Memorandum

To: Lyndon Robjent, PE, Publics Work Director
Carver County

From: Nick Semeja, PE

Date: May 6, 2022

Subject: US 212 Rural Freight Mobility and Safety Project – 2022 MPDG 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 212 Rural Freight Mobility and Safety Project – 2022 MPDG 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 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, 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, safety, and environmental benefits associated with trips moving reliably across the US 212 corridor through Carver County, Minnesota. Currently, the portion of US 212 from the cities of Norwood Young America to Cologne is a rural two-lane undivided highway with limited shoulders. This section is adjoined by a four-lane expressway facility on the west and a soon to be constructed four-lane expressway facility on the east; thus, serving as a major bottleneck for freight and commuter traffic traveling through the southwestern Twin Cities metro area. The study corridor is characterized by near-capacity daily traffic volumes, significant levels of freight and heavy vehicle activity, and numerous safety concerns.

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 US 212 corridor from the cities of Norwood Young America to Cologne in its current geometric and operational condition, with no modifications or

restrictions to current access. Regional roadway improvements that are currently programmed were included as part of the regional transportation network.

Build Alternative

The proposed project replaces approximately five miles of the existing two-lane undivided section with a four-lane divided roadway. Several spot mobility and safety improvements were also assumed throughout the study corridor. The comprehensive list of improvements that were considered in the BCA is summarized below:

- Conversion from two-lane undivided to four-lane divided expressway with restricted side-street left turn movements at all at-grade access locations from Cologne to Norwood Young America
- US 212 and Tacoma Avenue intersection – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and Salem Avenue intersection – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and CSAH 51 intersection – conversion from at-grade, side-street stop control to grade separated interchange
- US 212 and County Road (CR) 153 intersection – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and access to Carver County government building – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and CSAH 36 intersection – conversion from side-street stop control to three-quarter access (i.e. removing left turns from side-street only)

The Build Alternative also included the same programmed improvements to the regional transportation system that were assumed in the No Build Alternative.

BCA Methodology

The analysis primarily focused on benefits and cost for users along the project portion of US 212 under the No Build and Build Alternatives. A regional travel demand model was used to forecast growth along US 212 and estimate regional travel pattern shifts under each alternative. Regional benefits/costs on other facilities were quantified as a means of estimating additional regional impacts but were summarized independently from US 212 benefits/costs to provide a conservative estimate of project return on investment. Details regarding calculations of costs and benefits of US 212 users and regional users are provided in the workbook and outlined below.

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 of MnDOT Office of Transportation System Management, July 2021[1]) and were applied evenly over the duration of the construction period. These categories ranged from surface-level components like outer-course pavement (25 year service life) to major structures associated with the bridge and retaining walls (60 year service life). A detailed breakdown of these categories and remaining capital value factors are provided in the workbook.
- 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 and rehabilitation costs: These costs included major rehabilitation activities over the project lifespan and annual routine maintenance.

2. **Analysis Years**: This analysis assumed that construction would take place from year 2024 to 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 benefits for the twenty-year period from 2026 to 2045. The present value of all benefits and costs was calculated using 2020 as the year of current dollars.

3. **Economic Assumptions**: The value of time, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated March 2022[2]. Remaining capital value assumptions were consistent with rates from *Recommended remaining capital value factors for use in benefit-cost analysis in SFY 2022*[3], Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2021 (values were adjusted to reflect discount rate). Local vehicle operating costs for autos and trucks were obtained from *Recommended standard values for use in cost-effectiveness & benefit-cost analysis in SFY2022*[4], Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2021. The analysis was completed using assumed discount rate of seven percent.

4. **Travel Demand Model**: The analysis used the Carver County Regional Travel Demand Model to compare corridor growth rates and regional travel patterns under the No Build and Build Alternatives. This TDM was developed in 2017 (using year 2014 for existing year conditions) and has a forecast planning horizon of year 2040. The Carver County model was developed using the base Twin Cities Regional Activity Based Model. The model utilizes Metropolitan Council socioeconomic control totals for household, population, and employment for year 2040 outlined by the Thrive MSP 2040 planning process documents. The model was validated based on the Federal Highway Administration's Model Validation and Reasonableness Checking Manual.

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[1] Table 5: http://www.dot.state.mn.us/planning/program/benefitcost.html
[2] https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf
[3] http://www.dot.state.mn.us/planning/program/appendix_a.html
[4] https://www.dot.state.mn.us/planning/program/pdf/Table%20A.1%20SV%20L-ML-H%201-July-2021.pdf

Both the No Build and Build Alternatives assumed the same regional improvements as planned in the respective modeling years, including the US 212 expansion located to the east that is currently under construction. The subarea of the model used for the analysis is shown in Figure 1 below. A forecast year delta volume plot is also provided in the BCA Workbook.

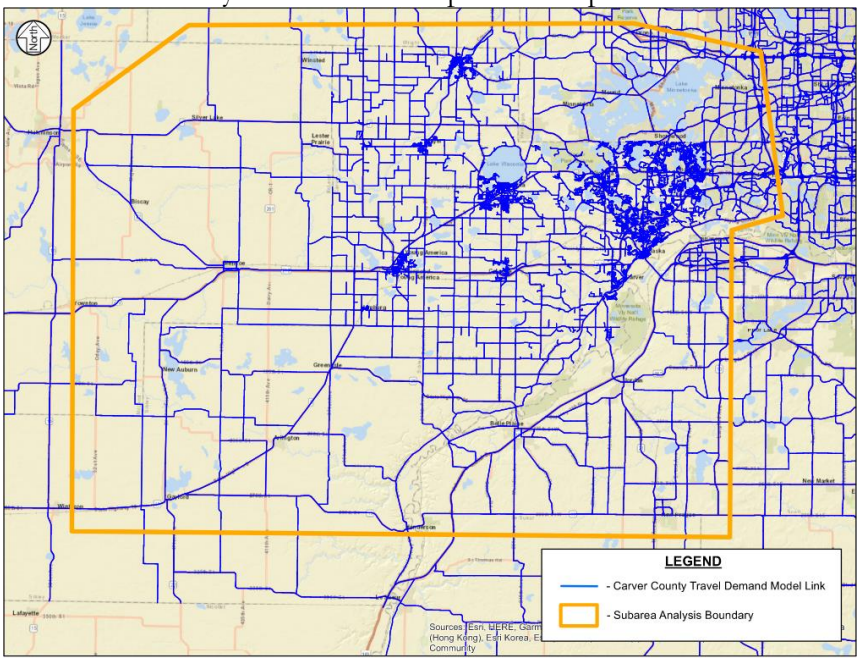

Figure 1. Travel Demand Model Subarea

5. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Year 2014 and 2040 VMT and VHT from the Carver County Regional Travel Demand Model were summarized for the No Build and Build Alternative. The regional model captured trip impacts related to increased free-flow speed and capacity on US 212 and network trip diversion. Travel time savings per user along the approximately 5-mile project portion of US 212 was assumed to be 0.7 minutes. This savings was applied to existing and forecast year users under No Build conditions to determine travel time benefits for 'existing' users. The savings per user was also applied to additional users drawn to the corridor under Build conditions. Travel time savings for additional users were valued at half the value of time as existing users, however.

   Microsimulation analysis was also conducted to evaluate the change in operations at the proposed US 212/CSAH 51 interchange. Macroscopic models are not suitable for analyzing changes in operations at the nodal level, so microsimulation was relied on to perform a more granular analysis. Synchro/SimTraffic models were developed for morning and afternoon peak hours to evaluate total user travel time under each operating condition. Year 2019 and year 2040 volumes were developed for both the No Build and Build Alternatives based on existing traffic count data and travel pattern shifts from the regional travel demand model. More trips were assumed to use the US 212/CSAH 51 junction under Build conditions, so benefit estimates based solely on total VHT from the microsimulation models likely underestimate subarea user benefits for the interchange project component. Total network VHT was summarized for each year under both alternatives and added to US 212 VHT from the travel demand model.

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.

6. **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 13.4 percent, based on year 2016 vehicle classification counts performed by MnDOT.
   - Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated March 2022. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

7. **Safety Analysis:** The Build Alternative improves the US 212 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 spot improvements consisting of RCIs, grade separation, and conversion to right-in right-out intersections were also assumed to produce safety benefits at the corresponding intersections. The analysis used three-year existing (2018-2020) crash data along the US 212 project area to develop annual crashes by severity for the No Build Alternative.

   The BCA referenced *A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota*[5], Minnesota Department of Transportation, Office of Traffic, Safety and Technology, to estimate crash impacts associated with conversions to RCIs. The study performed extensive before and after crash analyses at eight RCI locations in Minnesota. Crash impacts reported in the study were preferred for use in the BCA due to the study's thoroughness, the similar nature of geometrics and location of RCIs in the study compared to the US 212 corridor, and driver behavior at RCIs being better reflected using local data. Crash modification percentages by severity are summarized in Table 10 of the study and were used to estimate crash increases/decreases by severity at the US 212 RCI conversion locations.

   Note that the study in reference reported a 100 percent reduction in fatal crashes. The BCA was conservative by using the serious injury crash reduction percentage of 67 for fatal crashes, despite the study observing a 100 percent reduction in fatal crashes and an 86 percent reduction in severe crashes (K+As).

   Crash modification factors from CMF Clearinghouse were obtained for the other proposed US 212 improvements: convert an at-grade intersection into a grade-separated interchange, replace direct left-turns with right-turns/U-turns (for locations with restricted mainline and side-street left-turns), install right-in-right-out operations at stop-controlled intersection, and conversion from a two-lane roadway to a four-lane divided roadway. To determine estimated

[5] https://www.dot.state.mn.us/roadwork/rci/docs/trafficsafetyatrcistudy.pdf

reduction of existing intersection crashes, CMFs for relevant improvements were applied to crashes tied to each intersection. Estimated reductions in crashes due to the conversion from a two-lane undivided to a four-lane divided roadway were applied to the remaining non-intersection crashes along the US 212 segments being converted. Year 2040 crashes for the No Build Alternative were estimated based on VMT growth on the US 212 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.

The safety benefit was quantified for years 2014 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 March 2022.

8. **Environmental and Air Quality Impacts:** Changes in emissions are expected to be impacted by the time vehicles spend idling in the project area. The change in emissions was quantified for vehicles entering the US 212/CSAH 51 junction under No Build and Build conditions. Intersection delay between No Build and Build conditions was obtained from the microsimulation modeling results and converted to equivalents of vehicle-miles traveled (VMT) by applying fuel consumption for idling vehicles to average miles per gallon for passenger cars. The change in VMT equivalents was then 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 March 2022.

9. **Maintenance and Rehabilitation Costs**: It is expected that reconstructing the US 212 corridor will reduce the required future rehabilitation and maintenance activities to keep the roadway serviceable. Future maintenance activities were obtained for the No Build and Build scenarios from MnDOT Office of Materials and Road Research staff. The provided rehabilitation and maintenance schedules for each scenario are listed below.

   <u>No Build Scenario</u>

   - Medium (4") bituminous mill & overlay at year 0 (year 2022) ($350,000 per lane mile)
   - Thin (2") bituminous mill & overlay at year 14 ($250,000 per lane mile)
   - Medium (4") bituminous mill & overlay at year 24 ($350,000 per lane mile)
   - Unbonded concrete overlay at year 37 ($800,000 per lane mile)

   <u>Build Scenario</u>

   - Thin (2") bituminous mill & overlay at year 20 ($250,000 per lane mile)
   - Medium (4") bituminous mill & overlay at year 35 ($350,000 per lane mile)

   Routine annual 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 the Twin Cities metro area, was

applied in this analysis. This maintenance cost included costs associated with striping, snow plowing, minor repairs, and shoulder maintenance. Other maintenance costs between the alternatives were assumed to be similar.

10. **Calculation of Remaining Capital Value**: Because many components of the initial capital costs have service lives well beyond the 20-year analysis period (e.g. bridge at CSAH 51), the remaining capital value was calculated for the Build Alternative. This value was expressed in terms of 2020 dollars and was added to other user benefits in accordance with USDOT guidance. In determining remaining capital value, the initial costs of the proposed alternative were separated into the following categories:

    - Right of Way
    - Major Structures
    - Grading and Drainage
    - Sub-Base and Base
    - Surface
    - Miscellaneous Costs – Includes all previously incurred costs, engineering, mobilization, removals, utility relocation, traffic control, contingency, and program delivery. These were assumed to be sunk costs and assigned zero remaining capital value.

    Project components in each cost category were assumed a service life based on recommendations provided by MnDOT Office of Transportation System Management.

11. **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.
    - Travel time savings due to a reduction of nonrecurring congestion (e.g. due to crashes, inclement weather, work zones, etc.) from increased roadway capacity.
    - Crash reductions at local access locations (other than those specified in the analysis) on US 212 due to restricted left-turn movements.

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.

The project is expected to produce $76.6 million in benefits for users of the project portion of US 212 and the US 212/CSAH 51 interchange. Comparing to roughly $43.0 million in year 2020 costs, the project is expected to have a benefit-cost ratio of 1.8 and a net present value of $33.6. The project may bring an additional $27.7 million of net present value when accounting for regional impacts off the US 212 corridor resulting in a benefit-cost ratio of 2.4, as demonstrated in the BCA Workbook. Results of the benefit-cost analysis for US 212 users only are shown in Table 1 below. See Attachment A for the complete benefit-cost analysis workbook.

Table 1 – Total Project Results

	Initial Capital Cost (2020 Dollars)	Project Benefits (2020 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2020 Dollars)
No Build vs. Build	$43.0 million	$76.6 million	1.8	$33.6 million

Attachment

Benefit-Cost Analysis Worksheet