Technical Memo 9: Traffic Operations and Transit Ridership

Highway 169 Mobility Study

Version 1.0

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Introduction

This memorandum documents the traffic analysis and transit ridership forecasting completed for the Highway 169 Mobility Study. This work was completed to evaluate the performance of MnPASS and bus rapid transit (BRT) alternatives along Highway 169 between Highway 41 in Scott County to Highway 55 in Plymouth. Highway traffic volumes and transit ridership forecasts were developed using the Twin Cities Regional Travel Demand Model. Other analyses, including travel time reliability, traffic operations, and operations and maintenance considerations were evaluated using a series of sketch planning tools and are described in this memorandum. The results were prepared for use in an alternative screening evaluation.

Project Alternatives

A no build alternative and three build alternatives were considered in each of the evaluations undertaken as part of this effort. Details of these alternatives are described in the associated document titled "Detailed Description of Alternatives Technical Memorandum". All of the alternatives include a series of baseline assumptions. The three build alternatives are:

1. MnPASS on Highway 169 between Marschall Road and TH 55 combined with BRT service along Highway 169 between Marschall Road and downtown via I-394
2. MnPASS on Highway 169 between Marschall Road and TH 55 combined with BRT service along Highway 169 between Marschall Road and downtown via TH 55
3. MnPASS on Highway 169 between Marschall Road and I-494 (no BRT service)

The evaluations included an assessment of existing conditions (year 2014), and for horizon year 2040.

Highway Traffic Forecasts

Highway traffic forecasts were developed using the Metropolitan Council's Regional Travel Demand Model. This is a four-step model that estimates travel based on trip generation, trip distribution, mode choice, and route assignment. To develop travel demand forecasts for the alternatives and analysis years, a set of future year inputs to the travel demand models were generated to reflect expected background roadway system and land development. Development assumptions follow the local comprehensive plans as accepted by the Metropolitan Council as part of the recent update of the long-range transportation plan. Forecasts were developed in accordance with guidance provided by MnDOT (*Twin City Travel Demand Forecasts Prepared for MnDOT Metro: Model and Parameters for Adjustments to Model Inputs*, April 10, 2006), unless otherwise noted in this memorandum. Additional documentation of the regional travel demand model is available from the Metropolitan Council.

Travel demand models provide an estimation of traffic forecasts that include many future year assumptions. However, with uncertainty regarding future-year conditions, the model results should be considered estimates with some margin of error. MnDOT currently considers long-range forecasts to have a precision of +/- 15 percent. Decision-makers and designers should be aware of the uncertainty in long-range forecasts and whether that margin of error would affect outcomes or the recommended improvements.

Data Collection

Travel demand model validation was performed using freeway loop detector volumes from October 2014, obtained from loop detector data available through the Regional Traffic Management Center (RTMC). Balanced daily and peak period traffic flows were generated from this data along all freeway segments and ramps along Highway 169 in the study area.

Transportation Network Assumptions

Background highway and transit assumptions (those assumed in all alternatives) follow the Metropolitan Council's *Transportation Policy Plan*, adopted January 2015, and as reflected in the Metropolitan Council's Regional Travel Demand model base network as of January 2015. The following regionally significant transportation network improvements potentially affecting the study area are assumed to be constructed between years 2014 and 2040:

Table 1. Table 1: Programmed Projects in the Highway 169 Corridor 2015-2019

Current Revenue Scenario 2015-2018

Project Year	Responsible Agency	Funding Stream*	Project Description
2015	Shakopee	CMAQ	Three years of start-up operating funds for express bus service from Marschall Road to the University of Minnesota
2015	Shakopee	CMAQ	Purchase of three coach buses for the above named transit service from Marschall Road to the U of M
2015	MnDOT	State (100%)	Construct a noise wall on the east side of Highway 169 from 16th Street W to just north of Wayzata Boulevard in St. Louis Park
2016	MnDOT	State (100%)	Replace the existing signals at the ramp to Highway 7 in Hopkins
2016	MnDOT	State (100%)	Replace signs along Highway 169 between Scott County Road 14 in Louisville Township and Old Shakopee Road in Bloomington.
2016	MnDOT	State (100%)	Reconstruct and widen the right shoulder for bus use and add signage and guardrails along Highway 169 between Canterbury Road and CSAH 18 in Shakopee
2016	MnDOT	State (100%)	Install traffic management system along Highway 169 from the Hennepin/Scott County line to east of Highway 169 in Savage
2016	MVTA	CMAQ returned funds	Purchase four 40' buses for Highway 169 Connector express bus service between Shakopee and Minnetonka
2017	Scott County	TAP	Scott West Regional Trail right-of-way acquisition and connection
2017	MnDOT	State (100%)	Close access and construct a visual barrier at 16th Street West in St. Louis Park
2017	MnDOT	State (100%)	Lengthen the acceleration and deceleration lanes, and replace storm sewer, lighting, and traffic management system on Highway 169 at Cedar Lake Road on the border of St. Louis Park and Minnetonka
2017	MnDOT	NHPP	Mill and overlay, drainage, and noisewall removal and reconstruction from just north of Highway 62 in Edina to Highway 55 in Golden Valley
2017	Scott County	CMAQ	Deploy cameras, dynamic message signs, and vehicle detectors on Highway 169, as well as CSAH 83, CSAH 101, and local routes in Shakopee
TBD	MnDOT	TBD	Strategic Capacity Enhancement: construct an additional southbound lane from Scott County Road 18/Canterbury Road to Scott County Road 21
TBD	MnDOT	TBD	Redeck Highway 169 bridges over Highway 212/62 in Eden Prairie/Edina and construct new approach panels

* CMAQ = Congestion Mitigation and Air Quality
NHPP = National Highway Performance Program
STP=Surface Transportation Program

Table 2. Table 2: Programmed Projects in the Highway 169 Corridor 2019-2024

Project Year	Responsible Agency	Project Description
2019-2024	MnDOT	Replace bridge over Nine Mile Creek and repair seven other Highway 169 bridges

* Specific projects have not yet been identified beyond 2024.

Transit Projects:

- METRO Orange Line
- METRO Green Line extension
- Arterial BRT along Snelling Avenue in Saint Paul from 46th St. Station on METRO Blue Line to Roseville
- METRO Blue Line extension
- Gateway dedicated BRT
- Arterial BRT along Penn Avenue in Brooklyn Center and Minneapolis
- Arterial BRT along Chicago Avenue and Emerson and Fremont avenues in Brooklyn Center, Minneapolis, Richfield, and Bloomington
- METRO Red Line Stage 2 improvements including extension of BRT service to 181st Street in Lakeville

Land Use Assumptions

Development inputs to the model (population, households, retail employment and non-retail employment) were obtained from the *Thrive 2040 MSP* forecasts dated October 15, 2014, reflecting the current Metropolitan Council-accepted comprehensive plan information submitted by local communities.

Table 3. Summary of Existing and Project Population and Employment in Study Area Communities

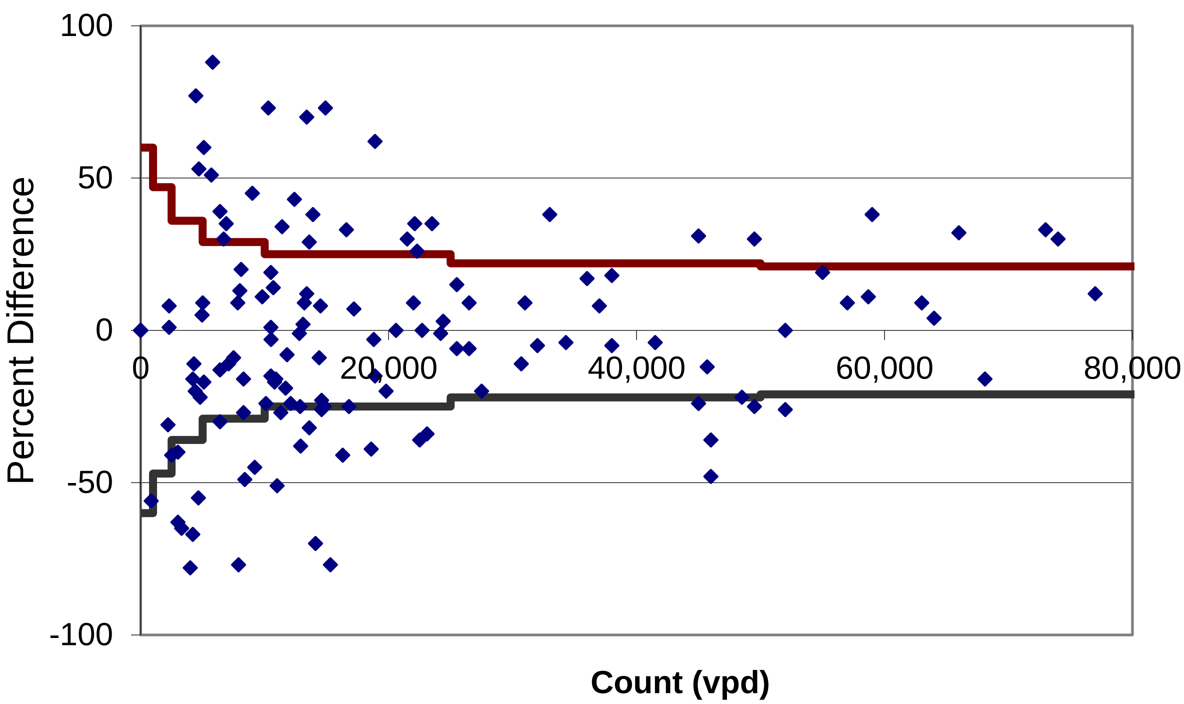
Community	Existing (2014)			Future (2040)		
	Population	Households	Employment	Population	Households	Employment
Bloomington	86,652	37,479	88,837	93,300	41,251	109,702
Eden Prairie	62,593	24,608	51,346	82,392	33,294	66,596
Hopkins	18,971	8,815	14,504	19,901	9,998	16,200
Plymouth	73,633	29,941	49,407	83,605	34,199	61,498
Shakopee	39,523	13,455	19,665	61,952	21,453	31,901

Existing Conditions Model Validation

Model validation compares model performance to real-word conditions, using known input and output data. For travel demand forecasting, the known input data include existing transportation network and land use information. The known output data are highway volumes and transit ridership. The results of model validation often lead to model adjustments than improve model performance and more realistic future forecasts.

The validation results show that 58 percent of area links fall within accepted guidelines (provided by *FHWA Travel Model Validation and Reasonableness Checking Manual*); where 26 percent of links are above and 16 percent of links are below the target range. An illustration of link errors is provided in Figure 3.

Figure 1. Existing Model Validation Link Error Comparison



Statistical error and measure of fit for this model were RMSE of 28 percent and R-square of 95.1 percent, respectively. These measures, along with the individual fit link validation results, are considered acceptable for development of highway forecasts, and are consistent with other comparable projects completed in the Twin Cities region. Based on the fit of the modeled roadway volumes, future year volumes were adjusted using the method described in NCHRP 255 *Highway Traffic Data for Urbanized Area Project Planning and Design*.

MnPASS Assignment

In order to successfully evaluate the NEPA alternatives, forecasting tools that reasonably reflect driver behavior related to managed lane facilities are necessary. While the Metropolitan Council travel demand model is equipped to produce managed lane forecasts, comparison to observed data has shown that additional refinement was needed. Adjustments to MnPASS assignment procedures were utilized based on refinements identified through the *I-35W North Managed Lanes Corridor Study*. These modifications include:

- An ingress/egress penalty to MnPASS lanes that discourages use by short trips (0.5 minute)
- Controlling for use by informal HOV trips by limiting to eligible corridor trips

Alternatives and Results

Travel demand forecasts have been prepared for year 2040 no build conditions and the three build alternatives. No build baseline forecasts include only the programmed improvements listed in the assumptions section.

2040 No Build

Figures 2 through 5 show daily traffic forecasts prepared for year 2040 no build conditions. Daily growth of highway volumes in the corridor is expected to be higher on the southern segments of Highway 169 compared to the southern segments. This is a reflection of more land available for future in Scott County compared to more mature land uses in Hennepin County. It also reflects current capacity constraints along the corridor, as the northern segments of Highway 169 are at or above capacity while the southern portion has some degree of remaining capacity available.

Overall, traffic patterns in the study area are expected to remain similar to existing conditions. These are characterized by peak period directional flows on Highway 169 south of I-494, with a strong direction bias northbound in the morning and southbound in the afternoon. North of I-494, particularly between TH 62 and I-394, flows are more balanced with heavy movements occurring both northbound and southbound during both daily peaks.

2040 Build Alternatives

Traffic forecasts results for Alternatives 1 and 2 produced identical highway volume projections. This is an intuitive result as the proposed highway improvements of adding MnPASS lanes along Highway 169 between Marschall Road and TH 55 do not differ between these alternatives. The results of these forecasts show substantial increases in daily traffic volumes using Highway 169 throughout the study area in response to the proposed capacity increase.

Forecast traffic volumes between Marschall Road and I-494 range from 41,600 to 140,100, representing an increase of 1,100 to 18,700 vehicles per day over no build conditions. North of I-494 to the I-394/TH 55 area forecast volumes of 73,400 to 122,500 are estimated, an increase of 3,800 to 22,400 over no build conditions. These are also reasonable in respect to existing and observed conditions on the Highway 169 corridor. Specifically, the segments south of I-494 experience direction peak period congestion – northbound in the morning peak and southbound in the afternoon. Conversely, the segments between I-494 and TH 55 experience congestion in both directions during both peak periods. As a result, the addition of MnPASS lanes on the northern portion of the corridor would be expected to serve traffic in both directions during both the morning and afternoon, contributing to approximately double to usage of the southern portion which would primarily serve only one direction during each peak.

Figure 2. Daily Traffic Volumes – Existing and Year 2040 No Build

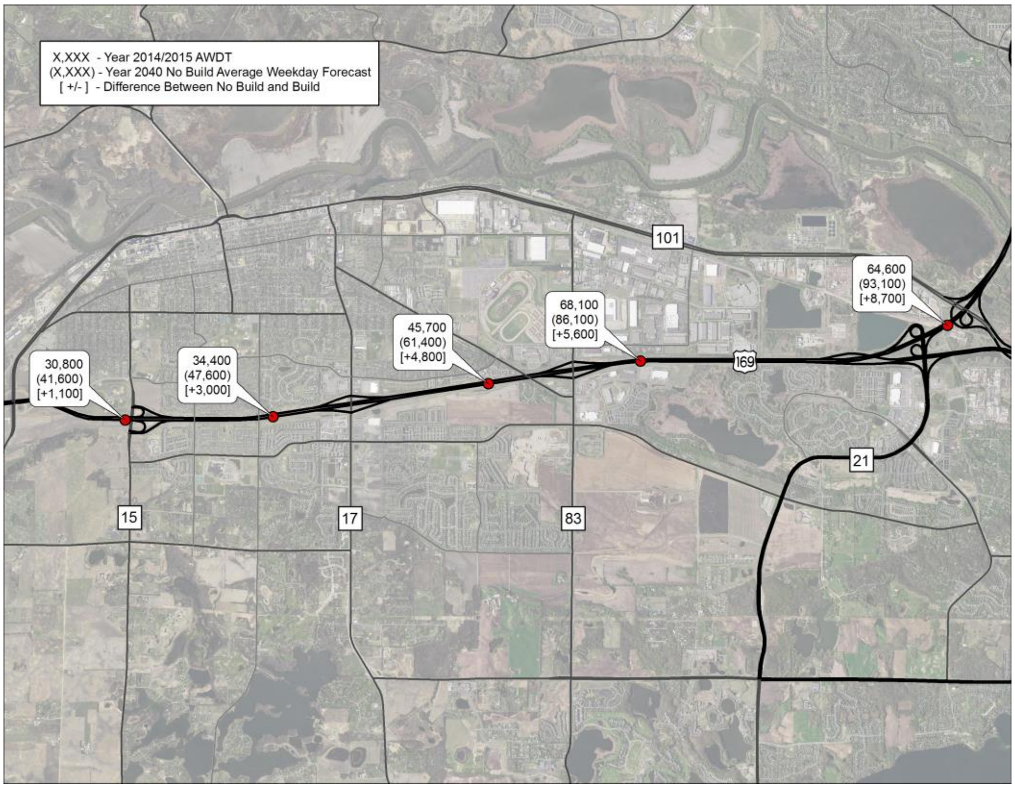


Figure 3. Daily Traffic Volumes – Existing and Year 2040 No Build

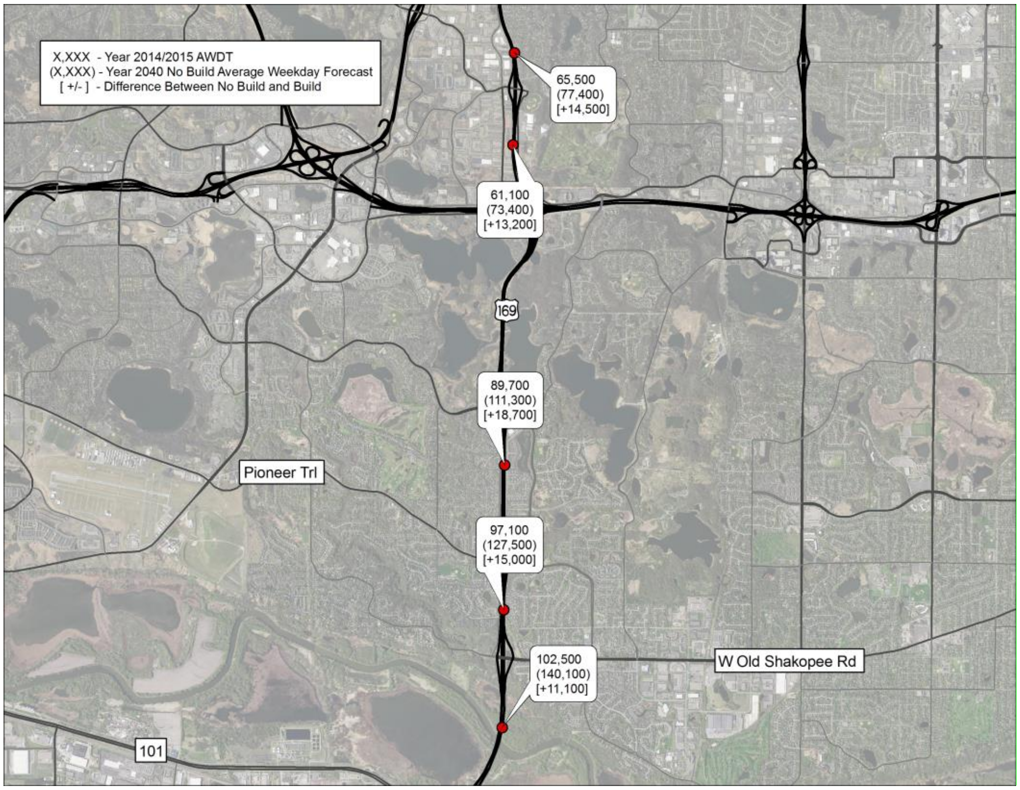


Figure 4. Daily Traffic Volumes – Existing and Year 2040 No Build

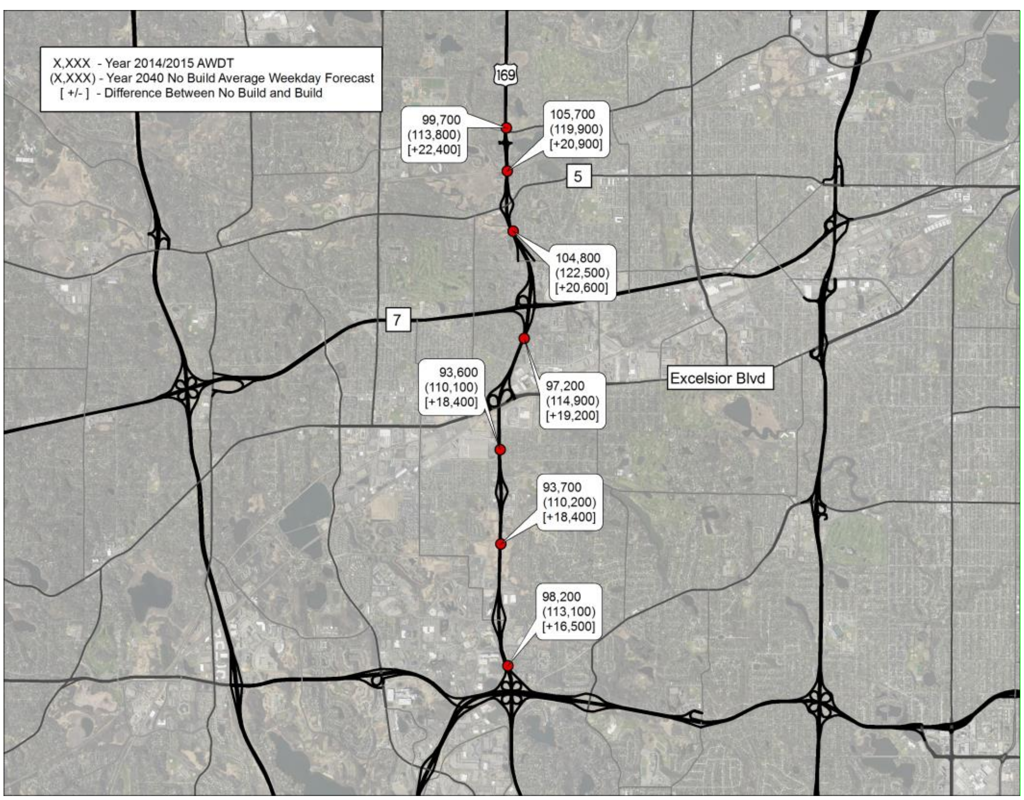
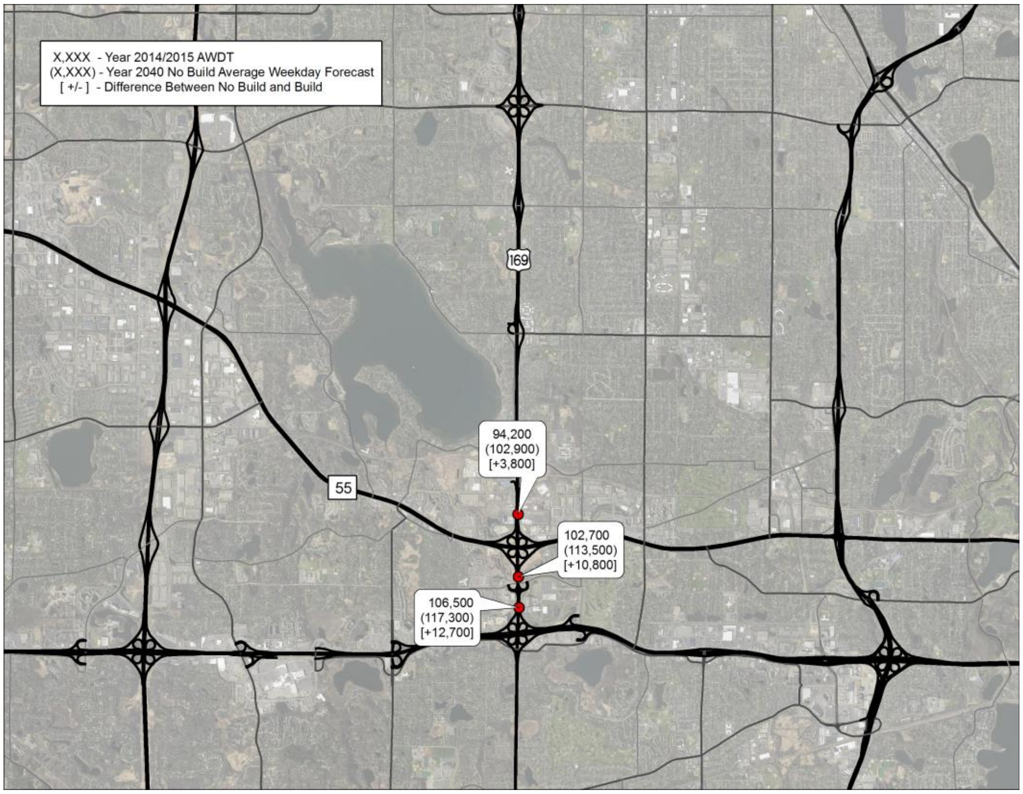


Figure 5. Daily Traffic Volumes – Existing and Year 2040 No Build



Corridor and System Performance Measures

The travel demand model outputs were also utilized to prepare a series of performance measures to compare the benefits expected among the alternatives. For this study these measures included the system-wide change in vehicle-hours traveled (VHT) and total peak-hour person throughput on Highway 169.

System VHT provides a measure of the total travel time savings expected for all highway users as a result of the proposed alternatives. This evaluation not only captures time savings for Highway 169 users benefitting from the additional capacity provided, but also saving from new users to shifting to Highway 169 from other routes and subsequent travel time improvements on those parallel routes.

Table 4. Change in Vehicle-Hours Traveled by Facility

Facility	Change in VHT (Alts 1 & 2)
MnPASS	16,650
General Purpose	-17,550
Non-Freeway	-4,600
Total	-5,500

Alternatives 1 and 2 were estimated to provide a decrease of 5,500 hours of daily travel time as a result of MnPASS lanes provided on Highway 169 between Marschall Road and TH 55 compared to the no build alternative. Alternative 3 had a lower reduction of 2,200 hours, which is reasonable given that Alternative 3 includes fewer new lane miles of capacity with MnPASS provided only between Marschall Road and I-494.

Table 5. Change in Vehicle-Hours Traveled

	Alternative 1	Alternative 2	Alternative 3
Change in vehicle hours traveled from No Build (does not include transit vehicles)	-5,500	-5,500	-2,200

Peak hour person throughput illustrates the expected number of people passing through specific points of Highway 169 during peak conditions. This is an important consideration in the context of a managed lane alternative, in which a primary objective is to move more people, not just vehicles, through advantages provided to carpools and transit vehicles. This evaluation incorporates the higher vehicle occupancy of these modes to capture these effects.

Table 6. Peak-Hour Person Throughput by Lanes and Mode – Northbound at MN River

Lanes/Mode	No Build	Alternative 1	Alternative 2
MnPASS	-	2,900	2,900
General Purpose	11,900	9,800	9,800
Transit	500	600	700
Total	12,300	13,300	13,400

Table 7. Peak-Hour Person Throughput by Lanes and Mode – Northbound South of I-394

Lanes/Mode	No Build	Build 1	Build 2
MnPASS	-	3,100	3,100
General Purpose	9,600	8,400	8,400
Transit	600	700	900
Total	10,200	12,200	12,400

Alternatives 1 and 2 have very similar person throughput estimates, which were summarized for northbound TH 169 at the Minnesota River and just south of I-394.

Table 8. Peak-Hour Person Throughput Summary

Total AM peak-hour person throughput	No Build	Alternative 1	Alternative 2	Alternative 3
Hwy 169 at Minnesota River	12,300	13,400	13,600	13,100
Hwy 169 South of I-394	10,200	12,300	12,400	10,100

Peak Hour Traffic Volumes

The daily traffic volume forecasts described previously in the Highway Traffic Forecast section were also utilized to develop balanced peak hour traffic volume estimates for each of the alternatives. These were subsequently utilized in the traffic operations assessment. These peak hour volume forecasts were developed using existing peak period traffic volumes and anticipated traffic growth from the daily traffic forecasts. This process takes into consideration capacity constraints at entry points into the corridor and separates volumes in MnPASS lanes from general purpose lanes in applicable segments. Tables containing all peak hour volumes on mainline segments and ramps along Highway 169 in the study area are provided in Appendix A.

Transit Ridership Forecasts

Transit ridership forecasts were developed to compare the anticipated utilization of alternatives providing BRT service along Highway 169 in the study area and into downtown Minneapolis. These include Alternatives 1 and 2, which are routed between Highway 169 and downtown Minneapolis via I-394 and TH 55, respectively. Additional details of the BRT and associated service proposed as part of these alternatives are provided in the *Detailed Definitions of Alternatives Technical Memorandum*. Transit ridership forecasts were not developed for Alternative 3, as it does assume any additional transit service is provided beyond no build conditions.

BRT Operations Assumptions

The BRT ridership forecast model uses several inputs from the alternatives service plan. All assumptions regarding the BRT service plan, run times, and connecting bus service are detailed in the *BRT Transit Service Plan and Operations and Maintenance Costs Technical Memo*. Key components guiding the transit ridership forecasts include the following:

Assumed BRT Service Frequency

The BRT operating plan assumes one route pattern that stops at all stations. Proposed frequencies are 10 minutes in the peak periods, 15 minutes in the midday and evening periods, and 30 minutes in the late evening and weekend early morning periods. A span of 18 hours from 5:00 am to 11:00 pm is proposed seven days a week. Proposed frequencies and span of service meet specifications in Metropolitan Council's Regional Transitway Guidelines.

Assumed BRT run times

BRT acceleration and deceleration rates, dwell times, traffic signal delays, and peak-period and off-peak speed were used to develop BRT run times in both peak and off-peak periods. Run times range from as long as 1 hour 39 minutes northbound in the morning peak to 1 hour 18 minutes southbound during off-peak times.

Assumed route and service changes or additions to connecting bus service

Several changes were recommended to background bus service to improve connections at proposed Highway 169 BRT stations. These include new routes, extensions or modifications to existing routes, or increased frequency of existing routes.

Transit Ridership Results

Transit ridership forecasts were developed using the Metropolitan Council's Regional Travel Demand Model, utilizing the same transportation network and land use assumptions as the highway traffic forecasts. The results of this analysis provide overall ridership for service along Highway 169, as well as several breakdown measures indicating different characteristics of the ridership.

Total bus rapid transit ridership is expressed through the station-to-station ridership totals for the Highway 169 BRT service under alternatives 1 and 2. This captures average daily riders on this service along any portion of the route. Alternative 1, with service between Highway 169 and downtown along I-394 is estimated at 7,400 riders per day. Alternative 2, routed along Highway 55, is slightly less with 6,600 riders per day.

Several subordinate ridership measures have also been prepared that help to understand the characteristics of the station-to-station BRT ridership. These include summaries or off-peak ridership, reverse-commute ridership, and transit-dependent ridership. It should be noted that these measures are not mutually exclusive, meaning that a single rider can qualify for more than one category, and are also not exhaustive, such that they some riders may not be in any categories and they do not sum to the BRT ridership totals.

Off-peak ridership provides an estimate of the portion of the BRT riders using the service outside of the morning and afternoon peak periods. Alternative 1 had produced a higher off-peak ridership of 3,100 per day compared to Alternative 2 of 2,700. Reverse commute ridership measures the number of riders using the service in the opposite direction of express bus service, which in this case indicates rides from along the southbound service during the AM and northbound service in the PM hours of the day. This measure is not limited to peak or off-peak times of day. Alternative 2 was estimated to have more reverse commute riders – 3,600 – compared to Alternative 1 with 2,800 per day. Finally, transit dependent ridership reflects the number of riders originated from zero car households, and again includes all times of day. Alternative 2 was also higher in the measure with 2,400 per day versus Alternative 1 which was estimated to be 2,000.

Additional measures summarizing transit ridership forecasts for the Highway 169 corridors incorporate transit routes beyond the station-to-station BRT service. These are primarily focused on express buses and other routes operating along a portion of Highway 169 in the study area. The first measure is ridership benefitting from improved transit advantages provided along Highway 169 as part of the project alternatives including bus shoulders and MnPASS lanes. For all three alternatives it is estimated that this would affect 1,000 additional riders. These are added to the station-to-station BRT ridership totals in the table below (8,400 and 7,600 for Alternatives 1 and 2, respectively). The second measure considers SouthWest Transit routes with the potential to shift to

Highway 169 to take advantage of improved travel times resulting from the additional capacity of the project alternatives. These routes do not necessarily utilize Highway 169 under existing or no build conditions, but their routing could potentially be modified if additional bus shoulders or MnPASS lanes were present. An estimated 2,500 riders could benefit from these changes under Alternatives 1 and 2.

Table 9. Transit Ridership Summary

Ridership Measure	Alternative 1	Alternative 2	Alternative 3
Total corridor ridership benefitting from improved transit advantages (includes BRT and express routes 490 and 493)	8,400	7,600	1,000
Southwest Transit routes with potential to shift to US 169 (670, 671, 690, 691, 692, 697, 698, and 699)	2,500	2,500	-
Off-peak period ridership	3,100	2,700	-
Reverse-commute direction ridership	2,800	3,600	-
Transit-dependent ridership	2,000	2,400	-
Bus rapid transit ridership	7,400	6,600	-

Traffic Operation Assessment

A lane assignment procedure was utilized to conduct a sketch-level capacity analysis as part of the traffic analysis for the Highway 169 Mobility Study. The lane assignment incorporates existing and proposed lane configurations to estimate bottleneck locations and resulting congestion levels throughout the study corridor. Lane assignment methodology implements a capacity analysis for freeways similar to an intersection critical lane analysis, which helps to identify segments that would be expected to have demand that exceeds available capacity, and would likely produce congestion.

Methodology

Year 2015 existing volumes from MnDOT loop detector data were balanced to create a balanced set of freeway volumes for each project location study area. The volumes were then imported into the lane assignment worksheets where lane usage was assigned using the lane-by-lane volumes at each detector station. Detailed review of each lane provides valuable insight to help pinpoint locations where existing bottleneck are observed to occur.

Using the *2015 MnDOT Congestion Report*, additional detail was layered onto existing volume from the detector data. The total traffic demand is considered to be responsible for this congestion and the resulting queues, allowing the process to reflect the existing conditions and along Highway 169.

Congestion levels produced by bottleneck locations were estimated in units of lane-mile-hours by referencing the volume at the bottleneck itself as well as directly upstream of the bottleneck to calculate the queue based on the Freeway Congestion Table in Figure 6. These estimates are based on the queue resulting from a bottleneck at jam density. The total lane-mile-hours was subsequently allocated to the freeway in the influence of each bottleneck location. Overall corridor congestion is calculated by summing all of the individual congestion values.

Figure 6. Freeway Congestion Reference Table

Upstream Flow (veh/hr/ln)	Severity of Congestion (ln-mi-hr)													
2600	6	7	8	9	11	12	14	16	17	19	21	23	26	28
2500	5	6	7	8	9	11	12	14	16	17	19	21	23	26
2400	4	5	6	7	8	9	11	12	14	16	17	19	21	23
2300	3	4	5	6	7	8	9	11	12	14	16	17	19	21
2200	2	3	4	5	6	7	8	9	11	12	14	16	17	19
2100	2	2	3	4	5	6	7	8	9	11	12	14	16	17
2000	1	2	2	3	4	5	6	7	8	9	11	12	14	16
1900	1	1	2	2	3	4	5	6	7	8	9	11	12	14
1800	0	1	1	2	2	3	4	5	6	7	8	9	11	12
1700	0	0	1	1	2	2	3	4	5	6	7	8	9	11
1600	0	0	0	1	1	2	2	3	4	5	6	7	8	9
1500	0	0	0	0	1	1	2	2	3	4	5	6	7	8
	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100
	Bottleneck Conflict Demand (veh/hr/ln)													

Future volumes for the project alternatives were referenced from the peak hour traffic forecasts provided in Appendix A. These mainline and ramp peak hour demand volumes were imported into lane schematic of the existing freeway and each respective alternative. Traffic volumes were also distributed evenly between lanes based on proximity to local and system interchanges to resemble the existing condition of the freeway. The results of this process provide an indication of duration and extent of congestion based on the relationship between the demand at the bottleneck and the demand upstream of the bottleneck.

Alternative Evaluation Results

Lane schematic diagrams were developed showing the details of the lane assignment evaluation for the Highway 169 corridor for each of the project alternatives. These include existing conditions, year 2040 no build, and year 2040 Alternatives 1, 2, and 3. These are included in Appendix B of this memorandum.

As a result of the forecast traffic growth, the duration and extent of congestion is expected to significantly increase between existing and year 2040 no build conditions. Many existing bottleneck locations become more severe reflecting increased volumes on Highway 169 and ramp access locations. In addition, several new bottleneck locations emerge as merging and weaving conflicts increase to a level expected to cause operational issues to occur.

The addition of MnPASS lanes to Highway 169 under the build alternatives are expected to help reduce some of the no build congestion under year 2040 conditions. This occurs as the added capacity reduces the traffic volumes in the general purpose lanes as a portion of the traffic shifts into the MnPASS lane. As a result, the volumes at the conflict points decreases, indicating lower levels for the duration and extent of congestion. Detailed results of these evaluations are shown in the lane schematic figures in Appendix B.

From the analysis, these operational improvements are summarized by their reduction in crash risk factors by alternative in terms of recurring congestion and freeway access conflicts. Recurring congestion is defined as the total lane-mile-hours of congestion estimated from the lane assignment process. This quantitative measure captures both the duration and extent of congestion through the corridor. Results for Alternatives 1 and 2 show reductions of 43 percent compared to year 2040 no build conditions. Alternative 3 had a lower reduction of 23 percent compared to no build, which is intuitive as MnPASS would lanes would be added to a shorter portion of the corridor under this alternative.

The other measure is a summary of the reduction in freeway access conflicts. As noted, bottleneck locations can be occur in merging and weaving segments when volumes exceed capacity. This measure is a count of the number of such locations along Highway 169 throughout the study area. Alternatives 1 and 2 each had reductions of 36 percent of the access conflict locations compared to no build. Alternative 3 was estimated to provide only a four percent reduction, suggesting that most of the bottlenecks present under no build conditions would remain despite the addition of MnPASS lanes between Marschall Road and I-494.

Table 10. Summary of Reduction in Crash Risk Factors

Reduction in crash risk factors	Alternative 1	Alternative 2	Alternative 3
Recurring Congestion (%)	43%	43%	23%
Freeway access conflicts (%)	36%	36%	4%

Travel Time Reliability

Reliability is an emerging area of transportation evaluation that considers the variability in travel times that occur due to weather, crashes, and other non-recurring conditions. Historical traffic measures often focus on average congestion, but ignore variability. Travel time reliability is important because the more travel times vary on a given route, the earlier travelers must leave to ensure on-time arrival. A congested but consistent commute is easier to plan for than a less congested but very unreliable commute. Understanding these effects for managed lanes is particularly important as these facilities are specially intended to provide free-flow travel for transit, carpools, and single-occupant vehicles willing to pay a congestion-sensitive toll. Communicating these results to stakeholders is critical in demonstrating the long-term value of this type of investment.

This memorandum documents the methodologies and results of the reliability analysis conducted for the TH 169 Mobility Study. The reliability results were developed for year 2040 no build and three 2040 build alternatives which include the addition of MnPASS lanes along the corridor This memorandum presents the assumptions and methods used in this analysis and the results of the evaluation.

Data Sources

Analysis of the TH 169 corridor was broken into eight segments, four in each direction. Data for the analysis came from a variety of sources. Travel time and volume data from the MnDOT's loop detector system were extracted using both MnDOT's Data Extract tool and the Traffic Information and Condition Analysis System (TICAS). Weather and precipitation data was obtained from the National Oceanic and Atmospheric Administration (NOAA), and Minnesota Department of Public Safety (DPS) crash records were accessed through the Minnesota Crash Mapping Analysis Tool (MnCMAT).

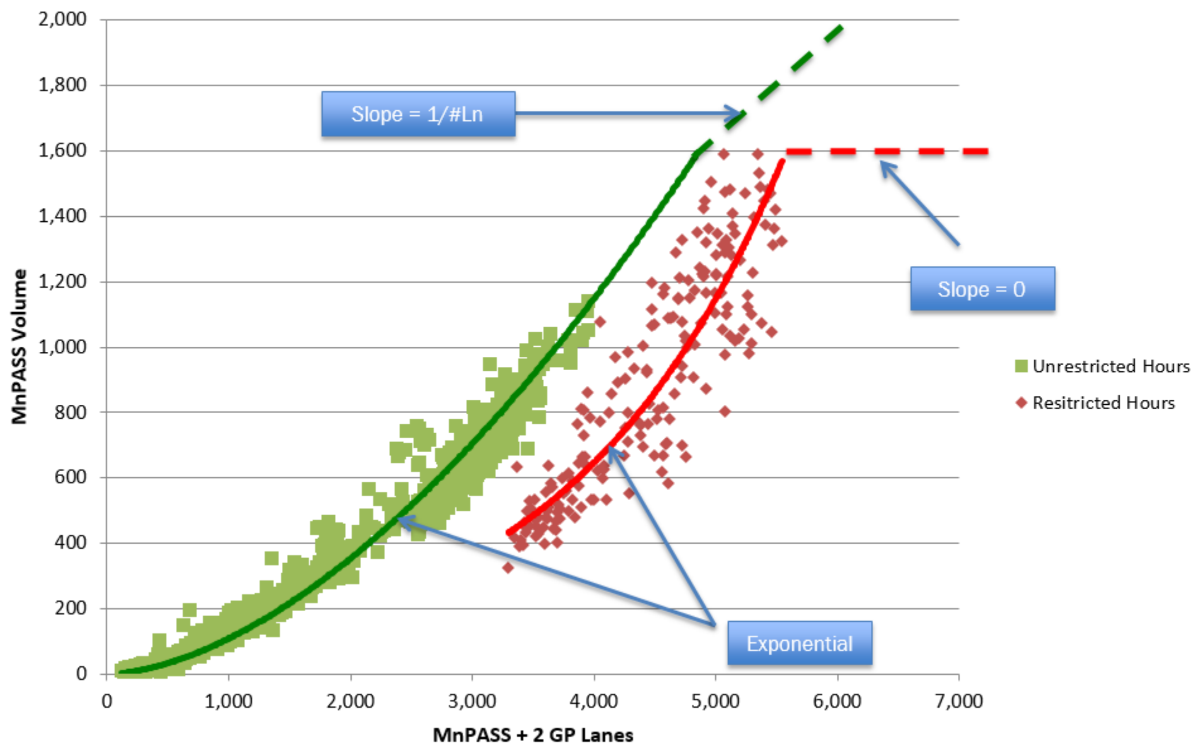
Methodology

To fully understand travel time reliability under existing conditions, one year of travel time data along the project corridor were collected for calendar year 2014. In addition, weather and crash data were obtained and integrated with the travel time data to isolate the effects of these factors. To project 2040 travel time reliability under the no-build and build alternatives, traffic volume forecasts were prepared using the Twin Cities Regional Travel Demand Model (RTDM) for each scenario. Combining the future forecasts and existing travel time reliability data, a model was created to predict reliability under each of the 2040 alternatives.

Relationship between MnPASS (MP) and General Purpose (GP) Lanes

This model required understanding the relationship between MnPASS and GP lanes, as the existing conditions along TH 169 do not include a MnPASS lane. To project the reliability conditions among MnPASS and GP lanes in 2040, existing volume data on road segments having similar MnPASS facilities were collected and analyzed. The example in Figure 1 shows the existing MnPASS and GP relationship of the northbound I-35W at the Minnesota River. The scatter plot reveals the relationship between the MnPASS and GP volumes during unrestricted (untolled) and restricted (tolled) hours. Exponential equations were found to provide the best fit for volumes under capacity, and were applied for future MnPASS build alternative. MnPASS lane capacity is capped at 1,600 vehicles/hour during restricted hours as the pricing algorithm controls demand to maintain free flow speeds.

Figure 7. Existing MnPASS and GP Relationship Example



Results

Person Throughput

Person throughput was calculated with volume and vehicle occupancy. The existing volumes were collected from the loop detectors, and the occupancies were from filed data collection. For 2040 alternatives, RTDM generated the volumes and SOV/HOV ratios, which were used to interpolate occupancies.

Peak period free flow person trips along TH 169 in each direction for the three build alternatives are summarized in the table below. Included in parentheses is the percentage change from the no-build condition. AM peak occurs between 6:00 and 9:00 and PM peak occurs between 15:30 and 18:30.

Table 11. Peak Period Free Flow Person Trips

	Alternative 1	Alternative 2	Alternative 3
NB AM Peak	7,000 (179%)	7,000 (179%)	5,900 (133%)
NB PM Peak	7,300 (82%)	7,300 (82%)	4,800 (19%)
SB AM Peak	6,800 (11%)	6,800 (11%)	6,200 (1%)
SB PM Peak	6,900 (54%)	6,900 (54%)	6,500 (43%)

* Percent change from no-build noted in parentheses

Figure 2-5 represent the person throughout along TH 169 during peak hours in each direction by travel time index (TTI level). The stacked bar charts show both the number of users being served under each alternative and their respective travel times. The stack bar charts include both the existing conditions, no-build, and three build alternatives. Because alternatives 1 and 2 differ only in BRT, they are combined.

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Figure 8. Reliability by Person Throughput – Northbound during AM Peak Period (6:00-9:00)

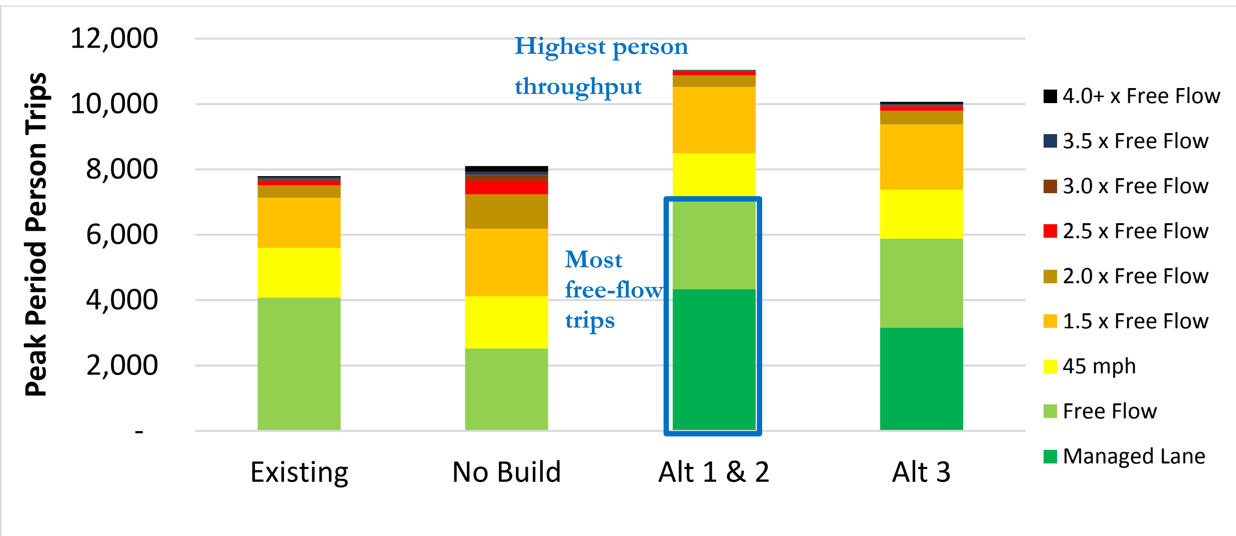


Figure 9. Reliability by Person Throughput – Northbound during PM Peak Period (15:30-18:30)

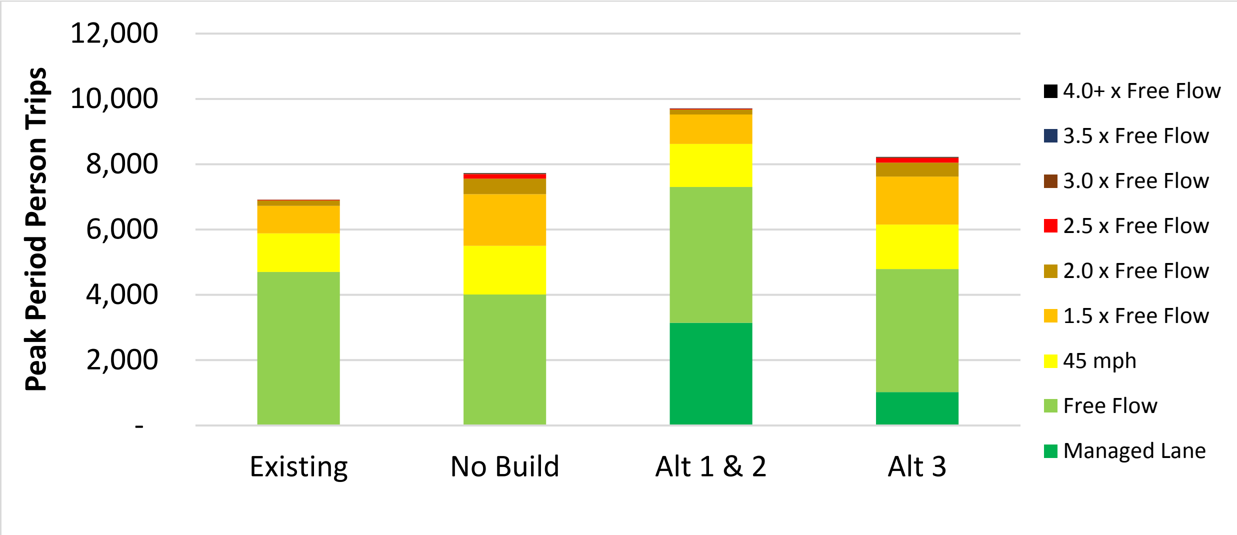


Figure 10. Reliability by Person Throughput – Southbound during AM Peak Period (6:00-9:00)

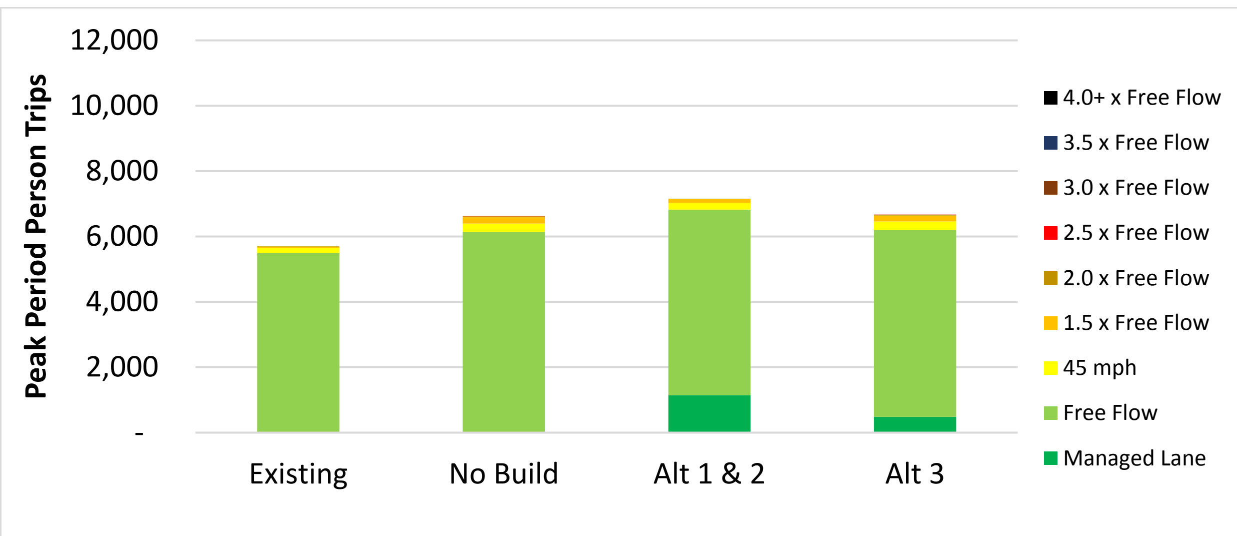
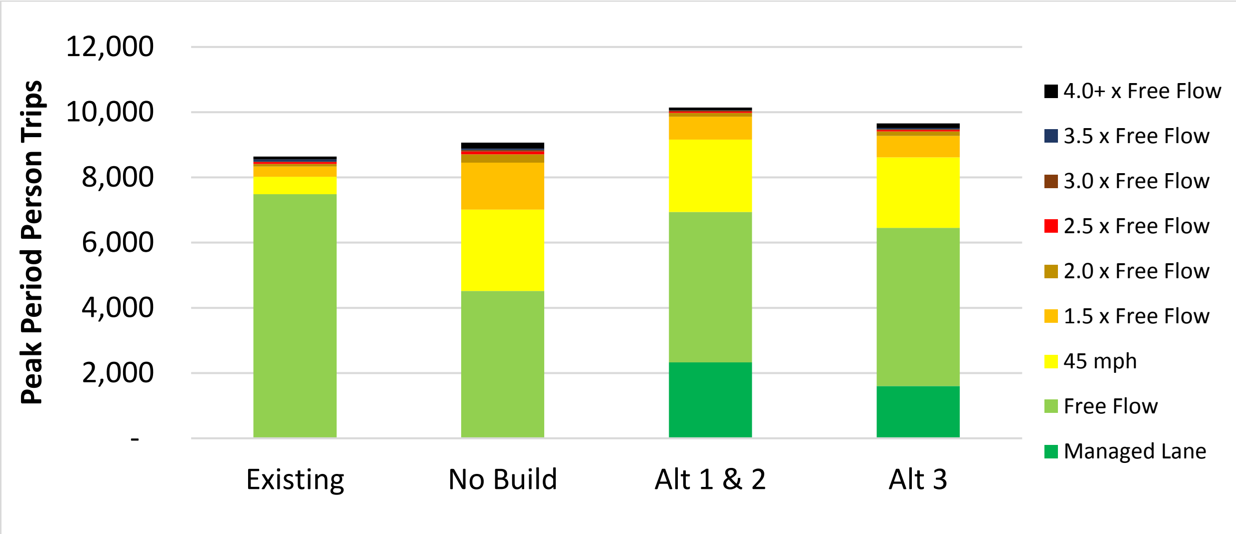


Figure 11. Reliability by Person Throughput – Southbound during PM Peak Period (15:30-18:30)



Travel Time Delay

Average travel time delay was calculated during peak periods along TH 169 in each direction. Delay in minutes under each alternative is summarized below. Included in parentheses is the percentage change from the no-build condition. AM peak occurs between 6:00 and 9:00 and PM peak occurs between 15:30 and 18:30.

Table 12. Average Delay in Minutes

	Alternative 1	Alternative 2	Alternative 3
NB AM Peak	6:10 (-77%)	6:10 (-77%)	7:50 (-72%)
NB PM Peak	3:20 (-67%)	3:20 (-67%)	7:50 (-23%)
SB AM Peak	0:30 (-39%)	0:30 (-39%)	0:40 (-3%)
SB PM Peak	4:30 (-56%)	4:30 (-56%)	4:50 (-52%)

* Percent change from no-build noted in parentheses

Key Findings

With the addition of MnPASS, users are offered a congestion-free option. This is reflected in the increase in free flow person trips offered under each of the alternatives. The stacked bar charts show both the number of users served under each alternative and their respective travel times, including the number of free flow trips. Alternatives 1 and 2 offer between 11% and 179% more free flow person trips during the peak periods over the no build alternative. Alternative 3 provides similar person throughput benefits over the no build in the northbound AM peak and southbound PM peak periods, but a much smaller increase in free flow trips in the northbound PM peak and southbound AM peak periods.

Travel time delay in alternatives 1 and 2 was reduced by between 39% and 77% compared to the no build alternative. As with person throughput, the delay reduction under alternative 3 was comparable to alternatives 1 and 2 in the northbound AM peak and southbound PM peak periods, but significantly less in northbound PM peak and southbound AM peak periods. These results are expected given that alternative 3 includes the addition of a MnPASS lane south of the Minnesota River, primarily benefiting northbound (inbound) AM traffic and southbound (outbound) PM traffic.

Operations & Maintenance Considerations

A qualitative assessment was conducted to consider the operations and maintenance ramifications of the project alternatives. These characteristics affect the actions and resources required to effectively operate and managed the Highway 169 with the proposed addition of MnPASS lanes and other alternative features. These have been broken down into three broad categories that include MnPASS operations & enforcement, incident management, and operations and maintenance cost factors. This section describes the findings of this assessment.

MnPASS Operations & Enforcement

Operations and enforcement are key components of successful deployment of MnPASS lanes. Two main characteristics were considered within this category.

- Violation monitoring
- Pulling-over vehicles safely
- RTMC Tolling & Lane Control

Violation monitoring focused on the ability of law enforcement vehicles to monitor violators. Law enforcement personnel often position their vehicles near the roadway providing a clear line of sight to monitor for violations, while maintaining safety for themselves and their vehicles. Pulling-over vehicles safely focused on the overall safety of law enforcement when pulling-over a violating vehicle. It should be noted that this included all violations, not just managed lane violations, such as speeding and drunk driving. The presence of shoulders was the critical feature associated with this evaluation.

Table 13. MnPASS Operations & Enforcement Evaluation

	Characteristic	South of River	River Bridge	River-494	494-Lincoln	Lincoln-394	394-55	Overall
Alt 1 & Alt 2	Violation Monitoring	Good	Poor	Good	Good	Fair-Poor	Fair-Poor	Fair
	Pulling Over Vehicles Safely	Good	Poor	Good	Good	Fair-Poor	Fair-Poor	
	RTMC Tolling & Lane Control	High						
Alt 3	Violation Monitoring	Good	Poor	Good	n/a	n/a	n/a	Good
	Pulling Over Vehicles Safely	Good	Poor	Good	n/a	n/a	n/a	
	RTMC Tolling & Lane Control	Med						

Incident Management

Incident management was evaluated by assessing three important characteristics:

- Disabled vehicle safety
- Snow storage
- Emergency responder accessibility

The ratings assigned to each alternative for incident management criteria were comparative, such that alternatives with relatively higher performance were rated higher than those with lower performance.

Disabled vehicle safety focused on the overall safety of disabled vehicles when stopped along the roadway, therefore wider shoulders provided a higher rating. Snow storage focused on the amount of storage available with improvements in the width or presence of shoulders and the presence of lane control signals providing a higher rating. The urgency and intensity of snow clearance activities was also considered for this evaluation. Under alternatives with minimal shoulders snow would need to be physically removed from the roadway area and be done rapidly to avoid lane blockages.

Emergency responder accessibility focused on the overall accessibility for emergency responders, with improvements in the number of lanes, the width or presence of shoulders, and the presence of lane control signals providing a higher rating. Results of this evaluation were consistent with those for disabled vehicle safety, as emergency responders face similar risks when responding to incidents as disabled vehicles face. Similar to the disabled vehicle evaluation, alternatives providing full shoulders and lane control signals resulted in higher ratings than those without those features. Results for incident management in the build managed lane condition are presented below.

Table 14. Incident Management Evaluation

	Characteristic	South of River	River Bridge	River-494	494-Lincoln	Lincoln-394	394-55	Overall
Alt 1 & Alt 2	Disabled Vehicle Safety	Good-Fair	Poor	Good-Fair	Good-Fair	Good-Fair	Fair	Good-Fair
	Snow Storage	Good	Poor	Good	Good	Fair	Fair-Poor	
	Emergency Responder Accessibility	Good	Poor	Good	Good	Good-Fair	Good-Fair	
Alt 3	Disabled Vehicle Safety	Good	Poor	Good	Good	Fair-Poor	Poor	Fair
	Snow Storage	Good	Poor	Good	Good	Fair-Poor	Poor	
	Emergency Responder Accessibility	Good	Poor	Good	Good	Fair-Poor	Poor	

Operations & Maintenance Cost Factors

The third category considered commitments required of MnDOT to operate and maintain Highway 169 following potential deployment of MnPASS. This is broken down into two measures including snow removal and pavement maintenance. Snow removal considerations are closely tied to the cross section of the roadway, where additional lanes and minimal shoulder widths may require more involved snow removal operations. The other measure of pavement maintenance considers the additional of new highway lane-miles that will add to routine maintenance commitments. The results of the cost factors evaluation are summarized below.

Table 15. Operations & Maintenance Cost Factors Evaluation

	Characteristic	South of River	River Bridge	River-494	494-Lincoln	Lincoln-394	394-55	Overall
Alt 1 & Alt 2	Snow Removal	None	High	None	None	Low	Med	Fair
	Pavement Maintenance (# lns)	2	2	2	2	2	2	
Alt 3	Snow Removal	None	High	None	None	Low	Low	Good-Fair
	Pavement Maintenance (# lns)	2	2	2	0	0	0	

The summary of these overall measures was rolled into a summary for each of the project alternatives. The general findings are that Alternatives 1 and 2 are expected to have the same performance while Alternative 3 has somewhat different characteristics. The alternatives also have divergent performance among the individual categories. For example, Alternatives 1 and 2 are expected to be better for incident management while Alternative 3 fared better in the MnPASS operations and cost factors categories.

Table 16. Operations & Maintenance Evaluation Summary

Operations & Maintenance Factors	Alternative 1	Alternative 2	Alternative 3
MnPASS Operations & Enforcement	Fair	Fair	Good
Incident Management	Good-Fair	Good-Fair	Fair
O&M Cost Factors	Fair	Fair	Good-Fair