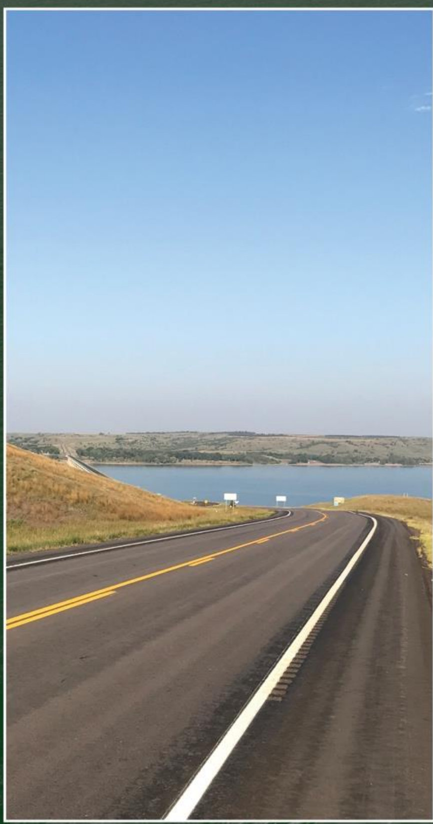
November 2019

SD44 Platte-Winner Bridge

CORRIDOR STUDY



Prepared for

South Dakota DOT

Connecting South Dakota and the Nation

South Dakota Department of Transportation

Prepared by HR Green, Inc.

Statement of Limitations

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Contents

List of Figures

List of Tables

List of Appendices

Section 1: Corridor Study Introduction

The South Dakota Department of Transportation (SDDOT) Major Bridge Investment Study, completed in August 2016, recommended the existing Highway 44 (SD44) bridge over the Missouri River (Platte – Winner Bridge) to be the next major SDDOT bridge to be replaced after the US14 / US83 / SD34 bridge (at Pierre/Fort Pierre) over the Missouri River. SDDOT's replacement of the Platte-Winner Bridge is anticipated to take place in the mid-2020's, with construction letting tentatively planned for Federal Fiscal Year 2024.

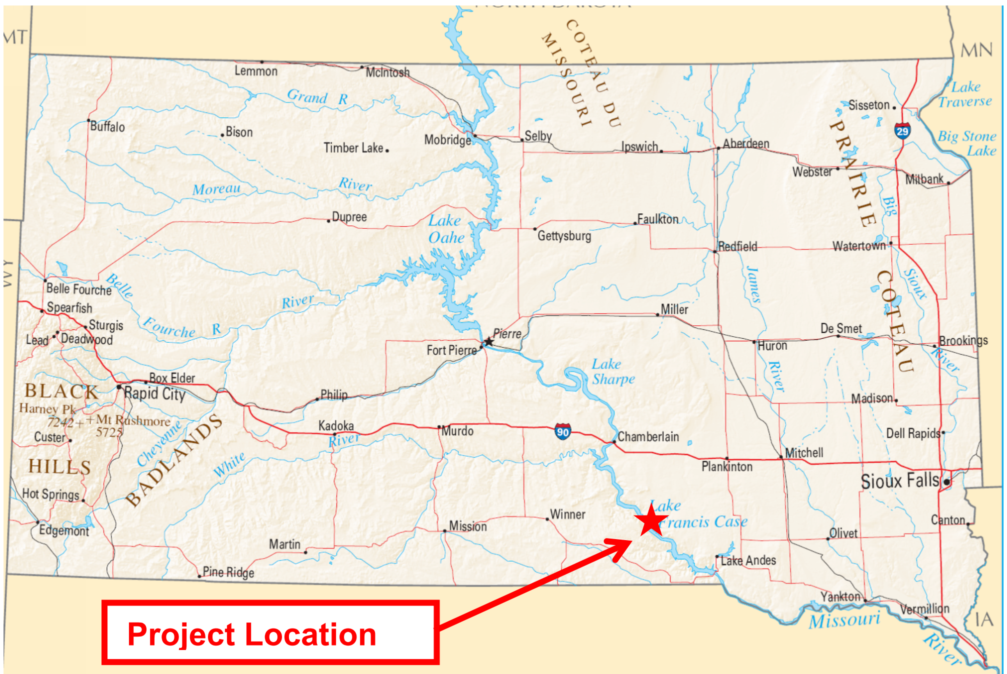


Figure 1. Project Location Map

Given the spacing between crossings of the Missouri River in South Dakota, the consequences of closing the existing bridge can be quite dramatic for users of the SD44 corridor between the cities of Platte and Winner. Closure of the bridge would create an approximately 85-mile detour, involving travel to the Interstate 90 crossing of the river at Chamberlain. While the timeframe of closure would be uncertain, construction of a project of this magnitude is expected to occur over multiple construction seasons, potentially requiring closure of the crossing for multiple years.

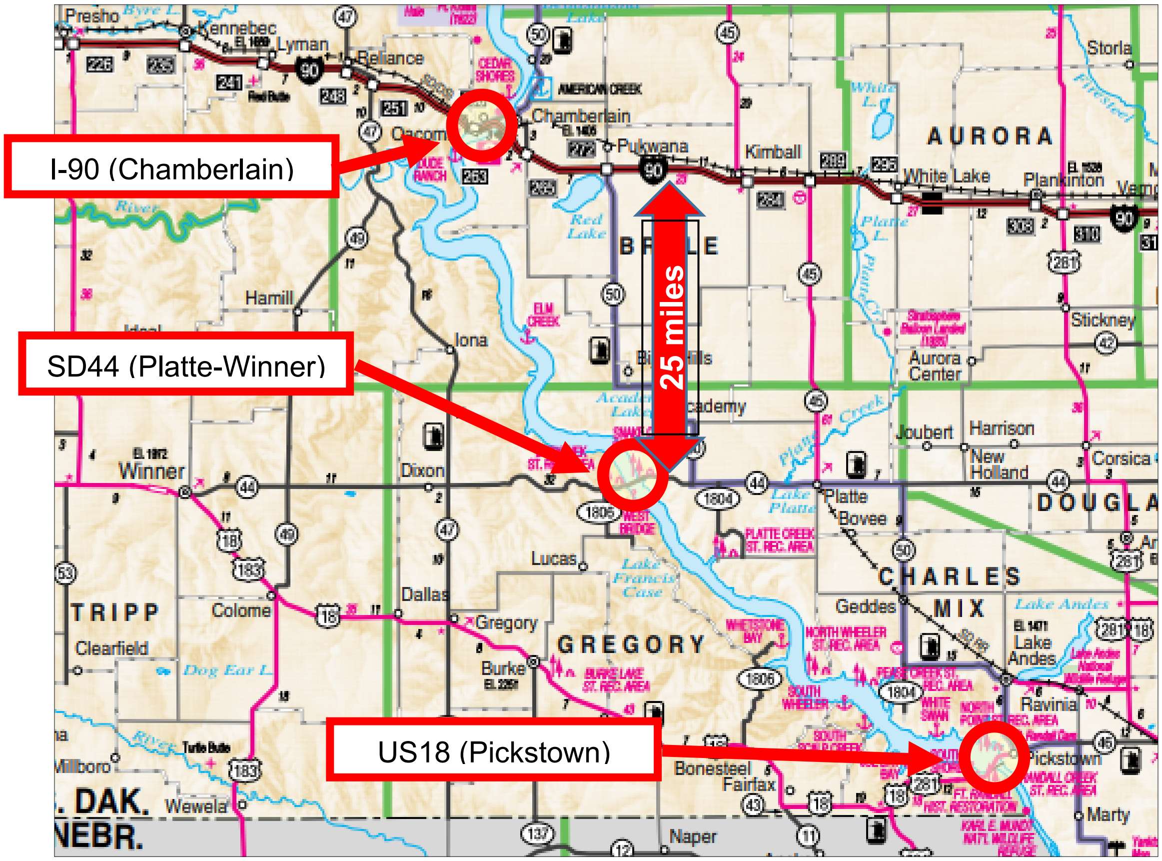


Figure 2. Missouri River Crossings Nearest the Platte-Winner Bridge

Bridge construction technology has advanced to the point where a 100-year design life is anticipated for important structures such as major river crossings. For this reason, it is valuable to consider the larger SD44 corridor and the implications a new bridge location will have on SDDOT's ability to maintain the SD44 highway alignment as a long-term inter-regional travel corridor

The purpose of this Corridor Study is to document the planning decision-making activities that were used by SDDOT and its project partners to meet the following objectives:

1) Complete a structure location and type study for a new long-term (100+ years) performing bridge considering economics, aesthetics, maintenance, and impact to the environment.
2) Complement and support the National Environmental Policy Act (NEPA) documentation and decisions necessary to advance the project into final design phase.
3) Complete a safety analysis of the highway corridor within the study area.
4) Identify locations on the highway corridor within the study area not in compliance with current design standards under both the current and forecasted future traffic conditions.

5) Create final products for use by SDDOT which will guide the DOT during the design phase of the bridge replacement and corridor improvement project.

1.1 Study Area

For purposes of evaluating a complete range of bridge and SD44 corridor alternatives, the initial project study area was defined by SDDOT as an approximate 21-mile long by 5-mile wide corridor centered on the SD44 highway corridor and marked on each end by the SD47 junction (to the west) and the SD50 junction (to the east).

The study area is within two counties: Gregory County (west of the Missouri River) and Charles Mix County (east of the Missouri River). The nearest population centers to this study area are Winner (approximately 20 miles west of the study limits) and Platte (approximately 10 miles east).

The study area is marked by the red box in the Figure below.

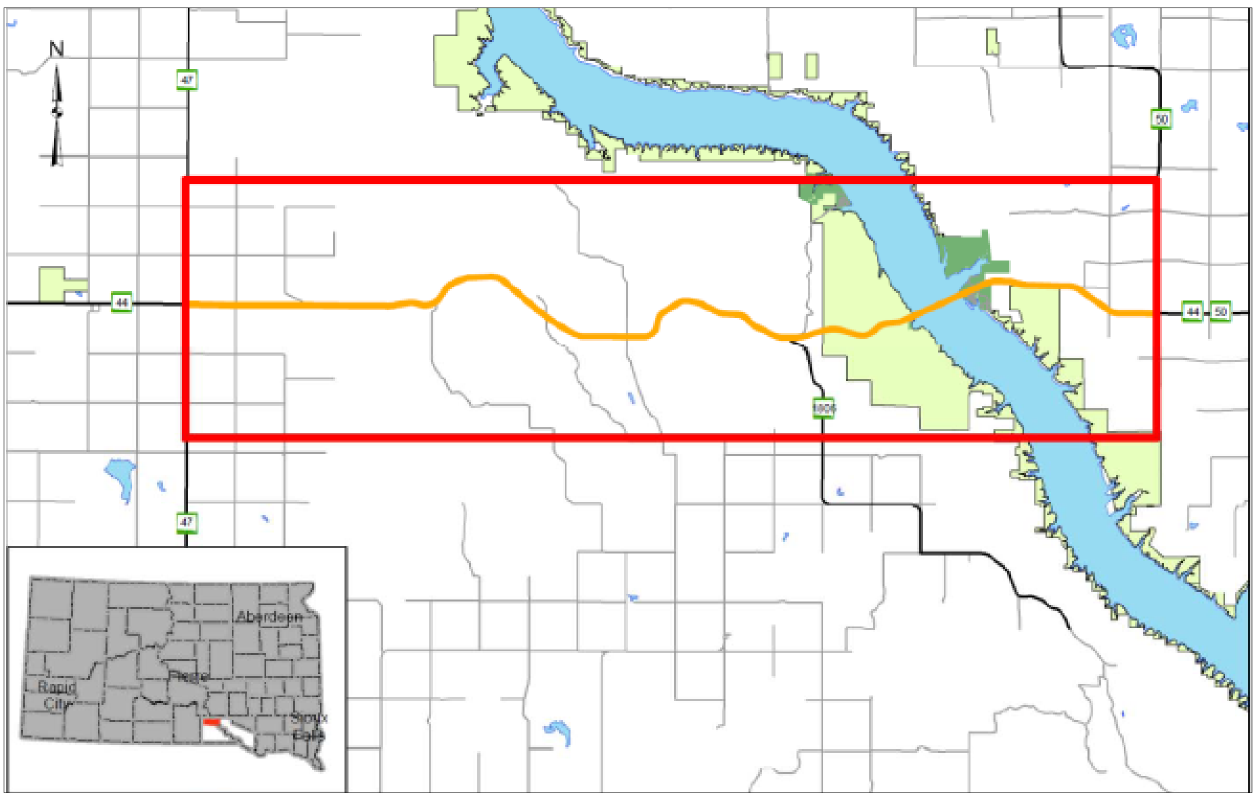


Figure 3. Project Study Area

Notable features within this study area include a variety of public recreational areas, including the Snake Creek Recreation Area (on the east bank of the river at SD44), West Bridge Park Area (on the west bank of the river at SD44), Buryanek Recreation Area (north study area limits on the river), and South Dakota Department of Game, Fish, and Parks (SDGFP) Game Production Areas on either side of the river. This segment of the Missouri River is also known as Lake Francis Case, a reservoir created by the Fort Randall Dam.

The Snake Creek Recreation Area is a particularly noteworthy resource in this study area owing to the fact that this state park managed by SDGFP is located on either side of SD44. Snake Creek Recreation Area is a 695-acre park with cabins, campgrounds, and boating facilities. The park was created following construction of the Platte-Winner Bridge in response to the increased demand for recreational activities on Lake Francis Case and the surrounding area.

1.2 Study Team

A Study Advisory Team (SAT) has been formed to provide input on the study through completion. The SAT is comprised of representative parties of the SDDOT, SDGFP, and Federal Highway Administration (FHWA). Members of the SAT include:

Table 1. SD44 Platte-Winner Bridge Corridor Study Advisory Team

Name of Member	Organization
Marion Barber / Tom Lehmkuhl	FHWA
Paul Coughlin	SDGFP - Wildlife
Steve Gramm	SDDOT - Project Development
Kevin Griese	SDDOT - Materials & Surfacing
Marc Hoelscher	FHWA
Mark Hoines	FHWA
Steve Johnson	SDDOT - Bridge Design
Jay Larson	SDDOT - Mitchell Region
Tom Lehmkuhl / Joanne Hight	SDDOT - Administration
Al Nedved	SDGFP
Jay Peppel	SDDOT - Mitchell Area
Claire Peschong / Alice Whitebird	SDDOT - Administration
Brian Raecke / Neil Schochenmaier	SDDOT - Road Design
Travor Diegel / Ryan Tobin / Hannah Covey	SDDOT - Project Development
Jay Tople	SDDOT - Materials & Surfacing

1.3 Study Process as Part of the NEPA Documentation

The SAT worked through a three-step process of issue identification and alternatives development in order to identify a Recommended Alternative. The following chapters of this Corridor Study are structured to walk through the decision-making steps involved in determining the Recommended Alternative for the proposed project. In general terms, the three steps involved the following:

- Step 1: evaluation of existing and future conditions, constraints, and public input to refine the study area and enable an initial range of alternatives
- Step 2: Additional engineering studies and refinement of alternatives based on key evaluation criteria
- Step 3: Determination of a Recommended Alternative

As described above, this Corridor Study has been prepared in concert with the NEPA documentation process. Formal NEPA documentation for the proposed project has been organized separately from this Corridor Study around the structure of an Environmental Assessment (EA). The EA adheres to federal requirements for: the identification of a project Purpose and Need, development of alternatives, evaluation of potential impacts, and using public and agency involvement to confirm the selection of a Preferred Alternative for the proposed project. This Corridor Study (and the technical appendices associated with it) serves as a companion document to the EA.

Public involvement was an important part of project decision-making, with outreach occurring through public open houses, Stakeholder Advisory Team meetings, and direct consultation with state and federal resource agencies.

Section 2: Study Area Conditions and Issue Identification

During the first step of project development, the team conducted an analysis of existing conditions to evaluate key issues that will drive the determination of a reasonable range of project alternatives. Based on the review of conditions, the project team anticipated a reduction in the extent of the study area as well. The review of issues and input received from the public did help to reduce the study area as described in Chapter 3.

The following sections summarize studies conducted for the project. Where applicable, technical memoranda are available to provide more details about the findings.

2.1 Bridge Assessment

2.1.1 Existing Bridge

The current bridge, completed in 1966, is a continuous welded plate-girder bridge with a total structure length of 5,655.5 feet and an out-to-out width of 30.3 feet, with a roadway width of 28.0 feet. It has 28 spans carried on 29 substructure units, with numbers 1 and 29 identified as “sills” rather than abutments. The deck and roadway are at elevation 1,409.0 feet with a 0.0-percent longitudinal grade from end to end. As indicated on plan sheets for the bridge (Appendix A), the navigation clearance is 30 feet from the bottom of the girders to the top of the reservoir’s “maximum operating pool,” which is at an elevation of 1,365 feet. The horizontal navigation opening is considered to be 225 feet wide, extending beneath a 250-foot span.

Figure 4. Existing Bridge Looking East

The girder superstructure is designed and constructed in four-span continuous units. The original plans identify two unit lengths including a “684.0-foot four-span unit” and a “900.0-foot four-span unit.” The 684-foot unit is comprised of four spans in the following span-length sequence: 152-190-190-152 (see Appendix A). The 900-foot unit is comprised of four spans in the following span-length sequence: 200-250-250-200. Within each unit, the spans are continuous, and at the end of each unit is either an expansion device or the sill, if at the end of the bridge.

Due to the current bridge's two girder system, it is not feasible to reconstruct the bridge and simultaneously maintain traffic on the bridge. This engineering constraint prevents SDDOT from building a new bridge in the existing location without long-term closure of the crossing to traffic.

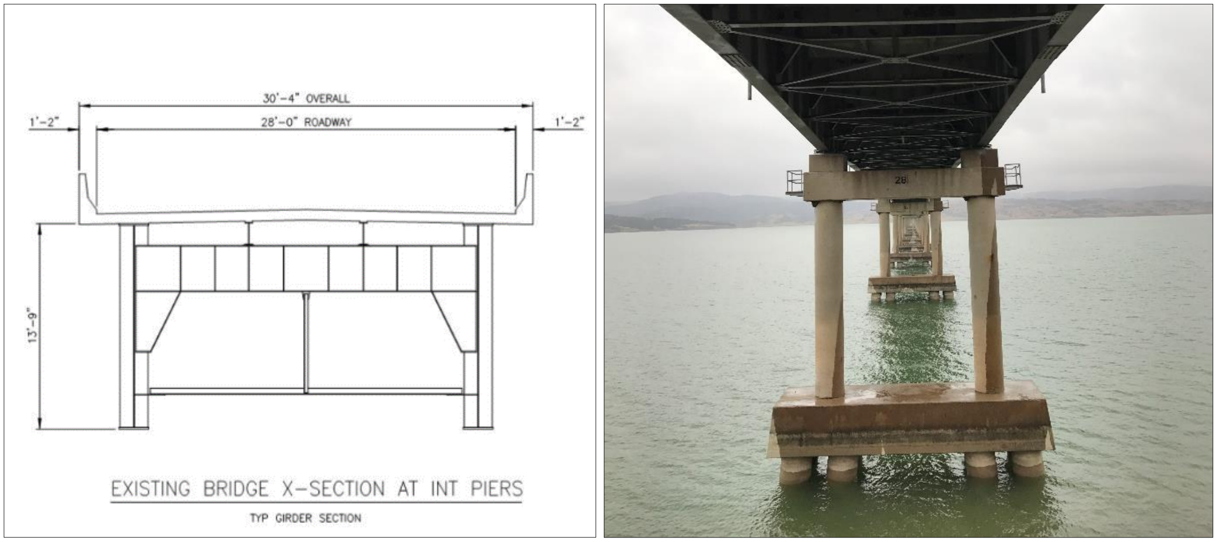


Figure 5. Existing Bridge Design Features

The Platte-Winner Bridge substructure consists of a concrete sill or abutment on each end and 27 concrete pile-supported piers between the sills. Each pier foundation is comprised of paired groups of hollow, prestressed-concrete cylinder piles, filled with sand and concrete after positioning, supporting a rectangular concrete pile cap above the water that ties the two pile groups into a single unit. Extending vertically from each footing is a pair of solid concrete columns that terminate in a pier cap carrying the bearings and the two-girder superstructure.

2.1.2 Construction Techniques

Each of the bridge's 276 piles are the same design and construction: a hollow, 48-inch-diameter cylinder with a 5-inch-thick pre-stressed, post-tensioned, concrete wall. The piles differ only in length, ranging from 50 to 176 feet, depending on where each is placed in the reservoir bottom. Construction of the bridge occurred after completion of the Fort Randall Dam, hence the Lake Francis Case reservoir was in place and piles were built within the river/ lake environment. Consequently, construction methods at the time required some piles to be air-jetted through 90 feet of mud and silt to reach the Niobrara chalk rock layer. At that point the air hammer would drive the piling into the chalk to the point of refusal, where the process would stop. This construction method created geotechnical conditions around the bridge foundations that have a direct impact on the location and design of a new bridge. See Section 2.3 for more about the geotechnical implications.

2.1.3 Repairs Made to the Original Bridge

In 1989, SDDOT made minor modifications to the bridge, including replacement of the original railing with concrete Jersey barriers (which continue to be in place). During that same repair project, SDDOT added drain openings through the curbs to convey stormwater from the roadway to the outside of the deck where vertical pipes added on the outside of the girders extend to the girder bottoms and open onto the reservoir.

In the winter of 1996-97, two of the existing pier pile caps near the middle of the bridge experienced significant cracking believed to be a result of impact from ice floes in the river. The damage required closure of the bridge for several months in 1997 while a repair strategy was designed and implemented. Many participants at this Corridor Study's public meetings recalled the challenges created by closure of the bridge and have expressed the need to avoid closure of the SD44 Missouri River crossing.

2.1.4 Potential New Bridge Types

At this scoping level of project development, the project team evaluated several major bridge types that would be capable of crossing the Missouri River in this study area. The team determined six major bridge types for preliminary evaluation: suspension, cable stay, arch, truss, girder/slab, and segmental. Representative images are show below in Table 2. These bridge types were also presented to the public at the first round of public meetings held in May 2017 and described in more detail in Section 2.5.2. Feedback provided during this scoping stage was incorporated into the project team's evaluation and screening of major bridge types after conclusion of the public meetings.

Table 2. Representative Images of Potential SD44 Bridge Types

 **Girder/Slab** Existing SD44 Platte-Winner Bridge – Missouri River	 **Segmental** Four Bears Bridge - Missouri River New Town, ND
 **Arch** Highway 61 Bridge - Mississippi River, Hastings, MN	 **Truss** I-70 Blanchette Memorial Bridge – Missouri River St. Louis, MO
 **Cable Stay** US 82 Bridge – Mississippi River Mississippi-Arkansas Border	 **Suspension** Golden Gate Bridge San Francisco, CA

2.2 Highway Assessment

The project team conducted several reviews of the SD44 highway corridor between SD47 and SD50. This assessment included a review of roadway geometry, traffic operations, and safety.

2.2.1 SD44 Geometric Review

Existing SD44 roadway dimensions and design were compared against the applicable version of the SDDOT Road Design Manual to evaluate potential risk areas that warrant consideration for improvement or as a component of project alternatives. This information served as a baseline of roadway data to provide background information against other corridor operations or safety issues identified as part of this study.

Two 12-foot lanes run through the entire project study area. Shoulder widths in the corridor do vary. The segment of SD44 east of the bridge has eight-foot shoulders. On the bridge, shoulders are two-feet wide. West of the bridge, shoulders vary between four-feet and six-feet wide. The most recent resurfacing project in this corridor was completed in 2016. Shoulder widths were not adjusted as part of that project.

Figure 6. Existing SD44 (West of River)

As described in the SD44 Geometric Review Technical Memorandum (see Appendix B), the evaluation of existing conditions with current design criteria and standards represents one perspective of the highway. It is understood that design standards change and the highway itself was constructed decades ago using standards current at that time. Further, geotechnical issues with the underlying soil conditions pose another consideration. Any changes to highway alignment or disturbance to the existing grade and hills can create a chain reaction of impacts, resulting in a broad area in need of slope flattening, hydraulic improvements, and stabilization.

2.2.2 SD44 Traffic Operations

To evaluate traffic operations on SD44, the project team conducted a study of traffic counts, turning movements, and capacity to provide service for bicycle use in the corridor. Key intersections that were studied included the following locations on SD44:

- SD47 (an all-way stop-controlled intersection at the corridor's western terminus)

- SD1806 (a two-way stop controlled intersection located approximately 2.5 miles west of the river)
- Snake Creek Recreation Area Access (a two-way stop controlled intersection approximately 1,000 feet east of the river)
- SD50 (a two-way stop controlled intersection at the corridor's eastern terminus)

Traffic turning movement counts were collected at these intersections in March 2017 to provide current data for an evaluation of existing conditions along with projections for traffic conditions in 2025 and 2050. Roadway operations are described in terms of "Level of Service" (LOS), with LOS ratings ranging from "A" (characterized as generally free-flowing with limited disruption caused by the presence of others) to "F" (congested conditions with travel demand higher than capacity of the roadway). The LOS ratings scale from A to F is applied to roadway segments and intersections and serves as a convenient measure of roadway operations and expected changes over time due to growth in traffic. For traffic operations in this project corridor, a goal of LOS B was established as the minimum allowable LOS for all highway segments and intersections.

The 2017 traffic counts determined that traffic volumes over the Platte-Winner Bridge are approximately 835 vehicles per day. While traffic volumes vary across the length of the study corridor, the operations analysis determined that all highway segments and studied intersections operate at LOS A. Projections for the corridor were then applied to 2025 and 2050 to evaluate LOS in future years.

The vast majority of the segments (the corridor was broken into sixteen segments) measured at LOS A; one segment indicated LOS B in 2025 and two segments indicated LOS B in 2050, both in the westbound direction west of the bridge. These segments are characterized by steep grades and/or substantial no-passing zones. The intersection at SD50 showed one approach (the SD50 approach) operating at LOS B, where a stop-sign controls that movement.

As implied by the analysis, traffic growth is not anticipated to be a problem in this study corridor. River crossing volumes are projected to be at approximately 1,400 vehicles per day in 2050. The traffic counts also documented the percentage of heavy vehicles using the corridor. Approximately 22% of the vehicles crossing the Platte-Winner Bridge are classified as trucks, which is a relatively high portion of vehicles using the corridor. Public feedback about traffic operations on SD44 (see Section 2.5.2) indicated concern about the width of the bridge and potential for conflicts caused by large vehicles crossing the one-mile distance of the bridge.

A review of the bicycle LOS indicated that a vast majority of the corridor scored a LOS F, particularly west of the river which includes a 4-foot shoulder, along with a 2-foot shoulder across the bridge. For segments east of the bridge, areas where bicycle LOS may currently be at level C generally trend toward LOS F over time due to the increase in traffic volumes that includes a large proportion of trucks. See Appendix C for more information about the traffic operations analysis conducted for existing conditions and future no-build conditions.

2.2.3 SD44 Crash Analysis

For an analysis of safety in the corridor, the study team conducted an assessment of crash data for the five-year period starting in January 2012 and ending December 2016. The data included information associated with each crash, such as injury severity, manner of collision, pavement conditions, date, and most harmful event, among others.

Each reported crash was categorized into intersection (major intersections only, excludes driveways) and highway segment crashes within the corridor. Intersection crashes were categorized as those occurring within a 250-foot radius of the center of a major intersection or categorized as an intersection crash in the crash report. Other crashes that occurred just outside of the 250-foot radius were individually evaluated to determine if the cause of crash was related to an occurrence or condition at an intersection. From this tabulation, crashes were further vetted based on harmful event, manner of collision, and junction classification to determine which crashes were categorized as intersection crashes.

Crash rates were calculated for both the intersections and highway segments. Intersection crash rate is calculated as crashes per million entering vehicles (MEV) and highway segment crash rate is calculated as crashes per million vehicle miles (MVM) traveled. For highway segments, a critical crash rate was also calculated based on the South Dakota statewide averages for similar facilities to account for vehicle exposure and the random nature of crashes. These critical crash rates were compared to the SD44 segment crash rates as another measure of the extent to which there may be safety concerns in the corridor.

Thirty-three crashes were reported along the SD44 corridor between 2012 and 2016. Eight of the 33 crashes resulted in an injury with one of those being a fatality. Sixteen crashes were noted as a wild animal hit in the crash report severity, though several of the no injury crashes were also related to vehicle-animal crashes.

Table 3. SD44 Study Area Total Crashes – Severity (2012 – 2016)

Severity	Crashes
Fatal Injury	1
Incapacitating Injury	1
Non-Incapacitating Injury	4
Possible Injury	2
No Injury	9
Wild Animal Hit	16
Total Crashes	**33**

Crashes along the SD44 study area corridor were categorized into intersection and segment crashes. One of the 33 reported crashes were identified as an intersection crash, and the remaining 32 were categorized as highway segment crashes. Table 4 below provides a summary of the highway segment crashes that occurred over the five-year period. None of the segments exhibited a crash rate higher than the statewide critical crash rate for similar roadways.

Table 4. SD44 Corridor Segment Crashes – Severity (2012-2016)

SD44 Segment Information				Crashes by Severity Category						Crash Rate (MVM)	Critical Crash Rate (MVM)
From	To	Length (miles)	Segment ADT	Fatal	Injury - Incapacitating	Injury - Non-Incapacitating	Injury - Possible	Property**	Total		
SD47	SD44 Frontage/ Drive (west of MRM 279)	4.2	436	0	0	1	0	4	5	**1.29**	**3.0**
SD44 Frontage/Drive (west of MRM 279)	Mid Span of Missouri River Bridge	12.5	426	1	1	3	1	11	17	**1.27**	**2.4**
Mid Span of Missouri River Bridge	MRM 293	1.9	661	0	0	0	0	1	1	**0.36**	**3.2**
MRM 293	SD50	2.7	698	0	0	0	0	9	9	**2.25**	**3.0**
SD44 SEGMENT TOTALS				**1**	**1**	**4**	**1**	**25**	**32**	**1.33**	**2.2**
				3%	*3%*	*13%*	*3%*	*78%*			

Table notes:
Crash rates presented in crashes per Million Vehicle Miles (MVM) traveled
Totals do not include crashes at major intersections (see intersection crash tables)
95 percent level of confidence (K=1.645) in critical crash rate calculation
*Rural Minor Arterial
**Includes both 'no injury' and 'wild animal' severity codes from crash report

A majority of crashes were vehicle-animal crashes (21 of 33 reported crashes), which occurred throughout the corridor in each of the four analyzed corridor segments. Of the remaining 12 crashes, 9 were associated with overturn/rollover type events, 2 others leaving the roadway and one rear-end. Overall, there was one fatal crash, one incapacitating crash and one non-incapacitating crash. There did not appear to be any strong trends with crashes occurring during certain months of the year. Seven crashes were identified to have occurred during ice, slush, or wet pavement conditions and four of those included an overturn/rollover event.

Details of the crash study are available in the SD44 Crash History Review Memorandum (Appendix D). Included in the details provided in that Memo, is information about each of the 33 crashes identified in the study corridor. Because this highway corridor travels through the Snake Creek Recreation Area, the study team considered potential safety concerns with traffic crossing between the north and south side of the park. The data for that area indicate one crash that occurred within the park limits, and that was a wild animal hit that caused damage only.

2.3 Geotechnical Assessment

The SD44 corridor has a significant history of geotechnical challenges since its opening in 1966. Numerous landslides have occurred in the area over this time, resulting in millions of dollars in repair and mitigation expenses to SDDOT. Additionally, understanding the geologic conditions adjacent to and beneath the Missouri River are of critical importance for identifying an optimal new bridge location.

2.3.1 Evaluation of Suitability for New Highway Alignment

The study team conducted an evaluation of the overall corridor to evaluate future landslide risk as well as the potential suitability of portions of the approximately 100-square mile study area for a new SD44 highway alignment. The project study area was broken into three different areas as follows:

- West Approach (west of the Missouri River) – Soils across the majority of this area are derived from weathering of the underlying Pierre Shale. The Pierre Shale is composed of several different members, including Elk Butte, Mobridge, Sully, Gregory, and Sharon Springs members, all of which are comprised primarily of bentonitic clay shale. This soil type, in combination with slopes that are generally steeper than 3:1 (horizontal: vertical) has been characterized by the study team as “marginally stable.” Disruption to the current state of these soils through erosion, sliding, construction, or other means will often lead to progressive failures that become larger (and more expensive to manage) over time.
- Missouri River – the soils adjacent to and beneath the river are generally comprised of alluvial soils deposited as the river meandered through the valley. Below this alluvium is the Niobrara Formation, commonly termed the Niobara “chalk”, and typically encountered approximately 100 feet below the current lake bottom. Several outcroppings of the Niobrara Formation exist along the edges of the river bank in this study corridor. The current river crossing takes advantage of one such outcropping as it represents a narrow point along the relatively uniform width of river corridor.
- East Approach (east of the Missouri River) – This area is underlain by soils similar to the west approach area until the landscape climbs out of the river valley on the east end of the study area. Similar instability in the landscape exists in the valley area, but the soils outside of the valley are more stable glacial soils.

The evaluation of suitability for a new highway alignment included an assessment of slope gradients across the study area. Per the discussion above, steep slopes represent a long-term risk for landslides and ongoing maintenance activity to protect a roadway alignment. Figure 7 provides an overview of slopes in the study area. As can be seen, high slopes are a dominant theme across the west approach area. This is a reflection of the overall study corridor landscape, where the river crossing elevation is at 1,410 feet above sea level and the landscape rises to approximately 2,100 feet above sea level anywhere from 2 to 6 miles west of the river.

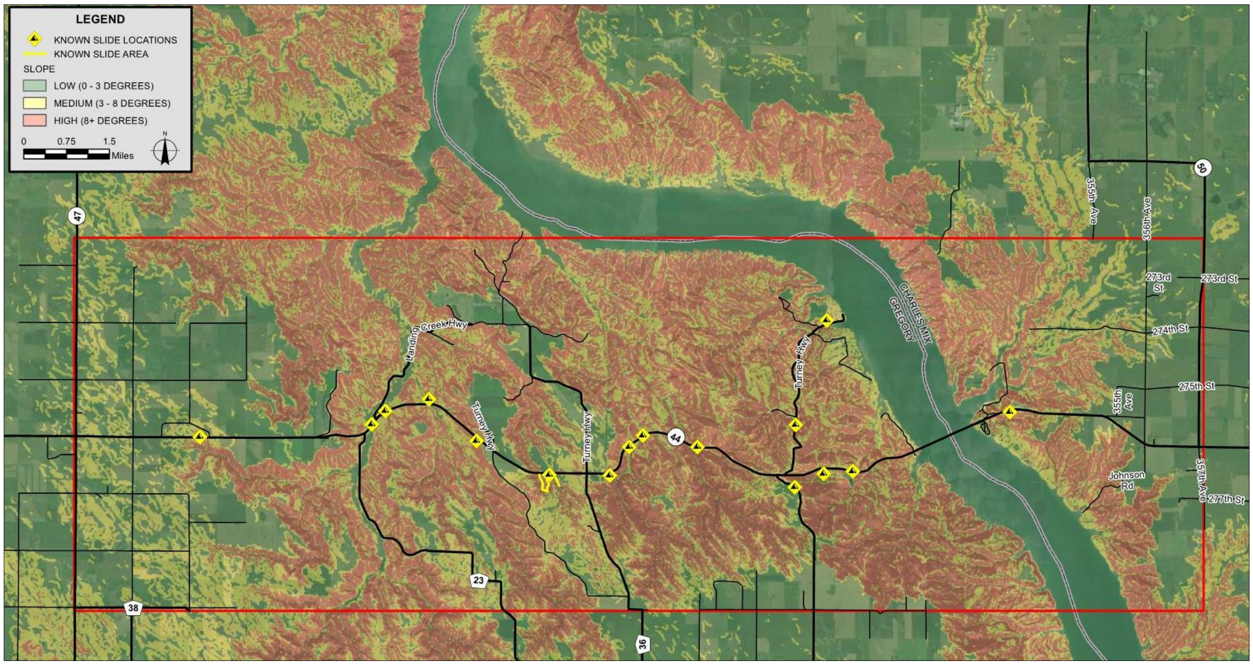


Figure 7. Study Area Slopes and Landslide Locations (also in Appendix E)

Figure 7 also includes mapping of identified landslides that have resulted in repairs and maintenance projects. Landslides at these locations have been primarily caused by poor drainage that leads to a buildup of pore water pressures, leading to failure of the marginally stable soils derived from shale. SDDOT has implemented a wide variety of repairs and mitigation measures to increase soil stability or reduce the potential for new slides. In some cases, the repairs have been made as far away as one mile from the SD44 roadway in order to redirect drainage away from and avoid concentrated flows at the roadway.

Due to SDDOT's long-standing repair and monitoring efforts in this corridor, existing corridor soils are well understood, the driving forces for slides have been properly characterized, and slide-prone areas are well known. SDDOT Materials and Surfacing department staff have described the SD44 roadway in this study area as currently being in the most stable condition they have observed.

The study team's complete evaluation of roadway alignment issues is provided in the Geotechnical Risk Evaluation Memorandum (Appendix E). In that memorandum, and for the reasons summarized above, the team concluded that from a geotechnical perspective, it is not prudent to consider new SD44 roadway alignment alternatives beyond that necessary to reconstruct the bridge and return to the existing alignment.

2.3.2 Evaluation of River Geology for Bridge Location

As described in Section 2.1, the existing bridge is supported on foundations comprised of prestressed, cylindrical-shell piles filled with concrete and sand after placement. The driven pile installation was aided by jetting, which resulted in a concentration of larger particles (cobbles and boulders) near the river bottom that were not carried to the surface by the jetting procedure. The concentration of cobbles and boulders surrounding the existing foundations represents a risk for the installation of foundations for a new bridge. New piles may be obstructed by these materials, preventing depths to the Niobrara Chalk from being achieved.

The project team conducted a review of design diagrams for construction of the existing bridge. Those drawings indicate that a zone of influence likely to contain concentrations of cobbles and boulders can be determined for each of the foundations based on depth of the pile and elevation of the lake bottom. This zone of influence should be avoided when constructing the new bridge foundations.

Based on these factors and for planning purposes, the design team recommended a minimum distance separating the existing bridge from a proposed new bridge. Deeper locations in the river require greater separation distance to minimize risk of encountering cobble or boulder conglomerations. For the purpose of developing initial bridge alternatives, the design team identified a 100-foot buffer distance around each pier as being a zone of influence.

2.3.3 Evaluation of Causeway Option

As a result of conversations that emerged from the public input meetings (see Section 2.5.2 below), the project team evaluated a causeway as one means of reducing the length of a new bridge. A causeway has been used effectively at the I-90 crossing over the Missouri River further north at Chamberlain, South Dakota.

The existing bridge elevation is 1,409 feet. The lake bed grade beginning just inside the east abutment drops to an elevation of about 1,300 feet within 250 feet of the bridge end. Consequently, to build a causeway from the east, fill thickness of over 100 feet would be needed to shorten the bridge 250 feet. Granular fill, fill placement under water, and relatively flat side slopes (i.e., large embankment footprint) would be required to construct the causeway. Special monitoring of the causeway embankment would be necessary to determine if settling of material is complete before construction of a roadway could occur, representing a potential construction staging/timing risk. Addition of this large quantity of fill to the river would require mitigation in the form of excavation elsewhere in the river system in order to avoid altering hydraulic conditions of the lake. Similar conditions and challenges exist on the west side of the river. The associated costs and impacts of a causeway are not clearly beneficial in comparison to construction of a bridge structure similar to what is there currently. For these reasons, the project team has recommended that a causeway is not appropriate for this project location.

2.4 Environmental Review

Upon beginning this study for a new bridge, SDDOT determined with FHWA that an Environmental Assessment (EA) will be the level of documentation needed to fulfill the environmental review requirements of NEPA. At the early stages of review, several environmental issue areas in this project location stood out as reasons the EA approach is appropriate. Those issues along with other areas of concern are briefly described here.

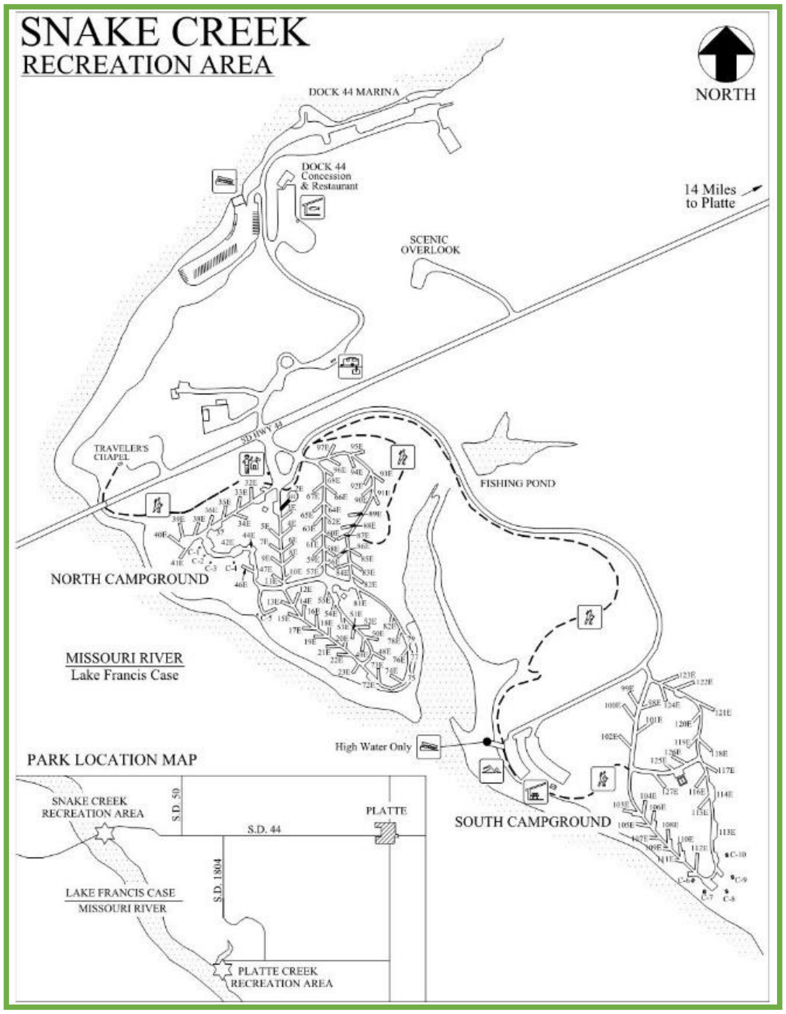


Figure 8. Snake Creek Recreation Area Map

- **Recreational Resources** – three State of South Dakota Recreation Areas (Snake Creek, West Bridge Park, and Buryanek) are located within the study area boundaries, in addition to multiple Game Production Areas. These resources are considered to be "Section 4(f)" resources, which require a heightened level of review. If impacts to Section 4(f) resources cannot be reasonably avoided, coordination with property owners is necessary in order to determine an appropriate level of mitigation. For this project, SDGFP and the U.S. Army Corps of Engineer (USACE) must be consulted as parties to the Section 4(f) resources. The Snake Creek Recreation Area is also a recipient of Land

and Water Conservation Fund (LWCF) grants, which means the National Park Service needs to be involved in order to comply with grant fund requirements.

- **Historic Resources** – river environments like the Missouri River valley are known to have higher potential for the existence of archeological resources dating back thousands of years. Additionally, the Platte-Winner Bridge is over fifty years old, making it a candidate for eligibility on the National Register of Historic Places. Coordination on these topics requires outreach to the South Dakota State Historic Preservation Office (SHPO) and adherence to Section 106 of the National Historic Preservation Act. Due to the USACE role in previous cultural resource studies in this area, FHWA delegated its authority for completion of the Section 106 process to USACE. In addition, Section 4(f) will apply to historic properties effected by the proposed project.
- **River/Lake Impacts** – construction of a new river bridge will require the involvement of multiple agencies to obtain the necessary permits. As an example, Lake Francis Case is an impoundment created by the Fort Randall Dam and operated by USACE. Section 404 and 408 permits from USACE will be required. Additionally, the U.S. Coast Guard (USCG) has responsibility for maintaining navigational clearance on the river.
- **Other Natural Resources** – The river has a fairly uniform width throughout the project study area, such that there does not appear to be any location that offers a significantly shorter span distance for a new bridge. Any rationale for relocating the bridge to a more distant location than the immediate crossing area would need to demonstrate substantial environmental benefits. This could come in the form of avoiding impacts to the resources identified above while also demonstrating sensitivity to existing resources, be it wetlands, agricultural resources, and natural habitat.

The EA process results in a stand-along EA document that is published and made available to the public separately from this Corridor Study document.

2.5 Public Involvement – Scoping Stage

2.5.1 Project Web Site

Shortly after the project was kicked-off, SDDOT made a project web site available to the public for project updates, background information and project studies, and news alerts for upcoming meetings. The web site address at the time of publication of this document is www.sd44bridge.com. SDDOT plans to keep the site available to the public for up to a year after completion of the study. After that time, the final project documents will be stored and made available on the SDDOT planning studies web site.

2.5.2 Public Meetings

During this first stage of project development, public meetings were held in the cities of Winner and Platte on May 22 and 23, 2017, respectively. In both cities, SDDOT conducted a “Stakeholder Advisory Meeting” in the afternoon, prior to a public open house held in the evening. Stakeholder Advisory Meeting attendees included a mix of business, community, and local government representatives. SDDOT presentations and meeting materials were the same for both meeting types. All meetings were well attended, with attendance ranging between approximately 25 and 75 participants at each meeting.

Following is a summary of the comments and questions that were received by the Study Advisory Team during this first round of public meetings, with responses and supplemental information provided as appropriate:

- **Avoid Closure of the Crossing** – the dominant theme heard from meeting participants was of the importance of the SD44 river crossing to the immediately surrounding communities and for inter-regional travelers. Participants recalled the closure that occurred in 1997 and the hardship that caused. SDDOT has made the commitment that no long-term closure of the bridge will occur as part of this project. Short-term closures (on the order of hours or days) during construction may be necessary; in those cases, SDDOT will provide advance notice to the public. This commitment is a significant contributing factor in eliminating the existing bridge location as an alternative for construction of a new bridge.
- **Bridge Width** – attendees noted that the roadway surface on the bridge is uncomfortably narrow, and can be problematic when attempting to drive large trucks or carry oversized machinery (e.g. farm equipment) across the river. SDDOT display materials at the meeting depicted the current bridge deck width of 28 feet (two 12-foot lanes and two 2-foot shoulders), along with the proposed new bridge cross section of 36 feet (two 12-foot lanes and two 6-foot shoulders), which is in line with SDDOT design guidance.
- **Bridge Type** – the project team presented information regarding potential structure types that could be used for a new bridge over the Missouri River. Major bridge categories including girder/slab, segmental, arch, truss, cable stay, and suspension were presented as candidate bridge types. Public comments noted that the existing bridge appears to be “appropriate” for this Missouri River valley setting such that it does not dominate the scenic landscape. Opportunities to reduce the bridge impact (such as with fewer piers in the river) were also noted as a potential benefit of the project.
- **Visibility of Crossing** – because the river crossing is at the bottom of a valley, meeting participants noted that the combination of downhill grades for vehicles approaching the river and a sinuous roadway that curves creates a situation where drivers do not see the bridge until they are relatively close to it. With the bridge’s narrow width and extensive length, oncoming drivers may not be prepared for potential conflicts on the bridge (for instance if an oversized vehicle that occupies more than one lane is crossing). This was especially noted as a concern for eastbound vehicles approaching the river. SDDOT noted that advance warning vehicles are a best practice commonly used for such situations, and that the practice appears to be used effectively in this location. There are no recorded crash incidents related to this issue in the five-year period studied for this project. As described above, plans for a wider new bridge will help address concerns about large vehicle conflicts. Within the range of alternatives that will be developed, there will likely be some alternatives that offer better visibility. While the issue will be considered in the evaluation of alternatives, it is not likely to be a driving factor in the selection of a new bridge alignment.

Figure 9. Visibility Concern (Eastbound SD44 Approaching the Bridge)

- **Removal of the Bridge** – meeting participants had multiple questions about what will happen with the existing bridge after construction of the new bridge. Some questions about whether it could be maintained as a pedestrian bridge were received. Others were also asking whether piers would be left in the river, and if so, if they would be visible above the water line. SDDOT plans to remove the existing bridge after the new bridge is built and operational. A different entity would need to take over ownership and maintenance obligations in order to keep the existing bridge in place. SDGFP would be a natural agency to consider it as a way to add a recreational amenity to Snake Creek Recreation Area. No parties (SDGFP included) have stated an interest in taking on the financial obligation and liability risk associated with ownership of the bridge. SDDOT anticipates removal of all or nearly all of the existing bridge. As such, the existing piers would be removed to a depth well below the lake elevation.
- **Use of a Causeway to Reduce Bridge Length** – attendees noted how the Interstate 90 bridge over the Missouri River includes a length of causeway built into the river as a sort of land bridge, ultimately helping to reduce the length of bridge structure over the river. Questions were asked about whether that would be feasible at this location. As described in Section 2.3.3 above, the project evaluated the feasibility of a causeway for this location and determined such a measure to not be applicable to the environment and crossing at SD44.
- **Recreational Value of Location** – comments were received about the importance of this river area as a recreational resource. The Snake Creek Recreation Area serves as a focal point for camping, fishing, and outdoor recreation. In recognition of this issue, SDDOT has included SDGFP as a member of the SAT so that their input can be provided throughout the course of the project. Additionally, as described in Section 2.4, federal law requires compliance with Section 4(f) policy, which includes taking measures to avoid or mitigate impacts to recreational resources.

- **Level of Environmental Study** – some questions were received about the level of study that will be conducted and agencies that will be involved, in particular, a question was asked about whether tribes will be invited to participate in reviews of the project. SDDOT has coordinated with the Federal Highway Administration (FHWA) in determining that an Environmental Assessment (EA) should be prepared for compliance with NEPA. As part of the EA process, agencies are invited to provide input, and SDDOT commits to conducting public meetings including one at the time of EA publication. As part of the EA process, SDDOT has reached out to tribes and will continue to work with those tribes indicating their desire to be involved in the environmental review.
- **Construction Impacts** – community members were interested in the impacts of construction, notably issues such as staging of the work (location), and potential services needed to meet the needs of construction workforce (such as short-term residence and family support services).

Section 3. Scoping Level Project Recommendations

The data collection efforts, technical studies, and outreach conducted during the scoping phase issues assessment described in Section 2 provided an understanding of the key project issues to consider in development of the range of project alternatives. Below is a summary of recommendations and findings from the scoping phase. These findings also helped to identify the criteria that would be foundational to the evaluation and screening of alternatives down to a Recommended Alternative.

3.1 Existing Bridge Location is not Feasible

The Platte-Winner Bridge history includes a notable damage event to piers that required temporary closure of the bridge while repairs were designed and implemented. The damage is believed to have been caused by ice floes impacting the bridge during the spring melt. This history creates uncertainty about the risk for such damage to occur to the bridge foundation elements in the future. Additionally, the bridge width and superstructure design prohibit substantive repair work from occurring while also maintaining traffic on the bridge. These factors point toward the need for a significant period of bridge closure for implementation of any alternative that would use the existing bridge footprint.

Feedback provided by community members during public meetings and in communications with the project team consistently identified a desire to avoid closure of the bridge. The SD44 highway corridor, with its Missouri River crossing, is a critical connection for local economies in the study area and for inter-regional traffic serving points beyond the study area. Closure of the crossing would create a detour route of over 80 miles for users of the bridge.

The combination of engineering issues and public input has made it clear to the project team that **use of the existing alignment is not a feasible alternative for a new SD44 bridge**.

3.2 Geotechnical Conditions Present Substantial Risks

The SD44 corridor has a long history of landslides and related geotechnical challenges that have resulted in millions of dollars of repair projects. One of the key objectives for SDDOT in this proposed project is to determine a long-term corridor associated with the new bridge that minimizes the risk for continued landslides and ongoing maintenance and repair investments.

Evaluations of soils and slopes across the study area helped to assess the risk for a new alignment to be prone to landslide issues. Mapping of slopes and soils demonstrated that there are no natural corridors available that would reduce the risk for landslides. This study area includes a climb of 600-700 feet from the river bridge to a western plateau where the landscape flattens and becomes relatively stable. Such a climb over a relatively short distance (approximately 2 to 6 miles) has created a landscape dominated by steep slopes.

SDDOT's investments in the existing SD44 highway corridor have also resulted in fewer landslide events in recent years. The corridor has become increasingly stable, and the SDDOT has a strong understanding of the corridor's conditions, such that the agency is able to anticipate areas where repairs are needed and where maintenance investments will pay off in the avoidance of significant costs due to emergency repairs and closures of the highway.

These geotechnical factors indicate that **there should be a strong preference for new highway alignment alternatives that maximize use of the existing corridor and reduce the**

extent of new corridor. In essence, geotechnical conditions in the study area suggest new alignments should be as close to the existing bridge as possible.

3.3 Construction Methods for Existing Bridge Created Foundations Risk

Section 2.3 describes the construction method used for driving pile into the river bottom when the existing bridge was built. The method resulted in conglomerations of cobble and boulders that are now a risk to the ability to drive piles for the new bridge. These conglomerations are anticipated to have occurred in a circle around each foundation, with boulders closer to the pier and the cobble gradually getting smaller in size as a function of distance from the pier.

The challenge with conglomerations of boulders and cobble is that piles driven for the new bridge that encounter this area may be met with resistance. Ultimately, the new bridge piles might not be able to be driven as deep as the bridge design would dictate and create a long-term risk to stability of the new bridge or costly design modifications that need to be implemented to provide a safe crossing.

A diagram of the anticipated zone of influence where boulders and cobble exist is provided in Figure 10. Based on the project team assessment, a buffer zone was developed to serve as an “off-limits” area for new bridge alignment. While it was already known that the existing bridge alignment could not be used, this foundations assessment provided greater clarity about feasible locations for a new bridge.

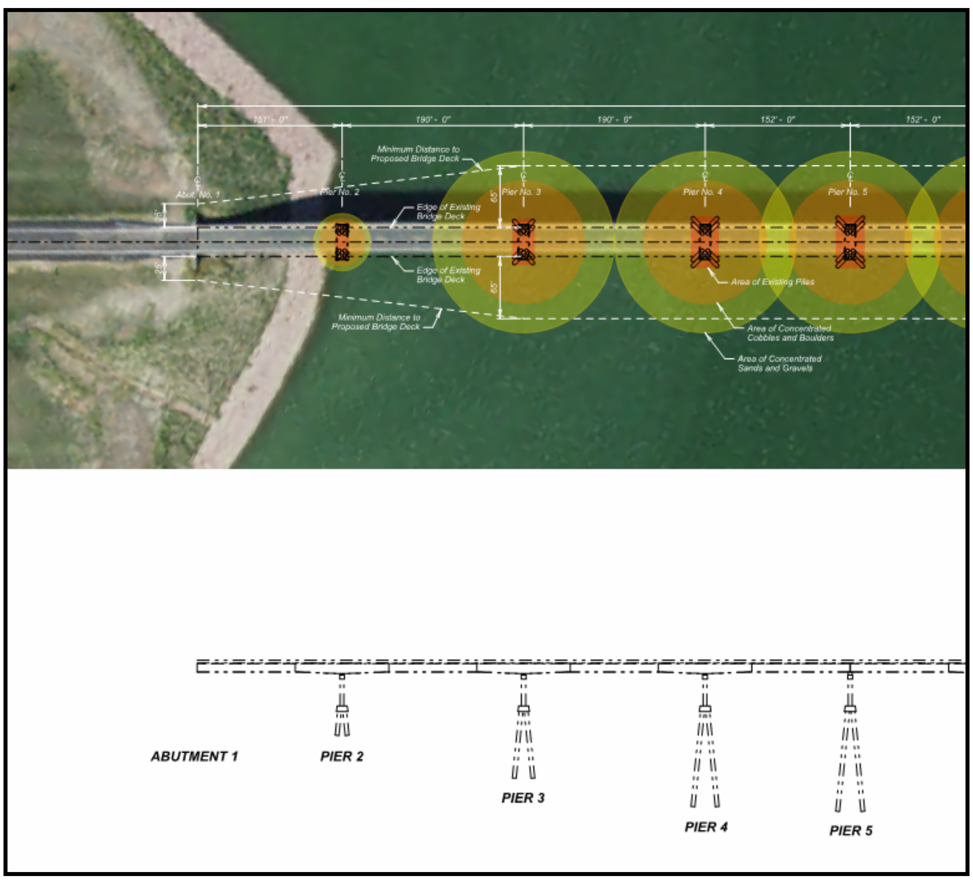


Figure 10. Zone of Influence Diagram at West End of Bridge

While above-river geotechnical conditions generally push feasible new bridge alignments *toward* the existing bridge, the geotechnical conditions underwater have the opposite effect. Conditions at the river bottom have created a buffer area around the existing bridge foundations that should not be considered for any new bridge foundation elements and push new bridge alignments *away* from the existing bridge.

3.4 Section 4(f) Recreational Resources will be Impacted

The combination of results described in Section 3.2 and 3.3 have implications on the area where potential new bridge crossing and highway alignments may be considered reasonable for further study. As shown in Figure 8, the current SD44 highway alignment runs directly through the Snake Creek Recreation Area. On the west side of the river, the Buryanek Game Production Area will be impacted by any new alignment route. Additionally, the West Bridge Lakeside Use Area (which includes the boat launch) is likely to be affected by the project, if not directly, indirectly by way of construction activities for the new bridge and highway alignment. Any attempt to avoid these resources would require significant realignment of SD44. Geotechnical conditions are prohibitive to such alignments; hence avoidance of the resources would require substantial financial and environmental impact costs.

Likewise, the need to push a new alignment away from the immediate vicinity of the existing bridge means that it will not be possible to create alternatives that avoid the use of state park resources. For purposes of alternatives development, this meant the project team needed to engage with SDGFP for a discussion of the resources found at Snake Creek Recreation Area and how to account for them in the development of new bridge alignment alternatives. While an impact may not be avoidable, various alternatives will impact resources such as the campgrounds immediately south of SD44 in different ways. Understanding the impacts of each alternative and the consequent measures needed to mitigate those impacts is a core function of the Section 4(f) review process.

3.5 Major Bridge Type Screening

After reviewing the six major bridge types that were initially considered as candidates for a new bridge over the Missouri River, the project team compiled input from the public and analyses with the SDDOT Bridge Office to create an evaluation matrix of the bridge types. That matrix is shown here as Table 5.

As can be seen in the evaluation matrix (which can also be viewed as part of the bridge types memorandum in Appendix G), two major bridge types stood out as being more appropriate for this river crossing location. The project team determined that the girder/slab and segmental bridge types are the major bridge types for further consideration and detailed study. The current Platte-Winner bridge is a girder style bridge, along with many of the other South Dakota crossings of the Missouri River. The state of North Dakota recently built a segmental bridge over the Missouri River (the Four Bears Bridge at New Town) in a similar setting as the Platte Winner Bridge.

Table 5. Major Bridge Type Comparison Matrix

Bridge Type	Aesthetics	Span Ranges	Construct-ability	Construction Cost	SD44 Corridor Feasibility	Relative Score
Girder/ Slab	0 conventional girder slab look, variable depth girders add interest	0 / + 100ft to 450ft	+ Conventional materials, precast or steel girders with concrete deck	0 / + conventional materials and cost	+ **feasible** due to achieving longer spans with conventional materials	**+ 3**
Segmental	+ tapered box shape, variable depth adds interest	0 / + 150ft to 650ft	0 concrete, special forms and equip, simultaneous erection at multiple piers	0 / - somewhat expensive compare to conventional	+ **feasible** due to longer spans eliminating substructure	**+ 2**
Arch	+ long spans with open look	+ 200ft to 700ft	- critical / complex connections, temporary stability of arch ribs critical	- expensive, shipping/erection logistics for prefabbed or CIP arches	- **not feasible** due to high cost and complex construction	**- 1**
Truss	- boxy imposing shape with lots of chord members detract from landscape	+ 400ft to 800ft	- labor intensive / non-redundant connections	- expensive driven by labor to fabricate and erect all the connections	- **not feasible** due to high cost and labor intensive fabrication and erection	**- 3**
Cable Stay	0 / - tall towers that may look out of place	+ 500ft to 1200ft	- highly specialized erection requirements	- (2) very expensive	- **not feasible** due to very high cost and specialized construction	**- 3.5**
Suspension	0 / - tall towers that may look out of place	+ 1000ft to 4000ft	- highly specialized erection requirements	- (2) very expensive	- **not feasible** due to very high cost and specialized construction	**- 3.5**

Section 4. Project Evaluation Criteria

That first screening eliminated large classes of bridge types (such as cable stay or arch) and identified concerns about new roadway alignments that would cause geotechnical disruption to the corridor. As described in Section 2, findings from that initial "scoping" assessment were presented to the public in May 2017 along with a request for additional input from the public to help understand the key issues and concerns to be addressed by SDDOT and FHWA. Key outcomes and recommendations from the scoping phase of work are identified in Section 3.

In the context of a corridor study that involves multiple stakeholders with ranging priorities, it is valuable to identify the set of criteria that will be used for evaluation of alternatives prior to the creation of specific project bridge or highway location alternatives. Agreement by project team stakeholders on the evaluation criteria creates an environment for balanced consideration of each alternative's merits and deficiencies. As part of an alternatives development workshop held in September 2017, the project team agreed upon the criteria to be used for 1) evaluation of SD44 roadway and bridge alignments, and 2) evaluation of bridge types for crossing the river.

The criteria, presented below for each of the two alternatives topics, are a reflection of the input received from SAT members, the public, and partner agencies during the scoping phase of this study.

4.1 Alignment Evaluation Criteria

For comparison of alternatives at this stage of development, all alternatives currently assume maintaining the same vertical profile as exists today.

Environmental Criteria

- **Section 4(f)** – Evaluation of potential impacts to State Parks (Snake Creek Recreation Area and West Bridge Recreation Area), Game Production Areas, and potential cultural resources including the existing bridge. *In the development of criteria, SDGFP indicated a strong preference to avoid impacts to the campground facilities at Snake Creek Recreation Area, essentially becoming the agency's top Section 4(f) resource priority.*
- **Section 6(f)** – Impacts to Snake Creek Recreation Area, which has received Land and Water Conservation Fund (LWCF) grants. Emphasis is on acres to be acquired for new right of way, and potential for turnback of existing right of way to compensate. If impacted acres are greater, additional mitigation will be necessary.
- **Cultural Resources (Section 106)** – Potential for impacts to architectural (existing bridge) or archaeological resources. Historic records indicate buried resources may exist on the east bank of the river.
- **Water Resources** – Potential floodplain, wetland, water quality, or other related water resource impacts
- **Multimodal** – Impacts to pedestrian or bicycle modes of transportation. For this project, the area of emphasis is at the Snake Creek Recreation Area and crossings between its north and south units.
- **Socioeconomic** – This consists of community and economic impacts associated with the project such as changes to or interruptions to commerce, and community identity impacts such as visual/aesthetics changes to the landscape or bridge.

- **Construction Impacts** – Impact of construction activities, primarily staging area accommodations and the potential for mitigation (such as conversion of staging area into a permanent boat landing).

Geotechnical Criteria

- **Risk for conflict with existing foundations** – relative risk for complications related to the existing bridge and surrounding environment (the "buffer area" where concentrations of boulders and related material may exist).
- **Roadway footprint/impacts and abutment location** – Geotechnical impacts of realigning portions of SD44 (cut/fill associated with new location).
- **Long-term maintenance** – Potential demand for, and costs related to, geotechnical mitigation or future maintenance needs based on new location of roadway.
- **Initial Construction Cost** – To differentiate from long-term costs, this focuses on the costs of geotechnical work related to construction of a new highway alignment.

Roadway/Traffic

- **Maintenance of Traffic** – Required or potential closures of SD44 due to construction activities.
- **Access** – Impacts to access, focused on State Park access locations.
- **Sight Lines/Geometry** – changes to drivers' view to or from the bridge, with recognition of stakeholder concerns regarding large farm equipment visibility, also consider the potential for needing a climbing lane due to the profile.
- **Safety** – Changes to the roadway that could positively or negatively affect safety performance of SD44
- **Length of new roadway** – amount of new roadway to be constructed, overall change to the length of the Winner-Platte corridor, includes cost of new construction.

Bridge Location

- **Length and Foundations** – length of new bridge from approximated location of new abutments and the implication for potential number of substructure units.
- **Ability to remove the existing bridge –** any factors about the new bridge (which must be built before the existing bridge can be removed) and its location that could create challenges for removing the current structure to the degree required by permitting agencies.

Constructability/ Cost Effectiveness

- **Constructability** – Alignment location, conflicts, and related grade as factors in a contractor's ability to construct the bridge and roadway efficiently in terms of cost or time.
- **Staging** – An assessment of how well an alignment location enables construction staging and accessibility for a contractor (focus on an assumed west bank staging location).
- **Right-of-Way** – Potential public and private parcel acquisition for the new alignment
- **Cost** – Range estimate for the total project cost.

4.2 Bridge Evaluation Criteria

From the first round of alternatives presentation and public input, the project team was able to identify the two major bridge types that are appropriate for further evaluation in this project area. Within the girder/slab and segmental major bridge types categories, there are several possible variations that can be evaluated. The criteria below were used to compare an array of specific bridge options within the major bridge categories.

- **Maintenance** – Long-term maintenance needs for bridge type, potential for closure to traffic.
- **Footprint of Foundations** – Number of substructure units required as a measure of the environmental impact of the bridge.
- **Staging/ Construction Impacts** – Requirements for contractor to construct the bridge and potential impacts associated with construction
- **Construction Duration** – Timeframe to construct the bridge (years)
- **Constructability** – Availability of contractors, experience with the bridge type, environmental conditions and suitability to construction of the bridge type.
- **Cost** – Superstructure and Substructure costs (range, in $ Million) to capture the total bridge cost.
- **Risk Factors** – Bridge type risks not captured in other criteria.

Section 5. Alternatives

5.1 Location of Feasible Alternatives

A range of project alternatives were prepared by the project team for use in the September 2017 Alternatives Workshop. Findings from the scoping phase of work helped to narrow the project area for the original study (which was approximately 100 square miles) down to a smaller footprint where feasible and prudent alternatives may be considered. This area of potential effect (or "APE") served as the general boundaries for which viable alternatives are located. From a NEPA review perspective, this APE is helpful for conducting more detailed environmental studies to evaluate qualitative and quantitative impacts associated with the project alternatives.

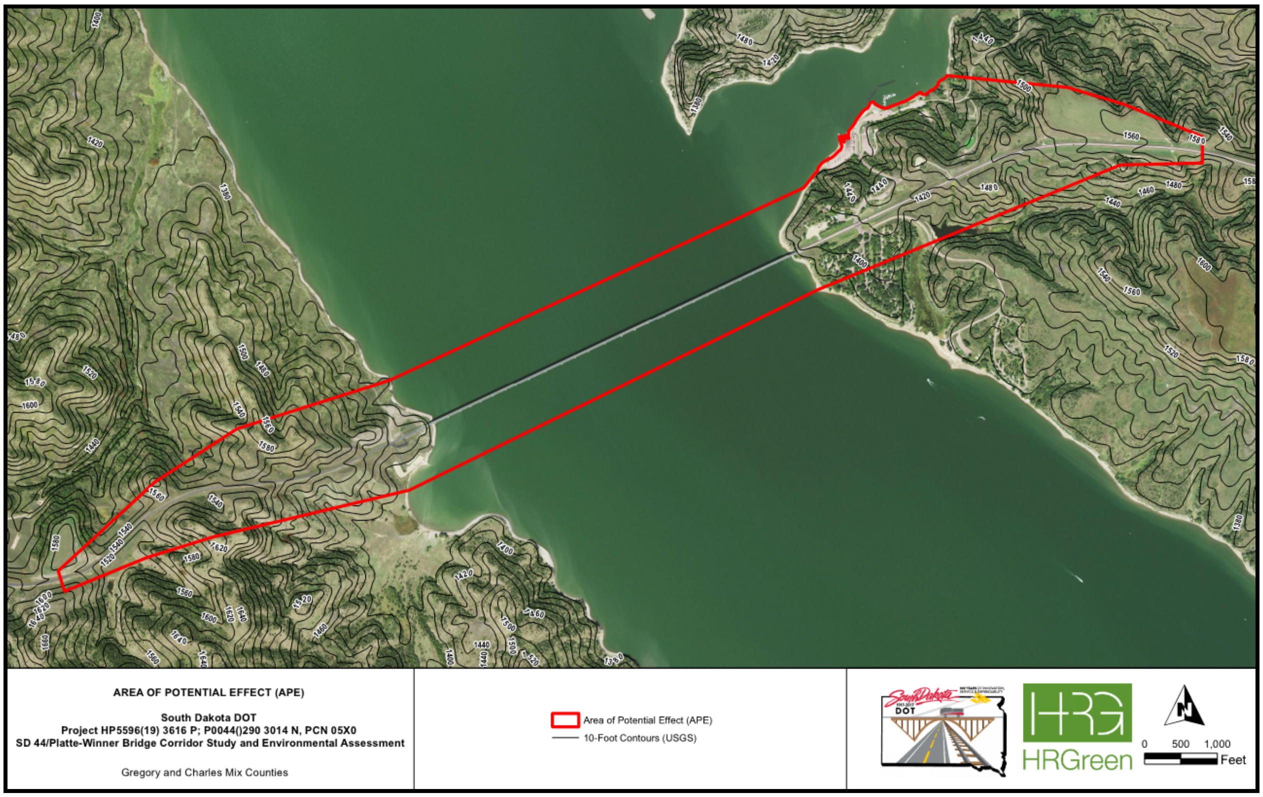


Figure 11. Area of Potential Effect

5.2 SD44 Highway and Bridge Alignment Alternatives

5.2.1 Initial Range of Alignment Alternatives

A total of nine new alignment alternatives were developed for comparison against the evaluation criteria. At this stage of alternatives development, all parties understood that an impact to Section 4(f) resources would occur. However, SDGFP placed a high priority on the minimization or avoidance of impacts to the Snake Creek Recreation Area campgrounds located south of SD44. This feedback was influential in the creation of alternatives: of the nine alternatives developed for evaluation, seven were located north of existing SD44 and two were south.

Alternatives were identified with labels reflecting their position compared to the existing bridge and highway alignment. Labels followed a convention of starting with either "N" or "S" to identify the alignment as being north or south of the existing alignment. Following the letter designation, a number was given to the alternative, which identifies the approximate distance (in feet) the alignment is located from the existing roadway. This convention assumes the alternative bridge location alignment is parallel to the existing bridge. In cases where the alternative is not parallel, the word "skew" was added to the label. Numbering associated with a skew alternative is given in a two number sequence, with the first number referencing the distance in feet from western bridge abutment, and the second number being the distance in feet from the eastern bridge abutment.

Brief descriptions of each roadway alignment alternative are provided below in Table 6.

Table 6. Initial Range of Alignment Alternatives

Alignment	Features	Design Intent and Notes
N100	100 foot parallel separation upstream of existing	Minimizes new roadway alignment by staying as close to the existing bridge location as feasible.
N400	400 foot parallel separation upstream of existing	Offers an alternative location for impacts minimization, including potential avoidance of cultural resources, while also offering potential Section 4(f) mitigation options with the space created, and leveraging the natural topography to keep the bridge length approximately the same as existing.
N400 – Modified West	Same as N400, with west end roadway option shown	Same as N400 except this alignment considers feedback about western approach sightlines by straightening the approach.
600N	600 foot parallel separation upstream of existing	By going this far north, the bridge length is extended substantially in order to avoid impacts to potential cultural resources. The parallel alignment creates a substantial segment of new alignment on the west side, which would require large amounts of earthwork.
North Skew (50-200)	Come into west bank at an angle to minimize length of new roadway	By coming in at an angle on the west side, the alignment is able to tie-in to existing roadway earlier and minimize geotechnical impacts. This causes the eastern side to push slightly further from the current highway into an area of uncertain cultural resources
North Skew (50-400)	Come into west bank at an angle to minimize length of new roadway, but push further north on the eastern bank	Similar to the North Skew (50-200) alignment, but perhaps creates more opportunity for cultural resource site avoidance and park impact mitigation
North Skew (400-50)	Straightens the approach to bridge from west, creating a more extensive line of sight across the river valley	This alignment considers feedback about western approach sightlines. Substantial geotechnical impacts would be involved on the west side, and the east bank side of this alignment is at risk for cultural resource impacts

Alignment	Features	Design Intent and Notes
S100	Minimize geotechnical impacts and amount of new roadway by going downstream as close as feasible to the existing bridge	The corridor works with the existing topography and geology to minimize geotechnical risks on the west approach. Campground and park access impacts are a concern.
South Skew (300-50)	Use skew to potentially return to SD44 more quickly on the east side	It is unclear whether the skew manages to avoid or minimize impacts to the campground or park access. By creating the skew, some of the geotechnical advantages of the south side are lost.

Images of each of the nine alignment alternatives are presented in Appendix H.

5.2.2 Evaluation of Alignment Alternatives

With the establishment of nine alignment alternatives, the project team was able to evaluate each alternative against the criteria as shown in Section 4. For purposes of comparison and evaluation, the team assumed the new alignment would carry approximately the same vertical profile through the corridor as the existing alignment. That is, the bridge and the roadway approaches would be at the same existing elevations in all alternatives.

The evaluation of alternatives was summarized in a matrix format to enable comparison of results. The qualitative analysis of each alternative against the evaluation criteria is represented with either a “+” (for relatively positive comparison against the range of alternatives), “0” (for a neutral comparison, neither strongly positive or negative compared to other alternatives), or “-“ (for a negative comparison against the range of alternatives).   Table 7 presents the findings from the study team’s evaluation of alternatives. Included in the table is a recommendation for each alternative, whether it should be retained for further evaluation or eliminated.

In summary, **the following alignment alternatives were recommended for further evaluation**:

- **S100;** a parallel alignment to the existing bridge approximately 100 feet downstream
- **N100**; a parallel alignment to the existing bridge approximately 100 feet upstream
- A **combined version of North Skew (50-200) and North Skew (50-400)**; the study team recognized that based on the evaluation there is possibly one distance on the east side between 200 and 400 feet that is optimal for minimizing overall impacts and optimizing the beneficial aspects of the skew.

Table 7. Matrix Evaluation of Roadway Alignment Alternatives

	Environmental							Geotechnical				Roadway/ Traffic					Bridge		Constructability/ Cost Effectiveness			
Alignment	Section 4(f) Recreation	Section 6(f)	Cultural Resources (Section 106)	Water Resources	Multimodal	Socioeconomic	Construction Impacts	Risk for conflict with existing foundations	Roadway Footprint Impact and Abutment Location	Long-Term Maintenance	Short –Term Cost	MOT	Access	Sight Lines/ Geometry	Safety	Length of New Roadway	Length of Bridge (incl. Foundations Count)	Ability to Remove the Existing Bridge	Constructability	Staging (west bank)	ROW	Cost
N100	0	0	-	+	0	0	+	0	0	+	0	0	0	0	0	0	+	0	+	0	+	+
N400	0	0	+	-	0	0	0	+	-	-	-	0	0	+	0	0	-	+	0	+	0	-
N400 – Modified West	0	0	+	0	0	-	0	+	-	-	-	-	0	+	0	0	-	+	-	+	0	-
N600	0	+	+	-	0	0	-	+	-	-	-	0	-	+	0	0	-	+	-	+	0	-

Alignment	Environmental	Geotechnical	Roadway/ Traffic	Bridge	Constructability/ Cost Effectiveness	RECOMMENDATION
N100	Direct impact to potential cultural resources site on east bank, avoids west end boat ramp and minimizes length of bridge over river; impacts access to north unit of SCRA and slight Section 6(f) impact, but mitigation measures appear feasible and relatively similar to other alternatives	Closest feasible upstream location minimizes geotechnical impact	Construction stage impact to SCRA north unit access, otherwise minimal change to existing condition	Adjacent location minimizes bridge length	Overall minimizes extent of new alignment and bridge, thus ROW and Cost minimized	**N100** **RETAIN for further evaluation**
N400	Able to avoid cultural resource sites but comes with potential for wetland impacts and longer bridge (river impact); avoids downstream side recreation resources but north side SCRA is more substantially impacted with uncertain ability to mitigate the access	Clearly avoids existing bridge foundations footprint but requires extensive cut on west side	Offers opportunity for slightly improved sightline for eastbound traffic approaching bridge	Longer bridge allows better access to remove existing	Distance upstream may enable staging to occur on same side of SD44 and avoid west end boat ramp, longer bridge and geotech create higher costs	**N400** **ELIMINATE – limited benefit beyond avoidance of potential cultural resources**
N400 – Modified West	Same as N400, but modified west side highway route creates potential for highway closure, (short term) lengthy detour.	Same as N400, but with more extensive geotechnical impacts, on both sides of SD44	Add more risk for highway closure and detour in order to improve the sightline	Longer bridge allows better access to remove existing	Impacting both sides of SD44 adds risk and cost	**N400 – Modified West** **ELIMINATE – main benefit of enhanced sight line is not enough to overcome other deficiencies including added geotech impacts**
N600	Route through SCRA may result in a net gain of property for Section 6(f) but at the cost of greater water resource impacts and disruption to the surrounding landscape, avoids the potential Section 106 site	Extensive geotechnical impacts for the new highway alignment (uncertain geologic conditions)	Access to the SCRA boat ramp area severely impacted during construction at minimum, among best options for eastbound river crossing sightline	Longer bridge allows better access to remove existing	Longer bridge and extensive earthwork (with added risk for unknown conditions) make this more expensive	**N600** **ELIMINATE – limited benefit beyond avoidance of potential cultural resources**

Alignment	Environmental							Geotechnical				Roadway/ Traffic					Bridge		Constructability/ Cost Effectiveness				
	Section 4(f) Recreation	Section 6(f)	Cultural Resources (Section 106)	Water Resources	Multimodal	Socioeconomic	Construction Impacts	Risk for conflict with existing foundations	Roadway Footprint Impact and Abutment Location	Long-Term Maintenance	Short –Term Cost	MOT	Access	Sight Lines/ Geometry	Safety	Length of New Roadway	Length of Bridge (incl. Foundations Count)	Ability to Remove the Existing Bridge	Constructability	Staging (west bank)	ROW	Cost	RECOMMENDATION
North Skew (50-200)	-	0	-	0	0	0	0	-	0	0	0	0	0	-	0	+	0	0	0	0	+	0	**North Skew (50-200)** **COMBINE WITH 50-400 to create one alignment that offers cultural resource avoidance while balancing other impacts**
	Skew doesn't go far enough north to avoid cultural resource and impacts several recreational resources but for that reason limits impacts in the other areas (Section 6(f) and water resources)							The skew helps to quickly get roadway alignment back to existing on the west side but at a risk of conflict with existing foundations.				Sight line concerns may worsen slightly but new roadway is minimized					Bridge removal is not anticipated to be a challenge even at this closest distance		Uncertain whether there is room available on the upstream side for staging				
North Skew (50-400)	-	0	+	0	0	0	0	-	0	-	0	0	-	-	0	0	-	0	0	0	0	-	**North Skew (50-400)** **COMBINE WITH 50-200 to create one alignment that offers cultural resource avoidance while balancing other impacts**
	Skews far enough north to avoid Section 106 potential resource. Still impacts Section 4(f) resources on north side, with potentially more challenging mitigation needs or measures for access during construction							Getting into greater geotechnical impacts on north side hills and into untested geology (higher risk)				Sight line concerns likely worsen slightly and access to park may be difficult during and after construction					Longer bridge		Uncertain whether there is room available on the upstream side for staging; longer bridge = higher cost				
North Skew (400-50)	+	+	-	0	0	0	0	-	-	-	-	0	0	+	0		-	0	0	0	+	-	**North Skew (400-50)** **ELIMINATE –benefit of sight line improvement (which has uncertain value due to limited documented safety concern) is not enough to justify other significant deficiencies, notably on geotechnical side**
	Alignment impacts a larger piece of the Game Production Area on the west side of the river, but is able to minimize impacts in SCRA and may offer a clean swap of land for Section 6(f). Directly impacts potential cultural resource site;							Extensive geotechnical impacts for the new highway alignment (uncertain geologic conditions) and skew risks conflict with foundations				Substantial improvement to the sightline concern for eastbound traffic					Longer bridge allows better access to remove existing		Uncertain whether there is room available on the upstream side for staging; longer bridge = higher cost; new alignment completely contained within park area (no private ROW)				

	Environmental							Geotechnical				Roadway/ Traffic					Bridge		Constructability/ Cost Effectiveness				
Alignment	Section 4(f) Recreation	Section 6(f)	Cultural Resources (Section 106)	Water Resources	Multimodal	Socioeconomic	Construction Impacts	Risk for conflict with existing foundations	Roadway Footprint Impact and Abutment Location	Long-Term Maintenance	Short –Term Cost	MOT	Access	Sight Lines/ Geometry	Safety	Length of New Roadway	Length of Bridge (incl. Foundations Count)	Ability to Remove the Existing Bridge	Constructability	Staging (west bank)	ROW	Cost	RECOMMENDATION
S100	-	+	+	0	0	0	0	0	+	+	+	0	-	0	0	+	+	0	+	0	+	+	**S100** **RETAIN for further evaluation**
	SCRA Campground and West End boat ramp impacts are substantial concerns for resources that already have demand exceeding supply. Appears to avoid all cultural resource concerns and because the new alignment is within the SCRA borders, a land swap for Section 6(f) appears feasible.							This route appears to optimize the avoidance of impacts relative to potential geotechnical concerns both at the abutment and along any new alignment				Entry to South Unit of SCRA could be difficult during construction. Location of alignment matches nicely with existing geometry on west end to limit new roadway					Possibly the shortest alignment alternative for any new bridge based on geology of area		New alignment completely within SCRA (limits ROW); shorter bridge = lower cost; west end route poses limited challenge to construction				
South Skew (300-50)	-	+	+	-	0	0	0	-	0	0	0	0	-	-	0	+	0	0	0	-	+	0	**South Skew (300-50)** **ELIMINATE – there are limited benefits in comparison to S100 and slightly more impacts**
	Adding the skew does little to change the impact on Section 4(f) resources (and avoidance of 6(f) or cultural resources), while introducing greater potential for wetland impacts on the west side. Staging may not be feasible on downstream side, requiring impact on other side of SD44.							Skew pushes abutment away from an advantageous area and may create more construction costs and geotechnical impact with new alignment while also increasing risk for conflict with existing foundations on the east end				Entry to South Unit of SCRA could be difficult during construction. More curvature for eastbound traffic may cause sightline issues					Longer bridge and the east end skew reduces gap between old and new bridge during removal		Uncertain ability to accommodate staging needs on west end; New alignment completely within SCRA (limits ROW)				

5.3 New Bridge Alternatives

As described in Section 3.5, the project team conducted a review of the major bridge types and determined two types to be feasible options for the new SD44 bridge: 1) girder/slab bridge, and 2) segmental bridge. Within each of these major bridge categories, variations in design are available. The study team conducted further evaluations of specific bridge types within both major bridge categories as a means to better understand feasible bridge designs and resulting impacts.

The complete analysis is provided in the memorandum found in Appendix G.

5.3.1 Girder/Slab Bridge Types Evaluation

In the Girder/Slab category, five bridge types were investigated: precast simple span made continuous girders, precast constant depth spliced girders, precast variable depth spliced girders, and two types of steel plate girders: constant depth and variable depth plate girders.

- **Precast simple span girders made continuous** for composite loading will have shorter spans and more substructure units. This method can be very cost effective when substructure costs are not the primary driver of the overall economy of construction. The superstructure is made from conventionally, locally available materials. Erection can be completed by standard cranes mounted on barges. Spans of up to 185 feet are feasible using pretensioned girders and conventional cast-in-place (CIP) slab construction. These span lengths are less than those of the existing bridge, meaning the number of substructure units would be increased by approximately 15%. In order to maintain navigational clearance per U.S. Coast Guard requirements meeting existing clearance, a new bridge using this type of structure would need to incorporate an additional structure type to provide two spans with minimum length of 250 feet.
- **Precast concrete constant depth spliced girders** can achieve spans up to 265 feet. The girders are produced in lengths up to 190ft at a precast plant to fit the pier layout. The pier segments are erected first and tied down to the piers with a CIP diaphragm. After the pier girders are stabilized, the end girders are erected. They are supported by strongbacks hung from the pier girders at one end and the end bent at the other end. Finally, the drop-in girders in the interior spans are erected on strongbacks hung from the pier girders. After all of the girders in a superstructure unit are erected, CIP closure pours are cast to tie the girders together and post-tensioning is stressed and grouted. At that point the girders act as a continuous beam. Finally, the deck and bridge rails are placed by conventional CIP construction. In this manner, the entire superstructure can be erected over the water without requiring temporary supports. The span configuration will achieve a reduction of approximately 7% in the number of piers required when compared to the existing bridge.
- **Precast concrete variable depth spliced girders** can achieve span lengths up to 320 feet. This option is nearly identical to the precast constant depth girders, with the exception that the pier girders get deeper over the piers. This achieves a greater negative moment capacity and allows for longer span lengths. The pier girders match the typical section at the ends to facilitate the closure connections with the end and drop-in girders. However, they vary linearly in depth such that they are approximately 4 feet to

4.5 feet deeper over the piers. This requires additional forms for the precaster, increasing the girder cost. The construction methods are the same as described for the precast constant depth girders. The number of piers is reduced by 20% over the existing bridge.

- **Steel plate girder** and slab construction also offers many of the same advantages of spliced precast girders. Both **constant depth and variable depth** girder arrangements are possible. Longer spans can be achieved, up to 320 feet for constant depth and 400 feet for variable depth plate girders. Additionally, post tensioning is not required, simplifying the superstructure erection procedures. Due to piece length requirements for shipping, temporary falsework or additional cranes will be necessary to erect the plate girders. Cost of steel plate girders versus precast concrete is a function of material availability, the relative location of steel/precast fabricators, fabrication cost, and labor cost. Steel prices are generally more volatile than precast concrete, making future price predictions more difficult. For the constant depth plate girders, the number of piers is reduced by 20% over the existing bridge. For the variable depth plate girders, the number of piers could be reduced by 35% compared to the existing bridge.

Recommendation: Among these four girder/slab bridge types, **the project team recommends eliminating the precast simple span girders made continuous option from further consideration**. While the conventional construction methods associated with this bridge type are a positive, the relatively short span lengths that this bridge type provides are a drawback for the new bridge. The remaining bridge types were retained for more detailed analysis against the established evaluation criteria described in Section 4.

5.3.2 Segmental Bridge Types

For the Segmental bridge types, the study team considered both span by span and balanced cantilever options. Summaries of each bridge type are provided below, along with the team's finding in regard to feasibility of the bridge type for this project.

- **Span by span** construction can achieve span lengths up to 175 feet, which would require a quantity of substructure units similar to simple span precast. Superstructure erection would be completely out of the water. The segments are delivered to a gantry that spans between piers. As each span is completed the gantry launches forward and additional segments are delivered over the previously completed spans. This construction method is typically used in urban areas where site conditions do not allow for falsework. The number of piers would increase by 20% compared to the existing bridge. In order to maintain navigational clearance per U.S. Coast Guard requirements meeting existing clearance, a new bridge using this type of structure would need to incorporate an additional structure type to provide two spans with minimum length of 250 feet.
- **Balanced cantilever construction**, span lengths up to 450 feet are achievable with precast segments. The Task Team recommends that precast segments be considered in lieu of CIP due to construction time. Precast segments can be produced and stockpiled at the same time as the foundations are being cast, shortening the overall project schedule. The segments are delivered by barge to the interior piers and erected by

barge mounted cranes or segment lifters from on top of the previously erected superstructure. The pieces are erected in both directions out from the pier to balance the loads during construction. While the longer span lengths will limit the quantity of substructure, the substructure size will increase due to heavier structure loads. Construction costs are higher due to specialized erection methods, equipment, and large amounts of post tensioning. Additionally, the contractor must build a facility for the production and storage of the precast segments adjacent to the site. The number of piers could be reduced by 50% compared to the existing bridge.

Recommendation: The **project team recommended elimination of the span by span segmental option from further consideration**. Segmental bridges are more complex to build, so in this project environment, the complexity would need to be rationalized by other benefits such as longer span lengths and fewer river piers. In the case of span by span construction, only relatively short spans are feasible, making this an undesirable bridge type for the new bridge.

5.3.3 Evaluation of Bridge Types

Similar to the process for evaluating alignment alternatives, the study team examined all remaining bridge types against the agreed-upon evaluation criteria. A matrix format was also applied to the evaluation along with the +, 0, - rating system for comparative evaluation of alternatives. The resultant evaluation matrix is shown in Table 8.

As shown in the matrix, one additional bridge type was recommended for elimination from further evaluation. The Segmental Concrete (Balanced Cantilever) bridge type was eliminated for reasons related to construction methods and requirements that are not anticipated to be a good fit for this project setting. For example, a large staging area (i.e. 10+ acres in size) may be necessary to accommodate the storage and work space needs of segmental construction. This project location is not well suited to large staging areas.

5.4 Public Involvement – Alternatives Screening Stage

After the project team conducted its evaluation of project alternatives, public meetings were announced by SDDOT and held on December 12 and 13, 2017. As in the first public meetings held in May 2017, the meetings were held in the cities of Winner and Platte. In both cities, SDDOT conducted a “Stakeholder Advisory Meeting” in the afternoon, prior to a public open house held in the evening. SDDOT presentations and meeting materials were the same for both meeting types. Attendance at this second round of meetings was slightly smaller, but similar to the first round of meetings.

The focus of materials and presentations to the public at these sessions was on the range of alternatives, the criteria used to evaluate them, and preliminary recommendations for screening. Meeting discussions also pointed toward the key issues that were anticipated to be central to final decision-making on the project. In general, the volume of comments from the public was greatly reduced in comparison to the first round of meetings. Following is a summary of the comments and questions that were received by the Study Advisory Team during this round of public meetings, with responses and supplemental information provided as appropriate.

- **Avoid Closure of the Crossing** – SDDOT reiterated its intention of avoiding closure of SD44 to traffic. Meeting participants concurred this as being a top priority.

- **Crossing visibility** – participants noted the concern about conflicts on the bridge and how improving sightlines of the bridge from the west approach would help to reduce the risk of large vehicles crossing the bridge resulting in conflicts.
- **North Side Alignments** – among the few written comments received from the public, responders identified that the north side of SD44 appears to be favorable in terms of limiting the amount of impact from the project.
- **Removal of the Bridge or Repurposing of the Bridge Use** – continued interest was expressed in what measures could be taken to leave piers from the existing bridge or the entire bridge in the river as a recreational asset. Piers provide in-river structure that may support fishing uses, and the bridge deck could potentially be used for pedestrian or bicycle functions. SDDOT could not commit to such measures. Any retention of the existing structure would require an evaluation of maintenance responsibilities and liability risk associated with the structure. Bridge removal planning will begin as part of this current study and be finalized as part of final design and permitting processes.

Table 8. Screened Bridge Type Options Comparison Matrix

Bridge Type	Maintenance	# of Foundations (Environmental Footprint)	Staging/ Construction Impacts	Construction Duration	Constructability	Construction Cost	Risk Notes	RECOMMENDATION
Precast Concrete Constant Depth – 265' Span Length	**0 / +** Painting not required for aesthetics only, not maintenance	**0**	**0**	**+** Offsite fabrication can proceed during cold weather	**0**	**0**	Limited local contractor experience with spliced girders	**RETAIN FOR FURTHER EVALUATION**
Precast Concrete Variable Depth – 320' Span Length	**0 / +** Painting not required for aesthetics only, not maintenance	**+** 20% less than existing	**0**	**+** Offsite fabrication can proceed during cold weather	**0**	**0**	Limited local contractor experience with spliced girders	**RETAIN FOR FURTHER EVALUATION**
Steel Plate Girder Constant Depth – 267' Span Length	**0**	**0**	**0**	**+** Offsite fabrication can proceed during cold weather	**0**	**0 / +** Lower preliminary cost estimate (CHANGE TO 0)	Falsework for girder erection	**RETAIN FOR FURTHER EVALUATION**
Steel Plate Girder Constant Depth – 320' Span Length	**0**	**+** 20% less than existing	**0**	**+** Offsite fabrication can proceed during cold weather	**0**	**0**	Falsework for girder erection	**RETAIN FOR FURTHER EVALUATION**
Steel Plate Girder Variable Depth – 400' Span Length	**0**	**+** 30% less than existing	**0**	**+** Offsite fabrication can proceed during cold weather	**–** Limited fabrication ability for haunch sections	**0 / -** Higher preliminary cost estimate	Falsework for girder erection	**RETAIN FOR FURTHER EVALUATION**
Segmental Concrete (Balanced Cantilever) – 400' Span Length	**0 / –** Additional inspection/maintenance at interior of box	**+** 30% less than existing	**–** Large staging area (10 acre) required for production and storage	**–** On site production is susceptible to cold weather, erect only ~40ft segments per day	**–**	**–** Large startup cost (~ $4mil) for production facility, heavy structure & larger foundations	No local contractor experience, complex construction inspection requirements	**ELIMINATE FROM FURTHER CONSIDERATION**

Notes:
- All bridges are assumed to include a 36-foot bridge deck (2 12-foot lanes and 2 6-foot shoulders), length of the bridge is dependent upon the roadway alignment
- All bridges are assumed to replicate the existing vertical clearance over the Missouri River and match in with the same road profile regardless of alignment location

All bridges feature a redundant superstructure

5.5 Finalist Alternatives for Further Evaluation

The outcome from the alternatives development and screening stage of this project was three remaining roadway alignments and one major bridge type category for consideration in the determination of a Recommended Alternative. The following alternatives were advanced by the study team:

Roadway Alternatives for Further Evaluation and Refinement

- S100
- N100
- North Skew (a combination of previously identified North Skew 50-200 and North Skew 50-400 alternatives)

Bridge Type Alternatives for Further Evaluation

- Girder/Slab Bridge Types
    - Precast Concrete Constant Depth
    - Precast Concrete Variable Depth
    - Steel Plate Girder Constant Depth
    - Steel Plate Girder Variable Depth

Section 6. Alternatives Refinement

6.1 Key Environmental and Engineering Issues

6.1.1 Revision to Bridge Buffer Distance

As the study team continued to evaluate the project constraints and opportunities related to the remaining alternatives, further evaluation of the foundation buffer distance was performed. One of the assumptions of the previous evaluation was the depth to which air-jetting could have influenced the sorting of cobbles and boulders in the lake bed. The study team determined that the assumption needed to be modified such that it is now assumed jetting could have extended clear to the layer of bedrock.

The changed assumption meant that a buffer area wider than 100 feet may be needed in some locations, notably the deeper piers. To account for this concern, the project team added 25 feet to the buffer distance, making the largest buffer distance 125 feet. Consequently, the alternatives that had been known as "S100" and "N100" became identified as "S125" and "N125."

6.1.2 Section 4(f) Resources

SDGFP team members provided an overview of the park resource usage and priorities. In the context of this part of South Dakota, Snake Creek Recreation Area is a key location for the provision of campground facilities, offering more than 100 sites and facilities to service recreational vehicles (e.g. dump station). All recreational campground facilities are south of SD44, with several running along or near the SDDOT highway right-of-way. Fishing is also a very popular activity at the park, with the summer months commonly experiencing full or near-full conditions at the boat launch parking area north of SD44. When this launch is full or if boaters wish to focus on the west side of the river, SDGFP also provides the west side area boat launch on the west bank and immediately south of SD44.

Other resources and activities at Snake Creek Recreation Area such as picnic areas, active play areas, trails, "Dock 44" (a privately operated restaurant and convenience store), and a fishing pond help to round out the options available for park users. SDGFP also noted that it recently rebuilt its welcome center to the park, which is located on the south side of SD44. SDGFP's preference would be to keep the welcome center in its current location.

The Platte-Winner bridge has also been determined to be eligible for listing on the National Register of Historic Places (NRHP). This designation means that as a historic resource, the bridge must be considered through the Section 4(f) and Section 106 processes for appropriate mitigation measures under the assumption the bridge will be removed upon completion of a new SD44 river crossing.

6.1.3 Archeological Resources

As part of the evaluation of the initial range of project alternatives, the project team conducted a review of previous cultural resource studies in the project area. That information helped identify potential resources and the extent to which they should dictate alternatives screening. In particular, the area at the east bank of the existing bridge showed multiple previous studies and a higher possibility of encountering cultural resources. Potential resources were identified on both sides of SD44 and the approximated locations of those resources (from previous studies) helped inform the alternatives screening process.

With the narrowing of alternatives, the project team was positioned to conduct an archeological study of each remaining alternative within the east bank area (entirely within the Snake Creek Recreation Area). In May 2018, the study team excavated trenches in or near each of the remaining project alternative alignment corridors. Findings from the study were mixed, with some locations indicating disturbance from previous construction activities. However, trenches on both sides of SD44 did indicate an intact soil profile demonstrating signs of previous human presence on this "plateau" area immediately east of the bridge abutment. No resources were discovered that required preservation or documentation actions. In the context of the remaining alternatives at the time, the areas surrounding S125 and N125 appeared more likely to be part of the plateau that contains archeological resources. The northern area where a North Skew alternative was under consideration showed slightly less potential due to changing topography (e.g. slope down toward the river) and signs of disturbance due to previous actions (buried construction debris).

6.1.4 In-River Ice Loading

Given the importance of apparent ice floe damages on the existing bridge as a driving factor in SDDOT's prioritization of bridge projects, the study team examined the design implications of ice loading on a new bridge. The study of ice loading risks in the river incorporated nearly fifty years of river elevation data during the December to May period (the timeframe each year during which ice damage is a potential concern).

Findings from the study of river elevation and ice loading helped to understand potential design parameters for river piers. Findings from the study determined that ice loading design parameters are not anticipated to have substantive implications on the determination of a recommended bridge location or type alternative.

6.1.5 Geotechnical Footprint of Alternatives

The potential impacts of each alternative on the surrounding landscape, notably the amount of earthwork required to meet SDDOT standards for the proposed highway corridor, could serve as an important differentiator in evaluating the long-term maintenance effects of the project. SDDOT standards for the corridor, such as a 5:1 backslope, help to create a stable corridor with the intention of avoiding potential future landslides. In this project environment, where the highway corridor is traveling through a river valley with notable slopes and ridges especially on the west side of the river, relatively minor differences between the highway alignment corridors can result in substantially different amounts of earthwork to achieve the SDDOT design standards.

The study team conducted a "cut/fill" analysis of the alternatives to evaluate which portions of a proposed corridor would require earthwork to remove soil ("cut") and to add soil ("fill") to achieve a final built corridor. While it is generally desirable to avoid or minimize the amount of cut and fill involved in a project, it may also be feasible to have a large amount of cut and fill areas, if the two volumes are able to balance out. That is, assuming the cut material can serve as fill soil for a stable built project, a perfectly balanced ratio of cut material to fill needs can work well in terms of construction complexity and cost. A project that is unbalanced in its cut/fill needs can create additional costs to manage the left over soil or the need for hauling in more from an external site.

The cut/fill assessment conducted on the three remaining alignment alternatives revealed that the south side ("S125") alternative was able to minimize the overall amount of cut and fill required without changing the elevation of the roadway or bridge that exists today. Analysis of the north side alternatives (using N125 and a north skew alternative 400 feet from the existing bridge on the east bank) showed that a large amount of cut would be necessary on both sides of the river if the existing roadway elevation is retained on the new project. See Figure 12 for a graphic and estimate of the volume of cut and fill for each alternative, the full-size version is available in Appendix I.

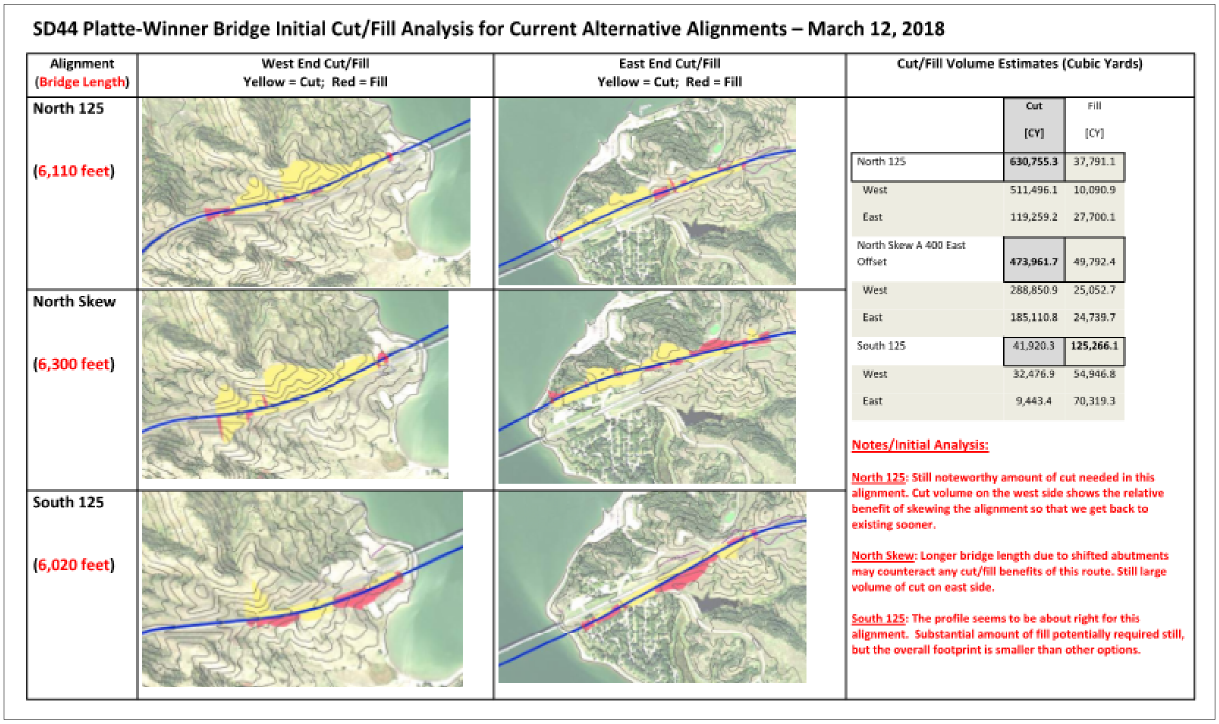


Figure 12. Volume of Cut and Fill for Refined Alternatives

6.1.6 Abutment Location and Design

An important component to determining the project footprint and impacts of road and bridge construction is the determination of bridge abutment locations. In short, the bridge abutment is the location where the project transitions from roadway construction to bridge construction. As an important transition area, the abutment area of a bridge may require additional structural stability and fortifications to assure a smooth connection between the highway corridor and the bridge structure is maintained. In this project's river environment, the natural topography can be challenging for locating the abutments due to the presence of steep bluff lines and variability in the location of bedrock that can provide a suitable foundation support for the abutment.

Recognizing that the soils in the area will pose some challenges (as described in Section 2.3), this decision document provides a little more flexibility in determining the optimum location for the abutments. The final location and grading configuration will need to be selected based on further geotechnical exploration, laboratory testing, and stability analyses performed with consideration to the above and below water topography, graded slopes extending from the tie-in points to the edge of roadway or abutment, and the resulting fill and structure loads placed on the native soils. Depending on the results of the analyses, there may be cost benefits to constructing the abutments closer to the river. This approach would result in a shorter bridge structure that may be less expensive to construct. But that must be weighed against the potential costs to locate suitable soils for fill, to mitigate settlement with deeper fills beneath the roadway, and grading adjacent to the river shoreline.

6.2 Revisions to Alignment Alternatives

6.2.1 Raising North Alignment Elevation

The ongoing study of project issues as summarized in Section 6.1 led to a review of the roadway alignment profile to be assumed for evaluation of project impacts. Key issues in this area included the following:

Archeological studies suggested that ground disturbance at depths of approximately 5 feet below the existing surface could result in impacts to potential cultural resources.

Cut/fill studies of the alignments were able depict 1) whether cut areas would be in the vicinity of potential archeological resources, and 2) the overall footprint of each alignment in terms of volume of earthwork needed

These two issues were central to the SDDOT decision to adjust the assumed elevation of alternatives on the north side of SD44. In order to reduce the amount of cut on both sides of the river and avoid impacts to potential cultural resources, SDDOT determined that alternatives north of SD44 should be raised approximately 10 feet from the current elevation. Because of the topography on the south side of SD44, a similar roadway elevation change was not necessary for the S125 alternative.

6.2.2 Screening of North Alignment Alternatives

In comparison of three remaining alignment alternatives, the continued studies helped to clearly identify differentiators between the S125 alignment and the northern alignments. The southern alignment offered clear benefits in terms of geotechnical impact minimization, but also represented the most direct impact to SDGFP’s campground facilities (their Section 4(f) resource priority).

For purposes of evaluating a wider environmental footprint, the comparison at this level included the N125 alignment and a North Skew alternative that is 400 feet from the existing bridge on the east bank. While these alternatives feature differentiators against the S125 alignment, when compared to each other, SDDOT determined that the N125 alignment did not compare favorably to the North Skew alignment due to the larger geotechnical footprint it created on the west side of the river and the comparative lack of flexibility in optimizing the footprint to avoid impacts to plateau area identified as potentially containing resources. For this reason, **SDDOT chose to eliminate the N125 alternative from further consideration as well as a North Skew alternative that is 400 feet from the existing alignment**. A “refined” North Skew alternative resulted as the recommendation; one that would align somewhere between 125 feet and 400 feet from the existing SD44 alignment on the east side of the river.

SD44 Northern Alignment Evaluation Matrix – August 2018

Alignment	Geotechnical	Cultural Resources	Section 4(f)/6(f)	Other Environmental Resources	Bridge*	Roadway	Cost	Constructability/Risk	Status/ Recommendation
North Skew 400'	West Side: Skew returns the highway to existing alignment closer to the river (versus N125 alignment) reducing the footprint East Side: 400-foot separation from SD44 pushes the alignment beyond the "shelf" and into uncertain geology with greater impacts to the ridgeline on this side	Alignment appears to avoid the "living surface" area encountered in the May 2018 dig and the unevaluated site previously identified, but overall footprint still at risk of conflicting	SCRA: Has potential to avoid the maintenance shops area – allowing it to stay in place during and after construction, but uncertain if that is the case. Other North side resources (residence, dump station) are impacted West End: space appears to be available for staging on the north side, limiting potential use of south side boat launch area for staging	East side habitat impact and disturbance to the landscape is heaviest with this option, potentially more challenging alignment for Section 408 permitting West side is already generally disturbed with minimal natural resources to be impacted	Longest distance between approximate abutment locations = 6,300 feet Outside of the in-river foundation "buffer area" by 40 feet	Pushing northward into the ridgeline on the east side creates risks for sightlines/access from the park and turning onto SD44 This alignment is very close to the slope down to the lagoon	Extra bridge length adds cost Uncertain geology on east side – likely additional geotechnical stability costs All north bridge alignments have substantial costs on west side due to footprint	Geotechnical risks on east side with roadway location along ridge and abutment on the north edge of the shelf that cuts back to the bay Separation from the in-river alignment minimizes foundations conflict risk	<u>Eliminate this alternative from further consideration</u> (east side benefits are minimal with greater footprint, and don't achieve desired footprint reductions on west side)
North 125'	West Side: Largest footprint of the three northern alignments, causes long-term maintenance concerns (landslides) East Side: Better understood geology and reduces the cut impacts to the ridgeline	Conflicts with the May 2018 cultural resource survey "living surface" and a previously unevaluated site – raising the alignment above the site is an avoidance option	SCRA: Has the potential to avoid the residence. Other North side resources (house, dump station are impacted) West End: less space for staging on north side compared to skewed alternatives; potentially causes need for south side boat launch area staging uses	East side natural resource impacts are minimal, shorter bridge length could result in less in-river impacts, but the footprint on the west impacts more habitat West side is already generally disturbed with minimal natural resources to be impacted	Distance between approximate abutment locations = 6,225 feet Alignment is optimized relative to the foundation buffer area (cannot get any closer)	Of the three alignments, this is closest to retaining the existing roadway geometry and sightlines	Largest west side footprint requires larger short-term investment in slope stabilization Slightly shorter bridge length is a minor cost savings versus other north options	Large footprint on west side is a long-term risk for slope stability Still outside of in-river foundations conflict buffer, but is effectively the closest of the three alignments to this risk area	<u>Eliminate this alternative from further consideration</u> (west side impacts and risks appear to far outweigh any east side benefits)
Refined North Skew	West Side: by pushing to the edge of the foundations buffer, the skew comes closer to SD44, further reducing the footprint East Side: better positioned to use the geologic shelf and reduce bridge length (versus North Skew 400)	Conflicts with the May 2018 cultural resource survey "living surface" and a previously unevaluated site – raising the alignment above the site is an avoidance option	SCRA: Residence, Maintenance, and Dump Station are impacted West End: appears to create most space on north side for staging, thereby limiting the potential need to use the south side of SD44 for staging	East side impacts are reduced (relative to North Skew 400) by running through the area occupied by buildings and better avoidance of the lagoon area West side is already generally disturbed but footprint is minimized through this area	Distance between approximate abutment locations = 6,250 feet Alignment is optimized relative to the foundation buffer area at west end	This alignment strikes a balance between the other alternatives and moves away from the lagoon pit slope. This Cut and fill volumes on the east side are fairly balanced	Extra bridge length adds minimal cost Reduced footprint on west side reduces costs to get back to SD44	Lowest risk option of the three – uses the east side shelf, the foundations risk is minimized on the eastern 2/3 of the in-river alignment, and the west side footprint is smallest.	**<u>Retain this alternative for further consideration and rename it as the "North" Alignment/Alternative</u>**

*Note: the bridge distance calculations are slightly outdated based on new guidance for bridge abutment design, but the relationships between alternatives remain the same, with no change relative benefits/issues

Figure 13. SD44 Northern Alignment Evaluation Matrix (Included in Appendix I)

6.2.3 Abutment Location and Impact

As referenced in Section 6.2.2, continued examination of the North Skew alternative determined that it could be optimized to align closer to the existing bridge. Doing this helps to reduce the length of the new bridge and further reduce the distance needed to tie-in to the existing highway on the west side of the project. Further geotechnical exploration, testing, and analysis will be critical to finalizing the location of the abutment as discussed in Section 6.1.6. However, the project team anticipates that constructing the east abutment closer to the existing bridge reduces the risk of affecting cultural resources that are potentially located near the river in Snake Creek Recreation Area. Another benefit of reducing the separation from existing SD44 is that the alignment may be able to take advantage of bedrock outcroppings on the east bank as part of the geotechnical design, thereby reducing the length of new bridge to a total length that is similar to the S125 alignment.

6.2.4 Bridge Deck Elevation

Modifications to the North Skew alignment did have an impact on the bridge design as well, creating a notable differentiation versus the S125 alternative. By raising the North Skew road elevation 10 feet, the elevation of the bridge deck was also raised 10 feet. In terms of engineering feasibility, this remains a viable alternative. The additional height of the bridge does not make the North Skew alignment less feasible. In terms of cost, this change does mean the bridge for a North Skew alignment will have taller, and consequently more expensive, piers; however, the cost increase was determined to be minimal in comparison with the overall bridge cost.

Section 7. Identification of Recommended Alternative

7.1 Comparison of Final Alternatives

The evaluation of alternatives referenced through Section 6 of this Corridor Study resulted in two alternatives remaining for comparison, a “South” alternative (the “South 125” option) and a “North” alternative (the “North Skew” option). The project study team developed engineering plan and profile designs for each remaining alternative to aid in the comparison. Because the transition from roadway to bridge marks a key area for potential impacts (both geotechnical and archeological), the team prepared initial concepts for abutment locations on both alignments as well. Each of these design drawings are presented in Appendix J.

Table 9 below provides a summary comparison of key factors in the determination of a Recommended Alternative, including notes about the how the North and South alignments differ relative to each of the factors.

Table 9. Factors for Comparison in SD44 Platte-Winner Bridge Recommended Alternative Determination Process (October 2018)

	Bridge Length	Bridge Design	Geotechnical – In River	Geotechnical – Out of River	Roadway Geometrics	Section 4(f)/6(f)	Section 106	Construction/ Staging	Cost
Comments	Differences between the alternatives are associated primarily with abutment location decisions. Current design concepts for each Alignment result in the north bridge being shorter by approximately 130 feet. North Alignment: Sta. 45+80 to 103+00 South Alignment 46+00 to 104+50	No substantive difference between the Alignments is anticipated horizontally. Given the minor difference in overall bridge length, we expect both bridges to have the same number of piers in the river. The North Alignment road profile is ten feet higher than the South (which is approximately at the existing SD44 elevation). A higher roadway will result in taller pier columns. Location of bridge abutments has been developed such that very little disturbance of the existing ground is necessary. That is, abutments will be primarily built on fill.	Both alignments stay out of the “buffer” area that is a concern for conflicts between new bridge piles and boulders/aggregate surrounding the old bridge. However, both alignments have portions of the corridor that are immediately adjacent to the buffer area. The North Alignment adjacent area is closer to the west bank of the river. The South Alignment adjacent area is in the middle of the river	Both alignments appear to take advantage of the prominent natural bedrock protrusion that led to building the current bridge in this location. The North Alignment roadway was raised ten feet to match in better with the existing topography on both sides of the river. West Side of River: Even with the profile raise, the North Alignment does require cutting into the existing slopes, which is a long-term maintenance (landslide) concern. South Alignment minimizes that impact East Side of River: some cutting into slopes will be needed for the North Alignment.	Both alignments have been conceptualized with roadways that comply with SDDOT standards, road width on the bridge is the same for both alignments and addresses a public concern about large equipment crossing the river. The North Alignment is elevated 10 feet from the current profile in order to fit into the landscape more appropriately. Stakeholders have expressed concern about visibility of the river crossing as they come down the hill from the west. The North Alignment potentially runs counter to that concern, though the profile raise might help to address that concern (which has not manifested in any crash problems). Similarly, the South Alignment may create sightline concerns for vehicles coming down to the river from the east and approaching the Snake Creek Recreation Area entrance	Both alternatives impact the Snake Creek Recreation Area (SCRA). The south Alignment has greater impact to recreational resources in SCRA, with impacts to the entrance area and campground (upwards of 12-15 sites impacted). The North Alignment impacts maintenance and support facilities within SCRA and poses a slight risk to boat launch access. West Side boat launch is directly impacted by the South Alignment; it is not impacted by North Alignment. Prior to any discussion of mitigation for this setting, a 4(f) analysis would identify the North Alignment as the alternative with “least overall harm” to Section 4(f) resources and therefore FHWA could only approve the North Alignment. This situation points to a need for <u>substantive</u> mitigation measures if the South Alignment is to be chosen and approved by FHWA. Section 6(f) impacts may be minimal in the South Alignment (no net loss of park land) versus a slight loss of park land with North Alignment that would require modest mitigation.	A Level III cultural resources survey in Summer 2018 identified a “living surface” area in SCRA on either side of the existing SD44 alignment with the potential for containing archeologic resources in areas outside of previously identified and unevaluated sites. Any ground disturbance created by a new alignment poses the risk for cultural resource impacts. Latest iterations of the North and South Alignments (including modifications to the abutment design on both alignments and raising the North Alignment profile ten feet) indicate that it is feasible to reduce ground disturbance to the extent that either alternative could be considered a “plating” option that simply builds on top of the existing ground with little to no disruption. This refinement to the alignments is encouraging for the opportunity to obtain a determination of no effect for the project, thereby resolving Section 106 permit concerns.	No key differentiators between the two alignments have been identified to date. Working assumption is that staging occurs on the west side of the river and on the same side of SD44 as the new alignment. Space appears to be available on both sides to do that. Construction impacts to access at SCRA appear to be negligible and manageable such that access to the recreational resources will not be significantly impacted during construction.	Factors likely to cause differences in cost include: Longer bridge – the South Alignment, at 130 feet longer, could be around $1M more expensive for its length. Taller bridge – the profile raise associated with the North Alignment will require taller pier columns. The extra cost is minimal relative to the total cost of the bridge (<1%), at this level of study it can be considered equivalent to the savings created by a shorter total span length. More earthwork – immediate costs for managing slope stability risks as part of construction, and then the longer-term risk of maintenance with landslides make the North Alignment more expensive. Section 4(f) impacts occur on both sides of SD44 with undetermined cost implications. However, the North Alignment may have relatively straight-forward replacement of shops versus complicated/costly mitigation of campground and West End boat launch impacts that would make the South Alignment costlier. That said, the extra cost could be considered long-term risk management (i.e. a one-time cost to reduce potential long-term maintenance costs associated with landslides).
Effect on Recom-mended Alternative Selection	Shorter bridge length favors the **North Alignment**	Lower bridge deck elevation creates slight preference toward **South Alignment,** but perhaps only from a cost perspective.	From a risk management perspective, the **North Alignment** could be argued to manage risk better than South because the location closest to existing bridge area is in shallower depth to bedrock.	Extent of earthwork impacts on the north side and relative ability to avoid impacts make the **South Alignment** preferable. Geotechnical risk is reduced with this alignment.	Lack of previous crash history in corridor makes differentiation difficult, if safety around SCRA is the top concern, it may make the **North Alignment** more desirable.	Lacking a definitive mitigation plan, the **North Alignment** is preferred due to least overall harm measure. SDGFP acceptance of a mitigation plan for South Alignment impacts would eliminate FHWA authority over this decision by way of a *de minimis* finding.	Current concept designs result in **no clear differentiation** between alignments	Current concept designs result in **no clear differentiation** between alignments. **<u>Contractor input may be necessary to identify differentiators here</u>.**	The cost factors described above may tend to balance out and result in **no clear differentiation** between alignments.

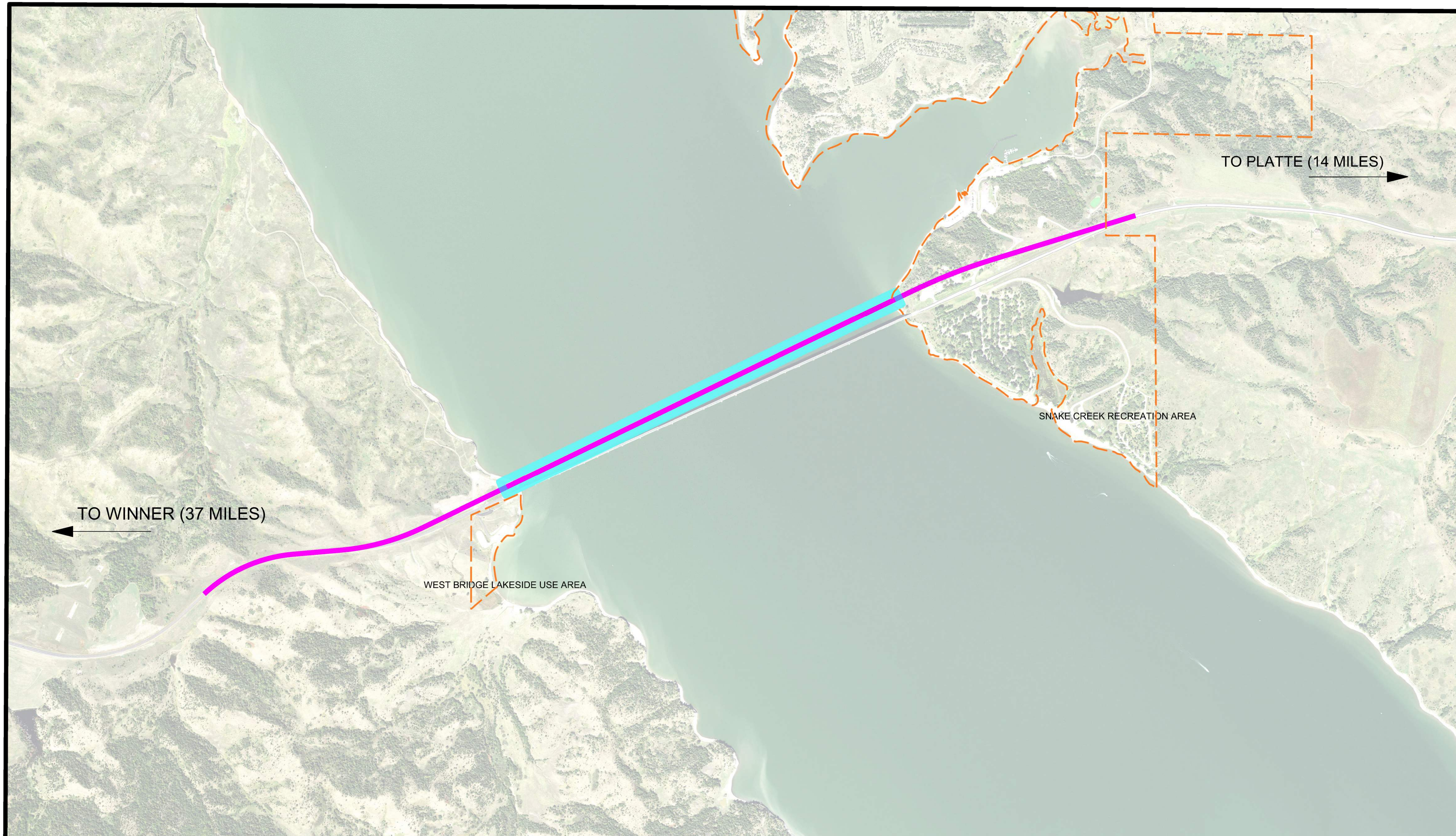
7.2 Recommended Alternative

In October 2018, SDDOT team members advised the study team that they have identified a Recommended Alternative to be pursued for further study and evaluation. The North Skew alignment was selected as the Recommended Alternative. A public press release was shared on the project web site and distributed to news outlets in December 2018 to provide a project update with the decision included.

The Recommended Alternative, shown on the following pages, will be evaluated through review of project impacts in a wide range of category areas that are part of an Environmental Assessment (EA). The EA process will result in the determination of a formal Preferred Alternative that will be presented to the public for comment.

7.3 Environmental Documentation and Mitigation Planning

The EA process results in a comprehensive understanding of anticipated impacts from the proposed project. Additionally, the EA will identify mitigation measures that are necessary to comply with relevant laws, regulations, and guidance.



PARK/RECREATION AREA BOUNDARY

RECOMMENDED ALTERNATIVE

APPROXIMATE EXTENT OF NEW BRIDGE

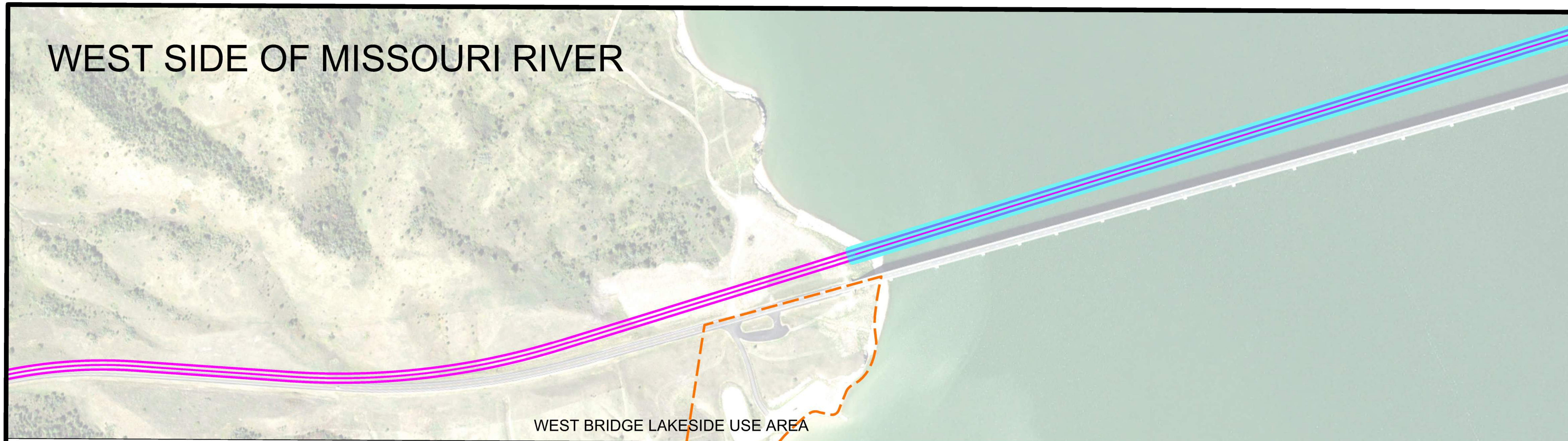
RECOMMENDED ALTERNATIVE ALIGNMENT

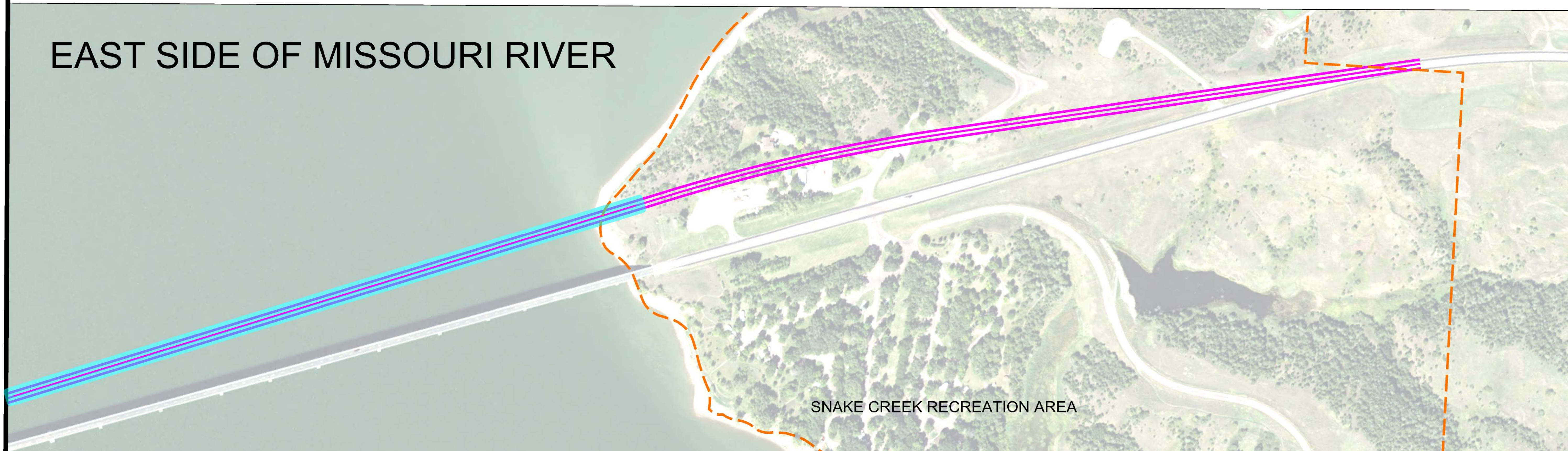
South Dakota DOT
Project HP5596(19) 3616 P; P0044()290 3014 N, PCN 05X0
SD 44/Platte-Winner Bridge Corridor Study and Environmental Assessment
Gregory and Charles Mix Counties

HRGreen

NORTH

0 600 1200
Feet





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