Memorandum

SRF No. 15508

To: Tom Lundberg, Program Development Manager
Minnesota Department of Transportation District 4

From: Nick Semeja, PE
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Date: August 17, 2023

Subject: West Central Minnesota I-94 Blowing and Drifting Snow Control Project

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 Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation Program (PROTECT) – 2023 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 West Central Minnesota I -94 Blowing and Dring Snow Control Project, hereafter referred to as the Project, is located along Interstate 94 (I-94) between the cities of Moorhead and Alexandria. The interstate is an invaluable transportation asset for the interstate and intrastate movement of people and goods and serves as a major connector between the Fargo-Moorhead Metropolitan Area and the Twin Cities. The Project will improve transportation safety for all users and bolster quality of life for those who live nearby or travel through the area.

Description of Alternatives

For the purpose of this analysis, a No Build and Build Alternative are under consideration.

No Build Alternative

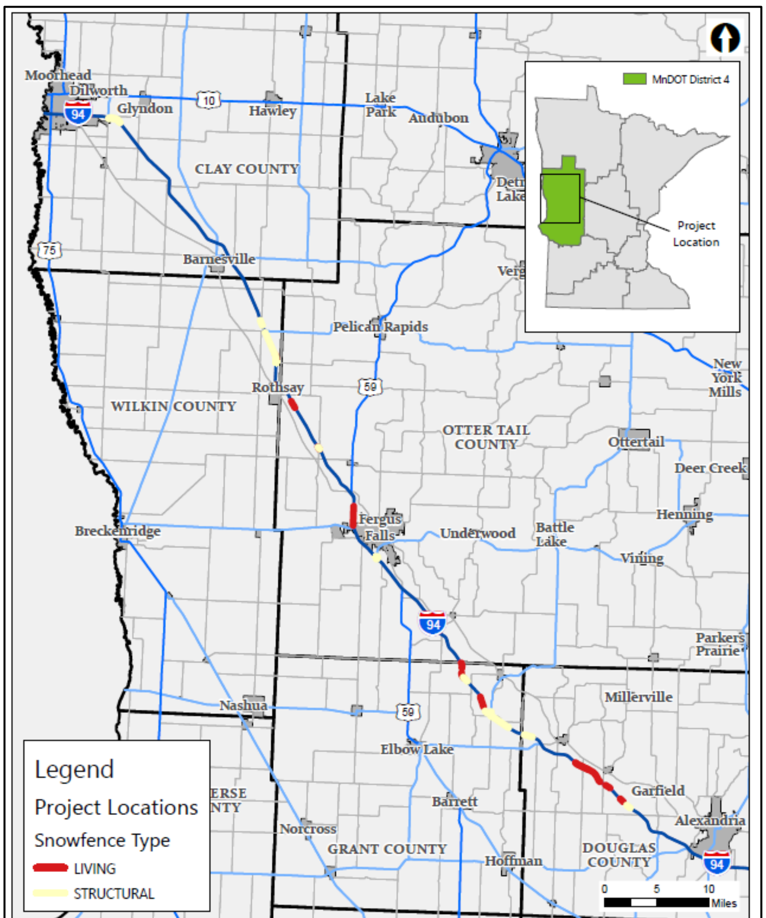
The Project aims to make considerable improvements in the safety, mobility, and roadway capacity of the project area. These improvements are necessary, as the status of the current infrastructure and configuration continues to cause issues for users in the winter.

MnDOT snowplow crews, Minnesota State Patrol, and other emergency responders have long fought a continuous battle against the harsh Minnesota winters which can drop upwards of a foot of snow and ice, creating unsafe travel conditions and, on occasion, forcing the closure of I-94. Combined with high winds and wind chill temperatures as low as negative 40 degrees Fahrenheit, these winter conditions can prove not only cumbersome for travelers along the Interstate corridor but also tragically fatal.

For the BCA, it is assumed that existing maintenance of the road will remain constant throughout the analysis period, which is likely a conservative assumption. The previous five years of equipment use, deicers, vehicle crashes, road closures associated with blowing snow events, and travel time impacts from blowing snow events were used as a basis for future No Build costs.

Build Alternative

The Project will install 23.5 total miles of snow fence across 38 sites, consisting of both structural and living snow fences. Snow fence sites are all along I-94 in Clay, Wilkin, Otter Tail, Grant, and Douglas Counties (see Figure 1). Of the 38 sites, 21 will be constructed using structural snow fences (10.5 miles), and 17 will be constructed using living snow fences (12.9 miles).



Snow Fence Locations
MnDOT District 4

This project will improve the system wide resiliency of Minnesota's transportation network by taking a comprehensive approach to snow fence installation and addressing blowing and drifting snow at the corridor level. It will mitigate the worst snow traps along the I-94 corridor, improving highway safety, reducing the need for wintertime maintenance, and enhancing operation of the interstate for local, statewide, and regional users. Project benefits include:

- Reducing snow drift and icy roads, improve roadway safety, reduce the occurrence of stranded motorists, and limit the need for emergency response. Snow fences also provide consistent driving conditions, reducing drifting snow and ice sporadically throughout the corridor.
- Reducing maintenance needs and costs during the winter months, which will allow MnDOT

maintenance crews to focus efforts on other state highways providing network wide safety and operational benefits.
- Reducing environmental impacts to surface waters and air quality by decreasing chloride usage on the interstate for ice melt and reducing fuel consumption for snowplows.
- Improving the overall operation of I-94 throughout the winter months, enhancing community access to vital goods and services, improving emergency response during storm events, and reducing delays in freight movement and shipping.
- Reducing the occurrence of interstate closure and issuance of travel advisories.
- Reducing exposure of emergency response providers to severe weather conditions to provide services to crashes and stranded vehicles.

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
   - Maintenance costs
2. **Analysis Years**: This analysis assumed that construction would take place in years 2028 and 2029. Therefore, year 2030 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 thirty-year period from 2030 to 2059. The estimated design life of the snow fences is also thirty years, so no residual project value after the analysis period was assumed. The present value of all benefits and costs was calculated using 2021 as the year of constant dollars.
3. **Economic Assumptions**: The value of time, per mile vehicle operating costs, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023[1]. The analysis was completed using a discount rate of seven percent.
4. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Travel time changes were calculated using snow event data from MnDOT and route/lane closure data associated with vehicle crashes from press release information. Adverse weather event data for the five winters between years 2018 and 2023 was provided by MnDOT. The dataset includes start and end times of the events, weather-related causes of the event (e.g.

[1] https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

rain, snow, blowing snow, ice, etc.), and the number of hours a bare lane was lost during the event and how long after the event it took to regain the bare lane (the sum of the two values being the total number of hours the bare lane was lost). A bare lane is defined by MnDOT as a lane being mostly free of ice and snow, to the degree that travel speeds are not impacted. Adverse weather events were screened to only include events that were listed to have blowing snow and wind/drifting.

Since adverse weather events often spanned several hours across the day, an average hourly volume was calculated by taking the average annual daily traffic volume (AADT) and dividing it by 24 hours. The average hourly volume was multiplied by the total duration the bare lane was lost to determine the total number of vehicles impacted by the event.

A reduction in travel speed of 20 mph from an assumed free flow speed of 70 mph (i.e. the posted speed) was assumed for blowing snow/ice events. Impacts to travel speeds in snow and ice conditions can vary based on the severity of the event. However, a review of vehicle speeds from vehicle probe data in Minnesota during snow events suggested a highway travel speed of roughly 50 mph. This speed would also reflect approximate free flow travel speeds on parallel routes if users opted to not use I-94 during adverse weather conditions.

To be conservative, a reduction in hourly vehicle demand was also assumed for snow events, as less people are likely to travel during these conditions. A 30 percent demand reduction was applied to determine the increase in travel time during blowing snow events.

The last adjustment made to estimate vehicle-hours of lost bare lane that would be impacted by the proposed snow fences was to take the ratio of added snow fence length (23.5 miles) and the analysis corridor length (93 miles, or the distance between Alexandria and Moorehead). This assumes that bare lane losses due to snow events are universally spread out along the I-94 corridor. However, this is likely to be a very conservative assumption considering a large portion of bare lane losses are occurring at at-risk locations where there are gaps in the existing snow fence network (10 miles), which is where the snow fences for this project are being proposed. The resulting impact on lost bare lane hours assumed for the project was 15 percent, which is a conservative estimate since the proposed snow fences would cover 25 percent of the corridor, or 28 percent of the corridor after accounting for existing coverage where lost bare lane hours are less likely.

An inventory of road or lane closures due to rollover, jackknife, or other crashes was provided by MnDOT. This data included directions of travel for closures, duration of closures, and locations of closures. Optimal detour routes based on travel time were chosen to estimate the added VHT from the I-94 closures under the No Build, and travel time for the existing route along I-94 and the detour routes were determined using Google Maps (routes are provided in the BCA Workbook).

The additional vehicle operating costs under a No Build scenario were estimated from the added time vehicles would spend driving compared to in a Build scenario. VMT equivalents based on VHT were derived using fuel usage rates and were applied to vehicle operating costs in the USDOT BCA Guidance. An annual growth rate of one percent was used in the analysis to predict traffic growth. This growth rate was based on historical traffic volumes along the I-94 corridor.

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 19.8 percent, based on year 2022 vehicle classification obtained from MnDOT.[2]
   - 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. **Safety Analysis:** The Build Alternative improves safety in the project area by providing snow fences to prevent snow and ice buildup and poor visibility due to blowing snow, which leads to unsafe driving conditions. Existing crash data was collected for the period starting in late October of 2017 and ending in late April of 2022, resulting in roughly four years and six months of crash data. Crashes were collected within 250 feet of proposed snow fence locations to determine No Build crash costs and potential crash cost savings from the snow fences.

   The crash modification factor for the "Install Snow Fencing[3] " was obtained from the Crash Modification Factors (CMF) Clearinghouse database. The crash modification factor was applied to all crash types with severities K, A, B, and C. A crash modification factor for property damage crashes was obtained from the same source.[4] The Crash Modification Factors were applied to No Build crash costs to determine safety benefits under a Build scenario.

7. **Environmental and Air Quality Impacts:** Changes in emissions are expected to be impacted by the additional VHT expected in a No Build scenario. The change in VHT between No Build and Build Alternatives was converted to equivalents of vehicle-miles traveled (VMT) by applying average fuel consumption per hour 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.

8. **Maintenance Costs**: Under the Build Alternative, routine maintenance would be needed on the snow fences. Extra maintenance is needed for the start-up of the living fences in the first three years. After the first three years, an annual maintenance cost of $500 per snow fence was assumed for living snow fences. A similar annual maintenance cost of $500 dollars was also

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[2] https://mndot.maps.arcgis.com/apps/webappviewer/index.html?id=7b3be07daed84e7fa170a91059ce63bb
[3] https://www.cmfclearinghouse.org/detail.php?facid=9119
[4] https://www.cmfclearinghouse.org/detail.php?facid=9118

assumed for structural snow fences. Snow fence maintenance costs per year were provided by MnDOT.

Preventive maintenance costs to keep the roadways clear of ice and snow are expected to notably decrease under the Build Alternative. Deicing costs and equipment costs associated with plows, blowers, tow trucks, and other trucks associated with maintenance were provided by MnDOT for both the No Build and Build Alternatives. No Build costs were based on existing costs for each proposed snow fence location along I-94. MnDOT provided estimates of cost reductions from each source of maintenance by assessing the impacts of previous snow fences. A log of existing maintenance activities and costs is provided in the BCA Workbook.

9. **Factors Not Quantified**: Several factors were not quantified as part of the analysis but have potential to produce other project benefits. These factors included the following:
   - Lost utility from users that don't go out on the road due to poor conditions under a No Build scenario
   - Less chlorides from reduced deicers getting into the environment under a Build scenario
   - Vehicle operating costs associated with additional VMT due to I-94 closures in the No Build scenario
   - Loss of emergency enforcement coverage due to required responses of incidents from adverse weather conditions that the snow fences are expected to mitigate
   - Secondary crashes associated with pile-up events that are more likely to occur under a No Build scenario
   - Reduced pavement deterioration on diversion routes when I-94 is closed due to adverse weather; these costs will be avoided under a Build scenario

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 shown for the project in Table 1 below. See Attachment A for the complete benefit-cost analysis workbook.

Table 1 – Total Project Results

	Initial Capital Cost	Project Benefits	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value
No Build vs. Build	$11.7 million	$36.5 million	3.13	$24.8 million

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