Memorandum

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Minnesota Department of Transportation District 6

From: Nick Semeja, PE

Date: September 6, 2022

Subject: I-90 Bridges Improvement and Mobility Project – 2022 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 I-90 Bridges Improvement and Mobility Project – 2022 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 and 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.

Interstate 90 (I-90) is an important east-west interstate corridor that connects vital economic centers across the United States. I-90 through Austin was the first section of the interstate constructed in Minnesota, in the late 1950s. The bridges along I-90 in Austin were constructed between 1958 and 1959. These bridges have served the transportation network for over 60 years and are well past their useful design life. Several operational and safety concerns exist for roadway users, freight haulers, and businesses along the project corridor. The existing transportation challenges in the area include:

- Poor state of repair of ten bridges including structurally deficient and/or functionally obsolete structure, poor deck condition and geometry, insufficient vertical clearances, and significant scour conditions at piers under water.
- Significant crash and safety concerns due to narrow bridges and insufficient sight lines, for both motorist and non-motorists.
- Congestion along the corridor due to inadequate traffic operations and queuing.
- Lack of Americans with Disabilities Act (ADA) compliant multimodal infrastructure.

The project consists of a bundle of ten bridges that includes reconstruction of eight bridges (five overhead structures, two mainline bridges, and one pedestrian bridge) and rehabilitation of two mainline bridges along I-90, at six sites.

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 any of the I-90 bridges associated with the project. According to the National Bridge Inventory Report[1], 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, substructure delamination, cracking of abutments and columns, spalled concrete, and exposed rebar. Other issues include steel girder fatigue, steel corrosion, and minor paint failure along with the bridge railings. All five of the overhead bridges have insufficient vertical clearance. Additionally, two of the bridges over Cedar River are experiencing critical river scour resulting in exposed footings.

Table 1 – Bridge Condition Ratings

Bridge	Location	NBI Condition Rating*					Remarks
		Deck	Super Structure	Sub-Structure	Channel	Culvert	
9183	MN 105 / Oakland Ave. over I-90	4	6	5	N	N	Structurally deficient
50803	US 218N over I-90	6	5	5	N	N	Functionally obsolete
50804	US 218N over I-90	5	5	6	N	N	Reconstructed to accommodate reconfiguration of the interchange and address critical safety concerns
9180	CSAH 45 / 4th Street NW over I-90	5	6	5	N	N	Functionally obsolete
6868	I-90 WB over the Cedar River	5	6	5	6	N	Scour critical, footing is exposed
6869	I-90 EB over the Cedar River	5	7	5	6	N	Scour critical, footing is exposed
9178	I-90 WB over CSAH 16/6th Street NE	5	6	6	N	N	The bridge will be rehabilitated and not replaced
9179	I-90 EB over CSAH 16/6th Street NE	5	6	6	N	N	The bridge will be rehabilitated and not replaced
9201	US 218S over I-90	4	6	6	N	N	Structurally deficient
9218	Ped bridge over the Cedar River	7	7	7	7	N	Bridge does not meet current ADA guidelines for width

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

The bridges were expected to close to traffic in year 2026 based on current bridge conditions and remaining service lives, apart from the I-90 bridges over CSAH 16/6th Street, which were assumed to close in year 2029. The remainder of the transportation network assumed no changes relative to its existing layout.

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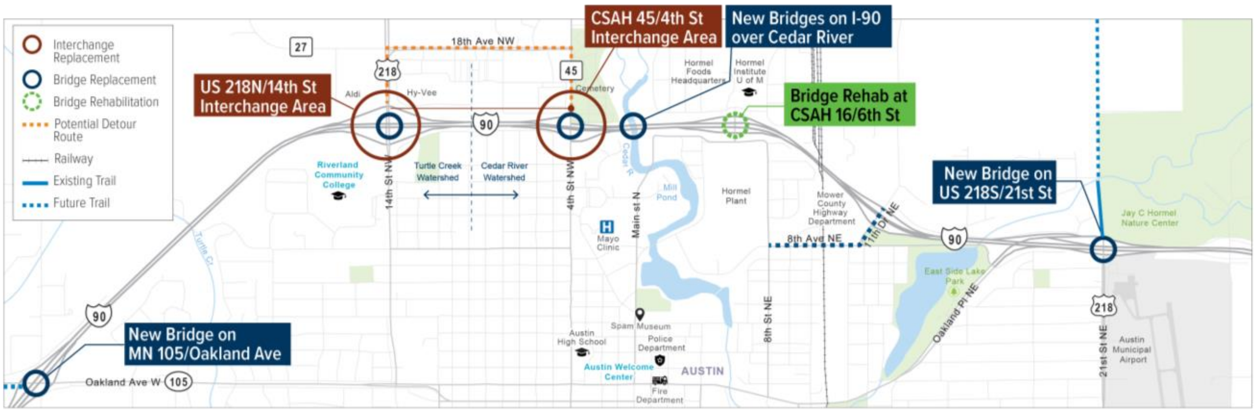
[1] https://projects.srfconsulting.com/bip/mndot-i-90-austin/NBI-Data.pdf

Build Alternative

The Build Alternative included reconstruction and rehabilitation of the bridges listed in Table 1 in addition to several other mobility, safety, and preservation improvements. A map of bridge reconstruction and rehabilitation projects is also provided in Figure 1.

Figure 1 – Project Location Map



Detail regarding the proposed improvements is provided below.

Benefits were quantified for the following improvements:

- Reconstructing bridges at six locations to restore them to a state of good repair, address structural and safety issues, and reduce future annual maintenance costs. These include:
  - Bridge 9183 along MN 105 (Oakland Avenue W) over I-90
  - Bridge 50804 along US 218N (14th Street) over I-90
  - Bridge 9180 along CSAH 45 (4th Street) over I-90
  - Bridges 6868 & 6869 along I-90 over Cedar River
  - Bridge 9201 along US 218S (21st Street) over I-90
  - Reconstructing the pedestrian bridge 9218 over the Cedar River
- Removing existing bridge 50803 along southbound US 218N to reconfigure the interchange.
- Rehabilitating bridges 9178 & 9179 along I-90 over CSAH 16 (6th Street NE) to repair structural issues such as cracking, spalling, and minor delamination in the bridge superstructure. These bridges are in better condition than the others and therefore are recommended for rehabilitation and not replacement.

Benefits were not quantified for the following improvements:

- Constructing two new tear drop roundabouts (RABs) at the I-90/ US 218N interchange ramp connections to address critical safety issues at this interchange.
- Raising the bridge heights on four overhead bridges (9183, 50804, 9180, and 9201) to meet the 16.5-foot minimum vertical clearance consistent with MnDOT standards for bridge design.
- Reconstructing ramp connections at four I-90 interchanges (MN 105, US 218N, CSAH 45, and US 218S) to match revised bridge profile and to improve safe merging of vehicles including heavy trucks.

- Reconstructing approximately 1,000 feet of CSAH 45 to match revised bridge profile, reconstruct existing driveways, median, and sidewalks.
- Reconstructing approximately 1,400 feet of I-90 mainline to match revised bridge profile over Cedar River.
- Widening of all the reconstructed bridges to include 8-foot paved shoulders along both traffic directions to allow for safer passing of queued vehicles or stopping of emergency vehicles as well as improved sight distances.
- Constructing 6-foot to 12-foot-wide multiuse trails/walkways along the four overhead bridges (9183, 50804, 9180, and 9201) and along the associated interchange connections to provide multimodal connectivity to the existing and planned trail networks in the area.
- Converting the I-90/CSAH 45 interchange to a single-point urban interchange (SPUI) design to address mobility and safety needs.
- Installing median inlets and storm sewer infrastructure throughout the Project corridor to resolve flooding and increase resiliency.
- Reconstructing the pedestrian bridge over the Cedar River.

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
   - Crashes by severity
   - Environmental and air quality impacts
   - Initial capital costs: Capital costs were expected to be incurred in years 2024 through 2026
   - 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 three-year period, starting in year 2024, with completion in year 2026. Therefore, year 2027 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 2027 to 2056[2].

[2] A thirty-year benefit cost analysis period was assumed considering the bridges are expected to have service lives far beyond the analysis period.

The present value of all benefits and costs was calculated using 2020 as the year of current dollars.

3. **Economic Assumptions**: 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 March 2022 (Revised)[3]. The analysis was completed using an assumed discount rate of seven 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 I-90 bridges closed (i.e., the No Build). Detour routes under No Build conditions were determined by evaluating alternate routes using Google Maps. Optimal routes from a VMT/VHT user cost perspective were chosen to reflect detour routes for the No Build. Existing routes and their associated detours that were quantified in the analysis are shown in the BCA Workbook and described below.

    - Eastbound and Westbound 1 – vehicles traveling from the west end of the project corridor to the east end (and vice versa) would need to detour around the Cedar River bridges. Vehicles were assumed to exit on CSAH 45 (4th Street) and take 4th Street/11th Avenue/Main Street/15th Avenue to the 6th Street eastbound I-90 on-ramp. The detour for the westbound vehicles were assumed to follow a similar route.
    - Eastbound 2 – for vehicles destined for north on US 218 (14th Street) or CSAH 45 (4th Street) and would no longer be able to take the bridges over I-90. Assuming other I-90 bridges (e.g. Cedar River bridges) are no longer serviceable, the assumed detour route for eastbound vehicles was to exit on CR 46 (roughly nine miles west of the project area) and take CR 46/31st Street/CR 27 to US 218 (14th Street). It was assumed all trips making this movement would originate from west of CR 46.
    - Eastbound and Westbound 3 – for vehicles that are using 4th Street to travel in and out of the City of Austin to/from the east end of I-90. These vehicles were assumed to detour around the Cedar River bridges by using Oakland Avenue/Oakland Place from near the city center.
    - Eastbound and Westbound 4 – for vehicles that are using 14th Street to travel in and out of the City of Austin to/from the east end of I-90. These vehicles were assumed to detour around the Cedar River bridges by using Oakland Avenue/Oakland Place from near the city center (similar to Detour 3).
    - Northbound and Southbound 5 – for vehicles using the US 218 (14th Street) and CSAH 45 (4th Street) bridges to get to/from the City of Austin from/to north of I-90. Since all project area bridges across I-90 west of the Cedar River are expected to be decommissioned under No Build conditions, the optimal detour route is for vehicles north of I-90 to take CR 2 east to CR 61, and then south to Oakland Place into the City of Austin (vice versa for northbound vehicles). It was assumed all trips making these north/south movements along US 218 and CSAH 45 would originate from the CR 2 intersection or further north, which can be considered a conservative estimate of potential VMT/VHT for the detour route.

[3] https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf

There are several other detours that were not quantified in the analysis that have the potential to add to benefits to the project. Notable non-quantified detours include existing trips using the Hwy 105 (Oakland Avenue) bridge to cross I-90 and vehicles using the US 218 (21st Street) bridge on the east end of the project area to cross I-90.

StreetLight[4] data was acquired to determine origin-destination percentages for eastbound and westbound I-90 users. These percentages were applied to AADTs[5] on I-90 and each cross street to determine the number of daily users that access each bridge from I-90 and thus, users that would have to use each detour. The origin-destination tables from StreetLight and the ensuing daily volume allocation to detour routes are provided in the BCA Workbook.

Lastly, forecasted growth rates were determined based on anticipated population growth in the City of Austin Comprehensive Plan[6]. The plan estimates that Austin will grow by 15.2 percent between years 2015 and 2035, indicating an annual growth rate of 0.76 percent. This growth rate was applied to existing volumes to determine annual growth throughout the benefit cost analysis period.

Travel times and miles-traveled for each detour route were compared to routes along I-90 assumed for the Build Alternative to determine a change in VMT and VHT for each user. The shifts in VMT and VHT were applied to the number of users estimated for each detour to determine annual VMT and VHT changes. Benefits were quantified for the thirty-year period between 2027 and 2056. 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.

Note that additional delay per user would be expected on detour routes through the City of Austin as more traffic is routed through facilities that are not designed to handle high volumes of traffic. Any additional delay due to the detour routes becoming over-capacity was not accounted for in the No Build Alternative, which can be considered a conservative estimate of project benefits.

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:

   - The assumed truck percentage on the study corridor was 11.5 percent and was based on years 2019 and 2020 daily traffic and heavy truck counts provided in the MnDOT Traffic Mapping Application[7].
   - Vehicle occupancy that was used in the analysis is consistent with values provided in Benefit Cost Analysis Guidance for Discretionary Grant Programs, dated March 2022

[4] https://www.streetlightdata.com/
[5] AADTs in the project area were obtained from MnDOT's Traffic Mapping Application
[6] Page 13 of http://www.ci.austin.mn.us/Econdev/ComprehensivePlan.pdf
[7] https://mndot.maps.arcgis.com/apps/webappviewer/index.html?id=7b3be07daed84e7fa170a91059ce63bb

(Revised). The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

6. **Safety Analysis:** The Build Alternative improves safety in the project area by allowing users to drive on a traditionally safer freeway facility to reach their destinations, rather than detouring through at-grade city streets. The change in VMT on I-90 and each detour route was applied to existing crash rates by severity on each corridor to determine the change in annual crashes by severity.

   Five years (2015 to 2019) of existing crash data was provided by MnDOT on I-90 and each detour route to determine average crash rates by severity on each corridor. The safety benefit was quantified for the thirty-year period from 2027 through 2056. 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.

7. **Environmental and Air Quality Impacts:** Annual VMT is expected to be impacted by the bridge closures on the I-90 project corridor. The change in VMT between the No Build Alternative and Build Alternative was caused by the diversions described in Section 4 of this memorandum "Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)." Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3[8]. 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 (Updated).

8. **Operating and Maintenance Costs**: Maintenance and inspection costs associated with the I-90 bridges were quantified for both the No Build and Build Alternatives. Condition-based annual average maintenance and inspection costs were provided by the MnDOT bridge office. Maintenance activities under the No Build Alternative were no longer assumed to occur once bridges were expected to close. Therefore, maintenance costs for the No Build were only applied for the I-90 bridges over 6th Street based on their expected condition prior to closure in year 2029. Average annual maintenance and inspection costs were assumed for all project bridges for the duration of the benefit-cost analysis period.

   Additionally, the MnDOT bridge office provided costs and schedules for more intermittent activities associated with the bridge decks and railings for each project bridge. These costs were expected to be incurred every five years following reconstruction.

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 2020 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

[8] https://www.epa.gov/moves

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:
    - Increased travel time reliability in the study area due vehicles continuing to use a higher-capacity facility (I-90) under the Build Alternative.
    - Safety and quality of life benefits associated with providing enhanced pedestrian and bicycle facilities and multimodal connections throughout the project area.
    - 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.
    - Benefits at the US 218 (14th Street) and CSAH 45 (4th Street) interchanges due to redesigns to address safety and mobility issues.
    - Safety and mobility benefits due to expanded shoulders at project interchanges.
    - Reduction in crashes for truck strikes at bridges with inadequate vertical clearance.
    - Travel time reductions for trucks that must use ramps to bypass bridges with inadequate vertical clearance.
    - Improved resiliency to floods and associated detours due to roadway profile and stormwater infrastructure enhancements along the corridor.
    - Construction impacts on I-90 user travel times; construction will be staged to keep the corridor open to traffic in both directions during construction. However, free-flow speeds will likely be reduced on certain sections of the project corridor where traffic will be traveling head-to-head on one side of the roadway for two out of the three construction years. This impact is likely to occur for a few months out of the year during construction season and will provide a disbenefit to the project.

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 (2020 Dollars)	Project Benefits (2020 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2020 Dollars)
No Build vs. Build	$31.0 million	$196.9 million	6.4	$165.9 million

Attachment

Benefit-Cost Analysis Worksheet