSTRUCTION COST ESTIMATE (2020 DOLLARS)

**ALTERNATIVE 2 - Rehabilitate**  
Bridge No. 8595  
April 2, 2018

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<th>ITEM NO.</th>
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<th>QUANTITY</th>
<th>UNIT COST</th>
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**ADDITIONAL COST TO ALTERNATIVE 2**  
$501,605

**ALTERNATIVE 2C COST RANGE**  
$893,900 TO $1,073,900
Appendix C – Bridges 8592, 8593 8594 & 8595 Original Construction Layout Plans
Appendix D – Bridges 8592, 8593 8594 & 8595 As-Built Wall Configuration
Whitewater State Park Culverts - TH 74 over Drainage Channel (SP 8508-38)
Condition and Rehabilitation Study – June 2018

As-built Configuration
Bridges 8592 through 8595

Gemini Research 09-2017