Memorandum

To: Amber Blanchard, PE, Major Projects Manager
Minnesota Department of Transportation

From: Nick Semeja, PE, Associate

Date: March 19, 2021

Subject: I-494: Airport to Highway 169 Projects 1 and 2 – 2021 INFRA 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 I-494: Airport to Highway 169 Projects 1 and 2 – 2021 INFRA 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 core elements that can be monetized are travel time, changes in vehicle operating costs, vehicle crashes, environmental impacts, capital costs and remaining capital value, and operating 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.

I-494 is part of a loop route to Interstate 94, circling through the southern and western regions of the Minneapolis – Saint Paul (MSP) metropolitan area in Minnesota. The southwest stretch of the corridor provides direct access to major destinations such as the Minneapolis-St. Paul International Airport and the Mall of America, cross city access for commuters and freight, and local access for the numerous businesses and residents along the freeway.

Existing highway mobility on the I-494 corridor is considered unacceptable based on congestion levels, safety, and operational issues during the peak as well as the off-peak travel periods as large amounts of freight moves from and through Minnesota and beyond. Current annual average daily traffic (AADT) on I-494 ranges from 150,000 (west of TH 100 intersection) to 131,000 (east of I-35W intersection) and can experience up to 10 hours of congestion in a day.

The proposed improvements will add capacity in the form of managed lanes on each direction of I-494, implement interchange improvements at the I-494/I-35W system interchange, provide various spot mobility improvements throughout the project area, and reconstruct surrounding infrastructure to an enhanced state-of-repair. The project aims to address existing and future mobility, safety, and accessibility issues.

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 I-494 project area in its current geometric and operational state. Traffic impacts associated with programmed regional roadway improvements were included in the analysis.

Build Alternative

The improvements for the Build Alternative considered in the BCA include:

- Construction of MnPASS lanes (managed, high occupancy vehicle (HOV) toll lanes) on I-494 between TH 100 and I-35W in both eastbound and westbound directions.
- Addition of a new directional ramp to facilitate the northbound to westbound movement at the I-494 and I-35W interchange. The existing loop in the northeast quadrant of the cloverleaf interchange and associated loop-to-loop weaving conflicts would be removed.
- Constructing an auxiliary lane on westbound I-494 from I-35W to France Avenue
- Reconstruction of a single full access interchange at Portland Avenue by constructing a new bridge at Portland Avenue and removing ramps at Nicollet Avenue and 12th Avenue to consolidate access along I-494. Existing entrance and exit ramps are close in proximity to adjacent interchanges which causes congestion and safety issues on I-494.
- Construction of a new pedestrian bridge near Chicago Avenue.
- Modifying the existing I-35W and 82nd Street interchange to provide access to the new I-35W northbound to I-494 westbound directional ramp.

The BCA for the Build Alternative also assumed the same programmed improvements to the regional transportation system that were assumed 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 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 2020[1]) 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.
- Operating and maintenance costs: These costs include routine maintenance on the additional pavement, operating costs associated with the managed lanes, and planned preservation activities.

2. **Analysis Years**: The analysis assumed that construction would take place over a four-year period and be completed in 2026. Therefore, year 2027 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 2027 to 2046. The present value of all benefits and costs was calculated using 2019 as the year of current dollars.

3. **Economic Assumptions**: The value of time, vehicle operating costs, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021. Remaining capital value assumptions were consistent with rates from *Recommended remaining capital value factors for use in benefit-cost analysis in SFY 2021*[2], Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2020 (values were adjusted to reflect discount rate). The analysis was completed using an assumed discount rate of seven percent.

4. **Travel Demand Model:** The Hennepin County Travel Demand Model (TDM) was used in this analysis to compare No Build and Build Alternatives under year 2026 and 2040 conditions. This TDM was developed in 2017 and is consistent with the Metropolitan Council's Activity Based Model and Thrive MSP demographic assumptions. These assumptions include socioeconomic control totals for household, population, and employment, as well as future roadway network improvements throughout the region, with additional refinement added in Hennepin County. As part of the model development, the TDM was validated based on the Federal Highway Administration's Model Validation and Reasonableness Checking Manual. Future year volumes were adjusted using the methodology described in NCHRP 255 (*Highway Traffic Data for Urbanized Area Project Planning and Design)*. The subarea of the model used for the analysis is shown in Figure 1.

[1] Table 5: http://www.dot.state.mn.us/planning/program/benefitcost.html
[2] http://www.dot.state.mn.us/planning/program/appendix_a.html

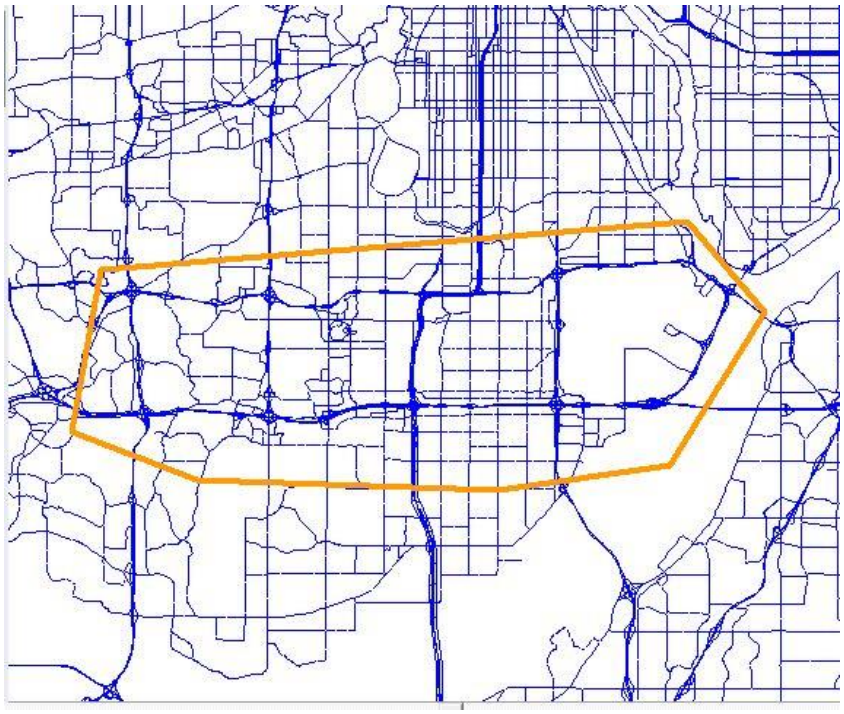

Figure 1. Travel Demand Model Subarea

5. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Travel time changes and differences in vehicle miles traveled in the I-494 study area were captured using an aggregation of macroscopic modeling and microsimulation modeling. The regional travel demand model discussed in Section 4 above outlines the tool used for the macroscopic modeling effort. The travel demand model assessed regional travel pattern shifts and VMT and VHT impacts associated with the capacity expansion. Year 2026 and year 2040 VMT and VHT were summarized for both the No Build and Build Alternatives based on the modeling assumptions described in the previous section. Note that VMT and VHT associated with links modeled in the microsimulation analysis were removed from the regional modeling summary to avoid double counting trip data.

   VISSIM microsimulation modeling was used to provide a more detailed evaluation of projects impacts on traffic operations near the project area. No Build and Build models were developed for five-hour morning and afternoon peak period operating conditions, for years 2026 and 2040. The microsimulation modeling network consisted of I-494, TH 100, I-35W, TH 77, and the adjacent local roadway network, as shown in Figure 2. Year 2026 and 2040 traffic volumes for each build option were developed using results from the regional travel demand modeling effort and additional volume-to-capacity reasonableness checks. VMT and VHT were summarized for No Build and Build models under year 2026 and 2040 traffic conditions. Results of the microsimulation analysis can be found in Appendix B.

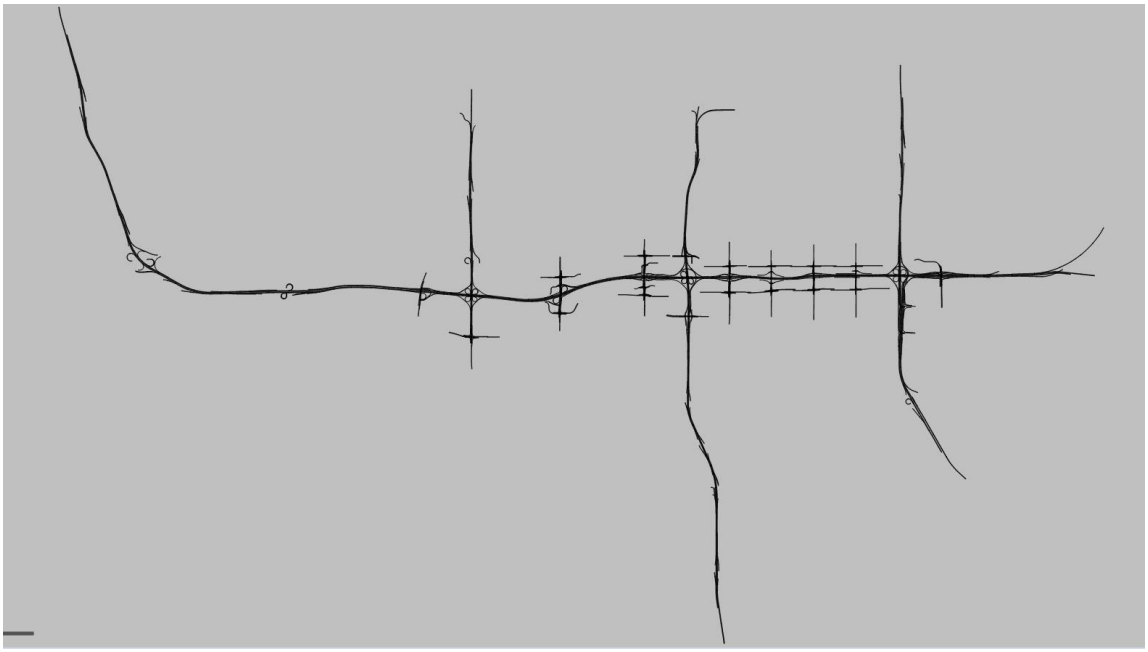

Figure 2. Microsimulation VISSIM Model

VMT and VHT were aggregated from the macro and microscopic modeling efforts to produce regional trip information. The BCA assumed VMT and VHT benefits would be accrued for 251 days of the year to reflect non-holiday weekday benefits only, which can be considered a conservative assumption since it is likely benefits would be realized outside of the peak periods and on weekends. Benefits for the analysis years between 2026 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 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:
   - The truck percentage used in the analysis was five percent and was based on year 2018 vehicle classification counts throughout the study area provided 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 February 2021. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.
7. **Safety Analysis:** The Build Alternative improves safety in the project area by relieving congestion and remediating geometric deficiencies. Existing three-year (2018 through 2020) crash data was collected for the study area and was disaggregated by locations where improvements are being proposed. The improvements to be considered in the BCA, their respective areas of influence, and sources for expected impact on crashes by severity are provided below:

- Adding one lane of capacity in each direction of freeway mainline: I-494 from TH 100 to I-35W[3]
- Replacing an interchange loop with a directional ramp: Northbound I-35W to Westbound I-494[4]
- Providing an auxiliary lane between ramps: Westbound I-494 from I-35W to France Avenue[5]
- Increase spacing between entrance and exit ramps: I-494 from Lyndale Avenue to Portland Avenue and Portland Avenue to TH 77[6]

Expected number of crashes by severity in year 2040 were calculated by multiplying the existing year crashes by the percent change in VMT between the year 2026 and forecast year 2040 No Build I-494 project links (excludes regional VMT). Note that this method provides a conservative estimate of year 2040 No Build crashes since the existing crash dataset was realized under lower traffic volumes than what was assumed for year 2026 traffic volumes. Thus, the growth applied to existing crashes to predict year 2040 crashes is likely underestimated.

Crash savings in years 2026 and 2040 were calculated by applying the appropriate crash modification factors listed above (also linked in footnotes) to the existing and forecast No Build crash datasets. Safety benefits for years other than 2026 and 2040 were interpolated/extrapolated based on an annual growth rate to determine total safety benefits for the period from years 2027 to 2046. 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.

8. **Environmental and Air Quality Impacts:** Existing, Opening Year, and Future Year emission quantities were developed using the latest Travel Demand Model (TDM) for the Twin Cities Metro region and the Environmental Protection Agency's latest version of the Motor Vehicle Emission Simulator (MOVES) version 3. Vehicle Miles Traveled (VMT) in conjunction with link speeds are summarized for each scenario from the TDM within the project influence area and are then formatted to be run in MOVES. MOVES is then run for each scenario assuming a yearly aggregate for each pollutant to determine the number of metric tons of each pollutant per year.

   Total change in emissions was valued in accordance with the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021.

9. **Operating and Maintenance Costs**: Routine annual maintenance costs and programmed rehabilitation activities were provided by MnDOT for the No Build and Build Alternatives and included in the BCA. The activities quantified for the No Build are programmed preservation activities for assets that will be fully reconstructed as part of the Build (i.e. reconstruction costs are included in the Build). Note that No Build activities and their associated quantities only reflect the extent to which rehabilitation is required for each asset,

[3] http://www.cmfclearinghouse.org/detail.cfm?facid=8335
[4] CMF ID 480 at https://www.virginiadot.org/business/resources/HSIP/Virginia_State_Preferred_CMF_List.pdf
[5] http://www.cmfclearinghouse.org/detail.cfm?facid=3898
[6] http://www.cmfclearinghouse.org/detail.cfm?facid=7445

rather than costs associated with reconstructing to the extent assumed for the Build. Costs were deflated from year of expenditure dollars back to present day dollars for use in the BCA. Preservation activities realized under the No Build are detailed in Table 1.

The Build assumed annual maintenance costs for the additional pavement on MnDOT's highway system. In addition to pavement maintenance, operating costs associated with the managed lane facility were included for the extents of the benefit-cost analysis period. These costs include the replacement of MnPASS readers, enforcement beacons, dynamic message signs, and general operating, enforcement, and maintenance costs and are shown in Table 2.

Table 1. No Build Rehabilitation and Maintenance Schedule

Activity	Year	Total Cost
Pavement Rehab (France Ave to I-35W)	2024	$6,671,111
Bridges 6851 and 6850 (I494 over I35W)	2031	$398,773
Bridge 9080 (12th Ave over I494)	2031	$3,355,828
Bridge 9079 (Portland Ave over I494)	2031	$3,736,196
Bridge 9077 (Nicollet Ave over I494)	2031	$3,122,699

Table 2. Build Operations and Maintenance Schedule

Item	Year	Cost per Unit	Total Cost
MnPASS Readers (10 units)	2036	$22,000	$220,000
Enforcement Beacons or IR Cameras (10 units)	2036	$7,500	$75,000
18-Foot DMS (8 units)	2041	$70,000	$560,000
40-Foot DMS (3 units)	2041	$160,000	$480,000
MnPASS Operations, Enforcement, and Maintenance (Yr 1/2)	2026-2027	$500,000	$1,000,000
MnPASS Operations, Enforcement, and Maintenance (Yr 3)	2028	$550,000	$550,000
MnPASS Operations, Enforcement, and Maintenance (Yr 4+)	2029-2046	$600,000	$10,200,000
Annual MnPASS Pavement Maintenance (20 years)	2026-2046	$24,250	$485,000

10. **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. These values were expressed in terms of 2019 dollars and were added to other project benefits in accordance with USDOT guidance. In determining remaining capital value of the initial capital cost, the costs of the Build Alternative were separated into the following categories:

    - Right of Way
    - Major Structures

- Grading and Drainage
- Sub-Base and Base
- Surface
- Miscellaneous Costs – Includes mobilization, removals, utility relocation, traffic control, 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 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 the increase in roadway capacity and safety.
    - Accessibility and quality of life benefits associated with the new pedestrian bridge near Chicago Avenue.
    - Benefits associated with potential bridge closures under a No Build scenario for structures undergoing reconstruction, rehabilitation, and maintenance as part of the Build project.
    - Construction was assumed to take place throughout the full year in 2023 and 2026 when it is only scheduled to take place for part of each year. This results in slightly greater present value initial construction costs and prolongs the period in which benefits can be accrued in the BCA.
    - There are likely additional safety savings associated with bridge braids (i.e. removing ramp-to-ramp weaves) proposed on the northbound and westbound approaches at the I-494 and I-35W system interchange than what was quantified in the BCA.

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 benefit-cost analysis workbook.

Table 2 – Total Project Results

	Initial Capital Cost (2019 Dollars)	Project Benefits (2019 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2019 Dollars)
No Build vs. Build	$221.3 million	$876.5 million	4.0	$655.2 million

Attachment A

Benefit-Cost Analysis Worksheet

Attachment B

VISSIM Microsimulation Analysis Results

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2026 No Build AM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	41.68	1,049,005	25,231	278,030
2	40.51	1,050,781	26,121	278,027
3	40.88	1,049,501	25,915	278,025
4	42.07	1,048,959	25,049	278,021
5	41.83	1,049,437	25,225	278,029
Average	41.39	1,049,537	25,508	278,026

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2026 No Build PM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	32.06	1,370,230	44,441	422,765
2	33.56	1,374,030	42,855	422,765
3	31.46	1,374,444	46,156	422,765
4	33.33	1,370,828	42,147	422,765
5	31.55	1,373,103	45,876	422,765
Average	32.39	1,372,527	44,295	422,765

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2026 Build AM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	48.59	1,105,775	23,609	293,363
2	48.38	1,106,494	23,508	293,363
3	48.74	1,106,529	23,671	293,365
4	48.99	1,104,535	23,293	293,364
5	49.11	1,104,508	23,369	293,369
Average	48.76	1,105,568	23,490	293,365

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2026 Build PM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	44.03	1,445,622	33,661	445,563
2	45.90	1,446,427	32,304	445,562
3	45.90	1,444,505	32,187	445,563
4	45.47	1,447,243	32,721	445,550
5	44.42	1,446,520	33,741	445,553
Average	45.15	1,446,063	32,923	445,558

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2040 No Build AM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	31.24	1,126,959	43,769	301,610
2	31.96	1,128,810	44,835	301,810
3	32.85	1,126,568	42,094	301,873
4	31.78	1,127,529	44,429	301,819
5	31.70	1,129,636	43,966	301,824
Average	31.91	1,127,900	43,819	301,787

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2040 No Build PM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	26.79	1,454,336	67,133	453,388
2	26.16	1,456,798	72,515	453,390
3	26.51	1,453,324	67,946	453,227
4	25.61	1,455,670	72,562	453,201
5	26.43	1,458,277	70,619	453,403
Average	26.30	1,455,681	70,155	453,322

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2040 Build AM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	41.10	1,201,617	37,585	318,657
2	41.35	1,201,276	36,128	318,649
3	40.83	1,202,067	36,142	318,647
4	40.59	1,203,066	35,740	318,645
5	39.95	1,203,220	37,327	318,654
Average	40.76	1,202,249	36,584	318,650

I-494: Airport to Hwy 169
VISSIM Network Results
Year 2040 Build PM

Simulation Run	Average Speed (mph)	VMT	VHT	Total Vehicles
1	33.13	1,574,498	64,738	484,501
2	35.26	1,575,096	61,566	484,479
3	34.19	1,574,534	58,787	484,501
4	35.76	1,572,190	56,810	484,501
5	35.77	1,575,363	58,975	484,502
Average	34.82	1,574,336	60,175	484,497