Memorandum

To: Steve Groen, Highway Superintendent
Minnehaha County

From: Nick Semeja, PE, Team Lead
Hunter Fier, Traffic Studies Engineer

Date: March 12, 2024

Subject: Minnehaha County Highway 104 Bridge Replacement Project – FY 2023-2024 Bridge Investment Program

Benefit-Cost Analysis Memorandum

Introduction

This memorandum summarizes the assumptions, methodology and results developed for the benefit-cost analysis of the No Build and Build Alternatives evaluated as part of the Minnehaha County Highway (Co. Hwy) 104 Bridge Replacement Project – FY 2023-2024 Bridge Investment Program Application. The objective of a benefit-cost analysis (BCA) is to bring all the direct effects of a transportation investment into a common measure (dollars), and to account for the fact that benefits accrue over an extended period while costs are incurred primarily in the initial years. The primary elements that can be monetized are travel time, changes in vehicle operating costs, vehicle crashes, environmental impacts, capital costs, remaining capital value, and maintenance costs. The benefit-cost analysis can provide an indication of the economic desirability of an alternative, but decision-makers must weigh the results against other considerations, effects, and impacts of the project.

Co. Hwy 104 is an important east-west rural major collector corridor, part of a broader transportation network that connects vital commodities and small communities in northern Minnehaha County to Interstate 29 (I-29), five-miles to the west of the Project, Minnesota State Highway 23, ten-miles to the east, and U.S. Highway 75 (US 75), 18-miles to the east. Co. Hwy 104 spans 12-miles from the Dell Rapids eastern city boundary to South Dakota State Highway 11 (SD 11) near the South Dakota-Minnesota border on the east. The Project is important to the County because of the essential mobility provided by Co. Hwy 104, connecting residents and critical rural commodities to and from destinations in northern Minnehaha County, southeastern Moody County, and southwestern Pipestone County, Minnesota, including residents between Dell Rapids and Minnesota. The existing transportation challenges in the area include:

- Poor state of repair of two bridges (bridge no. 50-216-015 and 50-219-015) including structurally deficient and/or functionally obsolete structure, poor deck condition, poor superstructure condition, fair substructure condition, and minimally tolerable structural evaluation appraisal;

- Fair state of repair of bridge 50-277-015 including structurally deficient and/or functionally obsolete structure, fair deck condition, fair superstructure condition, and satisfactory substructure condition;
- Significant mobility and reliability concerns along Co. Hwy 104 due to deteriorated conditions and potential load postings and/or closures of these bridges; and
- Outdated bridge component standards such as bridge railing, transitions, approach guardrails, and guardrail ends increase the safety risk for people traveling over the bridges.

The project consists of a bundle of three bridges to be reconstructed. Additionally, the Project includes roadway improvements associated with the bridges, including roadway reconstruction (approximately 300 linear feet per structure) with two 12-foot travel lanes and two-foot paved shoulder, replacement of roadway pavement markings, and replacement of rumble strips.

Description of Alternatives

For the purpose of this analysis, a No Build and Build Alternative were under consideration.

No Build Alternative

The No Build Alternative assumed that no major rehabilitation work would be undertaken on the Minnehaha County bridges. According to the National Bridge Inventory Report, the bridges are either structurally deficient, functionally obsolete, or in need of repair due to other existing moderate to serious issues (Table 1). In general, the bridges are experiencing significant structural issues including moderate to severe transverse and longitudinal cracking, cracking of abutments and columns, spalled concrete, and exposed rebar. Other issues include railing rust, exposed footing, and channel scour.

Table 1 – Bridge Condition Ratings

Bridge	Location	Deficient Status	NBI Condition Rating[1]					Remarks
			Deck	Super-Structure	Sub-Structure	Channel	Culvert	
50-216-015	MRM 21.6 CR 104 over Tributary to Big Sioux River	Structurally Deficient Functionally Obsolete	4	4	5	6	N	Built in 1922, reconstructed in 1966. Does not meet currently acceptable standards for: Bridge Railings, Transitions, Guardrail, and Guardrail Ends. Structural evaluation is minimum tolerable.
50-219-015	MRM 21.9 CR 104 over Tributary to Big Sioux River	Structurally Deficient Functionally Obsolete	4	4	5	7	N	Built in 1938. Does not meet currently acceptable standards for: Bridge Railings, Transitions, Guardrail, and Guardrail Ends. Structural evaluation is minimum tolerable.
50-277-015	MRM 27.7 CR 104 over West Pipestone Creek	Functionally Obsolete	5	5	6	6	N	Built in 1940. Does not meet currently acceptable standards for: Bridge Railings, Transitions, Guardrail, and Guardrail Ends. Structural evaluation is better than minimum adequate.

[1] Bridge condition scores greater than 7 suggest a bridge is new or was reparied to a *good* condition. Scores 5 and less indicate fair to serious condition and repair is required.

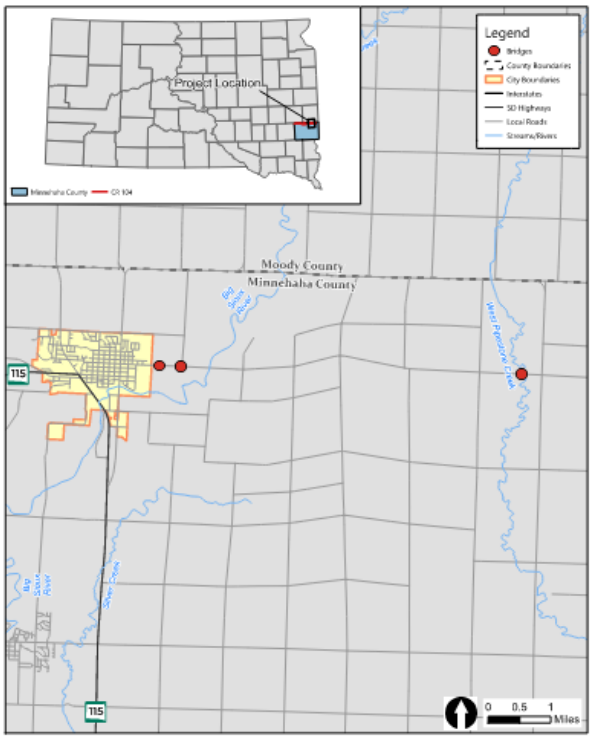
A memorandum summarizing the estimated bridge load posting and ultimate closure timelines is provided in Attachment A of the BCA Narrative. The bridges are expected to be load posted in year 2030 and closed in year 2044 based on current bridge conditions and remaining service life. The assessment also determined that rehabilitation or other maintenance activities to perpetuate closure of the bridges would not be economically viable. More detail regarding the bridge conditions, structural issues, and expected closure dates are in Attachment A of the BCA Narrative.

The remainder of the transportation network assumed no changes relative to its existing layout.

Build Alternative

The Build Alternative included reconstruction and rehabilitation of the three bridges.

Figure 1 – Project Location Map



Detail regarding the proposed improvements is provided below.

Benefits were quantified for the following improvements:

- Removing existing bridges 50-216-015, 50-219-015, and 50-277-015;
- Reconstructing all three bridges to current modern standards including bridge railings, transitions, approach guardrail, and bridge guardrail ends;
- Extending the width/length of all three bridges to accommodate SDDOT's 15-foot clear zone requirements.
    - Widening of all the reconstructed bridges to 28-foot total pavement width including up to four-foot paved shoulders along both traffic directions to allow for improved sight distances;

Benefits were not quantified for the following improvements:

- Installing pavement markings and rumble strips along each new bridge;
- Reconstructing approximately 250 to 300 feet of roadway associated with each bridge location to match revised bridge profile.

Maintenance costs associated with the bridges were expected to be incurred over the benefit cost analysis period. Similar to the No Build, no other improvements were considered for the Build Alternative in the analysis.

BCA Methodology

The following methodology and assumptions were used for the benefit-cost analysis:

1. Main Components: The main components analyzed included:
    - Travel time/delay
    - Vehicle operating costs
    - Air quality impacts
    - Crashes by severity
    - Initial capital costs: Capital costs were expected to be incurred in years 2028 through 2029
    - Remaining Capital Value: The remaining capital value (value of improvement beyond the analysis period) was considered a benefit and was added to other user benefits.
    - Operating and maintenance costs
2. **Analysis Years**: This analysis assumed that the Build Alternative would be constructed over a two-year period, starting in year 2028, with completion in year 2029. Therefore, year 2030 was assumed to be the first full year that benefits will be accrued from the project. The analysis primarily focused on annual benefits for the thirty-year period from 2030 to 2059[1]. The present value of all benefits and costs was calculated using 2022 as the year of constant dollars.
3. **Economic Assumptions**: Value of time, vehicle operating costs, emissions costs, and cost of crashes were obtained from the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs, dated December 2023[2]. The analysis was completed using an assumed discount rate of 3.1 percent.
4. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Changes in network VMT and VHT were based on anticipated detour routes vehicles would take to get to their destinations under a scenario with the bridges closed (i.e., the No Build) compared to a scenario with the bridges open (i.e., the Build). Detour routes under No Build conditions were provided by SDDOT and are assumed to follow state or county highways to bypass the project portion of Co. Hwy 104. VMT/VHT for the existing route and the detour route were determined per user using Google Maps. These routes and their associated detours are shown in the BCA Workbook.

    The shifts in VMT and VHT were applied to existing and forecast3 number of users along Co. Hwy 104 to determine annual VMT and VHT changes. Benefits were quantified for the

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1A thirty-year benefit cost analysis period was assumed considering the newly constructed bridges are expected to have service lives far beyond the analysis period.

2 https://www.transportation.gov/mission/office-secretary/office-policy/transportation-policy/benefit-cost-analysis-guidance

3 The annual growth rate for Co. Hwy 104 was obtained from NBI reports for the project bridges.

thirty-year period between 2030 and 2059. Benefits due to change in VMT and VHT were calculated using costs per mile and per hour that account for vehicle occupancy and different vehicle types.

5. **Vehicle Occupancy and Vehicle Types**: The composite cost per mile used in the benefit-cost analysis accounted for the percentage split of autos and trucks in the travel area. The composite cost per hour accounted for vehicle occupancy ratios and the percent split of autos and trucks traveling in the area. Key assumptions for these areas included:
    - Vehicle occupancy that was used in the analysis is consistent with values provided in USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs, dated December 2023. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.
    - The percentage of trucks (9.8 percent) in the area was obtained by a county study performed by Minnehaha County in 2024.
6. **Safety Analysis**: The Build Alternative improves safety in the project area by allowing users to drive fewer miles while on safer facilities to reach their destinations. Five years of existing crash data was gathered from the South Dakota Department of Safety for Co. Hwy 104 and the detour route to determine average crash rates by severity for each route. The change in VMT on Co. Hwy 104 and the detour route was applied to existing crash rates by severity on each corridor to determine the change in annual crashes by severity.

    The safety benefit was quantified for the thirty-year period between 2030 and 2059. Crash cost assumptions for the KABCO scale are consistent with values and methodologies published in the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs, dated December 2023.

    There was one crash in the five years of data that was associated with clear zone on the bridges (i.e. a vehicle struck the bridge rail). This crash was modified with a CMF in the build scenario, as the clear zone is being widened near the bridges under the Build Alternative.
7. **Environmental and Air Quality Impacts**: Annual VMT is expected to increase due to the bridge closures along Co. Hwy 104 under the No Build Alternative. Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3. Emission rates per vehicle type are provided in the attached BCA Workbook. Total change in emissions was valued in accordance with the Benefit Cost Analysis Guidance for Discretionary Grant Programs, dated December 2023.
8. **Operating and Maintenance Costs**: Maintenance and inspection costs associated with the Minnehaha County bridges were quantified for the Build Alternative. Maintenance activities, costs, and frequencies per bridge were provided by Minnehaha County and assumed for all three bridges. No maintenance was assumed for the No Build Alternative.
9. **Calculation of Remaining Capital Value**: Because the reconstructed bridges are expected to have service lives well beyond the 30-year analysis period, the remaining capital value was calculated for the Build Alternative. This value was expressed in terms of 2022 dollars and was added to other project benefits in accordance with USDOT guidance. In determining the remaining capital value of the Build Alternative, project components were assumed to have a

linear depreciation from the time construction was completed to the end of their service lives. The remaining capital value quantities were discounted and attributed to other project benefits for the Build Alternative.

10. **Factors Not Quantified**: Several factors were not quantified as part of the analysis that could potentially add to the benefits assumed in the BCA. These factors include the following:
    - Changes in needed upkeep and maintenance and additional delay per user on corridors associated with detour routes under the No Build Alternative due to a shift in VMT.
    - Safety benefits of installing pavement markings and rumble strips along each new bridge.
    - Safety benefits of modernizing bridge features such as bridge railing, transitions, approach guardrail, and bridge guardrail ends.
    - Intensified maintenance of the bridges and pavement may be necessary under the No Build Alternative between when construction would be completed under the Build Alternative and when bridges would be expected to close under the No Build Alternative.

BCA RESULTS

The benefit-cost analysis provides an indication of the economic desirability of a scenario, but results must be weighed by decision-makers along with the assessment of other effects and impacts. Projects are considered cost-effective if the benefit-cost ratio is at least 1.0. The larger the ratio number, the greater the benefits per unit cost. Results of the benefit-cost analysis are shown in Table 2. See the BCA Workbook for the complete benefit-cost analysis workbook.

Table 2 – Project BCA Results

	Initial Capital Cost (2022 Dollars)	Project Benefits (2022 Dollars)	Benefit-Cost Ratio (3.1% Discount Rate)	Net Present Value (2022 Dollars)
No Build vs. Build	$3.1 million	$74.9 million	24.1	$71.8 million

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Attachment A

Bridge Load Posting Timeline and Ultimate Closure Timeline Assessment

MEMORANDUM

DATE: February 6, 2024

FOR: Minnehaha County, South Dakota Bridge Type Study BIP Grant Application
Str. No.'s 50-216-015, 50-219-015, & 50-277-015 on County Highway 104 (Jasper Street)

AUTHOR: Chris Brozik, PE | Vice President, Civil Design Inc.

SUBJECT: **BIP Grant Application | Bridge Load Posting Timeline & Ultimate Closure Timeline**

In order to assist with the Benefit Cost Analysis (BCA) for the referenced grant application being prepared by SRF Consulting Group, there are three (3) main questions that require engineering judgement and expertise to best determine a valid answer.

The three (3) questions are as follows:

1) Based on current bridge conditions, when would County Highway 104 have to be load posted based on the earliest bridge posting date (assuming one posting would trigger detours around all bridges); the BCA requires an assumed estimated year in which this would occur.
Answer: 2030.

2) Similar to question 1), but for all traffic loading scenarios (passenger vehicles up to truck traffic). The BCA needs to compare the project to a hypothetical 'no build' scenario where the project work does not occur.
Answer: 2044.

3) Maintenance – Are maintenance items able to be performed as a build alternative to help extend the service life of each bridge in lieu of bridge replacement? Maintenance schedule and costs associated with each maintenance activity, if maintenance is a considerable build alternative.
Answer: Maintenance for each of the three (3) bridges is not economical due to the overall condition of the concrete slab/superstructure. Maintenance costs are not being considered as a build alternative is not economical. See additional explanation below.

Supplementary information to the answers above have been provided below.

Below are current conditions for each structure along with estimated years for needing to load post the bridge and estimated years for ultimate bridge closure (can no longer safely carry any traffic load, assuming no maintenance).

50-216-015 (Built in 1922):

- Condition Ratings: Deck – 4 Super – 4 Sub – 5 Suff. Rating – 48.50
- **Anticipate needing to post structure for reduced load within the next 8-12 years. (Priority 2)**
  - **Estimated load posting requirement in year 2032.**
- **Years until ultimate closure: Approximately 25-35 years (2049-2059).**

50-219-015 (Built in 1938):

- Condition Ratings: Deck – 4 Super – 4 Sub – 5 Suff. Rating – 35.30
- **Anticipate needing to post structure for reduced load within the next 6-8 years. (Priority 1)**
  - **Estimated load posting requirement in 2030.**
- **Years until ultimate closure: Approximately 20-25 years (2044-2049).**

50-277-015 (Built in 1940):

- Condition Ratings: Deck – 5 Super – 5 Sub – 6 Suff. Rating – 58.50
- **Anticipate needing to post structure for reduced load within the next 15 years. (Priority 3)**
  - **Estimated load posting requirement in year 2039.**
- **Years until ultimate closure: Approximately 40 years (2064).**

Below is an explanation as to why maintenance is not an economical consideration.

All three (3) bridges have issues with the concrete slab/superstructure due to an asphalt overlay being in-place for multiple years, resulting in moisture retention and chloride contamination. In my opinion, rehabilitation or preventative maintenance of the existing slabs is not feasible. Multiple other items would require addressing with the maintenance/rehabilitation of the slab including deck widening to accommodate current and future traffic needs, abutment widening to accommodate the deck widening, barrier rail upgrades, safety features such as approach guardrail, substructure repairs, scour mitigation, etc. Performing maintenance at this point on all three (3) bridges would not provide economic benefit as rehabilitation costs to extend the service life would likely exceed 60% of the replacement costs. For these reasons, maintenance costs associated with these structures were not included.

For reasons mentioned above, it is my opinion that there are no other rehabilitation activities that would be beneficial to extend the service life of the existing bridges prior to considering full reconstruction.

Respectfully,

Chris Brozik, PE
Vice President

Attachment B

Benefit-Cost Analysis Worksheet