

To: Joe Triplett, Chisago County Public Works Director
From: Nicole Bitzan, AICP, Senior Planner
Date: July 6, 2021
Subject: US Highway 8 Reconstruction Project – 2021 RAISE Discretionary Grant Program
Application 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 US Highway 8 Reconstruction Project – 2021 RAISE Discretionary Grant 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 allow for the fact that benefits accrue over a long period of time while costs are incurred primarily in the initial years. The primary elements that can be monetized are travel time, vehicle crashes, 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.

The primary issues to be addressed by the project are the travel time, operations, and safety benefits associated with reconstructing US 8 from I-35 to Karmel Avenue to a 4-lane divided roadway with a median and 8' shoulders. Currently, US 8 is a rural two-lane undivided highway with limited shoulders and just under 60 public and private accesses with multiple uncontrolled full intersections; all contributing to major safety concerns and traffic delays. US 8 serves as an interregional corridor for freight, commuter, seasonal recreation, and local traffic. Commuters and freight travel from the Twin Cities approximately 18 miles south to the Wisconsin border in the east.

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 included leaving the 8-mile US 8 corridor from the cities of Forest Lake to Chisago City in its current geometric and operational condition: with no modifications or restrictions to current access. This includes the two-lane undivided with a posted speed limit of 55 miles per hour with just under 60 public and private accesses to US 8. It was assumed that the existing roadway would have a mill and overlay completed in year 2025.

Build Alternative

The proposed project replaced the existing two-lane undivided sections with a four-lane divided roadway with 8' shoulders and a median. Over 40 private and public accesses will be closed and redirected to frontage or backage roads, when possible, to reduce vehicle conflict points and to improve traffic safety along the Project Corridor. Also, full access intersection improvements are proposed for the following eight intersections to include designated left- and right-turn lanes, reduction of skews, and a roundabout at Karmel Avenue.

- Greenway Avenue
- Heath Avenue
- Hale Avenue
- Pioneer Road (CSAH 23)
- James Avenue
- 276th Street
- Viking Boulevard (CSAH 36)
- Karmel Avenue – only roundabout

BCA Methodology

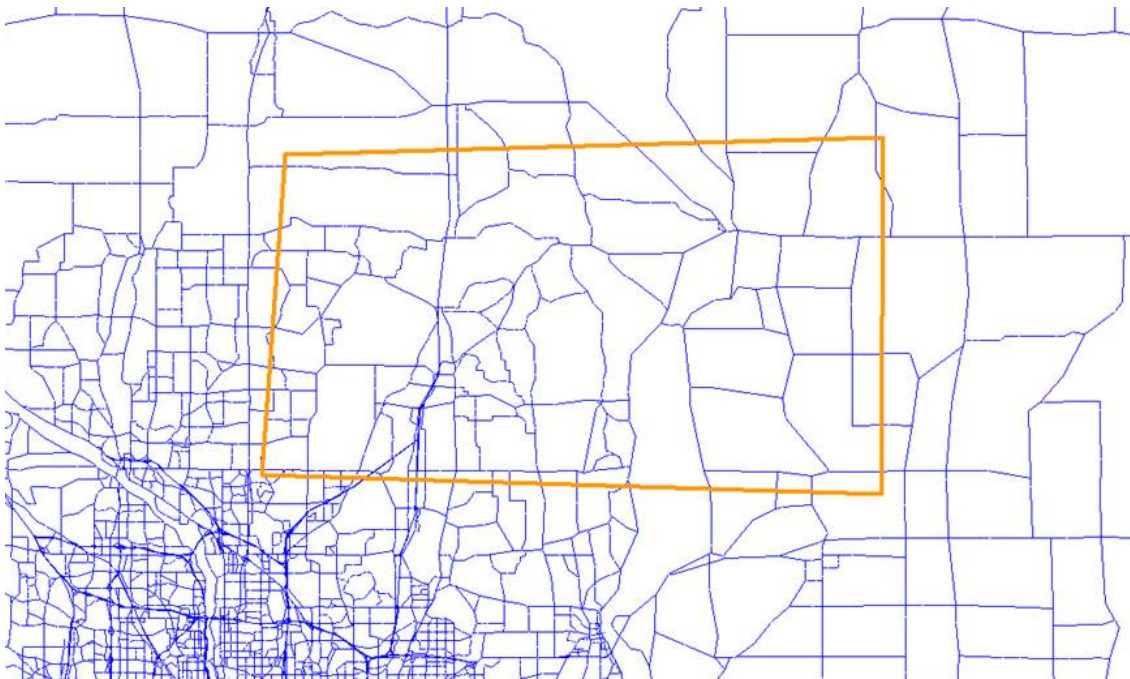
The following methodology and assumptions were used for the benefit-cost analysis:

1. **Main Components:** The main components analyzed included:
 - Travel time/delay (vehicle hours traveled – VHT)
 - Operating costs (vehicle miles traveled – VMT)
 - Crashes by severity
 - Environmental and air quality impacts
 - Initial capital costs: These costs were broken into distinct categories in accordance with service life (consistent with the recommendations from MnDOT Office of Transportation System Management, July 2019) and were applied evenly over the duration of the construction period.
 - 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.
 - Maintenance costs
2. **Analysis Years:** This analysis assumed that the Build Alternative would be constructed over a two-year period, starting in year 2024, with completion in year 2025. Therefore, year 2026 was assumed to be the first full year that benefits will be accrued from the project. The analysis focused on the estimated weekday benefits for the twenty-year period from 2026 to 2045¹. The present value of all benefits and costs was calculated using 2019 as the year of current dollars.

¹ The study used 365 days per year.

3. **Economic Assumptions:** The value of time and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021. Local values for vehicle operating costs (excluding emissions costs) were obtained from *Recommended standard values for use in cost-effectiveness and benefit-cost analysis in SFY2021* from MnDOT Office of Transportation System Management, July 2020². Remaining capital value assumptions were consistent with rates from *Recommended remaining capital value factors for use in benefit-cost analysis in SFY 2021*³, Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2020 (values were adjusted to reflect a seven percent discount rate). The analysis was completed using an assumed discount rate of seven percent.
4. **Development of Vehicle Hours Traveled (VHT) and Vehicle Miles Traveled (VMT):** Regional year 2014 and 2040 VMT and VHT from the Twin Cities Regional Travel Demand Model were summarized for the No Build and Build Alternatives. The project subarea as shown in Figure 1 was used for the VMT/VHT analysis. This subarea was selected as an “area of influence” to capture changes in travel patterns resulting from the improvement along US 8, as shown in Figure 2.

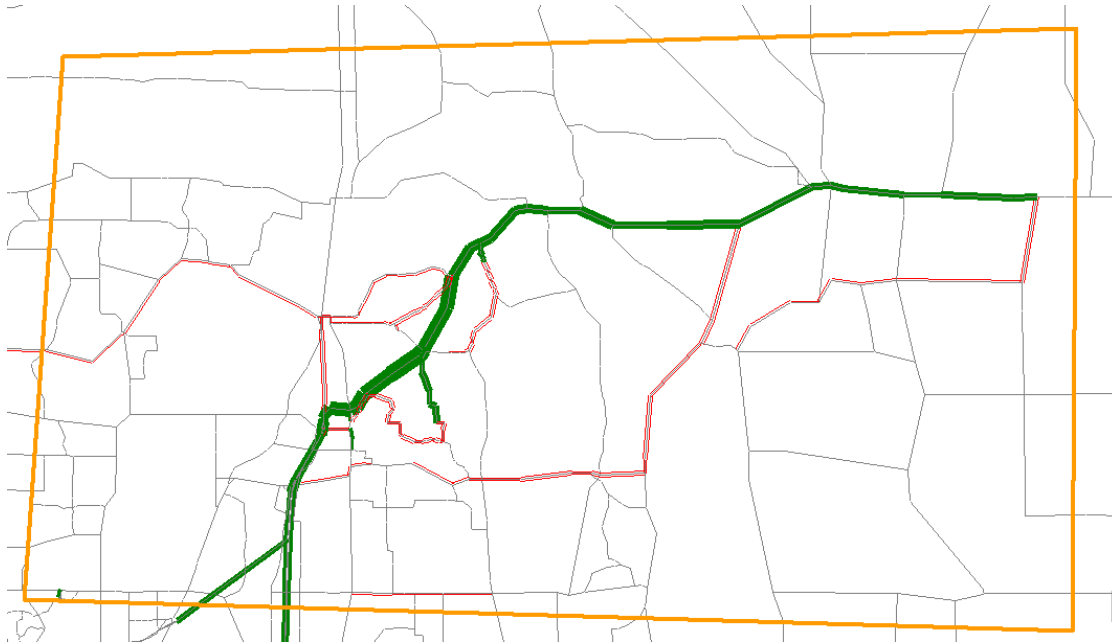
Figure 1. Project Subarea



² <https://www.dot.state.mn.us/planning/program/pdf/Table%20A.1%20SV%20L-ML-H%201-July-2020.pdf>

³ http://www.dot.state.mn.us/planning/program/appendix_a.html

Figure 2. Project Delta Plot



The regional model captured travel time changes related to trip diversion and increased free-flow speed on US 8. Benefits for the years between 2014 and 2040 were interpolated based on model results using an annual growth rate. VMT and VHT for years beyond year 2040 were extrapolated using the same annual growth rate. Savings due to reduction of VMT and VHT were calculated using costs per mile and per hour that account for vehicle occupancy and different vehicle types. Outcomes from travel demand modeling effort showed a 0.52% annual regional VMT growth under a build scenario.

5. **Vehicle Occupancy, Vehicle Types and Peak Hours:** 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:
 - The truck percentage used in the analysis was 6 percent, based on MnDOT's Traffic Volume Mapping Tool⁴ for AADT and HCAADT counts along the project length and dividing HCAADT with AADT.
 - Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck. These values are from the 2017 National Household Travel Survey.
6. **Safety Analysis:** The Build Alternative improves the US 8 corridor by converting it from a two-lane undivided roadway to a four-lane expressway. Reconstruction to a four-lane expressway is expected to generate safety benefits by transferring daily traffic from the existing facility to a historically safer four-lane divided roadway. Additionally, the roadway and intersection improvements consisting of medians, right- and left- turn lanes along both

⁴ <https://www.dot.state.mn.us/traffic/data/tma.html>

major roads, a roundabout, and access management to include closures and re-routes of accesses frontage/backage roads were also assumed to produce safety benefits at the corresponding intersections. The analysis used five-year existing (January 2015 to December 2019) crash data along the US 8 corridor between I-35 and Karmel Avenue to develop crash rates by severity for the No Build Alternative.

Detailed analysis was undertaken to identify crashes at each intersection undergoing improvements. Crash modification factors from CMF Clearinghouse and AASHTO HSM were obtained for each pertinent improvement type:

- Conversion from 2-lane to 4-lane divided,
- Install raised median,
- Provide a channelized left-turn lane on both major- and minor- road approaches,
- Provide a right turn lane on two approaches to an intersection (minor-road stop-controlled),
- Reduce access point density,
- Convert to roundabout.

To determine estimated reduction of existing intersection crashes, CMFs for relevant improvements were applied to crashes tied to each intersection. To determine estimated reduction of existing segment crashes, the CMF to reduce access point density, conversion from 2-lane to 4-lane divided, install raised median, and the sum of all intersection crash savings within the segment were calculated and applied. Year 2040 crashes for the No Build Alternative were estimated based on VMT growth on the US 8 project extents. Similar assumptions used to estimate existing year Build Alternative crashes by severity were applied to produce year 2040 estimates. Detailed calculations and sources for each CMF are outlined in the attached BCA Workbook.

VMT by facility type (e.g. collector, expressway, freeway, etc.) was extracted from the regional travel demand model to capture the level of diversion on adjacent corridors in the network. Metro district average crash rates by facility type and severity were obtained from the 2013 MnDOT Section Toolkit. Model VMT by facility type was applied to facility crash rates to project a weighted crash rate by severity for each scenario. The number of crashes by severity for each scenario were then estimated by applying scenario VMT to the weighted crash rates by severity. VMT for the project extents of US 8 was excluded from the regional crash analysis to isolate impacts of VMT shifts to other facilities and to avoid double counting US 8 crashes. The safety benefit was quantified for years 2015 and 2040 and interpolated/extrapolated based on an annual growth rate to determine total safety benefits for the period from year 2026 to 2045. Crash cost assumptions for the KABCO scale are consistent with values and methodologies published in the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021.

7. **Environmental and Air Quality Impacts:** Annual VMT in the surrounding transportation network is expected to increase since motorists would be more likely to take a longer route on local roadways to experience less travel time on an expressway facility. The change in VMT between No Build and Build conditions was obtained from the regional travel demand model and applied to emission rates by vehicle type. 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 February 2021.

8. **Maintenance Costs:** Roadway maintenance costs, associated with maintaining the additional roadway infrastructure under the Build Alternative, were considered as an additional cost to the Build Alternative. An annual maintenance cost of \$8,100 per lane mile, which derived from maintenance reports for similar facility types within Minnesota was applied in this analysis. This maintenance cost included costs associated with striping, minor repairs, and shoulder maintenance. Other maintenance costs between the alternatives were assumed to be similar.
9. **Calculation of Remaining Capital Value:**

Because many 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 2019 dollars and was added to other user benefits in accordance with USDOT guidance. In determining remaining capital value, the initial costs of the proposed alternatives were separated into the following categories:

 - Right of Way
 - Major Structures
 - Grading and Drainage
 - Sub-Base and Base
 - Surface
 - Miscellaneous Costs – Includes mobilization, temporary pavement and drainage, traffic control, contingency (risk), and program delivery. These were assumed to be sunk costs and assigned zero remaining capital value.
10. **Factors Not Quantified:** Several factors were not quantified as part of the analysis because review of initial data indicates low potential to yield substantial benefit. These factors included the following:
 - Trips lying outside the specified subarea may accrue benefits that were not accounted for.
 - Operating cost savings from improved vehicle efficiency due to increased average vehicle speeds in Build Alternative.
 - Crash costs associated with network trips diverting to/from different facility types outside of the specified sub-area were not quantified.
 - The methodology does not specifically monetize any transit or trail benefits.

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 greater than 1.0. The larger the ratio number, the greater the benefits per unit cost. Results of the benefit-cost analysis are included in Table 1 below. See [link](#) for the complete benefit-cost analysis workbook.

Table 1 - Results

	Project Benefits (2019 Dollars)	Project Costs (2019 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (NPV)
No Build vs. Build	\$109.8 million	\$47.7 million	2.30	62.1