Memorandum

To: Steve Gramm, P.E, Planning Squad Leader
South Dakota Department of Transportation

From: Matt Flanagan, Engineer
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Date: August 18, 2023

Subject: New Underwood Road Reconstruction - 2023 MPDG Grant Application

Benefit-Cost Analysis Memorandum

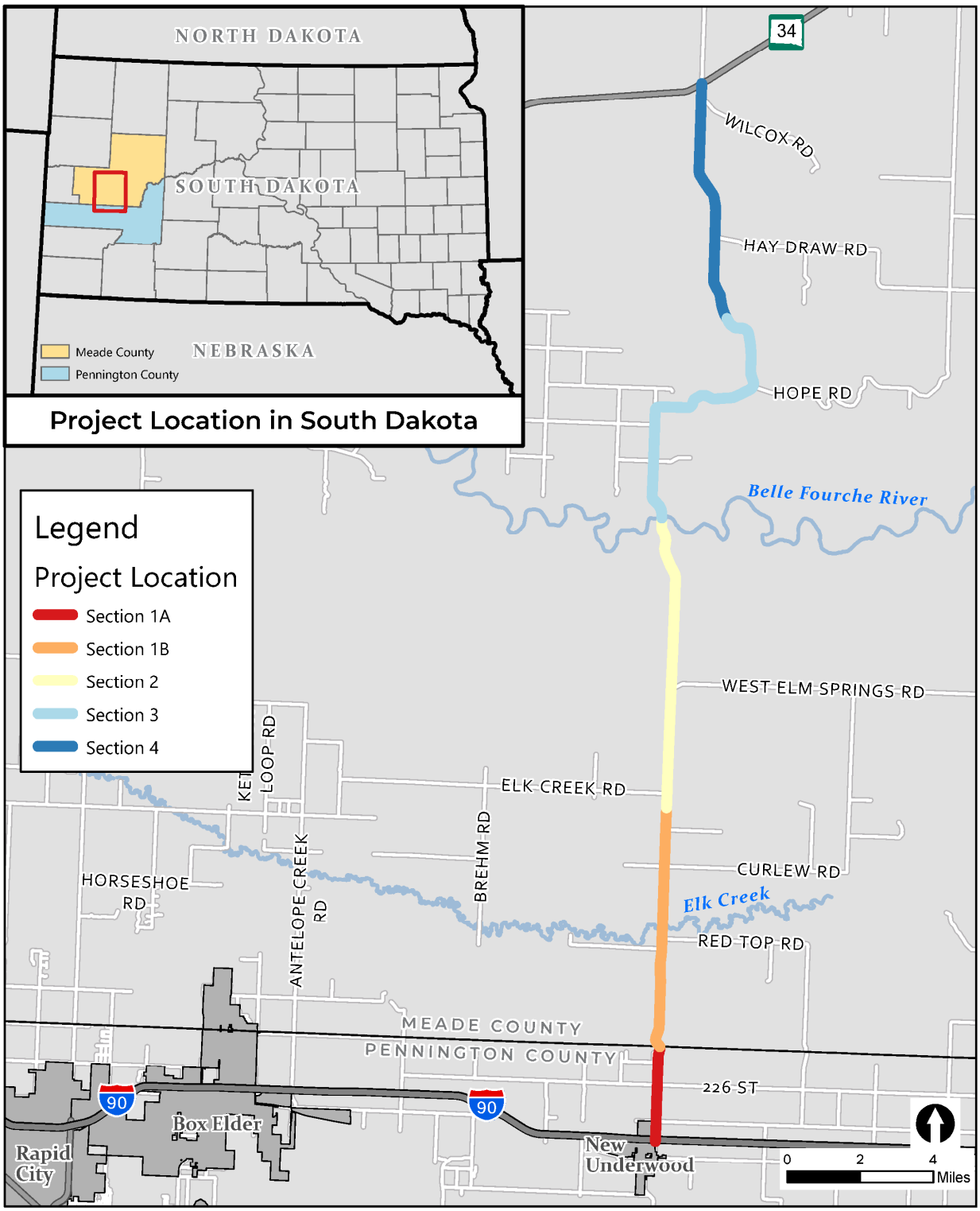
Introduction

This memorandum summarizes the assumptions, methodology, and results developed for the benefit-cost analysis (BCA) of the No Build and Build Alternatives as part of the New Underwood Road Reconstruction Project. The objective of a 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 incur primarily in the initial years. The primary elements that can be monetized are travel time, changes in vehicle operating costs, vehicle crashes, capital costs and remaining capital value, and maintenance costs. The BCA 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. The detailed calculations for this analysis is presented in Attachment A - BCA Calculations.

Project Overview

The South Dakota Department of Transportation (SDDOT) is requesting 80 percent of estimated multi-year phased construction costs, or $73.4 million out of an estimated $84.5 million, in Rural grant funding through the FY 2023/2024 Multimodal Project Discretionary Grant program (MPDG) to rehabilitate and reconstruct New Underwood Road. Project costs in non-participating categories total an additional $6.9 million, which the applicant will also be responsible. Thus, of a total project cost (the combination of Participating and Non-participating Costs) of $98.7 million, the SDDOT will be responsible for 26%, and requested Rural grant funding would represent 74%. The funds are imperative to SDDOT's New Underwood Reconstruction Project to immediately address and reconstruct 32.2 miles of New Underwood Road from South Dakota State Highway 34 (SD 34) to Interstate 90 (I-90). The project includes the rehabilitation of the existing two-lane roadway that will address critical roadway safety, resiliency, and transportation reliability needs. The project includes improvements to the roadway's width and inslopes, roadway resurfacing, the addition of paved shoulder lanes, median and edge running rumble strips, modifications to bridges approaches, and installation of important drainage features. Figure 1 contains a map showing the project location.

Figure 1: Project Location Map



As a critical arterial roadway in western South Dakota, New Underwood Road serves several vital purposes. As the only paved north-south aligned road east of Ellsworth Air Force Base that

connects SD 34 and I-90, New Underwood Road is a crucial link between residents of surrounding towns and hamlets of rural western South Dakota and the Lakota tribal nation.

A fundamental intent of the project is to improve safety conditions. This can be accomplished by adding paved shoulder lanes, slightly widening existing travel lanes, adding median and edge rumble strips, improving in slopes, addressing vertical and superelevated curves, and the installation of key roadway drainage features.

Description of Alternatives

Two alternatives were considered in this analysis, a No Build and Build Alternative.

No Build Alternative

The No Build Alternative includes leaving New Underwood Road in its existing state. Intensified maintenance activities are assumed to keep assets in the minimum acceptable state of operational quality. Due to poor pavement condition, this analysis assumes a reduction in posted speed limit along the project corridor. The No Build Alternative assumes the existing posted speed limit of 55 mph is reduced to 45 mph along the entire project segment of New Underwood Road beginning in Year 2032. Throughout the duration of the 20-year analysis period, the No Build Alternative assumes roadway users will continue to have the same trip origins, trip destinations, and travel routes as in the existing condition.

Due to the rural nature of the project area, few alternative routes for motorists in the region are available. If New Underwood Road is not improved, additional user delay is anticipated. Additional vehicle operating costs are also anticipated due to poor pavement condition.

Build Alternative

The Build Alternative consists of reconstructing New Underwood Road to current SDDOT standards. Specific design elements considered in this BCA are as follows:

- Reconstructs Approximately 16.1 miles of New Underwood Road
- Resurfaces Approximately 16.1 miles of New Underwood Road
- Installation of median and edge line rumble strips
- Application of edge line and centerline marking

Throughout the duration of construction, New Underwood Road will remain open to traffic and the posted speed limit is assumed to remain at 45 mph, the same posted speed limit as in the No Build Alternative. In the Build Alternative, users are assumed to have the same trip origins, destinations, and travel routes as in the No Build Alternative.

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
   - Crashes by severity
   - Initial capital costs: Capital costs were expected to be incurred in years: 2025, 2032, 2033, 2036 and 2037.
   - 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 in Years: 2025, 2032, 2033, 2036, and 2037. Year 2038 was assumed to be the first full year that most benefits will be accrued from the entirety of the project. The analysis primarily focused on annual benefits for the twenty-year period from year 2038 to year 2057[1]. Additional project benefits prior to the first full year of benefits in year 2038 were not included in this analysis.

   The exact months of construction are unknown. This analysis assumed a posted speed limit of 45 mph in the Build Alternative throughout the duration of construction. Various elements of construction will occur after year 2032. For this analysis, all construction impacts are assumed to occur in year 2032 and year 2036 for a duration of four months over summer.

3. **Economic Assumptions**: Value of time, inflation adjustment factors and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023[2]. The analysis was completed using an assumed discount rate of seven percent. The present value of all benefits and costs was calculated using 2021 as the year of current dollars.

4. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Existing VMT and VHT were calculated along the project segment of New Underwood Roadway using segment lengths obtained from project planning documents and the assumption that vehicles would travel at the posted speed limit of 55 mph in the Build Alternative and 45 mph in the No Build Alternative along the entire project segment of New Underwood Road.

   Travel times and trip distances were applied to the year 2021 and year 2041 daily traffic volumes to determine VHT and VMT, respectively. Travel time and vehicle operating cost benefits begin in year 2034 after the condition of the roadway in the Build Alternative is assumed to be restored to safely carry traffic at the 55 mph posted speed limit.

   The benefits for the years 2038 to year 2040 were interpolated using an annual growth rate and benefits for years beyond year 2041 were extrapolated using the same annual growth rate.

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[1] This analysis assumed a 365-day year to account for benefits incurred on weekends and recreational peaks in the project area.
[2] 2023 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs: https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

Total user costs per alternative is the sum of all user costs for the period from 2038 to 2057. 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**: Truck and auto travel time costs per hour and costs per vehicle mile traveled were used in addition to vehicle occupancy ratios, and the percent split of autos and trucks traveling on each route. Key assumptions for these areas included:

    - The corridor-wide truck percentage used in the analysis was estimated at 14 percent and is based on 2022 AADT and heavy vehicle percentages obtained from the SDDOT Data Needs Book on the adjacent roadway I-90.
    - Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

6. **Vehicle Operating Costs:** Improving pavement conditions along New Underwood Road is a primary objective of this project. As noted previously, the current pavement condition on New Underwood Road is degraded such that further analysis is necessary to capture the additional user costs associated with vehicle operating costs compared to a facility with sufficient pavement quality. Methods for estimating these additional costs per mile associated with pavement roughness are described in the National Cooperative Highway Research Program (NCHRP) Report 720. These methods were applied along with an understanding of the current pavement condition on the New Underwood Road corridor to develop localized per-mile vehicle operating costs due to pavement roughness.

7. **Safety Analysis:** Safety analysis made use of ten years of crash data along the New Underwood Road project segment form Years 2013-2022 and was obtained from SDDOT. Crash data was annualized to determine average annual crash costs and average annual number of crashes by severity associated with the No Build Alternative and the Build Alternative.

    Reductions in crashes along the New Underwood Road corridor were estimated using crash modification factors (CMFs). CMFs for the identified roadway improvements were obtained from the CMF Clearinghouse database. The following CMFs were used in this analysis:

    - Install Centerline and Shoulder Rumble Strips[3]
    - Resurface Pavement[4]
    - Place Edgeline and Centerline Markings[5]

    Annual crash costs and crashes by severity for years 2038 to 2057 were calculated by multiplying the base year crashes by the percent change in annual AADT between the base year (year 2017 being the center of the crash analysis period). Crash cost assumptions for the

[3] CMF ID# 6946: https://www.cmfclearinghouse.org/detail.php?facid=6946
[4] CMF ID# 2976: https://www.cmfclearinghouse.org/detail.php?facid=2976
[5] CMF ID# 101: https://www.cmfclearinghouse.org/detail.php?facid=101

KABCO scale are consistent with values and methodologies published in the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023.

8. **Operating and Maintenance Costs**: Changes in annual roadway maintenance costs are expected due to intensified maintenance that will be required to keep the No Build Alternative serviceable compared to what will be required on new infrastructure under the Build Alternative. Anticipated costs for the No Build Alternative and Build Alternatives were derived from MnDOT[6] pavement lifecycle studies and are shown in the BCA Calculations. This analysis assumes regular crack treatments to keep this segment of New Underwood in the minimal acceptable level of condition to carry traffic.

   This analysis uses a conservative assumption that the project segment of New Underwood Road was originally constructed around 1980. The true date varies across the project corridor.

9. **Calculation of Remaining Capital Value**: Because some components of the initial capital costs have service lives well beyond the 20-year analysis period, the remaining capital value was calculated for the Build Alternative. This value was expressed in terms of 2021 dollars and was added to other project benefits in accordance with USDOT guidance. The assumed service life of most project components in the Build Alternative was 20 years while some structures had an assumed service life of 75 years. Year 2038 was used as the first year for calculation of project components remaining service life. Beginning in year 2038, all project components are determined to be "complete", and the total service life service life of all project components begin to diminish at this time.

   Service life assumptions of project components were obtained through coordination with SDDOT. In determining the remaining capital value of the Build Alternative, project components were assumed to have a linear depreciation from the time each phase was completed to the end of the benefit-cost analysis period. 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:
    - Increased travel time reliability in the study area due to a reduction in crashes
    - Additional Safety Benefits
        - Address deficient horizontal and vertical curves to meet a 70-mph design speed.
        - Shoulder widening and restoration benefits.
    - Improved resiliency to floods and related detours through corridor profile enhancements.
        - Correction of inslopes to ensure proper roadway drainage.
        - New/additional rip rap on segments adjacent to water.
        - Replacement of pipe culverts.

[6] MnDOT Pavement Life-Cycle Cost Considerations (page 45):
http://www.dot.state.mn.us/assetmanagement/pdf/guide/06chap6.pdf

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 1. See Attachment A for the complete BCA Calculations.

Table 1 – Total Project Results

	Initial Capital Cost (2021 Dollars)	Project Benefits (2021 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2021 Dollars)
No Build vs. Build	$25.75 million	$28.30 million	1.10	$2.55 million

Attachment A

BCA Calculations