August 2016

REPORT FOR THE
SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

Major Bridge Investment Study

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Major Bridge Investment Study

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DISCLAIMERS

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A Study Advisory Team was formed to guide the study through completion. The Study Advisory Team includes representative parties of the SDDOT and Federal Highway Administration (FHWA).

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EXECUTIVE SUMMARY

Study Background

Waterways, canyons, roadways, and railroad tracks have always been an obstacle for travelers desiring to travel from one place to another safely and unimpeded. Bridges and other types of structures are necessary for roadway travel to cross these obstacles without the delay caused by long detours, wait times, reduced clearances, or reduced load limits. As South Dakota's economy depends upon an intact transportation system, a disruption of the system that would be caused by an unplanned closure or load restriction of a bridge or structure could be detrimental to South Dakota's economy. The SDDOT has identified 18 bridges and structures of importance based on size (cost to replace), uniqueness, and/or the potential for a significant disruption to traffic patterns due to closure or load restriction and labeled them as "major bridges".

The cost to replace a single one of these major bridges may be larger than what the SDDOT typically sees for the total of all bridge replacement projects in a given year. With the tightening of the transportation budget, the SDDOT is concerned that some of these major bridges will come due for replacement at the same time. Therefore, this Major Bridge Investment Study was developed to provide a systematic, long-range improvement plan that identifies and evaluates the existing conditions at each major bridge located throughout the state. It also establishes an implementation plan to address capacity and safety improvements, as well as the structural condition of each bridge.

This Major Bridge Investment Study addresses the evaluation and analysis of the 18 major bridges, grouped into three separate SDDOT regions, shown in the table to the right.

Structure Number	Highway or Street	Landmark or Common Name
Mitchell Region		
14-104-249	SD 19	Vermillion
05-090-279	SD 37	Running Water Standing Bear
12-085-080	SD 44	Platte – Winner
68-120-210	US 81	Yankton / Discovery
08-068-084	SD 90 L	Chamberlain Truss
08-061-094	I-90 E & W	Chamberlain
50-187-240	I-229 N & S	57th Street
50-205-209	11th Street	11th Street Viaduct
50-206-208	10th Street	10th Street Viaduct
Pierre Region		
65-000-020	US 12	Mobridge
33-100-118	US 14/SD 34/US 83	Pierre-Fort Pierre Waldron
28-035-151	SD 34	Bridger
69-390-535	SD 63	–
54-056-158	US 212	Forest City
16-737-253	SD 1806	Singing Bridge
Rapid City Region		
41-161-156	US 14A	Deadwood Box
24-162-058	US 18	Fossil Cycad National
52-430-314	Cambell Street	Cambell Street

Study Methodology

This study consisted of analyzing the baseline conditions at each structure, which included evaluating traffic operations and safety, roadway geometrics, structural conditions, and environmental resources. The results of this analysis identified the future needs for each location, which aided in the development of improvement scenarios for each of the 18 bridges. These scenarios included all improvement projects (maintenance, preservation, repairs, rehabilitation, and replacement) needed to maintain an acceptable state of repair through each bridge's year of replacement.

Each improvement scenario was then analyzed to determine a comparable list of benefits and faults, along with an estimated cost (by year) for each scenario. Using the analysis results, an implementation plan was developed with a prioritized ranking system. The ranking system has two key components: (1) prioritizing the improvements at an individual bridge level and (2) considering the cost of the recommended improvements in regard to anticipated funding levels at a system-wide level. The results from the prioritized ranking system were then used to establish a project programming strategy for funding projects for the range of years 2020 to 2040.

Data Collection and Analysis Summary

Information about each structure, the roadway approaches and traffic volumes were provided by SDDOT. The environmental information at each location was based on desktop reviews obtained through GIS and other electronic data and resources. A brief summary of the data collection process is provided in the following sections.

Traffic and Structural Data

The traffic count data provided by SDDOT included average daily traffic (ADT) counts, historic ADT counts, classification counts on the study roadway segments, and growth rates characterized by county, roadway type, and vehicle classification. The Sioux Falls Metropolitan Planning Organization (MPO) and Rapid City MPO provided the 2035 travel demand model information and land use plans for the surrounding roadway segments. SDDOT also summarized the crash history within the study area for the most recent five-year period available (2010–2014).

Additionally, SDDOT provided the most current Structure Inventory and Appraisal (SIA) forms, as well as the design plans from the original construction, widening and repair work, and Bridge Rating Files. Using these existing records, the study team was able to verify load carrying capacity, estimate deterioration rates, and conduct a life cycle cost analysis for each bridge location.

Environmental Reviews

The Initial Environmental Review (IER) for each bridge in this project focused on determining the major environmental resources present near each structure and whether there is a potential for impacts to those resources from the likely improvements. The IERs did not include detailed quantitative information on environmental impacts due to the existing level of project scope information. The information gathered is intended to guide further evaluation and analysis during subsequent project development phases.

Traffic Analysis

The most recent version of the Highway Capacity Software (HCS) was used to study mainline freeways, highways, ramps, and intersections. The analyses resulted in a key measure or "level of service" (LOS) rating of the traffic operational condition. Levels of service are described by a letter designation of either A, B, C, D, E or F, with LOS A representing essentially uninterrupted flow, and LOS F representing a breakdown of traffic flow with noticeable congestion and delay. For purposes of this study, the team assumed that LOS E (Volume to Capacity [V/C] ≥1.0) would be the capacity for the freeways, multilane highways, and two-lane highways in the study. The following table summarized the current level of service and V/C ratio for each structure location, along with the forecasted LOS and V/C ratio for the year 2035. Every location was determined to operate at LOS C or better for both the existing and future conditions.

Structure Number	Highway or Street	Landmark or Common Name	2015		2035	
			LOS	V/C	LOS	V/C
Mitchell Region						
14-104-249	SD 19	Vermillion	A	0.04	A	0.06
05-090-279	SD 37	Running Water Standing Bear	A	0.02	A	0.03
12-085-080	SD 44	Platte – Winner	A	0.03	A	0.04
68-120-210	US 81	Yankton / Discovery	A	0.12	A	0.15
08-068-084	SD 90 L	Chamberlain Truss	A	0.11	B	0.15
08-061-094	I-90 E & W	Chamberlain	B	0.35	C	0.57
50-187-240	I-229 N & S	57th Street	B	0.33	C	0.49
50-205-209	11th Street	11th Street Viaduct	B	0.31	C	0.35
50-206-208	10th Street	10th Street Viaduct	C	0.42	C	0.47
Pierre Region						
65-000-020	US 12	Mobridge	A	0.07	A	0.09
33-100-118	US 14/SD 34/US 83	Pierre-Fort Pierre Waldron	A	0.24	B	0.31
28-035-151	SD 34	Bridger	A	0.01	A	0.02
69-390-535	SD 63	–	A	0.01	A	0.01
54-056-158	US 212	Forest City	A	0.02	A	0.02
16-737-253	SD 1806	Singing Bridge	A	0.03	A	0.03
Rapid City Region						
41-161-156	US 14A	Deadwood Box	A	0.19	B	0.25
24-162-058	US 18	Fossil Cycad National Monument	A	0.07	A	0.09
52-430-314	Cambell Street	Cambell Street	B	0.34	C	0.51

Additional Lanes Needs Analysis

The following five study bridge locations were selected for an analysis to determine if additional lanes on the structure and roadway approaches would be required during the anticipated life of the structure:

- I-229 & 57th Street (SN 50-187-240)
- 11th Street (SN 50-205-209)
- 10th Street (SN 50-205-208)
- US 14A Deadwood Box (SN 41-161-156)
- Cambell Street (SN 52-430-314)

In addition, the team performed a cursory capacity check for all other study structures. It was assumed that once the V/C ratio of a structure exceeded 1.0, additional lanes would be required. For developing forecasts beyond 2035, the team used straight line growth rates to determine a future year at which the traffic capacity for a structure would be exceeded. It was also assumed that the design life on a structure would be 75 years. As a result, traffic projections were not forecasted beyond 2090.

Only two locations were determined to achieve a V/C ratio of greater than 1.0 prior to the year 2090. In Sioux Falls, both the I-229 mainline and the 57th Street segment underneath the interstate were forecast to reach capacity during the study period (2058 and 2073, respectively). The Cambell Street viaduct in Rapid City was forecast to reach capacity by the year 2066. The results from each bridge's traffic analysis can be found in that bridge's individual chapter located throughout **Sections II**, **III**, and **IV**.

Structure Number	Highway or Street	Landmark or Common Name	Year of V/C ≥ 1.00
50-187-240	I-229 N & S	I-229	2058
50-187-240	I-229 N & S	57th Street	2073
52-430-314	Cambell Street	Cambell Street	2066

Bridge Deterioration Rates

Using the AASHTOWare Bridge Management software, SDDOT was able to gain a micro-level understanding of the conditions for various bridge elements and track specific condition histories over time. This inspection data, combined with engineering judgement from previous experience, was used to produce Markov Chain deterioration rates. These rates were extrapolated to represent a close approximation of how an average element would deteriorate over time.

A shortlist of bridge element categories was developed and extrapolated to estimate the deterioration results to 75 years. The deterioration rates were validated by assuming trial actions that SDDOT would conduct to extend the life of the structure. This process ensured the deterioration rates were within a reasonable range of historical rehabilitation and replacement timeframes.

These deterioration rates were only applied to the twelve bridges that were being fully evaluated in this study. This analysis was not conducted for the six Cursory Only bridges identified in the study. Using the established methodology, the team was able to establish maintenance and replacement recommendations for these elements starting from their most recent inspected state. The team then used the ProValue® process developed by Benesch to incorporate these results to establish the bridge improvement scenarios.

Managing Uncertainty

The ASTM Standard, *Developing a Cost Effective Risk Mitigation Plan for New and Existing Constructed Facilities,* identifies three parts to a risk mitigation plan: engineering, financial, and management. In this study, uncertainty of structural behavior and appropriate risk mitigation actions were addressed. Potential engineering risk mitigation actions include maintenance, inspection, retrofit, and replacement of the bridge elements. Financial risk mitigation is based on the timing of the maintenance, retrofit, and replacement tasks. The cost of bridge replacement was compared to the savings of future maintenance costs beginning from the year it is replaced. Management mitigation is related to the decision by SDDOT to adjust the timing of any events to match the desired annual program. The decision to implement a management risk mitigation strategy is based on funding availability, cost of replacement, and desired cash flow.

Study Findings

Elements of each bridge were classified for its level of potential uncertainty related to specific bridge conditions. These uncertainty ratings were then used to make prioritization decisions for expenditure of funds on each bridge in the study. To measure the uncertainty of each bridge, six different criteria were identified and compared to each other based on their levels of concern.

Following are the criteria selected for the study bridges ranked in order of their relative importance:

1. Critical Factor
2. Historical Evidence
3. Inspectability
4. Predictability
5. Frequency of Inspection
6. Inconvenience to User

Using these uncertainty criterion, each bridge was assigned an overall average rating. These ratings are a guide to determining the timing, sequence, and type of work necessary at any of the individual bridge locations. It should also be noted that the ratings for each bridge were based on its current state. Any changes in bridge condition, inspection frequency, or other engineering uncertainty criteria, will require the affected uncertainty ratings to be updated. **Section 19.D** contains a section for each structure that includes the detail of each bridge, a summary of its condition, and their overall bridge uncertainty rating.

Engineering and Financial Uncertainty Mitigation

The work plan for the evaluation of the engineering and financial uncertainty for the selected structures is summarized in the following flow chart. Once the engineering uncertainty analysis was completed, a mitigation plan was developed to identify the maintenance and/or replace for each bridge. That information was then used as input to conduct the financial uncertainty analysis, which led to mitigation to spread costs over the course of the study period and prioritize the bridges for replacement and/or maintenance.

Engineering Uncertainty Assessment	Engineering Uncertainty Mitigation	Financial Uncertainty Mitigation
Set criteria for uncertainty	Estimate replacement cost	Revise events to spread costs
Rank and weight criteria	Set events of maintenance and/or replacement for each bridge based on uncertainty index	Summary (**Table 19.8**)
Rate each bridge for uncertainty (**Section 19.D.1 through 19.D.12**)	Compute present value	Prioritize the bridges for replacement and/or maintenance
Summary (**Table 19.2**)	Summarize the yearly maintenance cost	For details, see **Appendix G**
Prioritize the bridges for replacement and/or maintenance	Summary (**Table 19.7**)	
	For details, see **Appendix F**	

Seven bridges were selected for replacement in the engineering uncertainty mitigation plan.

These bridges, along with the year and cost of their replacement, are shown in the table below. The study plan provides for the bridges to be replaced on a five-year schedule. This schedule allows the replacements to be arranged within the bounds of the study period and reduces the occurrence of financial hardships. The replacement order is based on the rating of uncertainty. The seven bridges evaluated based on engineering uncertainty are shown in the following table.

Bridges	Engineering Uncertainty		Financial Uncertainty	
	Year of Replacement	Replacement Cost[1]	Year of Replacement	Replacement Cost[1]
Pierre-Fort Pierre/Waldron	2021	$33.9	2023	$35.3
Platte-Winner	2024	$76.6	2033	$94.1
Forest City	2029	$78.8	2043	$106.9
Mobridge	2034	$115.5	2038	$128.5
Chamberlain	2039	$57.4	N/A	N/A
Deadwood Box	2044	$41.0	2036	$34.0
Singing Bridge	2049	$88.5	N/A	N/A
Cambell Street	N/A	N/A	2024	$8.5
10th Street	N/A	N/A	2025	$8.7
11th Street	N/A	N/A	2026	$15.6

[1]Cost is measured in millions of dollars

*N/A indicates a replacement scenario was not identified

The order of maintenance and replacement events developed for the financial uncertainty mitigation plan was based on the understanding of system needs before the engineering mitigation workshop. At that time, the Chamberlain Bridge and Singing Bridge were not considered for replacement, while the Cambell Street Bridge was identified for replacement. In addition, the 10th Street and 11th Street bridges were included in this analysis in an effort to reduce overall maintenance costs. All eight bridges selected for replacement in the financial uncertainty mitigation plan, along with the year and cost of their replacement, are also provided in the above table.

Management Uncertainty Mitigation

The Engineering and Financial Uncertainty Mitigation plans were developed to provide SDDOT with guidance for development and implementation of the bridge maintenance and/or replacement program for these twelve bridges. By spreading the tasks within the limit of the structural needs, financial uncertainty mitigation allows costs to be spread out while also reducing the total maintenance and replacement costs due to inflation. It should be noted that costs are sensitive to the discount rate and inflation, and available funds can change from year to year. It is recommended that the information and mitigation plans developed in this report be used to develop the management uncertainty mitigation strategy on an annual basis when developing and updating the bridge maintenance and replacement program.

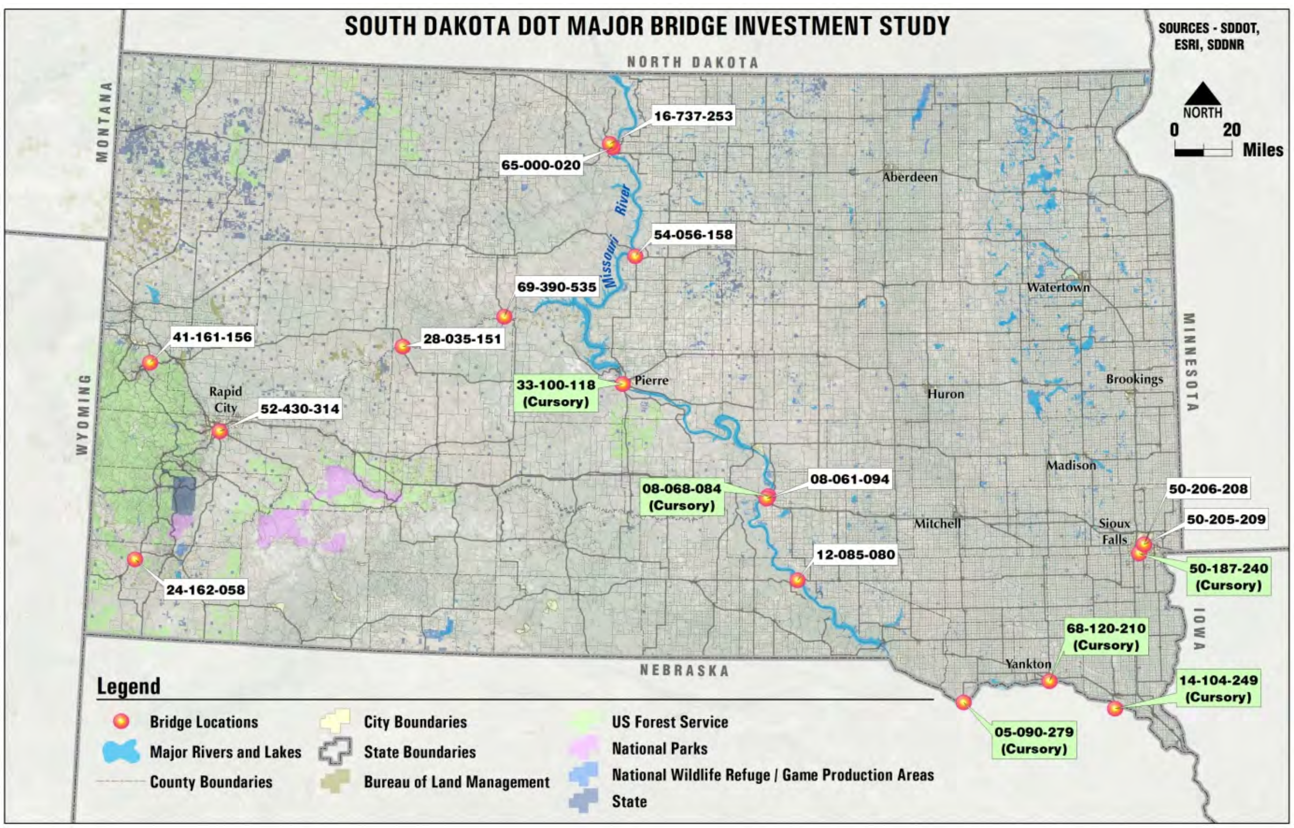
I. INTRODUCTION

The South Dakota Department of Transportation (SDDOT) retained Felsburg Holt and Ullevig (FHU) and Benesch to conduct this Major Bridge Investment Study to evaluate existing conditions and recommend long-range improvements at 18 major bridges throughout the State of South Dakota.

Many of the 18 major bridges in South Dakota identified for evaluation in this study were originally constructed in the late 1950s through the 1970s. Several have had major reconstruction projects since that time; however, some of those reconstructions occurred 25 to 30 years ago. The importance of these critical structures to the transportation system of South Dakota, along with the aging infrastructure and the reduced revenue available through traditional funding programs, led to the need for this Major Bridge Investment Study.

The purpose of this Major Bridge Investment Study is to provide a systematic, long-range improvement plan that identifies and evaluates the existing conditions at each major bridge located throughout the state and to establish an implementation plan to address capacity and safety improvements, as well as the structural condition of each bridge. This implementation plan was developed with an understanding of anticipated funding levels.

Structure Locations – Statewide



The scope of the study consisted of analyzing baseline conditions at each structure, which included evaluating traffic operations and safety, roadway geometrics, structural conditions, and environmental resources in the immediate vicinity of the structure. The baseline conditions analysis results determined the future needs for each location. The team then developed conceptual option scenarios (referred to as improvement scenarios) to maintain, preserve, repair, and replace each major bridge as necessary to maintain an acceptable state of repair through the year of replacement. Scenarios included all improvement projects (maintenance, preservation, repairs, rehabilitation, and replacement) needed between 2015 and the bridge's year of replacement necessary to meet study goals. It was determined that a 75-year analysis would be adequate to capture the potential replacement of each structure included in the study.

The team analyzed each improvement scenario to determine a comparable list of benefits and shortcomings of each scenario, along with an estimated cost (by year) for each scenario. Cost estimates included planning level estimates for right-of-way (ROW) easements, engineering services, construction costs, and other costs associated with each improvement of each scenario. The team then used a planning decision matrix to screen each improvement scenario for fatal flaws to determine which scenarios are feasible and should be included within a preliminary list of solutions for each bridge location.

The team then refined each improvement scenario advancing from this process to address the following information. This was not required for those bridges identified as Cursory Only reviews. The team compiled information from previous studies and other sources for the cursory reviewed bridges.

- Conceptual structure types, length(s), and width(s) for scenarios that include replacing/widening bridge projects
- Estimated structure touchdown points for scenarios that include replacement bridge projects
- General location of bridge piers relative to road, river, trail, and utility crossings for scenarios that include replacing/widening bridge projects
- General vertical and horizontal alignment and typical section of the mainline highway and all streets and trails affected by improvement scenarios
- Lane requirements on the mainline highway (including the structure) and all intersecting streets necessary to maintain the minimum corridor traffic level of service for each bridge location corridor per its functional classification
- ROW limits
- Local street connection modifications that may be needed as a result of implementing the option
- Impacts to recreational facilities, including the trail systems and watercraft access and crossings.
- Pedestrian and bicycle facilities along the highway (including the structure) and other connecting streets and the connection to any trail systems
- Impacts to the river floodplain and floodway, including navigational clearances where applicable
- Proposed access points, number of lanes, and future signal locations for each scenario
- General layouts, lanes, and level of service (LOS) analyses under the future traffic forecast

- Estimated improvement costs in 2015 dollars and the quantities used to estimate the costs, which included planning level estimates for ROW easements, engineering services, construction costs, and other costs associated with the various projects of each improvement scenario
- Planning level environmental, ROW, and safety impacts of each improvement scenario

Using the analysis results and refining the improvement scenarios, the team developed an implementation plan with a prioritized ranking system. This prioritized ranking system provided performance-based triggers for determining the timing of the proposed improvements. The ranking system has two key components: (1) prioritizing the improvements at an individual bridge level and (2) considering the cost of the recommended improvements in regard to anticipated funding levels at a system-wide level. The team used the results of the prioritized ranking system to establish a project programming strategy for funding projects for the range of years from 2020 to 2040.

This Major Bridge Investment Study addresses the evaluation and analysis of the 18 major bridges in three separate sections, with a separate chapter for each structure. The bridges are grouped within three SDDOT Regions as shown in the table below.

Study Bridges by Region

Structure Number	Highway or Street	Landmark or Common Name	Year Built or Reconstructed	Level of Analysis
Mitchell Region				
14-104-249	SD 19	Vermillion	2001	Cursory Only
05-090-279	SD 37	Running Water Standing Bear	1998	Cursory Only
12-085-080	SD 44	Platte – Winner	1966	Full Analysis
68-120-210	US 81	Yankton / Discovery	2008	Cursory Only
08-068-084	SD 90 L	Chamberlain Truss	1953 / 2010	Cursory Only
08-061-094	I-90 E & W	Chamberlain	1974	Full Analysis
50-187-240	I-229 N & S	57th Street	1995	Cursory Only
50-205-209	11th Street	11th Street Viaduct	1971 / 1986	Full Analysis
50-206-208	10th Street	10th Street Viaduct	1930 / 1979	Full Analysis
Pierre Region				
65-000-020	US 12	Mobridge	1959 / 1980	Full Analysis
33-100-118	US 14/SD 34/US 83	Pierre-Fort Pierre Waldron	1962	Cursory Only
28-035-151	SD 34	Bridger	1962	Full Analysis
69-390-535	SD 63	–	1981	Full Analysis
54-056-158	US 212	Forest City	1958 / 1980	Full Analysis
16-737-253	SD 1806	Singing Bridge	1963	Full Analysis
Rapid City Region				
41-161-156	US 14A	Deadwood Box	1967 / 1989	Full Analysis
24-162-058	US 18	Fossil Cycad National Monument	1982	Full Analysis
52-430-314	Cambell Street	Cambell Street	1964	Full Analysis

A Methods and Assumptions Document was prepared for review and approval by the SDDOT and FHWA to provide a guide and reference for the study. Both parties signed and approved the document on April 3, 2015, and April 7, 2015, respectively. **Appendix A** provides a copy of the signed document.

Data Collection Summary

SDDOT provided most of the data and information collected for the 18 bridges. The team categorized the information by three analysis areas: traffic, structural, and environmental.

Traffic Data

Traffic count data provided by SDDOT included average daily traffic (ADT) counts and classification counts on the study roadway segments. Historic ADT counts were also collected, in addition to growth rates by county, roadway type, and vehicle classification for the entire state. The Sioux Falls Metropolitan Planning Organization (MPO) and Rapid City MPO provided 2035 travel demand model information and land use plans for roadway segments associated with the study bridges and structures within their planning areas. SDDOT summarized the crash history within the study area for the most recent five-year period available (2010–2014).

Other Information

The team used information from previous studies compiled from SDDOT and other sources to provide a full picture of the issues that might affect the evaluation of each structure, including:

- Roadway geometrics
- Previous studies and reports
- Current ordinances and guidelines
- City and County development practices
- Land use information
- Statewide geographic information system (GIS)
- Existing development plans
- Existing street and roadway design standards of applicable agencies
- Design plans
- Vehicular classification data as needed
- Improvement project data for future projects
- Crash history and local knowledge
- Bicycle and pedestrian facilities, connections and needs
- Watercraft desires and needs where applicable
- US Army Corps of Engineers and US Coast Guard plans and requirements

Structural Data

SDDOT provided the most current Structure Inventory and Appraisal (SIA) forms. The inspection cycle is typically biannual, and sometimes annual, on these bridges. The team also collected as-built plans or design plans from the original construction, widening and repair work, and Bridge Rating Files.

The team used SDDOT's existing rating files (AASHTO Bridge Rating) to verify load carrying capacity to ensure that bridge widening or other modifications do not reduce capacity. The team estimated deterioration rates using SDDOT element inspection history for the specific group of bridges being evaluated. Where element deterioration history was limited, the team supplemented it with element history from SDDOT's statewide system, or historical trends in surrounding states as needed. The team used the ProValue® approach developed by Benesch to conduct a life cycle cost analysis for each bridge and related roadway. **Chapter 19 – Managing Uncertainty** provides that life cycle cost analysis, along with the development of a risk mitigation plan.

Environmental Reviews

The Initial Environmental Review (IER) for each bridge in this project focused on conducting desktop reviews of readily available environmental resource information for each bridge site to assist SDDOT with planning level information for each structure. The intent of the review was to determine, with reasonable assurance, the major environmental resources present near each structure and whether there was a potential for impacts to those resources from the likely improvements for each structure. The IERs do not include detailed quantitative information on environmental impacts due to the existing level of project scope information; however, the information gathered would guide further evaluation and analysis during subsequent project development phases. The environmental team used GIS and other electronic data to conduct the desktop review, including the following sources:

- Wild & Scenic Rivers
- National Wetland Inventory (NWI)
- US Fish and Wildlife Service (USFWS) Critical Habitat
- Federal Emergency Management Agency (FEMA) Floodzones
- Water Quality (303d Listed Waters)
- SDDOT Programmatic Biological Opinion
- Regulated Sites (HazMat) Review (Environmental Protection Agency Facility Registry Service [EPA FRS] and South Dakota Department of Environment and Natural Resources [SDDENR] Sites)
- Historic Preservation Structures
- SD Historic Bridges
- Drinking Water Sources (SDDENR)
- Parks & Open Space
- Federal Lands
- Geology of SD (DENR)
- Historic Districts
- Reservations and Tribal Lands
- Farmland Classification
- Historic Sites Survey
- Land and Water Conservation Fund (LWCF) (6f)
- National Park Service (NPS) Native American Graves Protection & Repatriation Act (NAGPRA)
- National Association of Tribal Historical Preservation Office

Appendix B includes an IER data form for each bridge describing the information collected using the above methodology and assumptions. An Environmental Constraints Map depicting the bridge location, study area, and evaluated resources also accompanies each IER report. The appropriate report sections summarize the findings of the IER for each bridge.

Traffic Analysis Methodology

For the traffic operational analysis, the team used procedures documented in the *Highway Capacity Manual 2010* (Transportation Research Board, 2010). The team applied this methodology to all study locations.

More specifically, the team used the following chapters of the HCM to analyze specific operational conditions:

Freeway Level of Service

- Chapter 11 – Basic Freeway Segments
- Chapter 13 – Freeway Merge and Diverge Segments
- Chapter 14 – Multilane Highways
- Chapter 15 – Two-Lane Highways

Study Intersections

- Chapter 18 – Signalized Intersections
- Chapter 19 – Two-Way Stop Controlled Intersections
- Chapter 20 – All-Way Stop Controlled Intersections

The team used the most recent version of the Highway Capacity Software (HCS) to study mainline freeways, highways, ramps, and intersections. The analyses resulted in a key measure or "level of service" (LOS) rating of the traffic operational condition. Levels of service are described by a letter designation of either A, B, C, D, E or F, with LOS A representing essentially uninterrupted flow, and LOS F representing a breakdown of traffic flow with noticeable congestion and delay. **Appendix C** includes the results from the team's analysis of each bridge's current traffic operational conditions.

The *AASHTO Green Book* and the *South Dakota DOT Roadway Design Manual* (Table 15-1) identify the preferred traffic operations goals as LOS C (LOS D minimum) for Principal and Minor Arterials, and LOS B (LOS C minimum) for Freeways, Interstates, and Expressways. However, for purposes of this study, the team assumed that LOS E (Volume to Capacity [V/C] > 1.0) would be the capacity for the freeways, multilane highways, and two-lane highways in the study. It was assumed that once the V/C ratio exceeds 1.0, additional lanes would be required.

Freeway Analysis

For basic freeways, LOS within a traffic stream can be determined in terms of the service flow rate for individual segments. Flow rates are measured in passenger cars per hour per lane (pcphpl). The following table depicts the LOS criteria for basic freeway segments in terms of flow rate.

Freeway HCS Criteria

FFS (mi/h)	Target Level of Service				
	A (pcphpl)	B (pcphpl)	C (pcphpl)	D (pcphpl)	E (pcphpl)
75	820	1,310	1,750	2,110	2,400
70	770	1,250	1,690	2,080	2,400
65	710	1,170	1,630	2,030	2,350
60	660	1,080	1,560	2,010	2,300
55	600	990	1,430	1,900	2,250
FFS = free-flow speed	pcphpl = passenger cars per hour per lane				

To determine LOS using the table, the team used the HCS 2010 software to develop a flow rate for the freeway based on the number of lanes, the heavy vehicle percentage, and the peak hour volume of the freeway. It was assumed that LOS E would be the capacity of the freeway (V/C = 1.0). The team compared existing and future flow rates to the LOS E threshold for the corresponding free-flow speed (FFS) on the freeway. It was assumed that the posted speed was the FFS. The freeway LOS was then determined based on which LOS threshold the existing and future flow rates fell in.

In addition, for merge and diverge areas, LOS can be determined in terms of the density for merge and diverge segments. Density is measured in passenger cars per mile per lane (pc/mi/ln). The table that follows depicts the LOS criteria for merge and diverge areas.

Freeway Level of Service (LOS) Criteria

Level of Service	Merge and Diverge Areas
	Density (pc/mi/ln)
A	≤ 10
B	> 10 to 20
C	> 20 to 28
D	> 28 to 35
E	> 35
F	Demand Exceeds Capacity
pc/mi/ln = passenger cars per mile per lane	

Multilane Highway Analysis

For multilane highways, LOS is a qualitative assessment of traffic operational conditions within a traffic stream and can be determined in terms of the service flow rate for individual segments. For this study, to determine the LOS of a multilane highway, the following table was used. The table depicts the LOS criteria for multilane highways in terms of flow rate.

Multilane Highway HCS Criteria

FFS (mi/h)	Target Level of Service				
	A (pcphpl)	B (pcphpl)	C (pcphpl)	D (pcphpl)	E (pcphpl)
60	660	1,080	1,550	1,980	2,200
55	600	990	1,430	1,850	2,100
50	550	900	1,300	1,710	2,000
45	490	810	1,170	1,550	1,900
40	440	720	1,040	1,410	1,800
35	380	630	920	1,280	1,700
30	320	540	800	1,160	1,600
FFS = free-flow speed	pcphpl = passenger cars per hour per lane				

To determine LOS using the above table, the team used HCS 2010 software to develop a flow rate for the multilane highway. The flow rate is based on the number of lanes, the heavy vehicle percentage, and the peak hour volume of the roadway. It was assumed that LOS E would be the capacity of the roadway (V/C = 1.0). Existing and future roadway flow rates were compared to the LOS E threshold for the corresponding FFS on the road. It was assumed that the posted speed was the FFS. The roadway LOS was then determined based on which LOS threshold the existing and future roadway flow rates fell in.

Two-Lane Highway Analysis

For two-lane highways, LOS is a qualitative assessment of traffic operational conditions within a traffic stream and can be determined in terms of the average daily traffic for individual segments. For this study, to determine the LOS of a two-lane highway, the following table was used. The table depicts the LOS criteria for two-lane highways. ADTs are shown in 1,000s.

Two-Lane Highway HCS Criteria

K-Factor	D-Factor	Class I-Level				Class I-Rolling				Class II-Rolling			
		LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E
0.09	50%	5.5	9.3	16.5	31.2	4.2	8.4	15.7	30.3	5	9.8	18.2	31.2
	55%	4.9	8.7	14.9	30.2	3.7	7.9	14.0	29.2	4.1	8.7	16.0	30.2
	60%	4.4	8.1	13.9	27.6	3.7	6.2	12.8	26.8	3.7	7.9	14.6	27.6
	65%	4.1	7.9	12.9	25.5	3.4	5.9	11.4	24.7	3.3	5.9	13.2	25.5

Notes: Assumed values for all entries: 10 percent trucks, PHF = 0.88, 12-ft lanes, 6-ft shoulders, 10 access point/mi.
Assumed values for Class I - level: BFFS = 65 mi/h, 20 percent no-passing zones.
Assumed values for Class I - rolling: BFFS = 60 mi/h, 40 percent no-passing zones.
Assumed values for Class II - rolling: BFFS = 50 mi/h, 60 percent no-passing zones.

This study evaluates two classes of two-lane highways: Class I (Principal Arterials) and Class II (Minor Arterials and Collectors). The study assumed that LOS E would be the capacity of the roadway (V/C = 1.0). The analysis compared the existing and future roadway ADTs to the LOS E threshold ADTs corresponding to the roadway K-Factor, D-Factor, and roadway class to develop a V/C ratio. The roadway LOS was then determined based on the LOS threshold of the existing and future roadway ADT.

Intersection Analysis

For intersections, LOS is a qualitative assessment of traffic operational conditions within a traffic stream and can be determined in terms of the average stopped delay per vehicle at a controlled intersection. Signalized intersection capacity analyses result in an overall LOS, representative of all movements through the intersection. Unsignalized, or stop sign controlled, intersection capacity analyses produce LOS results for each movement that must yield to conflicting traffic at the intersection. The following table summarizes LOS criteria for both signalized and unsignalized (stop sign controlled) intersections.

Intersection Level of Service (LOS) Criteria

Level of Service	Signalized Intersections	Stop Sign Controlled Intersections
	Average Control Delay per Vehicle (sec/veh)	Average Control Delay per Vehicle (sec/veh)
A	≤ 10	≤ 10
B	> 10 to 20	> 10 to 15
C	> 20 to 35	> 15 to 25
D	> 35 to 55	> 25 to 35
E	> 55 to 80	> 35 to 50
F	> 80	> 50

Travel Forecasting

The team developed future traffic volumes for 2035 traffic conditions for all the study area bridges and intersections. The team used growth rates provided by SDDOT or from local MPO models to complete forecasting. SDDOT provided three individual growth rates to determine future ADTs: one for autos and two for heavy vehicles. These rates included an overall growth rate, a Federal Highway Administration (FHWA) Vehicle Class 5-9 growth rate, and an FHWA Vehicle Class 10-13 growth rate. From the MPOs, growth was determined by calculating the annual growth rate percentage between the 2015 ADT volumes and the forecast 2035 volumes.

To develop 2035 ADTs, the team applied the three growth rates to existing ADTs and used a straight line growth projection to determine 2035 volumes. The team used the heavy vehicles rates in addition to the auto growth rates to account for the anticipated growth of freight traffic. Higher truck percentages are anticipated in the future for most of the bridge locations.

The team developed turning movement forecasts for the future year (2035) using methodology outlined in *NCHRP Report 765* for those locations with adjacent intersections included in the study area. However, if there were no land use changes in the immediate vicinity of the structure, the percentages assigned to each turning movement did not change. AM and PM peak hour traffic volumes were developed for both the base year (2015) and future year (2035). For the bridge improvement year scenarios required at individual locations, the team used traffic growth rate factors provided by SDDOT to develop ADT forecasts for the improvement years. The team developed a technical memo explaining the techniques and assumptions used in developing the forecasts and submitted it to the SAT for review and approval. **Appendix C** provides a summary of the traffic forecasting analysis and the analysis results of each bridge's traffic operational conditions for the year 2035.

Additional Lane Needs Analysis

The team chose five study bridge locations to perform an additional lane needs analysis:

- I-229 & 57th Street (SN 50-187-240)
- 11th Street (SN 50-205-209)
- 10th Street (SN 50-205-208)
- US 14A Deadwood Box (SN 41-161-156)
- Cambell Street (SN 52-430-314)

In addition, the team performed a cursory capacity check for all other study structures. This analysis determined if any additional lanes will be required in the future for any of these five structures. For forecasting beyond 2035, the team used straight line growth rates to determine a future year at which the traffic capacity for a structure would be exceeded. It was assumed once the V/C ratio of a structure exceeded 1.0 that additional lanes were required. It was also assumed that the design life on a structure would be 75 years so that traffic projections were not forecasted beyond 2090.

Bridge Deterioration Rates

SDDOT used the AASHTOWare Bridge Management software to compile inspection histories at a "bridge element" level. These bridge elements are divided into deck elements, girders, stringers, bearings, joints, etc. This allows SDDOT to have a micro-level understanding of the condition of various bridge elements and to track specific condition histories over time. This inspection data, combined with engineering judgment from previous experience, has produced

Markov Chain deterioration rates, which the program uses to approximate deterioration probabilities for every element within the database. **Appendix D** contains the deterioration rates.

Philosophy

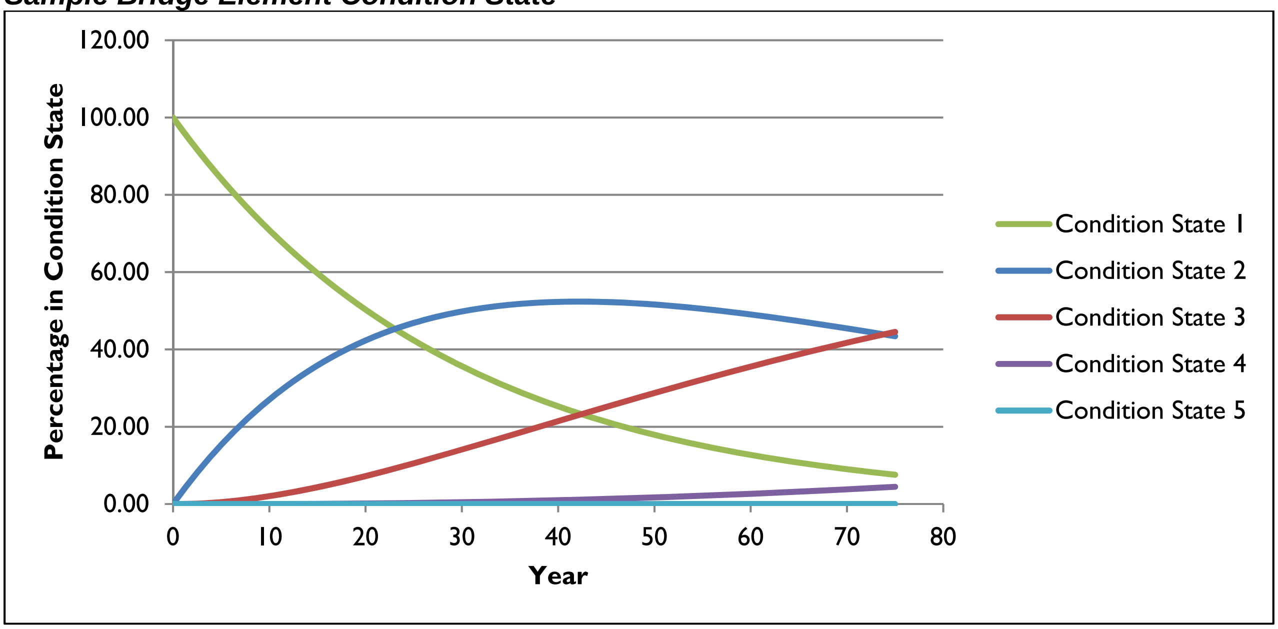
The Markov Chain probability matrix, which is established from years of inspection data, can be used to estimate deterioration rates looking forward. The table below is an example element with various deterioration probabilities between condition states.

Sample Bridge Element Deterioration Probabilities

Condition State		1	2	3	4	5	Total
State: 1 No deterioration	Do Nothing	96.62	3.38	0.00	0.00	0.00	100.00
State: 2 Cracks/spalls	Do Nothing	0.00	98.46	1.54	0.00	0.00	100.00
State: 3 Major cracks/spalls	Do Nothing	0.00	0.00	99.70	0.30	0.00	100.00
State:4 Broken/unstable	Do Nothing	0.00	0.00	0.00	90.00	0.00	90.00
State: 5 N/A	Do Nothing	0.00	0.00	0.00	0.00	0.00	0.00

These probabilities can be extrapolated over time to represent a close approximation of how an average element would deteriorate over time. This is done by taking the total quantity of the element and then transitioning a percentage of that total to the next state every year. When these assumptions are continued over an extended timeframe, deterioration can be plotted as shown in the following figure.

Sample Bridge Element Condition State



Simplification

Although the statewide database contains hundreds of element codes, the 12 bridges being fully evaluated in this study include only 38 bridge element/environment combinations pertinent to this evaluation. These elements were grouped into like categories resulting in a shortlist of 14 items. Elements were then divided into three main categories, which were relevant to their exposure to the environment and direct traffic impact. Deck and joints are the most exposed to direct traffic impact and were, therefore, the most detailed in this evaluation. This resulted in three unique deck elements and three unique joint elements. The second category summarized all other bridge elements directly exposed to the environment (above ground or water level). These eight elements were grouped as follows:

1. Unpainted steel open girder/beam
2. Painted steel girder/beam
3. Prestressed concrete stringer/beam
4. Painted steel truss chord/beam
5. Painted steel pin & hanger
6. Piers/abutments
7. Bearings
8. Approach

The team averaged the deterioration rates from the more detailed element descriptions to establish the deterioration rates for these eight elements.

Foundation elements such as submerged pile caps, footings, etc., are most protected from environmental deterioration. As such, the historical inspection results for these elements indicated very little deterioration over time when extrapolated. It was determined that these foundation elements would likely be controlled by scour events prior to deterioration concerns; therefore, they were not included in the deterioration analysis for each structure.

Validation

The team compiled the 14 shortlisted items into a spreadsheet that extrapolated the deterioration results to 75 years. The deterioration rates were validated by assuming trial actions that SDDOT would conduct to extend the life of the structure. Typically, a minor rehabilitation or repair was assumed earlier in the life of the element, as well as a major rehabilitation or replacement tested over a longer timeframe.

As shown in the following table, if the bearing element was assumed to justify rehabilitation when 20 percent was experiencing minor deterioration, the deterioration model estimated this would be required in nine years. A bearing replacement was assumed to be justified when 30 percent of the bearing had advanced corrosion, which corresponded to 45 years.

Sample Bridge Element Deterioration Probabilities

Condition State		1	2	3	4	5	Total
State: 1 No Deterioration	Do Nothing	96.62	3.38	0.00	0.00	0.00	100.00
State: 2 Cracks/Spalls	Do Nothing	0.00	98.46	1.54	0.00	0.00	100.00
State: 3 Major Cracks/Spalls	Do Nothing	0.00	0.00	99.70	0.30	0.00	100.00
	Action Summary				Action Year		
	Rehab when	5%	is in Cond. State		3		
	Replace when	25%	is in Cond. State		3		
Description	Condition State	0	1	2	3	4	5
State: 1 No Deterioration	Condition State 1	100.00	97.33	94.73	92.21	89.75	87.35
State: 2 Minor Deterioration	Condition State 2	0.00	2.67	5.21	7.62	9.92	12.10
State: 3 Advanced Corrosion	Condition State 3	0.00	0.00	0.06	0.17	0.34	0.55
**Example probabilities for first 5 years of analysis*							

The team used this validation process only to ensure deterioration rates were bracketed within a reasonable range of historical rehabilitation and replacement timeframes for various elements. Once these deterioration rates were validated, the deterioration rates were then applied to the specific bridges.

The 12 bridges evaluated contain various elements with a wide range of conditions. The team applied the established methodology to these elements starting from their most recent inspected state, and projected forward to establish maintenance and replacement recommendations. The team then used the ProValue® process to incorporate these results to establish the bridge improvement scenarios.

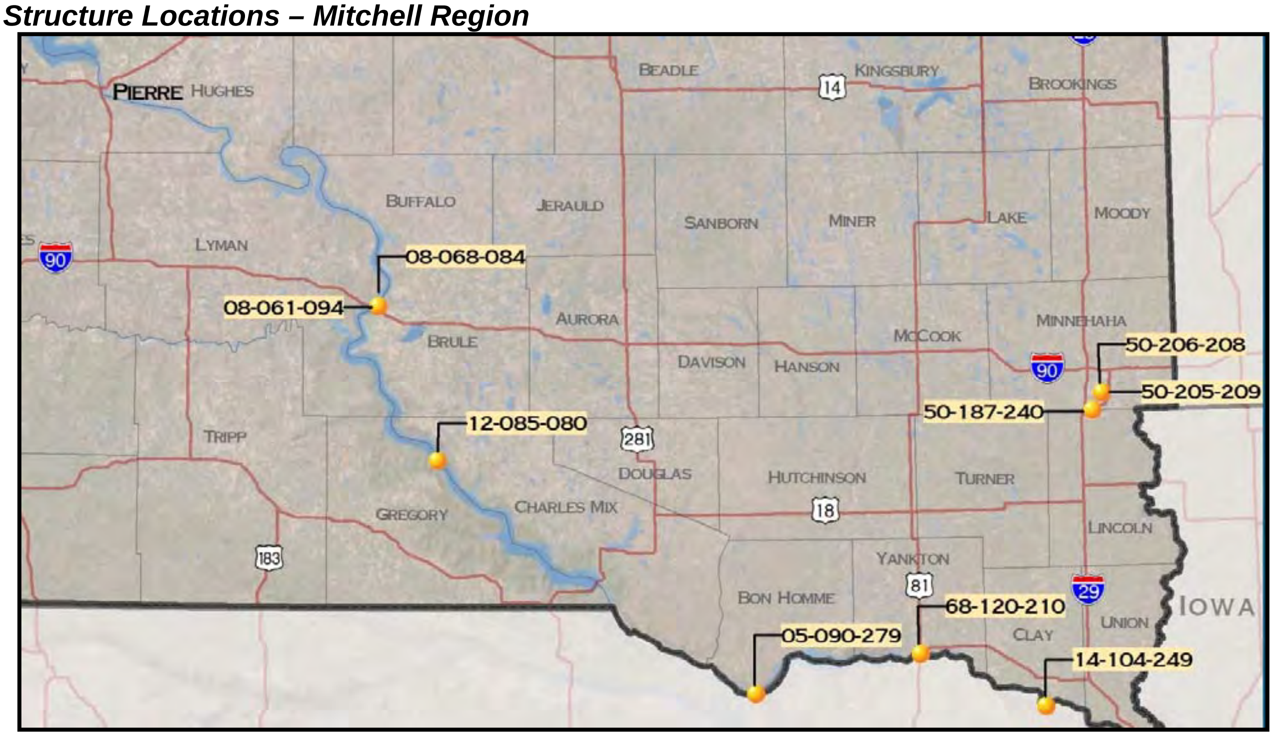
II. MITCHELL REGION

Nine of the study bridges are located in the Mitchell Region. Six of these structures are located over the Missouri River, with all but the SD 44 and I-90 E & W bridges having a cursory level review. The other three bridges are located in the urban area of Sioux Falls. The information and analysis for each bridge is provided within its own section for use as a standalone document.

Mitchell Region Bridges

Mitchell Region				
Structure Number	**Highway/ Street**	**Landmark or Common Name**	**Feature Intersected**	**Length (feet)**
14-104-249	SD 19	Vermillion	Missouri River	2,455
05-090-279	SD 37	Running Water Standing Bear	Missouri River	2,953
12-085-080	SD 44	Platte – Winner	Missouri River	5,656
68-120-210	US 81	Yankton / Discovery	Missouri River	1,590
08-068-084	SD 90 L	Chamberlain Truss	Missouri River	2,003
08-061-094	I-90 E & W	Chamberlain	Missouri River	2,031
50-187-240	I-229 N & S	57th Street	57th Street	180
50-205-209	11th Street	11th Street Viaduct	Big Sioux River/Railroad	1,578
50-206-208	10th Street	10th Street Viaduct	Railroad	844

Structure Locations – Mitchell Region

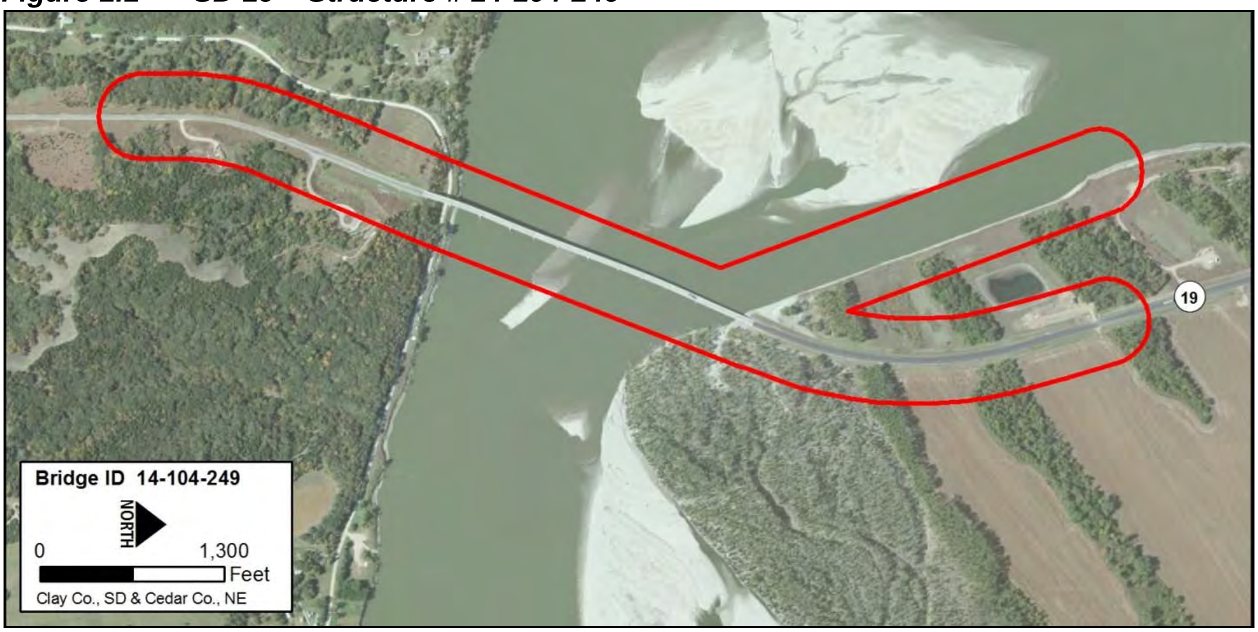


1. Structure # 14-104-249

Structure No. 14-104-249 (Vermillion Bridge) is located on South Dakota Highway 19/Nebraska Highway 15 (SD 19/N 15) over the Missouri River and the border between Clay County, South Dakota; and Dixon County, Nebraska. **Figure 1.1** shows the study area, which is approximately 1.5 miles long and 600 feet wide, centered on the structure, its approaches and channel rip rap. However, the search area for Wild and Scenic Rivers extends 1.5 miles upstream and downstream from the structure and the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

Because this structure was constructed in 2001 and is in good condition, the team provided a cursory level review. A cursory level review includes baseline conditions, future needs, and safety analyses. The team did not develop alternative improvement scenarios for this structure.

Figure 1.1 SD 19 – Structure # 14-104-249



1.A. Baseline Conditions Analysis

The team conducted the baseline conditions analysis for the Vermillion Bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

1.A.1. Additional Background Data

No additional data were available for this structure location.

1.A.2. Roadway Conditions

In South Dakota, on SD 19, the southbound approach to the bridge is a two-lane highway, 28 feet in width, with 8-foot surface shoulders. The speed limit is posted at 60 miles per hour (mph). On the bridge, the roadway width is 36 feet, which consists of two 12-foot driving lanes and 6-foot surfaced shoulders. In Nebraska on N 15, the northbound approach to the bridge is a two-lane highway, 24 feet in width with earth shoulders. The speed limit is posted at 60 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected Average Daily Traffic (ADT) between 1,501 and 2,500, the existing cross section of the southbound approach to the structure currently meets SDDOT design standards. The northbound approach lies within the Nebraska Department of Roads (NDOR) jurisdiction.

The SD 19 approach immediately north of the bridge is an asphalt surface and has a Surface Condition Index of 4.46. **Table 1.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 1.1 SD 19 (Structure #14-104-249) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (in) Avg/Max
4.46 (North)	4.72	4.96	4.92	5.00	4.82	4.30	0.2/0.5

1.A.3. Bridge Condition

The existing bridge conditions were evaluated in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. No load carrying capacity issues were found in the review of the bridge.
- Geometry. No geometric deficiencies were noted in the review of the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 7
  - Superstructure: 6
  - Substructure: 7
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 88.0, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Loose anchor rods, Pier 8 through Pier 12
  - Cracks developing in sides of elastomeric bearing pads
  - Loose plates at deck expansion joints (Pier 9 and Abut 13)

1.A.4. Traffic Analysis

SD 19, categorized as a Rural Other Principal Arterial, is located in Clay County. Based on the most current ADT volumes and growth rates provided by the SDDOT, the roadway has an ADT volume of 1,346 in 2015. No peak period turning movement counts were analyzed for this structure. The roadway has a heavy vehicle percentage of 11.8 percent.

A vehicle classification count was not available for this location. Based on other classification counts throughout the state, the team assumed that of the heavy vehicle percentage 64 percent would fall into FHWA Vehicle Class 5-9 and 36 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on SD 19's functional class and geographic location, a growth rate of 1.316 percent was provided. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.286 percent was provided, and a growth rate of 2.925 percent was provided for FHWA Vehicle Class 10-13. **Figure 1.2** shows the roadway and traffic conditions.

The team used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. SDDOT provided a ratio of peak hour to ADT (K factor) of 8.2 percent. In addition, the following assumptions were used: a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 19 currently operates at LOS A with a V/C ratio of 0.04.

1.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and the approaches on SD 19. **Tables 1.2 and 1.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 1.2 SD 19 (Structure #14-104-249) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe Same Direction	Sideswipe Opposite Direction	Total
6	0	0	0	0	0	6

All of the crashes that have occurred in the study area involved a single vehicle. One crash occurred on the bridge, and the other five occurred on the horizontal curve just north of the bridge. A curve warning sign (W1-1R) is present in advance of the curve for southbound travelers. Four of the five crashes north of the bridge involved an animal collision. A non-vehicular warning sign W11-3 (Deer) is present just north of the bridge warning northbound travelers. NDOR did not provide any crash data for the northbound bridge approach.

Table 1.3 SD 19 (Structure #14-104-249) – Crash Rates (2010–2014)

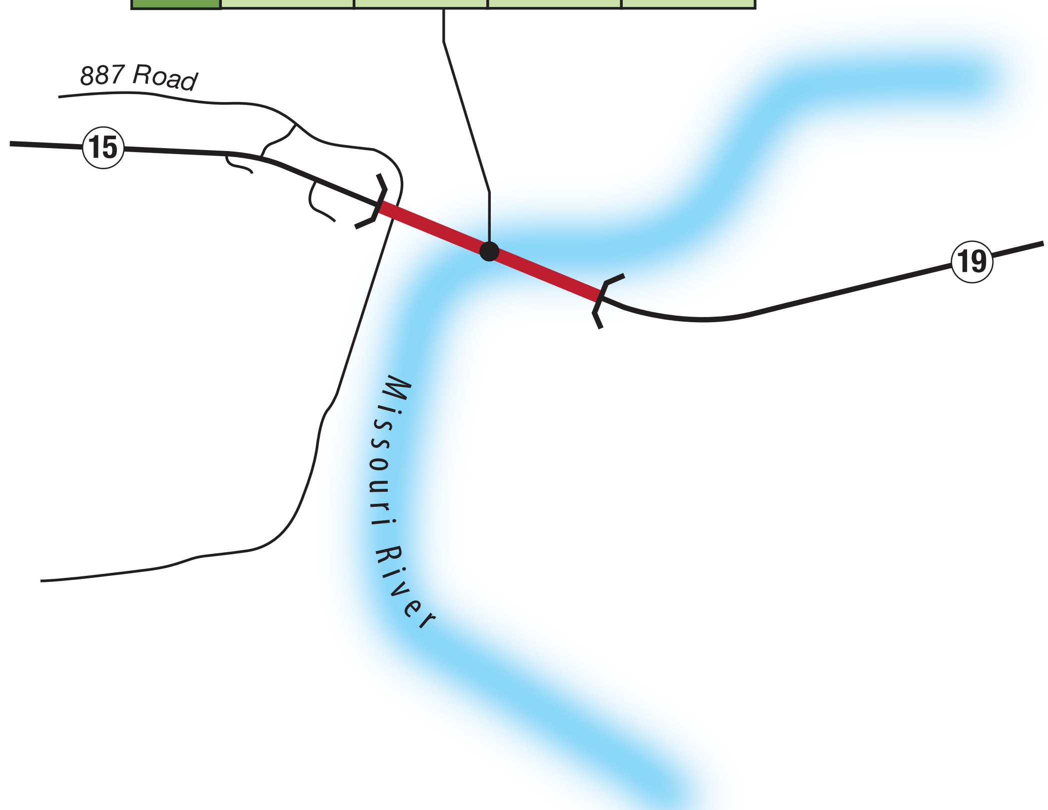
Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1- Fatal	2- Incap.	3- Non-Incap.	4- Possible	5- PDO	Total				
SD 19	0	1	0	0	5	6	1,346	2.46	2.44	13.91
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 2.44. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 13.91. **Table 1.4** shows the identified crash patterns and possible contributing factors.

Table 1.4 SD 19 (Structure #14-104-249) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Animal-related Collisions	▪ Bridge is located in heavily populated deer habitat

	ADT	HV%	V/C Ratio	LOS
2015	1,346	11.8%	0.04	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	60 mph
Bridge Roadway Width	36 Feet

North

NOTE: Drawing Not to Scale

Figure 1.2
2015 Existing Conditions
Vermillion/SD 19
14-104-249

FELSBURG HOLT & ULLEVIG
benesch

1.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. However, the paved shoulders on the South Dakota approach and across the bridge offer cyclists an alternative to ride with some separation from vehicular traffic. No paved shoulders are provided on the approaches to the structure.

1.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

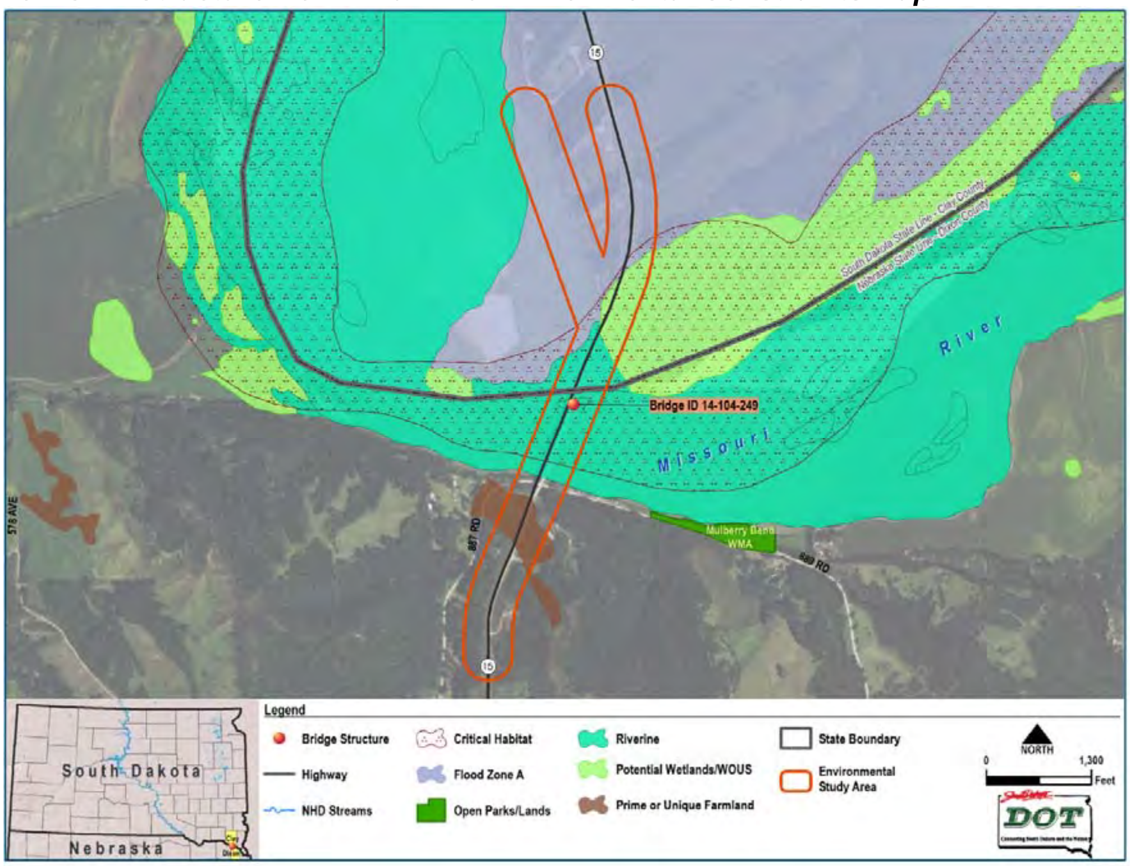
1.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover, and modern records of piping plover and interior least tern exist within the vicinity of the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for several other federally listed species and for state listed species for both South Dakota and Nebraska.
- Section 4(f). Section 4(f) properties are present within the project study area including the Missouri National Recreational River. The Mulberry Bend Wildlife Management Area is also in the vicinity of the project.
- Section 106. No known surveys have been conducted within the project study area. Future surveys could reveal new historic or archeological information.
- Wetlands and Waters of the US. Wetlands and Waters of the US are likely to be present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Wild and Scenic Rivers. This segment of the Missouri River is a Wild and Scenic River.
- Floodplains and Floodways. FEMA Flood Zone A is mapped within the project study area. A floodplain permit may be required depending on the scope of work required for the project.
- Title VI (Civil Rights) and Environmental Justice. Vulnerable age and low-income populations are present within the census blocks and census tracts of the study area; minorities are present in census blocks north of the project study area, closer to Vermillion, South Dakota. Project construction could potentially indirectly affect these populations.

- Prime and Unique Farmland. The project includes areas of "Prime Farmland" and "Farmland of Statewide Importance." A Form NRCS CPA-106 for Corridor Type Projects or Form AD1006 may be required.
- Section 9. A contractor's work plan must be submitted to the US Coast Guard before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Further agency coordination (FHWA, USFWS, South Dakota Game Fish & Parks [SDGFP], NEGPC, SDSHPO, NESHPO, NPS, US Coast Guard [USCG], and the Tribes) will be required during the NEPA process.

Figure 1.3 Structure No. 14-104-249 Environmental Constraints Map



1.B. Future Conditions Analysis

The team conducted a future conditions analysis for the Vermillion Bridge to determine future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

1.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 19 is estimated to have an ADT volume of 1,775, with a heavy vehicle percentage of 13.1 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.2 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and roadway ADT, SD 19 is anticipated to operate at LOS A with a V/C ratio of 0.06 in 2035. **Figure 1.4** summarizes the future roadway and traffic conditions.

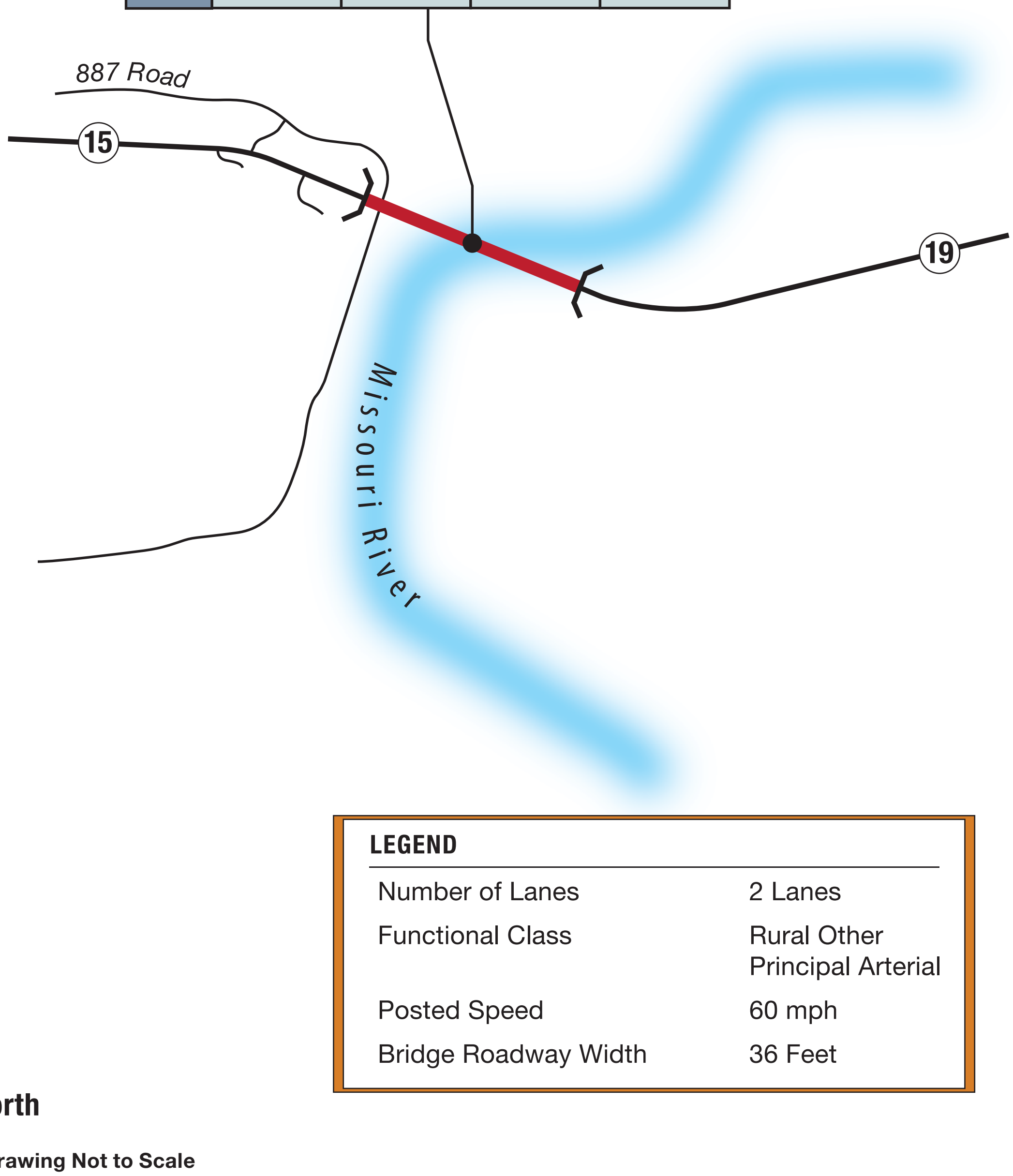
1.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

1.B.3. Safety Recommendations

A review of the crash data indicates a pattern of animal-related collisions. The team recommends that additional non-vehicular warning signs W11-3 (Deer) be installed in advance of the bridge approaches warning drivers in all directions that wildlife may be crossing in this area. The team also recommends that a deer fence, along with wildlife undercrossing, be considered in this area. A future study would need to be completed to determine the feasibility of the deer fence.

	ADT	HV%	V/C Ratio	LOS
2035	1,775	13.1%	0.06	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	60 mph
Bridge Roadway Width	36 Feet

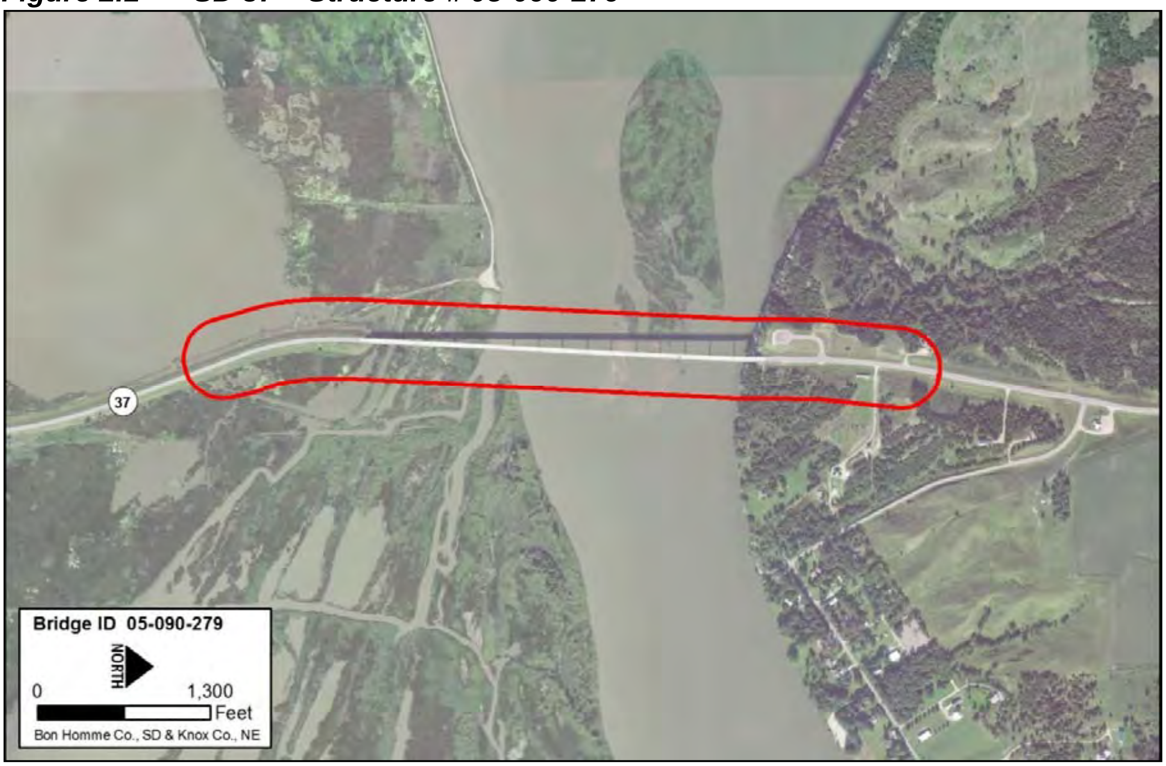
Figure 1.4
2035 Future Conditions
Vermillion/SD 19
14-104-249

2. Structure # 05-090-279

Structure No. 05-090-279 (Running Water/Standing Bear), located on South Dakota Highway 37/Nebraska Highway 14 (SD 37/N 14) over the Missouri River, borders between Bon Homme County, South Dakota; and Knox County, Nebraska. **Figure 2.1** shows the study area, which is approximately 1.1 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Wild and Scenic Rivers extends 1.5 miles upstream and downstream from the structure. The search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

Because this structure was constructed in 1998 and the Nebraska Department of Roads (NDOR) is responsible for maintenance, the team provided a cursory level review, which includes baseline conditions, future needs, and safety analyses. The team did not develop alternative improvement scenarios for this structure.

Figure 2.1 SD 37 – Structure # 05-090-279



2.A. Baseline Conditions Analysis

The team conducted the baseline conditions analysis for the SD 37/N 14 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

2.A.1. Additional Background Data

No additional data were available for this structure location.

2.A.2. Roadway Conditions

In South Dakota, on SD 37, the southbound approach to the bridge is a two-lane highway, 24 feet in width with earth shoulders. The speed limit is posted at 60 mph. On the bridge, the roadway width is 36 feet, which consists of two 12-foot driving lanes and 6-foot surfaced shoulders. In Nebraska on N 14, the northbound approach to the bridge is a two-lane highway, 24 feet in width with earth shoulders. The speed limit is posted at 60 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT between 551 and 1,500, the existing cross section of the southbound approach to the structure currently meets SDDOT design standards. The northbound approach and the bridge structure lie within NDOR's jurisdiction.

The SD 37 approach immediately north of the bridge is an asphalt surface and has a Surface Condition Index of 4.83. **Table 2.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 2.1 SD 37 (Structure #05-090-279) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (in) Avg/Max
4.83 (North)	4.75	5.00	5.00	5.00	5.00	5.00	0.0/0.0

2.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. The team found no load carrying capacity issues in the review of the bridge.
- Geometry. The team noted no geometric deficiencies in the review of the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 7
  - Superstructure: 8
  - Substructure: 4
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 62.8, indicating a structure in average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Scour at piers (NDOR has been evaluating mitigation of the scour)
  - Deck cracking

2.A.4. Traffic Analysis

SD 37, categorized as a Rural Other Principal Arterial, is located in Bon Homme County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 716 in 2015. No peak period turning movement counts were analyzed for this structure. The roadway has a heavy vehicle percentage of 15.9 percent. A vehicle classification count was available for this location. Based on the classification count, 74 percent would fall into FHWA Vehicle Class 5-9 and 26 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on the functional class and geographic location of the roadway, a growth rate of 1.289 percent was provided. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.215 percent was provided, and a growth rate of 2.900 percent was provided for FHWA Vehicle Class 10-13. **Figure 2.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.4 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and roadway ADT, SD 37 currently operates at LOS A with a V/C ratio of 0.02.

2.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and approaches on SD 37. **Tables 2.2** and **2.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 2.2 SD 37 (Structure #05-090-279) – Crash Data (2010–2014)

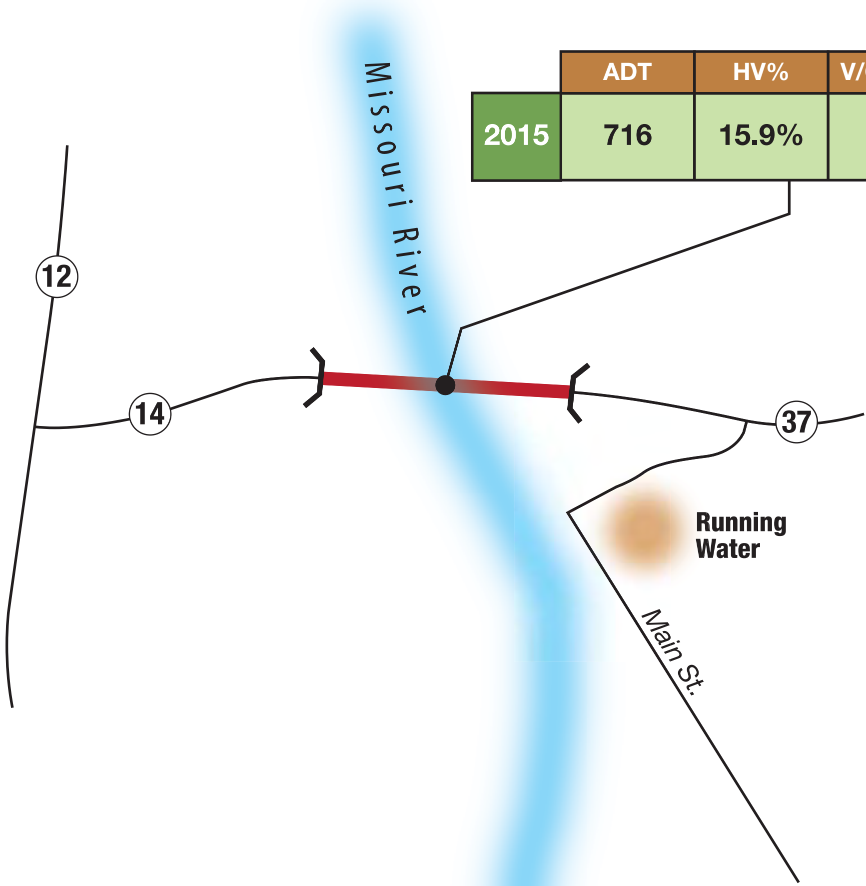
Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
0	0	0	0	0	0	0

A review of the crash history indicates there were no reported crashes over the five-year study period. NDOR did not provide any crash data for the northbound bridge approach.

Table 2.3 SD 37 (Structure #05-090-279) – Crash Rates (2010 – 2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
SD 37	0	0	0	0	0	0	716	1.31	0.00	0.00
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 0.00. The severity rate per MEV, which applies a cost factor to the different crash severity type, is also 0.00. There are no identifiable crash patterns at this location.



	ADT	HV%	V/C Ratio	LOS
2015	716	15.9%	0.02	A

LEGEND	
Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	60 mph
Bridge Roadway Width	36 Feet

North

NOTE: Drawing Not to Scale

Figure 2.2
2015 Existing Conditions
Running Water/Standing Bear SD 37
05-090-279

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2.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. However, the paved shoulders on the bridge offer cyclists an alternative to ride with some separation from vehicular traffic, but no paved shoulders are provided on the approaches to the structure.

2.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

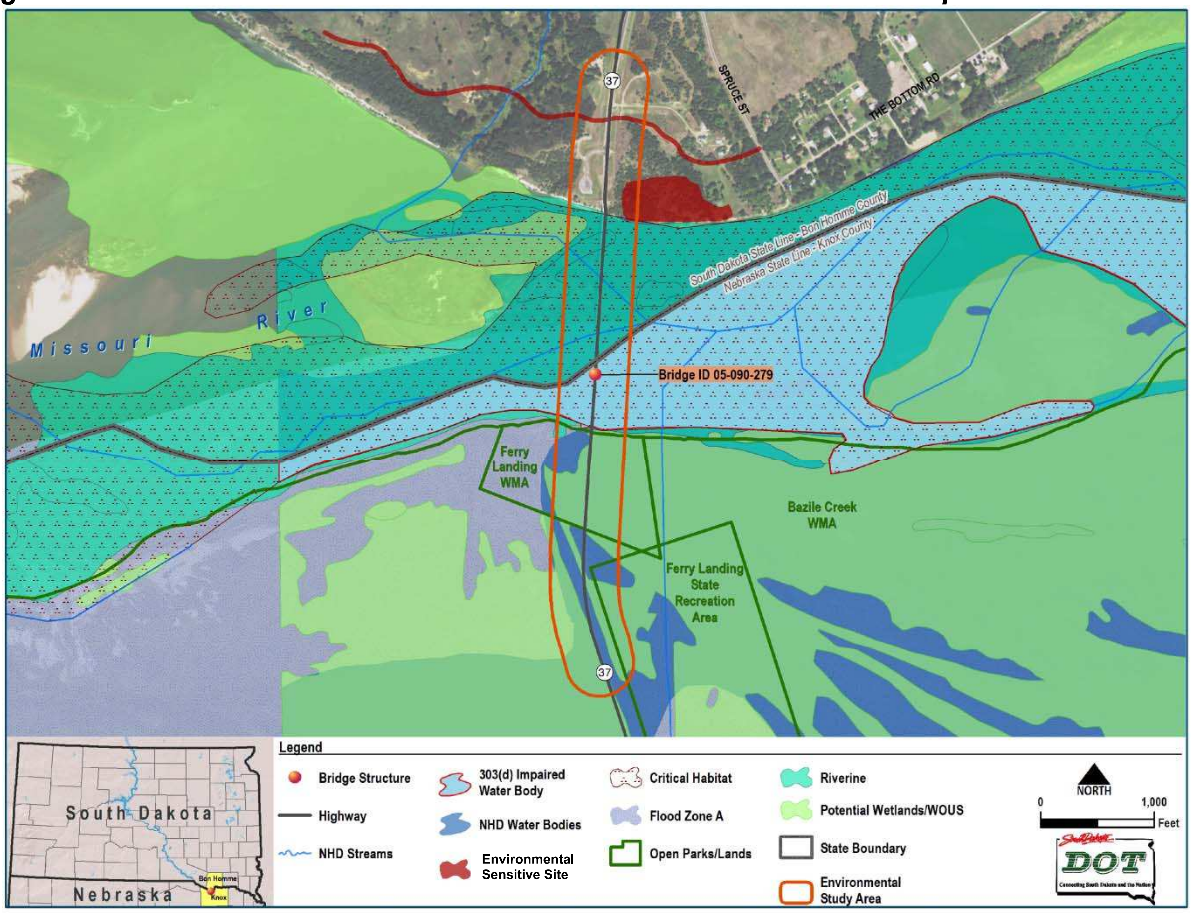
2.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for several other state and federally listed species. Modern records of piping plover and the interior least tern exist within the vicinity of the project study area. Coordination with USFWS and SDGFP will likely be necessary to avoid adverse impacts to these species.
- Section 4(f). Section 4(f) properties are present within the project study area on the north and south sides of the Missouri River, including Ferry Landing State Recreational Area (Nebraska) and the Chief Standing Bear Overlook (South Dakota). Specifically, the project is located in the Missouri National Recreational River Water Trail system. Several SRA and WRAs are also located within the near vicinity.
- Section 106. Historic and archeological resources are present within the study area, including one site listed on the National Register of Historic Places.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly near the banks of the Missouri River. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Wild and Scenic Rivers. The Niobrara River in Nebraska and this segment of the Missouri River are listed as Wild and Scenic Rivers. The Niobrara River is also on the Nationwide Rivers Inventory.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as chlorophyll A.

- Title VI (Civil Rights) and Environmental Justice. Minorities and vulnerable age populations are present within the study area and low-income populations are present in the vicinity; project construction could potentially indirectly affect these populations.
- Section 9. A contractor's work plan must be submitted to the US Coast Guard before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, NEGPC, SDSHPO, NESHPO, NPS, USCG, and the Tribes) will be required during the NEPA process.

Figure 2.3 Structure No. 05-090-279 Environmental Constraints Map



2.B. Future Conditions Analysis

The team conducted a future conditions analysis for the Running Water/Standing Bear Bridge to determine future traffic operations and the need for additional capacity. The team also suggested potential safety improvements if an identifiable crash pattern was observed.

2.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 37 is estimated to have an ADT volume of 937, with a heavy vehicle percentage of 17.1 percent.

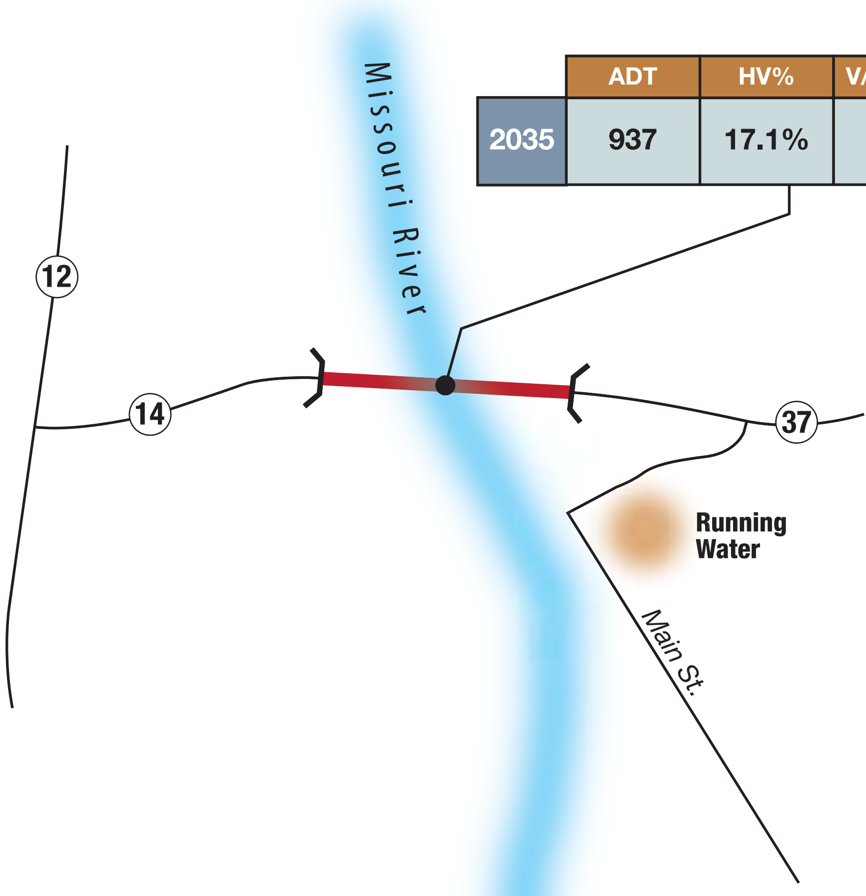
The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.4 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and the roadway ADT, SD 37 is anticipated to operate at LOS A with a V/C ratio of 0.03 in 2035. **Figure 2.4** summarizes the future roadway and traffic conditions.

2.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

2.B.3. Safety Recommendations

A review of the crash data indicates no identifiable crash pattern. There are no recommended safety improvements at this location.



	ADT	HV%	V/C Ratio	LOS
2035	937	17.1%	0.03	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	60 mph
Bridge Roadway Width	36 Feet

North

NOTE: Drawing Not to Scale

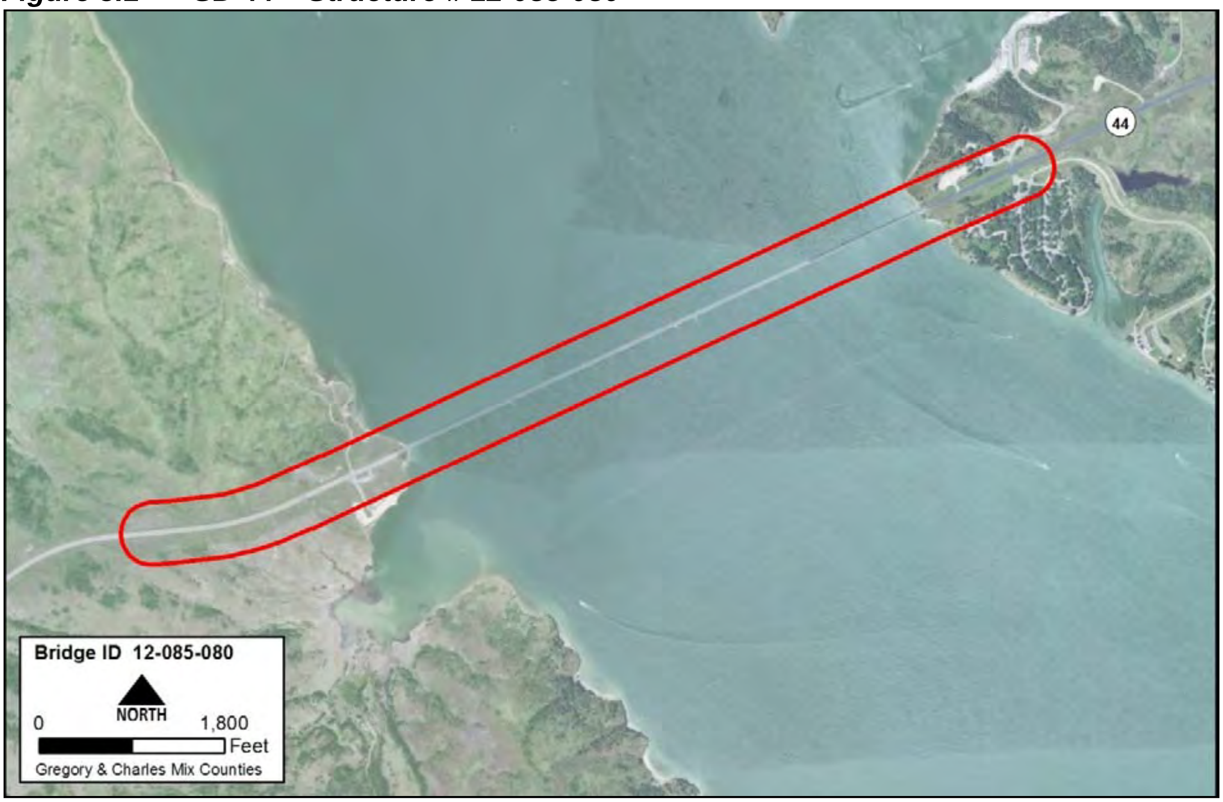
Figure 2.4
2035 Future Conditions
Running Water/Standing Bear SD 37
05-090-279

3. Structure # 12-085-080

Structure No. 12-085-080 (Platte/Winner) is located on South Dakota Highway 44 (SD 44) over the Missouri River in Charles Mix County. The study area, shown in **Figure 3.1**, is approximately 1.85 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1966. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 3.1 SD 44 – Structure # 12-085-080



3.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the SD 44 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

3.A.1. Additional Background Data

No additional data were available for this structure location.

3.A.2. Roadway Conditions

On SD 44, the west roadway approach to the bridge consists of two-lanes, 28 feet in width, with 4-foot surfaced shoulders. The east roadway approach consists of two-lanes, 26 feet in width, with 8-foot surfaced shoulders. The speed limit is posted at 65 mph. On the bridge, the roadway width is 28 feet, which consists of two 12-foot driving lanes and 2-foot surfaced shoulders, with a posted speed limit of 60 mph.

Per Table 7-1 from Chapter 7 of the SDDOT Roadway Design Manual, for a two-lane roadway with a projected ADT between 551 and 1,500, the existing cross sections of the approaching roadways to the structure currently meet SDDOT design standards. However, for the bridge, Table 7-1 indicates that a minimum bridge width of 36 feet should be provided. The current bridge width of 28 feet does not meet SDDOT design standards.

The SD 44 approaches are asphalt surfaces. The approach immediately east of the bridge has a Surface Condition Index of 4.67, and the approach immediately west of the bridge has an index of 4.01. **Table 3.1** shows the detailed pavement index values provided in the 2015 Highway Needs and Project Analysis Report.

Table 3.1 SD 44 (Structure #12-085-080) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (in Avg/Max
4.67 (East)	4.77	5.00	5.00	4.79	5.00	4.63	0.1/0.3
4.01 (West)	4.01	4.19	4.60	5.00	4.30	4.56	0.1/0.3

3.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (33 tons) and a fracture critical bridge.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and limited shoulders.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 6
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 78.4, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.

- Numerous cracks in the girders, which have been drilled to arrest the cracks
- Some section loss in the girders and floor beams
- Column and pile cracks
- Pile cap deterioration
- Two-girder system with floor beams, which makes widening the superstructure difficult

3.A.4. Traffic Analysis

SD 44, categorized as a Rural Minor Arterial, is located between Gregory County and Charles Mix County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 951 in 2015. No peak period turning movement counts were analyzed for this structure. The roadway has a heavy vehicle percentage of 27.1 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 62 percent would fall into FHWA Vehicle Class 5-9 and 38 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.381 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.405 percent was developed, and a growth rate of 2.921 percent was developed for FHWA Vehicle Class 10-13. **Figure 3.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.4 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 44 currently operates at LOS A with a V/C ratio of 0.03.

3.A.5 Safety Analysis

The team used crash records compiled from SDDOT for the structure and approaches on SD 44. **Tables 3.2** and **3.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 3.2 SD 44 (Structure #12-085-080) – Crash Data (2010–2014)

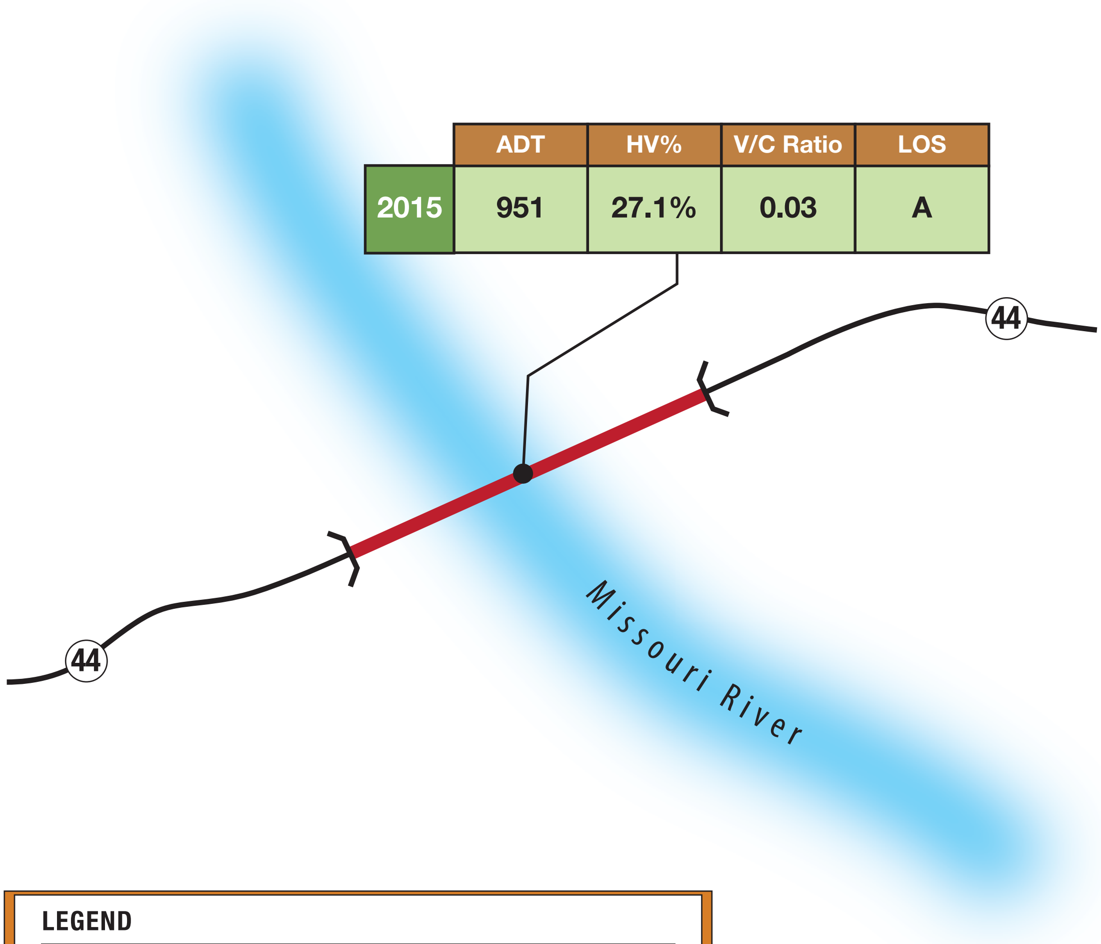
Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
1	0	0	0	0	0	1

The crash that occurred in the study area involved a single vehicle, occurred just north of the bridge, and involved an animal collision.

Table 3.3 SD 44 (Structure #12-085-080) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
SD 44	0	0	0	0	1	1	951	1.74	0.58	0.58
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

	ADT	HV%	V/C Ratio	LOS
2015	951	27.1%	0.03	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	65 mph
Bridge Roadway Width	28 Feet

North

NOTE: Drawing Not to Scale

Figure 3.2
2015 Existing Conditions
Platte-Winner/SD 44
12-085-080

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The crash rate per MEV for the roadway segment is 0.58. The severity rate per MEV, which applies a cost factor to the different crash severity type, is also 0.58. **Table 3.4** shows the identified crash patterns and possible contributing factors.

Table 3.4 SD 44 (Structure #12-085-080) – Crash Patterns (2010 - 2014)

Crash Pattern	Contributing Factors
Animal-related Collisions	▪ Bridge is located in heavily populated deer habitat

3.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. The paved shoulders on the bridge are not wide enough to provide adequate separation between vehicles and bicyclists. The shoulders on the roadway approaches are sufficient to offer cyclists an alternative to ride with some separation from vehicular traffic.

3.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

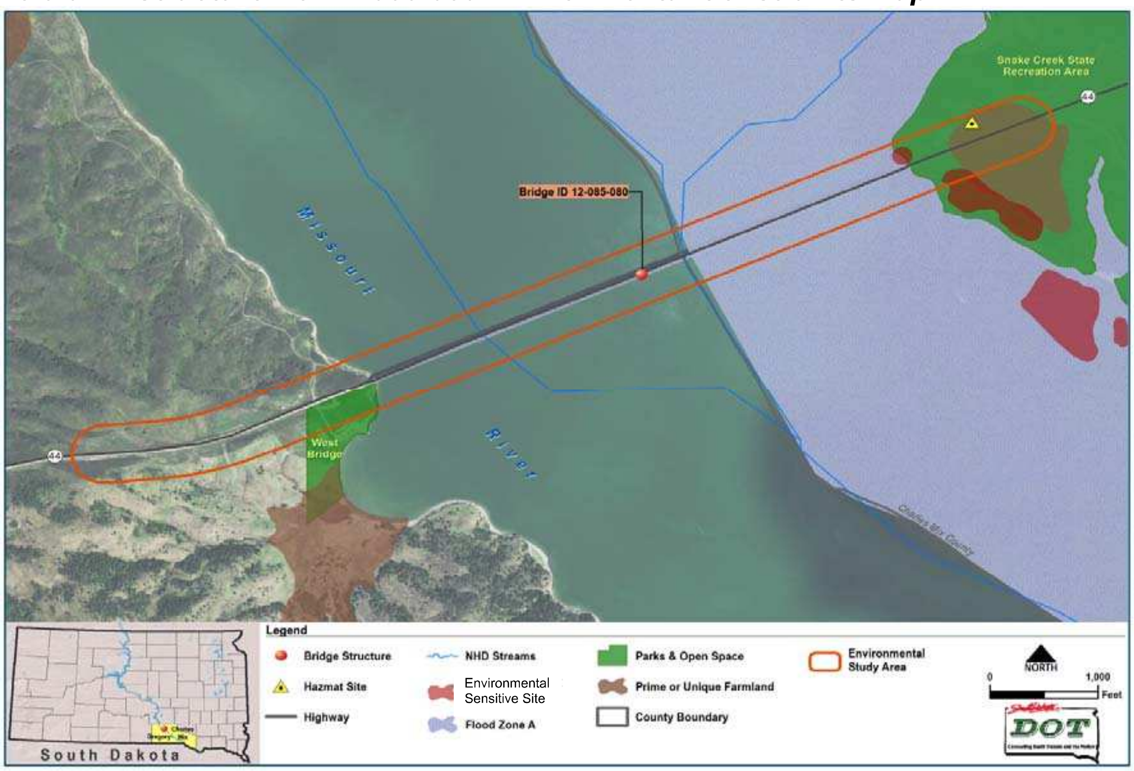
3.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. No documented records of state or federally endangered species are present within a mile of the project, but potential habitat is present within and adjacent to the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f) and Section 6(f). The Snake Creek State Recreation Area, located within the study area on the east side of the river, is both a Section 4(f) and 6(f) property.
- Section 106. Historic and archeological resources are present within the study area along the east banks of the river. These sites are unevaluated for listing on the NRHP and may require further surveys and evaluation.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Regulated Materials. Regulated materials within the project study area include aboveground storage tanks for gasoline and diesel located at the Snake Creek Recreation Area (Shop Area) toward the east end of the study area.

- Floodplains and Floodways. FEMA Flood Zone A is mapped within the project study area; however, not all of the area has been mapped for floodplains and floodways. A floodplain permit may be required depending on the scope of work required for the project.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low income populations are present in the vicinity of the study area and could potentially be indirectly affected by construction of the project.
- Section 9. A contractor’s work plan must be submitted to the US Coast Guard before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Coordination with FHWA, USFWS, SDGFP, USCG, and the Tribes will likely be required.

Figure 3.3 Structure No. 12-085-080 Environmental Constraints Map



3.B. Future Conditions Analysis

The team conducted a future conditions analysis for the Platte/Winner Bridge to determine future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

3.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 44 is estimated to have an ADT volume of 1,298, with a heavy vehicle percentage of 29.7 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis used a K factor of 8.4 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and the roadway ADT, SD 44 is anticipated to operate at LOS A with a V/C ratio of 0.04 in 2035. **Figure 3.4** summarizes the future roadway and traffic conditions.

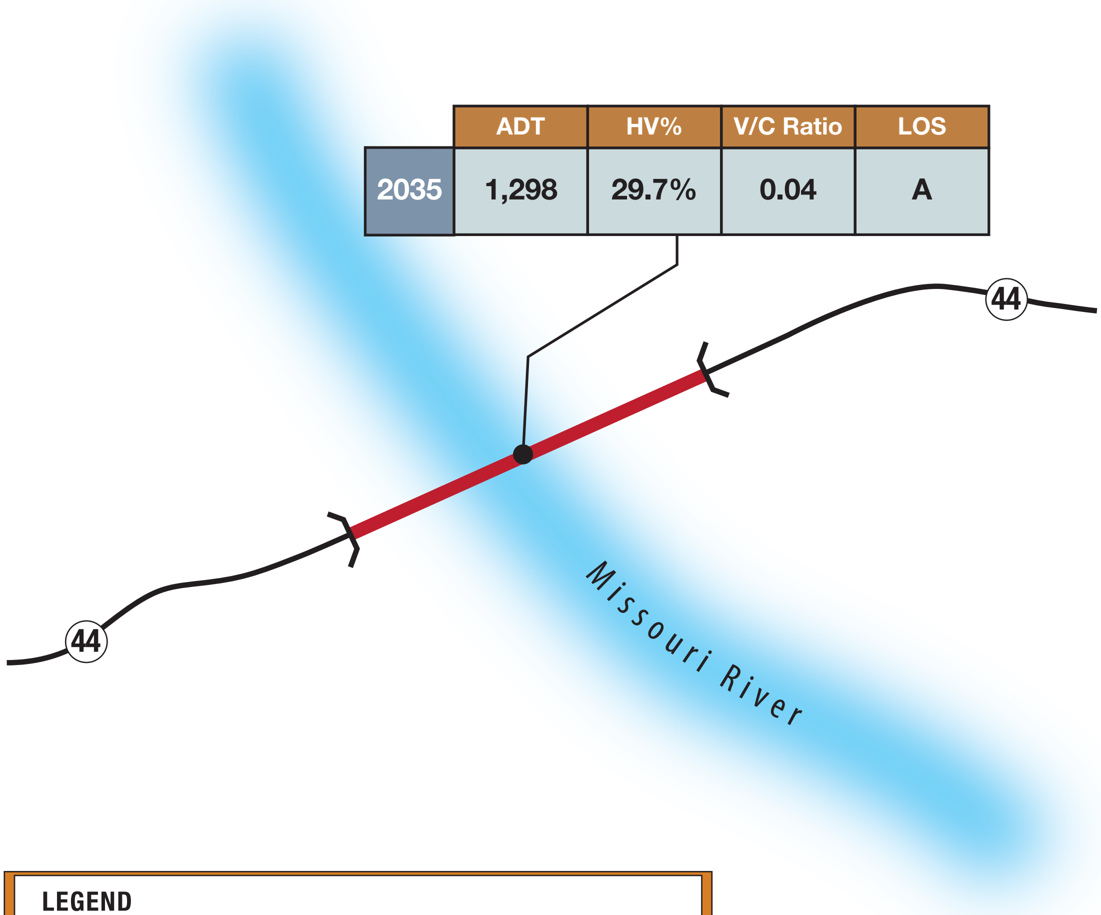
3.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

3.B.3. Safety Recommendations

A review of the crash data indicates a pattern of animal-related collisions. The team recommends that additional non-vehicular warning signs W11-3 (Deer) be considered in advance of the bridge approaches warning drivers in all directions that wildlife may be crossing in this area. The team also recommends that a deer fence, along with wildlife undercrossing, be considered in this area. A future study would need to be completed to determine the feasibility of the deer fence.

	ADT	HV%	V/C Ratio	LOS
2035	1,298	29.7%	0.04	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	65 mph
Bridge Roadway Width	36 Feet

North

NOTE: Drawing Not to Scale

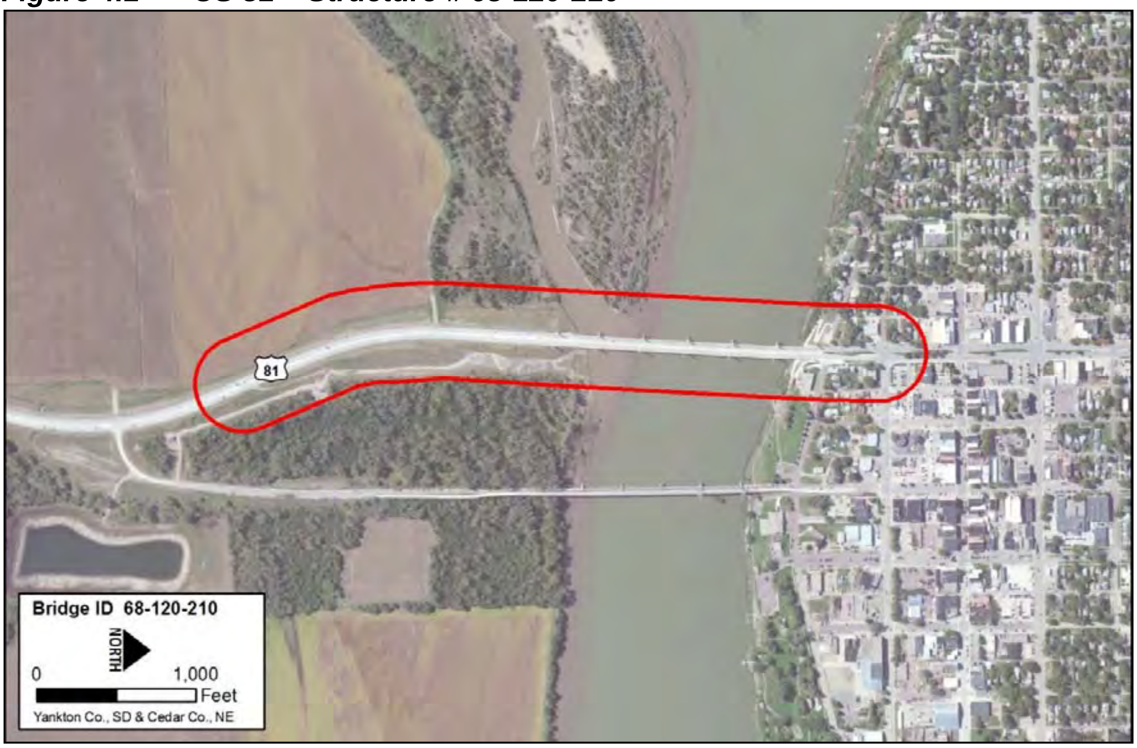
Figure 3.4
2035 Future Conditions
Platte-Winner/SD 44
12-085-080

4. Structure # 68-120-210

Structure No. 68-120-210 (Yankton/Discovery), located on US 81 over the Missouri River, borders between Yankton County, South Dakota; and Cedar County, Nebraska. The study area is approximately 0.87 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Wild and Scenic Rivers extends 1.5 miles upstream and downstream from the structure. The search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

Because this structure was constructed in 2008, is in good condition, and is maintained by Nebraska, the team performed a cursory level review, which includes baseline conditions, future needs, and safety analyses. The team did not develop alternative improvement scenarios for this structure.

Figure 4.1 US 81 – Structure # 68-120-210



4.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the US 81 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

4.A.1. Additional Background Data

The team requested additional traffic count data for the intersection of US 81 with 2nd Street in Yankton, South Dakota; however, no data were available. The team reviewed the *Two Bridges to the Future* report prepared by RDG for this evaluation.

4.A.2. Roadway Conditions

In South Dakota, on US 81, the southbound approach to the bridge is an urban four-lane median divided roadway consisting of four 12-foot lanes with a 30-foot raised median. Curb and gutter is provided on both sides. The speed limit is posted at 30 mph. On the bridge, the roadway width is 72 feet, which consists of two 13-foot and two 12-foot driving lanes, 3-foot surfaced shoulders, and a striped 16-foot median. In Nebraska on US 81, the northbound approach to the bridge consists of a rural four-lane median divided roadway. The inside lanes are both 13 feet in width, and the outside lanes are each 12 feet wide. The raised median is 16 feet, and 10-foot paved shoulders are provided. The speed limit is posted at 45 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, for urban areas, shoulders may not be provided. Consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (speeds less than 40 mph) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. As such, the existing cross section on the southbound roadway approach of US 81 meets SDDOT design standards. The northbound approach and the bridge lie within NDOR's jurisdiction.

The US 81 approach immediately north of the bridge is a concrete surface, with a Surface Condition Index of 5.00. **Table 4.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 4.1 US 81 (Structure #68-120-210) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
5.00 (North)	3.50	5.00	5.00	5.00	5.00	5.00	5.00

4.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. The review found no load carrying capacity issues with the bridge.
- Geometry. The review noted no geometric deficiencies with the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 8
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, appropriate width, etc. This bridge's current sufficiency rating is 91.5, indicating a structure in above average structural condition.

- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Deck cracking
  - Bent anchor bolts and bearing plates

4.A.4. Traffic Analysis

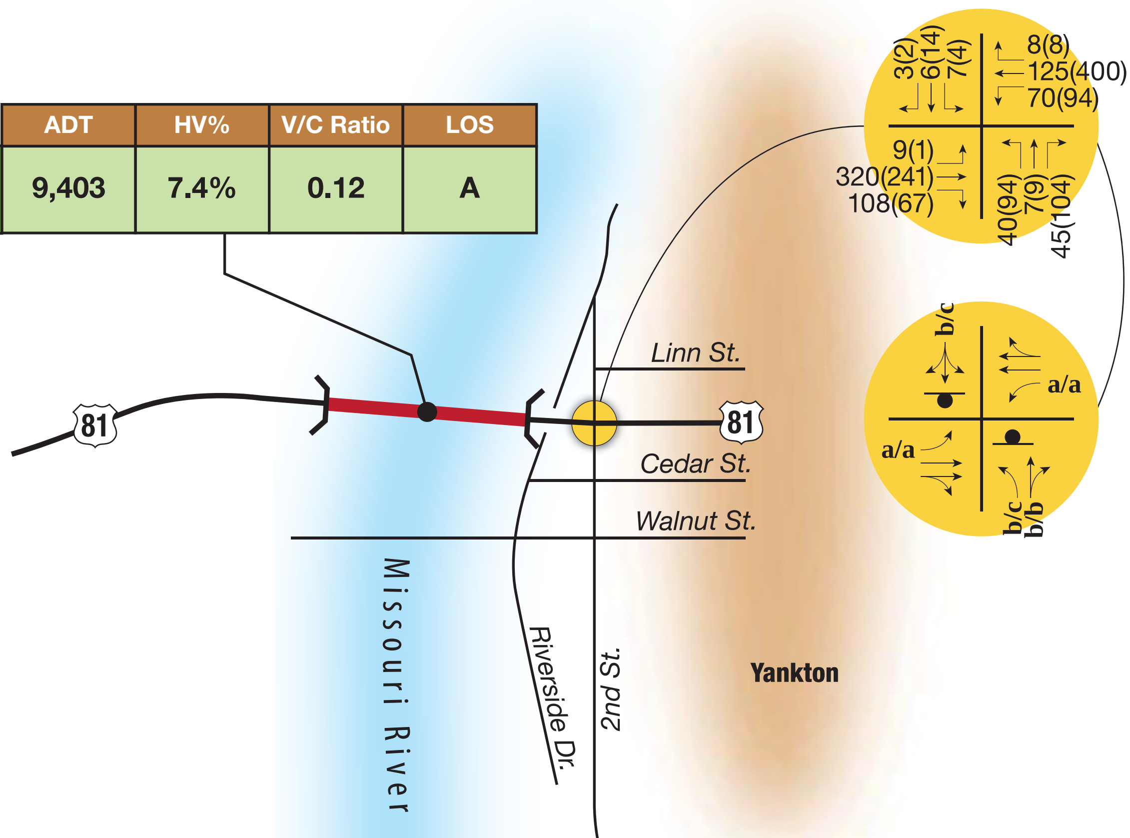
US 81, categorized as a Rural Other Principal Arterial, is located in Yankton County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 9,403 in 2015. Peak period turning movement counts were provided at the intersection of US 81 with 2nd Street. The roadway has a heavy vehicle percentage of 7.4 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 73 percent would fall into FHWA Vehicle Class 5-9 and 27 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on the functional class and geographic location of the roadway, a growth rate of 1.088 percent was provided. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.939 percent was provided, and a growth rate of 2.861 percent was provided for FHWA Vehicle Class 10-13. **Figure 4.2** summarizes the roadway and traffic conditions**.**

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.2 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on the HCM methodologies and peak hour traffic volumes, US 81 currently operates at LOS A with a peak flow rate of 228 pcphpl and a V/C ratio of 0.12.

At the unsignalized intersection of US 81 with 2nd Street, all critical movements currently operate at LOS C or better in both the AM and PM peak hours under 2015 traffic conditions.

	ADT	HV%	V/C Ratio	LOS
2015	9,403	7.4%	0.12	A



LEGEND

Number of Lanes	4 Lanes
Functional Class	Rural/Urban Other Principal Arterial
Posted Speed	45 mph
Bridge Roadway Width	72 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

x/x = AM/PM Peak Hour Unsignalized Intersection Level of Service

= Stop Sign

North

NOTE: Drawing Not to Scale

Figure 4.2
2015 Existing Conditions
Yankton/Discovery US 81
68-120-210

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4.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure, approaches on US 81 and intersections within the study area. **Tables 4.2** and **4.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 4.2 US 81 (Structure #68-120-210) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
1	0	0	9	0	0	10

All of the crashes that occurred in the study area were located 450 feet north of the bridge at the intersection of 2nd Street with US 81 (Broadway Street) in the city of Yankton. The predominant crash pattern was drivers performing a southbound left-turn at the intersection of 2nd Street with Broadway to go eastbound on 2nd Street. One of these angle collisions resulted in a fatality at the intersection.

Table 4.3 US 81 (Structure #68-120-210) – Crash Rates (2010–2014)

Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
US 81 / 2nd St.	1	0	0	3	6	10	14,623	26.69	0.37	21.21
Incapacitating (Incap.)	Property Damage Only (PDO)	* MEV= Million Entering Vehicles								

The crash rate per MEV for the roadway segment is 0.37. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 21.21. **Table 4.4** shows the identified crash patterns and possible contributing factors.

Table 4.4 US 81 (Structure #68-120-210) – Crash Patterns (2010 - 2014)

Crash Pattern	Contributing Factors
Angle Collision	▪ Drivers performing left turns with an unsafe gap time ▪ Misjudging speed of major road vehicle ▪ Not conscious of divided roadway

4.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. The paved shoulders on the bridge are not wide enough to provide adequate separation between vehicles and bicyclists. The shoulders on the northbound approach are sufficient to offer cyclists an alternative to ride with some separation from vehicular traffic. In Yankton, on the southbound approach, sidewalks are provided on both sides of the roadway. As stated in the *Two Bridges to the Future* report, the old Meridian Bridge has been converted to provide two levels for pedestrian, bicyclists, and other recreational users.

4.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the

Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

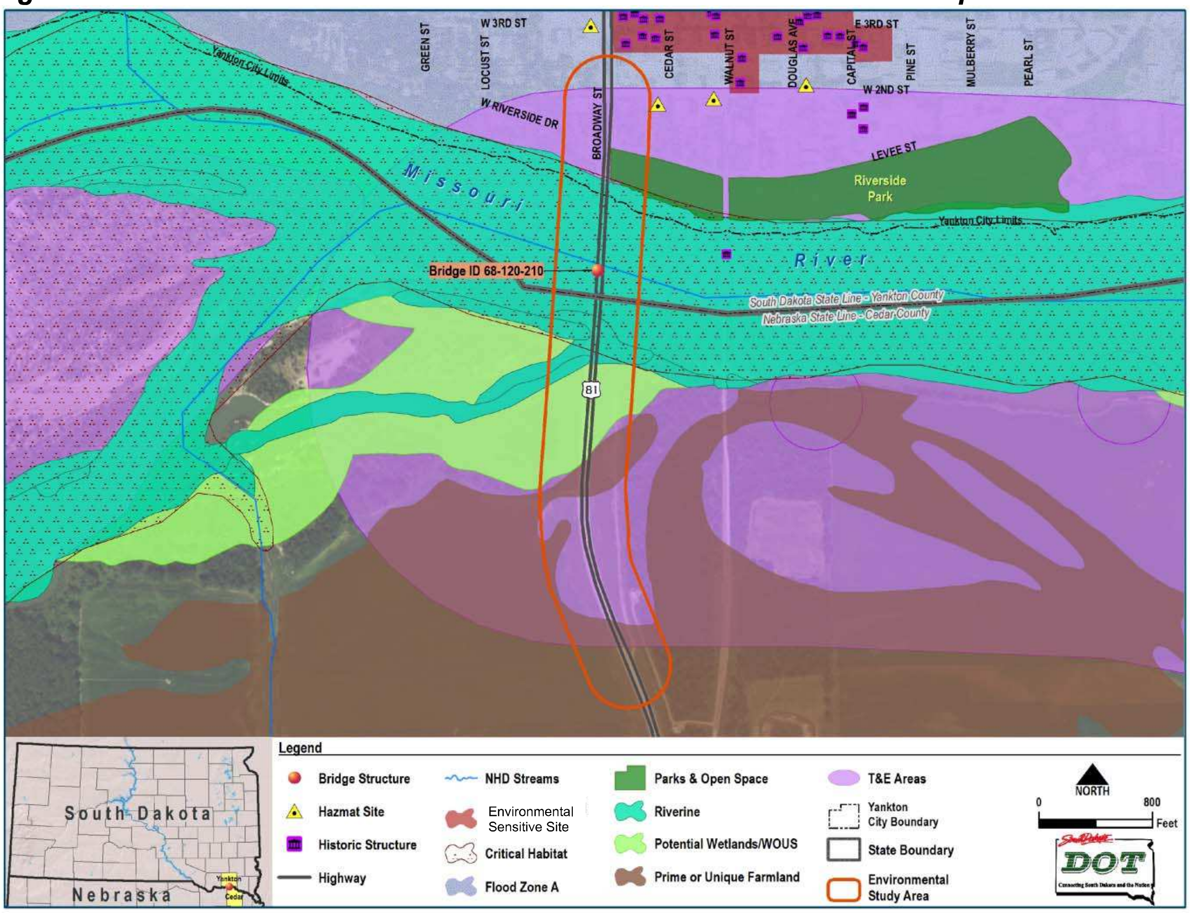
4.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for other state and federally listed species, and modern records of interior least tern, piping plover, false map turtle, and bald eagle exist within the vicinity of the project study area.
- Section 4(f) and Section 6(f). Riverside Park is a Section 4(f) and Section 6(f) property within the study area on the north side of the Missouri River; the Missouri National Recreation River is 4(f).
- Section 106. Known historic and archeological resources are not present within the study area but are in close proximity. A historic district is adjacent to the north end of the study area; this district contains many buildings eligible for listing on the NRHP. A bridge to the east of the project structure is also eligible. Further surveys and evaluation may be necessary.
- Wetlands and Waters of the US. Wetlands and Waters of the US are present within the project study area, particularly near the banks of the Missouri River, and include forested and scrub-shrub wetlands. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Wild and Scenic Rivers. The segment of the Missouri River that passes under the project bridge has been identified as a Wild and Scenic River.
- Regulated Materials. Regulated materials within the project study area include underground storage tanks for gasoline located at the Freedom Value Center gas station near the north end of the project. Several other active underground gasoline storage tanks are located at facilities in Yankton within a half mile of the project but outside the study area.
- Floodplains and Floodways. FEMA Flood Zone A is mapped within the project study area. A floodplain permit may be required depending on the scope of work required for the project.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within the vicinity of the study area and could potentially indirectly affect these populations.

- Prime and Unique Farmland. Prime farmland is located within the study area on the south side of the river. Impacts may require a Form NRCS CPA-106 for Corridor Type Projects or AD1006.
- Section 9. A work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, NEGPC, SDSHPO, NESHPO, NPS, USCG, and the Tribes) will be required during the NEPA process.

Figure 4.3 Structure No. 68-120-210 Environmental Constraints Map



4.B. Future Conditions Analysis

The future conditions analysis conducted for the Yankton/Discovery Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

4.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 81 is estimated to have an ADT volume of 11,788, with a heavy vehicle percentage of 8.3 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis used a K factor of 8.2 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and HCS 2010, US 81 is anticipated to operate at LOS A with a flow rate of 285 (pcphpl), which equates to a V/C ratio of 0.15 in 2035. **Figure 4.4** summarizes the future roadway and traffic conditions.

At the unsignalized intersection of US 81 with 2nd Street, all critical movements are anticipated to operate at LOS D or better in both the AM and PM peak hours under 2035 traffic conditions. The westbound left-turn movement is anticipated to operate at LOS D in the PM peak hour. All the remaining movements operate at LOS C or better.

4.B.2. Additional Lane Needs

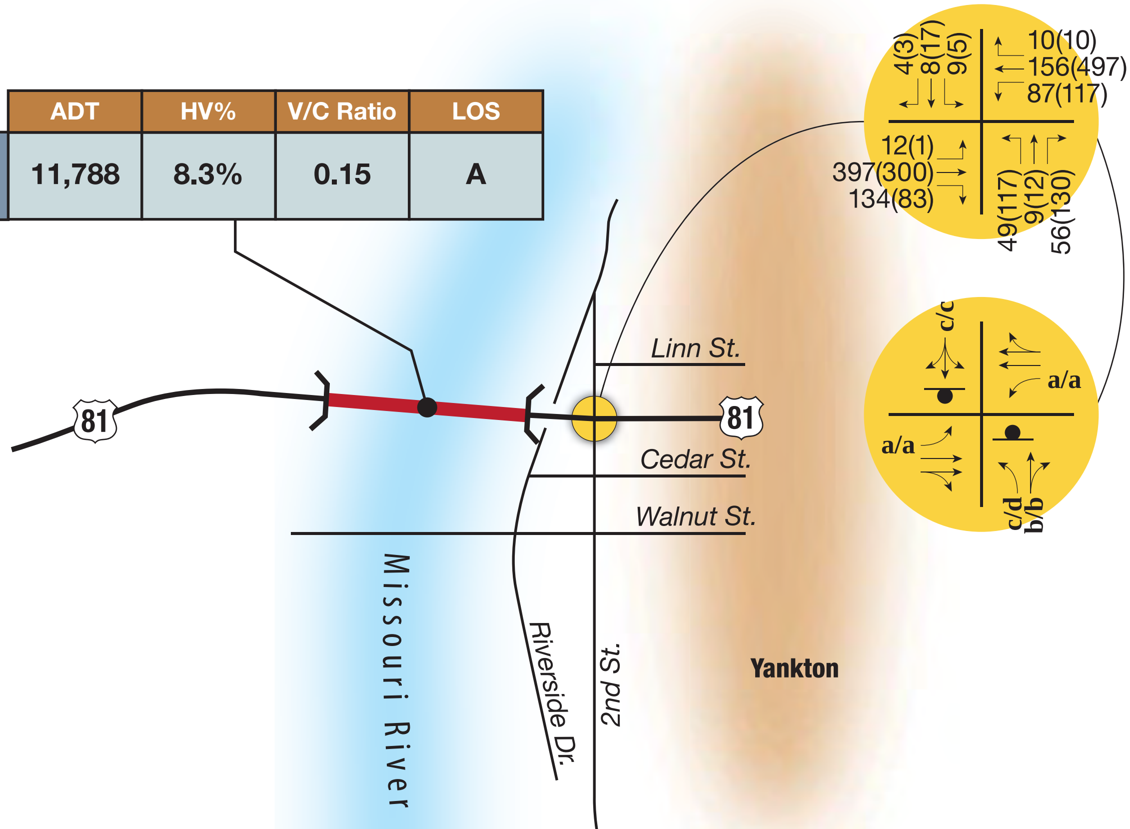
Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

4.B.3. Safety Recommendations

A review of the crash data indicates a pattern of angle collisions at the intersection of US 81 with 2nd Street just north of the bridge. The analysis recommended, as a potential countermeasure, that offset left-turns be considered for both the northbound and southbound approaches of the intersection.

No crashes were reported on the bridge or on the south approach. Before improvements are implemented, a more detailed safety study should be completed at the intersection.

	ADT	HV%	V/C Ratio	LOS
2035	11,788	8.3%	0.15	A



LEGEND

Number of Lanes	4 Lanes
Functional Class	Rural/Urban Other Principal Arterial
Posted Speed	45 mph
Bridge Roadway Width	72 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

x/x = AM/PM Peak Hour Unsignalized Intersection Level of Service

(stop sign symbol) = Stop Sign

North

NOTE: Drawing Not to Scale

Figure 4.4
2035 Future Conditions
Yankton/Discovery US 81
68-120-210

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5. Structure # 08-068-084

Structure No. 08-068-084 (Chamberlain Truss) is located on SD 90L immediately west of Chamberlain, between Lyman County and Brule County. The study area is approximately 1.47 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure constructed in 1953 underwent a major rehabilitation in 2010. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 5.1 SD 90 L – Structure # 08-068-084

5.A. Baseline Conditions Analysis

The baseline conditions analysis for the 90L bridge examined each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

5.A.1. Additional Background Data

The team requested additional traffic count data for the intersections of W. King Avenue with Courtland Street (SD 50) and Main Street in Chamberlain, South Dakota; however, no additional traffic information is available.

5.A.2. Roadway Conditions

On SD 90L, the eastbound roadway approach to the bridge is a rural two-lane roadway consisting of two 12-foot lanes with 8-foot surfaced shoulders, with a posted speed limit of 45 mph. On the bridge, the two-lane roadway width is 47 feet, which consists of an 18-foot driving lane with 1-foot 4-inch curb and gutter on both sides of the roadway in each direction. An 8-foot 5-inch median separates the travel ways. In Chamberlain on W. King Avenue, the westbound approach to the bridge consists of an urban four-lane undivided roadway. The cross section consists of four travel lanes, two 12-foot inside lanes and two 13-foot outside lanes. The speed limit is posted at 30 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a rural two-lane roadway with a projected ADT above 2,500, the existing cross section of the eastbound roadway approach to the structure and the bridge roadway currently meet SDDOT design standards.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, for urban areas, shoulders may not be provided. Consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (speeds less than 40 mph) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. As such, the existing cross section on the westbound roadway approach of W. King Avenue meets SDDOT design standards.

The SD 90L approach immediately east of the bridge is a concrete surface and has a Surface Condition Index of 5.00. The approach immediately west of the bridge is an asphalt surface and has an index of 4.73. **Table 5.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 5.1 SD 90: (Structure #08-068-084) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
5.00 (East)	3.50	5.00	5.00	5.00	5.00	5.00	5.00
Surface Condition Index	**Roughness Index**	**Transverse Cracking**	**Fatigue Cracking**	**Patching/Patch Deterioration**	**Block Cracking**	**Rut Index**	**Rut Depth (in) Avg/Max**
4.73 (West)	3.50	5.00	5.00	5.00	5.00	4.65	0.1/0.2

5.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (35 tons), and the bridge is fracture critical.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and no sidewalks.

- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 7
  - Superstructure: 7
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, appropriate width, etc. This bridge's current sufficiency rating is 88.8, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - A few cracked truss welds
  - A few minor cracks in eye bars
  - Footing scour
  - The use of truss spans at this bridge, which makes widening the superstructure difficult

5.A.4. Traffic Analysis

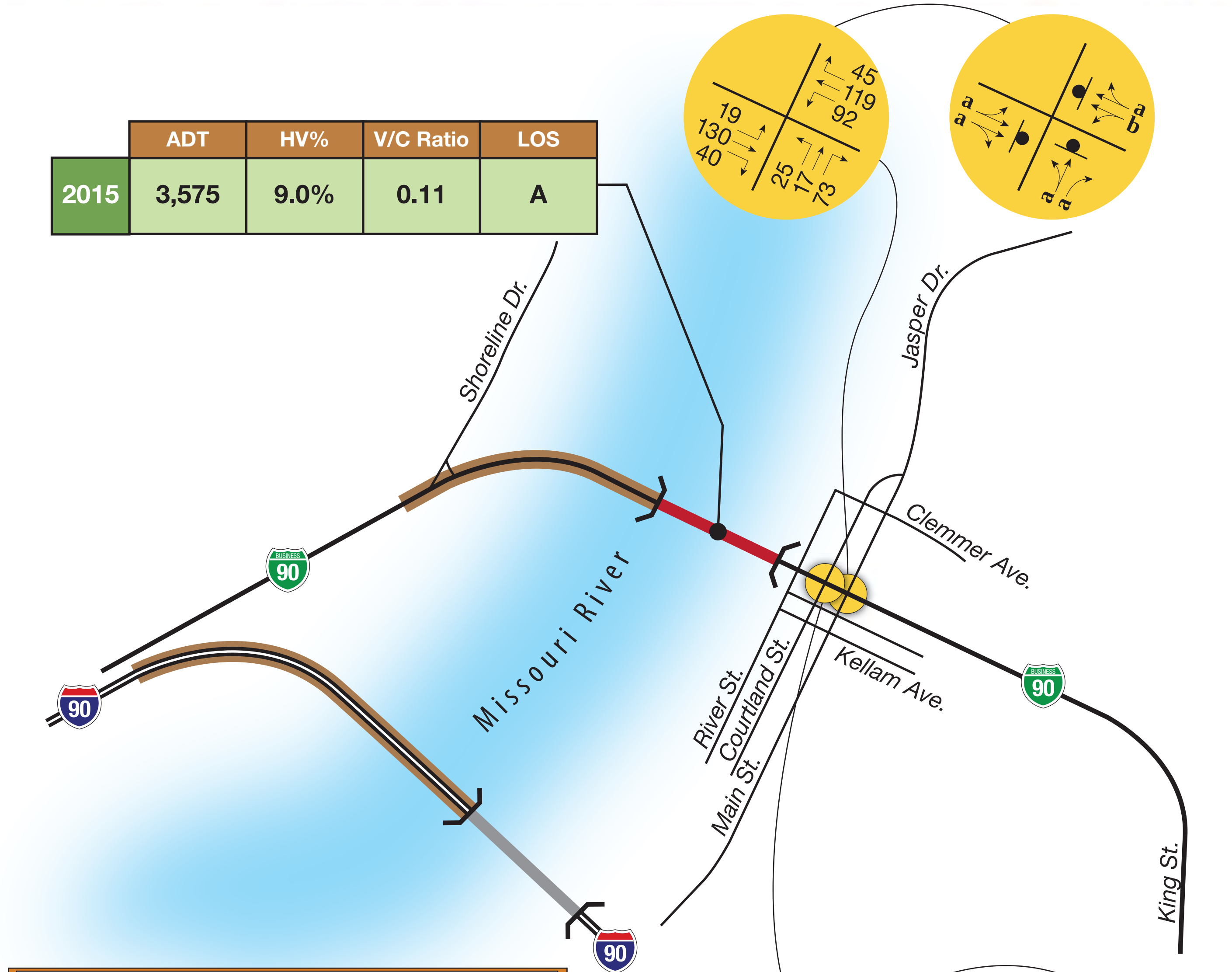
The SD 90L, categorized as a Rural Other Minor Arterial, is located between Lyman County and Brule County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 3,575 in 2015. No peak period turning movement counts were available at the intersections of W. King Avenue with Courtland Street (SD 50) and Main Street. As such, FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop design hour traffic volumes for the intersections. The roadway has a heavy vehicle percentage of 9.0 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 73 percent would fall into FHWA Vehicle Class 5-9 and 27 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.449 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.535 percent was developed, and a growth rate of 2.959 percent was developed for FHWA Vehicle Class 10-13. **Figure 5.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.1 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 90L currently operates at LOS A with a V/C ratio of 0.11.

At the unsignalized intersections of SD 90L (W. King Avenue) with Courtland Street and Main Street, all critical movements currently operate at LOS C or better under 2015 design hour traffic conditions.

	ADT	HV%	V/C Ratio	LOS
2015	3,575	9.0%	0.11	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	30 mph
Bridge Roadway Width	36 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2015 Design Hourly Volumes (DHV)

x/x = 2015 Design Hourly Volumes (DHV) Unsignalized Intersection Level of Service

(stop sign symbol) = Stop Sign

North

NOTE: Drawing Not to Scale

Figure 5.2
2015 Existing Conditions
Chamberlain Truss/I-90
08-068-084

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5.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and approaches on SD 90L. **Tables 5.2** and **5.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 5.2 SD 90L (Structure #08-068-084) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
0	1	0	1	0	0	2

Two collisions occurred on the westbound approach to the bridge on SD 90L (W. King Avenue). Both collisions occurred in the city of Chamberlain on the four-lane section of W. King Avenue. One collision was a rear end and the other was an angle collision with a possible injury.

Table 5.3 SD 90L (Structure #08-068-084) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
I-90 Loop (W. King Ave.)	0	0	0	1	1	2	3,575	6.52	0.31	1.08
Incapacitating (Incap.)	Property Damage Only (PDO)					* MEV= Million Entering Vehicles				

The crash rate per MEV for the roadway segment is 0.31. The severity rate per MEV, which applies a cost factor to the crash severity type, is 1.08. There is no identifiable crash pattern.

5.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. The paved shoulders on the bridge are not wide enough to provide adequate separation between vehicles and bicyclists. The shoulders on the eastbound approach are sufficient to offer cyclists an alternative to ride with some separation from vehicular traffic. In Chamberlain, on the westbound approach, sidewalks are provided on both sides of the roadway.

5.A.7. Coast Guard Requirements

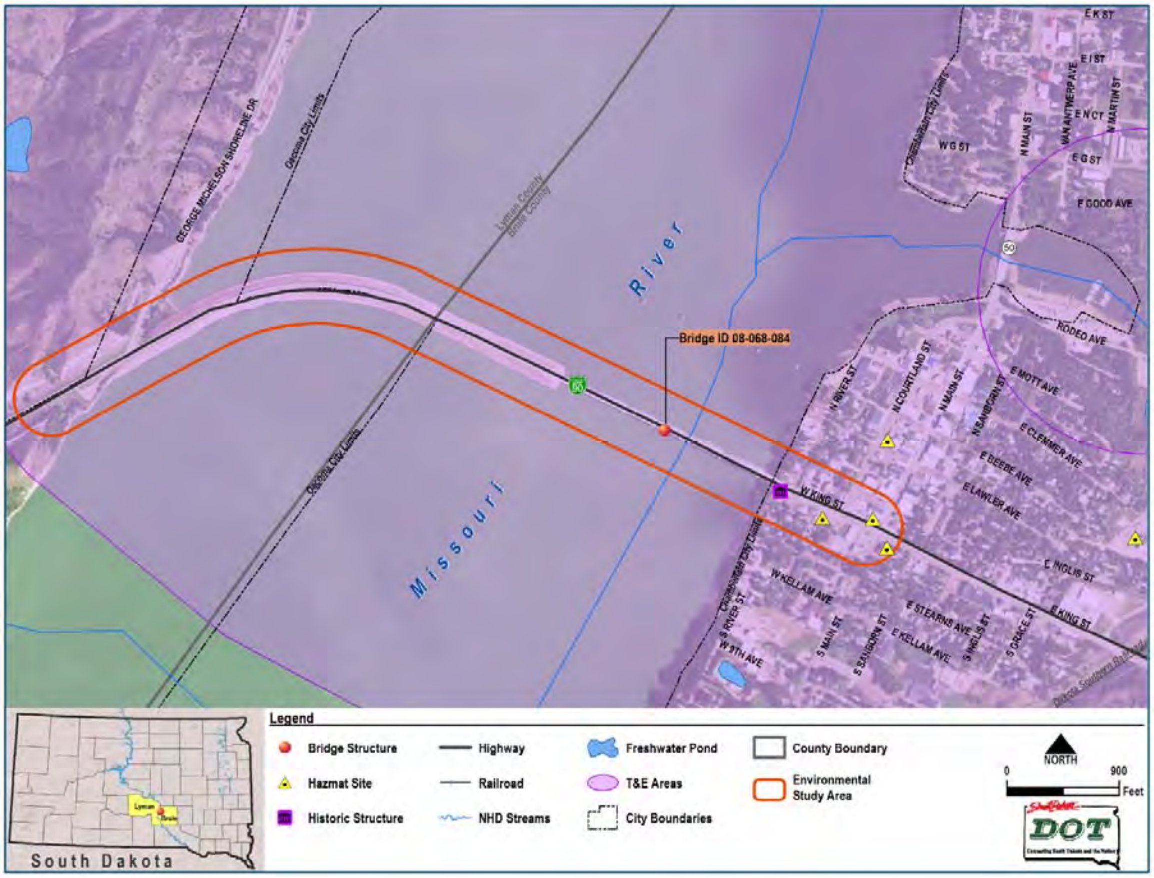
All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

5.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. Modern records of the whooping crane, river otter, and sturgeon chub exist within the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for several other state and federally listed species.
- Section 106. The project bridge is eligible for listing on the NRHP. Other structures in the project study area may require further evaluation.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Regulated Materials. Regulated materials within the project study area include active sites with gasoline and diesel underground storage tanks in or near the east end of the study area. A fuel oil power plant is also located in Chamberlain within 0.5 mile of the project study area.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within or near the study and could potentially be indirectly affected.
- Section 9. A contractor’s work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Coordination with FHWA, USFWS, SDGFP, USCG, and the Tribes will likely be required.

Figure 5.3 Structure No. 08-068-084 Environmental Constraints Map



5.B. Future Conditions Analysis

The future conditions analysis conducted for the Chamberlain Truss Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

5.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 90L is estimated to have an ADT volume of 4,824 with a heavy vehicle percentage of 10.1 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis used a K factor of 8.1 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and roadway ADT, the I-90 Loop is anticipated to operate at LOS B with a V/C ratio of 0.15 in 2035. **Figure 5.4** summarizes the future roadway and traffic conditions.

At the unsignalized intersections of SD 90L (W. King Avenue) with Courtland Street and Main Street, all critical movements are anticipated to operate at LOS C or better under 2035 design hour traffic conditions.

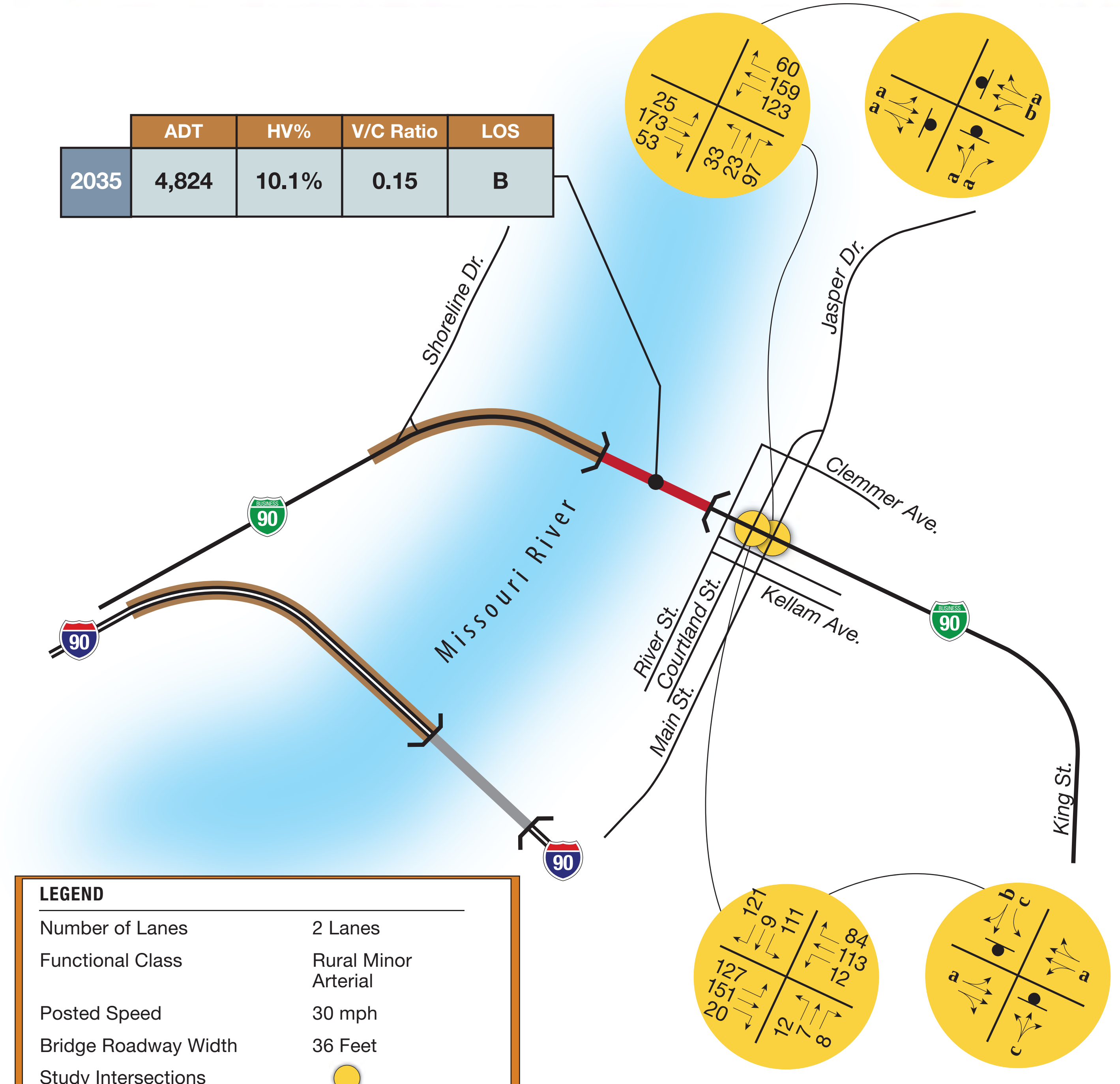
5.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

5.B.3. Safety Recommendations

A review of the crash data indicates there is no identifiable crash pattern. There are no recommended safety improvements at this location.

	ADT	HV%	V/C Ratio	LOS
2035	4,824	10.1%	0.15	B



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	30 mph
Bridge Roadway Width	36 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2035 Design Hourly Volumes (DHV)

x/x = 2035 Design Hourly Volumes (DHV) Unsignalized Intersection Level of Service

● = Stop Sign

Figure 5.4
2035 Future Conditions
Chamberlain Truss/I-90
08-068-084

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6. Structure # 08-061-094

Structure No. 08-061-094 (I-90 E&W – Chamberlain), located immediately south of Chamberlain between Lyman County and Brule County, crosses the Missouri River. The study area is approximately 1.5 miles long and 600 feet wide, centered on the structure and its approaches. The portion of the study area along South Main Street and perpendicular to I-90 is 0.5 miles long and 600 feet wide and encompasses the on-ramps and off-ramps for I-90. The search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1974. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 6.1 I-90 E & W – Structure # 08-061-094

6.A. Baseline Conditions Analysis

The baseline conditions analysis conducted for the I-90 Eastbound and Westbound bridges examined each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

6.A.1. Additional Background Data

The team requested additional traffic count data for the ramps and ramp terminals of I-90 with the Main Street Interchange (Interchange #263) in Chamberlain; however, no traffic count data were available.

6.A.2. Roadway Conditions

On the I-90 eastbound approach to the bridge, the interstate is a rural four-lane depressed median divided roadway consisting of two 12-foot lanes with a 10-foot surfaced outside shoulder and 4-foot inside surfaced shoulder in both travel directions. The median width is approximately 55 feet. Rumble strips are provided on both the inside and outside shoulders of the interstate.

On the bridge, the four-lane interstate roadway total width is 81 feet, which consists of two 12-foot lanes with a 9-foot surfaced outside shoulder and 3-foot inside surface shoulder in both travel directions. The shoulders also include a 1-foot curb and gutter on both sides of the roadway in each direction. A 2-foot median barrier separates the travel ways. A 1-foot 6-inch barrier rail is provided on the outside edge of the travel ways. On the I-90 westbound approach to the bridge, the interstate is a rural four-lane median divided roadway consisting of two 12-foot lanes with a 10-foot surfaced outside shoulder and 4-foot inside surfaced shoulder in both travel directions. The median barrier is 2 feet wide.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a rural four-lane interstate with a projected ADT less than 30,000, the existing cross section of both the roadway approaches to the structure currently meet SDDOT design standards. However, Footnote 11 of Table 7-1 indicates that where truck traffic exceeds 250 directional design hourly volume (DDHV), a paved shoulder of 12-foot should be considered. At this location, the DDHV exceeds 250 trucks and 12-foot shoulders should be considered per SDDOT design standards.

For the bridge, Footnote 10 indicates that, on bridges, a 6-foot inside shoulder should be provided. Currently only 4 feet (3-foot shoulder plus 1-foot curb and gutter) is provided. Footnote 11 also applies to the outside shoulder of the bridge, which means that while the existing 10-foot outside shoulder (9-foot shoulder plus 1-foot curb and gutter) does meet current SDDOT design standards, 12-foot outside shoulders should be considered.

The I-90 approaches to the bridge provide concrete surfaces. The approach immediately east of the bridge has a Surface Condition Index of 3.20, and the approach immediately west of the bridge has an index of 4.72. **Table 6.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 6.1 I-90 (Structure #08-061-094) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
3.20 (East)	3.38	4.60	3.20	5.00	5.00	3.20	5.00
4.72 (West)	4.71	5.00	4.88	5.00	5.00	4.85	5.00

6.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. The team found no load carrying capacity issues in the review of the bridge. However, the bridge is fracture critical.
- Geometry. The review noted no geometric deficiencies in the bridge.

- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
    - Deck: 6
    - Superstructure: 6
    - Substructure: 7
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 97, indicating the structure is in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
    - Deck cracking
    - Girder pack rust
    - Two-girder system with floor beams, which makes widening the superstructure difficult

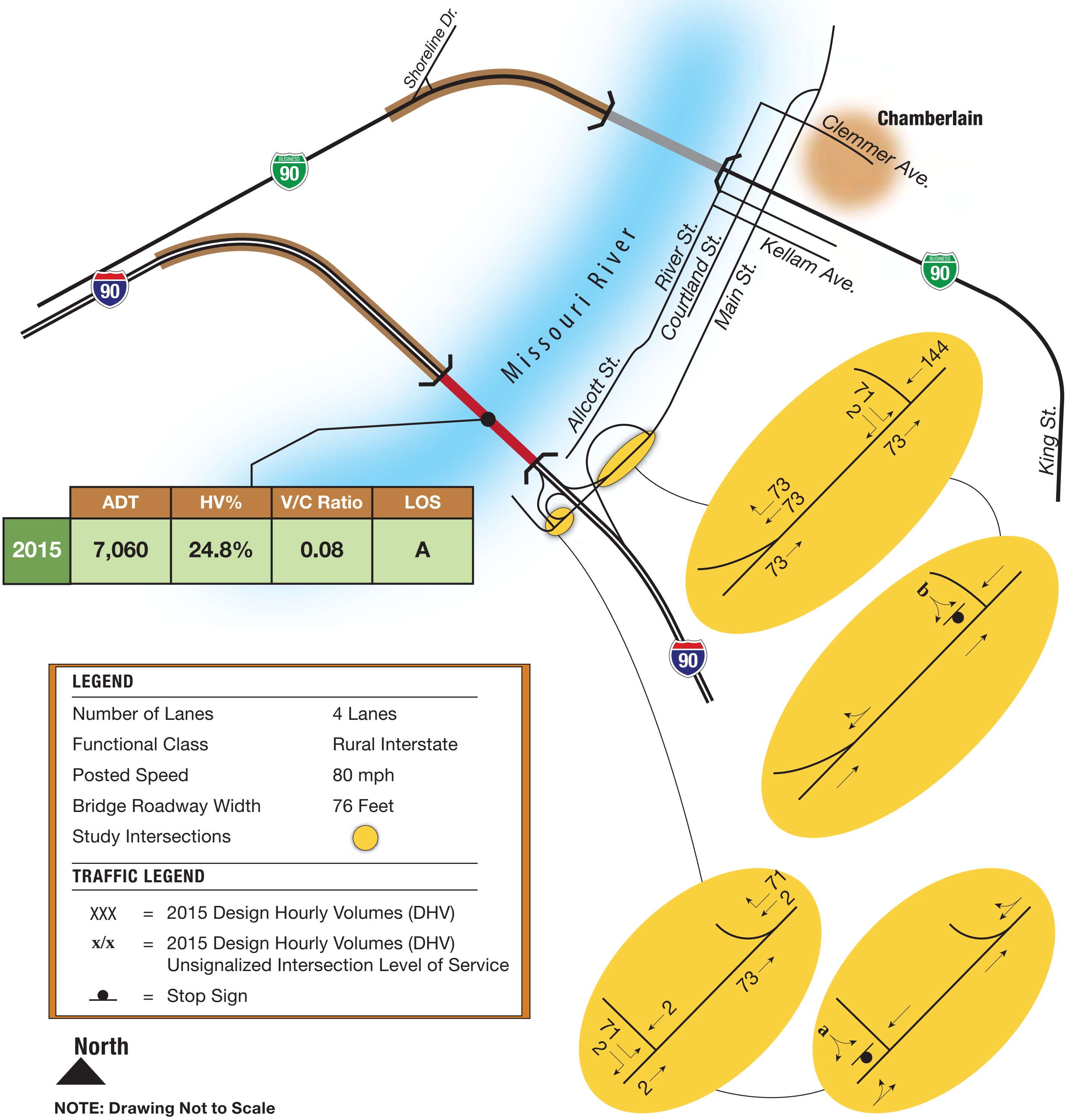
6.A.4. Traffic Analysis

I-90, categorized as a Rural Other Interstate, is located between Lyman County and Brule County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 7,060 in 2015. No peak period turning movement counts were available at the ramp terminals of I-90 with the Main Street Interchange. As such, FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop design hour traffic volumes for the intersections. The roadway has a heavy vehicle percentage of 24.8 percent. A vehicle classification count was not available for this location. Based on other classification counts throughout the state, the team assumed that of the heavy vehicle percentage 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.449 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.535 percent was developed, and a growth rate of 2.959 percent was developed for FHWA Vehicle Class 10-13. **Figure 6.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.3 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and peak hour traffic volumes, I-90 currently operates at LOS A with a flow rate of 185 pcphpl and a V/C ratio of 0.08.

At the unsignalized ramp terminals at the I-90 interchange with Main Street, all critical movements currently operate at LOS B or better under 2015 design hour traffic conditions.



	ADT	HV%	V/C Ratio	LOS
2015	7,060	24.8%	0.08	A

LEGEND

Number of Lanes	4 Lanes
Functional Class	Rural Interstate
Posted Speed	80 mph
Bridge Roadway Width	76 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2015 Design Hourly Volumes (DHV)

x/x = 2015 Design Hourly Volumes (DHV) Unsignalized Intersection Level of Service

(stop sign symbol) = Stop Sign

Figure 6.2

2015 Existing Conditions
Chamberlain/I-90
08-061-094

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6.A.5. Safety Analysis

The team used crash records compiled from SDDOT for I-90 in both the eastbound and westbound directions and on the ramps at the main street interchange. **Tables 6.2** and **6.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 6.2 I-90 (Structure #08-061-094) – Crash Data (2010–2014)

Location	Crash Type: No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
I 90 WB	11	1	0	1	0	0	13
I 90 EB	9	1	0	1	0	0	11
Main St. Interchange Ramps	6	0	0	0	0	0	6
Total	26	2	0	2	0	0	30

On westbound I-90, most collisions involved only one vehicle with an unknown object. Similar to westbound I-90, eastbound I-90 had multiple collisions involving a single vehicle striking an unknown object. Two collisions were animal related. On the I-90 Main Street Interchange Ramps, all of the collisions involved only one vehicle with an unknown object.

Table 6.3 I-90 (Structure #08-061-094) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
I 90 WB	0	0	1	2	10	13	7,060	12.88	1.01	2.55
I 90 EB	0	1	0	1	9	11	7,060	12.88	0.85	3.43
Main St. Interchange Ramps	0	0	1	1	4	6	4,000	7.30	0.82	2.84

Incapacitating (Incap.) Property Damage Only (PDO) * MEV= Million Entering Vehicles
N/A = Traffic Volume Data Currently not Available

The crash rates per MEV for the westbound I-90 and eastbound I-90 roadway segments are 1.01 and 0.85, respectively. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 2.55 for westbound I-90 and 3.43 for eastbound I-90. At the Main Street Interchange Ramps, the crash rate is 0.82, and the severity rate is 2.84. **Table 6.4** shows the identified crash patterns and possible contributing factors.

Table 6.4 I-90 (Structure #08-061-094) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Fixed Object Crash	▪ Guardrail

6.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge or roadway approaches. The paved shoulders on the bridge and roadway approaches are sufficient to offer cyclists an alternative to ride with some separation from vehicular traffic. Bicycling is allowed on the interstate shoulder in South Dakota unless specifically prohibited.

6.A.7. Coast Guard Requirements

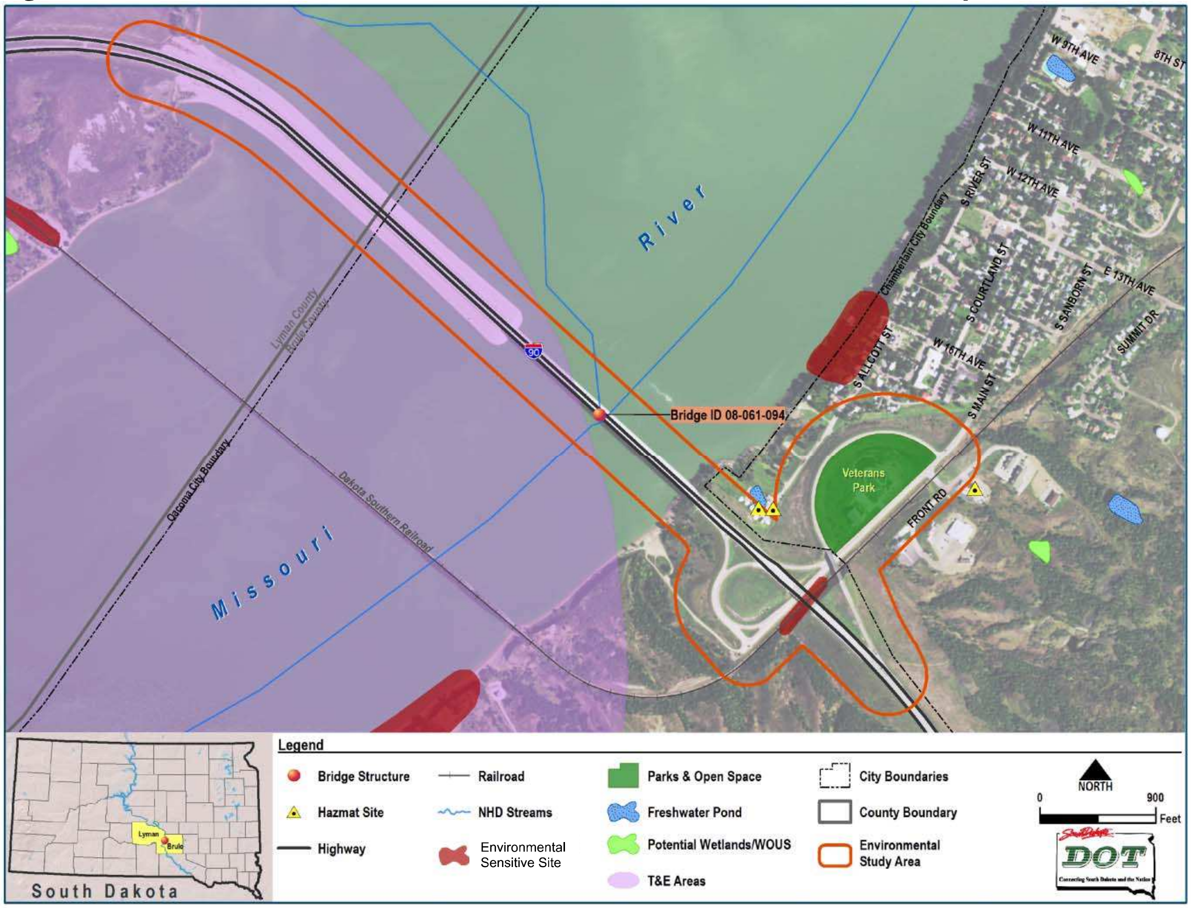
All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

6.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. Modern records of sturgeon chub exist within the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for several other state and federally listed species.
- Section 4(f) and Section 6(f). Section 4(f) properties are present within the project study area on the east side of the Missouri River, including South Dakota Veterans Park. The team suggests coordinating with the SDGFP during later phases of project planning to determine if South Dakota Veterans Parks is a Section 6(f) property.
- Section 106. Historic and archeological resources are present within the study area. Some sites are unevaluated and may require further surveys and evaluation.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly near the banks of the Missouri River. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Regulated Materials. Regulated materials within the project study area include underground storage tanks for gasoline. Additionally, a water treatment facility of the city of Chamberlain located within the study area has been in noncompliance for water quality standards but has low potential to impact the project.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within or near the study and could potentially be indirectly affected.
- Section 9. A contractor's work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Coordination with FHWA, USFWS, SDGFP, USCG, and the Tribes will likely be required.

Figure 6.3 Structure No. 08-061-094 Environmental Constraints Map



6.B. Future Conditions Analysis

The future conditions analysis conducted for the I-90 Chamberlain Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

6.B.1. Future Traffic Analysis

Using the previously mentioned growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, I-90 is estimated to have an ADT volume of 9,724 with a heavy vehicle percentage of 27.2 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis used a K factor of 8.3 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and HCS 2010, I-90 is anticipated to operate at LOS A with a flow rate of 257 (pcphpl), which equates to a V/C ratio of 0.11 in 2035. Figure 6.4 summarizes the future roadway and traffic conditions.

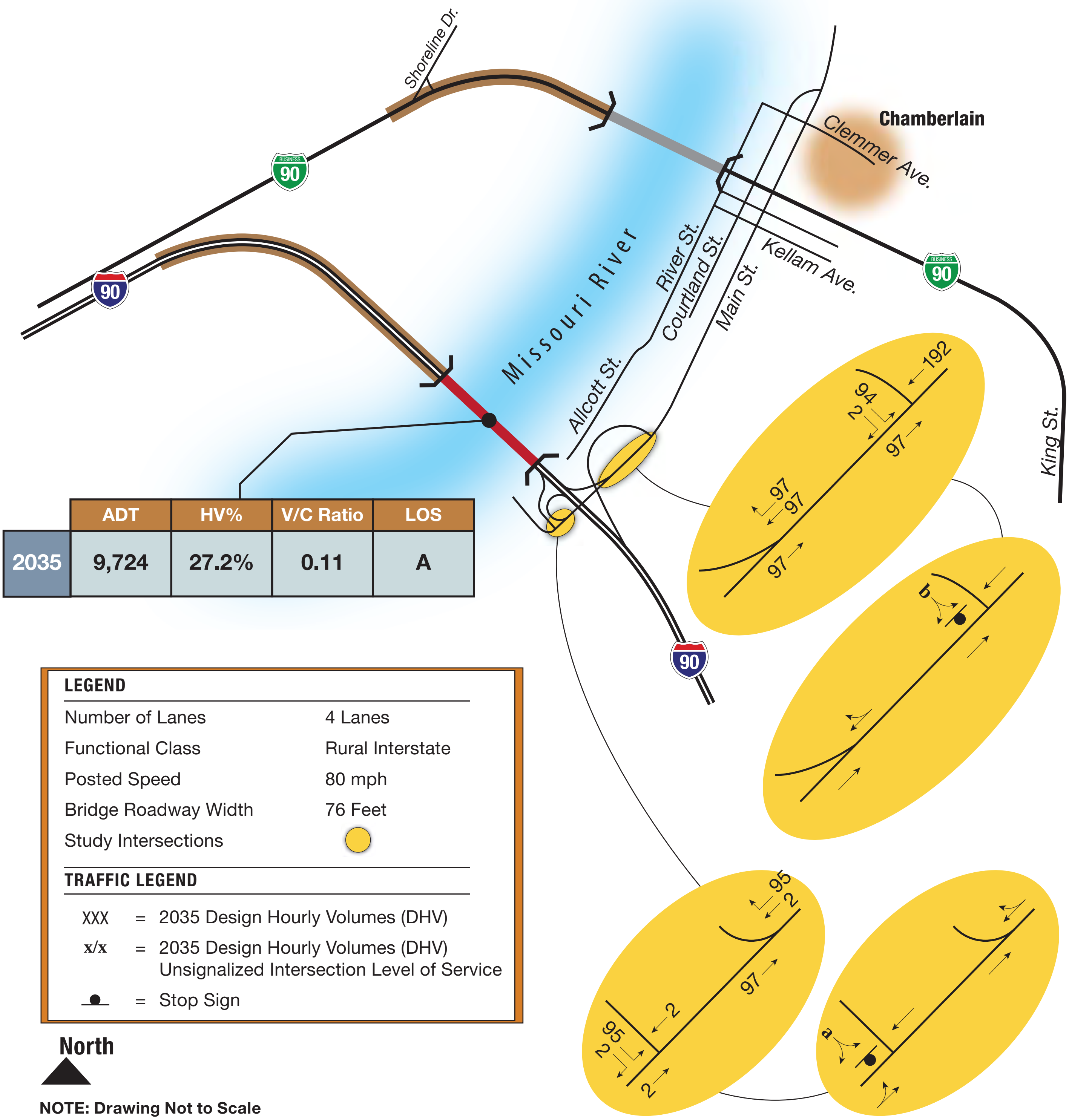
At the unsignalized ramp terminals at the I-90 interchange with Main Street, all critical movements are anticipated to operate at LOS B or better under 2035 design hour traffic conditions.

6.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

6.B.3. Safety Recommendations

The only identifiable crash patterns are fixed object collisions. Most of these collisions are guardrail related. It is recommended that rumble strips be considered on the paved shoulders of I-90 in the study area as a countermeasure.



	ADT	HV%	V/C Ratio	LOS
2035	9,724	27.2%	0.11	A

LEGEND

Number of Lanes	4 Lanes
Functional Class	Rural Interstate
Posted Speed	80 mph
Bridge Roadway Width	76 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2035 Design Hourly Volumes (DHV)

x/x = 2035 Design Hourly Volumes (DHV)
Unsignalized Intersection Level of Service

(stop symbol) = Stop Sign

North

NOTE: Drawing Not to Scale

Figure 6.4
2035 Future Conditions
Chamberlain/I-90
08-061-094

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7. Structure # 50-187-240

Structure No. 50-187-240 (I-229 N&S – 57th Street), located on I-229 in the south central portion of Sioux Falls, is the border between Lincoln County and Minnehaha County. The bridge spans West 57th Street, a five-lane, undivided roadway. The study area is generally centered on the structure and its approaches, extending approximately 0.5 miles along I-229 and 0.5 miles along West 57th Street.

This structure was constructed in 1995. Because this structure is currently under study as a part of the *I-229 Major Investment Corridor Study*, the team provided a cursory level review, including baseline conditions, future needs, and safety analyses. The team did not develop alternative improvement scenarios for this structure.

Figure 7.1 I-229 N & S – Structure # 05-187-240

7.A. *Baseline Conditions Analysis*

The team conducted a baseline conditions analysis for the I-229 North and South bridges for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

7.A.1. Additional Background Data

The City of Sioux Falls provided historic average daily traffic (ADT) data and peak hour counts for the study area roadways. The team also used data from the *I-229 Major Investment Corridor Study* to analyze traffic operations on I-229 and 57th Street. The team downloaded a copy of study documents from the City of Sioux Falls project website.

7.A.2. Roadway Conditions

West 57th Street passes under the I-229 structures. On the approaches to the underpass, 57th Street provides an urban five-lane cross section with curb and gutter, 62 feet in width. Through the underpass, the cross section widens to 80 feet with a 12-foot-wide painted median and 10-foot outside shoulders; the outside shoulders taper back approximately 300 feet to the east and west of the underpass entrance. Inside the underpass, 2-foot-wide paved sections are provided behind the curb on both the inside and outside shoulders. The speed limit is posted at 40 mph.

On I-229, the roadway cross section is a six-lane divided interstate, 150 feet in width. I-229 provides six 12-foot driving lanes with 6-foot inside paved shoulders and 10-foot outside paved shoulders. A 46-foot grass median is also provided. The speed limit is posted at 65 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, consideration should be made on 57th Street to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (40 mph or less) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. The existing cross section on 57th Street meets SDDOT design standards, but bicycle and pedestrian facilities are not provided. The cross section on I-299 also meets SDDOT design standards.

The I-229 approaches to the bridge provide concrete surfacing. The approach immediately east of the bridge has a Surface Condition Index of 3.31, and the west approach has an index of 2.95. **Table 7.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 7.1 I-229 (Structure #05-187-240) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
3.31	4.11	3.84	3.25	4.78	5.00	2.90	5.00
2.95	4.23	2.97	2.95	3.99	5.00	2.59	5.00

7.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. The review of the bridge found no load carrying capacity issues.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard lateral clearance under the structure and no sidewalks under the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
    - Culvert: 8

- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 82, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate. No major structural issues were found for this buried structure.

7.A.4. Traffic Analysis

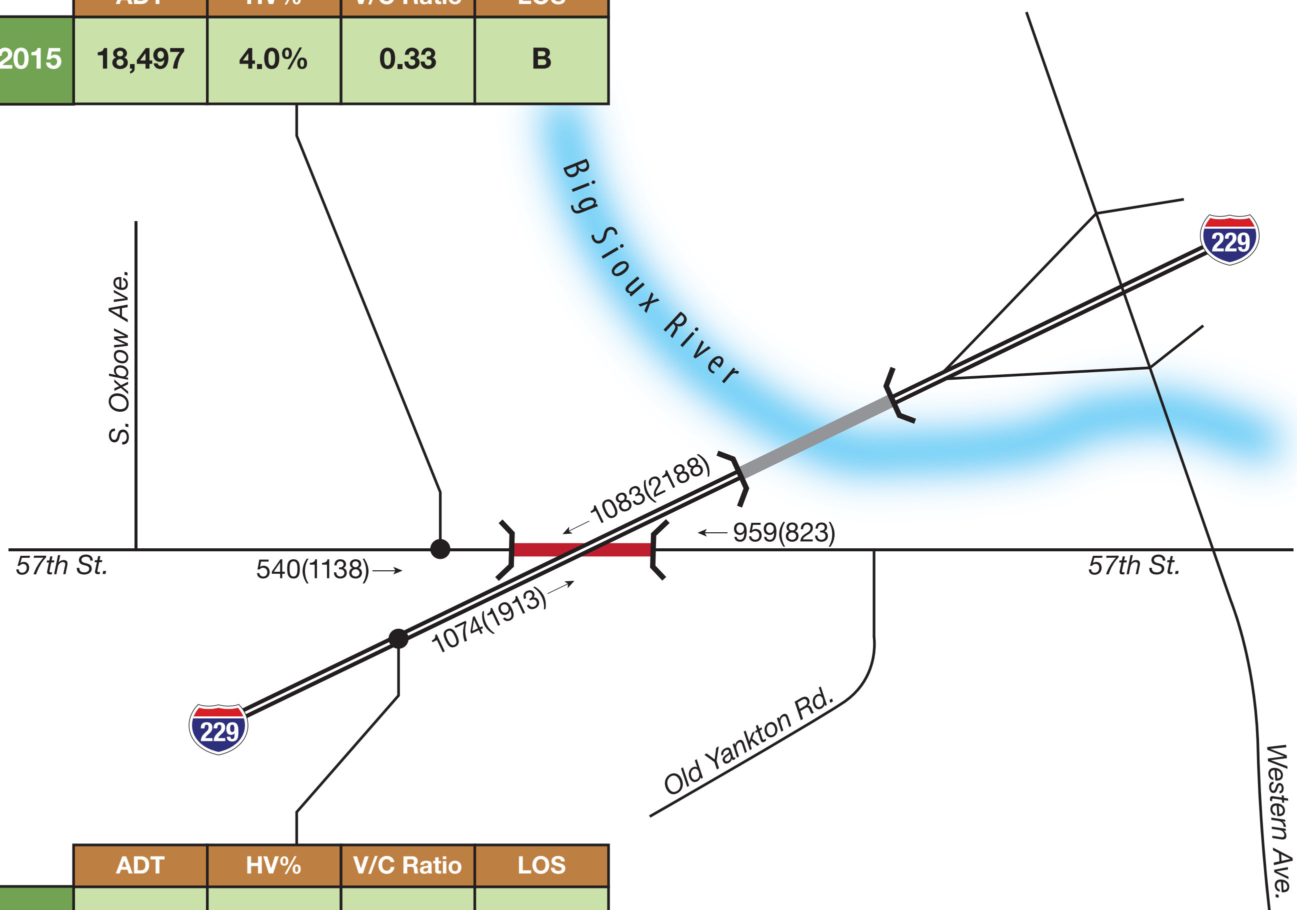
57th Street, categorized as an Urban Minor Arterial, is located on the Lincoln and Minnehaha county line. I-229 is categorized as Urban Interstate and is located in both Lincoln and Minnehaha counties. Based on the most current ADT volumes and growth rates provided by SDDOT and the City of Sioux Falls, 57th Street has an ADT volume of 18,497 in 2015, and I-229 has an ADT of 37,215. No peak period turning movement counts were analyzed for this structure. 57th Street has a heavy vehicle percentage of 4.0 percent, and I-229 has a heavy vehicle percentage of 7.5 percent.

A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

The Sioux Falls MPO provided 2035 travel demand model information for the 57th Street Tunnel study area. Based on the Sioux Falls model, 57th Street has an annual growth rate of 2.472 percent, and I-229 has an annual growth rate of 1.931 percent. SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. For heavy vehicles, FHWA Vehicle Class 5-9, growth rates of 1.790 percent and 1.961 percent were developed for 57th Street and I-229, respectively. Growth rates for FHWA Vehicle Class 10-13 of 3.097 percent and 2.963 percent were developed for 57th Street and I-229, respectively. **Figure 7.2** summarizes the roadway and traffic conditions.

The analysis used HCS 2010 software to determine the existing LOS of the roadways for the length of the tunnel structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.9 percent and a peak hour factor (PHF) of 0.92. The team used peak hour model output from the Sioux Falls MPO as a basis for the LOS calculations. Based on HCM methodologies and peak hour traffic volumes, 57th Street currently operates at LOS B with a flow rate of 630 (pcphpl), which equates to a V/C ratio of 0.33. I-229 currently operates at LOS B with a flow rate of 824 (pcphpl), which equates to a V/C ratio of 0.35.

	ADT	HV%	V/C Ratio	LOS
2015	18,497	4.0%	0.33	B



	ADT	HV%	V/C Ratio	LOS
2015	37,215	7.5%	0.35	B

LEGEND

Number of Lanes	6 Lanes (I-229) 5 Lanes (57th Street)
Functional Class	Urban Interstate (I-229) Urban Minor Arterial (57th Street)
Posted Speed	65 mph (I-229) 40 mph (57th Street)
Bridge Roadway Width	150 Feet (I-229) 80 Feet (57th Street)

North

NOTE: Drawing Not to Scale

Figure 7.2
2015 Existing Conditions
I-229 over 57th Street
50-187-240

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7.A.5. Safety Analysis

The team used crash records compile from SDDOT for northbound and southbound I-229 and 57th Street. **Tables 7.2** and **7.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 7.2 I-229 and 57th Street (Structure #50-187-240) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
I-229 SB	19	4	0	1	1	0	25
I-229 NB	9	1	0	2	1	0	13
57th St.	6	7	0	5	1	0	19
Total	**34**	**12**	**0**	**8**	**3**	**0**	**57**

Most crashes on I-229 consisted of single vehicle crashes with an unknown object. There were four incidences of rear end collisions on southbound I-229 on the structure. Three identifiable crash patterns occurred on 57th Street. A combination of rear ends, angle crashes, and collisions with a fixed object was observed. Most rear end and angle type collisions occurred near the intersections of Bur Oak Plaza and Old Yankton Road with 57th Street.

Table 7.3 I-229 and 57th Street (Structure #50-187-240) – Crash Rates (2010–2014)

	Crashes by Severity									
Roadway Segment	1- Fatal	2- Incap.	3- Non- Incap.	4- Possible	5- PDO	Total	Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
I-229 SB	0	0	3	3	19	25	18,492	33.75	0.74	2.05
I-229 NB	0	0	2	0	11	13	18,746	34.21	0.38	0.95
57th St.	0	0	2	3	14	19	18,497	33.76	0.56	1.59
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rates per MEV for the southbound I-229 and northbound I-229 roadway segments are 0.74 and 0.38, respectively. The severity rate per MEV, which applies a cost factor to the different crash severity types, is 2.05 for southbound I-229 and 0.95 for northbound I-229. The crash rate per MEV for the roadway segment of 57th Street is 0.56. The severity rate per MEV is 1.59. **Table 7.4** shows the identified crash patterns and possible contributing factors.

Table 7.4 I-229 and 57th Street (Structure #50-187-240) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Fixed Object Crash (I-229)	▪ Guardrail
Rear Ends (57th Street)	▪ Rear driver aggressive looking over shoulder ▪ Front driver less aggressive and hesitates
Angle (57th Street)	▪ Inadequate gaps - peak period

7.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided through the underpass or on its approaches along 57th Street. The outside shoulders would be of sufficient width for cyclists to ride with some separation from vehicular traffic through the tunnel. Existing pedestrian and bicycle facilities are provided on both the north and south sides of 57th Street. To the east of the underpass, a sidewalk runs along the south side of 57th Street, terminating just west of Old Yankton Road. To the west of the underpass, the sidewalks run along both the north and south sides of 57th Street, terminating at the intersection with Burr Oak Plaza. A connection to the Sioux Falls Bike Trail also terminates on the north side of 57th Street at Burr Oak Plaza. There is currently a gap in the bicycle/pedestrian network along 57th Street approaching the underpass.

7.A.7. Coast Guard Requirements

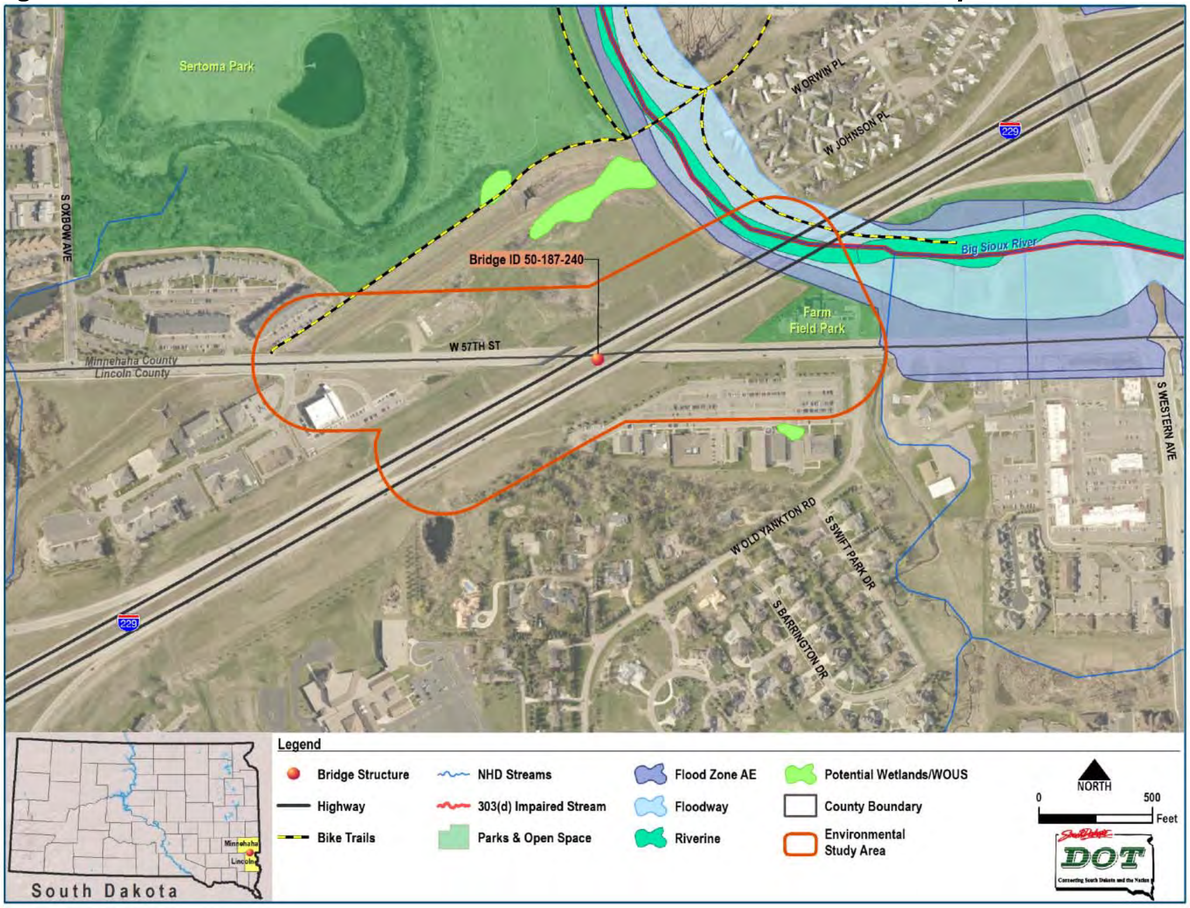
Coast Guard requirements are not applicable for this structure.

7.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. No documented records of state or federally endangered species are present within a mile of the project, but potential habitat is present within and adjacent to the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f) and Section 6(f). A Section 4(f) property, Farm Field Park, is present in the southeast corner of the project study area. Section 6(f) properties are present in the vicinity of the project but are unlikely to be impacted.
- Section 106. Archeological surveys were conducted within portions of the study area, with last surveys conducted in 1993 and 1994. Additional surveys may reveal new information.
- Wetlands and Waters of the US. The perennial Big Sioux River is present in the northeast corner of the project study area. Other wetlands and Waters of the US may be present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as E. Coli, Fecal Coliform, and Total Suspended Solids. Total Maximum Daily Loads for non-point sources should be considered for drainage associated with any bridge improvements.
- Floodplains and Floodways. FEMA Flood Zone AE and floodway are mapped within the project study area. A floodplain permit may be required depending on the scope of work required for the project.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within the vicinity of the study area and could potentially be indirectly affected. Limited English Proficiency populations are present in other areas of Sioux Falls but not within or adjacent to the study area.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, and the Tribes) will be required during the NEPA process.

Figure 7.3 Structure No. 50-187-240 Environmental Constraints Map



7.B. Future Conditions Analysis

The future conditions analysis conducted for the I-229 bridges over 57th Street determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

7.B.1. Future Traffic Analysis

The Sioux Falls MPO provided 2035 travel demand model information for I-229 and 57th Street in the study area. Based on the Sioux Falls model, 57th Street has an annual growth rate of 2.47 percent, and I-229 has an annual growth rate of 1.93 percent.

For 2035, 57th Street is projected to have an ADT volume of 30,000, and I-229 is projected to have an ADT of 58,000. The heavy vehicle percentage on 57th Street is forecast at 3.9 percent and 7.6 percent on I-229.

The team used peak hour model output from the Sioux Falls MPO as a basis for the LOS calculations, with a PHF of 0.92. The PM peak hour was identified as the controlling peak period for analysis. The results below are shown for the 2035 PM peak period. Based on HCM methodologies and HCS 2010, 57th Street is anticipated to operate at LOS C with a flow rate of 924 (pcphpl), which equates to a V/C ratio of 0.49. I-229 is anticipated to operate at LOS C with a flow rate of 1,343 (pcphpl), which equates to a V/C ratio of 0.57. **Figure 7.4** summarizes the 2035 future roadway and traffic conditions.

7.B.2. Additional Lanes Needs

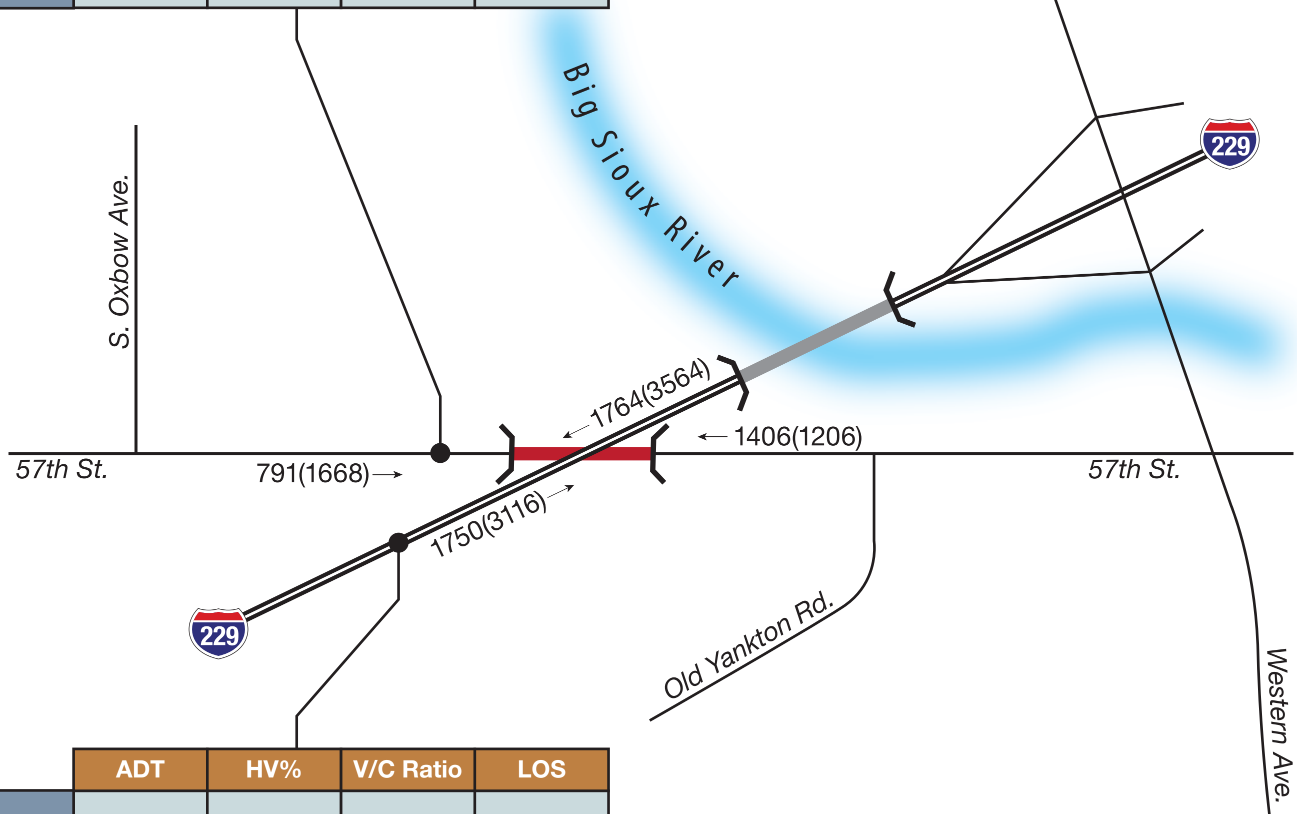
This structure was identified as one of the key locations to determine the approximate year that additional lanes would be needed. Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes. The year at which additional lanes were required was determined when the V/C ratio exceeded 1.0. Traffic volumes were grown annually in an iterative process until this threshold was exceeded. Based on the results of the additional lanes needs analysis, 57th Street is anticipated to reach a V/C ratio greater than 1.0 in year 2073. For I-229, traffic forecasts for year 2058 indicate a V/C ratio greater than 1.0.

The team compared the results of this analysis with initial findings in the *I-229 Major Investment Corridor Study.* The methodologies for determining V/C ratios varied between the studies; however, similar results and findings were determined.

7.B.3. Safety Recommendations

On I-229, the only identifiable crash patterns are fixed object collisions. Most of these collisions are guardrail related. The installation of rumble strips on the paved shoulders of I-229 may help to reduce these types of collisions; however, in an urban environment, they may be undesirable due to potential noise impacts. On 57th Street, there is a pattern of angle and rear end type collisions. These types of crash patterns are typical for urban roadways with closely spaced access points. No countermeasures are recommended; however, if a significant pattern becomes apparent in the future, a more detailed safety study should be completed along the corridor.

	ADT	HV%	V/C Ratio	LOS
2035	30,000	3.9%	0.49	C



	ADT	HV%	V/C Ratio	LOS
2035	58,000	7.6%	0.57	C

LEGEND

Number of Lanes	6 Lanes (I-229) 5 Lanes (57th Street)
Functional Class	Urban Interstate (I-229) Urban Minor Arterial (57th Street)
Posted Speed	65 mph (I-229) 40 mph (57th Street)
Bridge Roadway Width	150 Feet (I-229) 80 Feet (57th Street)

North

NOTE: Drawing Not to Scale

Figure 7.4
2035 Future Conditions
I-229 over 57th Street
50-187-240

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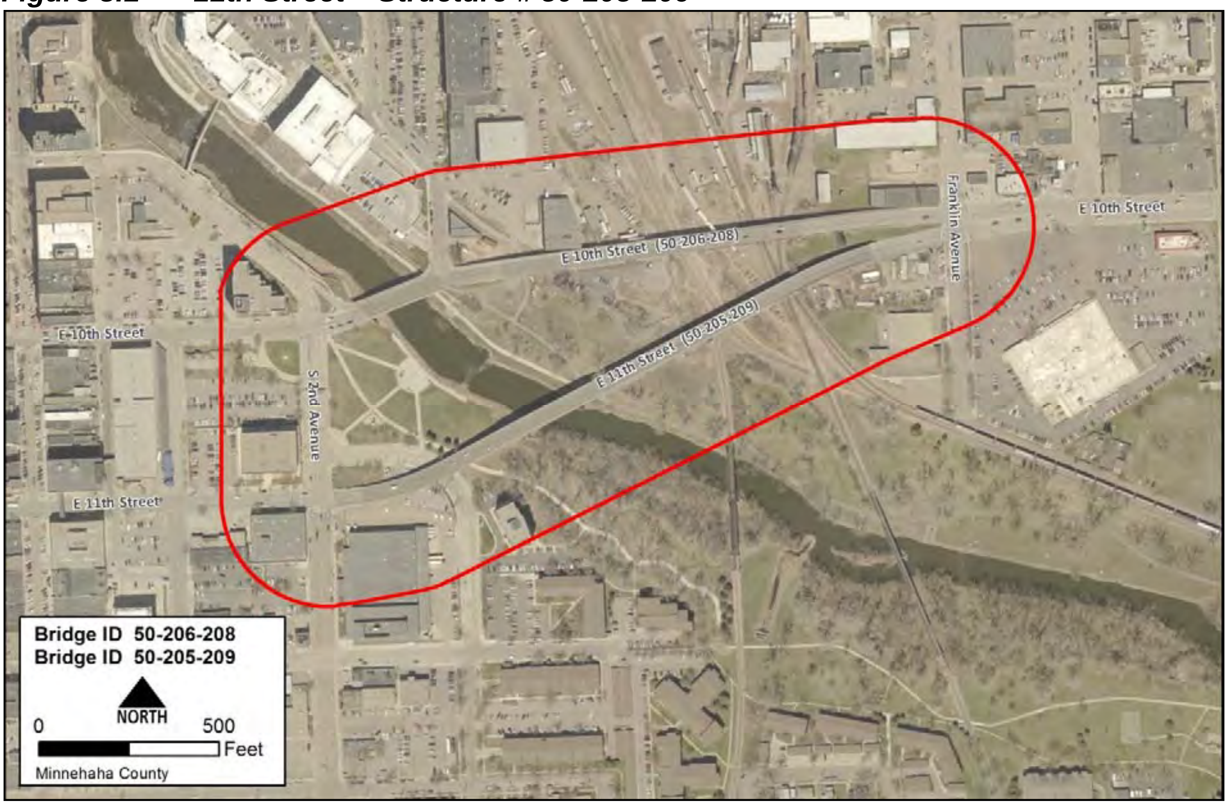
8. Structure # 50-205-209

Structure No. 50-205-209 (SD 42 – 11th Street) spans the BNSF rail yard and the Big Sioux River near downtown Sioux Falls in Minnehaha County. The study area is approximately 0.5 miles long and extends approximately 300 feet beyond the center of the structure to the south but extends approximately 600 feet beyond the structure to the north. The study area is combined with that of another adjacent project structure to the north (Structure No. 50-206-208 on E. 10th Street). The search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure, constructed in 1971, underwent a major rehabilitation provided in 1986. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 8.1 11th Street – Structure # 50-205-209



8.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the 11th Street bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

8.A.1. Additional Background Data

The City of Sioux Falls provided historic average daily traffic (ADT) data and peak hour counts for the study area roadways, along with peak hour turning movement counts for the study area intersections. The team also reviewed data from the *I-229 Major Investment Study Exit 6 – 10th Street*, the *Sioux Falls MPO Multi-Use Trail Study*, and *the Sioux Falls Greenway & Riverfront Master Plan* for this evaluation. The team downloaded the study documents from the City of Sioux Falls project website.

8.A.2. Roadway Conditions

The 11th Street Viaduct spans the BNSF Railway tracks and the Big Sioux River in Downtown Sioux Falls. 11th Street runs one-way eastbound and has an urban three-lane cross section with curb and gutter, 40 feet in width. A barrier wall is adjacent to both the inside and outside lanes; no shoulders are provided. A 5-foot-wide sidewalk is provided on the south side of the viaduct behind the barrier wall. The speed limit on 11th Street is posted at 30 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (40 mph or less) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. Because the 5-foot sidewalk on the south side of the viaduct provides a facility for pedestrians and bicycles, the existing cross section on 11th Street meets SDDOT design standards.

The City of Sioux Falls provided pavement conditions for the approaches to the 11th Street viaduct in their *2014 Pavement Management Report*. The report provides an Overall Condition Index (OCI) with three levels of condition. Pavements with an OCI of 10 are in perfect condition, a score of 8.5 to 9.5 indicates that maintenance is needed, while a score below 8.5 indicates that surface remedial treatment is needed. The OCI score shown in **Table 8.1** begins just west of the structure at the intersection with 2nd Avenue South and extends across the bridge to near the intersection with North Franklin Avenue to the east.

Table 8.1 11th Street Viaduct (Structure #50-205-209) – Pavement Condition (2014)

From	To	Surface Type	OCI	Length (ft)
2nd Ave. South	North Franklin Ave.	Concrete	8.97	1,950

8.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. The review of this bridge found no load carrying capacity issues.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and substandard horizontal clearance to the railroad centerline.

- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 7
  - Superstructure: 6
  - Substructure: 7
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 79.5, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Fatigue cracking in welds of diaphragms and stiffeners
  - Bolts missing in girder splices

8.A.4. Traffic Analysis

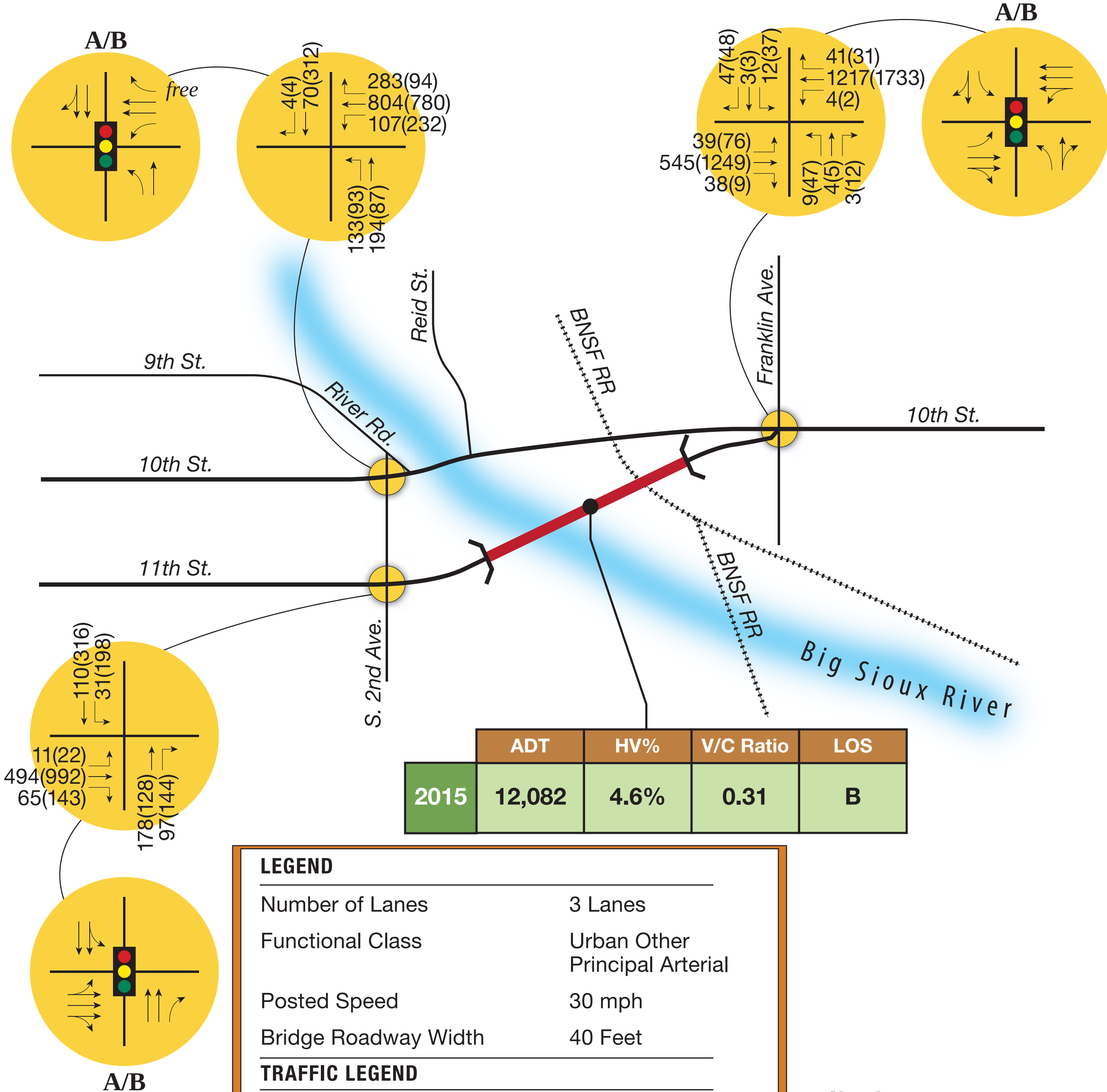
Located in Minnehaha County, 11th Street is categorized as an Urban Other Principal Arterial. Based on the most current ADT volumes and growth rates provided by SDDOT and the City of Sioux Falls, 11th Street has an ADT volume of 12,082 in 2015, and a heavy vehicle percentage of 4.6 percent. Peak period turning movement counts were provided for this structure at the intersections of 11th Street/2nd Avenue and at 10th Street/11th Street with Franklin Avenue. **Figure 8.2** shows the AM and PM peak hour turning volumes, along with the intersection lane configuration.

A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

The Sioux Falls MPO provided 2035 travel demand model information for the 11th Street Viaduct study area. Based on the Sioux Falls model, 11th Street has an annual growth rate of -0.087 percent (future volumes are expected to decrease). SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. For heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.381 percent was used, and a growth rate of 2.971 percent was used for FHWA Vehicle Class 10-13. **Figure 8.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. Peak hour model output from the Sioux Falls MPO was used as a basis for the LOS calculations; a peak hour factor (PHF) of 0.92 was used. Based on HCM methodologies and peak hour traffic volumes, 11th Street currently operates at LOS B with a peak flow rate of 495 pcphpl and a V/C ratio of 0.31.

The signalized intersections of 11th Street/2nd Avenue and 10th Street/Franklin Avenue currently operate at LOS B or better under 2015 AM and PM peak hour traffic conditions.



	ADT	HV%	V/C Ratio	LOS
2015	12,082	4.6%	0.31	B

LEGEND

Number of Lanes	3 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	30 mph
Bridge Roadway Width	40 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

X/X = AM/PM Peak Hour Signalized Intersection Level of Service

= Traffic Signal

= Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 8.2
2015 Existing Conditions
11th Street Viaduct over Big Sioux River and BNSF RR
50-205-209

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8.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the 11th Street roadway structure and for the intersection of 11th Street/2nd Avenue. **Tables 8.2** and **8.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 8.2 11th Street (Structure #50-205-209) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
11th St. Bridge	2	1	1	0	0	0	4
11th St./2nd Ave.	6	4	1	19	3	0	33
Total	**8**	**5**	**2**	**19**	**3**	**0**	**37**

At the intersection of 11th Street/2nd Avenue, the most consistent crash pattern was a right-angle collision between two vehicles. Six collisions also involved a single vehicle with a fixed object.

Table 8.3 11th Street (Structure #50-205-209) – Crash Rates (2010–2014)

Roadway Segment or Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
11th St. Bridge	0	1	0	1	2	4	12,082	22.05	1.50	8.47
11th St./2nd Ave.	0	3	4	6	20	33	22,374	40.83	0.81	4.57
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment of the 11th Street Bridge is 1.50. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 8.47. The crash rate per MEV for the intersection of 11th Street/2nd Avenue is 0.81. The severity rate per MEV is 4.57. **Table 8.4** shows the identified crash patterns and possible contributing factors.

Table 8.4 11th Street (Structure #50-205-209) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Angle (11th St./2nd Ave.)	▪ Inadequate gaps - peak period

8.A.6. Bicycle/Pedestrian Facilities

Currently, the 5-foot sidewalk on the south side of the viaduct provides access for pedestrians and bicycles; there are no pedestrian facilities on the north side of the viaduct. The width of the sidewalk on the south side does not allow bicycles to pass each other head to head.

On the east end of the viaduct, the sidewalk ties into the signalized intersection of 10th Street/ 11th Street with Franklin Avenue. All four legs of the intersection provide crosswalks and pedestrian signal heads.

On the west end of the viaduct, the sidewalk ties into the signalized intersection of 11th Street/ 2nd Avenue. All four legs of the intersection provide crosswalks and pedestrian signal heads. A connection is provided to the Beadle Greenway just to the north of 11th Street in Fawick Park.

8.A.7. Coast Guard Requirements

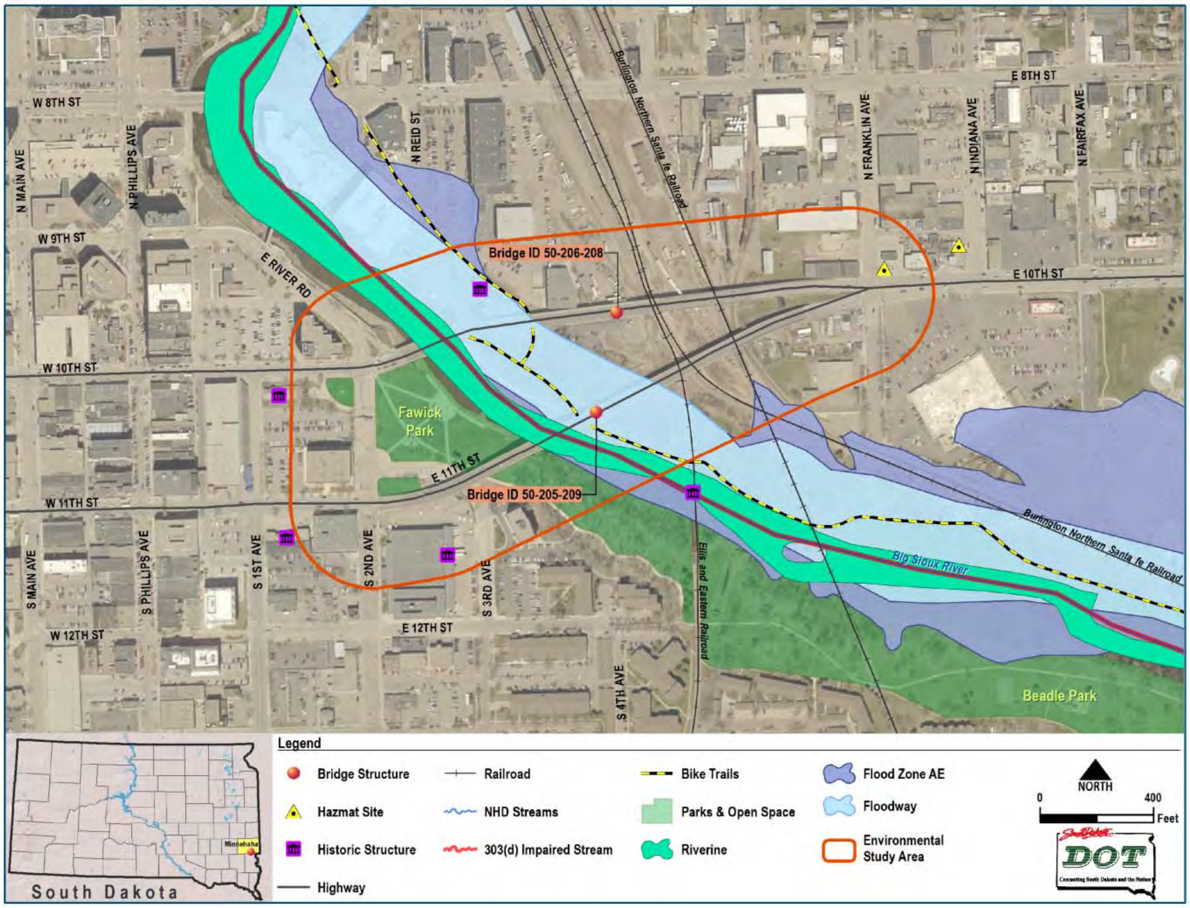
Coast Guard requirements are not applicable to this structure.

8.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. Modern records of the state threatened northern river otter are present in the project study area and habitat is present in the Big Sioux River. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f). Section 4(f) properties are present within the study area, including Fawick Park, Beadle Greenway Park, and the Sioux Falls Bike Trail.
- Section 106. Historic properties within the study area include a building eligible for placement on the National Register of Historic Places and an age-eligible unevaluated structure. Further surveys and evaluation may be necessary.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly along the fringes of the Big Sioux River. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as E. Coli, Fecal Coliform, and Total Suspended Solids. Total Maximum Daily Loads for non-point sources should be considered for drainage associated with any bridge improvements.
- Regulated Materials. Regulated materials within the project study area include sites with gasoline below ground storage tanks near the east end of the project study area.
- Floodplains and Floodways. FEMA Flood Zone AE and floodway are mapped within the project study area. A floodplain permit may be required depending on the scope of work required for the project.
- Right-of-Way. Some businesses in the area are close to the project ROW. The likelihood for displacement will depend on the scope of work and will be determined during later phases of construction.
- Title VI (Civil Rights) and Environmental Justice. Low-income, minority, and vulnerable age populations are present within the vicinity of the project and could potentially be indirectly affected.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, and the Tribes) will be required during the NEPA process.

Figure 8.3 Structure No. 50-205-209 Environmental Constraints Map



8.B. Future Conditions Analysis

The future conditions analysis conducted for the 11th Street Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

8.B.1. Future Traffic Analysis

The Sioux Falls MPO provided 2035 travel demand model information for 10th Street and 11th Street in the study area. Based on the Sioux Falls model, 11th Street has an annual growth rate of -0.09 percent and 10th Street has an annual growth rate of 0.13 percent. The team confirmed these numbers with Sioux Falls MPO. The slight decrease on 11th Street and increase on 10th Street are related to a future Rice-Russell connection shown in the traffic model study area. For 2035, 11th Street is estimated to have an ADT volume of 11,801 and a heavy vehicle percentage of 7.0 percent. Although traffic volumes have not increased significantly, heavy vehicle volumes are anticipated to increase. This is due to the application of the heavy vehicle growth rates when developing the traffic forecasts. SDDOT provided the rates, which show higher growth for heavy vehicles.

The analysis used peak hour model output from the Sioux Falls MPO as a basis for the LOS calculations and a PHF of 0.92. The PM peak hour was identified as the controlling peak period for the analysis. The results below are shown for the 2035 PM peak period. Based on HCM methodologies and HCS 2010, 11th Street is anticipated to operate at LOS C with a flow rate of 552 (pcphpl), which equates to a V/C ratio of 0.35.

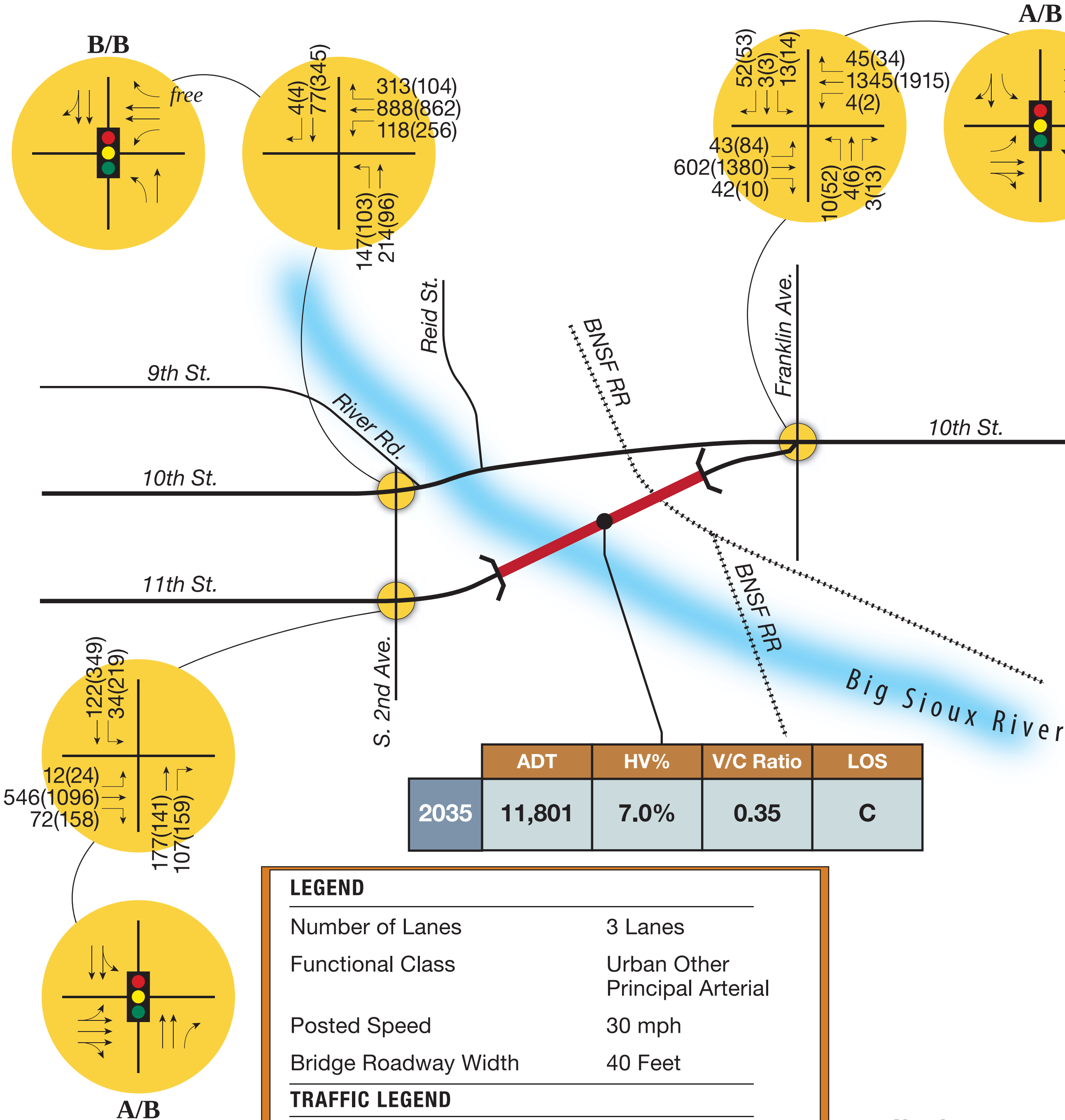
The signalized intersections of the 11th Street/2nd Avenue and 10th Street/Franklin Avenue are anticipated to operate at LOS B or better under 2035 AM and PM peak hour traffic conditions. **Figure 8.4** summarizes 2035 future roadway and traffic conditions.

8.B.2. Additional Lanes Needs

The analysis identified this structure as one of the key locations to determine the approximate year in which additional lanes would be needed. Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes. The analysis determined the year at which additional lanes will be required when the V/C ratio exceeded 1.0. Traffic volumes were grown annually in an iterative process until this threshold was exceeded. Based on the results of the additional lanes needs analysis, it was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

8.B.3. Safety Recommendations

The analysis shows a pattern of angle collisions at the 11th Street intersection with 2nd Street. This type of crash pattern is typical for a signalized intersection. No countermeasures are recommended; however, if the pattern continues to worsen or a more significant pattern becomes apparent in the future, a more detailed safety study should be completed at the intersection.



	ADT	HV%	V/C Ratio	LOS
2035	11,801	7.0%	0.35	C

LEGEND

Number of Lanes	3 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	30 mph
Bridge Roadway Width	40 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

X/X = AM/PM Peak Hour Signalized Intersection Level of Service

= Traffic Signal

= Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 8.4

2035 Future Conditions

11th Street Viaduct over Big Sioux River and BNSF RR

50-205-209

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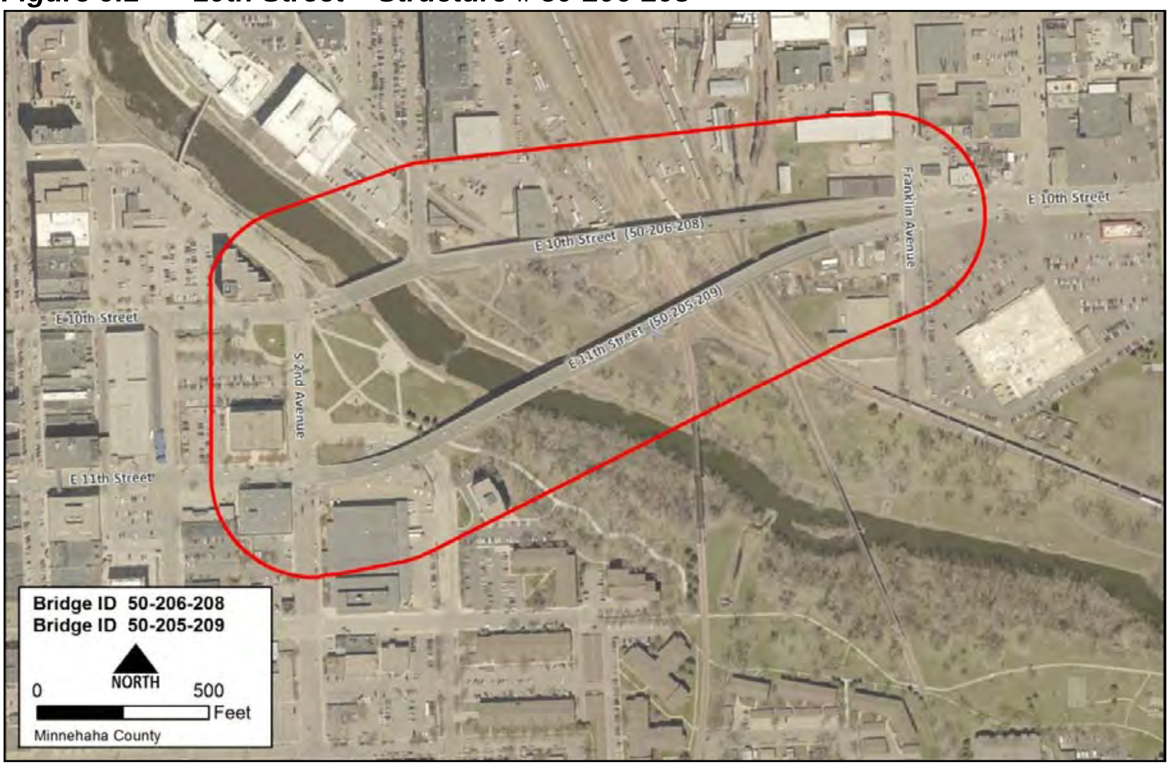
9. Structure # 50-206-208

Structure No. 50-206-208 (SD 42 – 10th Street) spans the BNSF rail yard and the Big Sioux River near downtown Sioux Falls in Minnehaha County. The study area is approximately 0.5 miles long and extends approximately 300 feet beyond the center of the structure to the north, but extends approximately 600 feet beyond the structure to the south. The study area is combined with that of another adjacent project structure to the south (Structure No. 50-205-209 on E. 11th Street). The search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure, constructed in 1930, underwent a major rehabilitation in 1979. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 9.1 10th Street – Structure # 50-206-208



9.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the 10th Street bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

9.A.1. Additional Background Data

The City of Sioux Falls provided historic average daily traffic (ADT) data and peak hour counts for the study area roadways and peak hour turning movement counts for the study area intersections.

The team also reviewed data from the I-229 Major Investment Study Exit 6 – 10th Street, the Sioux Falls MPO Multi-Use Trail Study, and the Sioux Falls Greenway & Riverfront Master Plan for this evaluation. The team downloaded study documents from the City of Sioux Falls project website.

9.A.2. Roadway Conditions

The 10th Street Viaduct spans the BNSF Railway tracks and yard in downtown Sioux Falls. 10th Street runs one-way westbound and has an urban three-lane cross section with curb and gutter, 40 feet in width. There is a barrier wall adjacent to both the inside and outside lanes; no shoulders are provided. A 5-foot-wide sidewalk is provided on the north side of the viaduct behind the barrier wall. The speed limit on 10th Street is posted at 30 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (40 mph or less) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. Because the 5-foot sidewalk on the north side of the viaduct provides a facility for pedestrians and bicycles, the existing cross section on 10th Street meets SDDOT design standards.

The City of Sioux Falls provided pavement conditions for the approaches to the 10th Street viaduct in their *2014 Pavement Management Report*. The report provides an Overall Condition Index (OCI) with three levels of condition. Pavements with an OCI of 10 are in perfect condition, a score of 8.5 to 9.5 indicates that maintenance is needed, while a score of below 8.5 indicates that surface remedial treatment is needed. **Table 9.1** shows the OCI scores for the approaches and bridge surface for the 10th Street viaduct.

Table 9.1 10th Street Viaduct (Structure #50-205-208) – Pavement Condition (2014)

From	To	Surface Type	OCI	Length (ft)
2nd Ave. South	River Road South	Concrete	7.40	123
River Road South	Reid Street South	Concrete	8.51	379
Reid Street South	North Franklin Ave.	Concrete	8.59	1,438

9.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (33 tons).
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and substandard horizontal clearance to the railroad centerline.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge.
  - Deck: 7
  - Superstructure: 5
  - Substructure: 6

- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 64.8, indicating a structure in average structural condition. This bridge is classified as Functionally Obsolete because the underclearance item codes as 2.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Girder rust and section loss in cross-braces
  - Spalling at Abutment 20, backwall cracked
  - Past movement allowance at Abutment 20
  - Cracked bearing plates

9.A.4. Traffic Analysis

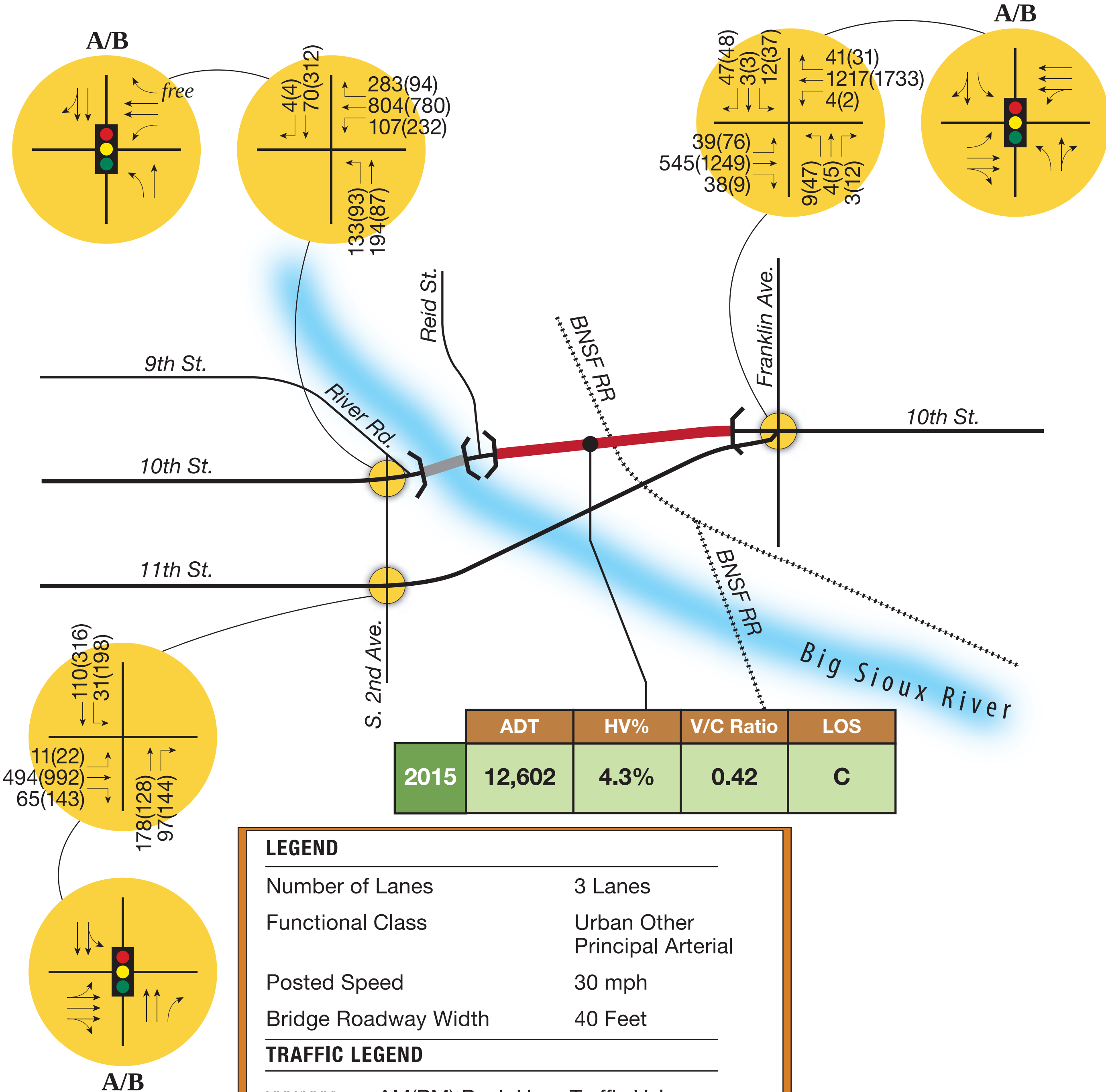
10th Street, categorized as an Urban Other Principal Arterial, is located in Minnehaha County. Based on the most current ADT volumes and growth rates provided by SDDOT and the City of Sioux Falls, 10th Street has an ADT volume of 12,602 in 2015 and a heavy vehicle percentage of 4.3 percent. Peak period turning movement counts were provided for this structure at the intersections of 10th Street/2nd Avenue and at 11th Street/10th Street with Franklin Avenue. **Figure 9.2** shows the AM and PM peak hour turning volumes, along with the intersection lane configuration.

A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

The Sioux Falls MPO provided 2035 travel demand model information for the 10th Street Viaduct study area. Based on MPO model, 10th Street has an annual growth rate of 0.129 percent. SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. For heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.381 percent was used, and a growth rate of 2.971 percent was used for FHWA Vehicle Class 10-13. **Figure 9.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used peak hour model output from the Sioux Falls MPO as a basis for the LOS calculations and a peak hour factor (PHF) of 0.92. Based on HCM methodologies and peak hour traffic volumes, 10th Street currently operates at LOS C with a peak flow rate of 675 pcphpl and a V/C ratio of 0.42.

The signalized intersections of 10th Street/2nd Avenue and 11th Street/Franklin Avenue currently operate at LOS B or better under 2015 AM and PM peak hour traffic conditions.



	ADT	HV%	V/C Ratio	LOS
2015	12,602	4.3%	0.42	C

LEGEND

Number of Lanes	3 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	30 mph
Bridge Roadway Width	40 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

X/X = AM/PM Peak Hour Signalized Intersection Level of Service

= Traffic Signal

= Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 9.2
2015 Existing Conditions
10th Street Viaduct over BNSF RR
50-206-208

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9.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the intersections of 10th Street with Reid Street and 2nd Avenue, and for the intersection of 10th Street/11th Street with Franklin Avenue. **Tables 9.2** and **9.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 9.2 10th Street (Structure #50-206-208) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
10th St./Reid St.	0	3	0	0	0	0	3
10th St./2nd Ave.	1	2	0	1	3	0	7
10th St./11th St./Franklin Ave.	5	5	0	6	3	0	19
Total	**6**	**10**	**0**	**7**	**6**	**0**	**29**

The intersection of 10th Street with Reid Street had only rear end collisions. Two types of crashes were present for the intersection of 10th Street with 2nd Avenue: sideswipes in the same direction and rear end crashes. On Franklin Avenue, where 10th Street and 11th Street converge, there were multiple types of crashes with no identified distinct pattern.

Table 9.3 10th Street (Structure #50-206-208) – Crash Rates (2010–2014)

Roadway Segment or Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
10th St./Reid St.	0	0	0	0	3	3	13,402	24.46	0.12	0.12
10th St./2nd Ave.	0	0	0	1	6	7	20,819	37.99	0.18	0.32
10th St./11th St./Franklin Ave.	0	1	3	1	14	19	24,415	44.56	0.43	1.82
Incapacitating (Incap.)	Property Damage Only (PDO)					* MEV= Million Entering Vehicles				

For the intersections of 10th Street with Reid Street, and 10th Street and 2nd Avenue, the crash rates per MEV are 0.12 and 0.18, respectively. The severity rate per MEV is 0.12 for the intersection of 10th Street with Reid Street and 0.32 for the intersection of 10th Street with 2nd Avenue. The crash rate per MEV for the intersection of 10th Street and 11th Street converging with Franklin Avenue is 0.43. The severity rate per MEV is 1.82. **Table 9.4** shows the identified crash patterns and possible contributing factors.

Table 9.4 10th Street (Structure #50-206-208) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Rear End (10th St. / Reid St.)	▪ Rear driver aggressive looking over shoulder ▪ Front driver less aggressive and hesitates

9.A.6. Bicycle/Pedestrian Facilities

Currently, the 5-foot sidewalk on the north side of the viaduct provides access for pedestrians and bicycles; there are no pedestrian facilities on the south side of the viaduct. The width of the sidewalk on the north side does not allow bicycles to pass each other head to head.

On the east end of the viaduct, the sidewalk ties into the signalized intersection of 10th Street/ 11th Street with Franklin Avenue. All four legs of the intersection provide crosswalks and pedestrian signal heads.

On the west end of the viaduct, the sidewalk turns to the north onto Reid Street; there is no sidewalk ramp or crosswalk to continue along 10th Street. The closest crosswalk is one block to the north across Reid Street where a connection is provided to the Sioux Falls Bike Trail. A sidewalk is provided on both sides of the 10th Street bridge over the Big Sioux River, just to the west of the 10th Street Viaduct.

9.A.7. Coast Guard Requirements

Coast Guard requirements are not applicable to this structure.

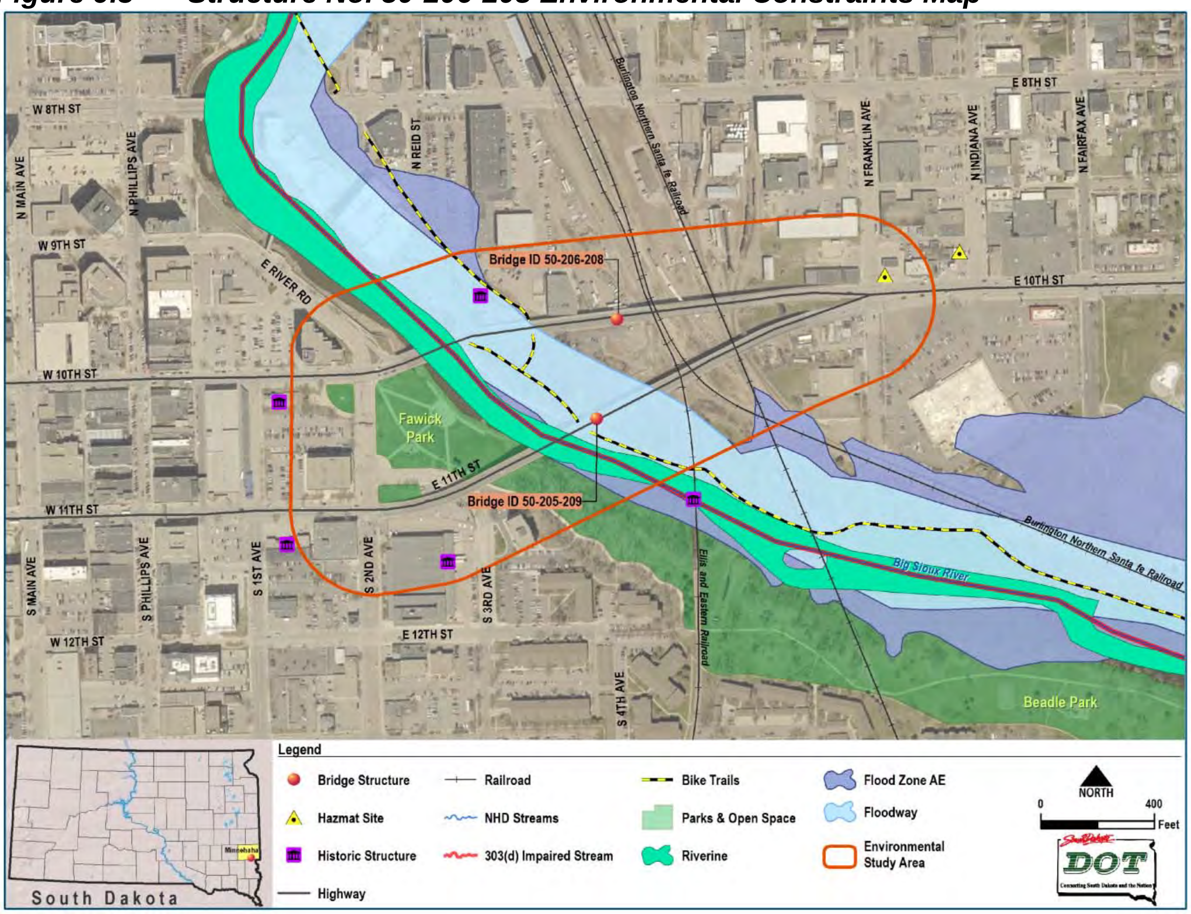
9.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. Modern records of the state threatened northern river otter are present in the project study area, and habitat is present in the Big Sioux River. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f). Section 4(f) properties are present within the study area, including Fawick Park and the Sioux Falls Bike Trail.
- Section 106. Historic properties within the study area include a building eligible for placement on the National Register of Historic Places and an age-eligible unevaluated structure. Further surveys and evaluation may be necessary.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly along the fringes of the Big Sioux River. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.

- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as E. Coli, Fecal Coliform, and Total Suspended Solids. Total Maximum Daily Loads for non-point sources should be considered for drainage associated with any bridge improvements.
- Regulated Materials. Regulated materials within the project study area include sites with gasoline below ground storage tanks near the east end of the project study area.
- Floodplains and Floodways. FEMA Flood Zone AE and floodway are mapped within the project study area. A floodplain permit may be required depending on the scope of work required for the project.
- Right-of-Way. Some businesses in the area are close to the project ROW. The likelihood for displacement will depend on the scope of work and will be determined during later phases of construction.
- Title VI (Civil Rights) and Environmental Justice. Low-income, minority, and vulnerable age populations are present within the vicinity of the project and could potentially be affected. Limited English Proficiency populations are also present in the project vicinity.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, and the Tribes) will be required during the NEPA process.

Figure 9.3 Structure No. 50-206-208 Environmental Constraints Map



9.B. Future Conditions Analysis

The future conditions analysis conducted for the 10th Street Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

9.B.1. Future Traffic Analysis

The Sioux Falls MPO provided 2035 travel demand model information for 10th Street and 11th Street in the study area. Based on the MPO model, 11th Street has an annual growth rate of -0.09 percent, and 10th Street has an annual growth rate of 0.13 percent. These numbers were confirmed with Sioux Falls MPO. The slight decrease on 11th Street and increase on 10th Street are related to a future Rice-Russell connection shown in the model study area. For 2035, 10th Street is estimated to have an ADT volume of 12,798 and a heavy vehicle percentage of 6.3 percent. Although traffic volumes have not increase significantly, heavy vehicle volumes are anticipated to increase due to the application of the heavy vehicle growth rates when developing the traffic forecasts. SDDOT provided the rates, which show higher growth rates for heavy vehicles.

The analysis used peak hour model output from the Sioux Falls MPO as a basis for the LOS calculations and a PHF of 0.92. The analysis identified the PM peak hour as the controlling peak period. The results below are shown for the 2035 PM peak period. Based on HCM methodologies and HCS 2010, 10th Street is anticipated to operate at LOS C, with a flow rate of 552 (pcphpl), which equates to a V/C ratio of 0.47.

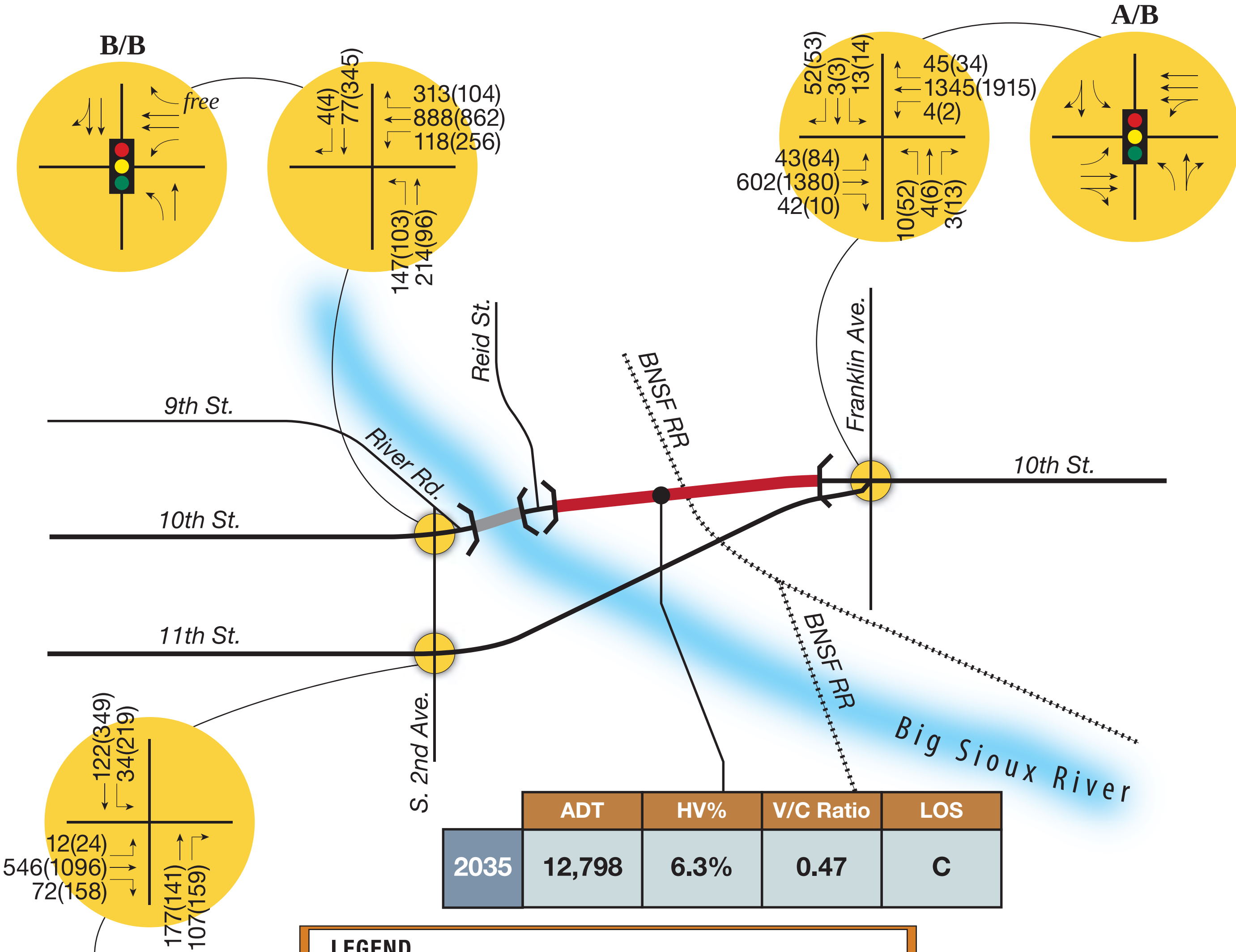
The signalized intersections of the 10th Street with 2nd Avenue and 11th Street/Franklin Avenue are anticipated to operate at LOS B or better under 2035 AM and PM peak hour traffic conditions. **Figure 9.4** summarizes the 2035 future roadway and traffic conditions.

9.B.2. Additional Lanes Needs

The analysis identified this structure as one of the key locations to determine the approximate year in which additional lanes would be needed. Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes. The year at which additional lanes were required was determined when the V/C ratio exceeded 1.0. Traffic volumes were grown annually in an iterative process until this threshold was exceeded. Based on the results of the additional lanes needs analysis, it was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

9.B.3. Safety Recommendations

The 10th Street intersection with 11th Street/Franklin Street shows a pattern of rear-end and angle collisions. The intersection of 10th Street with Reid Street shows a pattern of rear end collisions. These types of crash patterns are typical for signalized intersections. Although no countermeasures are recommended, if the pattern continues to worsen or a more significant pattern becomes apparent in the future, a more detailed safety study should be completed at the intersection.



	ADT	HV%	V/C Ratio	LOS
2035	12,798	6.3%	0.47	C

LEGEND

Number of Lanes	3 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	30 mph
Bridge Roadway Width	40 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

X/X = AM/PM Peak Hour Signalized Intersection Level of Service

(traffic signal symbol) = Traffic Signal

(yellow circle symbol) = Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 9.4

2035 Future Conditions
10th Street Viaduct over BNSF RR
50-206-208

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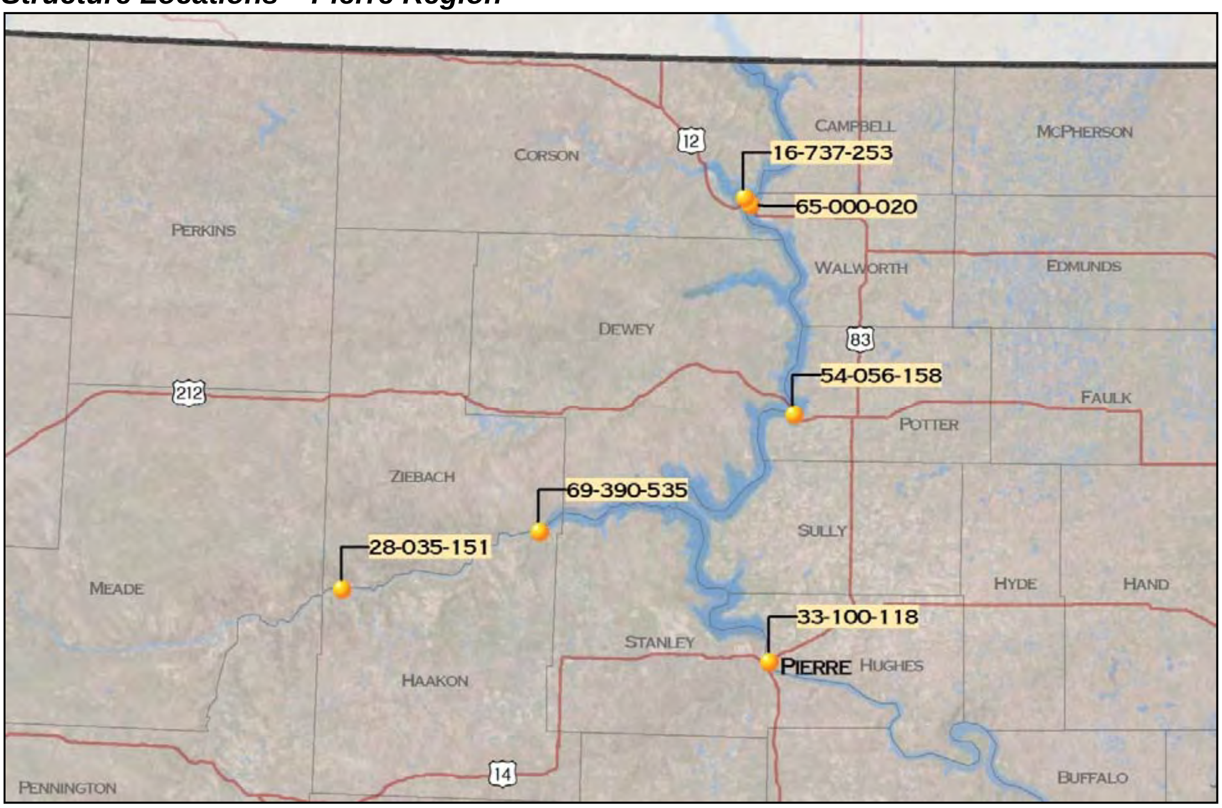
III. PIERRE REGION

Six of the study bridges are located in the Pierre Region. Three of these structures are located over the Missouri River. Because there is currently a study underway for the Pierre-Fort Pierre/Waldron bridge on US 14/SD 34/US 83, only a cursory level review was conducted at that location. The information and analysis for each bridge is provided within its own section for use as a standalone document.

Pierre Region Bridges

Pierre Region				
Structure Number	**Highway/ Street**	**Landmark or Common Name**	**Feature Intersected**	**Length (feet)**
65-000-020	US 12	Mobridge	Missouri River	5,058.5
33-100-118	US 14/SD 34/US 83	Pierre-Fort Pierre/Waldron	Missouri River	1,659
28-035-151	SD 34	Bridger	Cheyenne River	1,204
69-390-535	SD 63	—	Cheyenne River	2,109
54-056-158	US 212	Forest City	Missouri River	4,619.3
16-737-253	SD 1806	Singing Bridge	Grand River	4,001.33

Structure Locations – Pierre Region



10. Structure # 65-000-020

Structure No. 65-000-020 (US 12 – Mobridge) crosses the Missouri River, immediately northwest of Mobridge. The study area is approximately 2.5 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure, constructed in 1959, underwent a major rehabilitation in 1980. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 10.1 US 12 – Structure # 65-000-020

10.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the US 12 / SD 20 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

10.A.1. Additional Background Data

The team requested additional traffic count data for the intersection of US 12 / SD 20 with SD 1806 west of Mobridge, South Dakota; however, turning movement traffic data were unavailable.

10.A.2. Roadway Conditions

On US 12/SD 20, the approaches to the bridge are two-lane highways, 24 feet in width, with 10-foot surfaced shoulders. The speed limit is posted at 55 mph. On the bridge, the roadway width is 26 feet, which consists of two 13-foot driving lanes and no shoulders.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT above 2,500, the existing cross sections of the roadway approaches to the structure currently meet SDDOT design standards. However, for the bridge, Table 7-1 indicates that a minimum bridge width of 40 feet be provided. The current roadway width of 26 feet does not meet SDDOT design standards.

The US 12/SD 20 approaches to the bridge are asphalt surfaced. The approach immediately east of the bridge has a Surface Condition Index of 4.83, and the approach immediately to the west has an index of 4.49. **Table 10.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 10.1 US 12/SD 20 (Structure #65-000-020) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
4.83 (East)	4.75	5.00	5.00	5.00	5.00	5.00	0.0/0.0
4.49 (West)	4.49	4.50	4.76	5.00	5.00	4.52	0.1/0.3

10.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (34 tons) and a fracture critical bridge.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard overall width for the current two lanes of traffic and no shoulders.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 5
  - Substructure: 5
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, appropriate width, etc. This bridge's current sufficiency rating is 44.6. This bridge is classified as Functionally Obsolete because the deck geometry item codes as 3.

- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Scour at Pier 13
  - Cracked welds
  - Expansion joint gland failure and limited bearing movement at Pier 4 due to locked bumpers
  - Sill shifted

10.A.4. Traffic Analysis

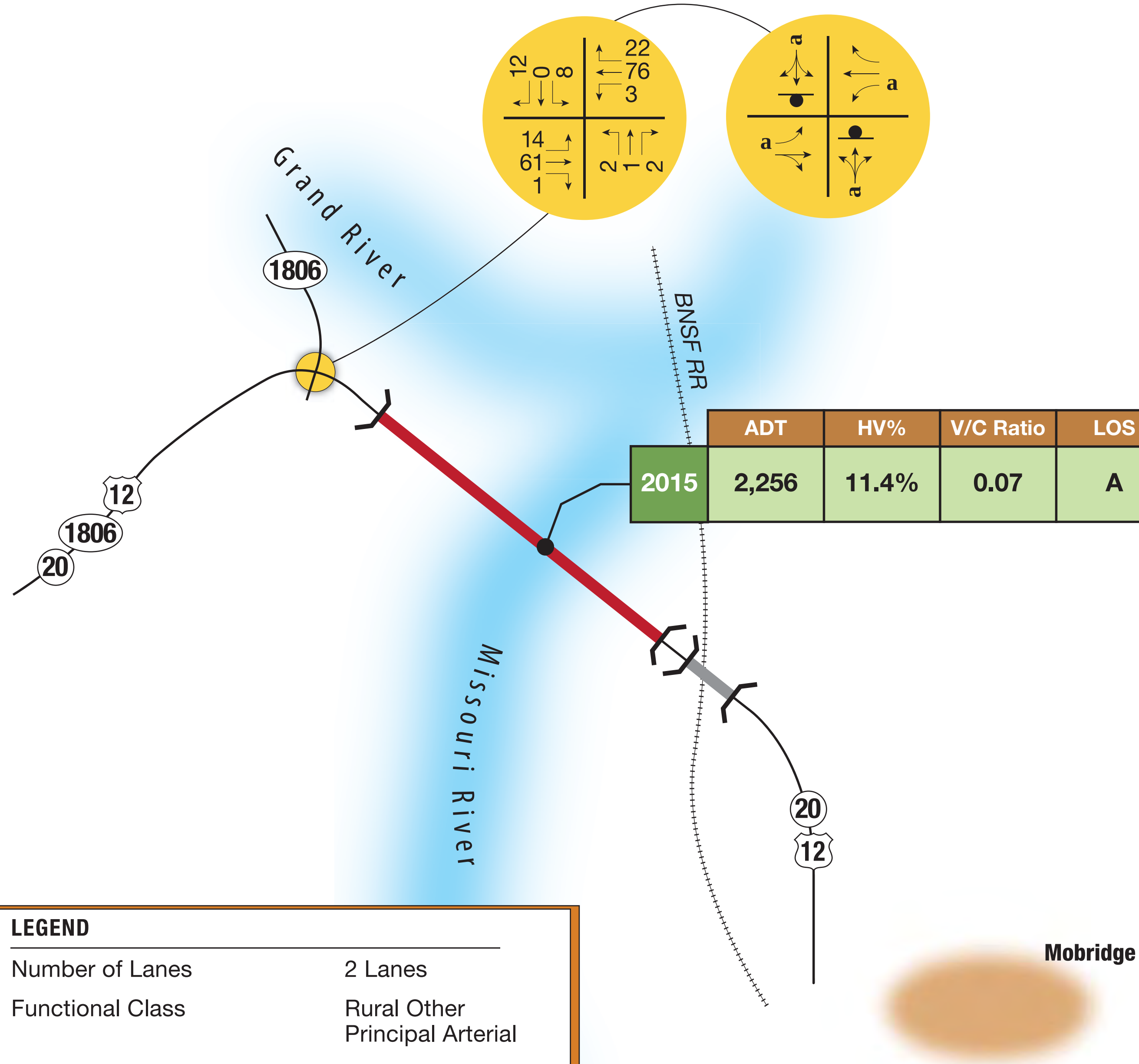
US 12 / SD 20, categorized as a Rural Other Principal Arterial, is located between Corson County and Walworth County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 2,256 in 2015. No peak period turning movement counts were available at the intersection of US 12 / SD 20 with SD 1806. As such, FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop design hour traffic volumes for the intersections.

The roadway has a heavy vehicle percentage of 11.4 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 68 percent would fall into FHWA Vehicle Class 5-9 and 32 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.235 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.909 percent was developed, and a growth rate of 2.844 percent was developed for FHWA Vehicle Class 10-13. **Figure 10.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.1 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, US 12/SD 20 currently operates at LOS A with a V/C ratio of 0.07.

At the unsignalized intersection of US 12 / SD 20 with SD 1806, all critical movements currently operate at LOS A under 2015 design hour traffic conditions.



	ADT	HV%	V/C Ratio	LOS
2015	2,256	11.4%	0.07	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	55 mph
Bridge Roadway Width	26 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Design Hour Traffic Volumes

X/X = AM/PM Design Hour Signalized Intersection Level of Service

= Stop Sign

= Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 10.2
2015 Existing Conditions
Mobridge/US 12
65-000-020

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10.A.5. Safety Analysis

The analysis used crash records compiled from SDDOT for the structure and the approaches on US 12/SD 20. The analysis also examined crash data for the intersection of US 12 / SD 20 with SD 1806. **Tables 10.2** and **10.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 10.2 US 12/SD 20 (Structure #65-000-020) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
US 12 / SD 20	8	0	1	1	1	1	12
US 12 / SD 20 / SD 1806	1	1	0	1	0	0	3
Total	**9**	**1**	**1**	**2**	**1**	**1**	**15**

Most crashes occurring on US 12 / SD 20 bridge were single vehicle collisions with a fixed object. On the bridge approaches, several crashes were animal-related collisions. A vehicle on US 12 / SD 20 crossed the centerline and struck another vehicle head on resulting in one fatality and two others with minor injuries. At the intersection of US 12 / SD 20 with SD 1806, no distinct crash pattern was identified.

Table 10.3 US 12/SD 20 (Structure #65-000-020) – Crash Rates (2010–2014)

Roadway Segment or Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
US 12 / SD 20	1	0	1	0	10	12	3,368	6.15	1.95	91.5
US 12 / SD 20 / US 1806	0	0	0	0	3	3	3,115	5.68	0.53	0.53
Incapacitating (Incap.)		Property Damage Only (PDO)				* MEV= Million Entering Vehicles				

The crash rate per MEV for US 12 / SD 20 is 1.95. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 91.5. The crash rate per MEV for the intersection of US 12/ SD 20 with SD 1806 is 0.53, with a crash rate per MEV of 0.53. **Table 10.4** shows the identified crash patterns and possible contributing factors.

Table 10.4 US 12/SD 20 (Structure #65-000-020) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Fixed Object	▪ Bridge rail is too close to travel way
Animal-related Collisions	▪ Bridge is located in heavily populated deer habitat

10.A.6. Bicycle/Pedestrian Facilities

Currently, the bridge provides no bicycle or pedestrian facilities. However, on the bridge approaches, the paved shoulders offer cyclists an alternative to ride with some separation from vehicular traffic.

10.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

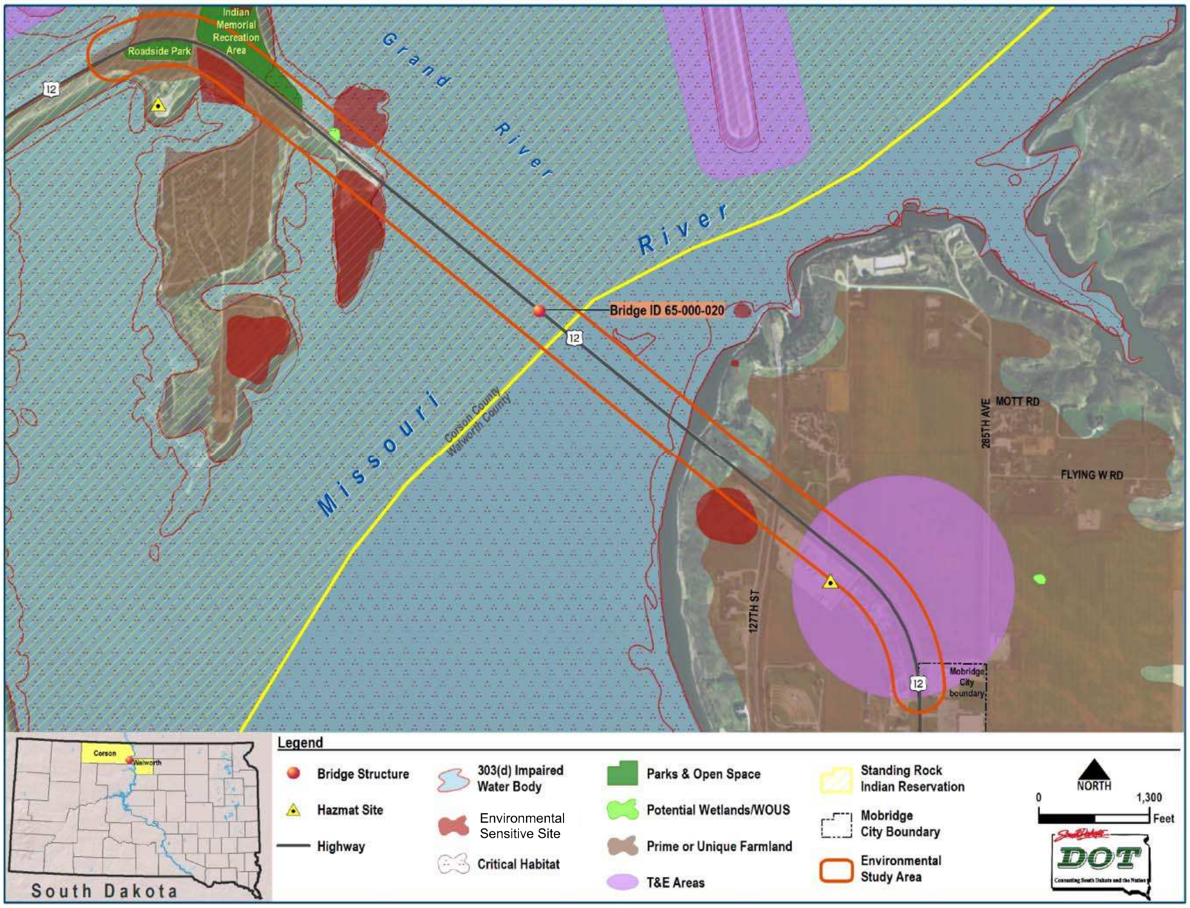
10.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Suitable habitat also appears to be present for several other state and federally listed species, and modern records of piping plover, whooping crane, and false map turtle exist within the vicinity of the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f). Section 4(f) properties are present within the project study area on the west side of the Missouri River, including Indian Memorial Recreation Area and Roadside Park.
- Section 106. Historic and archeological resources are present within the study area, including one site listed on the National Register of Historic Places. A number of unevaluated sites are also present and will likely require further surveys and evaluation.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly near the banks of the Missouri River/Lake Oahe. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as pH.
- Regulated Materials. Regulated materials within the project study area include active sites with gasoline and diesel underground storage tanks near both the east and west ends of the project.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within the vicinity of the study area and could potentially be indirectly affected.
- Prime and Unique Farmland. The east and west ends of the project study area include "Prime farmland if irrigated." A Form NRCS CPA-106 for Corridor Type Projects or Form AD1006 may be required.
- Section 9. A contractor's work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.

- Tribal Consultation. The west side of the project is within the Standing Rock Indian Reservation. Tribal consultation will be required with those tribes that have a cultural or historic interest in Corson or Walworth counties.
- Agency Coordination. The project is located on US Army Corps of Engineers (USACE) property. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, USCG, USACE, and the Tribes) will be required during the NEPA process.

Figure 10.3 Structure No. 65-000-020 Environmental Constraints Map



10.B. Future Conditions Analysis

The future conditions analysis conducted for the Mobridge Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

10.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 12 / SD 20 is estimated to have an ADT volume of 2,914, with a heavy vehicle percentage of 12.3 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.2 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and roadway ADT, US 12 / SD 20 is anticipated to operate at LOS A with a V/C ratio of 0.09 in 2035.

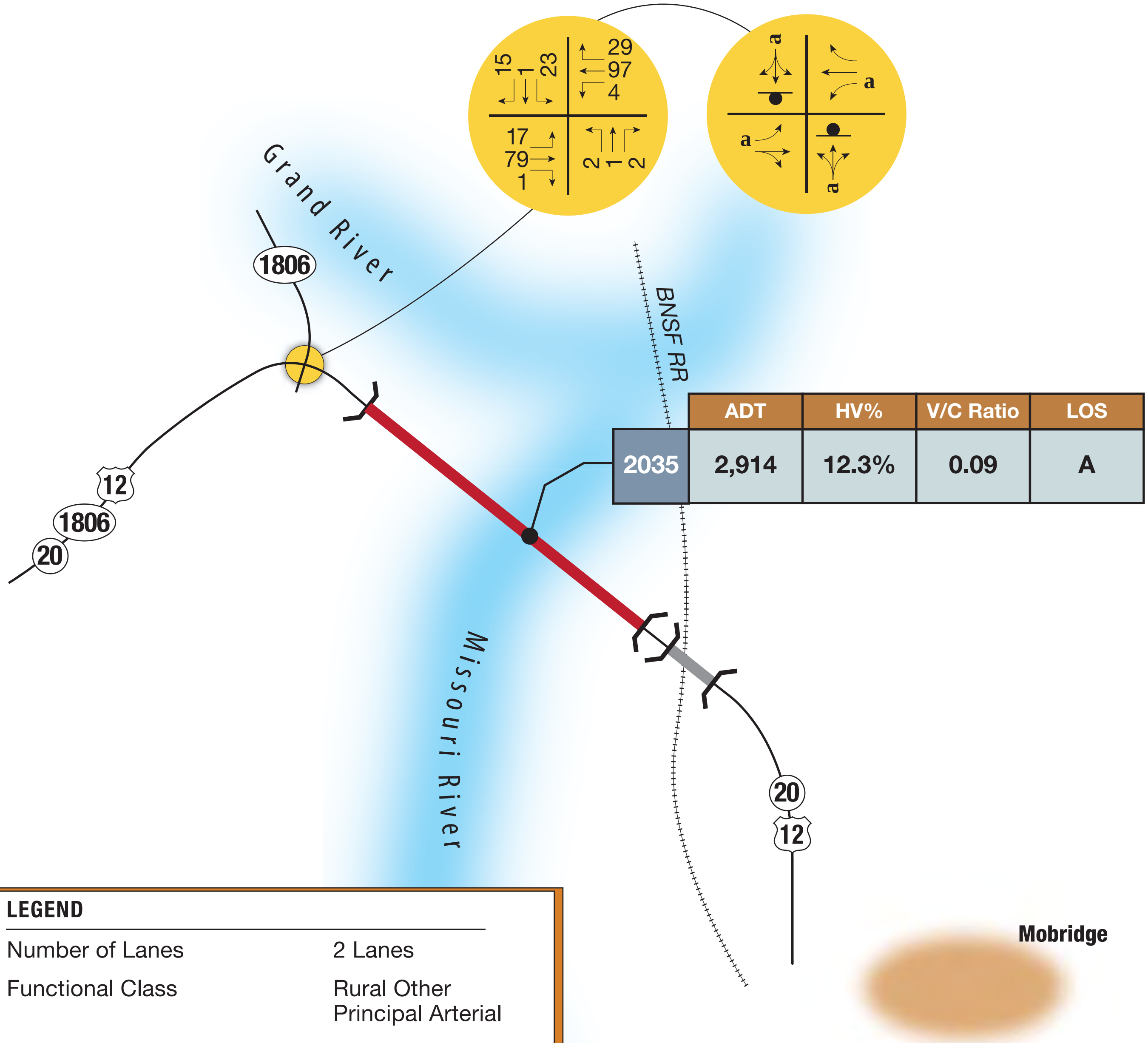
At the unsignalized intersection of US 12 / SD 20 with SD 1806, all critical movements are anticipated to operate at LOS A under 2035 design hour traffic conditions. **Figure 10.4** summarizes the future roadway and traffic conditions.

10.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

10.B.3. Safety Recommendations

The intersection of US 12 / SD 20 with SD 1806 showed no distinct crash pattern. On the bridge, a pattern of fixed object crashes was present. It is recommended that wider shoulders be considered and rumble strips be provided on the paved shoulders. The bridge approaches showed a pattern of animal related collisions. The team recommends that additional non-vehicular warning signs W11-3 (Deer) be considered in advance of the bridge approaches warning drivers in all directions that wildlife may be crossing in this area.



	ADT	HV%	V/C Ratio	LOS
2035	2,914	12.3%	0.09	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	55 mph
Bridge Roadway Width	26 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Design Hour Traffic Volumes

X/X = AM/PM Design Hour Signalized Intersection Level of Service

(stop sign symbol) = Stop Sign

(yellow circle symbol) = Study Intersection(s)

North

NOTE: Drawing Not to Scale

Figure 10.4
2035 Future Conditions
Mobridge/US 12
65-000-020

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11. Structure # 33-100-118

Structure No. 33-100-118 (US 14 – Pierre/Fort Pierre/Waldron) crosses the Missouri River and connects the communities of Pierre and Fort Pierre in Stanley County and Hughes County. The study area is approximately 1 mile long and 0.15 mile wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1962. Because a study is currently underway for this structure, only a cursory level review was needed. A cursory level review includes baseline conditions, future needs, and safety analyses. The team did not develop alternative improvement scenarios for this structure.

Figure 11.1 US 14/US 83/SD 34 – Structure # 33-100-118

11.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the US 14/US 83/SD 34 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

11.A.1. Additional Background Data

The team reviewed the *US 14 Missouri River Bridge Replacement, Forecasts and Traffic Study* prepared by URS. The forecasted traffic volumes from the study indicate that the existing five-lane cross section on the westbound approach of the bridge will be overcapacity near the horizon year of 2045. The four-lane divided cross section on the eastbound approach to the bridge will be overcapacity several years later. The study is not yet complete; however, the preliminary bridge typical section does not include adequate width to widen to six-lanes without future construction.

11.A.2. Roadway Conditions

On the westbound approach of US 14 to the bridge, the roadway is an urban five-lane section with a two-way left-turn lane (TWLTL). The roadway cross section consists of five 12-foot lanes with curb and gutter provided on both sides, with a posted speed limit of 35 mph. On the bridge, the roadway width is approximately 56 feet, which consists of two 13-foot 10-inch westbound lanes and two 13-foot 3-inch eastbound driving lanes. A 2-foot wide median barrier separating traffic is provided. A barrier is also provided on the edge of the outside driving lanes. The eastbound approach to the bridge consists of an urban four-lane median divided roadway with turn lanes. The cross section includes four 12-foot-wide travel lanes with a 16-foot raised median. Curb and gutter is provided. The posted speed limit is 35 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, for urban areas, shoulders may not be provided. Consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (speeds ≤ 40 mph) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. As such, the existing cross section on the roadway approaches of US 14 meet SDDOT design standards.

On the bridge, for a low speed divided highway (speeds less than 40 mph), a minimum 2-foot shy distance should be provided between the travel way and median barrier. As such, the existing cross section on US 14 bridge meets SDDOT design standards.

The US 14/US 83/SD 34 approaches to the bridge are concrete surfaced. Both approaches to the bridge have a Surface Condition Index of 4.60. **Table 11.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 11.1 US 14/US 83/SD 34 (Structure #33-100-118) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
4.60 (East)	3.67	5.00	4.60	5.00	5.00	4.00	5.00
4.60 (West)	3.81	5.00	4.60	4.73	5.00	4.07	5.00

11.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a low Inventory Rating (22 tons), an Operating Rating barely meeting standards (36.8 tons), and the bridge is fracture critical. Deficiencies in structural capacity limit the options for additional dead load on the bridge, as it would likely further reduce the load rating and require posting.
- Geometry. Geometric deficiencies and concerns for the bridge include limited shoulders.

- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 5
  - Superstructure: 5
  - Substructure: 5
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 51.8. If one of the condition ratings drops to a 4 or less, the bridge would then be classified as Structurally Deficient.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Deck cracking
  - Cracked welds
  - Partially deboned concrete overlay
  - Girder rust
  - A two-girder system with floor beams, which makes widening the superstructure difficult

11.A.4. Traffic Analysis

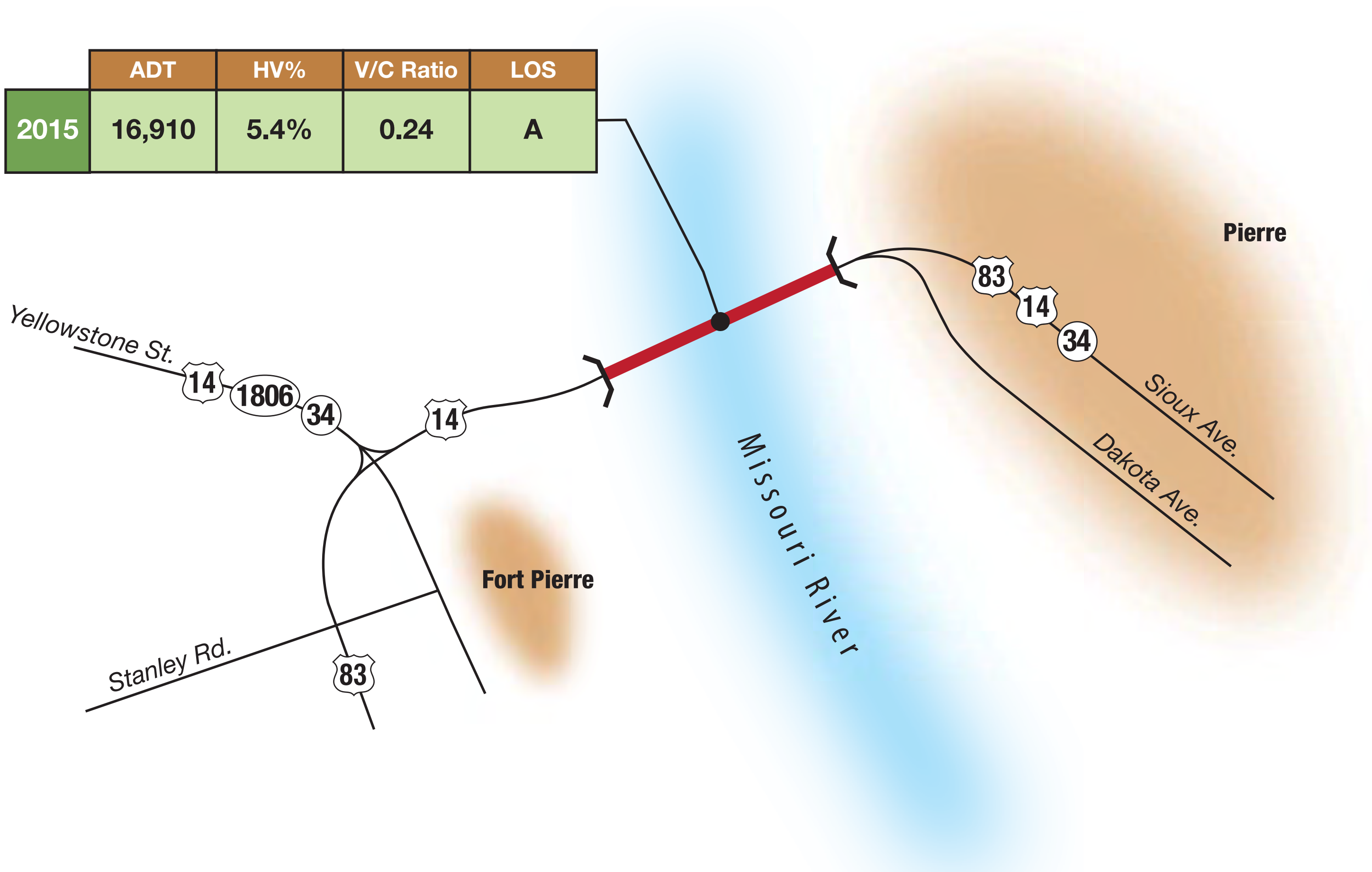
US 14, categorized as a Rural Other Principal Arterial, is located between Stanley and Hughes counties. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 16,910 in 2015. The analysis examined no peak period turning movement counts for this structure. The roadway has a heavy vehicle percentage of 5.4 percent.

A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 84 percent would fall into FHWA Vehicle Class 5-9 and 16 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.254 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.993 percent was developed, and a growth rate of 2.846 percent was developed for FHWA Vehicle Class 10-13. **Figure 11.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.8 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and peak hour traffic volumes, US 14 currently operates at LOS A, with a peak flow rate of 414 pcphpl and a V/C ratio of 0.24.

	ADT	HV%	V/C Ratio	LOS
2015	16,910	5.4%	0.24	A



LEGEND

Number of Lanes	4 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	35 mph
Bridge Roadway Width	56 Feet

North

NOTE: Drawing Not to Scale

Figure 11.2
2015 Existing Conditions
Pierre-Fort Pierre/Waldon/US 14
33-100-118

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11.A.5. Safety Analysis

The team used crash records compiled from SDDOT for US 14 and the intersection of US 14 with Yellowstone Street. US 14 was broken into two segments for analysis purpose. The segment of US 14 (W. Sioux Avenue) from Poplar Avenue to Dakota Avenue was broken out separately due to close spacing of access points along that segment of US 14. **Tables 11.2** and **11.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 11.2 US 14 (Structure #33-100-118) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
US 14 / Yellowstone St.	3	6	0	5	0	0	14
US 14	10	3	0	3	1	0	17
US 14 (W. Sioux Ave.)	3	6	0	21	4	0	34
Total	**16**	**15**	**0**	**29**	**5**	**0**	**65**

The intersection of US 14 with Yellowstone Street showed a pattern of angle and rear end collision types. On US 14, which includes the bridge structure and the eastbound approach, a pattern of fixed object collisions was identified. For the more urban US 14 (W. Sioux Avenue) section, a pattern of rear end and angle type collisions was identified.

Table 11.3 US 14 (Structure #33-100-118) – Crash Rates (2010–2014)

Roadway Segment / Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
US 14 / Yellowstone St.	0	0	3	3	8	14	16,231	29.62	0.47	1.97
US 14	0	1	1	1	14	17	16,910	30.86	0.55	1.94
US 14 (W. Sioux Ave.)	0	0	8	5	21	34	17,418	31.79	1.07	4.30
Incapacitating (Incap.)	Property Damage Only (PDO)						* MEV= Million Entering Vehicles			

The crash rate per MEV for the structure on US 14 is 0.55. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 3.88. For the intersection of US 14 with Yellowstone Street, the crash rate per MEV is 0.47, and the severity rate per MEV is 1.97. On W. Sioux Avenue in the city area, the crash rate per MEV is 1.07, and the severity rate per MEV is 4.30. **Table 11.4** shows the identified crash patterns and possible contributing factors.

Table 11.4 US 14 (Structure #33-100-118) – Crash Patterns (2010 – 2014)

Crash Pattern	Contributing Factors
Fixed Object Collisions (US 14)	▪ Drivers hitting the guardrail ▪ Bridge rail is too close to travel way
Rear Ends (US 14 [W. Sioux Ave.])	▪ Close spacing of access points
Angle (US 14 [W. Sioux Ave.])	▪ Inadequate gaps – peak period ▪ Close spacing of access points

11.A.6. Bicycle/Pedestrian Facilities

Currently, a 4-foot 6-inch sidewalk is provided on the south side of the bridge. The sidewalk connects trails that parallel the Missouri River on both sides.

11.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet' to 4 feet below the low steel elevation. The approval process involves the Coast Guard reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

11.A.8. Environmental Resource Review

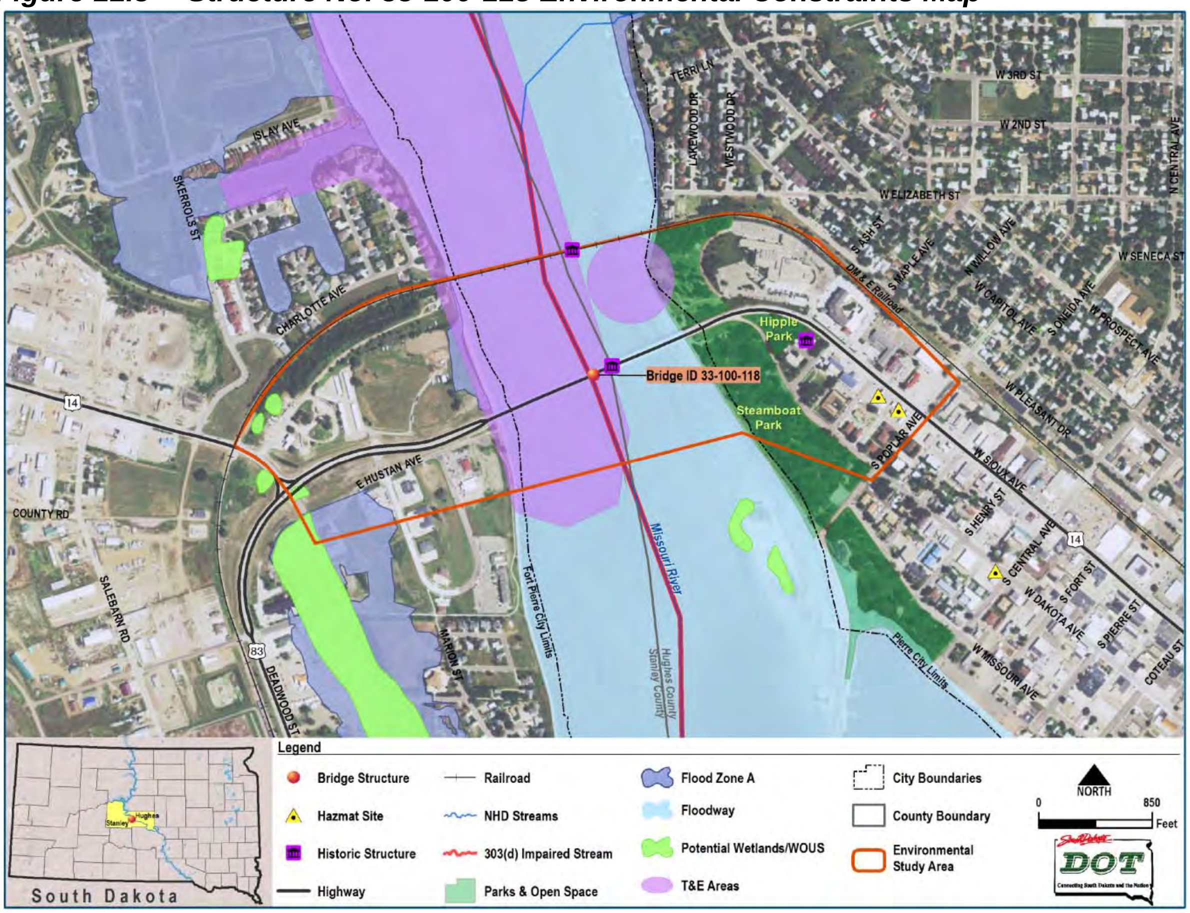
The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area contains suitable habitat for several state and federally listed species. Modern records of northern river otter, piping plover, interior least tern, and pallid sturgeon exist within the vicinity of the project study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f) and Section 6(f). Section 4(f) properties are present in the project study area on the east side of the Missouri River, including Steamboat Park and Hipple Park. Coordination with the SDGFP may be necessary to determine if Steamboat Park or Hipple Park is a Section 6(f) property.
- Section 106. Historic resources are present in the study area as identified in the *Environmental Assessment and Section 4(f) De Minimis Analysis* study completed in May 2016 for the replacement of this structure. However, only one structure, the CN&W Railroad bridge was listed on the NHRP, and no archeological sites were uncovered within the study area. As a result, SHPO provided a finding of *No Historic Properties Affected*.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area. Impacts to these resources will depend on the scope of work and

will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.

- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area. The cause of the impairment is listed as Temperature.
- Regulated Materials. Regulated materials are present within the project study area and include active sites with gasoline and diesel aboveground and below ground storage tanks.
- Title VI (Civil Rights) and Environmental Justice. Minorities and vulnerable age populations are present within the study area and low-income populations are present in the vicinity; these populations could potentially be affected.
- Section 9. A contractor's work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, USCG, and the Tribes) will be required during the NEPA process.

Figure 11.3 Structure No. 33-100-118 Environmental Constraints Map



11.B. Future Conditions Analysis

The future conditions analysis conducted for the Pierre/Fort Pierre/Waldron Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

11.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 14 is estimated to have an ADT volume of 21,717, with a heavy vehicle percentage of 5.5 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.2 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and HCS 2010, US 14 is anticipated to operate at LOS A, with a flow rate of 531 (pcphpl), which equates to a V/C ratio of 0.31 in 2035. **Figure 11.4** summarizes the future roadway and traffic conditions.

11.B.2. Additional Lane Needs

The *US 14/US 83/SD 34 Missouri River Bridge Replacement Study* indicated that if a new structure is built, the bridge should be built with a four-lane cross section, with the ability to be expanded to six-lanes when needed. This would only occur if/when Sioux Avenue is also expanded to six-lanes through Pierre. Year 2125 was assumed to be the horizon year of the bridge life for that bridge replacement study.

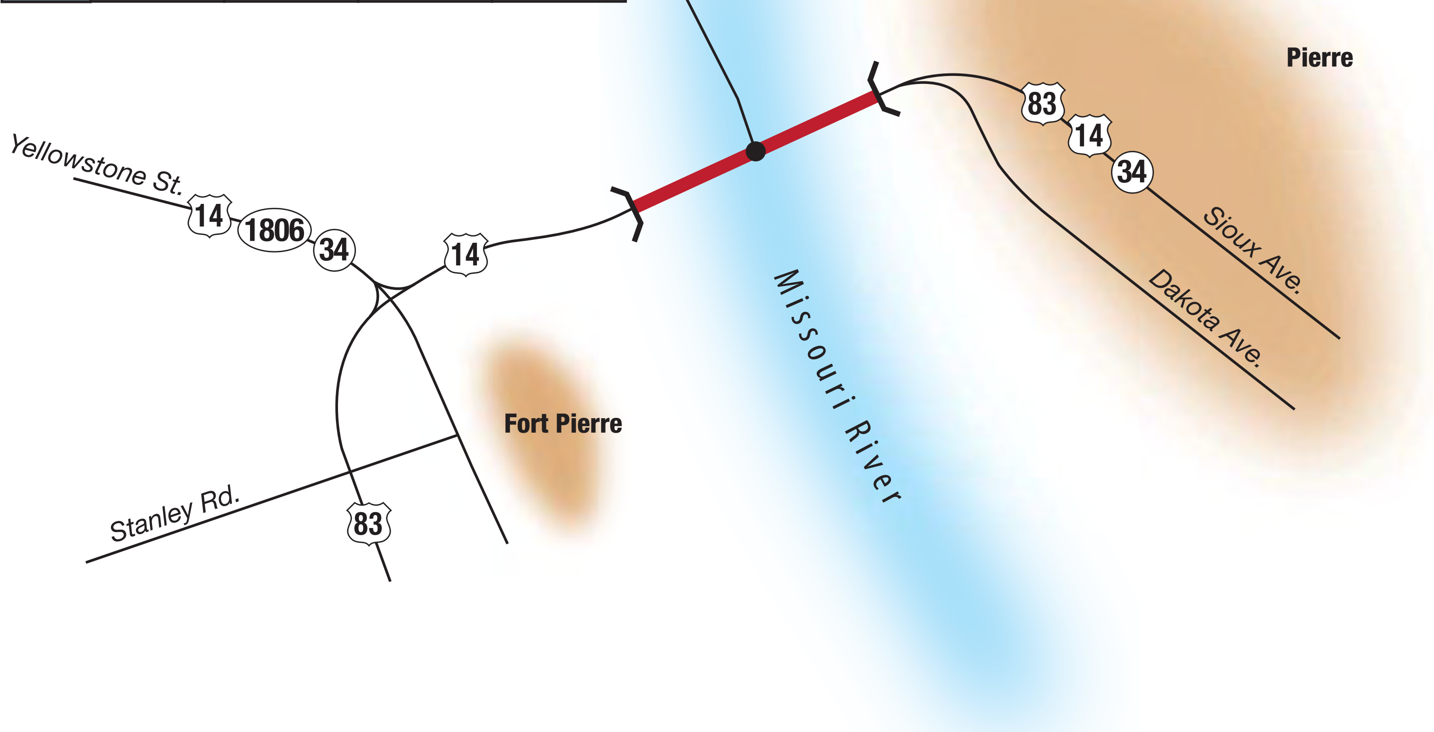
For this study, using the previously mentioned forecasting methodologies and growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. The analysis determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches. Further traffic analysis indicates that in year 2129, the capacity of a four-lane bridge would be exceeded and six-lanes would be required to accommodate the forecast traffic volumes.

11.B.3. Safety Recommendations

The more urban section of US 14 (W. Sioux Avenue) showed a pattern of angle and rear end collision types. These types of crash patterns are typical for this type of roadway section. No countermeasures are recommended; however, if the pattern continues to worsen or a more significant pattern becomes apparent in the future, a more detailed safety study should be completed at the intersection.

US 14, which includes the bridge structure and the eastbound approach, showed a pattern of fixed object collisions. Most of these crashes were guardrail related. On the bridge, it is recommended that wider shoulders be considered and rumble strips be provided on the paved shoulders. While the installation of rumble strips on the paved shoulders of US 14 may help to reduce these types of collisions, in an urban environment, they may be undesirable due to potential noise impacts.

	ADT	HV%	V/C Ratio	LOS
2035	21,717	5.5%	0.31	B



LEGEND

Number of Lanes	4 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	35 mph
Bridge Roadway Width	56 Feet

North

NOTE: Drawing Not to Scale

Figure 11.4
2035 Future Conditions
Pierre-Fort Pierre/Waldon/US 14
33-100-118

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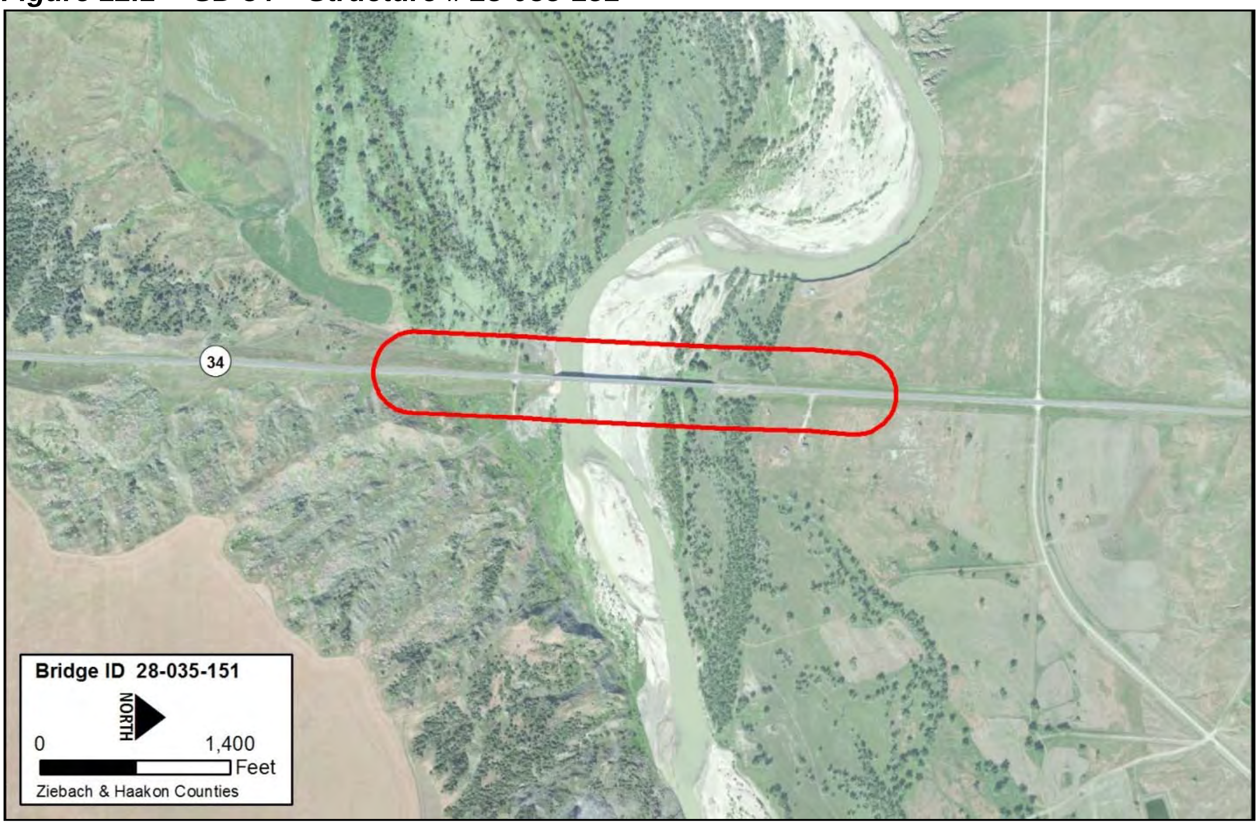
12. Structure # 28-035-151

Structure No. 28-035-151 (Bridger) is located on SD 34 over the Cheyenne River between Ziebach and Haakon counties, approximately 1.7 miles southwest of Bridger. The study area is approximately 1.5 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1962. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 12.1 SD 34 – Structure # 28-035-151



12.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the SD 34 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

12.A.1. Additional Background Data

The team requested no additional data for this structure location.

12.A.2. Roadway Conditions

On SD 34, the approaches to the bridge are both two-lane highways, 12 feet each, with 4-foot surfaced shoulders, with a posted speed limit of 65 mph. On the bridge, the roadway width is 30 feet, which consists of two 13-foot driving lanes and 2-foot surfaced shoulders, with a posted speed limit of 65 mph. Rumble strips are present on the shoulders of both approaches.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, the current ADT is between 251 and 500. Using the criteria for that ADT category, the existing configuration of the approaching roadways and the bridge structure width does meet SDDOT design standards. However, traffic projections show a future ADT between 551 and 1,500. When this threshold is met, the existing total surface width of the approaching roadways to the structure, as well as the bridge width, will not meet SDDOT design standards.

The SD 34 approaches to the bridge are asphalt surfaced. The approach immediately north of the bridge has a Surface Condition Index of 4.59, and the approach immediately to the south has an index of 4.64. **Table 12.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 12.1 SD 34 (Structure #28-035-151) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
4.59 (North)	4.88	4.90	4.99	4.99	4.98	4.43	0.2/0.6
4.64 (South)	4.91	4.88	4.96	5.00	4.96	4.51	0.1/0.4

12.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- <u>Capacity</u>. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (34 tons).
- <u>Geometry.</u> Geometric deficiencies and concerns for the bridge include substandard overall width for the current two lanes of traffic.
- <u>NBI Condition Ratings.</u> NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 5
  - Substructure: 5
- <u>Sufficiency Rating.</u> NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 75.8, indicating a structure in above average structural condition.

- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Deck cracking
  - Girder rust
  - Deck deterioration along curbline
  - Scour at piers, exposing piling with section loss
  - Shifting channel, resulting in a bridge opening that is not optimally aligned with the river

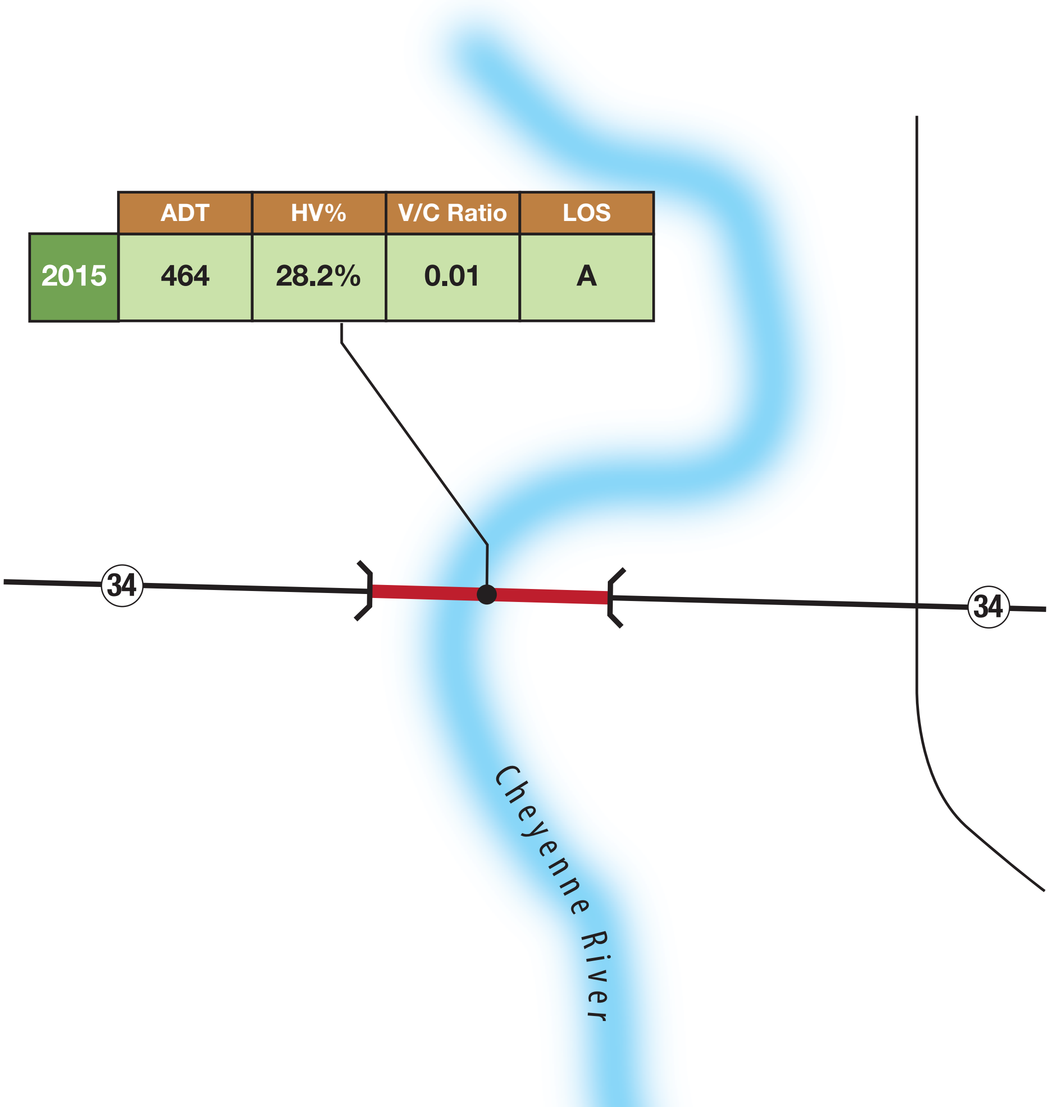
12.A.4. Traffic Analysis

SD 34, categorized as a Rural Other Principal Arterial, is located between Ziebach and Haakon counties. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 464 in 2015. The analysis included no peak period turning movement counts for this structure. The roadway has a heavy vehicle percentage of 28.2 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 78 percent would fall into FHWA Vehicle Class 5-9 and 22 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.224 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.749 percent was developed, and a growth rate of 2.851 percent was developed for FHWA Vehicle Class 10-13. **Figure 12.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.2 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 34 currently operates at LOS A with a V/C ratio of 0.01.

	ADT	HV%	V/C Ratio	LOS
2015	464	28.2%	0.01	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	30 Feet

North

NOTE: Drawing Not to Scale

Figure 12.2
2015 Existing Conditions
Bridger/SD 34
28-035-151

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12.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and the approaches on SD 34. **Tables 12.2** and **12.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 12.2 SD 34 (Structure #28-035-151) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
3	0	0	0	0	0	3

All of the crashes that occurred in the study area involved a single vehicle. One crash occurred on the bridge, and the other two occurred just south of the bridge.

Table 12.3 SD 34 (Structure #28-035-151) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
SD 34	0	0	0	0	3	3	464	0.85	3.55	3.55
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 3.55. The severity rate per MEV, which applies a cost factor to the different crash severity type, is also 3.55. There are no identifiable crash patterns at this location.

12.A.6. Bicycle/Pedestrian Facilities

Currently, the bridge provides no bicycle or pedestrian facilities. The paved shoulders on the bridge are not wide enough to provide adequate separation between vehicles and bicyclists. The shoulders on the roadway approaches are sufficient to offer cyclists an alternative to ride with some separation from vehicular traffic.

12.A.7. Coast Guard Requirements

Coast Guard requirements are not applicable for this structure.

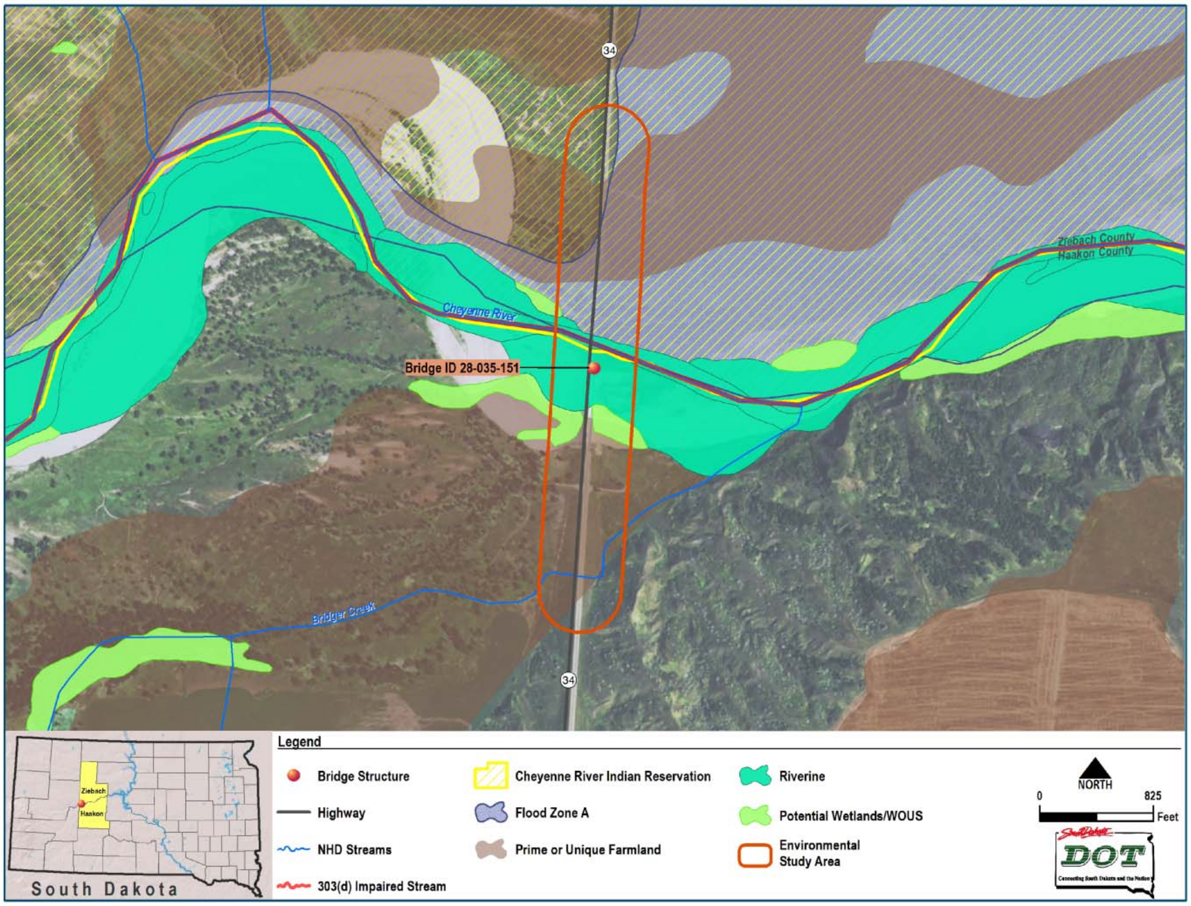
12.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. Suitable habitat appears to be present for several state and federally listed species. Modern records of the interior least tern exist within the vicinity of the project study area. Per the 2008 USFWS biological opinion for stream crossing projects in South Dakota, interior least tern surveys are required for Cheyenne River projects, and coordination with USFWS is required if habitat or individuals are identified within 0.5 mile. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.

- Section 106. Archeological surveys were conducted within portions of the study area in 2006 and 2009, but much of the study area has not been surveyed. Additional surveys may reveal new information.
- Wetlands and Waters of the US. National Wetland Inventory wetlands are mapped within the project study area; wetlands may also be present in ditches or other depressions in the study area. Bridger Creek is an intermittent creek mapped in the project study area. Impacts to these resources will depend on the scope of work. If impacts are determined likely, then a full delineation would be recommended.
- Wild and Scenic Rivers. The stretch of the Cheyenne River in the project study area is listed on the Nationwide Rivers Inventory. Coordination with the National Park Service may be necessary.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area and include E. Coli, Fecal Coliform, and Total Suspended Solids as the causes of the impairment. Consideration for Total Maximum Daily Loads for non-point sources should be considered for drainage associated with any bridge improvements.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present in the project vicinity and could potentially be affected by the project because this bridge is the major river crossing in the area. One residence has a drive coming directly off the highway within the study area.
- Prime and Unique Farmland. The north and south ends of the project study area include “Prime farmland if irrigated” and “Farmland of statewide importance.” Form NRCS CPA-106 for Corridor Type Projects or Form AD1006 may be required.
- Tribal Consultation. The north side of the project is within the Cheyenne River Indian Reservation. Tribal consultation will be required with those tribes that have a cultural or historic interest in Haakon and Ziebach counties.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, NPS and the Tribes) will be required during the NEPA process.

Figure 12.3 Structure No. 28-035-151 Environmental Constraints Map



12.B. Future Conditions Analysis

The future conditions analysis conducted for the Bridger Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

12.B.1. Future Traffic Analysis

Using the growth rates provided by the SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 34 is estimated to have an ADT volume of 593, with a heavy vehicle percentage of 28.4 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis used a K factor of 8.2 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and the roadway ADT, SD 34 is anticipated to operate at LOS A with a V/C ratio of 0.02 in 2035. **Figure 12.4** summarizes the future roadway and traffic conditions.

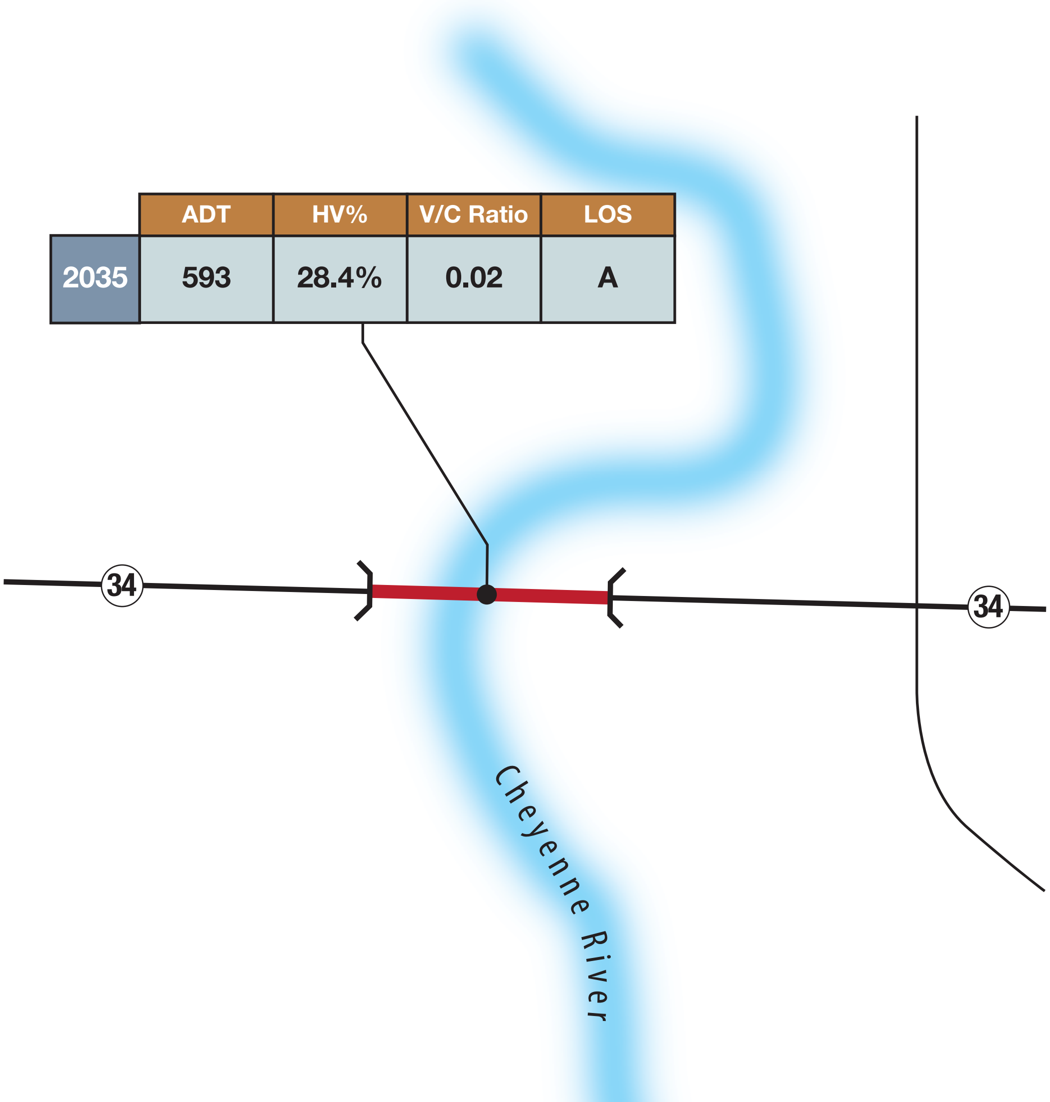
12.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

12.B.3. Safety Recommendations

A review of the crash data indicates there is no identifiable crash pattern. There are no recommended safety improvements at this location.

	ADT	HV%	V/C Ratio	LOS
2035	593	28.4%	0.02	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	36 Feet

North

NOTE: Drawing Not to Scale

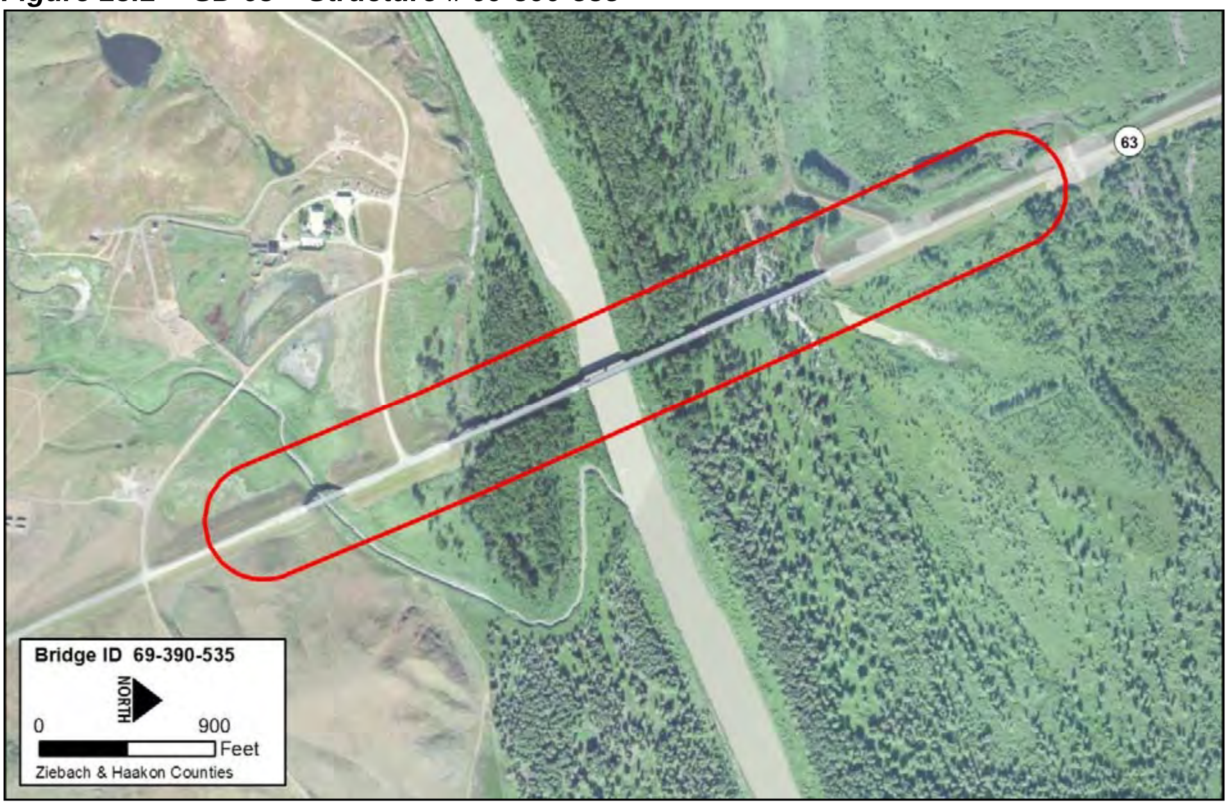
Figure 12.4
2035 Future Conditions
Bridger/SD 34
28-035-151

13. Structure # 69-390-535

Structure No. 69-390-535 (SD 63) is located on SD 63 over the Cheyenne River between Zieback and Haakon counties. The study area is approximately 1 mile long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1981. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 13.1 SD 63 – Structure # 69-390-535



13.A. *Baseline Conditions Analysis*

The team conducted a baseline conditions analysis for the SD 63 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

13.A.1. Additional Background Data

The team requested no additional data for this structure location.

13.A.2. Roadway Conditions

On SD 63, the approaches to the bridge are both two-lane highways with 12-foot lanes and 4-foot surfaced shoulders. On the bridge, the roadway width is 32 feet, which consists of two 12-foot driving lanes and 4-foot surfaced shoulders. The speed limit is posted at 65 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT between 251 and 500, the existing cross section of the bridge and roadway approaches to the structure currently meets SDDOT design standards.

The SD 63 approaches to the bridge are asphalt surfaced. The approach immediately north of the bridge has a Surface Condition Index of 4.66, and the approach immediately to the south has an index of 4.68. **Table 13.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 13.1 US 63 (Structure #69-390-535) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
4.66 (North)	4.99	4.90	5.00	5.00	5.00	4.51	0.1/0.2
4.68 (South)	4.99	4.89	4.97	5.00	5.00	4.55	0.1/0.4

13.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated within each category:

- Capacity. The review found no load carrying capacity issues with the bridge.
- Geometry. The review found no geometric deficiencies with the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 6
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 93.2, indicating a structure in above average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Pier Wall delamination
  - Deck cracking with efflorescence
  - Scour at piers; however, bridge is not scour critical

13.A.4. Traffic Analysis

SD 63, categorized as a Rural Minor Arterial, is located between Ziebach and Haakon counties. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 349 in 2015. The analysis used no peak period turning movement counts for this structure. The roadway has a heavy vehicle percentage of 14.2 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 63 percent would fall into FHWA Vehicle Class 5-9 and 37 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.224 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.749 percent was developed, and a growth rate of 2.851 percent was developed for FHWA Vehicle Class 10-13. **Figure 13.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.1 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 63 currently operates at LOS A with a V/C ratio of 0.01.

13.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and the approaches on SD 63. **Tables 13.2** and **13.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 13.2 SD 63 (Structure #69-390-535) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
3	0	0	0	0	0	3

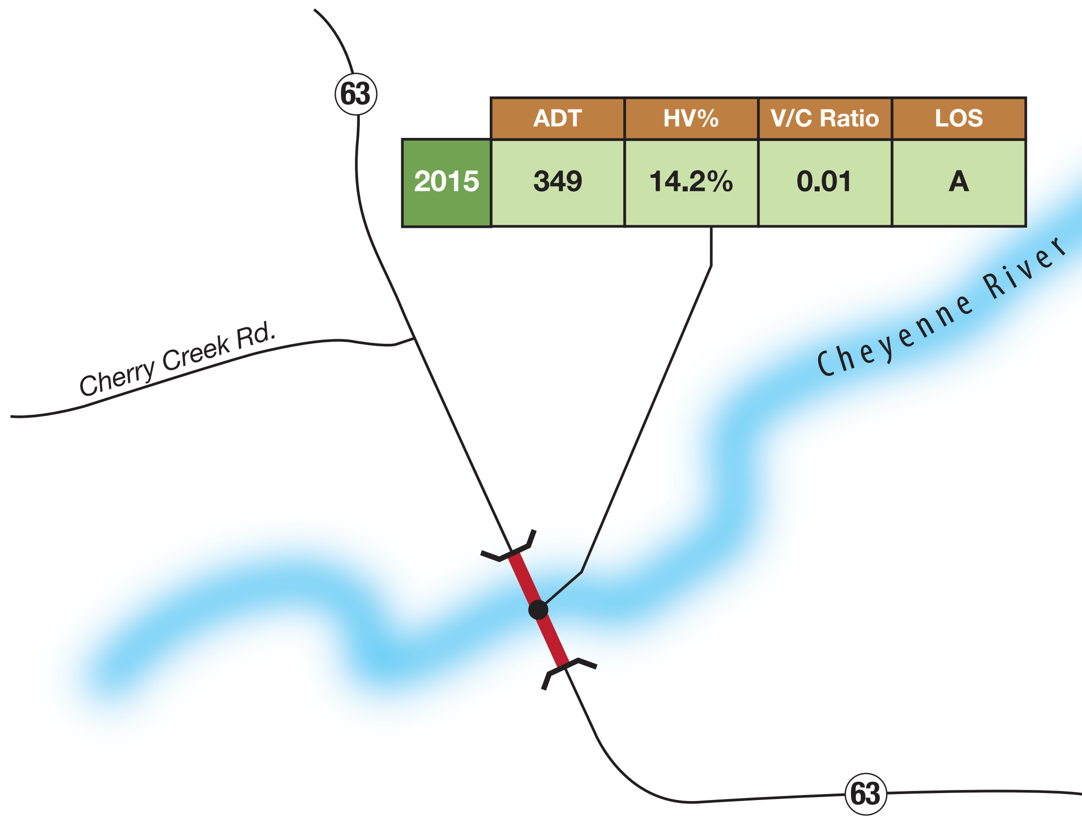
All of the crashes that occurred in the study area involved a single vehicle and appear to have occurred on the bridge or near the bridge approaches. Two of the crashes involved animal collisions; the other crash type is unknown.

Table 13.3 SD 63 (Structure #69-390-535) – Crash Rates (2010 – 2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3-Non-Incap.	4-Possible	5-PDO	Total				
SD 63	0	0	0	0	3	3	349	0.64	4.71	4.71
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 4.71. The severity rate per MEV, which applies a cost factor to the different crash severity type, is also 4.71. There are no identifiable crash patterns at this location.

	ADT	HV%	V/C Ratio	LOS
2015	349	14.2%	0.01	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	65 mph
Bridge Roadway Width	32 Feet

North

NOTE: Drawing Not to Scale

Figure 13.2
2015 Existing Conditions
SD 63/Cheyenne River
69-390-535

FELSBURG HOLT & ULLEVIG
benesch

13.A.6. Bicycle/Pedestrian Facilities

Currently, the bridge provides no bicycle or pedestrian facilities. The paved shoulders on the bridge and roadway approaches are not wide enough to provide adequate separation between vehicles and bicyclists.

13.A.7. Coast Guard Requirements

Coast Guard requirements are not applicable for this structure.

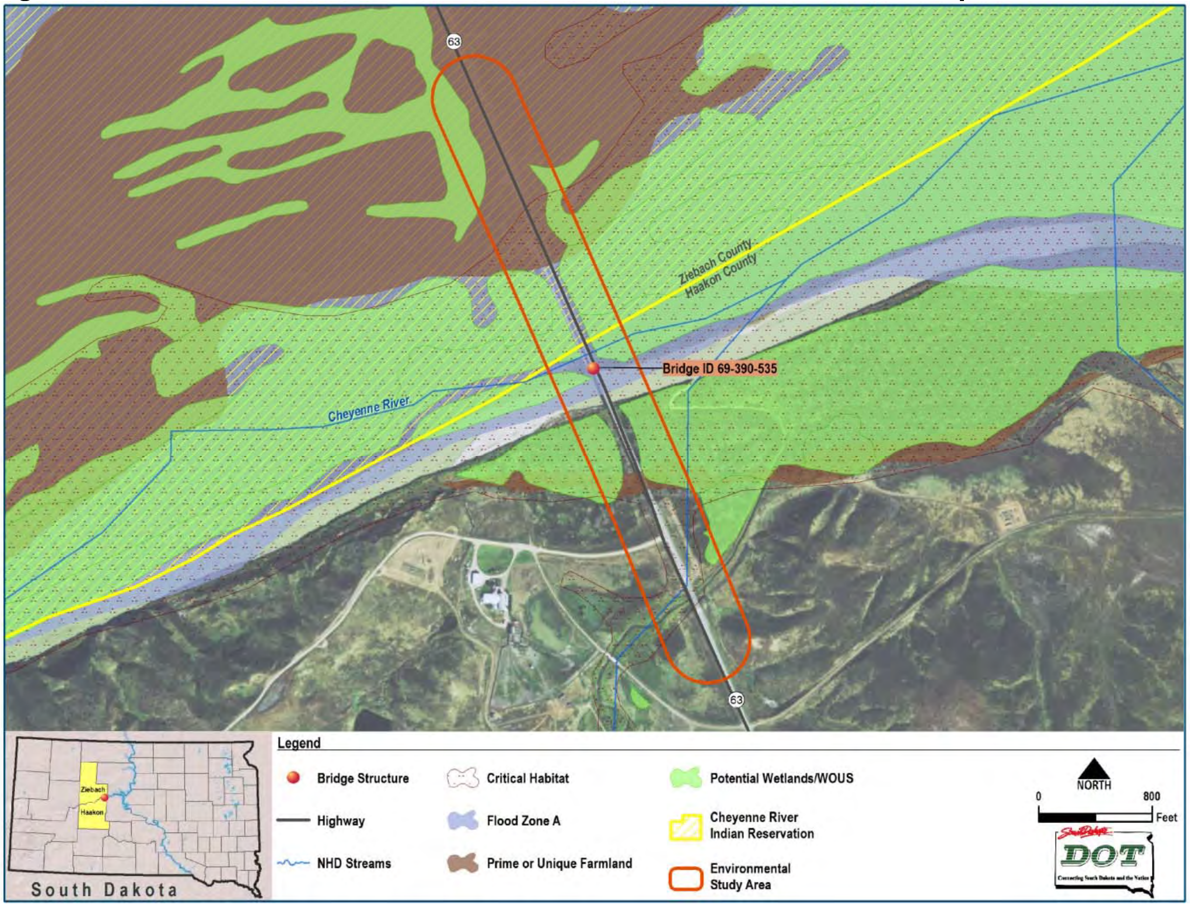
13.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Suitable habitat also appears to be present for several other state and federally listed species. Per the 2008 USFWS biological opinion for stream crossing projects in South Dakota, interior least tern surveys are required for Cheyenne River projects, and coordination with USFWS is required if habitat or individuals are identified within 0.5 mile of the project. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- Section 4(f). Wetlands and Waters of the US are likely present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Section 106. Archeological and historical surveys were conducted within the study area in 1988 and 2010. Additional surveys could reveal new information.
- Wetlands and Waters of the US. Wetlands and Waters of the US are likely present within the project study area. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Wild and Scenic Rivers. The Cheyenne River is listed on the Nationwide Rivers Inventory between Lake Oahe and Slate Springs Draw, which includes the stretch in the project study area.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present within the vicinity of the study area and could potentially be affected by the project.
- Prime and Unique Farmland. The project study area contains “Prime farmland if irrigated” and “Farmland of statewide importance.” A Form NRCS CPA-106 for Corridor Type Projects or Form AD1006 may be required.
- Tribal Consultation. The north side of the project is within the Cheyenne River Indian Reservation. Tribal consultation will be required with those tribes that have a cultural or historic interest in Haakon and Ziebach counties.

- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, NPS, and the Tribes) will be required during the NEPA process.

Figure 13.3 Structure No. 69-390-535 Environmental Constraints Map



13.B. Future Conditions Analysis

The future conditions analysis conducted for the SD 63 Bridge over the Cheyenne River determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

13.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 63 is estimated to have an ADT volume of 451 with a heavy vehicle percentage of 15.2 percent.

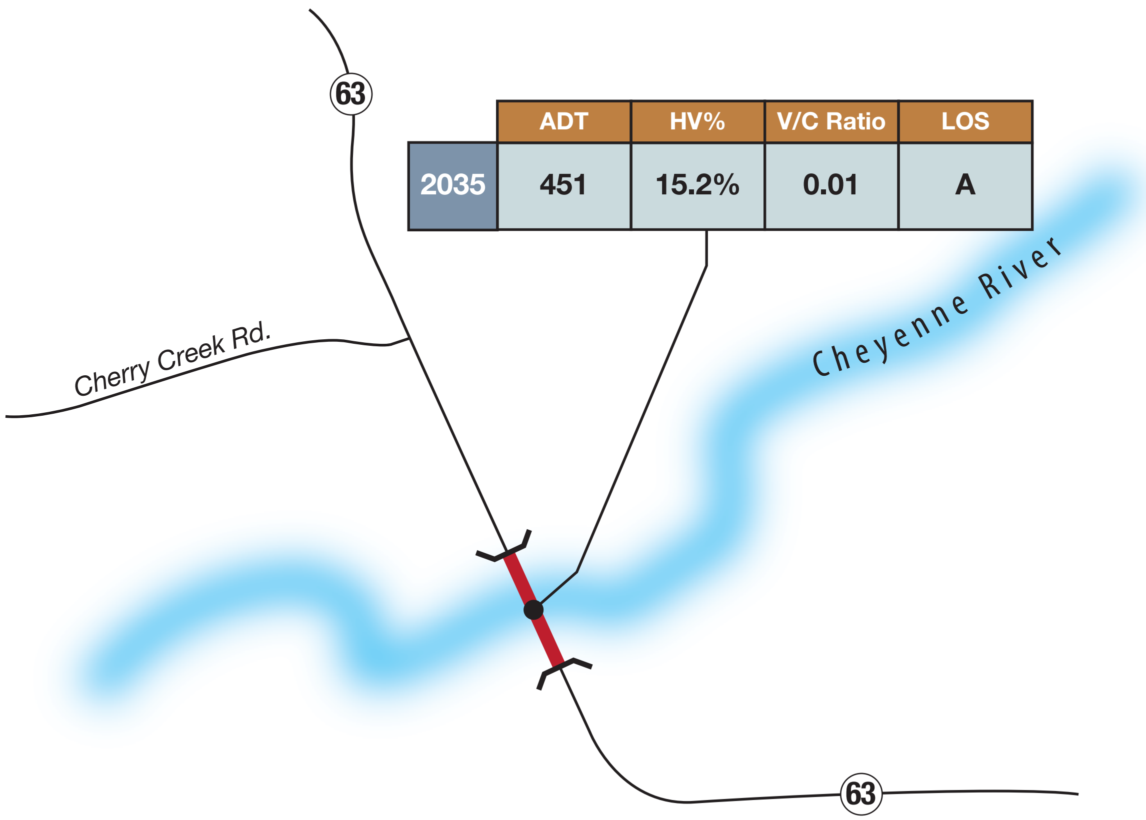
The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.1 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and the roadway ADT, SD 63 is anticipated to operate at LOS A with a V/C ratio of 0.01 in 2035. **Figure 13.4** summarizes the future roadway and traffic conditions.

13.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

13.B.3. Safety Recommendations

A review of the crash data indicates a pattern of animal-related collisions. The team recommends that additional non-vehicular warning signs W11-3 (Deer) be considered in advance of the bridge approaches warning drivers in all directions that wildlife may be crossing in this area.



	ADT	HV%	V/C Ratio	LOS
2035	451	15.2%	0.01	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Minor Arterial
Posted Speed	65 mph
Bridge Roadway Width	32 Feet

North

NOTE: Drawing Not to Scale

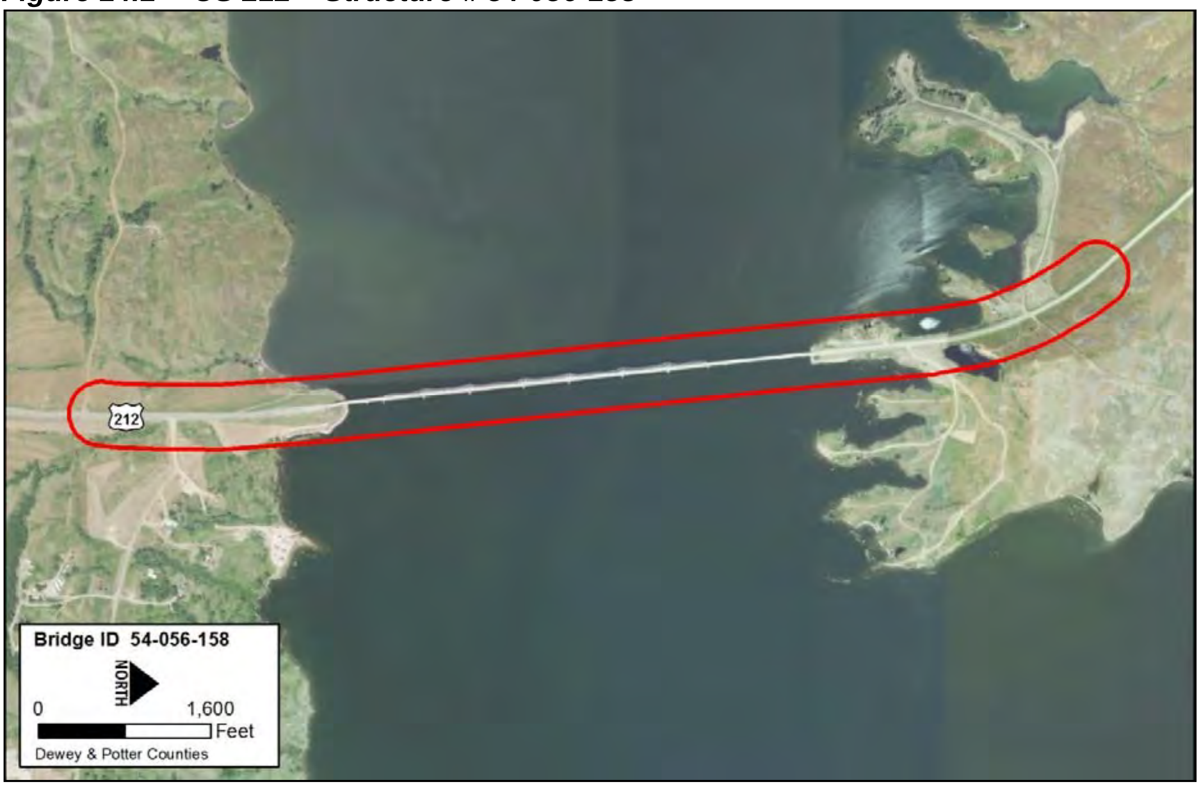
Figure 13.4
2035 Future Conditions
SD 63/Cheyenne River
69-390-535

14. Structure # 54-056-158

Structure No. 54-056-158 (Forest City) is located over the Missouri River on US 212 approximately 18 miles west of Gettysburg, between Dewey and Potter counties. The study area is approximately 2.0 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure, constructed in 1958, underwent a major rehabilitation in 1980. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. The team developed and evaluated alternative improvement scenarios for this structure.

Figure 14.1 US 212 – Structure # 54-056-158



14.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the US 212 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure. Because this bridge is located over the Missouri River, coordination with the Coast Guard is also required.

14.A.1. Additional Background Data

The team requested no additional data for this structure location.

14.A.2. Roadway Conditions

On US 212, the northbound approach to the bridge consists of two-lanes, 12 feet each, with 12-foot surfaced shoulders. On the bridge, the roadway width is 26 feet, which consists of two 13-foot driving lanes with no shoulders. The southbound approach to the bridge consists of two-lanes, 12 feet each, with 7-foot surfaced shoulders. The speed limit is 55 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT between 551 and 1,500, the existing cross section of roadway approaches to the structure currently meets SDDOT design standards. However, for the bridge, Table 7-1 indicates that a minimum bridge width of 36 feet be provided. The current roadway width of 26 feet does not meet SDDOT design standards.

The US 212 approaches to the bridge are asphalt surfaced. The approach immediately north of the bridge has a Surface Condition Index of 3.70, and the approach on the south side of the bridge has an index of 3.36. **Table 14.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 14.1 US 212 (Structure #54-056-158) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
3.70 (North)	3.97	4.18	4.69	5.00	3.61	4.55	0.1/0.3
3.36 (South)	3.44	4.90	4.60	3.30	4.30	4.48	0.1/0.5

14.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (34 tons) and a fracture critical bridge.
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and no shoulders.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 5
  - Substructure: 5
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 59.1, indicating a structure in below average structural condition. This bridge is classified as Functionally Obsolete because the approach roadway alignment item codes as 3.

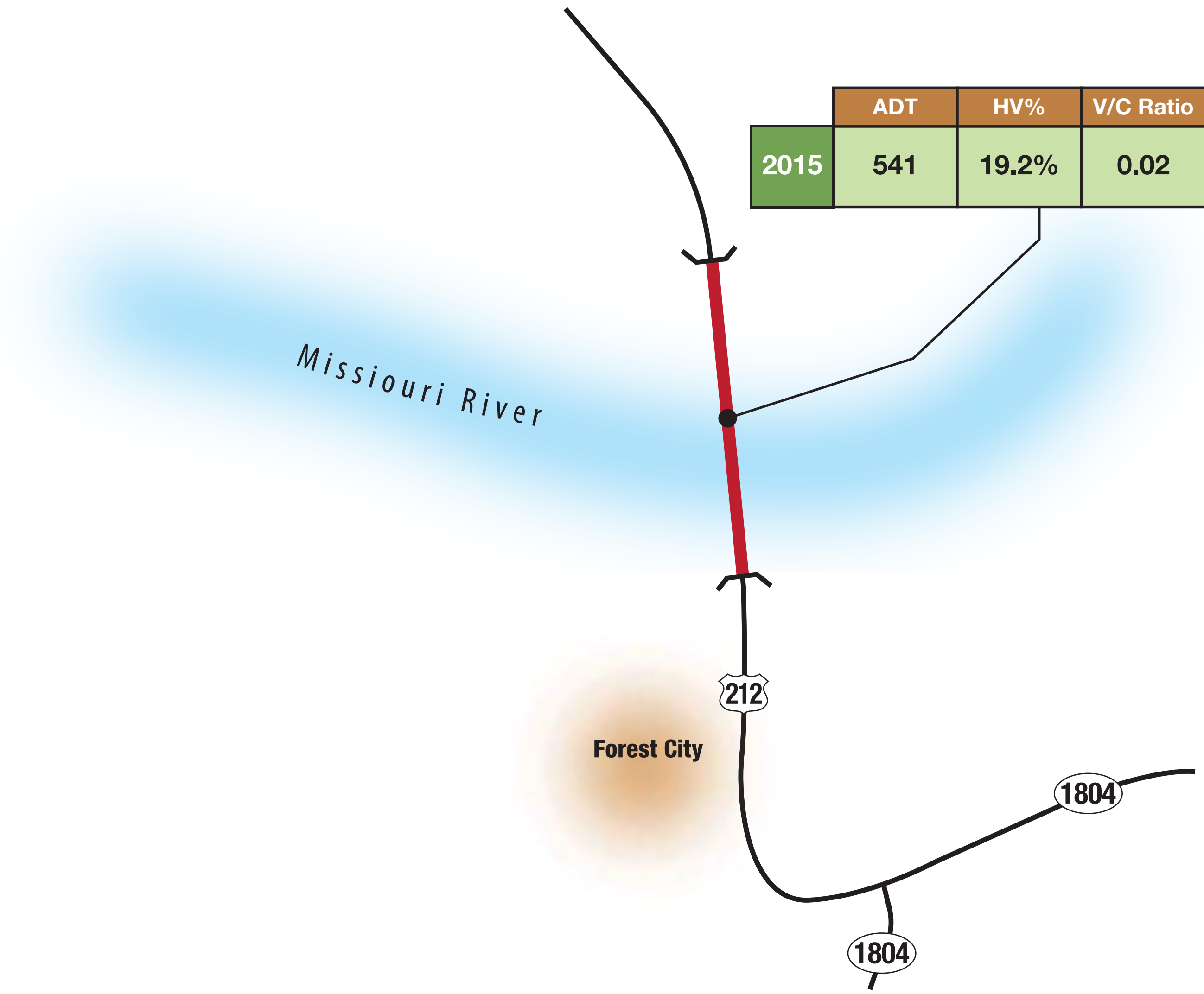
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Major landslide problems creating substructure and approach problems
  - Severe settlement of the approaches
  - Some truss and girder section loss
  - Pier cap and column cracking
  - A few cracked truss welds
  - Use of truss spans at this bridge, which makes widening the superstructure difficult

14.A.4. Traffic Analysis

US 212, categorized as a Rural Other Principal Arterial, is located between Dewey and Potter counties. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 541 in 2015. The analysis did not include peak period turning movement counts for this structure. The roadway has a heavy vehicle percentage of 19.2 percent. A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 66 percent would fall into FHWA Vehicle Class 5-9 and 34 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Because this bridge lies within two counties, an average rate was developed between the two. Based on the functional class and geographic location of the roadway, a growth rate of 1.150 percent was developed. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.017 percent was developed, and a growth rate of 2.861 percent was developed for FHWA Vehicle Class 10-13. **Figure 14.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis used a ratio of peak hour to ADT (K factor) of 8.1 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and roadway ADT, US 212 currently operates at LOS A with a V/C ratio of 0.02.



	ADT	HV%	V/C Ratio	LOS
2015	541	19.2%	0.02	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	26 Feet

North

NOTE: Drawing Not to Scale

Figure 14.2
2015 Existing Conditions
Forest City/US 212
54-056-158

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14.A.5. Safety Analysis

The analysis used crash records compiled from SDDOT for the structure and the approaches on US 212. **Tables 14.2** and **14.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 14.2 US 212 (Structure #54-056-158) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
2	0	0	0	0	0	2

All of the crashes that occurred in the study area involved a single vehicle. One crash occurred on the bridge and the other on the southbound approach to the structure. The manner of collision for both crashes is unknown. The crash on the bridge occurred during construction and is contributed to a shift in traffic.

Table 14.3 US 212 (Structure #54-056-158) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
US 212	0	0	1	0	1	2	541	0.99	2.03	11.83
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 2.03. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 11.83. There are no identifiable crash patterns at this location.

14.A.6. Bicycle/Pedestrian Facilities

Currently, the bridge provides no bicycle or pedestrian facilities. However, on the bridge approaches, the paved shoulders offer cyclists an alternative to ride with some separation from vehicular traffic.

14.A.7. Coast Guard Requirements

All rehabilitation work is approved on an individual basis. Containment must be used on the bridges to keep debris, etc., from falling into the river. The containment is allowed to project approximately 2 feet to 4 feet below the low steel elevation. The approval process involves the USCG reviewing the contractor's work plan. All bridge replacements are approved on an individual basis. The general guideline is that the new bridge must meet or exceed the currently provided clearances.

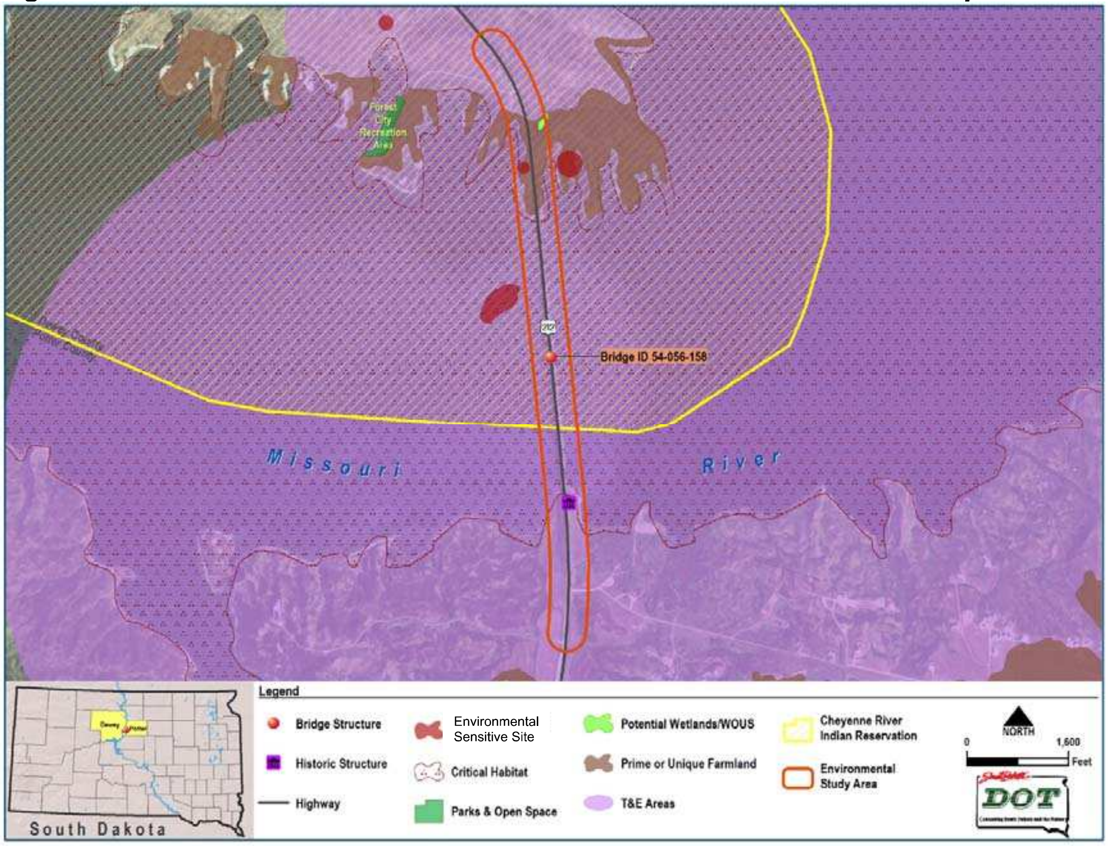
14.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Additionally, suitable habitat appears to be present for several other state and federally listed species, and modern records of piping plover exist within the vicinity of the project study area.

- Section 4(f). Section 4(f) properties are present within the project study area on the north side of the Missouri River, including Forest City Recreation Area.
- Section 106. Historic and archeological resources are present within or near the study area and will likely require further surveys and evaluation.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, particularly near the banks of the Missouri River. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Title VI (Civil Rights) and Environmental Justice. Minorities and vulnerable age populations are present within the study area and low-income populations are present in the vicinity; these populations could potentially be indirectly affected by the project.
- Prime and Unique Farmland. The north end of the project study area contains “Prime farmland if irrigated.” A NRCS CPA-106 (Corridor Type Projects) or AD-1006 Form may be required.
- Section 9. A contractor’s work plan must be submitted to the USCG before beginning any work. A Conditions of Approval Letter will be required for minor work or a Section 9 permit for major work.
- Tribal Consultation. The north side of the project is within the Cheyenne River Indian Reservation. Tribal consultation will be required with those tribes that have a cultural or historic interest in Dewey and Potter counties.
- Agency Coordination. The project is located on USACE property on the south bank of the Missouri River. Further agency coordination (FHWA, USFWS, SDGFP, USCG, SDSHPO, USACE, and the Tribes) will be required during the NEPA process.

Figure 14.3 Structure No. 54-056-158 Environmental Constraints Map



14.B. Future Conditions Analysis

The future conditions analysis conducted for the Forest City Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

14.B.1. Future Traffic Analysis

SDDOT provided growth rates for the analysis, which used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 212 is estimated to have an ADT volume of 695 with a heavy vehicle percentage of 21.0 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure, a K factor of 8.1 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and roadway ADT, US 212 is anticipated to operate at LOS A with a V/C ratio of 0.02 in 2035. **Figure 14.4** summarizes future roadway and traffic conditions.

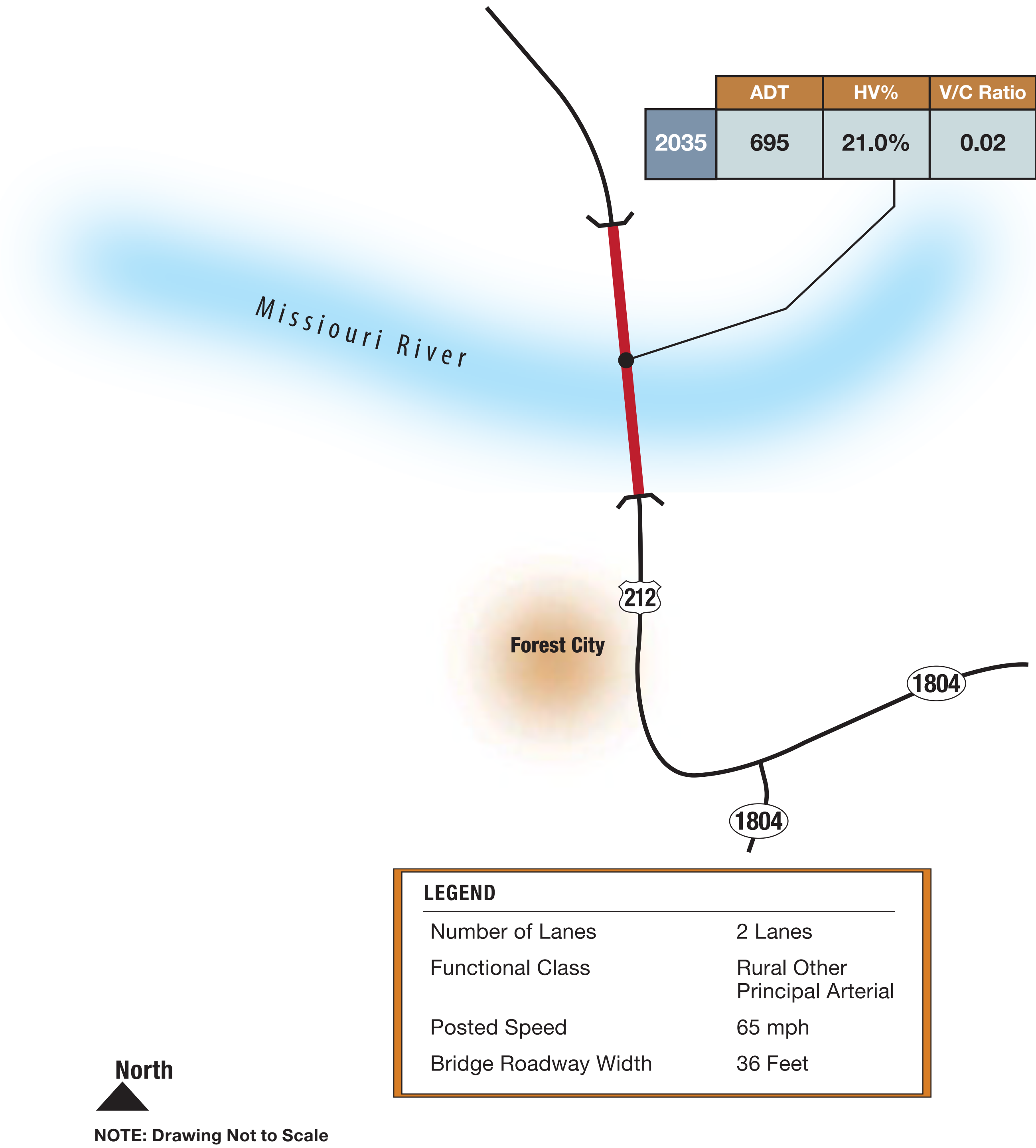
14.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

14.B.3. Safety Recommendations

A review of the crash data indicates that there is no identifiable crash pattern. The team made no recommendations for safety improvements at this location.

	ADT	HV%	V/C Ratio	LOS
2035	695	21.0%	0.02	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	36 Feet

Figure 14.4
2035 Future Conditions
Forest City/US 212
54-056-158

15. Structure # 16-737-253

Structure No. 16-737-253 (Singing Bridge) is located over the Grand River in Corson County on SD 1806. The study area is approximately 1.5 miles long and 600 feet wide, centered on the structure and its approaches. However, the search area for Nationwide River Inventory rivers and South Dakota Department of Environment and Natural Resources (SDDENR) Active Program Sites extends 0.5 miles upstream and downstream from the structure.

This structure was constructed in 1963. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 15.1 SD 1806 – Structure # 16-737-253

15.A. *Baseline Conditions Analysis*

The team conducted a baseline conditions analysis for the SD 1806 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

15.A.1. Additional Background Data

The team requested additional traffic count data for the intersection of US 12/SD 20 with SD 1806 west of Mobridge, South Dakota; however, no additional traffic data were available.

15.A.2. Roadway Conditions

On SD 1806, the approaches to the bridge consist of two-lanes, 12 feet in width each, with earth shoulders. On the bridge, the roadway width is 24 feet, which consists of two 12-foot driving lanes and no shoulders. The speed limit is posted at 55 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT between 551 and 1,500, the existing cross sections of the roadway approaches to the structure do not currently meet SDDOT design standards. Table 7-1 indicates that a total surfaced width of 36 feet should be provided. The current roadway width is 24 feet with no surfaced shoulders. A minimum 6-foot surface shoulder should be provided. For the bridge, Table 7-1 indicates that a minimum bridge width of 36 feet should be provided. The current roadway width of 24 feet does not meet SDDOT design standards.

The SD 1806 approaches to the bridge are asphalt surfaced. The approach immediately north of the bridge has a Surface Condition Index of 3.63, and the approach immediately south of the bridge has an index of 4.08. **Table 15.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 15.1 SD 1806 (Structure #16-737-253) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
3.63 (North)	3.76	4.61	4.22	3.63	4.00	4.54	0.1/0.4
4.08 (South)	4.30	4.61	4.08	5.00	4.30	4.63	0.1/0.2

15.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (34 tons).
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width and no sidewalks.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
    - Deck: 7
    - Superstructure: 6
    - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 80.3, indicating a structure in above average structural condition. This bridge is classified as Functionally Obsolete because the approach roadway alignment codes as 3.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as underwater

inspections and fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.

- Abutments shifting, limiting room for expansion
- Scour at piers with exposed piling; however, bridge is not scour critical
- Numerous columns with poorly consolidated concrete and several with exposed reinforcing steel below waterline

15.A.4. Traffic Analysis

SD 1806, categorized as a Rural Major Collector, is located in Corson County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 826 in 2015. No peak period turning movement counts were available at the intersection of US 12/SD 20 with SD 1806. As such, FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop design hour traffic volumes. The roadway has a heavy vehicle percentage of 4.1 percent.

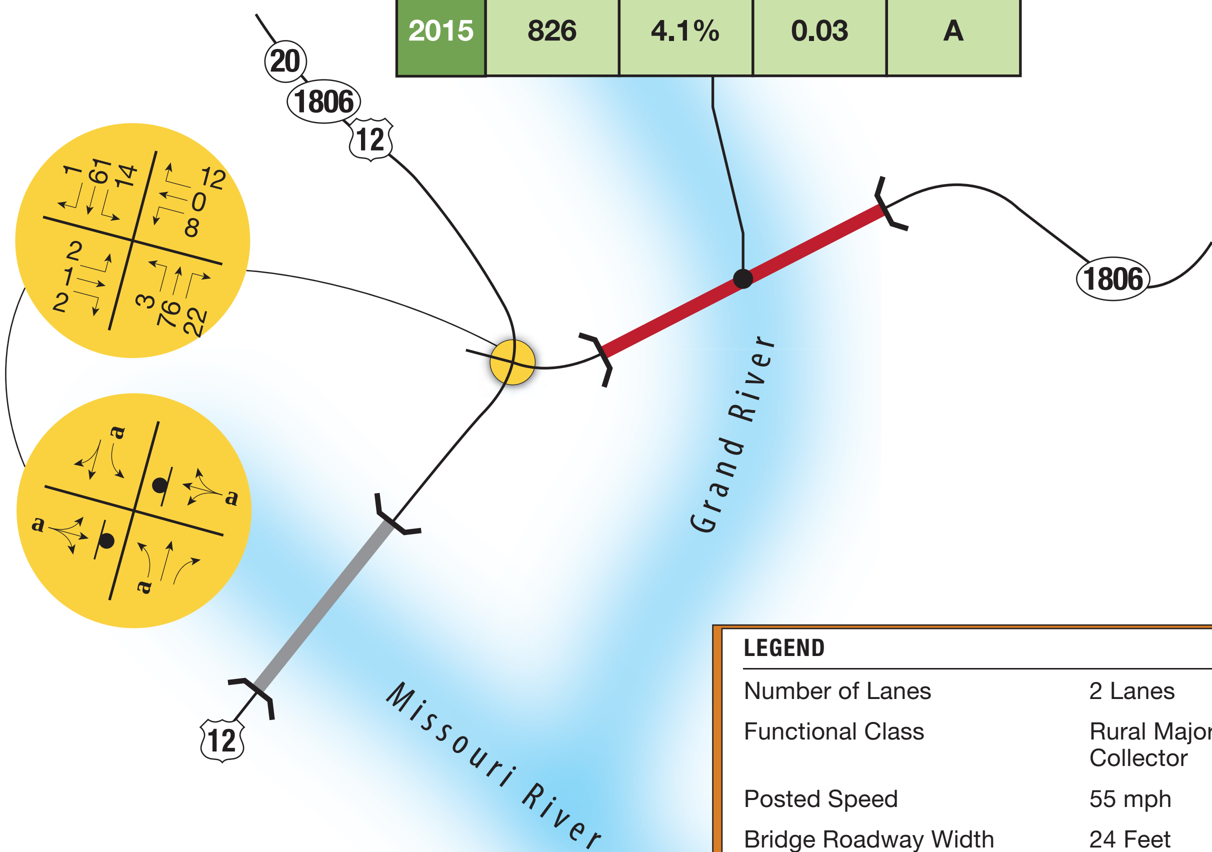
A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on the functional class and geographic location of the roadway, a growth rate of 1.300 percent was provided. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 0.873 percent was provided, and a growth rate of 2.863 percent was provided for FHWA Vehicle Class 10-13. **Figure 15.2** summarizes the roadway and traffic conditions**.**

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.1 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, SD 1806 currently operates at LOS A with a V/C ratio of 0.03.

At the unsignalized intersection of US 12/SD 20 with SD 1806, all critical movements currently operate at LOS A under 2015 design hour traffic conditions.

	ADT	HV%	V/C Ratio	LOS
2015	826	4.1%	0.03	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Major Collector
Posted Speed	55 mph
Bridge Roadway Width	24 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2015 Design Hourly Volumes (DHV)

x/x = 2015 Design Hourly Volumes (DHV) Unsignalized Intersection Level of Service

= Stop Sign

North

NOTE: Drawing Not to Scale

Figure 15.2
2015 Existing Conditions
Singing Bridge/Hwy 1806
16-737-253

FELSBURG HOLT & ULLEVIG
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15.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and the approaches on SD 1806. **Tables 15.2** and **15.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 15.2 SD 1806 (Structure #16-737-253) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
2	0	0	0	0	0	2

Both crashes that occurred in the study area involved a single vehicle and appear to have occurred on the roadway approaches. No crashes occurred on the bridge. Both crashes involved animal collisions.

Table 15.3 SD 1806 (Structure #16-737-253) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
SD 1806	0	0	0	0	2	2	826	1.51	1.33	1.33
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 1.33. The severity rate per MEV, which applies a cost factor to the different crash severity types, is also 1.33. **Table 15.4** shows the identified crash patterns and possible contributing factors.

Table 15.4 SD 1806 (Structure #16-737-253) – Crash Patterns (2010–2014)

Crash Pattern	Contributing Factors
Animal-related Collisions	▪ Bridge is located in heavily populated deer habitat

15.A.6. Bicycle/Pedestrian Facilities

Currently, the bridge or roadway approaches provide no bicycle or pedestrian facilities.

15.A.7. Coast Guard Requirements

Coast Guard requirements are not applicable for this structure.

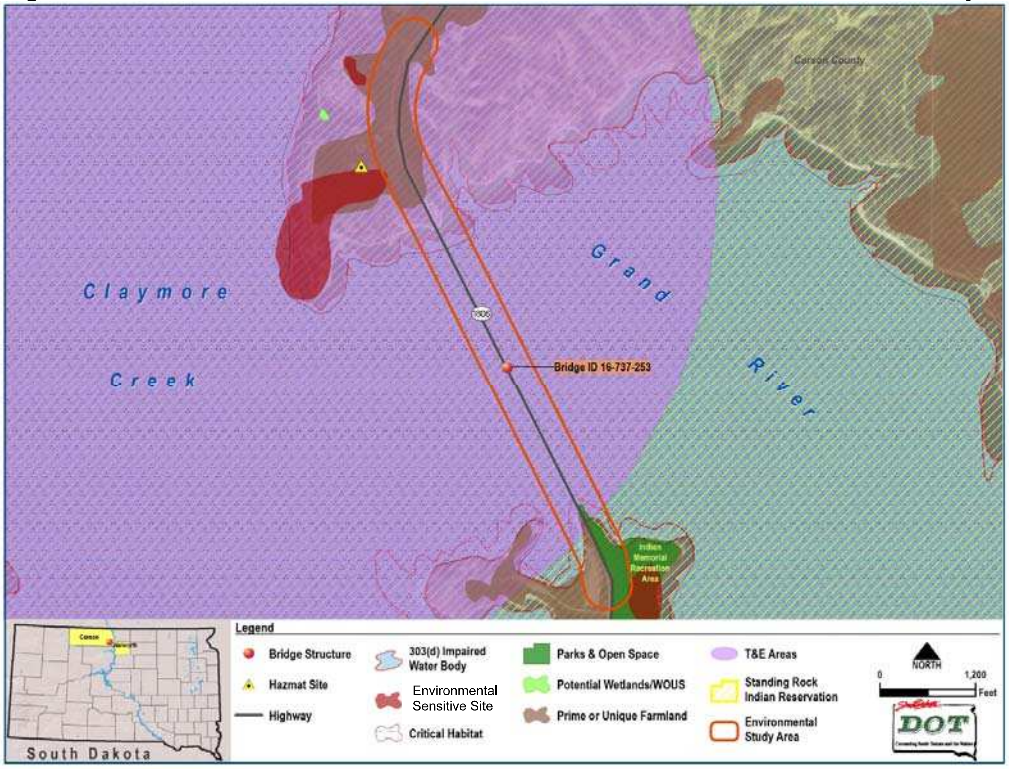
15.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Threatened and Endangered Species. The project study area is within federally designated critical habitat for the piping plover. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities. Suitable habitat also appears to be present for several other state and federally listed species. Modern records of piping plover and false map turtle exist within the vicinity of the project study area.

- Section 4(f). Section 4(f) properties are present within the project study area on the south side of the Grand River, including Indian Memorial Recreation Area and Roadside Park, which contains a historical marker.
- Section 106. Historical and archeological sites are present within the study area. Most of these sites are unevaluated and will likely require further surveys and evaluation.
- Wetlands and Waters of the US. Wetlands may be present within the project study area, particularly near the river banks or in ditches or other depressions adjacent to the river. Impacts to these resources will depend on the scope of work. If impacts are determined likely, then a full delineation would be recommended.
- Water Quality. SDDENR impaired (303(d)) water bodies are present within the project study area and include pH as the cause for impairment.
- Regulated Materials. Regulated materials in the vicinity of the project study area include active gasoline tanks near the south end of the project study area.
- Title VI (Civil Rights) and Environmental Justice. Minorities, vulnerable age populations, and low-income populations are present in the project vicinity and could potentially be indirectly affected.
- Prime and Unique Farmland. The north and south ends of the project study area include "Prime farmland if irrigated." A small area of "Farmland of statewide importance" is also present at the south end of the study area. NRCS CPA-106 for Corridor Type Project or AD1006 Form may be required.
- Tribal Consultation. The project is within the Standing Rock Indian Reservation. Tribal consultation will be required with those tribes that have a cultural or historic interest in Corson County.
- Agency Coordination. The project is located on USACE property. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, USACE, and the Tribes) will be required during the NEPA process.

Figure 15.3 Structure No. 16-737-253 Environmental Constraints Map



15.B. Future Conditions Analysis

The future conditions analysis conducted for the Singing Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

15.B.1. Future Traffic Analysis

SDDOT provided growth rates for the analysis, which used a straight line growth projection to determine 2035 traffic volumes. In 2035, SD 1806 is estimated to have an ADT volume of 1,073 with a heavy vehicle percentage of 4.4 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure, a K factor of 8.1 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and the roadway ADT, SD 1806 is anticipated to operate at LOS A with a V/C ratio of 0.03 in 2035. At the unsignalized intersection of US 12 / SD 20 with SD 1806, all critical movements are anticipated to operate at LOS A under 2035 design hour traffic conditions. **Figure 15.4** summarizes the future roadway and traffic conditions.

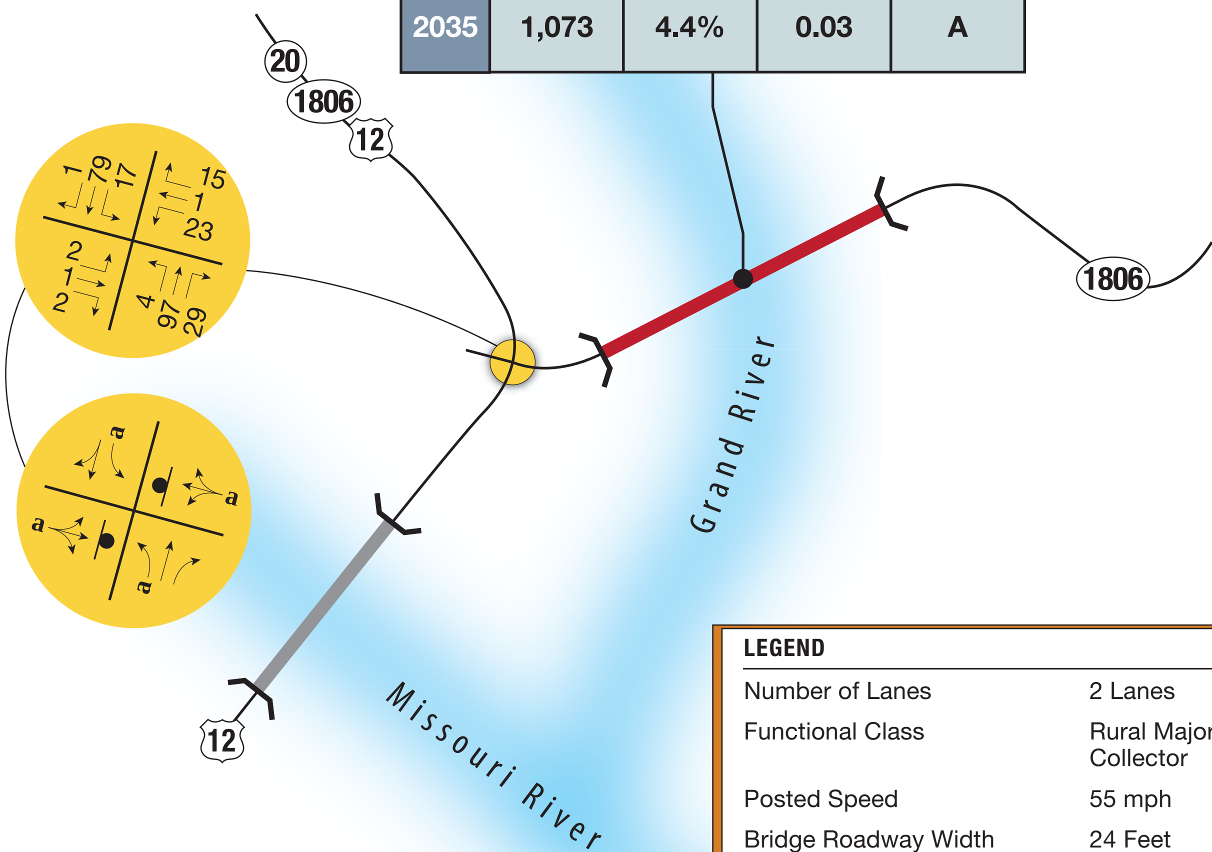
15.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. Traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

15.B.3. Safety Recommendations

A review of crash data indicates a pattern of animal-related collisions. The team recommends that additional non-vehicular warning signs W11-3 (Deer) be considered before bridge approaches to warn drivers in all directions that wildlife may be crossing in this area.

	ADT	HV%	V/C Ratio	LOS
2035	1,073	4.4%	0.03	A



LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Major Collector
Posted Speed	55 mph
Bridge Roadway Width	24 Feet
Study Intersections	(yellow circle)

TRAFFIC LEGEND

XXX = 2035 Design Hourly Volumes (DHV)

x/x = 2035 Design Hourly Volumes (DHV) Unsignalized Intersection Level of Service

= Stop Sign

North

NOTE: Drawing Not to Scale

Figure 15.4
2035 Future Conditions
Singing Bridge/Hwy 1806
16-737-253

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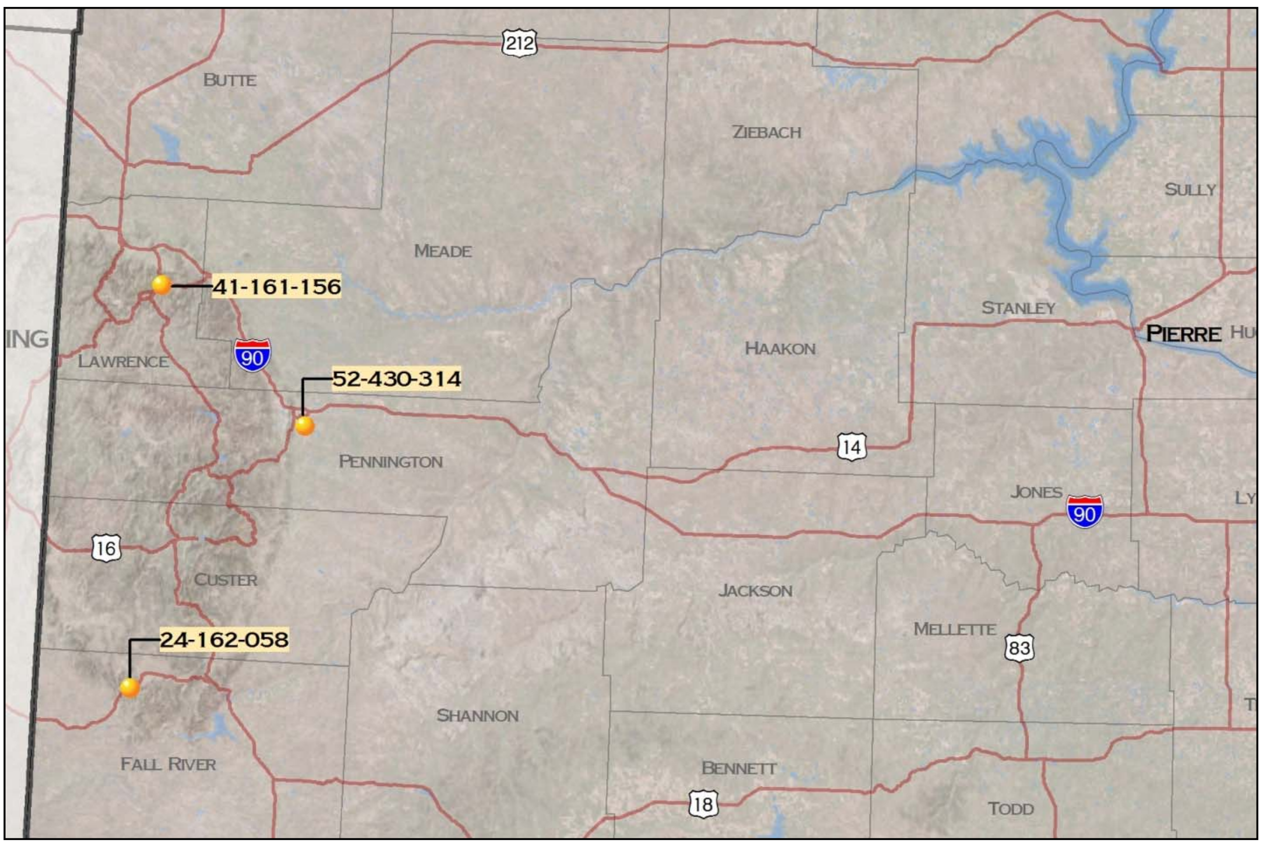
IV. RAPID CITY REGION

Three of the study bridges are located in the Rapid City Region. Two of the bridges are located in more urbanized areas, in Deadwood and Rapid City. The information and the analysis for each bridge are provided within their own section for use as a standalone document.

Rapid City Region Bridges

Rapid City Region				
Structure Number	Highway/ Street	Landmark or Common Name	Feature Intersected	Length (feet)
41-161-156	US 14A	Deadwood Box	Whitewood Creek	1,768
24-162-058	US 18	Fossil Cycad National Monument	Canyon	804
52-430-314	Cambell Street	Cambell Street	Railroad/Street	724.2

Structure Locations – Rapid City Region

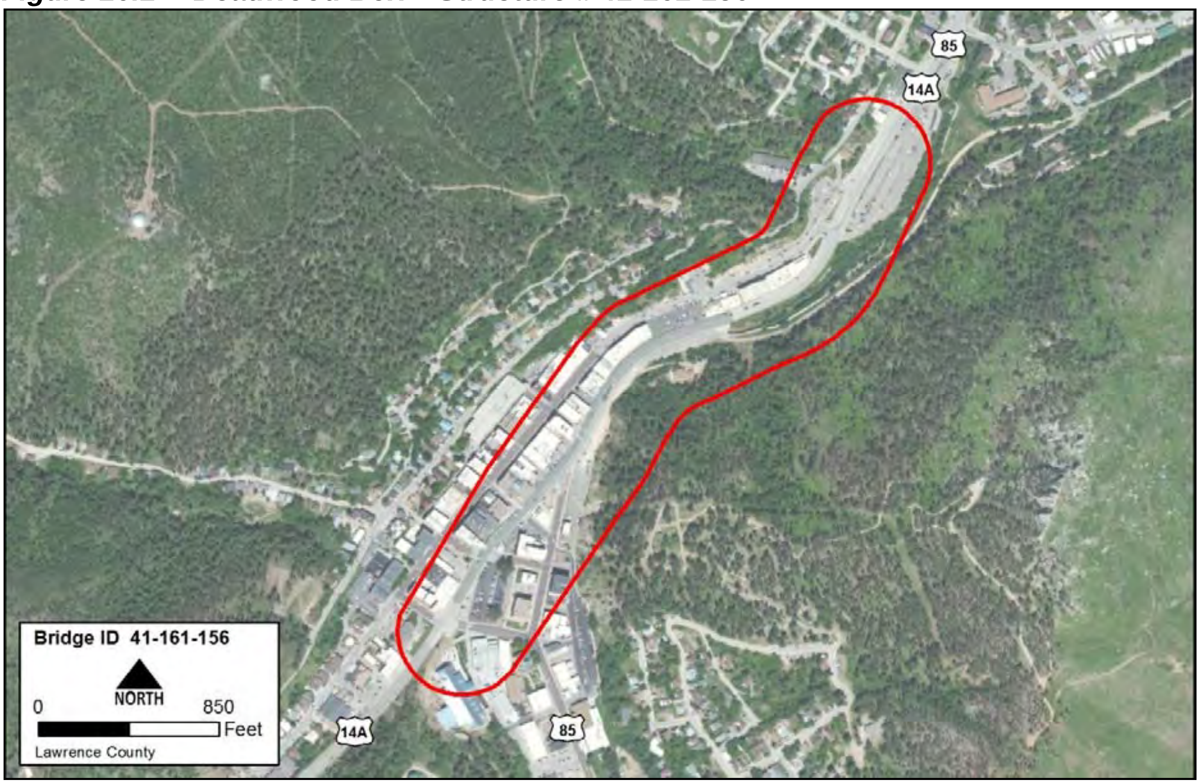


16. Structure # 41-161-156

Structure No. 41-161-156 (US 14A – Deadwood Box) is located in the city of Deadwood in Lawrence County. The study area is approximately 0.70 miles long and 600 feet wide, centered on the structure and its approaches. The structure is completely underground and runs from the downtown Deadwood area to the northeast.

This structure, constructed in 1967, underwent a major rehabilitation in 1989. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 16.1 Deadwood Box – Structure # 41-161-156



16.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the Deadwood Box for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

16.A.1. Additional Background Data

The team obtained historic peak hour turning movement counts from the city of Deadwood for some intersections in the study area. The team also used data from the *City of Deadwood Pedestrian Circulation and Enhancement Study* for this structure. The team downloaded study documents from the SDDOT website.

16.A.2. Roadway Conditions

The Deadwood Box runs under US 14A (Pioneer Way) from Railroad Avenue on the north to Pine Street on the south. On US 14A, the roadway generally has an urban four-lane undivided cross section with curb and gutter, 48 feet in width. The roadway consists of four 12-foot driving lanes; in some segments a barrier is adjacent to the outside lanes on both sides of the roadway. A 6-foot sidewalk is provided at the back of curb on the east side of US 14A for the entire length of the box structure. The speed limit on US 14A is posted at 30 mph.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, for urban areas shoulders may not be provided. Consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For low speed highways (40 mph or less) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. Because the 6-foot sidewalk on the east side of US 14A provides a facility for pedestrians and bicycles, the existing cross section meets SDDOT design standards.

The US 14A approaches to the bridge are concrete surfaced. The approach immediately north of the bridge has a Surface Condition Index of 3.90, and the approach immediately south of the bridge has an index of 3.20. **Table 16.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 16.1 US 14A (Structure #41-161-156) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	D-Cracking/ASR	Joint Spalling	Corner Cracking	Faulting	Joint Seal Damage	Punchouts
3.90 (North)	4.22	3.90	4.00	5.00	5.00	4.00	5.00
3.20 (South)	3.80	5.00	3.20	5.00	5.00	4.00	5.00

16.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. The review revealed no load carrying capacity issues for the bridge.
- Geometry. The existing bridge is a buried structure with various roadway and local amenities atop the bridge. Therefore, no geometric limitations were identified for the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 5
  - Superstructure: 7
  - Substructure: 4
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, and appropriate width. This bridge's current sufficiency rating is 38.0. This bridge is Structurally Deficient. The structurally deficient designation is controlled by poor substructure condition (coded 4), including significant full height cracking of the abutment walls.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results. Structural issues have been

limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.

- Spalls and cracks in abutment walls
- Multiple expansion joints with leaking indicated below the deck
- Minor girder and stringer deterioration

16.A.4. Traffic Analysis

US 14A, categorized as a Rural Other Principal Arterial, is located in Lawrence County.

Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 11,269 in 2015. The roadway has a heavy vehicle percentage of 2.9 percent. SDDOT provided AM peak period turning movement counts for this location at the intersections of US 14A with Lee Street, Deadwood Street, Pine Street, and Wall Street; however, no data was provided for the PM peak hour. In addition, no peak period data was provided for the intersections of US 14A with Sherman Street and Lower Main Street. FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop the missing peak hour traffic volumes for the intersections. **Figure 16.2** shows the AM and PM peak hour turning volumes, along with the intersection lane configuration.

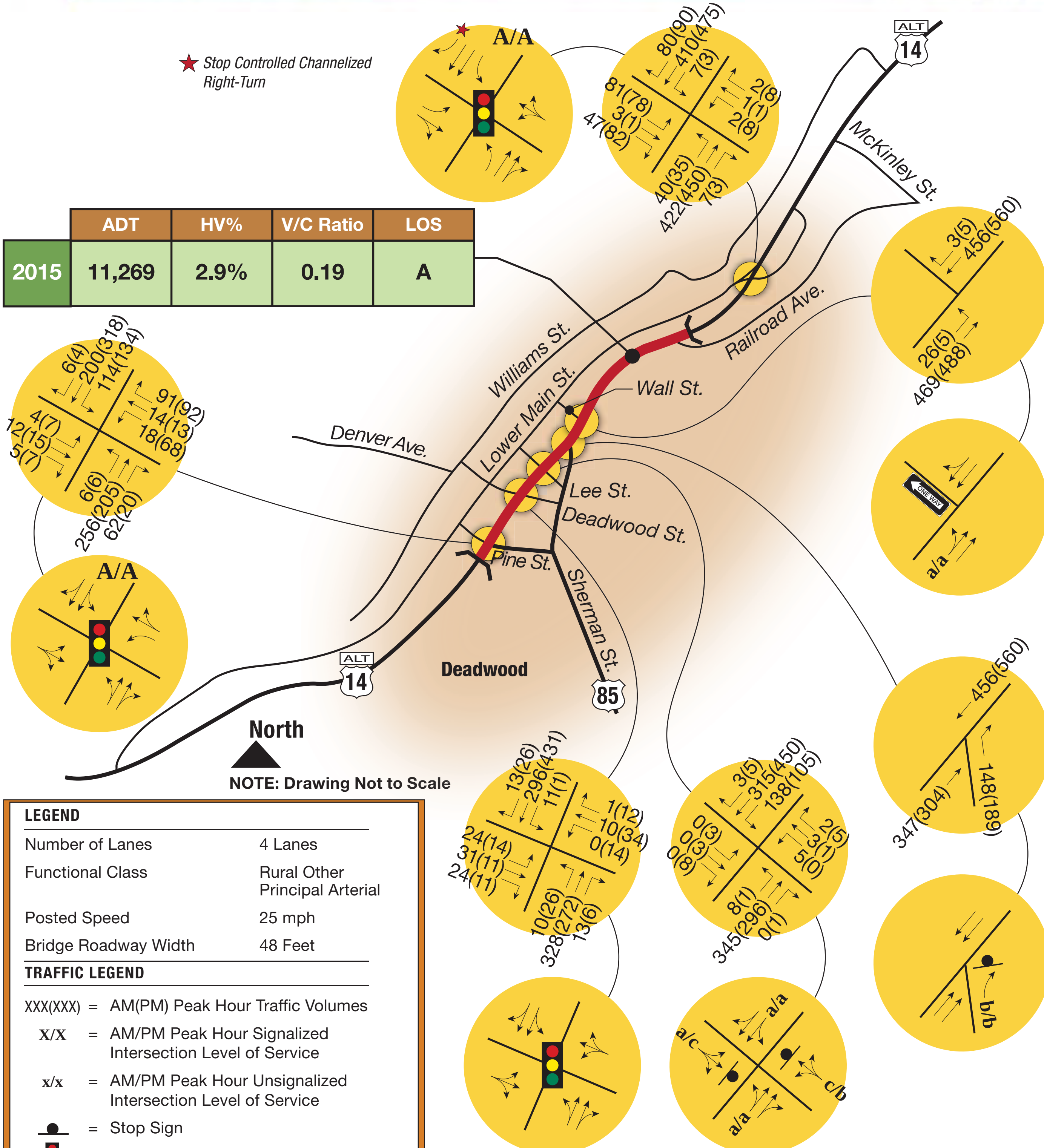
A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on the functional class and geographic location of the roadway, a growth rate of 1.315 percent was used. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.170 percent was used, and a growth rate of 2.886 percent was used for FHWA Vehicle Class 10-13. **Figure 16.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the box structure. The analysis also used a PHF of 0.88. The analysis used existing peak hour traffic counts to determine the K Factor and D Factor. Based on HCM methodologies and peak hour traffic volumes, US 14A currently operates at LOS A with a peak flow rate of 311 pcphpl and a V/C ratio of 0.19.

At the unsignalized intersections of US 14A with Lee Street, Sherman Street, and Wall Street, all critical movements currently operate at LOS C or better under 2015 peak hour traffic conditions. The signalized intersections of US 14A with Pine Street, Deadwood Street, and Lower Main Street currently operate at LOS A under 2015 AM and PM peak hour traffic conditions.

	ADT	HV%	V/C Ratio	LOS
2015	11,269	2.9%	0.19	A



NOTE: Drawing Not to Scale

LEGEND	
Number of Lanes	4 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	25 mph
Bridge Roadway Width	48 Feet

TRAFFIC LEGEND

- XXX(XXX) = AM(PM) Peak Hour Traffic Volumes
- X/X = AM/PM Peak Hour Signalized Intersection Level of Service
- x/x = AM/PM Peak Hour Unsignalized Intersection Level of Service
- ● = Stop Sign
- 🚦 = Traffic Signal
- ○ = Study Intersection(s)*

*Turning Movement Counts Currently Not Available

Figure 16.2
2015 Existing Conditions
Deadwood Box/US 14A
41-161-156

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16.A.5. Safety Analysis

The team used crash records compiled from SDDOT for multiple intersections along US 14A in the City of Deadwood, South Dakota. The intersecting streets consist of Pine Street, Lee Street, Deadwood Street, Wall Street, Sherman Street, and Railroad Avenue. **Tables 16.2** and **16.3** summarize the crash history for the most recent five-year period (2010–2014).

Table 16.2 US 14A (Structure #41-161-156) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
US 14A / Wall St.	1	6	0	1	0	0	8
US 14A / Railroad Ave.	0	0	1	1	0	0	2
US 14A / Pine St.	1	3	0	4	0	0	8
US 14A / Deadwood St.	1	0	0	4	0	0	5
US 14A / Lee St.	1	2	0	1	0	0	4
US 14A / Sherman St.	0	2	0	0	0	0	2
Total	**4**	**13**	**1**	**11**	**0**	**0**	**29**

Most collisions that occurred along US 14A were rear end and angle type crashes. Most rear end collisions occurred around the intersection of US 14A and Wall Street. Angle type collisions were identified along the whole US 14A corridor, but most were isolated at the Pine Street and Deadwood Street intersections.

Table 16.3 US 14A (Structure #41-161-156) – Crash Rates (2010–2014)

Roadway Segment or Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
US 14A / Wall St.	0	1	2	1	4	8	10,724	19.57	0.41	3.10
US 14A / Railroad Ave.	0	0	0	1	1	2	11,269	20.57	0.10	0.34
US 14A / Pine St.	0	0	0	0	8	8	8,779	16.02	0.50	0.50
US 14 A / Deadwood St.	0	0	0	1	4	5	8,076	14.74	0.34	0.68
US 14A / Lee St.	0	0	0	1	3	4	8,076	14.74	0.27	0.62
US 14A / Sherman St.	0	0	1	0	1	2	10,724	19.57	0.10	0.60

Incapacitating (Incap.) Property Damage Only (PDO * MEV= Million Entering Vehicles
N/A = Traffic Volume Data Currently not Available

The crash rate per MEV for the intersection of US 14A with Wall Street is 0.41. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 3.10. At the intersection of US 14A with Railroad Avenue, the crash rate per MEV is 0.10, with a severity rate per MEV of 0.34. The crash rate per MEV for the intersection of US 14A with Pine Street is 0.50, with a severity rate per MEV of 0.50. The intersection of US 14A with Deadwood Street has a crash rate per MEV of 0.34, with a severity rate per MEV of 0.68. The crash rate per MEV for the intersection of US 14A with Lee Street is 0.27, with a severity rate per MEV of 0.62. The crash rate per MEV for the intersection of US 14A with Sherman Street is 0.10, with a severity rate per MEV of 0.60. **Table 16.4** shows the identified crash patterns and possible contributing factors.

Table 16.4 US 14A (Structure #41-161-156) – Crash Patterns (2010 - 2014)

Crash Pattern	Contributing Factors
Rear End	▪ Typical crash pattern at signalized intersections ▪ No turn-lanes provided. Turning vehicles stopped in through lane.
Angle	▪ Inadequate gaps – peak period

16.A.6. Bicycle/Pedestrian Facilities

A 6-foot sidewalk is provided at the back of curb on the east side of US 14A for the entire length of the box structure. Pedestrian crosswalks across US 14A are provided at the unsignalized intersections of US 14A with Wall Street and Lee Street, and at the signalized intersections of US 14A with Deadwood Street and Pine Street. There is a high level of pedestrian activity in the study area.

16.A.7. Coast Guard Requirements

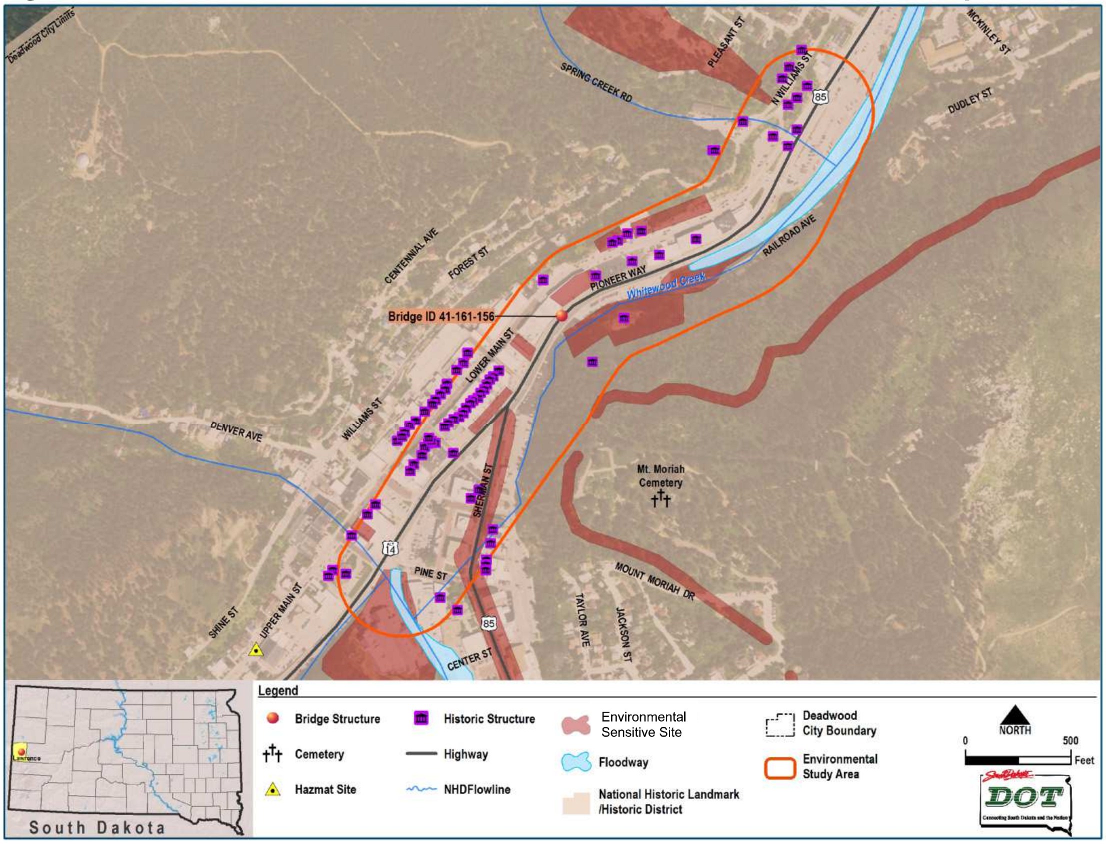
Coast Guard requirements are not applicable for this structure.

16.A.8. Environmental Resource Review

The environmental resources review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases:

- Section 4(f). Section 4(f) and Section 106 properties are present within the project study area. The project is located within the Deadwood Historic District, and portions of the Black Hills National Forest boundary intersect with the study area.
- Section 106. Historic and archeological resources are present within the study area, including the Deadwood Historic District, which is listed on the National Register of Historic Places.
- Regulated Materials. Regulated material sites within the project study area include one closed aboveground storage tank and several closed underground storage tanks in the southern portion of the study area. A drycleaning facility is located within 0.5-miles of the project study area. Further evaluation during the NEPA process is recommended.
- Floodplains and Floodways. A floodplain permit would likely be required from the local jurisdiction.
- Title VI (Civil Rights) and Environmental Justice. Minorities and low-income populations are present within the study area and could potentially be indirectly affected by project construction.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, and the Tribes) will be required during the NEPA process.

Figure 16.3 Structure No. 41-161-156 Environmental Constraints Map



16.B. Future Conditions Analysis

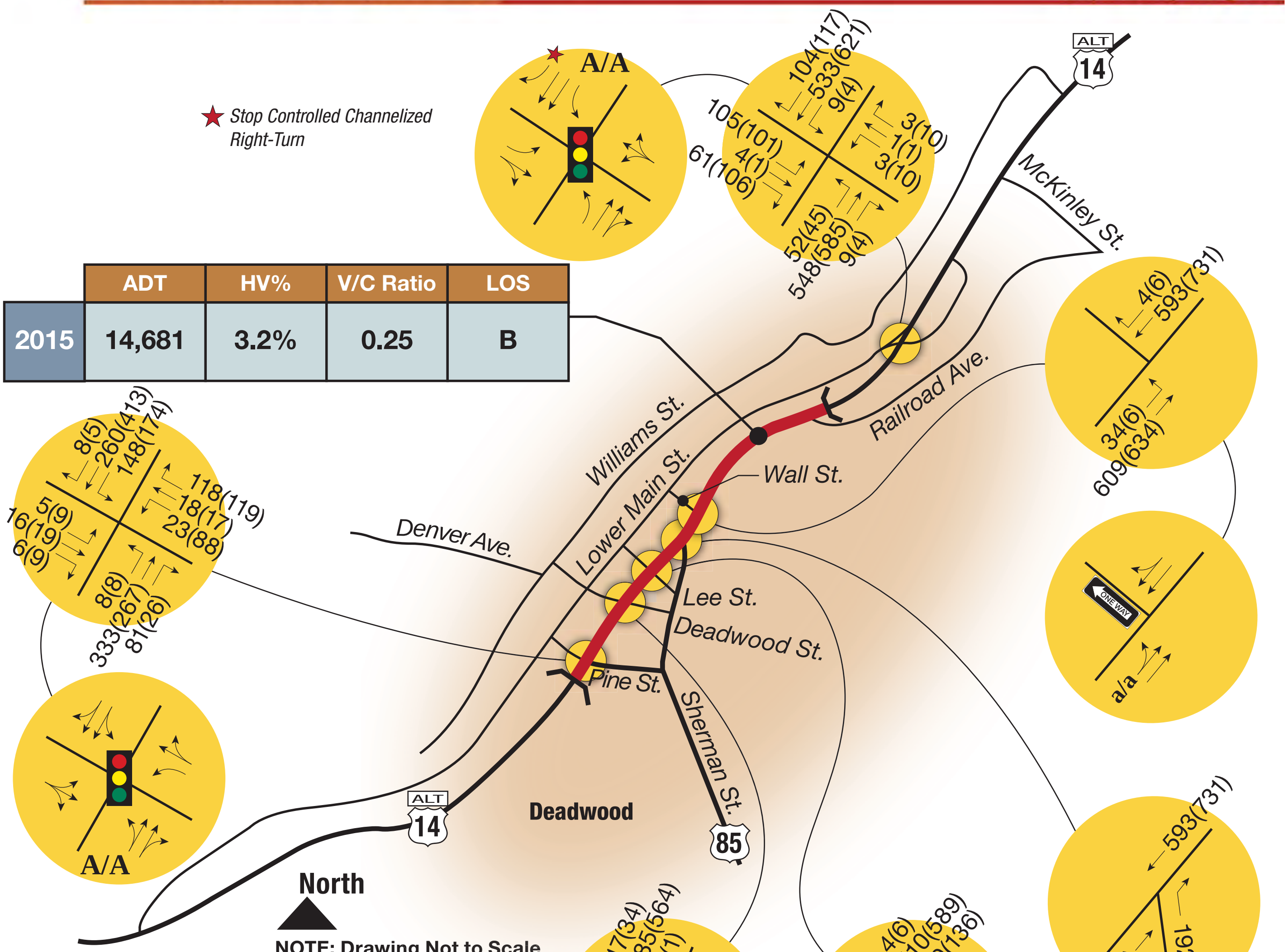
The future conditions analysis conducted for the Deadwood Box determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

16.B.1. Future Traffic Analysis

SDDOT provided growth rates for the analysis, which used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 14A is estimated to have an ADT volume of 14,681, with a heavy vehicle percentage of 3.2 percent.

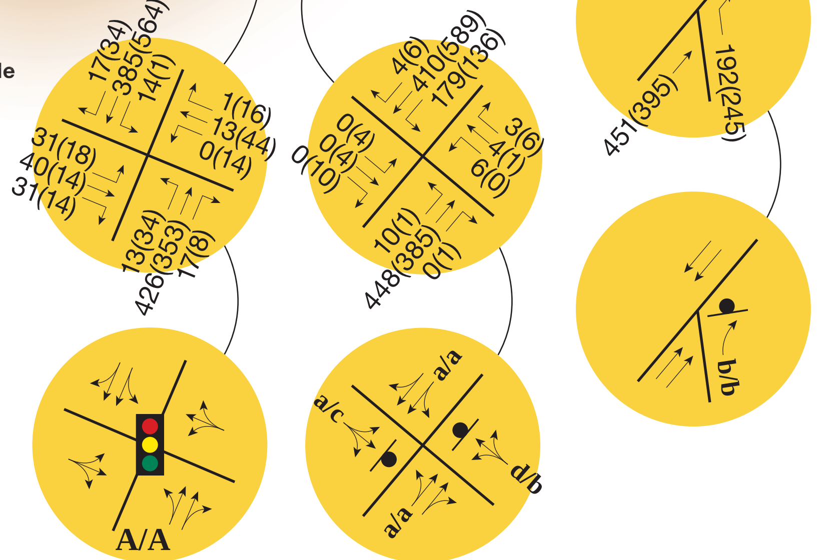
The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the structure. The PM peak hour was identified as the controlling peak period for analysis along US 14A. Based on HCM methodologies and peak hour traffic volumes, US 14A is anticipated to operate at LOS B, with a flow rate of 833 (pcphpl), which equates to a V/C ratio of 0.25 in 2035.

At the unsignalized intersections of US 14A with Lee Street, Sherman Street, and Wall Street, all critical movements are anticipated to operate at LOS D or better under 2035 peak hour traffic conditions. The westbound shared left/through/right movement at the intersection with Lee Street is anticipated to operate at LOS D in the AM peak hour. This is the only movement projected to operate below LOS C. The signalized intersections of US 14A with Pine Street, Deadwood Street, and Lower Main Street are anticipated to operate at LOS A under 2035 AM and PM peak hour traffic conditions. **Figure 16.4** summarize the future roadway and traffic conditions.



	ADT	HV%	V/C Ratio	LOS
2015	14,681	3.2%	0.25	B

NOTE: Drawing Not to Scale



LEGEND

Number of Lanes	4 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	25 mph
Bridge Roadway Width	48 Feet

TRAFFIC LEGEND

XXX(XXX) = AM(PM) Peak Hour Traffic Volumes

X/X = AM/PM Peak Hour Signalized Intersection Level of Service

x/x = AM/PM Peak Hour Unsignalized Intersection Level of Service

= Stop Sign

= Traffic Signal

= Study Intersection(s)*

*Turning Movement Counts Currently Not Available

Figure 16.4
2035 Future Conditions
Deadwood Box/US 14A
41-161-156

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16.B.2. Additional Lane Needs

This structure was identified as one of the key locations to determine the approximate year that additional lanes would be needed. Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes. The year at which additional lanes were required was determined when the V/C ratio exceeded 1.0. Traffic volumes were grown annually in an iterative process until this threshold was exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

16.B.3. Safety Recommendations

At all study intersections along US 14A, there is a pattern of angle and rear-end type collisions. These types of crash patterns are typical at signalized intersections and urban roadways with closely spaced access points. No countermeasures are recommended; however, if a significant pattern becomes apparent in the future, a more detailed safety study should be completed along the corridor.

16.B.4. Traffic Maintenance During Construction

Because much of the Deadwood Box is located directly under US 14A, challenges will be associated with traffic maintenance during reconstruction. One option for maintaining two lanes of traffic in each direction would be to develop a one-way pair system using Main Street to the west for two-lanes of southbound travel, and the combination of Sherman Street and a shoofly on the east side of existing US 14A for two-lanes of northbound travel (see **Figure 16.5**).

This concept would provide the maximum number of lanes through Deadwood during reconstruction of the box, while providing access and circulation via the cross streets. It is also recommended that the reconstruction of the box be performed in short segments to best accommodate local and through traffic.

Constructing the shoofly would allow the box culvert to be constructed on its current alignment. The new roadway could be constructed on top of the box culvert as it exists now; however, consideration should be given to constructing a new US 14A alignment to the east and shifting the location of the parking lots to the west side of the highway as was recommended in the *Deadwood Pedestrian Circulation and Enhancement Study*. This configuration would put the box under the parking lots and eliminate the need for pedestrians to cross the highway to reach downtown businesses.

Another option would be to realign the channel at the north end of the project to allow a significant portion of the structure to be constructed offline from existing traffic and existing flows. Under this option, the two northbound lanes would be provided on the two western lanes of US 14A. The northern portion of the box (north of Sherman Street), would be constructed immediately to the east of US 14A, under the current parking lots. This portion of the existing box would be filled in following the realignment of the channel through the newly constructed box. It is assumed that the channel would remain open during construction along its original alignment, and the south end of the box would be constructed during low flows.

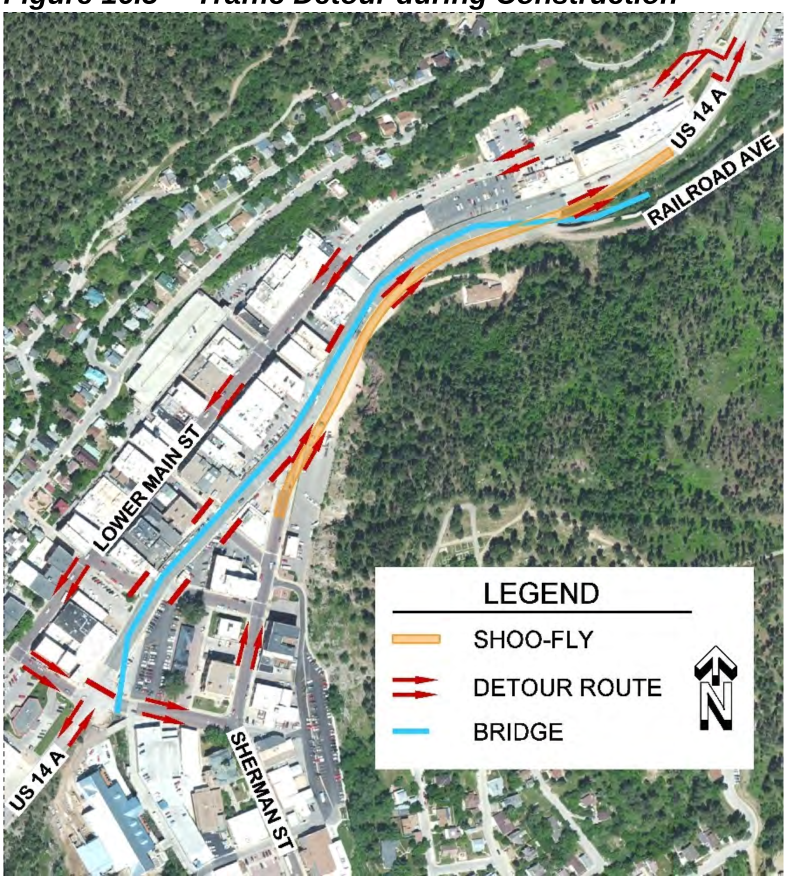
A few connection and cross over points would need to be phased to accommodate continual traffic flow during reconstruction. Locations include:

- South End. Because the structure begins on the south side of Pine Street, that first segment would need to be reconstructed before northbound traffic could be routed over to Sherman Street. Two northbound lanes could be provided on the west side of US 14A to provide enough room to construct the first 200 feet of the box. This will also impact the parking lot located immediately to the north of Pine Street. Once this section is complete, northbound traffic can be routed to Sherman Street.

- Middle Section. If the box is constructed to the east of its current alignment, it will be necessary for traffic to cross the box to reach the two western lanes of existing US 14A north of Sherman Street. There is room on the east side of Sherman Street through sections of paved and unpaved parking lots to construct a temporary shoofly to shift traffic further to the east to provide enough room to reconstruct the box approximately 250 feet to 300 feet beyond the intersection with Sherman Street. Once this section of box is complete, traffic can be directly routed from Sherman Street to the western two lanes of existing US 14A.
- North End. The box would need to be extended to the north beyond its current end point to provide room to transition from the temporary shoofly and ultimately the newly constructed US 14A roadway over to the existing lanes. This transition could be kept to a minimum distance or incorporated into the horizontal curve located to the north of the existing end of the box.

It is recommended that a more detailed analysis of traffic control be developed with the reconstruction plans for the Deadwood Box. The exact location of the existing box would need to be determined to ensure that there is adequate room near the west edge of the existing box to construct the new box for the segment north of Sherman Street.

Figure 16.5 Traffic Detour during Construction

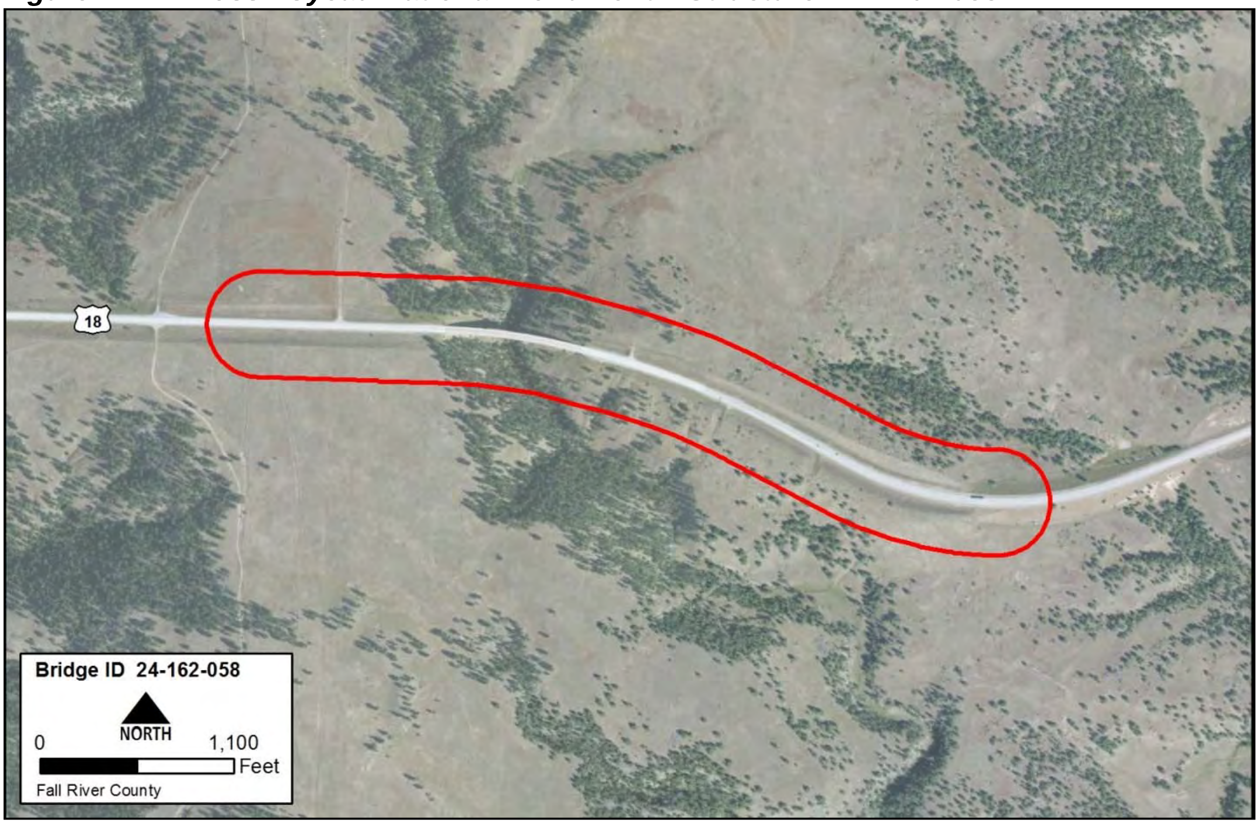


17. Structure # 24-162-058

Structure No. 24-162-058 (Fossil Cycad National Monument) spans a canyon along US 18, located approximately 16 miles west of Hot Springs in Fall River County. The study area for this structure is approximately 1 mile long and 600 feet wide, centered on the roadway.

This structure was constructed in 1982. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 17.1 Fossil Cycad National Monument – Structure # 24-162-058



17.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the US 18 bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

17.A.1. Additional Background Data

The team requested no additional data for this structure location.

17.A.2. Roadway Conditions

On US 18, the approaches to the bridge consist of two-lanes, 12 feet each, with 8-foot surfaced shoulders. On the bridge, the roadway width is 40 feet, which consists of two 12-foot driving lanes and 8-foot surfaced shoulders. The speed limit is posted at 65 mph.

Per Table 7-1 from Chapter 7 of the *SDDOT Roadway Design Manual*, for a two-lane roadway with a projected ADT above 2,500, the existing cross sections of the bridge and roadway approaches to the structure currently meet SDDOT design standards.

The US 18 approach immediately east of the bridge has a Surface Condition Index of 4.97. **Table 17.1** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 17.1 US 18 (Structure #24-162-058) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
4.97	4.98	5.00	5.00	5.00	5.00	4.97	0.0/0.1

The US 18 approach immediately west of the bridge has a Surface Condition Index of 4.78. **Table 17.2** shows the detailed pavement index values provided in the *2015 Highway Needs and Project Analysis Report*.

Table 17.2 US 18 (Structure #24-162-058) – Pavement Condition (2014)

Surface Condition Index	Roughness Index	Transverse Cracking	Fatigue Cracking	Patching/Patch Deterioration	Block Cracking	Rut Index	Rut Depth (Inches) Avg/Max
4.78	4.94	5.00	5.00	5.00	5.00	4.69	0.1/0.2

17.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. The review found no load carrying capacity issues with the bridge.
- Geometry. Geometric deficiencies and concerns for the bridge are limited to a lack of sidewalks on the bridge.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 5
  - Superstructure: 5
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, appropriate width, etc. This bridge's current sufficiency rating is 85.4, indicating a structure in above average structural condition.
- Structural Issues. Identified by reviewing the most current SI&A reports, field photos, and specific inspection results, structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Cracks in the abutment backwall
  - Deck cracking with leakage
  - Loose bolts on the diaphragms
  - Steel girder painting

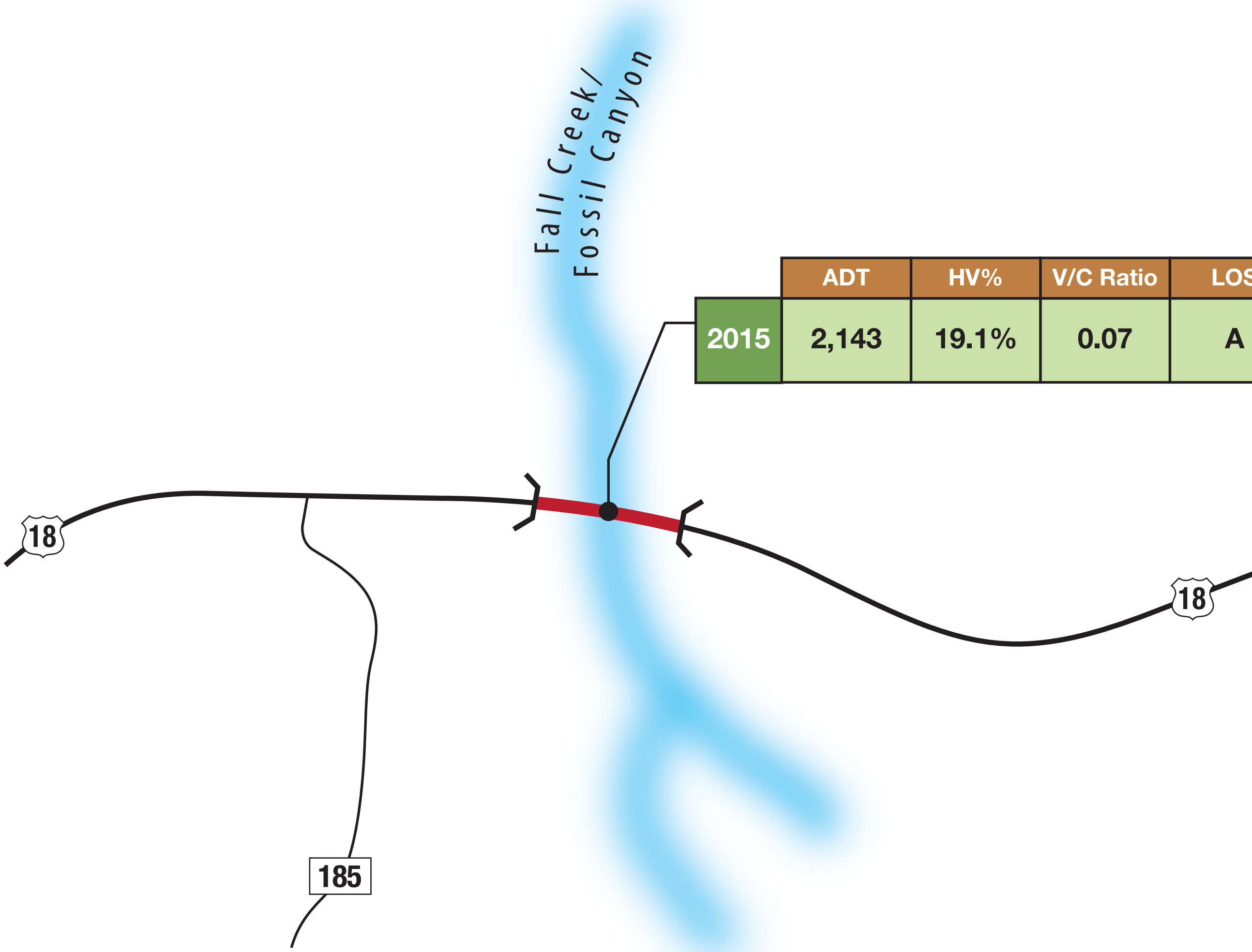
17.A.4. Traffic Analysis

US 18, categorized as a Rural Other Principal Arterial, is located in Fall River County. Based on the most current ADT volumes and growth rates provided by SDDOT, the roadway has an ADT volume of 2,143 in 2015. The analysis included no peak period turning movement counts for the structure. The roadway has a heavy vehicle percentage of 19.1 percent.

A vehicle classification count was available for this location. Based on the classification count, of the heavy vehicle percentage, 67 percent would fall into FHWA Vehicle Class 5-9 and 33 percent into FHWA Vehicle Class 10-13.

SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. Based on the functional class and geographic location of the roadway, a growth rate of 1.484 percent was provided. Furthermore, for heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.223 percent was provided, and a growth rate of 2.897 percent was provided for FHWA Vehicle Class 10-13. **Figure 17.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis also used a ratio of peak hour to ADT (K factor) of 8.4 percent, a directional (D factor) of 50 percent, and a peak hour factor (PHF) of 0.88. Based on HCM methodologies and the roadway ADT, US 18 currently operates at LOS A with a V/C ratio of 0.07.



	ADT	HV%	V/C Ratio	LOS
2015	2,143	19.1%	0.07	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	40 Feet

North

NOTE: Drawing Not to Scale

Figure 17.2
2015 Existing Conditions
Fossil Canyon National Monument/US 18
24-162-058

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17.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the structure and the approaches on US 18. **Tables 17.3** and **17.4** summarize the crash history for the most recent five-year period (2010–2014).

Table 17.3 US 18 (Structure #24-162-058) – Crash Data (2010–2014)

Crash Type						
No Collision between 2 MV	Rear end	Head on	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
3	0	0	1	0	0	4

All but one crash that occurred in the study area involved a single vehicle. Of the single vehicle crashes, two of the crashes involved animal collisions; the other crash type is unknown. One crash involved a right angle collision between two vehicles causing a possible injury.

Table 17.4 US 18 (Structure #24-162-058) – Crash Rates (2010–2014)

Roadway Segment	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1-Fatal	2-Incap.	3- Non-Incap.	4-Possible	5-PDO	Total				
US 18	0	0	0	1	3	4	2,143	3.91	1.02	2.32
Incapacitating (Incap.)			Property Damage Only (PDO)				* MEV= Million Entering Vehicles			

The crash rate per MEV for the roadway segment is 1.02. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 2.32. There are no identifiable crash patterns at this location.

17.A.6. Bicycle/Pedestrian Facilities

Currently, no bicycle or pedestrian facilities are provided on the bridge. However, the paved shoulders on the bridge and roadway approaches are wide enough to offer cyclists an alternative to ride with some separation from vehicular traffic.

17.A.7. Coast Guard Requirements

Coast Guard requirements are not applicable to this structure.

17.A.8. Environmental Resource Review

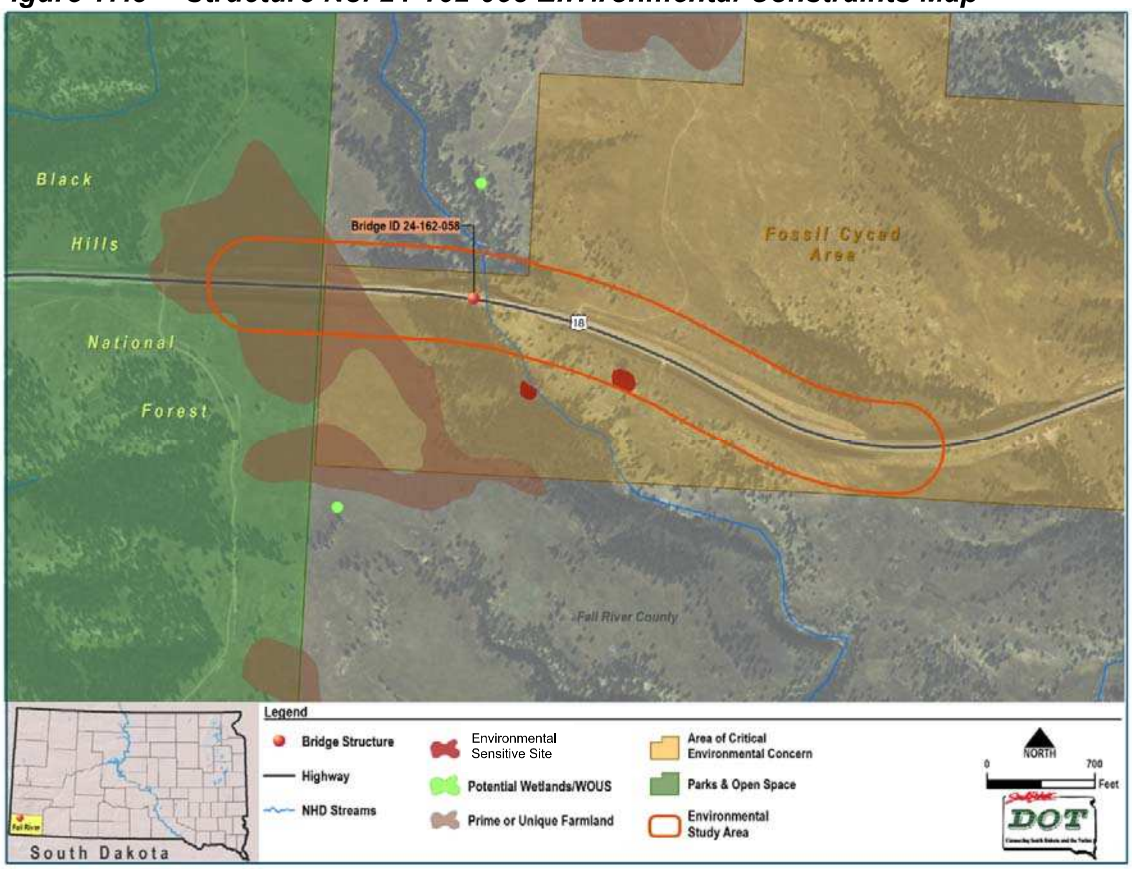
The environmental review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases.

- <u>Threatened and Endangered Species.</u> No documented records of state or federally endangered species are present within 1 mile of the project, but potential habitat is present within the study area. Northern long-eared bats may roost in the expansion joints or other crevices of bridges, particularly when tree roosts are unavailable. During the summer roosting season, the underside of the bridge should be inspected for the presence of bats before initiating construction activities.
- <u>Section 4(f).</u> Possible Section 4(f) properties are present within the vicinity of the project study area and include the Black Hills National Forest, present at the west end of the project study area. Additionally, most of the study area is within the Fossil Cycad Area,

which is designated as an Area of Critical Environmental Concern and managed by the Bureau of Land Management (BLM). This designation puts restrictions on what activities can occur on the property. Coordination with the BLM will be necessary.

- Section 106. Historic and archeological resources are present within the project study area. The project study area is located at the former site of the Fossil Cycad National Monument, which once contained hundreds of fossil cycads at the surface. Additional historic, archeological, and paleontological surveys and evaluations will likely be necessary for this project.
- Prime and Unique Farmland. The west end of the project study area contains soil classified as "Prime farmland if irrigated." A Form NRCS CPA-106 for Corridor Type Projects or Form AD1006 may be required.
- Agency Coordination. The project is located on U.S. Forest Service and BLM property. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, USFS, BLM, and the Tribes) will be required during the NEPA process.

Figure 17.3 Structure No. 24-162-058 Environmental Constraints Map



17.B. Future Conditions Analysis

The future conditions analysis conducted for the Fossil Cycad National Monument Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

17.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, US 18 is estimated to have an ADT volume of 2,918, with a heavy vehicle percentage of 20.2 percent.

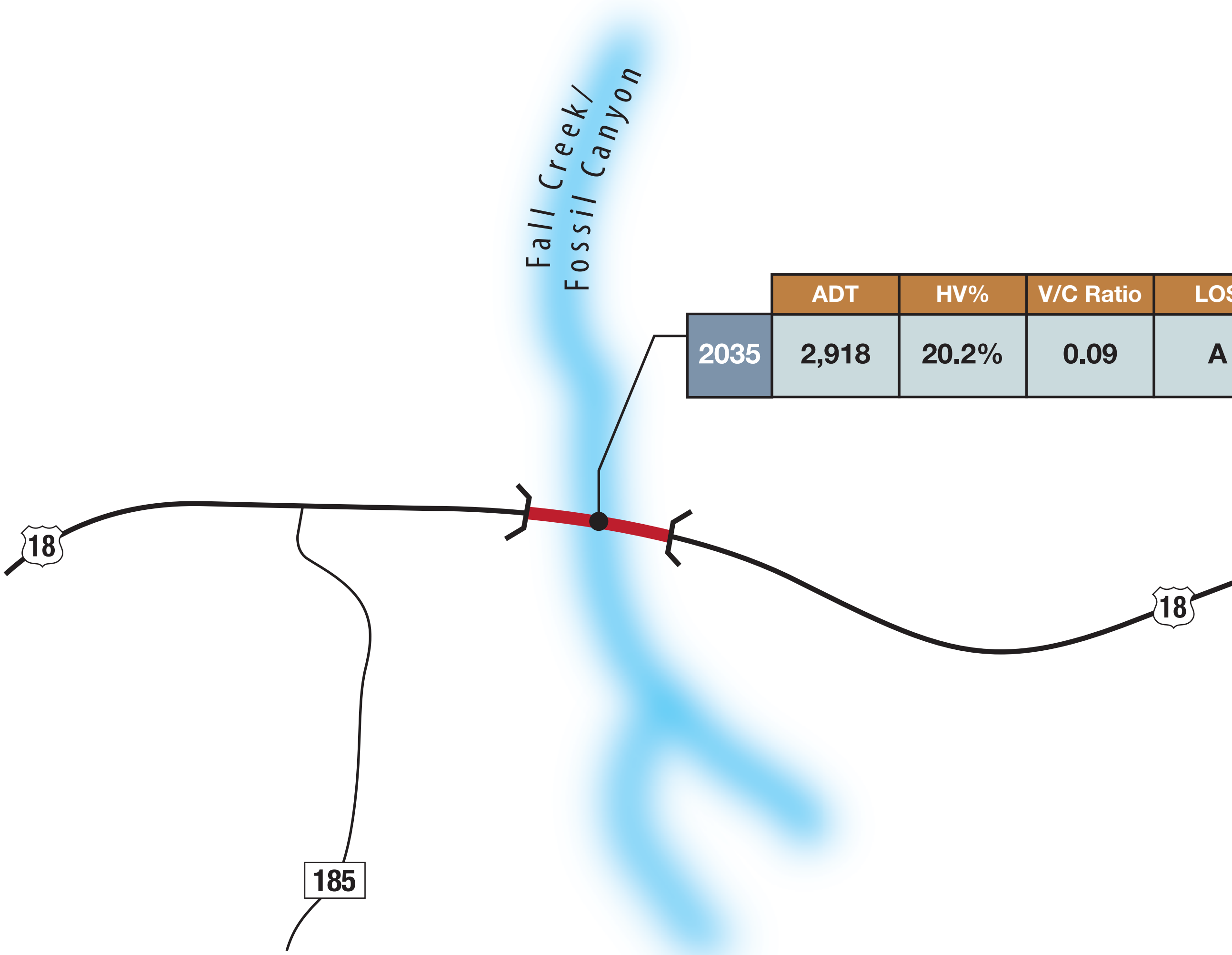
The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the bridge structure. The analysis also used a K factor of 8.4 percent, a D factor of 50 percent, and PHF of 0.88. Based on HCM methodologies and roadway ADT, US 18 is anticipated to operate at LOS A with a V/C ratio of 0.09 in 2035. **Figure 17.4** summarizes the future roadway and traffic conditions.

17.B.2. Additional Lane Needs

Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes to determine when capacity (V/C > 1.0) would be exceeded. It was determined that traffic volumes in 2090 would still be below the capacity of the bridge and roadway approaches.

17.B.3. Safety Recommendations

A review of crash data indicates there is no identifiable crash pattern. There are no recommended safety improvements at this location.



	ADT	HV%	V/C Ratio	LOS
2035	2,918	20.2%	0.09	A

LEGEND

Number of Lanes	2 Lanes
Functional Class	Rural Other Principal Arterial
Posted Speed	65 mph
Bridge Roadway Width	40 Feet

North

NOTE: Drawing Not to Scale

Figure 17.4
2035 Future Conditions
Fossil Canyon National Monument/US 18
24-162-058

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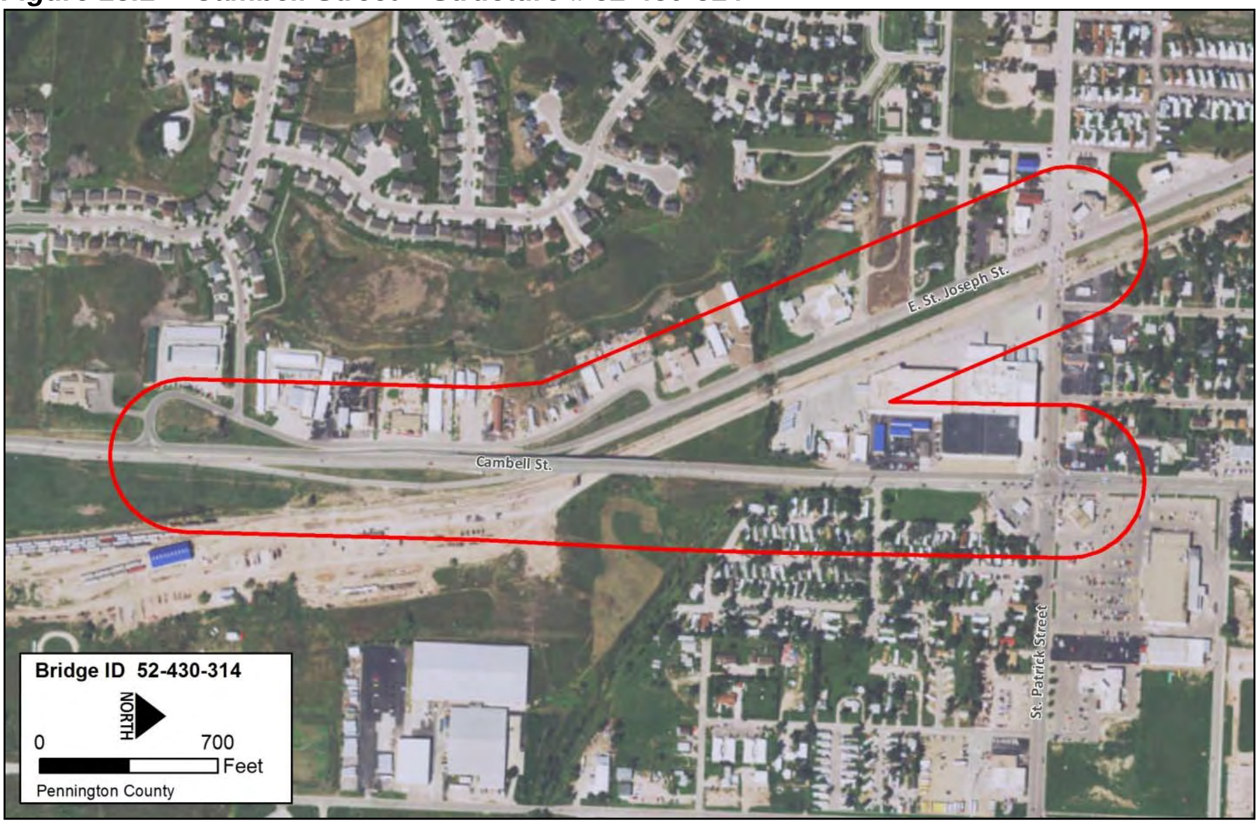
18. Structure # 52-430-314

Structure No. 52-430-314 (Cambell Street), located in southeast Rapid City in Pennington County at the interchange with East St. Joseph Street, provides a grade separation over Sioux Avenue and the Rapid City, Pierre and Eastern Railroad. The study area is approximately 0.75 miles long and 600 feet wide, centered on the structure and its approaches, as well as on East St. Joseph Street northwest of the project structure.

This structure was constructed in 1964. The team conducted a full analysis and review of the structure and the approaches, including baseline conditions, future needs, and safety analyses. **Chapter 19** presents alternative maintenance and replacement scenarios developed for this structure.

Figure 18.1 Cambell Street – Structure # 52-430-314



18.A. Baseline Conditions Analysis

The team conducted a baseline conditions analysis for the Cambell Street bridge for each primary function, including roadway and bridge conditions, traffic operations and safety, and environmental resources in the vicinity of the structure.

18.A.1. Additional Background Data

The team obtained historic average daily traffic (ADT) data for the study area roadways from the City of Rapid City. The team requested turning movement counts, but none were available for the study intersections.

18.A.2. Roadway Conditions

On Cambell Street, the approaches to the viaduct are urban four-lane cross sections, with curb and gutter, 48 feet in width. The speed limit is posted at 45 mph. On the viaduct, the roadway width is 48 feet, which consists of four 12-foot driving lanes with a barrier adjacent to the outside lanes.

Per Chapter 7 of the *SDDOT Roadway Design Manual*, for urban areas, shoulders may not be provided. Consideration should be made to provide shoulder widths to accommodate parking and/or shared use or bicycle lanes. For moderate speed highways (45 to 55 mph) with curb and gutter, 3-foot shoulders plus gutter pan is standard; however, the shoulder may be dropped if other bicycle facilities are provided in the area. As such, the existing cross section on Cambell Street does not meet SDDOT design standards.

All streets in the City of Rapid City are evaluated every two years using a national standard called the PCI. Streets are given an index ranging from 0 to 100, with 100 being the best and 0 being the worst. The most recent evaluation was performed in fall 2011. The PCI is used to determine the method of treatment for streets such as street rehabilitation or complete reconstruction. The Cambell Street approaches on each end of the bridge have a pavement condition index of between 90 and 100.

18.A.3. Bridge Condition

The team evaluated the existing bridge conditions in regard to the load carrying capacity of the bridge, geometrics, NBI condition ratings, and overall structural issues identified in previous reports and field inspections. The following sections highlight the critical elements associated with each category:

- Capacity. Load carrying capacity deficiencies and concerns for the bridge include a slightly low Inventory Rating (35.7 tons).
- Geometry. Geometric deficiencies and concerns for the bridge include substandard width, minimal shoulders, and no sidewalk.
- NBI Condition Ratings. NBI Condition Ratings evaluate the overall condition of major bridge elements on a scale from 0 (Failed Condition) to 9 (Excellent Condition). The following are the condition ratings for this specific bridge:
  - Deck: 6
  - Superstructure: 5
  - Substructure: 6
- Sufficiency Rating. NBI calculates a sufficiency rating for each bridge, which includes the three condition ratings above, in addition to factors such as essentiality for public use, safety, appropriate width, etc. This bridge's current sufficiency rating is 68.0, indicating a structure in average structural condition.
- Structural Issues. Structural issues have been identified by reviewing the most current SI&A reports, field photos, and specific inspection results such as fracture critical inspections. Structural issues have been limited to those that best inform, limit, and prioritize the improvement scenarios where appropriate.
  - Minor girder rust
  - Fatigue cracking in the stiffeners and diaphragms
  - Fatigue cracking of the girders

- Deck cracking with efflorescence
- Deck delaminations
- Possible loss of bearing at selected girders

18.A.4. Traffic Analysis

Cambell Street, categorized as an Urban Minor Arterial, is located in Pennington County. Based on the most current ADT volumes and growth rates provided by SDDOT and Rapid City MPO, the roadway has an ADT volume of 20,559 in 2015. The roadway has a heavy vehicle percentage of 6.0 percent. Because existing peak period count data were not available for the intersection at this location, FHU used the Rapid City MPO model to develop peak period turning movement counts for the intersection of the St. Joseph Street ramps with Cambell Street. FHU used engineering judgment and methodologies outlined in *NCHRP 765* to develop peak hour turning movement counts at the intersections of Bridge View Drive with Cambell Street and St. Joseph Street and at the intersections of St. Patrick Street with St. Joseph Street and Cambell Street. **Figure 18.2** shows the AM and PM peak hour turning volumes, along with the intersection lane configuration.

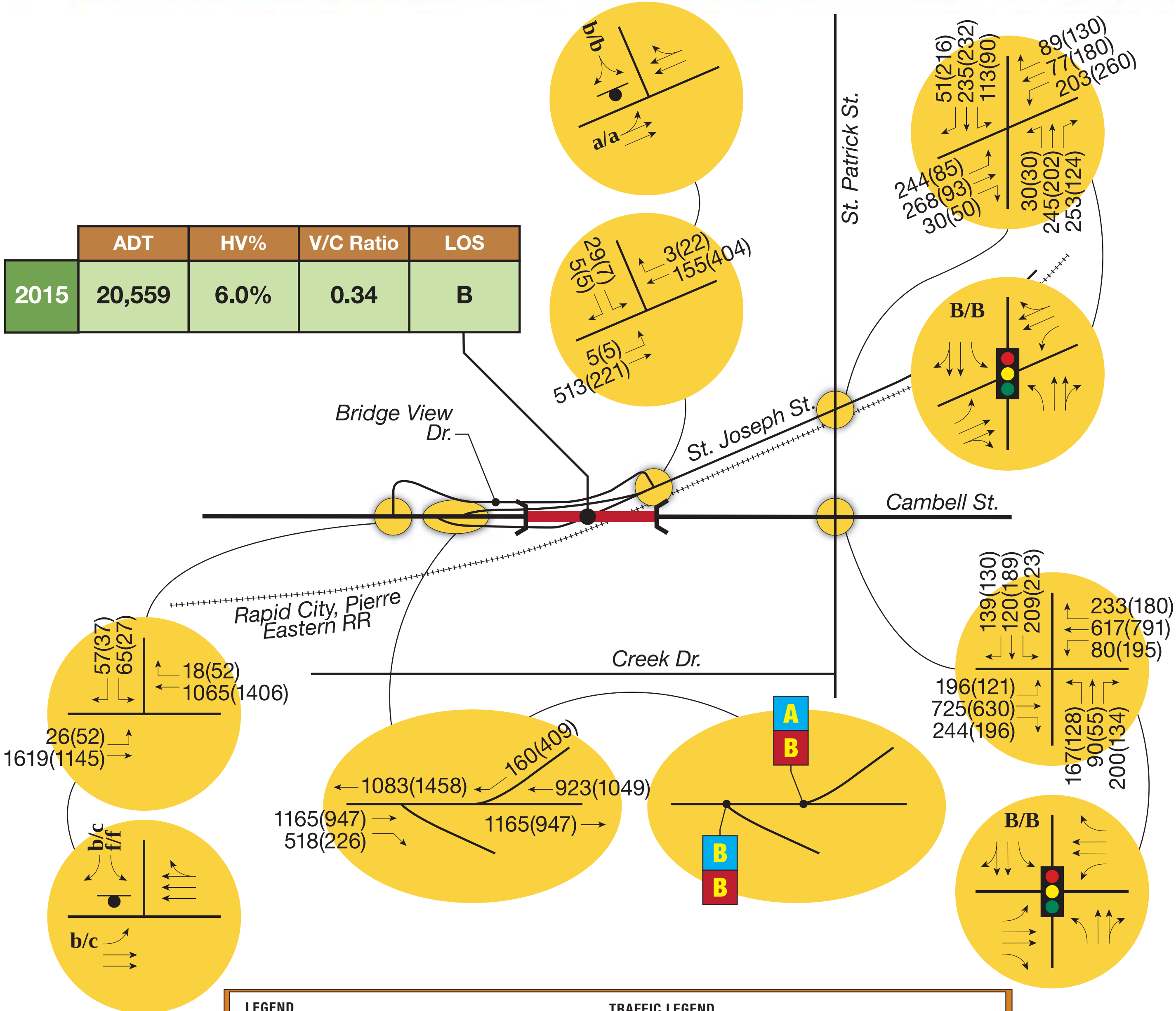
A vehicle classification count was not available for this location. Based on other classification counts throughout the state, it was assumed of the heavy vehicle percentage that 65 percent would fall into FHWA Vehicle Class 5-9 and 35 percent into FHWA Vehicle Class 10-13.

Based on the Rapid City model, Cambell Street has an annual growth rate of 2.230 percent. SDDOT provided growth rates by county, roadway type, and vehicle classification for the entire state. For heavy vehicles, FHWA Vehicle Class 5-9, a growth rate of 1.775 percent was provided, and a growth rate of 2.822 percent was provided for FHWA Vehicle Class 10-13. **Figure 18.2** summarizes the roadway and traffic conditions.

The analysis used HCM 2010 and HCS 2010 software to determine the existing LOS of the roadway for the length of the bridge structure. The analysis assumed a PHF of 0.92. The K Factor and D Factor were determined from the existing peak hour traffic counts. Based on HCM methodologies and peak hour traffic volumes, Cambell Street currently operates at LOS B with a peak flow rate of 652 pcphpl and a V/C ratio of 0.34. Based on HCS 2010, all ramp merge and diverge areas currently operate at LOS B or better during the peak periods.

At the unsignalized intersection of St. Joseph Street with Bridge View Drive, all critical movements currently operate at LOS B or better in the AM and PM peak hours. At the unsignalized intersection of St. Joseph Street with Bridge View Drive, all critical movements currently operate at LOS C or better in the AM and PM peak hours with the exception of the eastbound left-turn lane, which operates at LOS F in both peak periods. However, it is not uncommon for unsignalized side street movements to operate at LOS F in peak hours in urban areas. The signalized intersections of St. Patrick Street with St. Joseph Street and Cambell Street both currently operate at LOS B in the AM and PM peak hours.

	ADT	HV%	V/C Ratio	LOS
2015	20,559	6.0%	0.34	B



LEGEND

Number of Lanes	4 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	45 mph
Bridge Roadway Width	52 Feet
Study Intersections	(yellow circle)

North

NOTE: Drawing Not to Scale

TRAFFIC LEGEND

- XXX(XXX) = 2015 AM(PM) Peak Hour Traffic Volumes
- X/X = 2015 AM/PM Peak Hour Signalized Intersection Level of Service
- x/x = 2015 AM/PM Peak Hour Unsignalized Intersection Level of Service
- X (blue) = 2015 AM Merge/Diverge Level of Service
- X (red) = 2015 PM Merge/Diverge Level of Service
- = Stop Sign
- = Traffic Signal

Figure 18.2

2015 Existing Conditions
Cambell Street
52-430-314

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18.A.5. Safety Analysis

The team used crash records compiled from SDDOT for the roadway segment of Cambell Street from St. Patrick Street to Bridge View Drive, as well as the intersections of St. Joseph Street with St. Patrick Street, and Cambell Street with St. Patrick Street and Bridge View Drive. **Tables 18.1** and **18.2** summarize the crash history for the most recent five-year period (2010–2014).

Table 18.1 Cambell Street (Structure #52-430-314) – Crash Data (2010–2014)

	Crash Type						
Location	No Collision between 2 MV	Rear End	Head On	Angle	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Total
Cambell St.	4	6	0	6	1	0	17
St. Joseph St. / St. Patrick St.	6	19	0	50	0	0	75
Cambell / St. Patrick St.	3	32	0	37	4	0	76
Cambell / Bridge View Dr.	3	0	0	2	0	0	5
Total	**16**	**57**	**0**	**95**	**5**	**0**	**173**

The signalized intersections of St. Patrick Street with Cambell Street and St. Joseph Street both showed a pattern of rear end and angle type collisions. The roadway segment of Cambell Street also had a similar pattern of rear end and angle collisions. Most rear end collisions were observed occurring from the southbound approach of the bridge to the crest of the bridge structure. The angle type crashes were primarily located at driveway access points along Cambell Street. At the intersection of Cambell Street with Bridge View Drive, angle and fixed object type crashes were identified but no distinct crash pattern was present.

Table 18.2 Cambell Street (Structure #52-430-314) – Crash Rates (2010–2014)

Roadway Segment or Intersection	Crashes by Severity						Total Entering Vehicles	5-Year (MEV)*	Crash Rate Per MEV*	Severity Rate Per MEV*
	1- Fatal	2- Incap.	3- Non-Incap.	4- Possible	5- PDO	Total				
Cambell St.	0	2	2	3	10	17	16,580	30.26	0.56	3.57
St. Joseph St. / St. Patrick St.	0	4	13	10	48	75	19,155	34.96	2.15	10.42
Cambell St. / St. Patrick St.	0	2	8	9	57	76	31,879	58.18	1.31	4.39
Cambell St. / Bridge View Dr.	0	0	2	0	3	5	21,059	38.43	0.13	0.63
Incapacitating (Incap.)	Property Damage Only (PDO)						* MEV= Million Entering Vehicles			

The crash rate per MEV for the road segment of Cambell Street is 0.56. The severity rate per MEV, which applies a cost factor to the different crash severity type, is 3.57. At the intersection of St. Joseph Street with St. Patrick Street, the crash rate per MEV is 2.15, and the severity rate per MEV is 10.42. The crash rate per MEV for the intersection of Cambell Street with St. Patrick Street is 1.31, with a severity rate per MEV of 4.39. At the intersection of Cambell Street with Bridge View Drive, the crash rate per MEV is 0.13, with a severity rate per MEV of 0.63. **Table 18.3** shows the identified crash patterns and possible contributing factors.

Table 18.3 Cambell Street (Structure #52-430-314) – Crash Patterns (2010 - 2014)

Crash Pattern	Contributing Factors
Rear End (St. Joseph St. / St. Patrick St.) (Cambell St. / St. Patrick St.)	▪ Typical crash pattern at signalized intersections
Angle (St. Joseph St. / St. Patrick St.) (Cambell St. / St. Patrick St.)	▪ Typical crash pattern at signalized intersections ▪ Intersection of St. Joseph Street with St. Patrick Street is on a skew.

18.A.6. Bicycle/Pedestrian Facilities

Currently, the viaduct provides no bicycle or pedestrian facilities. There are also no shoulders or wide outside lanes for cyclists as an alternative to ride with some separation from vehicular traffic. No other pedestrian or bicycle facilities are available on adjacent roadways in the study area.

18.A.7. Coast Guard Requirements

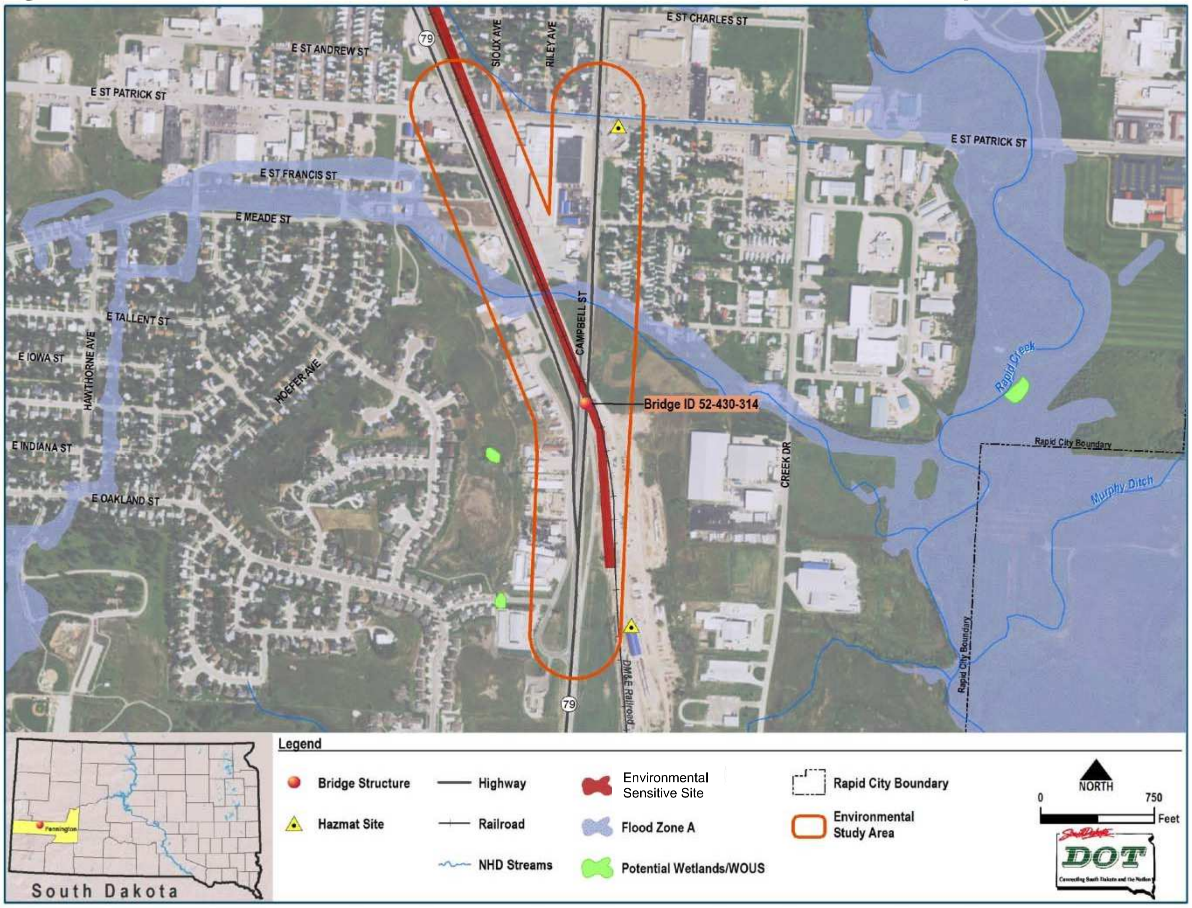
Coast Guard requirements are not applicable for this structure.

18.A.8. Environmental Resource Review

The environmental review evaluated the potential for impacts to the natural and human environment based on the aforementioned basic scope of proposed work. The following list of findings indicates where items of potential concern were identified and where further evaluation and analysis are foreseen during subsequent project development phases.

- Section 106. The railroad that passes under the project bridge is a historic property that is eligible for listing on the National Register. Further surveys and evaluation may be necessary.
- Wetlands and Waters of the US. Wetlands and Waters of the US may be present within the project study area, including an intermittent stream that passes through the study area on the north side of the project bridge. Impacts to these resources will depend on the scope of work and will be determined during later stages of project development. If impacts are determined likely, then a full delineation would be recommended.
- Regulated Materials. Regulated materials within the project study area include active aboveground and below ground storage tanks with gasoline or diesel.
- Floodplains and Floodways. The project study area passes through a small area of Zone AE Floodplain. A Floodplain Permit may be necessary if changes to the culvert north of the project bridge are necessary.
- Right-of-Way. If the scope of work includes ROW acquisition, it is possible that displacements will be necessary due to the presence of businesses and mobile homes near the project roadway.
- Title VI (Civil Rights) and Environmental Justice. Low-income, minority, and vulnerable age populations are present within the study area and could potentially be directly or indirectly affected by the project.
- Agency Coordination. Further agency coordination (FHWA, USFWS, SDGFP, SDSHPO, and the Tribes) will be required during the NEPA process.

Figure 18.3 Structure No. 52-430-314 Environmental Constraints Map



18.B. Future Conditions Analysis

The future conditions analysis conducted for the Cambell Street Bridge determined future traffic operations and the need for additional capacity. Potential safety improvements were also suggested if an identifiable crash pattern was observed.

18.B.1. Future Traffic Analysis

Using the growth rates provided by SDDOT, the analysis used a straight line growth projection to determine 2035 traffic volumes. In 2035, Cambell Street is estimated to have an ADT volume of 31,960, with a heavy vehicle percentage of 5.9 percent.

The analysis used HCM 2010 and HCS 2010 software to determine the future LOS of the roadway for the length of the structure. The PM peak hour was identified as the controlling peak period for analysis along Cambell Street. Based on HCM methodologies and peak hour traffic volumes, Cambell Street is anticipated to operate at LOS C, with a flow rate of 969 (pcphpl), which equates to a V/C ratio of 0.51 in 2035.

Based on HCS 2010, all ramp merge and diverge areas are anticipated to operate at LOS B or better during the peak periods in 2035. At the unsignalized intersection of St. Joseph Street with Bridge View Drive, all critical movements are anticipated to operate at LOS C or better in the AM and PM peak hours. At the unsignalized intersection of St. Joseph Street with Bridge View Drive, all critical movements are anticipated to operate at LOS D or better in the AM and PM peak hours, with the exception of the eastbound left-turn lane, which operates at LOS F in both peak periods, and the northbound left-turn lane, which is anticipated to operate at LOS E in the PM peak hour. It should be noted that it is not uncommon for unsignalized side street movements to operate at LOS F in peak hours in urban areas. A MUTCD traffic signal warrant analysis was completed for 2035 traffic volumes and signal warrants were not satisfied. A right-turn reduction of 100 percent was applied. If a traffic signal were installed, traffic operations of LOS A or LOS B would be anticipated. The signalized intersections of St. Patrick Street with St. Joseph Street and Cambell Street are anticipated to operate at LOS D or better in the AM and PM peak hours. **Figure 18.4** summarizes the future roadway and traffic conditions.

18.B.2. Additional Lane Needs

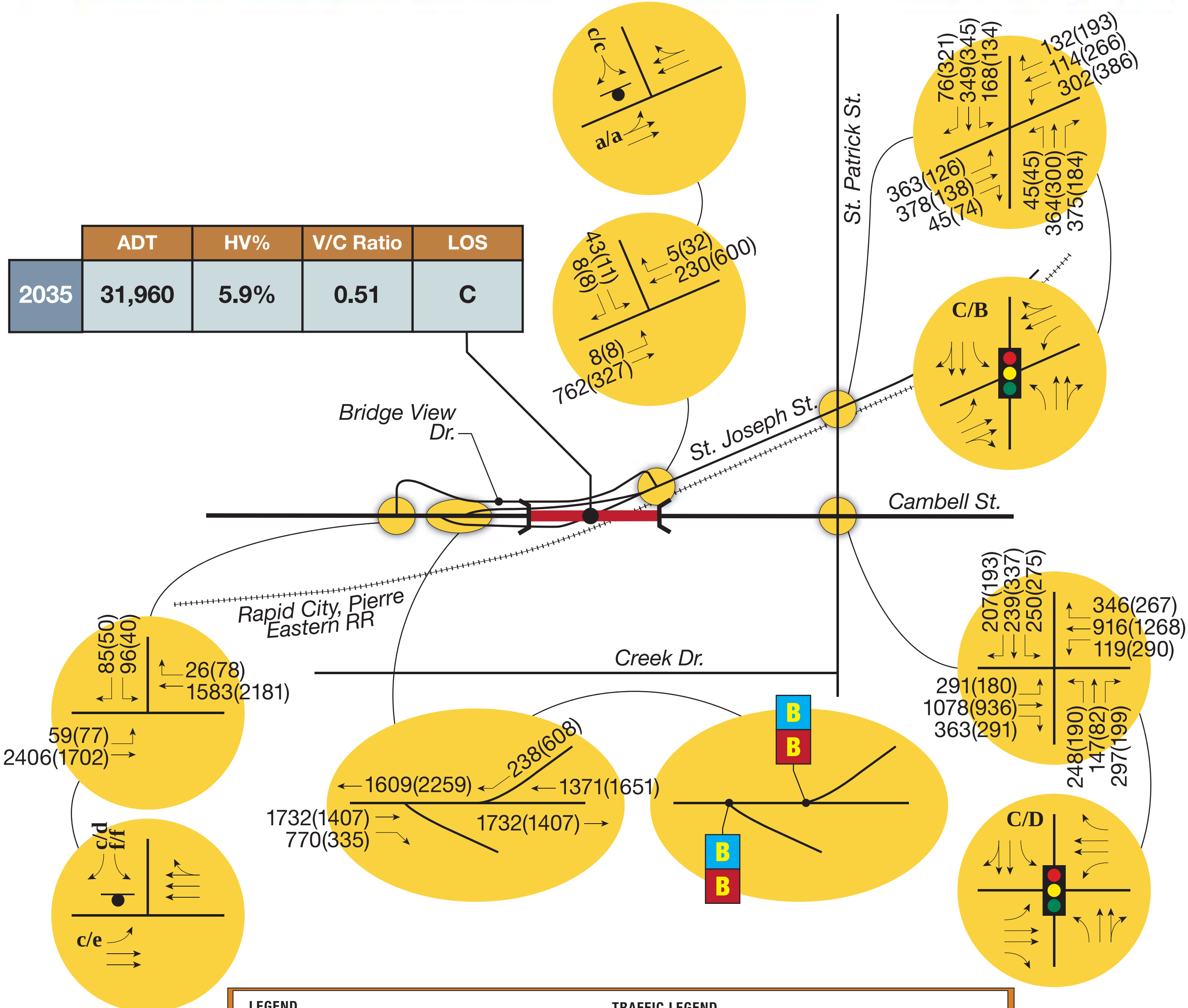
This structure was identified as one of the key locations to determine the approximate year that additional lanes would be needed. Using the previously mentioned growth rates, the analysis applied a straight line projection to the 2035 traffic volumes. The year at which additional lanes were required was determined when the V/C ratio exceeded 1.0. Traffic volumes were grown annually in an iterative process until this threshold was exceeded. Based on the results of the additional lanes needs analysis, Cambell Street is anticipated to reach a V/C ratio greater than 1.0 in year 2066.

18.B.3. Safety Recommendations

Two study intersections showed a crash pattern. These intersections are located approximately 1,500 feet north of the Cambell Street bridge and the recommended improvements would not have any impact on the structure or cross section of the bridge.

At the intersections of St. Patrick Street with St. Joseph Street and Cambell Street, a pattern of angle and rear-end type collisions is observed. Although these types of crash patterns are typical at signalized intersections, these two locations have a high number of these types of collisions. Based on the data provided, it is difficult to determine what factors are contributing to the crashes at this intersection. As such, it is recommended that a more detailed safety study be completed at these two intersections to determine if any necessary intersection safety improvements are needed.

	ADT	HV%	V/C Ratio	LOS
2035	31,960	5.9%	0.51	C



LEGEND

Number of Lanes	4 Lanes
Functional Class	Urban Other Principal Arterial
Posted Speed	45 mph
Bridge Roadway Width	52 Feet
Study Intersections	(yellow circle)

North

NOTE: Drawing Not to Scale

TRAFFIC LEGEND

- XXX(XXX) = 2035 AM(PM) Peak Hour Traffic Volumes
- X/X = 2035 AM/PM Peak Hour Signalized Intersection Level of Service
- x/x = 2035 AM/PM Peak Hour Unsignalized Intersection Level of Service
- X (blue) = 2035 AM Merge/Diverge Level of Service
- X (red) = 2035 PM Merge/Diverge Level of Service
- = Stop Sign
- = Traffic Signal

Figure 18.4

2035 Future Conditions
Cambell Street
52-430-314

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IV. MANAGING UNCERTAINTY

19. Scope and Approach

The approach to this study is based on the following excerpts from the SDDOT Request for Proposals dated October 31, 2014:

> The cost to replace a single one of these major bridges may be larger than the SDDOT typically sees as the total of all bridge replacement projects in a given year. With the tightening of transportation budgets, the SDDOT is also concerned that some of these major bridges will come due for replacement at the same time. As such, the SDDOT believes that a systematic, long range improvement plan for these bridges needs to be developed to spread out those costs over time as much as practical.
>
> The study is expected to fulfill the following objectives:
>
> 1. Identify items not in compliance with current design standards under both the current and predicted future traffic conditions for the major bridges and their approaching roadways.
> 2. Develop a feasible life-cycle cost solution for each of the study bridges that will take each bridge to the end of its service life (time of replacement) while keeping each bridge in a state of good repair for as long as practical.
> 3. Create a final product for use by the SDDOT which will guide the Department in the implementation of recommended improvements"

Reference: ASTM E2506 -11 *Developing a Cost Effective Risk Mitigation Plan for New and Existing Constructed Facilities*.

The referenced ASTM Standard identifies three parts to a risk mitigation plan: engineering, financial, and management. SDDOT addresses engineering uncertainty with immediate action to remedy the situation. In this study, uncertainty of structural behavior and appropriate risk mitigation actions were addressed. Potential engineering risk mitigation actions include maintenance, inspection, retrofit, and replacement of the bridge elements. Financial risk mitigation is based on the timing of the maintenance, retrofit, and replacement tasks. The cost of bridge replacement was compared to the savings of future maintenance costs beginning from the year it is replaced. Management mitigation is related to the decision by SDDOT to adjust the timing of any events to match the desired annual program. The decision to implement a management risk mitigation strategy is based on funding availability, cost of replacement, and desired cash flow. In most cases, the cost of replacement for each structure required reconstruction of the highway approaches to the bridge. Those cost estimates are shown in **Appendix E**, along with a sketch of the limits of reconstruction.

Figure 19.1 Study Work Plan

Engineering Uncertainty Assessment

- Set criteria for uncertainty
- Rank and weight criteria
- Rate each bridge for uncertainty (**Section 19.D.1 through 19.D.12**)
- Summary (**Table 19.2**)
- Prioritize the bridges for replacement and/or maintenance

Engineering Uncertainty Mitigation

- Estimate replacement cost
- Set events of maintenance and/or replacement for each bridge based on uncertainty index
- Compute present value
- Summarize the yearly maintenance cost
- Summary (**Table 19.7**)
- For details, see **Appendix F**

Financial Uncertainty Mitigation

- Revise events to spread costs
- Summary (**Table 19.8**)
- Prioritize the bridges for replacement and/or maintenance
- For details, see **Appendix G**

19.A. Engineering Uncertainty Assessment

Elements of each bridge were classified for its level of potential uncertainty related to specific bridge conditions. These uncertainty ratings can be used to make prioritization decisions for expenditure of funds on each bridge in the study.

19.A.1. Criteria

The first step was to develop criteria to be used to measure uncertainty. Higher levels of uncertainty result in assigning higher rating values. Full descriptions of the uncertainty ratings developed for each criterion are provided in **Section 19.D**, **Summary of Individual Bridges Uncertainty Index Rating**. Following are the criteria selected for the study bridges:

1. <u>Inspectability.</u> If an element is easily visible to any inspector, the uncertainty is minimized. Elements that are not visible, such as piles, were rated as a high uncertainty.
2. <u>Predictability.</u> Based on the type of structure, designers can predict its uncertainty level. For example, fatigue life of a steel girder can be computed, resulting in a low to medium uncertainty rating. The behavior of some foundation elements during extreme weather conditions cannot be reliably predicted, resulting in a medium to high uncertainty rating.
3. <u>Critical Factor.</u> This is the most important criterion in defining the overall uncertainty level. It reflects the level of structural integrity for a bridge element. When comparing a two girder system with a multiple stringer system, the non-redundant two girder system has a higher uncertainty rating.
4. <u>Historical Evidence.</u> This rating depends on multiple factors. If no critical deficiency is noted in a series of inspections, the element was rated low for uncertainty. If a crack is noted in a past inspection and it remains unchanged, the rating would be low to moderate uncertainty. If the crack is widened or continues to propagate, the uncertainty rating goes up.
5. <u>Inconvenience to Users.</u> Route ADT, percentage of trucks, and the proximity and type of alternate routes form the basis for the rating.
6. <u>Frequency of Inspection.</u> Annual inspection or a bridge monitoring system was rated as low uncertainty. The typical five-year underwater inspection was rated as a high uncertainty factor due to the lengthy interval between inspections. If there is major concern, using a shorter inspection interval resulted in lower uncertainty.

Ranking of Criteria

The next step was to rank these criteria based on their relative levels of concern. Criteria were compared to each other, ranked in order of importance, and assigned a weight of importance. Each criterion was compared against the other criteria for its relative importance. At each diagonal, the horizontal row and vertical column will be opposite numbers. The rest of the criteria were compared similarly. When numbers were added vertically, the ranking of criteria was obtained. If there is a breakdown in logic, two criteria may have the same ranking. For example, there may be two 3's and either a 2 or 4 may be missing. If this occurred, the logic was rechecked to correct the error.

A weighting scale of 1 through 10 is applied to each criterion to quantify the relative importance of each criterion. A higher element rating connotes a greater level of uncertainty, and a higher weighting scale connotes a greater level of relative importance. **Table 19.1** shows the ranking and weights of importance for the six selected criteria. All of the bridges included in the uncertainty assessment were rated with these criteria. Critical Factor and Historical Evidence are ranked as the most important factors in this assessment.

Table 19.1 Criteria Ranking – Engineering Uncertainty

Criteria Ranking - Engineering Uncertainty							
Criteria		1	2	3	4	5	6
1	Inspectability	1	1	0	0	1	1
2	Predictability	0	1	0	0	1	1
3	Critical Factor	1	1	1	1	1	1
4	Historical Evidence	1	1	0	1	1	1
5	Inconvenience to User	0	0	0	0	1	0
6	Frequency of Inspection	0	0	0	0	1	1
Rank		3	4	1	2	6	5
Weight of Importance		7	7	10	8	5	7

Rating Measurement of Criteria Scale

The next step is to define the scale for each criterion. Following is a description of the metrics used to assign uncertainty ratings to each criterion.

Criterion #1: Inspectability

1 Good inspectability (e.g., no equipment to inspect at arm length, all surfaces visible)
2 Moderately good inspectability (e.g., minimal equipment to inspect at arm length, all surfaces visible)
3 Moderate inspectability (e.g., accessible, but not necessarily at arm length, some surfaces may be hidden)
4 Poor inspectability (e.g., wide bridge with inability to fully access bridge with snooper)
5 Very poor inspectability (e.g., foundations underwater)

Criterion #2: Predictability

1. Highest predictability (e.g., straightforward and/or conventional superstructure and substructure elements)
2. Higher predictability (e.g., loading and performance of steel superstructures with direct load paths or prestressed concrete superstructures)
3. Moderate predictability (e.g., loading and performance of steel superstructures with indirect load paths redundancy)
4. Lower predictability (e.g., uncertain loading and performance of substructure elements)
5. Lowest predictability (e.g., highly variable lateral loads to a foundation)

Criterion #3: Critical Factor

1. Extremely non-critical (highly detectible failure of component with high redundancy)
2. Very non-critical (detectible failure of component with good redundancy)
3. Moderately critical (failure of component that is difficult to detect, but with good redundancy)
4. Very critical (detectible failure of component with low redundancy)
5. Extremely critical (failure of component would be difficult to detect and lead to immediate catastrophic failure of bridge)

Criterion #4: Historical Evidence

1. Past inspections indicate at most a few minor deficiencies
2. Past inspections indicate a minor deficiency exists in a stable condition
3. Past inspections indicate a moderate deficiency exists in a stable condition or that a minor deficiency exists that is progressing
4. Past inspections indicate a serious deficiency exists in a stable condition or that a moderate deficiency exists that is progressing
5. Past inspections indicate a serious deficiency is progressing rapidly or similar serious damage is again possible

Criterion #5: Inconvenience to User

1. Low inconvenience to user (<200 additional travel hours per day)
2. Moderately low inconvenience to user (200 to 600 additional travel hours per day)
3. Moderate inconvenience to user (600 to 1,500 additional travel hours per day)
4. Moderately high inconvenience to user (1,500 to 5,000 additional travel hours per day)
5. Very high inconvenience to user (>5,000 additional travel hours per day)

Criterion #6: Frequency of Inspection

1. Very high frequency of inspection (e.g., bridge monitoring)
2. High frequency of inspection (reduced 12- to 23-month inspection cycle)
3. Moderate frequency of inspection (standard 24-month inspection cycle)
4. Low frequency of inspection (not visible every 24-month inspection cycle or extended to 25- to 60-month inspection cycle)
5. Very low frequency of inspection (greater than 60-month inspection cycle)

Using each uncertainty criterion, the bridges were rated for their uncertainty level on a scale of 5 to 1, where 5 is high uncertainty, 3 is medium uncertainty, and 1 is low uncertainty. By multiplying these ratings by the weight of the criterion and summing products, a total score for each alternative is determined. This score, divided by the sum of the weight of importance, is the average rating of the bridge.

19.A.2. Summary of Uncertainty Assessment

Table 19.2 is the result of the uncertainty assessment of the bridges. **Section 19.D** provides detailed summaries of individual bridge assessments. The criteria scale discussed in **Section 19.A.1** forms the basis for the rating of individual bridges. The particular details are provided under each bridge heading.

Table 19.2 Summary of Uncertainty Ratings

Criteria	Elements	Platte-Winner	Chamberlain	11th street	10th Street	Mobridge	Bridger	Cheyenne River	Forest City	Singing Bridge	Deadwood	Fossil Cycad	Cambell Street
Inspectability	Superstructure	3	4	2	3	4	3	2	4	3	4	2	2
	Substructure	3	3	2	2	3	2	2	3	3	4	3	2
	Foundation	5	5	4	4	5	4	4	5	5	4	4	4
Predictability	Superstructure	3	3	3	3	4	2	2	4	2	3	4	2
	Substructure	4	3	2	3	3	3	2	3	3	2	4	1
	Foundation	5	4	3	2	4	3	3	4	4	2	4	2
Critical Factor	Superstructure	4	4	2	2	5	3	2	5	2	4	3	4
	Substructure	3	4	4	4	4	1	2	5	3	3	3	5
	Foundation	4	4	2	2	4	3	3	5	4	2	3	2
Historical Evidence	Superstructure	3	2	2	4	4	3	3	4	2	4	3	4
	Substructure	5	2	3	3	3	2	2	4	3	4	2	3
	Foundation	5	4	1	1	4	3	3	4	3	2	1	1
Inconvenience to User	Superstructure	3	2	2	2	4	2	2	3	1	5	4	2
	Substructure	3	2	2	2	4	2	2	3	1	5	4	2
	Foundation	3	2	2	2	4	2	2	3	1	5	4	2
Frequency of Inspection	Superstructure	2	2	3	3	2	3	3	2	3	3	3	3
	Substructure	2	3	3	3	3	3	3	3	3	3	3	3
	Foundation	4	4	5	5	4	4	5	4	4	5	5	5

Indicates bridges not being replaced in financial mitigation scenario

19.A.3 Overall Bridge Uncertainty Ratings

The bridge uncertainty rating factor for the entire bridge is an aggregate measure of the relative uncertainty associated with each studied structure. This relative measure can be used to determine the order in which deficiencies at the study bridges should be addressed. The chosen action should be based on the uncertainty level of the three individual elements: superstructure, substructure, and foundation.

It should be noted that the ratings for each bridge are based on its current state. If there are changes in bridge condition, inspection frequency, or other engineering uncertainty criteria, the affected uncertainty ratings will need to be updated. Modifications to the ratings could lead to changes in priorities in the engineering uncertainty mitigation plan.

When the overall rating of a bridge foundation indicates replacement, the entire bridge should be replaced because foundation replacement for a bridge that is to remain in place is typically not cost-effective. If the overall foundation rating is below 3.5 and the superstructure rating requires replacement, the structure should be programmed for superstructure replacement only. Based on these criteria, the following structures should be considered for future replacement in the order indicated below:

1. Platte –Winner
2. Forest City
3. Mobridge
4. Chamberlain
5. Singing Bridge

The rating developed for the Deadwood structure indicates that the proposed work could be limited to superstructure replacement with substructure repair. The ratings for the study bridges are a guide to determine the timing, sequence, and type of work necessary at any of the individual bridge locations. However, SDDOT elected to include Deadwood for replacement to minimize future costs associated with continued maintenance on a structure exhibiting widespread deficiencies. **Section 19.D** contains the detail of each bridge, a summary of its condition, and the rating based on the scale shown above.

Table 19.3 Summary of Uncertainty Indices

	Elements	Platte-Winner	Chamberlain	11th street	10th Street	Mobridge	Bridger	Cheyenne River	Forest City	Singing Bridge	Deadwood	Fossil Cycad	Cambell Street
Uncertainty Index	Superstructure	3.07	2.93	2.32	2.84	3.91	2.73	2.34	3.80	2.20	3.80	3.11	2.98
	Substructure	3.36	2.93	2.80	2.95	3.34	2.09	2.16	3.64	3.00	3.41	3.09	2.86
	Foundation	4.39	3.93	2.77	2.61	4.16	3.20	3.36	4.27	3.64	3.14	3.39	2.61
	Overall	3.61	3.27	2.63	2.80	3.80	2.67	2.62	3.90	2.95	3.45	3.20	2.82

The above ratings are color coded based on appropriate recommendations for maintenance at each bridge.

Superstructure		
1.0 (inclusive) to 2.0 (inclusive)	Low Uncertainty. It requires standard inspection.	
2.0 to 2.75 (inclusive)	Moderately low Uncertainty. It requires routine maintenance.	
2.75 to 3.5 (inclusive)	Medium Uncertainty. It requires increased maintenance to preserve element lifespan.	
3.5 to 4.25 (inclusive)	Moderately high Uncertainty. It requires retrofit (if feasible) to extend bridge service life. Otherwise replace.	
4.25 to 5.0 (inclusive)	High Uncertainty. It requires replacement.	

Substructure		
1.0 (inclusive) to 2.0 (inclusive)	Low Uncertainty. It requires standard inspection.	
2.0 to 2.75 (inclusive)	Moderately low Uncertainty. It requires routine maintenance.	
2.75 to 3.5 (inclusive)	Medium Uncertainty. It requires increased maintenance to preserve element lifespan.	
3.5 to 4.25 (inclusive)	Moderately high Uncertainty. It requires retrofit (if feasible) to extend bridge service life. Otherwise replace.	
4.25 to 5.0 (inclusive)	High Uncertainty. It requires replacement.	

Foundation		
1.0 (inclusive) to 1.75 (inclusive)	Low Uncertainty. It requires standard inspection.	
1.75 to 2.5 (inclusive)	Moderately low Uncertainty. It requires routine maintenance.	
2.5 to 3.5 (inclusive)	Medium Uncertainty. It requires increased maintenance to preserve element lifespan.	
3.5 to 4.25 (inclusive)	Moderately high Uncertainty. It requires retrofit (if feasible) to extend bridge service life. Otherwise replace.	
4.25 to 5.0 (inclusive)	High Uncertainty. It requires replacement.	

19.B. Uncertainty Mitigation Plan

19.B.1. Procedure

The uncertainty index and past history information developed in this analysis were used to create a maintenance and replacement strategy for each bridge. **Appendix B** contains a detailed summary of replacement costs, maintenance costs, and life cycle costs for each bridge. **Appendix B** also contains a proposed order of maintenance and replacement events for all bridges based on the engineering uncertainty mitigation plan. **Appendix C** contains a proposed order of maintenance and replacement events for all bridges based on the financial uncertainty mitigation plan.

The following factors are the basis for estimating costs:

- Discount Rate = 4.43%
- Inflation rate = 2%
- Study Period = 50

The uncertainty mitigation plan is divided into three steps.

- Engineering Uncertainty Mitigation Plan
- Financial Uncertainty Mitigation Plan
- Management Uncertainty Mitigation Plan

19.B.2. Treatment of Inflation

(Ref: National Institute of Standards and Technology)

A life-cycle cost analysis (LCCA) can be performed in constant dollars or current dollars. Constant-dollar analyses exclude the rate of general inflation, while current-dollar analyses include the rate of general inflation in all dollar amounts, discount rates, and price escalation rates. Both types of calculations result in identical present-value life-cycle costs.

Constant-dollar analysis is recommended for all federal projects, except for projects financed by the private sector (ESPC, UESC). The constant-dollar method has the advantage of not requiring an estimate of the rate of inflation for the years in the study period. Alternative financing studies are usually performed in current dollars if the analyst wants to compare contract payments with actual operational or energy cost savings from year to year.

This study uses constant dollars (no inflation) for comparing various scenarios of replacement year versus continued maintenance. It uses current dollars (includes inflation) for assessing the cash flow in a given year.

19.B.3. Computation of Life-Cycle Cost of Each Bridge

Following is the process that was used to compute the life cycle cost of each bridge (see **Appendix B** for specific details):

Step 1: Review the inspection report. List the bridge condition and history of maintenance.

Step 2: Establish the discount rate, inflation rate, service life, and study period. Establish unit prices for new construction and maintenance. Most of this data is common to all bridges.

Step 3: Estimate design factors such as span configuration, number of beams, deck width, etc., for a new bridge.

Step 4: Estimate the cost of deck replacement, superstructure replacement, and total replacement.

Step 5: Estimate the maintenance events and the year of maintenance. Estimate the cost of each event. Based on the unit prices and the events of maintenance, a total maintenance cost is calculated. To determine the cash flow for each year, inflation is included in the computation. The maintenance events also include bridge replacement using the uncertainty index as a guide. Based on the year of replacement, the maintenance cost will vary. To compare various scenarios, cost should be compared in present value, using the discount rate only. The present value of replacement decreases as the year of replacement moves further into the future.

Step 6: Tabulate the cost of each maintenance event including inflation for each year. Also compute the present value of the cost. Explore the possibility of replacing the bridge and show the future maintenance cost savings. This shows the year where economy favors the replacement. **Table 19.4** shows the yearly expenses and present value for the Deadwood structure as an example.

Step 7: Assume the cost shown in Step 6 is the best estimate. Compute the minimum potential cost and maximum potential cost.

Step 8: Compute contingency for events of each year and sum the best estimate cost with contingency. Contingencies are calculated based on the estimated probability that the predicted cost will be equal to, less than, or greater than the predicted value. Repeat Steps 1 through 8 for each bridge (see **Appendix B** for details).

Step 9: Tabulate the yearly expense of each bridge and sum the expenses for each year.

The Deadwood structure is shown as an example of the process. The uncertainty index for the Deadwood structure is as follows:

- Superstructure 3.80
- Substructure 3.41
- Foundation 3.14
- Overall 3.45

This bridge is classified as having medium uncertainty. It requires increased maintenance to preserve element lifespan. If the bridge is maintained for the next 50 years without replacement, the present value of the total maintenance cost is $5.6 million (see **Table 19.4**). The breakeven between replacement and no replacement occurs in year 2035. Based on the uncertainty index, the superstructure should be replaced, but the substructure could be repaired. However, SDDOT has identified this structure for replacement to minimize future maintenance costs.

Engineering uncertainty mitigation is based on the bridge replacement in year 2044. The present value of the total maintenance cost is $12.2 million (including replacement and total yearly expenses with inflation totals $52.0 million). See **Table 19.5** for details.

The next step is to look at the financial uncertainty mitigation. It includes analyzing the yearly expense with inflation and cash flow. By moving the replacement from 2044 to 2036, the total yearly expenses with inflation is reduced from $52.0 million to $36.2 million. The total present value of maintenance is also reduced from $12.2 million to $11.5 million (see **Table 19.6**).

Table 19.4 Deadwood Structure Breakeven Analysis

Year	Yearly Expenses With Inflation	No Inflation is Considered			
		Present Value of Maintenance (2017)	Total Project Present Value if the bridge is replaced in any year	Present Value (if the Bridge is Replaced)	
				Sum of Future Maintenance Savings	Cost of Bridge Replacement minus Future Maintenance Savings
2017	$ -	$ -	$17,509,986	$5,598,311	$11,911,675
2018	$ -	$ -	$16,767,199	$5,598,311	$11,168,888
2019	$ -	$ -	$16,055,922	$5,598,311	$10,457,611
2020	$ -	$ -	$15,374,818	$5,598,311	$9,776,506
2021	$ -	$ -	$14,722,606	$5,598,311	$9,124,295
2022	$210,504	$154,149	$14,098,062	$5,598,311	$8,499,751
2023	$ -	$ -	$13,500,012	$5,444,163	$8,055,849
2024	$1,811,336	$1,170,983	$12,927,331	$5,444,163	$7,483,168
2025	$ -	$ -	$12,378,944	$4,273,180	$8,105,764
2026	$ -	$ -	$11,853,819	$4,273,180	$7,580,640
2027	$ -	$ -	$11,350,971	$4,273,180	$7,077,792
2028	$248,633	$125,272	$10,869,455	$4,273,180	$6,596,275
2029	$ -	$ -	$10,408,364	$4,147,908	$6,260,456
2030	$ -	$ -	$9,966,833	$4,147,908	$5,818,926
2031	$ -	$ -	$9,544,033	$4,147,908	$5,396,125
2032	$ -	$ -	$9,139,168	$4,147,908	$4,991,260
2033	$ -	$ -	$8,751,477	$4,147,908	$4,603,569
2034	$ -	$ -	$8,380,233	$4,147,908	$4,232,325
2035	$ -	$ -	$8,024,737	$4,147,908	$3,876,829
2036	$9,243,828	$2,829,011	$7,684,321	$4,147,908	$3,536,414
2037	$148,595	$42,729	$7,358,347	$1,318,896	$6,039,450
2038	$ -	$ -	$7,046,200	$1,276,167	$5,770,033
2039	$ -	$ -	$6,747,295	$1,276,167	$5,471,128
2040	$ -	$ -	$6,461,070	$1,276,167	$5,184,902
2041	$ -	$ -	$6,186,986	$1,276,167	$4,910,819
2042	$ -	$ -	$5,924,529	$1,276,167	$4,648,362
2043	$334,627	$66,206	$5,673,206	$1,276,167	$4,397,039
2044	$ -	$ -	$5,432,545	$1,209,962	$4,222,583
2045	$ -	$ -	$5,202,092	$1,209,962	$3,992,130
2046	$1,339,268	$219,791	$4,981,415	$1,209,962	$3,771,454
2047	$72,454	$11,172	$4,770,100	$990,171	$3,779,929
2048	$ -	$ -	$4,567,749	$978,998	$3,588,750
2049	$ -	$ -	$4,373,981	$978,998	$3,394,983
2050	$ -	$ -	$4,188,434	$978,998	$3,209,435
2051	$ -	$ -	$4,010,757	$978,998	$3,031,759
2052	$199,989	$22,582	$3,840,618	$978,998	$2,861,619
2053	$ -	$ -	$3,677,696	$956,416	$2,721,280
2054	$ -	$ -	$3,521,685	$956,416	$2,565,269
2055	$ -	$ -	$3,372,293	$956,416	$2,415,876
2056	$312,728	$27,521	$3,229,237	$956,416	$2,272,821
2057	$ -	$ -	$3,092,251	$928,895	$2,163,356
2058	$1,698,516	$131,960	$2,961,075	$928,895	$2,032,180
2059	$ -	$ -	$2,835,464	$796,935	$2,038,529
2060	$ -	$ -	$2,715,181	$796,935	$1,918,247
2061	$ -	$ -	$2,600,001	$796,935	$1,803,067
2062	$13,161,506	$796,935	$2,489,707	$796,935	$1,692,773
2063	$ -	$ -	$2,384,092	$ -	$2,384,092
2064	$ -	$ -	$2,282,957	$ -	$2,282,957
2065	$ -	$ -	$2,186,112	$ -	$2,186,112
2066	$ -	$ -	$2,093,376	$ -	($3,504,936)
Total	**$28,781,984**	**$5,598,311**			

Table 19.5 Deadwood Structure Engineering Mitigation

Year	Yearly Expenses With Inflation	No Inflation is Considered			
		Present Value of Maintenance (2017)	Total Project Present Value if the bridge is replaced in any year	Present Value (if the Bridge is	
				Sum of Future Maintenance Savings	Cost of Bridge Replacement minus Future Maintenance Savings
2017			$21,741,131	$12,199,259	$9,541,872
2018			$20,818,856	$12,199,259	$8,619,597
2019			$19,935,704	$12,199,259	$7,736,445
2020			$19,090,016	$12,199,259	$6,890,757
2021			$18,280,203	$12,199,259	$6,080,944
2022	$2,462,201	$1,795,544	$17,504,743	$12,199,259	$5,305,484
2023			$16,762,179	$10,403,714	$6,358,464
2024			$16,051,114	$10,403,714	$5,647,400
2025			$15,370,214	$10,403,714	$4,966,500
2026			$14,718,198	$10,403,714	$4,314,483
2027			$14,093,840	$10,403,714	$3,690,126
2028			$13,495,969	$10,403,714	$3,092,255
2029			$12,923,460	$10,403,714	$2,519,746
2030			$12,375,237	$10,403,714	$1,971,523
2031			$11,850,270	$10,403,714	$1,446,556
2032			$11,347,572	$10,403,714	$943,858
2033			$10,866,200	$10,403,714	$462,486
2034	$10,327,520	$3,529,908	$10,405,247	$10,403,714	$1,533
2035			$9,963,849	$6,873,806	$3,090,043
2036			$9,541,175	$6,873,806	$2,667,369
2037			$9,136,431	$6,873,806	$2,262,625
2038			$8,748,856	$6,873,806	$1,875,050
2039			$8,377,723	$6,873,806	$1,503,917
2040			$8,022,334	$6,873,806	$1,148,528
2041			$7,682,020	$6,873,806	$808,214
2042			$7,356,143	$6,873,806	$482,337
2043			$7,044,090	$6,873,806	$170,284
2044	$37,109,642	$6,745,274	$6,745,274	$6,873,806	($128,532)
2045			$6,459,135	$128,532	$6,330,603
2046			$6,185,133	$128,532	$6,056,602
2047			$5,922,755	$128,532	$5,794,224
2048			$5,671,508	$128,532	$5,542,976
2049			$5,430,918	$128,532	$5,302,386
2050			$5,200,534	$128,532	$5,072,002
2051			$4,979,924	$128,532	$4,851,392
2052			$4,768,671	$128,532	$4,640,140
2053			$4,566,381	$128,532	$4,437,849
2054			$4,372,671	$128,532	$4,244,140
2055			$4,187,179	$128,532	$4,058,648
2056			$4,009,556	$128,532	$3,881,024
2057			$3,839,468	$128,532	$3,710,936
2058			$3,676,594	$128,532	$3,548,063
2059			$3,520,631	$128,532	$3,392,099
2060			$3,371,283	$128,532	$3,242,751
2061	$2,068,855	$128,532	$3,228,270	$128,532	$3,099,739
2062			$3,091,325		$3,091,325
2063			$2,960,188		$2,960,188
2064			$2,834,615		$2,834,615
2065			$2,714,368		$2,714,368
2066			$2,599,223		($9,600,036)
Total	**$51,968,218**	**$12,199,259**			

Table 19.6 Deadwood Structure Financial Mitigation

Year	Yearly Expenses With Inflation	No Inflation is Considered			
		Present Value of Maintenance (2017)	Total Project Present Value if the bridge is replaced in any year	Present Value (if the Bridge is	
				Sum of Future Maintenance Savings	Cost of Bridge Replacement minus Future Maintenance Savings
2017	$ -	$ -	$21,741,131	$11,510,870	$10,230,261
2018	$ -	$ -	$20,818,856	$11,510,870	$9,307,986
2019	$ -	$ -	$19,935,704	$11,510,870	$8,424,834
2020	$ -	$ -	$19,090,016	$11,510,870	$7,579,146
2021	$ -	$ -	$18,280,203	$11,510,870	$6,769,333
2022	$2,462,201	$1,795,544	$17,504,743	$11,510,870	$5,993,873
2023	$ -	$ -	$16,762,179	$9,715,325	$7,046,853
2024	$ -	$ -	$16,051,114	$9,715,325	$6,335,789
2025	$ -	$ -	$15,370,214	$9,715,325	$5,654,888
2026	$ -	$ -	$14,718,198	$9,715,325	$5,002,872
2027	$ -	$ -	$14,093,840	$9,715,325	$4,378,515
2028	$ -	$ -	$13,495,969	$9,715,325	$3,780,644
2029	$ -	$ -	$12,923,460	$9,715,325	$3,208,134
2030	$ -	$ -	$12,375,237	$9,715,325	$2,659,911
2031	$ -	$ -	$11,850,270	$9,715,325	$2,134,944
2032	$ -	$ -	$11,347,572	$9,715,325	$1,632,247
2033	$ -	$ -	$10,866,200	$9,715,325	$1,150,874
2034	$ -	$ -	$10,405,247	$9,715,325	$689,922
2035	$ -	$ -	$9,963,849	$9,715,325	$248,523
2036	$ 31,672,722	$ 9,541,175	$9,541,175	$9,715,325	($174,151)
2037	$ -	$ -	$9,136,431	$174,151	$8,962,280
2038	$ -	$ -	$8,748,856	$174,151	$8,574,706
2039	$ -	$ -	$8,377,723	$174,151	$8,203,573
2040	$ -	$ -	$8,022,334	$174,151	$7,848,183
2041	$ -	$ -	$7,682,020	$174,151	$7,507,870
2042	$ -	$ -	$7,356,143	$174,151	$7,181,993
2043	$ -	$ -	$7,044,090	$174,151	$6,869,939
2044	$ -	$ -	$6,745,274	$174,151	$6,571,124
2045	$ -	$ -	$6,459,135	$174,151	$6,284,984
2046	$ -	$ -	$6,185,133	$174,151	$6,010,983
2047	$ -	$ -	$5,922,755	$174,151	$5,748,605
2048	$ -	$ -	$5,671,508	$174,151	$5,497,357
2049	$ -	$ -	$5,430,918	$174,151	$5,256,767
2050	$ -	$ -	$5,200,534	$174,151	$5,026,383
2051	$ -	$ -	$4,979,924	$174,151	$4,805,773
2052	$ -	$ -	$4,768,671	$174,151	$4,594,521
2053	$ -	$ -	$4,566,381	$174,151	$4,392,230
2054	$ -	$ -	$4,372,671	$174,151	$4,198,521
2055	$ -	$ -	$4,187,179	$174,151	$4,013,029
2056	$2,044,174	$174,151	$4,009,556	$174,151	$3,835,405
2057	$ -	$ -	$3,839,468	$ -	$3,839,468
2058	$ -	$ -	$3,676,594	$ -	$3,676,594
2059	$ -	$ -	$3,520,631	$ -	$3,520,631
2060	$ -	$ -	$3,371,283	$ -	$3,371,283
2061	$ -	$ -	$3,228,270	$ -	$3,228,270
2062	$ -	$ -	$3,091,325	$ -	$3,091,325
2063	$ -	$ -	$2,960,188	$ -	$2,960,188
2064	$ -	$ -	$2,834,615	$ -	$2,834,615
2065	$ -	$ -	$2,714,368	$ -	$2,714,368
2066	$ -	$ -	$2,599,223	$ -	($8,911,647)
Total	**$36,179,097**	**$11,510,870**			

19.C. Engineering, Financial, and Management Uncertainty Mitigation

19.C.1 Engineering Uncertainty Mitigation

Seven bridges were selected for replacement in the engineering uncertainty mitigation plan. The study plan provides for the bridges to be replaced on a five-year schedule. Shorter and longer replacement schedule periods were also considered. However, a shorter length of time between replacements was deemed to increase the financial hardship beyond what is acceptable, and a longer replacement schedule would extend beyond the bounds of the study period. The replacement order is based on the rating of uncertainty. It should be noted that the Pierre-Fort Pierre/Waldron Bridge has already been programmed for replacement.

Bridge replacement recommendations are as follows:

1. Pierre-Fort Pierre/Waldron Year 2021
2. Platte-Winner Year 2024
3. Forest City Year 2029
4. Mobridge Year 2034
5. Chamberlain Year 2039
6. Deadwood Box Year 2044
7. Singing Bridge Year 2049

Table 19.7 represents the summary of yearly cash flows optimized to mitigate engineering uncertainty. The total present value of yearly maintenance and replacement is $225.9 million. **Figure 19.2** shows the cash flow with seven bridges dominating the cash flow. The costs presented in **Figure 19.2** and **Table 19.7** include contingencies.

Figure 19.2 Cash Flow for Engineering Uncertainty Mitigation

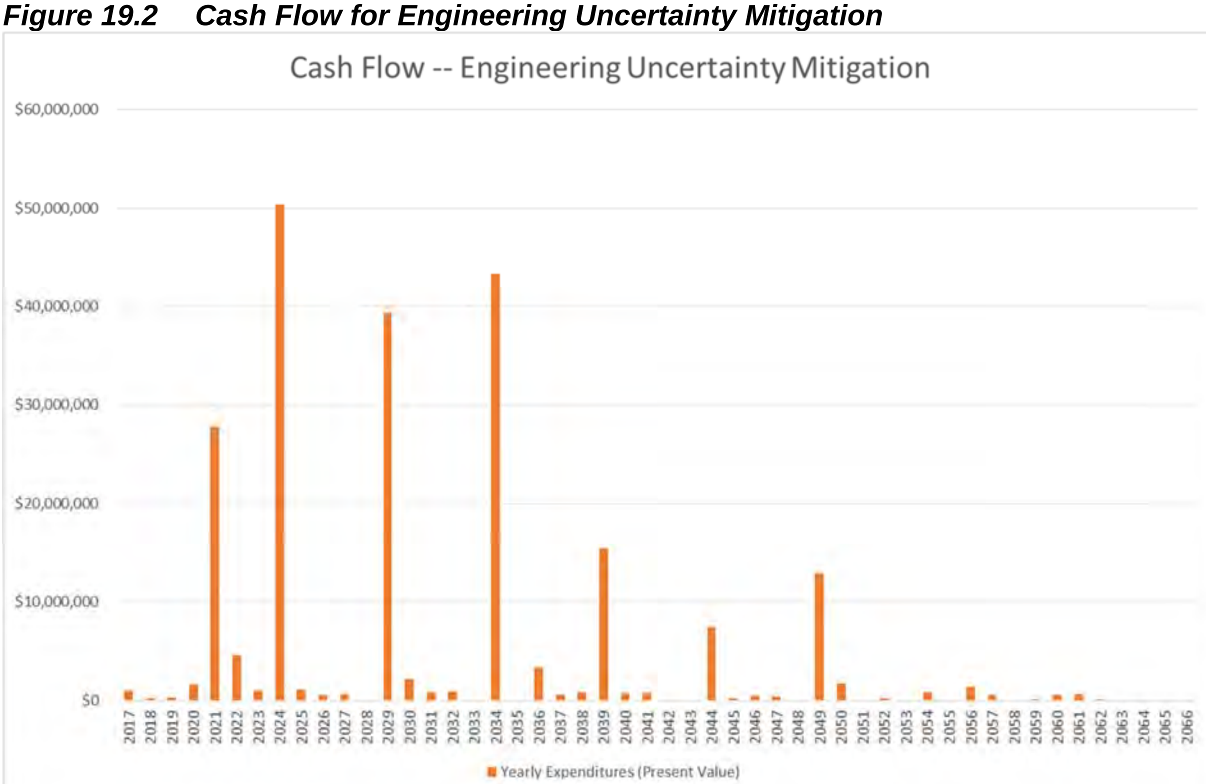


Table 19.7 Yearly Cash Flow and Present Value of Replacement / Maintenance

(yellow)	Signifies year of replacement

Discount Rate	4.43%
Inflation Rate	2.00%

		1	2	3	4	5	6	7	8	9
		12-085-080	08-061-094	50-205-209	50-205-208	65-000-020	28-035-151	69-390-535	54-056-158	16-737-253
Year	**Years**	**Platte-Winner**	**Chamberlain**	**11th St Viaduct**	**10th St Viaduct**	**Mobridge**	**Bridger**	**Cheyenne River**	**Forest City**	**Singing Bridge**
2017	0					$35,739				$731,500
2018	1					$31,977			$170,544	
2019	2									
2020	3		$241,088	$770,604	$404,693		$221,792			
2021	4								$1,828,581	
2022	5						$2,060,452			$1,683,519
2023	6		$1,484,301							
2024	7	$76,561,939		$398,263				$1,358,768		
2025	8					$1,937,862				
2026	9				$87,421					
2027	10			$184,708						
2028	11									
2029	12			$879,451				$21,086	$78,814,919	$4,119,840
2030	13			$3,066,839	$1,682,893					
2031	14									
2032	15		$1,824,802				$544,578			
2033	16									
2034	17				$150,526	$115,481,022				
2035	18									
2036	19				$94,327					$10,895,553
2037	20						$2,113,256			
2038	21									
2039	22		$57,388,270					$4,356,059		
2040	23			$1,170,398	$635,880					
2041	24	$2,848,640								
2042	25			$262,866						
2043	26									
2044	27									
2045	28						$724,129			
2046	29				$412,085				$2,551,158	
2047	30									
2048	31									
2049	32			$208,242				$1,281,538		$88,536,991
2050	33			$1,426,709	$7,605,941					
2051	34									
2052	35						$2,110,017			
2053	36									
2054	37					$3,737,725				
2055	38									
2056	39	$3,937,983	$3,098,897					$9,132,370		
2057	40			$1,061,349			$2,290,595			
2058	41									
2059	42			$1,383,614						
2060	43			$5,710,181	$3,133,398					
2061	44			$2,927,874				$1,668,260	$3,619,958	
2062	45									
2063	46									
2064	47									
2065	48				$587,636					
2066	49						$614,843			

Table 19.7 (cont.) Yearly Cash Flow and Present Value of Replacement / Maintenance

(Yellow) Signifies year of replacement

	10	11	12	Cursory Review Bridges					
	41-161-156	24-162-058	52-430-314	33-100-118	14-104-249	08-068-084	50-187-240		
Year	**Deadwood Box**	**Fossil Cycad National Monument**	**Cambell Street**	**Pierre-Fort Pierre/ Waldron**	**Vermillion**	**Chamberlain Truss**	**57th Street**	**Total Yearly Cost With Inflation**	**Yearly Cost (Present Value)**
2017		$269,091					$16,302	$1,052,632	$1,052,632
2018								$202,521	$190,127
2019			$389,607					$389,607	$343,380
2020			$327,144					$1,965,322	$1,626,138
2021				$33,934,248				$35,762,829	$27,779,861
2022	$2,573,000							$6,316,971	$4,606,612
2023								$1,484,301	$1,016,177
2024								$78,318,971	$50,337,173
2025								$1,937,862	$1,169,282
2026						$926,561		$1,013,982	$574,382
2027		$201,481			$850,866		$54,513	$1,291,568	$686,852
2028								$0	$0
2029								$83,835,296	$39,293,572
2030		$168,995	$89,446					$5,008,173	$2,203,680
2031		$365,253	$1,816,115					$2,181,369	$901,100
2032								$2,369,380	$918,867
2033								$0	$0
2034	$11,102,084							$126,733,632	$43,317,086
2035								$0	$0
2036		$125,286						$11,115,166	$3,348,362
2037								$2,113,256	$597,645
2038				$436,596		$2,958,230		$3,394,825	$901,328
2039								$61,744,329	$15,389,949
2040					$1,156,494		$201,430	$3,164,202	$740,421
2041			$636,907					$3,485,548	$765,703
2042			$220,241					$483,107	$99,634
2043								$0	$0
2044	$41,006,155							$41,006,155	$7,453,528
2045					$692,579			$1,416,709	$241,751
2046								$2,963,242	$474,711
2047		$2,880,467						$2,880,467	$433,211
2048								$0	$0
2049			$7,113,437					$97,140,208	$12,876,109
2050						$5,098,801		$14,131,451	$1,758,518
2051								$0	$0
2052								$2,110,017	$231,417
2053				$655,415			$36,118	$691,533	$71,203
2054					$4,902,205			$8,639,930	$835,158
2055								$0	$0
2056								$16,169,250	$1,377,518
2057		$4,177,429				$308,684		$7,838,058	$626,889
2058								$0	$0
2059			$909,660					$2,293,274	$161,654
2060			$168,300					$9,011,879	$596,377
2061	$2,410,216			$445,506				$11,071,813	$687,858
2062						$1,965,117		$1,965,117	$114,615
2063								$0	$0
2064								$0	$0
2065								$587,636	$28,359
2066		$245,937					$127,887	$988,668	$44,792
									$225,873,631

19.C.2. Financial Uncertainty Mitigation

The financial mitigation plan was developed before the workshop where engineering uncertainty indices were calculated for the study bridges.

The 10th Street and 11th Street bridges were included in the financial uncertainty mitigation plan to reduce overall maintenance costs. These bridges will be turned over to the City of Sioux Falls for maintenance after a major rehabilitation or replacement occurs. The order of maintenance and replacement events developed for the financial uncertainty mitigation plan is based on the understanding of system needs before the engineering mitigation workshop. At that time, the Chamberlain Bridge and Singing Bridge were not considered for replacement, although the Cambell Street Bridge was identified for replacement.

1. Pierre-Fort Pierre/Waldron	Year 2023
2. Cambell Street	Year 2024
3. 10th Street	Year 2025
4. 11th Street	Year 2026
5. Platte-Winner	Year 2033
6. Deadwood Box	Year 2035
7. Mobridge	Year 2038
8. Forest City	Year 2043

All bridges were analyzed for engineering and financial uncertainty mitigation. **Table 19.8** represents the summary of yearly cash flows optimized to mitigate financial uncertainty. The total present value of yearly maintenance and replacement is $175.3 million. **Figure 19.3** shows the cash flow for financial uncertainty mitigation. The costs presented in **Figure 19.3** and **Table 19.8** include contingencies.

Figure 19.3 Cash Flow for Financial Uncertainty Mitigation

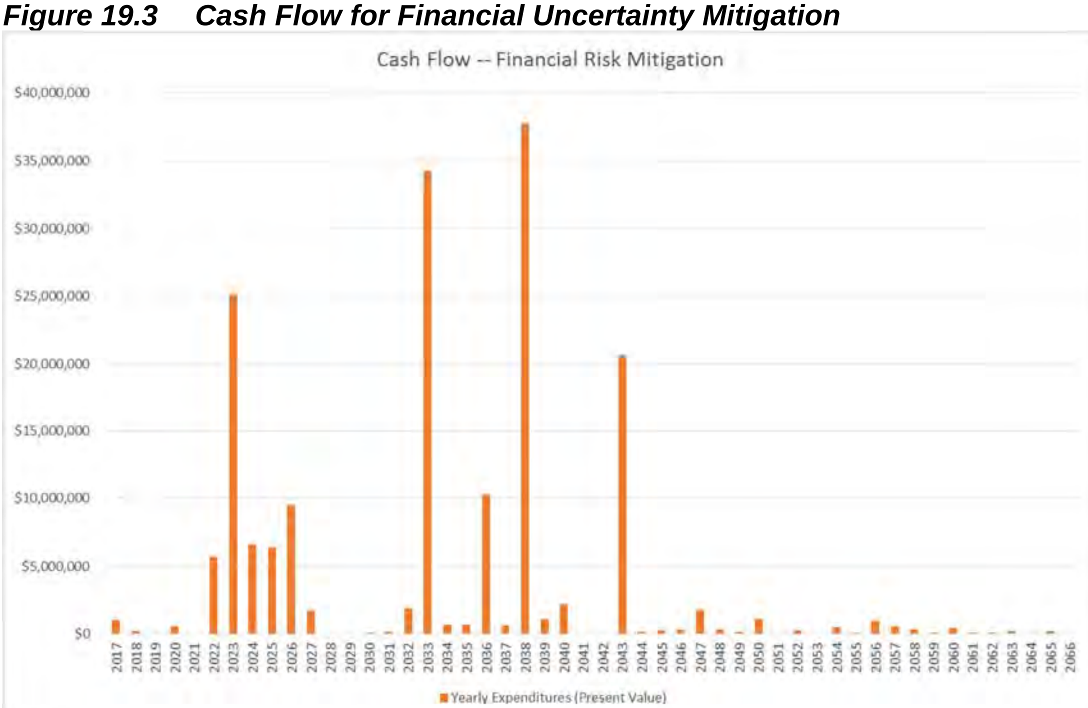


Table 19.8 Yearly Cash Flow and Present Value of Replacement / Maintenance

Discount Rate	4.43%
Inflation Rate	2.00%

(Yellow) Signifies year of replacement

		1	2	3	4	5	6	7	8	9
		12-085-080	08-061-094	50-205-209	50-205-208	65-000-020	28-035-151	69-390-535	54-056-158	16-737-253
Year	Years	Platte-Winner	Chamberlain	11th St Viaduct	10th St Viaduct	Mobridge	Bridger	Cheyenne River	Forest City	Singing Bridge
2017	0					$35,739				$731,500
2018	1					$31,977			$170,544	
2019	2									
2020	3		$241,088				$221,792			
2021	4									
2022	5						$2,060,452		$1,499,986	$1,683,519
2023	6		$1,484,301							
2024	7							$1,358,768	$379,919	
2025	8				$8,651,181	$1,937,862				
2026	9	$349,684		$15,556,417						
2027	10	$2,140,923								
2028	11									
2029	12							$21,086		
2030	13									
2031	14									
2032	15						$544,578			$4,372,007
2033	16	$94,125,359								
2034	17		$1,898,524							
2035	18								$2,177,560	
2036	19									
2037	20						$2,113,256			
2038	21					$128,488,755				$10,814,674
2039	22							$4,356,059		
2040	23		$7,561,632							
2041	24									
2042	25									
2043	26								$106,896,787	
2044	27									
2045	28						$724,129			
2046	29									$2,080,412
2047	30		$9,125,624							
2048	31									$2,380,222
2049	32							$1,281,538		
2050	33	$3,496,816								
2051	34									
2052	35						$2,110,017			$238,337
2053	36									
2054	37									
2055	38									
2056	39							$9,132,370		
2057	40						$2,290,595			
2058	41					$4,152,772				
2059	42									$206,963
2060	43		$3,443,007							$3,098,486
2061	44							$1,668,260		
2062	45									
2063	46								$3,766,204	
2064	47									
2065	48	$4,830,648								
2066	49						$614,843			

Table 19.8 (cont.) Yearly Cash Flow and Present Value of Replacement / Maintenance

(yellow)	Signifies year of replacement								
	10	11	12	Cursory Review Bridges					
	41-161-156	24-162-058	52-430-314	33-100-118	14-104-249	08-068-084	50-187-240		
Year	**Deadwood Box**	**Fossil Cycad National Monument**	**Cambell Street**	**Pierre-Fort Pierre/ Waldron**	**Vermillion**	**Chamberlain Truss**	**57th Street**	**Total Yearly Cost With Inflation**	**Yearly Cost (Present Value)**
2017		$269,091					$16,302	$1,052,632	$1,052,632
2018								$202,521	$190,127
2019								$0	$0
2020			$216,248					$679,129	$561,921
2021								$0	$0
2022	$2,573,000							$7,816,957	$5,700,467
2023				$35,305,192				$36,789,493	$25,186,690
2024			$8,479,548					$10,218,235	$6,567,465
2025								$10,589,042	$6,389,297
2026						$926,561		$16,832,662	$9,535,067
2027		$201,481			$850,866		$54,513	$3,247,784	$1,727,160
2028								$0	$0
2029								$21,086	$9,883
2030		$168,995						$168,995	$74,360
2031		$365,253						$365,253	$150,882
2032								$4,916,585	$1,906,698
2033								$94,125,359	$34,268,844
2034								$1,898,524	$648,908
2035								$2,177,560	$698,734
2036	$34,048,176	$125,286						$34,173,462	$10,294,504
2037								$2,113,256	$597,645
2038						$2,958,230		$142,261,659	$37,770,560
2039								$4,356,059	$1,085,760
2040				$454,234	$1,156,494		$201,430	$9,373,790	$2,193,461
2041								$0	$0
2042								$0	$0
2043								$106,896,787	$20,696,788
2044			$675,891					$675,891	$122,854
2045					$692,579			$1,416,709	$241,751
2046								$2,080,412	$333,282
2047		$2,880,467						$12,006,091	$1,805,669
2048								$2,380,222	$336,069
2049								$1,281,538	$169,870
2050						$5,098,801		$8,595,617	$1,069,639
2051								$0	$0
2052								$2,348,354	$257,557
2053							$36,118	$36,118	$3,719
2054					$4,902,205			$4,902,205	$473,860
2055				$681,894				$681,894	$61,880
2056	$2,320,137							$11,452,507	$975,681
2057		$4,177,429				$308,684		$6,776,708	$542,002
2058								$4,152,772	$311,813
2059			$909,660					$1,116,623	$78,711
2060								$6,541,493	$432,895
2061								$1,668,260	$103,644
2062						$1,965,117		$1,965,117	$114,615
2063				$463,504				$4,229,708	$231,601
2064								$0	$0
2065								$4,830,648	$233,122
2066		$245,937					$127,887	$988,668	$44,792
									$175,252,881

19.C.3. Management Uncertainty Mitigation Plan

By spreading the tasks within the limit of the structural needs, financial uncertainty mitigation allows costs to be spread out while also reducing the total maintenance and replacement costs due to inflation. It should be noted that costs are sensitive to the discount rate and inflation, which can change yearly. Available funds can also change from year to year. As a result, it is recommended that this data be used for management uncertainty mitigation annually.

19.D. Summary of Individual Bridges Uncertainty Index Rating

The 12 study bridges were analyzed to determine their level of engineering uncertainties. The results are discussed in this section and summarized in **Tables 19.2 and 19.3**. The following pages summarize individual bridge information, with complete analysis information in **Appendix B**.

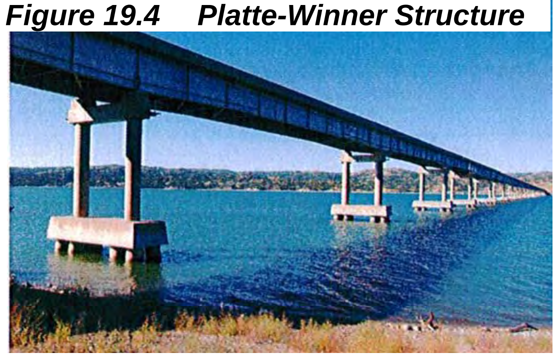
19.D.1. Platte-Winner Structure # 12-085-080

<u>Existing Condition</u>

Year Built:	1966
Sufficiency Rating:	78.4
NBI Rating – Deck:	6
NBI Rating – Superstructure:	6
NBI Rating – Substructure:	6

The bridge has the following traffic volume: ADT (2015) of 951. The superstructure is a non-redundant two-girder system.

Figure 19.4 Platte-Winner Structure



<u>*Condition of the Bridge Under Each Criterion*</u>

- Inspectability
  - *Superstructure*: Superstructure generally accessible by snooper
  - *Substructure*: Piers are in water but generally visible from snooper or boat
  - *Foundation*: Underwater
- Predictability
  - *Superstructure*: Two-girder system with floor beams and stringers
  - *Substructure*: Two-column bents with combined footings, damage previously sustained during extreme loading event that is difficult to predict
  - *Foundation*: Previous damage due to ice and wind loads applied, effects of repair are difficult to ascertain
- Critical Factor
  - *Superstructure*: Two-girder system, detectible deficiencies, limited redundancy
  - *Substructure*: Two-column system with continuous footing, partial redundancy
  - *Foundation*: Large diameter piles with good redundancy, footing also considered in this evaluation
- Historical Evidence
  - *Superstructure*: Moderate fatigue cracking appears stable
  - *Substructure*: Major damage at Pier 16 & 17 bottom diaphragm, similar damage possible at other piers
  - *Foundation*: Major damage at Pier 16 & 17 pile footing, similar damage possible at other piers

- Inconvenience to user
  ADT = 951 Detour Length = 73 miles
- Frequency of Inspection
  - *Superstructure:* 12 months
  - *Substructure:* 12 months
  - *Foundation:* 60 months – underwater

Rating of the Bridge and Findings

Table 19.9 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and substructure have medium uncertainty and will likely require increased maintenance to preserve their lifespans. The foundation rating indicates high uncertainty relative to its future behavior. The Platte-Winner bridge is, therefore, identified for replacement in the near future.

Table 19.9 Platte-Winner Structure Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	3.0	21.0	3.0	21.0	5.0	35.0
2	Predictability	7	3.0	21.0	4.0	28.0	5.0	35.0
3	Critical Factor	10	4.0	40.0	3.0	30.0	4.0	40.0
4	Historical Evidence	8	3.0	24.0	5.0	40.0	5.0	40.0
5	Inconvenience to User	5	3.0	15.0	3.0	15.0	3.0	15.0
6	Frequency of Inspection	7	2.0	14.0	2.0	14.0	4.0	28.0
Total Weighted Rating		44		135.0		148.0		193.0
Average Weighted Rating			3.07		3.36		4.39	
			3.61					

19.D.2. Chamberlain 08-061-094

Existing Condition

Year Built: 1974
Sufficiency Rating: 97
NBI Rating – Deck: 6
NBI Rating – Superstructure: 6
NBI Rating – Substructure: 7

The bridge has the following traffic volume:
ADT (2015) of 7060

The superstructure is a non-redundant two-girder system.

Figure 19.5 Upstream Elevation

Figure 19.6 Piers

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Bridge is wide enough that it is not fully accessible by snooper
  - *Substructure*: Piers are in water but generally visible from snooper or boat
  - *Foundation*: Underwater
- Predictability
  - *Superstructure*: Two-girder system with floor beams and stringers
  - *Substructure*: Two-column bents with individual footings
  - *Foundation*: Some individual spread footings with ice and wind loads applied
- Critical Factor
  - *Superstructure*: Two-girder system, detectible deficiencies, limited redundancy
  - *Substructure*: Two-column bents with low redundancy
  - *Foundation*: Scour at spread footings could cause critical failure
- Historical Evidence
  - *Superstructure*: Deck and soffit cracking (minor deficiency progressing), minor fatigue cracking appears stable
  - *Substructure*: Minor surface cracks appear stable
  - *Foundation*: Scour appears to be progressing at Pier 8 (pier is founded on chalk, SDDOT geotech confirms this layer is stable in scour conditions), spreading of embankment is occurring at east abutment
- Inconvenience to user

  ADT = 7,060 Detour Length = 2 miles

- Frequency of Inspection
  - *Superstructure:* 12 months
  - *Substructure:* 24 months
  - *Foundation:* 60 months underwater

<u>*Rating of the Bridge and Findings*</u>

Table 19.10 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and substructure have medium uncertainty and will likely require increased maintenance to preserve their lifespans. Due to the geotechnical issues at the east end of the structure, the Chamberlain bridge has been identified for replacement within the study period.

Table 19.10 Chamberlain Uncertainty Index

Uncertainty Index								
			Superstructure		Substructure		Foundation	
		Weight of Importance	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
	Criteria	(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	4.0	28.0	3.0	21.0	5.0	35.0
2	Predictability	7	3.0	21.0	3.0	21.0	4.0	28.0
3	Critical Factor	10	4.0	40.0	4.0	40.0	4.0	40.0
4	Historical Evidence	8	2.0	16.0	2.0	16.0	4.0	32.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	2.0	14.0	3.0	21.0	4.0	28.0
	Total Weighted Rating	**44**		**129.0**		**129.0**		**173.0**
	Average Weighted Rating		**2.93**		**2.93**		**3.93**	
			3.27					

19.D.3. 11th Street Viaduct 50-205-209

Existing Condition

Year Built:	1971
Major Rehabilitation:	1986
Sufficiency Rating:	79.5
NBI Rating – Deck:	7
NBI Rating – Superstructure:	6
NBI Rating – Substructure:	7

The bridge has the following traffic volume: ADT (2015) of 12,062. The superstructure is a redundant multi-girder system.

Figure 19.7 11th Street Viaduct

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper or lift
  - *Substructure*: Piers accessible from dry land
  - *Foundation*: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder configuration, horizontal curve
  - *Substructure*: Three-column bents mostly on dry land
  - *Foundation*: Some individual spread footings, spread footings at piers adjacent to river
- Critical Factor
  - *Superstructure*: Multi-girder system with good redundancy
  - *Substructure*: Three-column bents with good redundancy; no railroad crash walls are present at the bents near the tracks. Crash walls are planned for the future, which would require an update of the uncertainty rating.
  - *Foundation*: Multiple footings founded on quartzite with good redundancy

- Historical Evidence
  - *Superstructure*: Minor fatigue cracking appears to be stable
  - *Substructure*: Minor surface cracks appear stable
  - *Foundation*: No notable deficiencies recorded
- Inconvenience to user

  ADT = 12,062 Detour Length = 1 mile
- Frequency of Inspection
  - *Superstructure:* 24 months
  - *Substructure*: 24 months
  - *Foundation*: Buried – not visible

Rating of the Bridge and Findings

Table 19.11 summarizes the uncertainty index for this bridge. The superstructure and foundation have medium uncertainty and will likely require increased maintenance to preserve their lifespans. The superstructure has moderately low uncertainty and will require routine maintenance. SDDOT has an agreement to eventually relinquish full ownership responsibility, including maintenance of the 11th Street Bridge, to the City of Sioux Falls. Once a major rehabilitation project or replacement occurs, the City will assume responsibility for maintenance. Based on these conditions, the 11th Street Bridge has been identified for replacement in the financial uncertainty mitigation plan. However, the engineering uncertainty index indicates that replacement within the study period is not required.

Table 19.11 11th Street Viaduct Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	2.0	14.0	2.0	14.0	4.0	28.0
2	Predictability	7	3.0	21.0	2.0	14.0	3.0	21.0
3	Critical Factor	10	2.0	20.0	4.0	40.0	2.0	20.0
4	Historical Evidence	8	2.0	16.0	3.0	24.0	1.0	8.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating		44		102.0		123.0		122.0
Average Weighted Rating			2.32		2.80		2.77	
					2.63			

19.D.4. 10th Street Viaduct 50-206-208

Existing Condition

Year Built:	1930
Major Rehabilitation:	1979
Sufficiency Rating:	64.8
NBI Rating – Deck:	7
NBI Rating – Superstructure:	5
NBI Rating – Substructure:	6

The bridge has the following traffic volume: ADT (2015) of 12,602. The superstructure is a redundant multi-girder system.

Figure 19.8 10th Street Viaduct

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper or lift; however, gunite on some girders makes detection of defects more difficult
  - *Substructure*: Piers are accessible from dry land
  - *Foundation*: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder configuration, complicated framing in spans over west railroad tracks
  - *Substructure*: Multi-column bents on dry land
  - *Foundation*: Individual spread footings on dry land
- Critical Factor
  - *Superstructure*: Multi-girder system with good redundancy
  - *Substructure*: Three-column bents with good redundancy; no railroad crash walls are present at the bents near the tracks. Crash walls are planned for the future, which would require an update of the uncertainty rating.
  - *Foundation*: Multiple footings founded on rock with good redundancy
- Historical Evidence
  - *Superstructure*: Cracked welds at bearings, substantial section loss noted at girders
  - *Substructure*: Minor cracks and spalling at piers, moderate cracks at abutments
  - *Foundation*: No notable deficiencies recorded

- Inconvenience to user
  ADT = 12,602 Detour Length = 1 mile
- Frequency of Inspection
  - *Superstructure:* 24 month
  - *Substructure:* 24 month
  - *Foundation:* Buried – not visible

Rating of the Bridge and Findings

Table 9.12 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure, substructure, and foundation have medium uncertainty and will likely require increased maintenance to preserve their lifespans. SDDOT has an agreement to eventually relinquish full ownership responsibility including maintenance of the 10th Street Bridge to the City of Sioux Falls. Once a major rehabilitation project or replacement occurs, the City will assume responsibility for maintenance. Based on these conditions, the 10th Street Bridge has been identified for replacement in the financial uncertainty mitigation plan. However, the engineering uncertainty index indicates that replacement within the study period is not required.

Table 19.12 10th Street Viaduct Uncertainty Index

Uncertainty Index									
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	3.0	21.0	2.0	14.0	4.0	28.0
2	Predictability	7	3.0	21.0	3.0	21.0	2.0	14.0
3	Critical Factor	10	2.0	20.0	4.0	40.0	2.0	20.0
4	Historical Evidence	8	4.0	32.0	3.0	24.0	1.0	8.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating		44		125.0		130.0		115.0
Average Weighted Rating			2.84		2.95		2.61	
			2.80					

19.D.5. Mobridge 65-000-020

Existing Condition

Year Built:	1959
Major Rehabilitation:	1980
Sufficiency Rating:	44.6
NBI Rating – Deck:	6
NBI Rating – Superstructure:	5
NBI Rating – Substructure:	5

The bridge has the following traffic volume: ADT (2015) of 3368. The superstructure is a non-redundant through-truss with non-redundant approach spans consisting of a two-girder system.

Figure 19.9 Upstream Elevation

Figure 19.10 Piers

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Truss is difficult to fully inspect
  - *Substructure*: Piers are in water but generally visible from snooper or boat
  - *Foundation*: Underwater
- Predictability
  - *Superstructure*: Two-girder system with floor beams and stringers, plus cantilevered through-truss spans with pin and hanger end support details on the drop-in truss simple spans
  - *Substructure*: Two-column bents throughout with bottom diaphragm on tall piers
  - *Foundation*: Single combined footings with H-piles
- Critical Factor
  - *Superstructure*: Two-girder system, cantilevered truss; failure of one truss component or approach span girder could lead to catastrophic failure of the bridge
  - *Substructure*: Two-column bents with diaphragms with moderate redundancy, locked expansion bearings, slide concerns at bridge end
  - *Foundation*: Scour at pile foundations appears to be stable, local embankment slide concerns at bridge end
- Historical Evidence
  - *Superstructure*: Fatigue cracking and section loss appear to be progressing
  - *Substructure*: Minor to moderate cracking (cracks of 1/8” width or more with efflorescence) appears stable
  - *Foundation*: Over 20’ of scour at several piers, appears to be stable at this time
- Inconvenience to user

  ADT = 3,368 Detour Length = 99 miles

- Frequency of Inspection
  - *Superstructure:* 12 months
  - *Substructure:* 24 months
  - *Foundation:* 60 months underwater

<u>*Rating of the Bridge and Findings*</u>

Table 9.13 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and foundation have moderately high uncertainty and require retrofit or replacement. The substructure has medium uncertainty and will likely require increased maintenance to preserve its lifespan. Due to the concerns with the foundation and superstructure, the structure at Mobridge has been identified for replacement within the study period.

Table 19.13 Mobridge Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	4.0	28.0	3.0	21.0	5.0	35.0
2	Predictability	7	4.0	28.0	3.0	21.0	4.0	28.0
3	Critical Factor	10	5.0	50.0	4.0	40.0	4.0	40.0
4	Historical Evidence	8	4.0	32.0	3.0	24.0	4.0	32.0
5	Inconvenience to User	5	4.0	20.0	4.0	20.0	4.0	20.0
6	Frequency of Inspection	7	2.0	14.0	3.0	21.0	4.0	28.0
Total Weighted Rating		44		172.0		147.0		183.0
Average Weighted Rating			3.91		3.34		4.16	
			3.80					

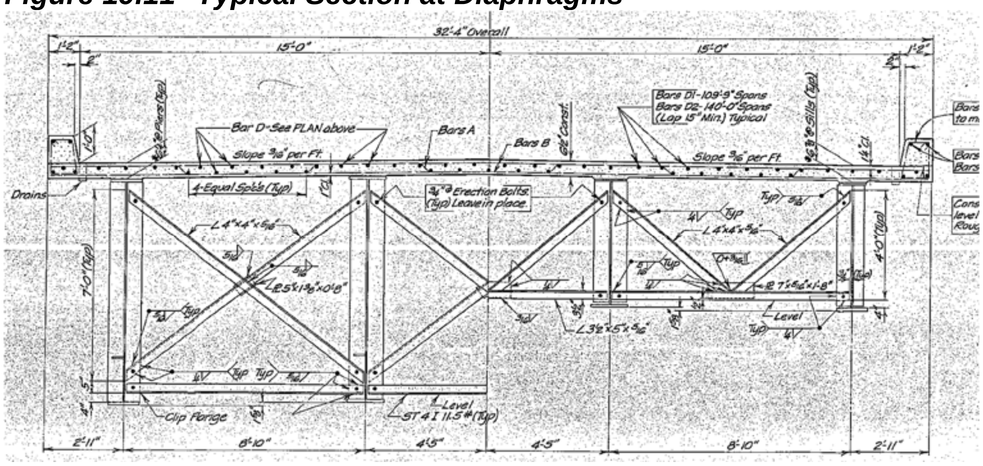
19.D.6. Bridger 28-035-151

Existing Condition

Year Built:	1962
Sufficiency Rating:	75.8
NBI Rating – Deck:	6
NBI Rating – Superstructure:	5
NBI Rating – Substructure:	5

The bridge has the following traffic volume: ADT (2015) of 464. The superstructure is a redundant multi-girder system.

Figure 19.11 Typical Section at Diaphragms



Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper
  - *Substructure*: Most piers are generally accessible from dry land
  - *Foundation*: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder configuration
  - *Substructure*: Solid wall piers, some on spread footings, debris piled against piers, scour at several footings
  - *Foundation*: Spread footings and footings with H-piles; underpinning at some pile footings
- Critical Factor
  - *Superstructure*: Multi-girder system with good redundancy, girder field splices are welded
  - *Substructure*: Solid wall piers with high redundancy
  - *Foundation*: Scour visible at several pier footings
- Historical Evidence
  - *Superstructure*: Small amount of bottom flange section loss
  - *Substructure*: Some spalling and cracking
  - *Foundation*: Piles previously added to pier footings, foundations are now stable

- Inconvenience to user
  ADT = 464   Detour Length = 99 miles
- Frequency of Inspection
  - *Superstructure:* 24 months
  - *Substructure:* 24 months
  - *Foundation:* Many footings are buried – not visible

Rating of the Bridge and Findings

Table 19.4 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and substructure have moderately low uncertainty and will require routine maintenance. The foundation has medium uncertainty and will likely require increased maintenance to preserve its lifespan. Due to the historical condition of the bridge, along with the uncertainty rating analysis, the structure at Bridger has been identified for continued maintenance but not replacement within the study period.

Table 19.14 Bridger Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	3.0	21.0	2.0	14.0	4.0	28.0
2	Predictability	7	2.0	14.0	3.0	21.0	3.0	21.0
3	Critical Factor	10	3.0	30.0	1.0	10.0	3.0	30.0
4	Historical Evidence	8	3.0	24.0	2.0	16.0	3.0	24.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	4.0	28.0
Total Weighted Rating		44		120.0		92.0		141.0
Average Weighted Rating			2.73		2.09		3.20	
			2.67					

19.D.7. Cheyenne River 69-390-535

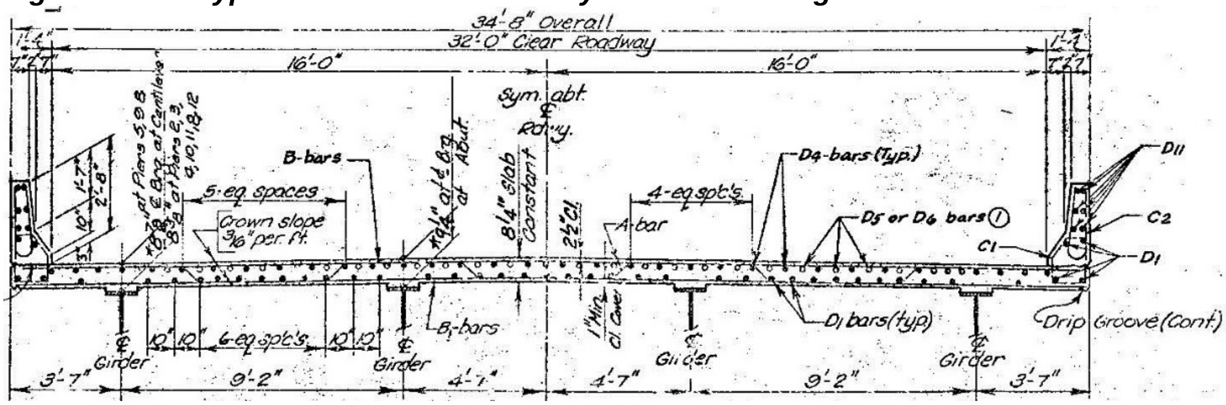
Existing Condition

Year Built:	1981
Sufficiency Rating:	93.2
NBI Rating- Deck:	6
NBI Rating – Superstructure:	6
NBI Rating – Substructure:	6

The bridge has the following traffic volume: ADT (2015) of 349. The superstructure is a redundant multi-girder system.

Figure 19.12 Cheyenne River Bridge

Figure 19.13 Typical Slab Section of Cheyenne River Bridge



Condition of the Bridge Under Each Criteria

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper
  - *Substructure*: Piers are nearly all accessible from dry land
  - Foundation: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder system with well-defined load paths
  - *Substructure*: Hammerhead piers
  - *Foundation*: Spread footings (in main channel) and footings on H-piles, none exposed
- Critical Factor
  - *Superstructure*: Multi-girder system with good redundancy
  - *Substructure*: Hammerhead piers with good redundancy
  - *Foundation*: Single pier spread footings founded on rock or on H-piles with good redundancy, spread footings are founded on competent shale

- Historical Evidence
  - *Superstructure*: Moderate to heavy rusting near open deck joints, some loss of lubricant in pot bearings
  - *Substructure*: Minor cracks and surface spalling at piers and abutments
  - *Foundation*: Evidence that scour occurs during high flow events but that it fills back in afterward
- Inconvenience to user

  ADT = 349   Detour Length = 50 miles
- Frequency of Inspection
  - *Superstructure*: 24 months
  - *Substructure*: 24 months
  - *Foundation*: Buried – not visible

Rating of the Bridge and Findings

Table 19.15 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and substructure have moderately low uncertainty and will require routine maintenance. The foundation has moderate uncertainty and will likely require increased maintenance to preserve its lifespan. Due to the historical condition of the bridge, along with the uncertainty rating analysis, the Cheyenne River Bridge has been identified for continued maintenance but not replacement within the study period.

Table 19.15 Cheyenne River Bridge Uncertainty Index

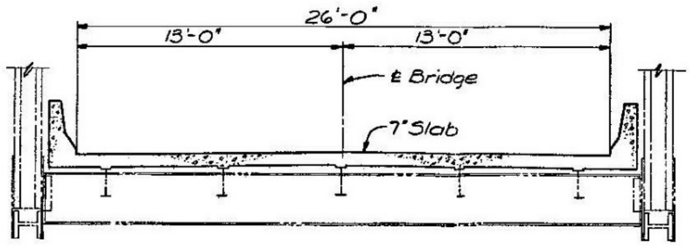
Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	2.0	14.0	2.0	14.0	4.0	28.0
2	Predictability	7	2.0	14.0	2.0	14.0	3.0	21.0
3	Critical Factor	10	2.0	20.0	2.0	20.0	3.0	30.0
4	Historical Evidence	8	3.0	24.0	2.0	16.0	3.0	24.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating		44		103.0		95.0		148.0
Average Weighted Rating			2.34		2.16		3.36	
			2.62					

19.D.8. Forrest City 54-056-158

Existing Condition

Year Built:	1958
Major Rehabilitation:	1980
Sufficiency Rating:	59.1
NBI Rating – Deck:	6
NBI Rating – Superstructure:	5
NBI Rating – Substructure:	5

Figure 19.14 Typical Section at Panel Point



The bridge has the following traffic volume: ADT (2015) of 541. The superstructure is a non-redundant through-truss with non-redundant approach spans consisting of a two-girder system.

Figure 19.15 Elevation of Forrest City Bridge

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Truss is difficult to fully inspect
  - *Substructure*: Piers are in water but partially visible from snooper or boat (half of column height is below water level)
  - *Foundation*: Underwater
- Predictability
  - *Superstructure*: Two-girder system with floor beams and stringers, plus cantilevered through-truss spans with pin and hanger end support details on the drop-in truss simple spans
  - *Substructure*: Two-column bents throughout with bottom diaphragm on tall piers
  - *Foundation*: Single combined footings with H-piles, some on north end are spread footings
- Critical Factor
  - *Superstructure*: Two-girder system, cantilevered truss; failure of one truss component or approach span girder could lead to catastrophic failure of the bridge
  - *Substructure*: Two-column bents with diaphragms with moderate redundancy, serious slide concerns at bridge end that also affect several piers on east side of river
  - *Foundation*: Scour at pile foundations appears to be stable, serious slide concerns at bridge end that also affect several piers

- Historical Evidence
  - *Superstructure*: Fatigue cracking and section loss appear to be progressing
  - *Substructure*: Moderate cracking and spalling appears stable, potentially some more minor deterioration progressing, it appears that the slide may be causing cracking and other distress in several piers
  - *Foundation*: Minor (<5') scour at two piers; potentially aggradation elsewhere, it appears that the slide may be causing distress in the foundations of several piers and an abutment
- Inconvenience to user

  ADT = 541 Detour Length = 99 miles
- Frequency of Inspection
  - *Superstructure*: 12 months
  - *Substructure*: 24 months
  - *Foundation*: 60 months underwater

Rating of the Bridge and Findings

Table 19.16 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure and substructure have moderately high uncertainty and will require retrofit or replacement. The foundation has high uncertainty and will requires replacement. Due to the concerns with all bridge components, the Forrest City Bridge has been identified for replacement within the study period.

Table 19.16 Forest City Bridge Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
	Criteria	(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	4.0	28.0	3.0	21.0	5.0	35.0
2	Predictability	7	4.0	28.0	3.0	21.0	4.0	28.0
3	Critical Factor	10	5.0	50.0	5.0	50.0	5.0	50.0
4	Historical Evidence	8	4.0	32.0	4.0	32.0	4.0	32.0
5	Inconvenience to User	5	3.0	15.0	3.0	15.0	3.0	15.0
6	Frequency of Inspection	7	2.0	14.0	3.0	21.0	4.0	28.0
	Total Weighted Rating	44		167.0		160.0		188.0
	Average Weighted Rating		3.80		3.64		4.27	
					3.90			

19.D.9. Singing Bridge 16-737-253

Existing Condition

Year Built: 1963
Sufficiency Rating: 80.3
NBI Rating – Deck: 7
NBI Rating – Superstructure: 6
NBI Rating – Substructure: 6

The bridge has the following traffic volume: ADT (2015) of 826. The superstructure is a redundant multi-girder system.

Figure 19.16 Elevation of Singing Bridge

Figure 19.17 Singing Bridge Piers

Condition of the Bridge Under Each Criterion

- Inspectability
  - _Superstructure_: Superstructure generally accessible by snooper
  - _Substructure_: Piers are in water, but generally visible from snooper or boat
  - _Foundation_: Underwater
- Predictability
  - _Superstructure_: Multi-girder system with well-defined load paths
  - _Substructure_: Two-column bents with individual footings connected by diaphragm, some combined spread footings
  - _Foundation_: Individual footings H-piles with bottom diaphragm, some at end spans are on spread footings
- Critical Factor
  - _Superstructure_: Multi-girder system with good redundancy
  - _Substructure_: Two-column system with continuous diaphragm and footing, partial redundancy
  - _Foundation_: Scour at pile foundations appears to be generally stable, relatively small number of H-piles at each pier
- Historical Evidence
  - _Superstructure_: Isolated areas of light section loss, some surface rusting
  - _Substructure_: Moderate cracking and spalling appears stable, potentially some more minor deterioration progressing
  - _Foundation_: Minor (<5') scour at some piers; Moderate honeycombing and spalling at some footings appear generally stable
- Inconvenience to user

  ADT = 826 Detour Length = 27 miles

- Frequency of Inspection
  - Superstructure: 24 months
  - Substructure: 24 months
  - Foundation: 60 months underwater

Rating of the Bridge and Findings

Table 19.17 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure has moderately low uncertainty and will require routine maintenance. The substructure has medium uncertainty and will likely require increased maintenance to preserve its lifespan. The foundation has medium uncertainty and requires retrofit or replacement. Due to the concerns with the foundation, the Singing Bridge has been identified for replacement within the study period.

Table 19.17 Singing Bridge Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	3.0	21.0	3.0	21.0	5.0	35.0
2	Predictability	7	2.0	14.0	3.0	21.0	4.0	28.0
3	Critical Factor	10	2.0	20.0	4.0	40.0	4.0	40.0
4	Historical Evidence	8	2.0	16.0	3.0	24.0	3.0	24.0
5	Inconvenience to User	5	1.0	5.0	1.0	5.0	1.0	5.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	4.0	28.0
Total Weighted Rating		44		97.0		132.0		160.0
Average Weighted Rating			2.20		3.00		3.64	
			2.95					

19.D.10. Deadwood Structure 41-161-156

Existing Condition

Year Built:	1967
Major Rehabilitation:	1989
Sufficiency Rating:	38
NBI Rating – Deck:	5
NBI Rating – Superstructure:	7
NBI Rating – Substructure:	4

The bridge has the following traffic volume: ADT (2015) of 11,269. The superstructure is a redundant floor beam and stringer system.

Figure 19.18 Deadwood Structure Outlet

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Top of superstructure not visible due to overlay, access below difficult due to length of buried structure
  - *Substructure*: Upper portions difficult to access
  - *Foundation*: Foundations are buried, portions not accessible due to concrete floor
- Predictability
  - *Superstructure*: Floor beams and stringers (prestressed), simple configuration, effects on prestressed elements in a humid environment are difficult to predict
  - *Substructure*: Deep walls on spread footings
  - *Foundation*: Portions of structure where no concrete flow liner is present, the spread footings are founded on rock, portions of the structure where a concrete flow liner is present are founded on soil
- Critical Factor
  - *Superstructure*: Floor beams and stringers with low redundancy (failure of a floor beam could lead to failure of a large deck section)
  - *Substructure*: Continuous deep walls, cracking in walls could adversely affect the superstructure
  - *Foundation*: Continuous spread footings founded on rock
- Historical Evidence
  - *Superstructure*: Moderate efflorescence and deterioration of floor beams near deck joints, many deck joints have failed, allowing water infiltration, other superstructure elements generally in good condition
  - *Substructure*: Cracking in walls near beam seats, efflorescence present in many locations, concrete floor deteriorating and washing away
  - *Foundation*: Some scour present at various locations

- Inconvenience to user
  ADT = 11,269   Detour Length = 48 miles
- Frequency of Inspection
  - *Superstructure*: 24 months
  - *Substructure*: 24 months
  - *Foundation*: Buried – not visible

Rating of the Bridge and Findings

Table 19.18 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure has moderately high uncertainty and will require retrofit or replacement. The substructure and foundation have medium uncertainty and will likely require increased maintenance to preserve their lifespans. The rating developed for the Deadwood structure indicates that the proposed work could be limited to superstructure replacement with substructure repair. The ratings for the study bridges are a guide to determine the timing, sequence and type of work necessary at any of the individual bridge locations. To minimize future costs, the Deadwood structure has been identified for replacement within the study period.

Table 19.18 Deadwood Structure Uncertainty Index

		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	4.0	28.0	4.0	28.0	4.0	28.0
2	Predictability	7	3.0	21.0	2.0	14.0	2.0	14.0
3	Critical Factor	10	4.0	40.0	3.0	30.0	2.0	20.0
4	Historical Evidence	8	4.0	32.0	4.0	32.0	2.0	16.0
5	Inconvenience to User	5	5.0	25.0	5.0	25.0	5.0	25.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating		44		167.0		150.0		138.0
Average Weighted Rating			3.80		3.41		3.14	
					3.45			

19.D.11. Fossil Cycad 24-162-058

Existing Condition

Year Built:	1982
Sufficiency Rating:	85.4
NBI Rating – Deck:	5
NBI Rating – Superstructure:	5
NBI Rating – Substructure:	6

The bridge has the following traffic volume: ADT (2015) of 2,143. The superstructure is a redundant multi-girder system.

Figure 19.19 Fossil Cycad Piers

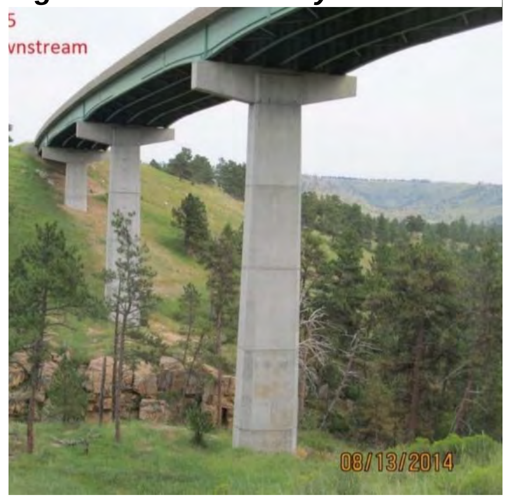
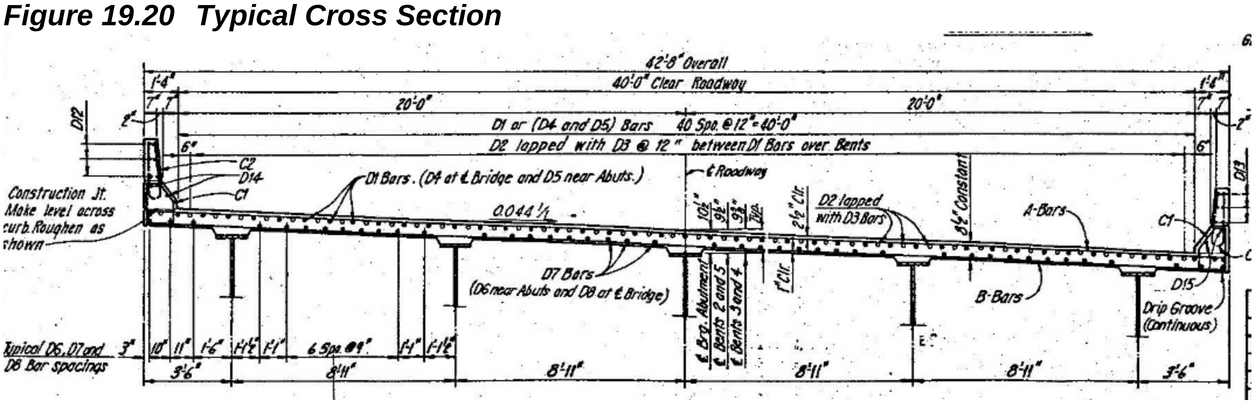


Figure 19.20 Typical Cross Section



Condition of the Bridge Under Each Criteria

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper
  - *Substructure*: Piers are all accessible from dry land but are very tall, limiting overall access
  - *Foundation*: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder system with well-defined load paths, on horizontal curve, tall structure in canyon increases wind effects
  - *Substructure*: Tall hammerhead piers in canyon
  - *Foundation*: Spread footings outside channel
- Critical Factor
  - *Superstructure*: Multi-girder system on horizontal curve with good redundancy
  - *Substructure*: Tall hammerhead piers
  - *Foundation*: Single pier spread footings founded on rock

- Historical Evidence
  - *Superstructure*: Minor surface rust in a few locations, rust spots progressing on top flanges near deck cracks, transverse deck cracks with efflorescence, loose field splice bolts
  - *Substructure*: Minor cracks and surface spalling at piers and abutments
  - *Foundation*: No notable deficiencies recorded
- Inconvenience to user

  ADT = 2,143 Detour Length = 58 miles
- Frequency of Inspection
  - *Superstructure*: 24 months
  - *Substructure*: 24 months
  - *Foundation*: Buried – not visible

<u>*Rating of the Bridge and Findings*</u>

Table 19.19 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure, substructure, and foundation have medium uncertainty and will likely require increased maintenance to preserve their lifespans. Due to the historical condition of the bridge, along with the uncertainty rating analysis, the Fossil Cycad Bridge has been identified for continued maintenance but not replacement within the study period.

Table 19.19 Fossil Cycad National Monument Uncertainty Index

Uncertainty Index								
		Superstructure		Substructure		Foundation	
	Weight of Importance	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria	(1-10)	(1-5)		(1-5)		(1-5)	
1 Inspectability	7	2.0	14.0	3.0	21.0	4.0	28.0
2 Predictability	7	4.0	28.0	4.0	28.0	4.0	28.0
3 Critical Factor	10	3.0	30.0	3.0	30.0	3.0	30.0
4 Historical Evidence	8	3.0	24.0	2.0	16.0	1.0	8.0
5 Inconvenience to User	5	4.0	20.0	4.0	20.0	4.0	20.0
6 Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating	44		137.0		136.0		149.0
Average Weighted Rating		3.11		3.09		3.39	
		3.20					

19.D.12. Cambell Street 52-430-314

Existing Condition

Year Built: 1964
Sufficiency Rating: 68
NBI Rating – Deck: 6
NBI Rating – Superstructure: 5
NBI Rating – Substructure: 6

The bridge has the following traffic volume: ADT (2015) of 20,559. The superstructure is a redundant multi-girder system.

Figure 19.21 Cambell Street Bridge

Condition of the Bridge Under Each Criterion

- Inspectability
  - *Superstructure*: Superstructure accessible by snooper or lift
  - *Substructure*: Piers are accessible from dry land
  - *Foundation*: Buried foundations, but effects due to potential defects will be visible
- Predictability
  - *Superstructure*: Multi-girder configuration
  - *Substructure*: Two-column bents mostly on dry land, no elevated environmental loads
  - *Foundation*: Individual belled spread footings at each column
- Critical Factor
  - *Superstructure*: Multi-girder system with good redundancy, web seems to be very thin, which may be exacerbating fatigue issues
  - *Substructure*: Two-column bents with low redundancy, several bents are located closer than 25' to railroad tracks and are not heavy construction
  - *Foundation*: Multiple footings founded on rock
- Historical Evidence
  - *Superstructure*: Extensive fatigue cracking that appears to have been arrested by retrofits
  - *Substructure*: Minor surface cracks appear stable
  - *Foundation*: No notable deficiencies recorded

- Inconvenience to user
  ADT = 20,559 Detour Length = 0 miles
- Frequency of Inspection
  - *Superstructure*: 24 months
  - *Substructure*: 24 months
  - *Foundation*: Buried – not visible

Rating of the Bridge and Findings

Table 19.20 summarizes the uncertainty index for this bridge. This evaluation indicates that the superstructure, substructure, and foundation have medium uncertainty and will likely require increased maintenance to preserve their lifespans. Due to the historical condition of the bridge, along with the uncertainty rating analysis, the Cambell Street Bridge has been identified for continued maintenance but not replacement within the study period.

Table 19.20 Cambell Street Uncertainty Index

Uncertainty Index								
		Weight of Importance	Superstructure		Substructure		Foundation	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)	(1-5)		(1-5)		(1-5)	
1	Inspectability	7	2.0	14.0	2.0	14.0	4.0	28.0
2	Predictability	7	2.0	14.0	1.0	7.0	2.0	14.0
3	Critical Factor	10	4.0	40.0	5.0	50.0	2.0	20.0
4	Historical Evidence	8	4.0	32.0	3.0	24.0	1.0	8.0
5	Inconvenience to User	5	2.0	10.0	2.0	10.0	2.0	10.0
6	Frequency of Inspection	7	3.0	21.0	3.0	21.0	5.0	35.0
Total Weighted Rating		44		131.0		126.0		115.0
Average Weighted Rating			2.98		2.86		2.61	
			2.82					