Downtown Streets Engineering Study

Purchase Order 2024000187

Preliminary DRAFT Engineering Report

September 2024

Prepared For:
Municipality of Anchorage

Prepared By:
Kinney Engineering, LLC
3909 Arctic Blvd, Ste 400
Anchorage, AK 99503
907-346-2373
AECL1102

Table of Contents

Figures

Tables

Abbreviations

ADA	Americans with Disabilities Act
AMATS	Anchorage Municipal Area Transportation Solution
CBD	Central Business District
DCM	Design Criteria Manual
DOT&PF	Alaska Department of Transportation and Public Facilities
LOS	Level of Service
LTS	Level of Traffic Stress
MOA	Municipality of Anchorage
TMC	Turning Movement Count
TMV	Turning Movement Volume
vph	Vehicles per Hour
vphpl	Vehicles per Hour per Lane

Definition of Terms

Level of Service (LOS): Performance measure concept used to quantify the operational performance of a facility and present the information to users and operating agencies. The actual performance measure used varies by the type of facility; however, all use a scale of A (best conditions for individual users) to F (worst conditions). Often, LOS C or D in the most congested hours of the day will provide the optimal societal benefits for the required construction and maintenance costs.

Level of Traffic Stress (LTS): The measure of the perceived level of stress that a person biking experiences based on roadway design, traffic volumes, and motor vehicle. LTS is ranked on a scale of 1 to 4. Separated bicycle facilities are ranked LTS 1, the most comfortable. High-speed high-volume roads with no shoulder are ranked LTS 4, the least comfortable.

Executive Summary

The executive summary will summarize the engineering report, call attention to any areas of interest or concern, and give recommendations.

[Write Last]

1 Introduction

The Downtown Streets Engineering Study will result in a series of recommendations for projects and lay the groundwork to establish a Downtown Streets Capital Improvement Program (DTCIP). The Downtown Streets Engineering Study will analyze existing conditions in downtown Anchorage bounded by N Street on the west, Ingra Street on the east, 10th Avenue on the south, and Ship Creek to the north. Analyzed road design changes are identified in Our Downtown: Anchorage Downtown District Plan 2021, hereafter referred to as the Our Downtown Plan.

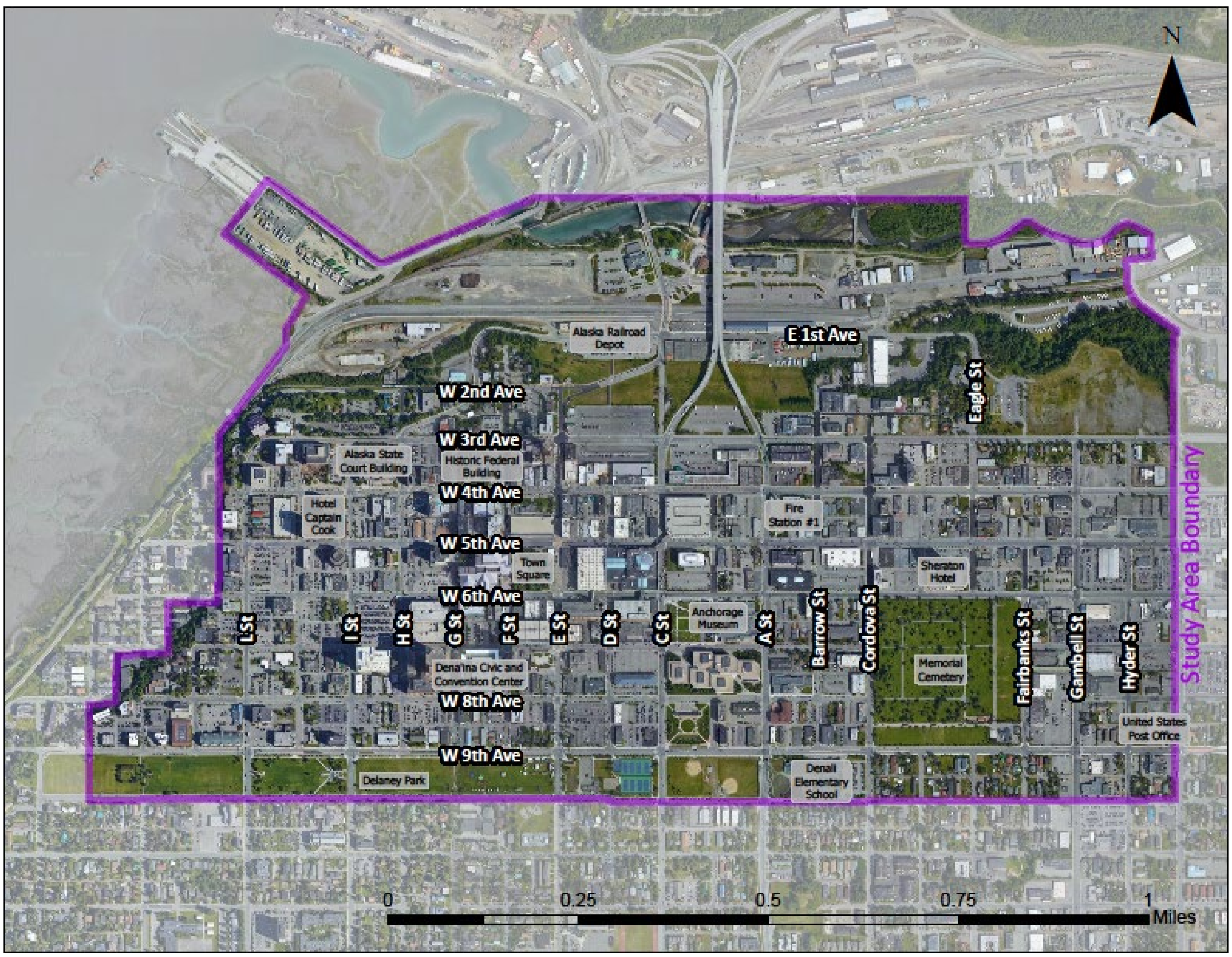


Figure 1. Study Area for Downtown Streets Engineering Study

2 Existing and No Build Conditions

Downtown Anchorage is built on a grid network of one-way and two-way streets. Five couplets serve drivers traveling to downtown, from downtown, or through downtown. Posted speed limits on couplets are 30 mph to 35 mph, while the posted speed limit is 25 mph on the remainder of the network. The signal progression along the couplets is set to progress traffic traveling the speed limit.

The couplets serving downtown Anchorage are below.

- L Street and I Street are extensions of Minnesota Drive. L Street serves southbound drivers. I Street serve northbound drivers.
- C Street and A Street are extensions of C Street. C Street serves southbound drivers. A Street serves northbound drivers.
- Gambell Street and Ingra Stret are extensions of New Seward Highway. Gambell Street serves southbound drivers. Ingra serves northbound traffic.
- 5th Avenue and 6th Avenue are extensions of the Glenn Highway. 5th Avenue serves westbound drivers. 6th Avenue serves eastbound drivers.
- 3rd Avenue and 4th Avenue are extension of Mountain View Drive. 3rd Avenue is a one-way westbound road east of C Street. 4th Avenue is a one-way eastbound road east of A Street.

All couplets, except the 3rd Avenue and 4th Avenue couplet, connect to a principal arterial or interstate. Within the study area, couplets are typically three lanes with an occasional turning lane, except for Gambell Street which is four lanes.

Almost all the downtown network has sidewalk. However, there is almost no dedicated bicycle infrastructure, and infrastructure connecting bicycles to downtown is limited. Anchorage Administrative Code 13 AAC 02.400 states bicycles should not be ridden on sidewalks downtown. As a result, bicycles must be ridden on shoulders, typically with on-street parking, or in travel lanes with vehicles. Just south of the study area, 10th Avenue is a bicycle boulevard providing some east-west connectivity.

2.1 Bicycle Operations

Bicycle level of traffic stress (LTS) describes how comfortable a road is for a person bicycling on it. There are four levels of LTS. The most comfortable LTS 1, describes separated bicycle lanes. Roads with buffered bike lanes are described as LTS 2. Busy roads with narrow shoulder or bike lane are described as LTS 3, while LTS 4 is describes no bike lanes on a busy road. Roads with bicycle LTS 3 or LTS 4 are for experienced riders, while roads with LTS 1 or LTS 2 are more suitable for inexperience riders. Factors impacting bicycle LTS include traffic volumes, traffic speeds, roadway classification, and bike infrastructure.

Figure 2 shows bicycle LTS in downtown Anchorage. Overall, downtown Anchorage has gaps within its bicycle network for bicycle riders uncomfortable riding next to motorized traffic without at least a buffer. Within the study area, there are no continuous LTS 1 or LTS 2 roads extending east of Cordova Street. North-south access to and from downtown is also limited to LTS 4 roads except for A Street which transitions from LTS 4 to LTS 1 south of 13th Avenue.

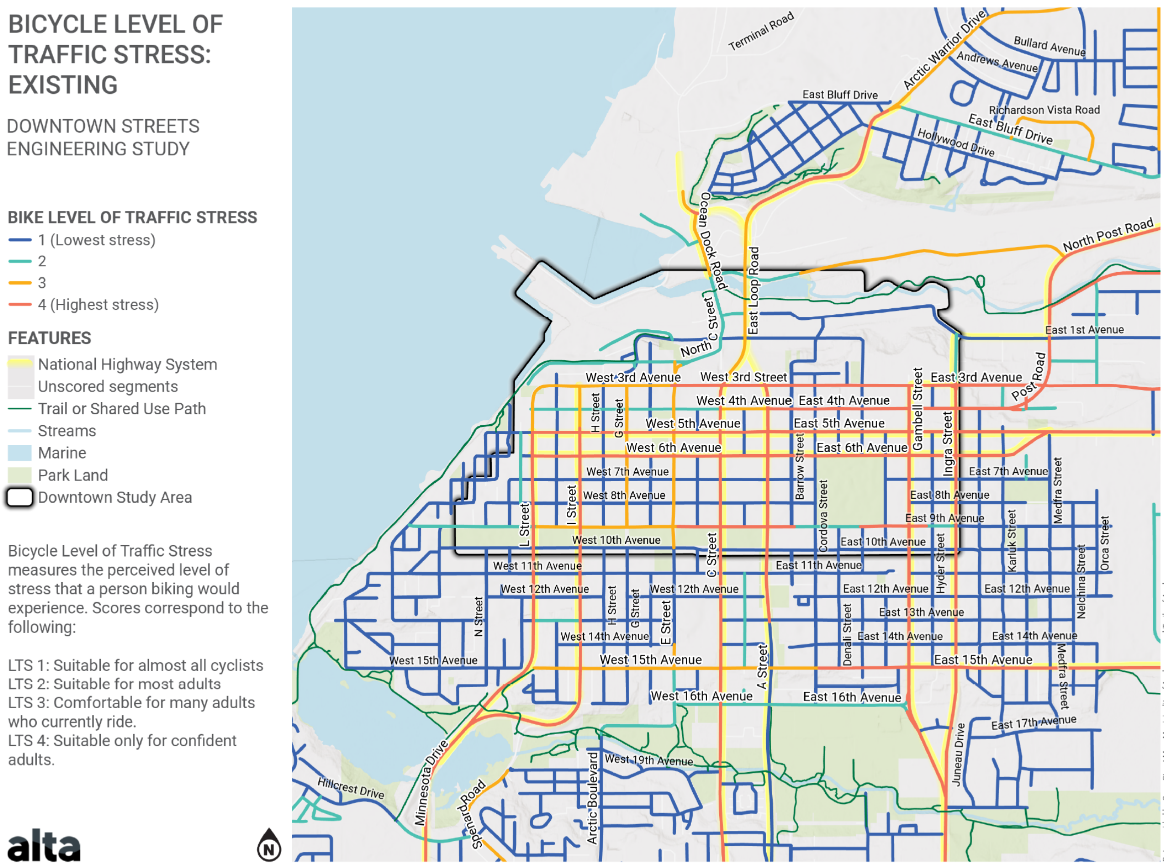


Figure 2. Downtown Bicycle Level of Stress

Figure 3 shows low street bicycle islands, or cohesive zones where cyclists can navigate through a network of streets characterized by low stress. Islands shaded darker are larger islands of low stress network. Downtown is encompassed by a low stress bicycle network. However, between L Street and Ingra Street, the low stress bicycle network is fragmented, and suitable for highly experienced bicyclists or bicyclists willing to take on a greater amount of risk.

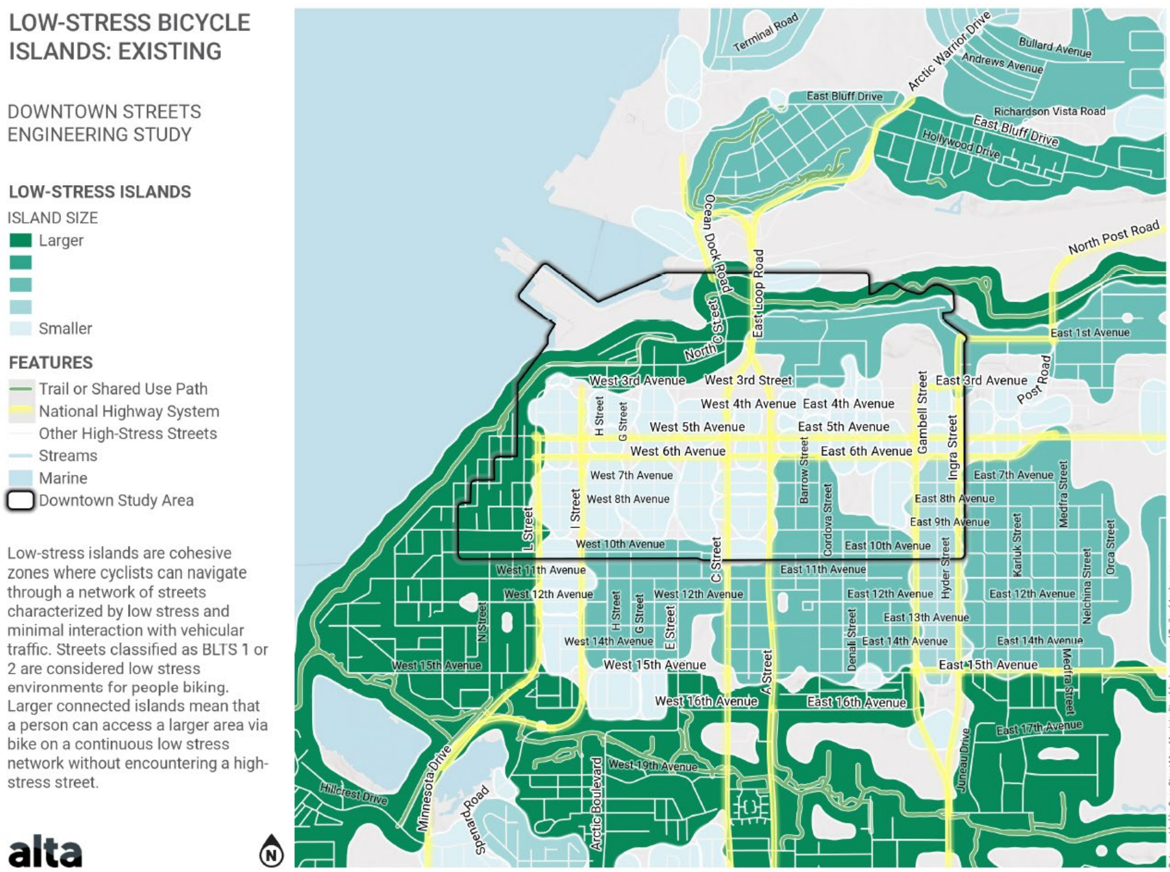


Figure 3. Bicycle Islands Under Existing Conditions

Figure 4 shows high stress intersections in and surrounding the study area. High stress intersections are intersections where low stress roads (bicycle LTS 1 or bicycle LTS 2) intersect with high stress roads (bicycle LTS 3 or bicycle LTS 4). The study area is almost surrounded by high stress intersections, adding to the difficulty for bicyclists to travel to or from downtown. Additionally, high stress intersections divide downtown into sections making it difficult to travel between different areas downtown.

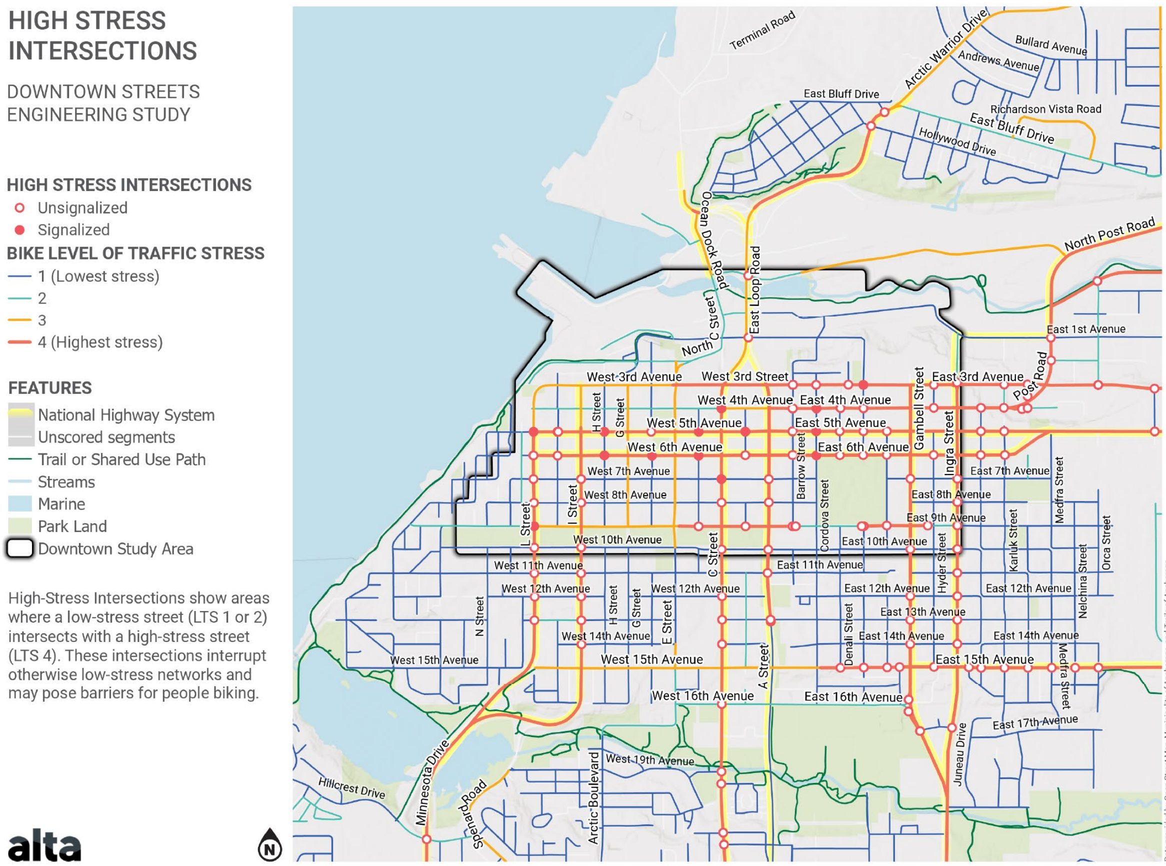


Figure 4. High Stress Intersections (Bicycle)

2.2 Intersection Operations

Intersection level of service (LOS) is a qualitative measure representing vehicle delay at an intersection. The Municipality of Anchorage's Project Management & Engineering Design Criteria Manual (DCM) states that, in the design year, intersections should have a LOS of D or better. While vehicle LOS should not be the only measure for the design of urban streets, vehicle LOS can be useful for understanding the experience of drivers. Figure 5 and Figure 6, respectively, summarize intersection PM peak hour LOS within the study area under existing conditions and during the design year (2050). Intersection LOS was calculated using Highway Capacity Manual methods and the turning movement volumes (TMV) described in Appendix A: Turning Movements, Traffic Volumes.

Currently, four intersections experience LOS D to F: Ingra Street at 5th Avenue 3rd Avenue at E Street, 6th Avenue at Ingra Street, and 9th Avenue at L Street.

Using the forecasted future volumes, in 2050, a fifth intersection is predicted to operate at LOS D to F: 6th Avenue at Gambell Street. Figure 6 shows some intersections with improved operations in 2050. Improved operations are the result of optimized signal timings.

[We will be adding AM peak hour information to future versions of this report.]

	L Street	K Street	I Street	H Street	G Street	F Street	E Street	D Street	C Street	B Street	A Street	Barrow Street	Cordova Street	Eagle Street	Gambell Street	Ingra Street
3rd Avenue			A	C			D		B		B			B		
4th Avenue	C		B	B	B	A	B	A	C	A	B		B		B	A
5th Avenue	B		A	A	A	A	A	A	C	A	B		A		B	F
6th Avenue			B	B	B	A	A	A	B		B		B		B	D
7th Avenue				B	B		B		A		B					
9th Avenue	D		C		A		B		C		B		B		C	C

Figure 5. Existing PM Peak Level of Service

	L Street	K Street	I Street	H Street	G Street	F Street	E Street	D Street	C Street	B Street	A Street	Barrow Street	Cordova	Eagle Street	Gambell	Ingra Street
3rd Avenue			A	B			F		B		B			B		
4th Avenue	C		A	B	B	A	B	A	B	A	B		B		B	B
5th Avenue	B		A	A	A	A	A	A	A	A	A		A		C	E
6th Avenue			B	B	B	A	A	A	B		B		B		F	D
7th Avenue				A	A		B		A							
9th Avenue	D		C		A		B		A		B		C		B	C

Figure 6. 2050 No Build PM Peak Level of Service

3 Evaluation of Engineering Road Design Changes

Several road design changes were recommended in the Our Downtown Plan. This report evaluates their feasibility from an engineering perspective, including considering impacts and benefits.

3.1 Ownership of 5th Avenue and 6th Avenue

For the four pairs of one-way couplets in downtown Anchorage (5th and 6th Avenue, L and I Street, A and C Street, and Gambell and Ingra Street), there is not a document vesting ownership to the Alaska Department of Transportation and Public Facilities (DOT&PF); however, DOT&PF and FHWA have invested time and money for maintenance and construction over time. As a result, regardless of ownership, both DOT&PF and FHWA have an interest, and may potentially have a vested right, in these corridors.

MOA is interested in having more control over the design and management of these corridors; as it relates to this study, the focus is on 5th and 6th Avenues. This study identified three pathways the MOA could pursue:

- MOA can use the existing MTP process to implement the community vision for downtown.
- MOA can use shorter-term planning and funding opportunities and work with DOT&PF and FHWA to implement the community vision for downtown.
- MOA can request to remove the NHS designation from these streets (or portions of these streets) and can ask DOT&PF to relinquish ownership and convey it to MOA. Note that no high classification routes have been successfully conveyed to date in Alaska, and that this process is likely to take a significant amount of time.

3.2 Reduce Speed Limit in Downtown to 20 mph and 25 mph

The Our Downtown Plan supports reducing speed limits to 25 mph on high volume roads and 20 mph on low volume roads and adjusting traffic signal timing to match. Suggested reductions are changing speed limits to 20mph on 2nd Avenue, 3rd Avenue, 4th Avenue, 7th Avenue, 8th Avenue, and 9th Avenue, reducing speed limits to 25 mph on 5th Avenue and 6th Avenue, and reducing speeds limits to 20 mph or 25 mph on A Street through L Street.

The reduction of speed limits on MOA streets is regulated by municipal code. A comprehensive speed study is required before any changes are made. Comprehensive speed study is not defined within municipal code, but will likely need to cover current driver speeds, crash history, bicycle level of traffic stress, pedestrian experience, and land use.

Other agencies throughout the county have implemented area wide speed limit changes by various methods and have achieved different levels of success. Findings are summarized in Appendix B: Speed Limit Reduction Studies.

3.2.1 Pedestrian Safety

The AMATS Safety Plan identified several intersections and street segments as high crash frequency locations. Specifically, 5th Avenue, C Street, Ingra Street, and Gambell Street have higher occurrences of bicycle and pedestrian crashes.

Speed is a critical factor in pedestrian crashes. Pedestrians have a 90% survival rate when struck by a vehicle traveling at 20 mph. The pedestrian survival rate drops to 50% when hit by a vehicle traveling at 30 mph and 10% when a vehicle is traveling at 40 mph.

Additionally, drivers have a wider field of vision when driving at a lower rate of speed. They are more able to identify pedestrians in or entering the roadway and react accordingly.

3.2.2 Arterial Travel Time

Using the speed limits proposed in the Our Downtown Plan, travel times for drivers along downtown arterials were compared between future volumes with no road changes (no build conditions) and future volumes with a reduced speed limit. The project team evaluated alternatives using Synchro's Arterial LOS feature .

For the analysis, speed limits were reduced to 25 mph on L Street, I Street, C Street, A Street, Gambell Street, Ingra Street, 5th Avenue, and 6th Avenue. On the remaining streets, speed limits were reduced to 20 mph. In the Synchro software, signal splits and offsets were optimized while leaving signal cycle lengths at existing lengths. Table 1 summarizes and compares PM peak travel times for drivers along several downtown streets under no-build conditions and under reduced speed limits.

Driver travel time increased the most for A Street, an increase of about 50 seconds. Drivers on other corridors would experience an increase in travel time of around 30 seconds or less. For through traffic, these travel time increases are a small portion of the total trip time and are unlikely to result in drivers choosing to take a different route.

[We will be adding AM peak hour information to future versions.]

Table 1. Comparison of No Build and Reduced Speed Limit Alternatives (2050 Forecasted Volumes)

				No Build		Reduced Speed		
Street	**Direction**	**Extent 1**	**Extent 2**	**Travel Time (seconds)**	**Arterial Speed (mph)**	**Travel Time (seconds)**	**Arterial Speed (mph)**	**Change in Time (seconds)**
5th Avenue	Westbound	Ingra Street	L Street	385	12.7	417	11.8	32
6th Avenue	Eastbound	I Street	Ingra Street	455	9.2	487	8.6	31
I Street	Northbound	9th Avenue	4th Avenue	123	10.0	134	9.2	11
L Street	Southbound	4th Avenue	5th Avenue	139	13.6	162	11.7	23
A Street	Northbound	9th Avenue	3rd Avenue	222	2.9	271	19.6	49
C Street	Southbound	4th Avenue	9th Avenue	141	10.4	146	10.1	4
Ingra Street	Northbound	9th Avenue	4th Avenue	265	8.4	298	7.4	33
Gambell Street	Southbound	4th Avenue	9th Avenue	260	5.7	287	5.1	27

3.2.3 Low Stress Bicycle Islands with Speed Limit Reduction

Slowing driver speeds increases connectivity for bicyclists downtown. Figure 7 shows how overall, downtown becomes a less stressful and more connected environment for bicyclists. However, between 5th Avenue and 6th Avenue, there are still many small low-stress islands. The study area is almost bisected by these small low-stress islands. F Street provides a low stress connection across 5th Avenue and 6th Avenue, connecting the study area.

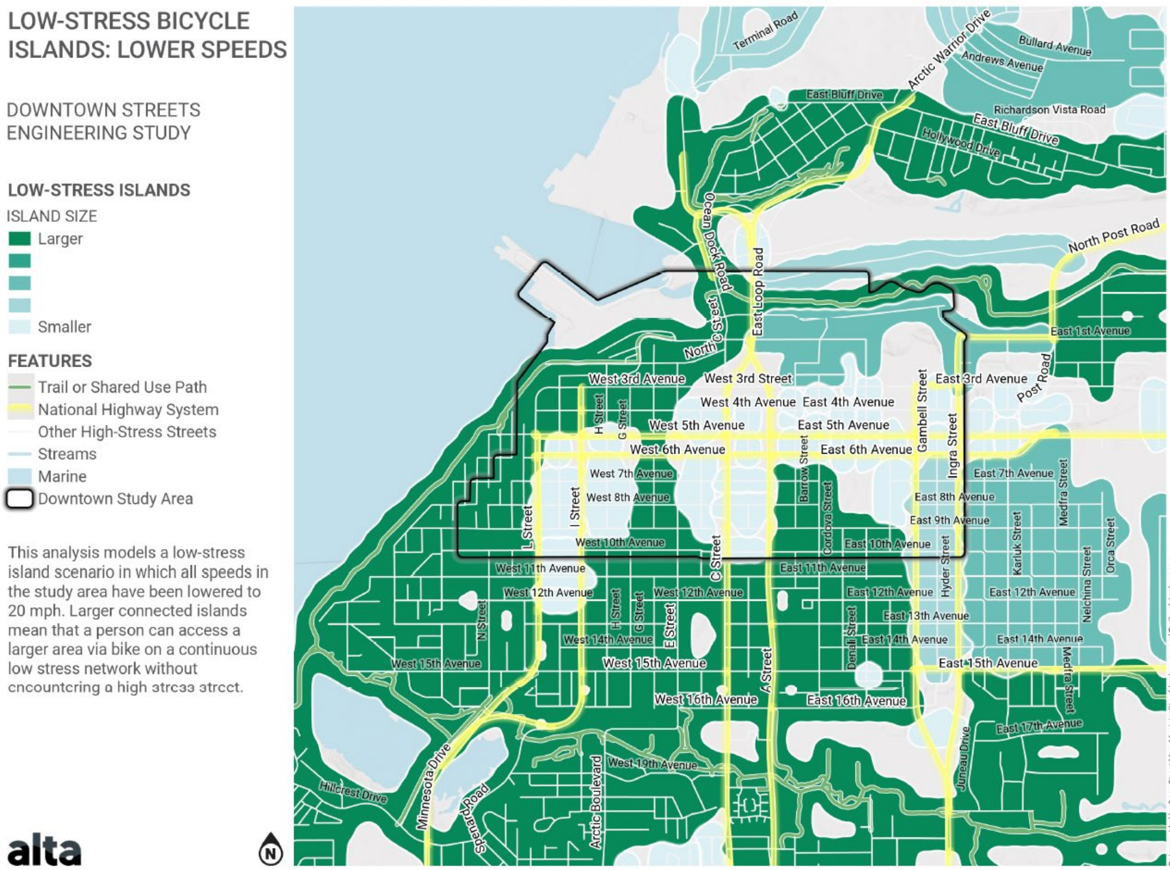


Figure 7. Bicycle Islands with Speed Limit Reduction

3.2.4 6th Avenue and A Street Cycle Track (Pilot Study)

During the summer of 2024, a temporary bi-directional cycle track was installed in downtown Anchorage on 6th Avenue between L Street and A Street and on A Street between 10th Avenue and 6th Avenue, reducing the street width from three to two lanes. Reducing the number of travel lanes may have an impact on driver behavior and driver speed. While the cycle track is deployed, the MOA is collecting vehicle speed data along 6th Avenue. This data will provide insight into driver behavior and inform our understanding of how to achieve a reduction in driver speeds through traffic calming measures.

3.2.5 Summary

This report only considers the impact of signal timing changes due to reduced speed limits in Downtown Anchorage. Per AMC 9.26.030, municipal code requires a “comprehensive speed study” in order to change speed limits.

Many other jurisdictions have reduced speed limits in their downtown areas; their experience suggests that changing the speed limit may not be enough to actually reduce vehicle speeds. Changing the coordinated signal timing may help, as well as other road design changes to encourage drivers to slow down such as narrower lanes, curb bulb-outs, parking, and raised intersections.

Based on travel times along the main arterials, drivers are unlikely to choose to take a different route if speeds are reduced downtown. Furthermore, the LTS analysis indicates that riding a bicycle downtown would become significantly more comfortable if speeds are reduced. Reduced driver speeds would also increase the comfort and safety of other non-motorized road users. The data from the 6th Avenue Protected Bike Lane Pilot Study will help to inform if a reduction from 3 lanes to 2 lanes would encourage a reduction in vehicle speeds (although it should be noted that speed limits were not changed with the pilot study).

3.3 D Street and F Street Conversions from One-way Streets to Two-way Streets

D Street between 4th Avenue and 5th Avenue and F Street between 3rd Avenue and 5th Avenue are northbound one-way segments. Currently, D Street is a one-lane street with on-street parking on both sides. At 4th Avenue curb bulbs have been installed, reducing the pavement width to allow only one vehicle to pass.

F Street is also a single lane with on-street parking and vertical concrete road design changes that reduce the pavement width.

Existing sidewalks on both sides of D Street and F Street allow pedestrians to travel north and south. However, bicyclists are obligated to follow the rules of the road and would need to travel to C Street or G Street to travel south. One-way segments of D Street and F Street are low volume local roads. Road design changes such as a counterflow cycle lane would allow for southbound bicycles on D Street and F Street.

3.3.1 Summary

Because both D and F Street are only one-lane wide, converting them to two-way would require complete reconstruction of the roads to provide enough width for two lanes. Two-way conversion would have little benefit for vehicle travel but might benefit bicyclists. Alternatively, bicycle-only infrastructure could be built to add contraflow bicycle travel.

3.4 5th and 6th Avenue Conversion to Two-way Streets

The proposal to convert 5th and 6th Avenue from one-way to two-way was analyzed in two pieces.

- Reduction in number of lanes from three lanes to two lanes

- Conversion to two-way

Note that the reduction of 4th Avenue from three to two lanes was also considered, because several stakeholders expressed interest in a lane reduction for 4th Avenue.

3.4.1 Reduction of 4th, 5th, and 6th Avenues from Three Lanes to Two Lanes (Remain One-way)

Removing a travel lane from 4th Avenue, 5th Avenue, and 6th Avenue would allow space to be reallocated to sidewalks, bike lanes, bike parking, parklets, improved bus stops, etc., working towards the Our Downtown Plan priorities of optimizing multi-modal access to and within downtown and creating a place that is enjoyable and safe for walking, biking, and using public transit.

3.4.1.1 Volume Threshold Analysis

The project team performed a preliminary assessment of the impact of the lane reductions was done using an analysis spreadsheet that compares peak hour turning movement volumes to volume thresholds. The tool estimates the roadway capacity for motorized vehicles at an intersection depending on the number of through and turning lanes for each approach. For each peak hour, the analysis compares the entering volumes to intersection capacity and estimates if the intersection is under capacity, near capacity, or over capacity for each roadway configuration. Drivers at over capacity intersections are expected to experience excessive delay and queuing.

Empirical studies referenced in the 1997 Highway Capacity Manual found that, in work zones, between 1,100 and 1,600 vehicles per hour per lane (vphpl) can be accommodated when lanes are reduced from three to two. Downtown Anchorage streets are busy with pedestrian and bicycle activity and on-street parking, demanding extra attention from drivers, similar to a work zone. The project team has found these values to work well to quickly estimate the driver experience in Alaska. As such, 1,100 vphpl per leg was used as the upper limit of capacity for this analysis.

Using existing volumes, Figure 8 summarizes intersection capacity under existing conditions and and Figure 9 summarizes conditions with a single lane closed on both 5th Avenue and 6th Avenue. Under existing conditions, a majority of intersections along 5th Avenue and 6th Avenue are near capacity, but only 5th Avenue at Ingra Street operates over capacity. This is consistent with anecdotal driver experience during the PM peak. Reducing 5th Avenue and 6th Avenue each by a lane creates near capacity conditions along the entirety of 5th Avenue, and creates over capacity conditions at A Street and Gambell. Similar reductions in capacity occur along 6th Avenue, with 6th Avenue and C Street also operating over capacity. Drivers at these over-capacity intersections would experience queues and delays similar to what is currently experienced at the intersection of 5th Avenue with Ingra Street Other east-west corridors would continue to operate under capacity.

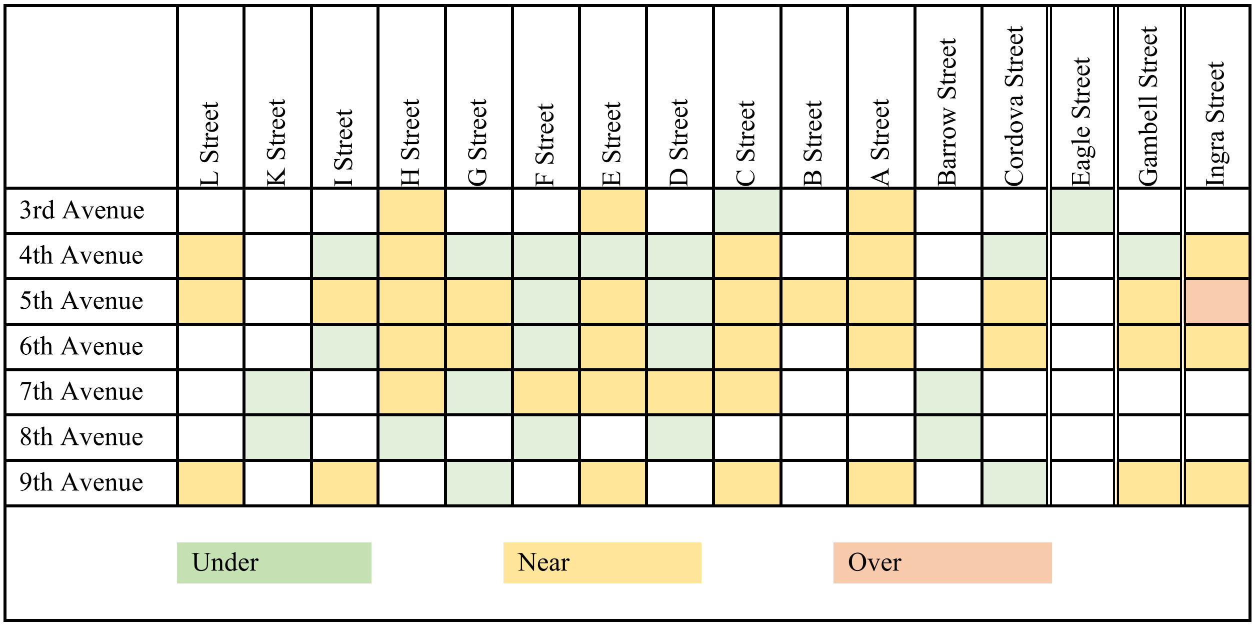


Figure 8. Existing PM Peak No Build Capacity Conditions

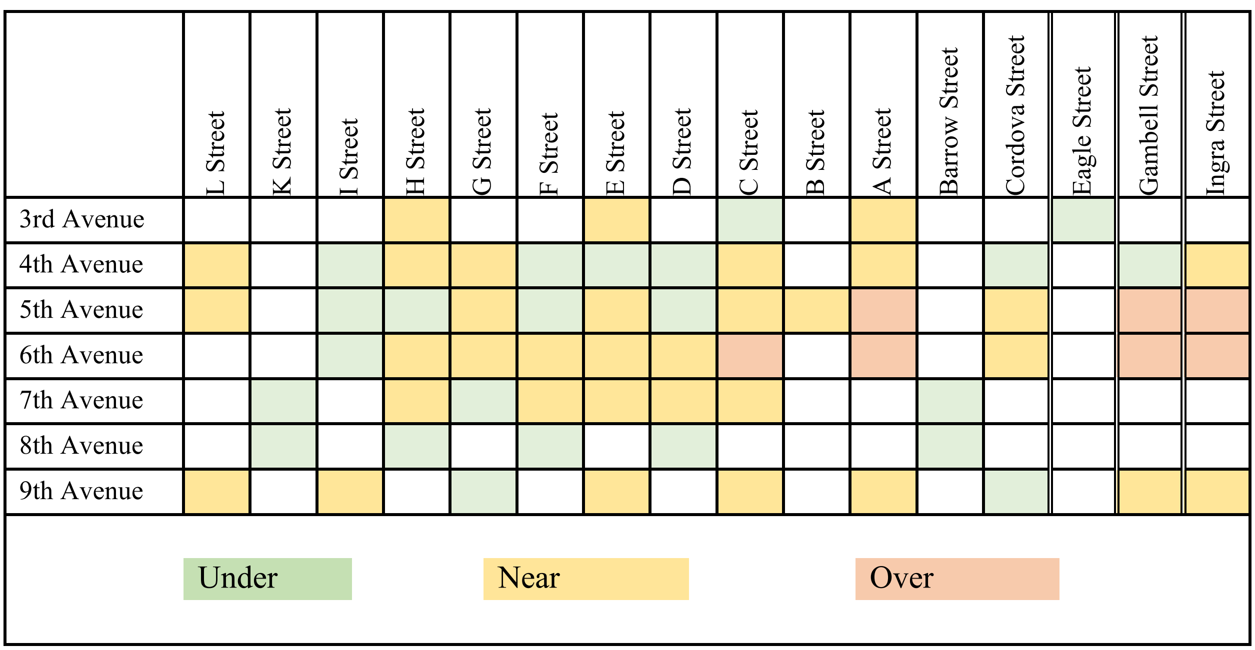


Figure 9. Existing PM Peak Lane Closure Capacity Conditions

Figure 10 and Figure 11 summarize the capacity rankings for each intersection during the PM Peak for the future (2050) volumes No Build scenario and for the Lane Reduction scenario, respectively. For this analysis, drivers are assumed to take the same route as currently. Under future volumes, 5th Avenue and 6th Avenue west of C Street will continue to operate below capacity if reduced by a lane. However, east of C Street, intersections operate above capacity. Other east-west streets will continue to operate below capacity.

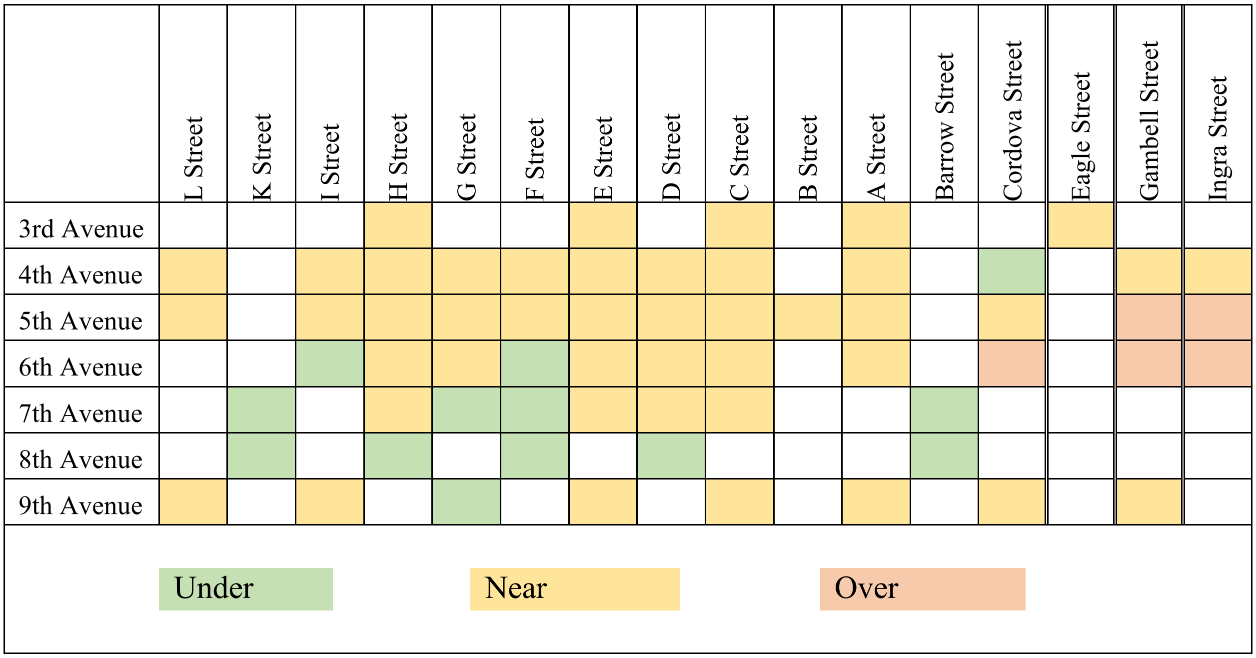


Figure 10. Future (2050) PM Peak No Build Capacity Conditions

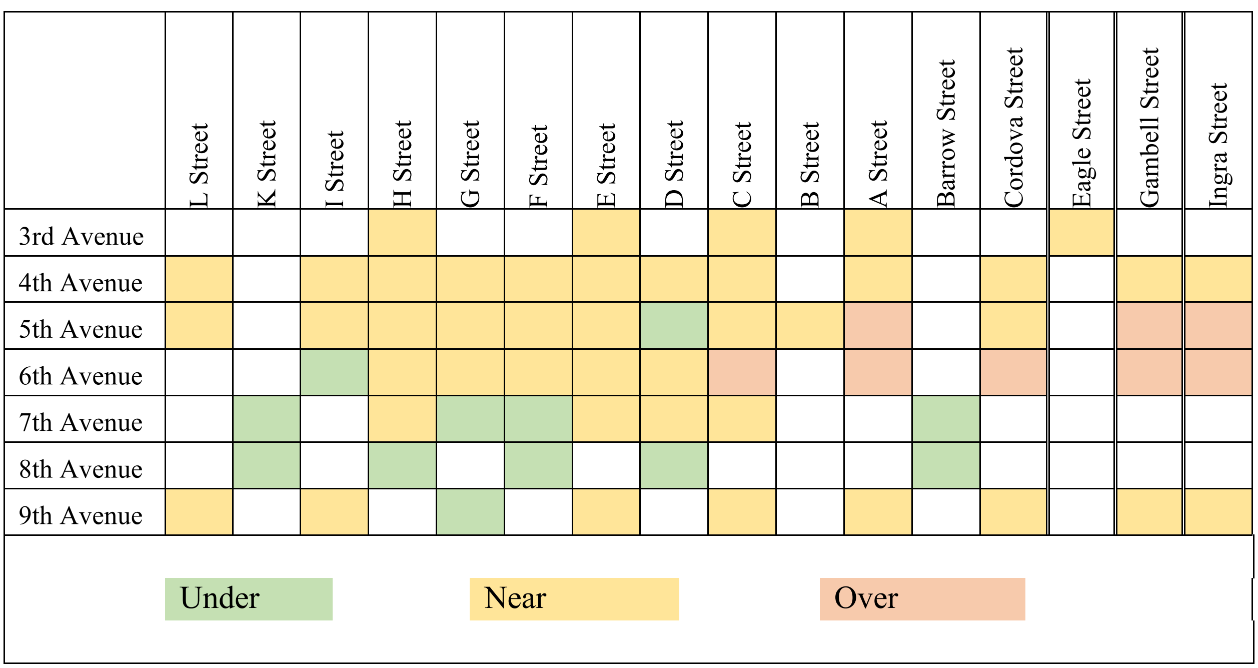


Figure 11. Future PM Peak Lane Closure Capacity Conditions

In addition to reducing capacity at the intersections, turning and parking vehicles would have a bigger impact on driver speeds and stopping when reducing from three to two lanes. With three lanes, through vehicles can drive in the center lane and avoid having to slow down behind vehicles that are turning or parking. With only two lanes, through vehicles will have to slow down or change lanes to avoid turning or parking traffic ahead. This would likely result in lower speeds through downtown, which would improve pedestrian comfort and safety. Additionally, some drivers may choose to take a different path, rather than drive through downtown.

[We will be adding Synchro LOS information and discussion of travel times along 5th Avenue and 6th Avenue to future versions.]

3.4.1.2 Pedestrian Considerations

A reduction from three to two lanes on 4th, 5th, and 6th Avenues would reduce the distance that pedestrians are conflicting with vehicle traffic at intersections, which reduces the likelihood of crashes. It may allow for shorter signal cycles which could reduce waiting times for pedestrians arriving at the signal.

3.4.1.3 Heavy Vehicle Considerations

Narrowing the vehicle travel way can make it more difficult for larger vehicles (like buses and trucks) to turn on downtown streets. The Built Environment Memo (May 2024) identifies roads most likely to be used by larger vehicles, including freight and transit bus routes. Turns between A and C Streets and 5th and 6th Avenues are common. If 5th and 6th Avenues are only two lanes wide, turning trucks would have to use both lanes to complete their turns. The turning maneuver for a tractor-trailer combination, turning from C Street to 6th Avenue and from 6th Avenue to A Street was tested as part of the 6th Avenue Protected Bike Lane Pilot Study.

3.4.1.4 Opportunities for Alternative Uses of the Right of Way

This section will include illustrations of potential alternative uses of the right-of-way should the number of lanes on 4th, 5th, and 6th Avenues be reduced to two lanes. Options could include bike lanes, transit-only lanes, on street parking, bicycle parking, parklets, outdoor dining, etc. Appendix C: Transit presents some ideas for supporting transit in the corridors.

3.4.1.5 Summary

Reconfiguring 4th Avenue from A Street to Ingra Street from three to two eastbound lanes is expected to have few impacts on vehicle traffic. Similarly, few impacts are expected for reducing 5th and 6th Avenues from three to two lanes between L Street and C Street. Between C and Ingra Streets, reducing 5th and 6th Avenues would result in additional delays and queuing; some drivers may choose to travel a different route, avoiding downtown.

3.5 Rebuild 6th Avenue and E Street Intersection

The Downtown Core Streets Street Scape Master Plan identified reconstructing 6th Avenue between E Street and D Street as a safety need. The JC Penny parking garage entrance on the southeast corner of the intersection is cited as an unsafe pedestrian crossing. The Our Downtown Plan shows there is still public support for improvements to the area. Possible improvements include bulb-outs and a raised intersection at 6th Avenue and E Street.

[This treatment has not been analyzed. Proposed analysis includes: Research the effectiveness of raised crosswalks on pedestrian safety, driver safety, vehicle speed. Determine impacts of reduced speeds on surrounding roadwork. Include project scope, schedule, and cost.]

3.6 Rebuild G Street between 3rd Avenue and 5th Avenue

In the Our Downtown Plan, G Street between 3rd Avenue and 5th Avenue, or G Street Art Central, is described as a unique district with an eclectic mix of art galleries and showrooms that attracts pedestrian activity. The plan promotes reducing G Street from southbound two lanes to one lane to allow more space for pedestrian and bicycle activity, enable more parking stalls, and calm traffic. The Our Downtown Plan presents one possible option for reconfiguring the right of way; however, multiple stakeholders have suggested other potential concepts.

Current and forecasted traffic volumes are low enough that reducing G Street to one lane between 3rd and 5th Avenues is expected to have minimal impacts on drivers. G Street is currently identified by Bike Anchorage as a bicycle-friendly street; however, the LTS analysis designates G Street as LTS 3.

The reconstruction project should further identify opportunities and constraints for this corridor in selecting a preferred alternative to design. Note that reducing lanes on G Street may create a lane shift at 5th Avenue and G Street which may require signal heads to be adjusted. Three versions of high-level (planning) cost estimates were developed for reconfiguring G Street between 3rd Avenue and 5th Avenue:

- Quick Build: includes restriping and flex-posts or similar for curb bulbouts, signal head adjustments at 5th Avenue. Estimated cost of $90,000.
- Half-width Construction: includes rebuilding half the road with new curb/streetscape to accommodate parking (eastside will remain unchanged). Estimated cost of about $650,000.
- Full reconstruction: includes corridor upgrade from 3rd to 5th Avenues (similar to 4th Avenue corridor with street trees and curb bulbouts. Estimated cost of about $1,200,000.

Note that the intersection of 4th Avenue and G Street is being modified as part of the 4th Avenue Signal and Lighting Upgrade project. Changes to the roadway include new curb bulbouts that are designed for the one-way traffic on G Street.

3.7 E Street Corridor Enhancements

[This treatment has not been analyzed. Analysis would include conversion to two-way, pedestrian enhancements, transit corridor enhancements, evaluation of whether a bus-only street could work.

3.8 Bicycle Racks, Seating, Lighting, Trash Receptacles

This section provides guidance on the design and installation of street furniture as part of any of these projects.

The MOA's Title 21 Land Use Code provides the following guidance when installing furnishings such as bicycle racks, seating, and trash receptacles in the right of way.

> Furnishings should be installed in curb bulbouts or the "furniture zone".
>
> At least one foot of clearance should be maintained behind the back of curb.
>
> The furniture zone extends to four feet behind the curb.
>
> Eight feet of unobstructed sidewalk space is required. Sidewalk space may be narrowed to five feet for temporary features with a waiver.

3.8.1 Bicycle Racks

Bicycle parking downtown is not always obvious or convenient. Figure 12 presents a screen shot of the bicycle parking map (https://www.bikeanchorage.org/bikeparkingmap) developed by Bike Anchorage, made with user data, showing bike parking locations throughout the city and providing some basic information, such as the type of rack and whether the parking is covered.

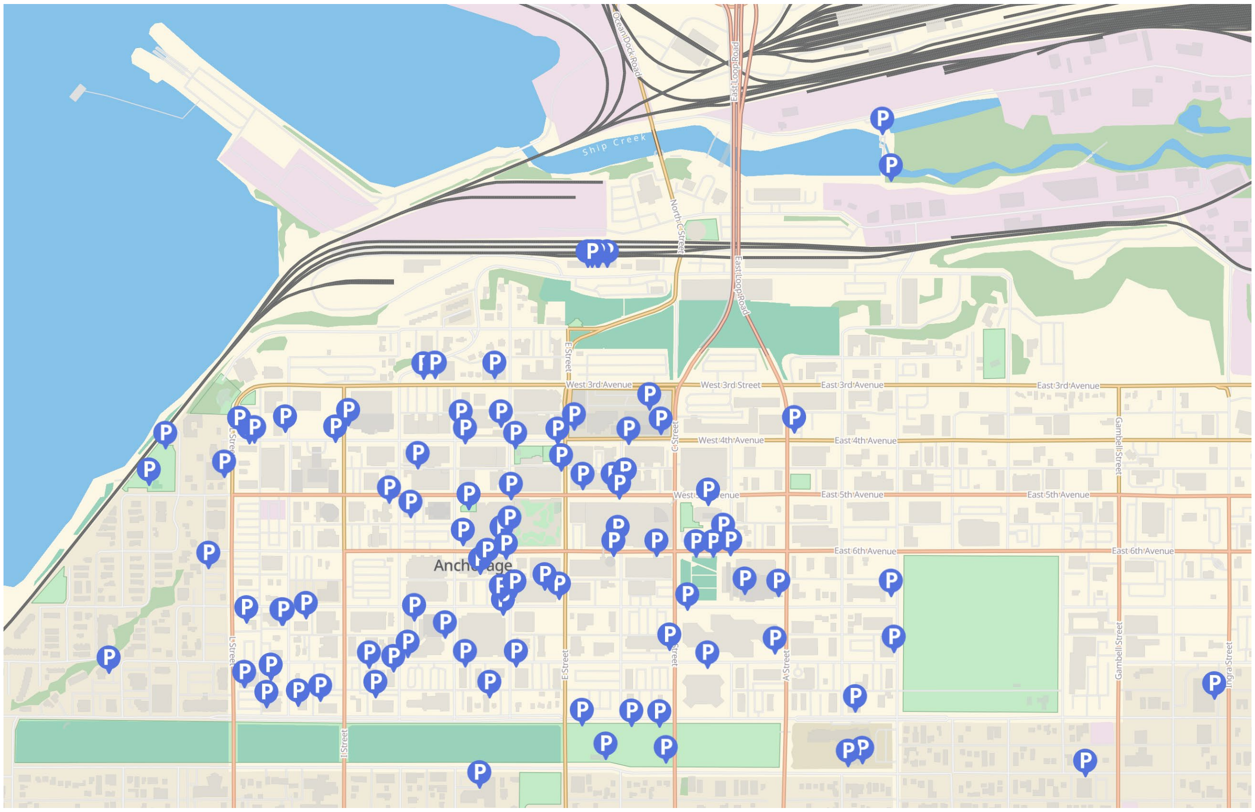


Figure 12. Bike Parking Locations (Source: Bike Anchorage)

Bicycle rack standards are published in MOA's Title 21 Land Use Code. Standards include required bicycle rack features, installation location, and the minimum number of bicycle racks to be installed per land use type. A minimum of two bicycle parking spaces must be provided for each principal usage, with specific requirements based on the type of use.

Bicycle racks must be securely anchored, tamper-resistant, and support the bicycle frame and one wheel to be locked with a standard U-type lock. Horizontal racks must support the bicycle at two or more points. The required dimensions for a bicycle parking space are six feet long and two feet wide. There are specific dimensions for vertical and stacked bike racks. Standards ensure the practical usability of these spaces. There must be a minimum of five feet of clear space behind each parking space to allow for maneuvering, and a clearance of two feet six inches from walls and other obstructions, except for horizontal racks attached to walls, which require at least one-foot clearance. Furthermore, all bicycle parking areas must be illuminated, hard-surfaced, and kept clear of obstructions, mud, and snow to maintain accessibility and usability throughout the year.

Re-allocating in-street parking to in-street bike parking may be one strategy to increase bicycle parking. Snow removal should be considered when determining the shape and placement of a bike parking area in the public right of way.

3.8.2 Seating

The U.S Access Board provides standards that benches must meet to comply with the Americans with Disabilities Act (ADA) guidelines. A single bench should have the right height, back support, and at least one armrest. When there are multiple benches, at least half should meet these ADA standards, and half of those should have an armrest. Offering different bench styles can meet various user needs. For easy maintenance, it's best to mount benches on a concrete pad or have paving around and under them, including a paved area in front of the bench.

Benches must be at least 43 inches long and 20-24 inches wide, with seats positioned 17-19 inches above ground level to ensure accessibility (ADAAG §903). Design considerations include preventing water accumulation and avoiding materials that retain heat in hot climates.

3.8.3 Lighting

The DCM outlines the standards and practices for pedestrian scale lighting, emphasizing the need for well-illuminated pedestrian pathways to ensure safety and visibility. Consistent and adequate illumination for pedestrian pathways running parallel to roadways enhances pedestrian visibility and reduces conflicts with vehicular traffic. The 2018 Downtown Lighting and Signals Upgrade Reconnaissance Study prioritizes lighting and signal upgrades for downtown street corridors based on the number of poor and fair infrastructure elements on a block.

Luminaires that provide white light, such as metal halide, induction, and enhanced color high-pressure sodium lamps, all with a CRI of 65 or greater, are required. LEDs also offer a reliable source of white light, which enhances perception-reaction time, peripheral vision, and object identification. For pedestrian facilities adjacent to roadways, maintained illuminance values must meet specific standards, with a minimum average horizontal illuminance of 20.0 lux and a vertical illuminance of 10.0 lux. Uniformity in lighting is essential, and the average-to-minimum ratio should not exceed the recommended values. The optimal placement for lighting poles is 3 feet behind the edge of pedestrian facilities to ease winter maintenance and reduce the risk of vehicle collisions. Intersection illumination is critical due to the high number of pedestrian and vehicular conflict points. Lights should be placed on the far right of intersections to silhouette pedestrians, improving visibility. Proper spacing and positioning of lighting are essential to ensure effective lighting and pedestrian safety.

3.8.4 Trash Receptacles

Supplying and maintaining trash receptacles in public areas can create a healthier and more pleasant environment.

The Anchorage Downtown Partnership is responsible for trash pick-up and disposal within the public right of way within the Downtown Improvement District. Other than the information found in Title 21, there is little MOA guidance about desirable features or placement of trash receptacles.

San Francisco Better Streets provides recommendations for general trash receptacle placement within high pedestrian activity areas, such as civic centers, commercial areas, and transit stops. That publication recommends trash receptacles at the corners of intersections and placed at a maximum of one every 200 feet in commercial areas. The publication recommends seeking private sponsorship if more trash receptacles are required.

4 References

"Bicycle Parking Guidebook | Sportworks." *Sportworks*, https://www.sportworks.com/bike-parking-guidebook. Accessed 15 July 2024.

"Bike Parking." *Bike Anchorage*, https://www.bikeanchorage.org/bikeparking. Accessed 15 July 2024.

Chapter 21.07: Development and Design Standards. 23 Mar. 2024, https://www.muni.org/Departments/OCPD/Planning/Projects/t21/Documents/Chapter%207.pdf.

City of New York. *Vision Zero Action Plan City of New York 2014*. 2014, https://www.nyc.gov/html/visionzero/pdf/nyc-vision-zero-action-plan.pdf.

Design Criteria Manual, Chapter 7 Public Transportation. 1 Jan. 2007, https://www.muni.org/Departments/project_management/Design%20Criteria%20Manual/DCM%207%20Public%20Transportation.pdf.

Impact of Speed Limit Changes on Urban Streets | MnDOT Digital Library. https://mdl.mndot.gov/items/202322. Accessed 15 July 2024.

Jason Anderson, et al. *Effect of Residential Street Speed Limit Reduction on Driving Speeds in Portland, Oregon*. 1 Jan. 2022, https://www.researchgate.net/publication/358254262_Effect_of_Residential_Street_Speed_Limit_Reduction_on_Driving_Speeds_in_Portland_Oregon.

Michael Kiesling and Matthew Ridgway. *Effective Bus-Only Lanes*. https://nacto.org/wp-content/uploads/2015/04/effective_bus_only_lanes_kiesling.pdf.

Michelle Danila, et al. *Safety Zones Speed Evaluation*. TOOLE Design, 2020, https://www.cambridgema.gov/-/media/Files/Traffic/visionzerodocuments/20230411safetyzoneevaluationmemo_rev.pdf.

Municipality of Anchorage. *Design Criteria Manual Chapter 4 Pathways & Trails*. https://www.muni.org/Departments/project_management/Documents/Final%20Draft_DCM%20Chapter%204%20Pathways%20n%20Trails_13_1206.pdf.

Owen Kehoe, et al. *Transit Speed & Reliability, Guidelines & Strategies*. 1 Aug. 2021, https://kingcounty.gov/~/media/depts/metro/about/planning/speed-reliability-toolbox.pdf.

Seattle Department of Transportation Speed Limit Case Studies. July 2020, https://www.seattle.gov/Documents/Departments/SDOT/VisionZero/SpeedLimit_CaseStudies_Report.pdf.

"Sidewalk Trashcans." *SF Better Streets*, 25 Dec. 2011, https://www.sfbetterstreets.org/find-project-types/streetscape-elements/street-furniture-overview/sidewalk-trashcans/.

Speed Limits in Cambridge. https://www.cambridgema.gov/en/streetsandtransportation/policiesordinancesandplans/visionzero/speedlimitsincambridge. Accessed 15 July 2024.

Transit Street Design Guide. https://nacto.org/publication/transit-street-design-guide/introduction/.

Vanterpool, Veronica. "Cities Can Look to Boston, IIHS for Inspiration to Reduce Speed Limits." *Vision Zero Network*, 3 Dec. 2018, https://visionzeronetwork.org/cities-can-look-to-boston-iihs-for-inspiration-to-reduce-speed-limits/.

"Vision Zero: 20 Mph Speed Limit Shows Results." *Portland Bureau of Transportation*, https://content.govdelivery.com/accounts/ORPORTLAND/bulletins/2a13547. Accessed 15 July 2024.

Appendix A: Turning Movements, Traffic Volumes, and Analysis Methods

Turning movement volumes (TMV) during the AM and PM peaks were used to analyze intersection operations. TMVs were estimated using turning movement counts (TMC), average annual daily traffic (AADT), and the iterative directional method outlined in NCHRP 765 Analytical Travel Forecasting Approaches for Project-Level Planning and Design.

TMCs at signalized intersections and all-way stop controlled intersections were provided by the Municipality of Anchorage (MOA). TMCs were collected between July 2013 and August 2022, and were collected by manually counting or with pneumatic tubes. Table 2 summarizes the collection dates and collection methods for the TMCs.

Table 2. Summary of Turning Movement Counts and Collection Technique

	L Street	K Street	I Street	H Street	G Street	F Street	E Street	D Street	C Street	B Street	A Street	Barrow Street	Cordova Street	Eagle Street	Gambell Street	Ingra Street
3rd Avenue				9/18			8/20		3/22		4/21			8/22		
4th Avenue	3/18		8/20	5/21	6/16	10/18	8/22	8/20	8/22		3/22		5/22		10/18	9/21
5th Avenue	8/22		6/16	5/21	5/21		6/16	6/22	6/16	5/21	7/18		8/18		7/13	6/16
6th Avenue			3/22	5/22	8/18	5/21	6/22	5/21	7/18		6/16		5/22		7/18	5/17
7th Avenue		6/19		6/19	9/18	6/18	8/18	5/19	10/18			6/22				
8th Avenue		8/19		7/21		2/21		8/19				6/19				
9th Avenue	3/22		3/22		8/20		5/21		6/22		6/14		6/22		6/14	5/16

Manual | Pneumatic | Induction

Traffic volumes and TMCs change with time and are affected by season, with volumes typically increasing during the summer months. 2019 DOT&PF AADTS were used to estimate existing conditions. 2022 AADTs, the most recent data available, have not returned to 2019 volumes. Figure 13 shows AADTS for several downtown routes between 2014 and 2022.

Traffic volumes are not available on every street segment within the study area. Where AADTs were not collected they were estimated. At intersections of two one-way streets, AADTs were estimated comparing vehicle trips into the intersection and vehicle trips out of the intersection; on local roads AADTs were estimated using interpolation; at other locations AADTs were estimated by applying hourly and monthly factors to TMCs. Design year AADTS were then forecasted by applying growth factors calculated by comparing the 2019 base model and the 2050 future travel demand model.

Applying the iterative directional method to the collected TMCs and estimated AADTs, existing TMCs were estimated. The iterative direction method produces planning level TMVs suitable for intersection analysis, intersection design, and traffic signal timing. TMVs between intersections were adjusted proportionally where determined appropriate to do so.

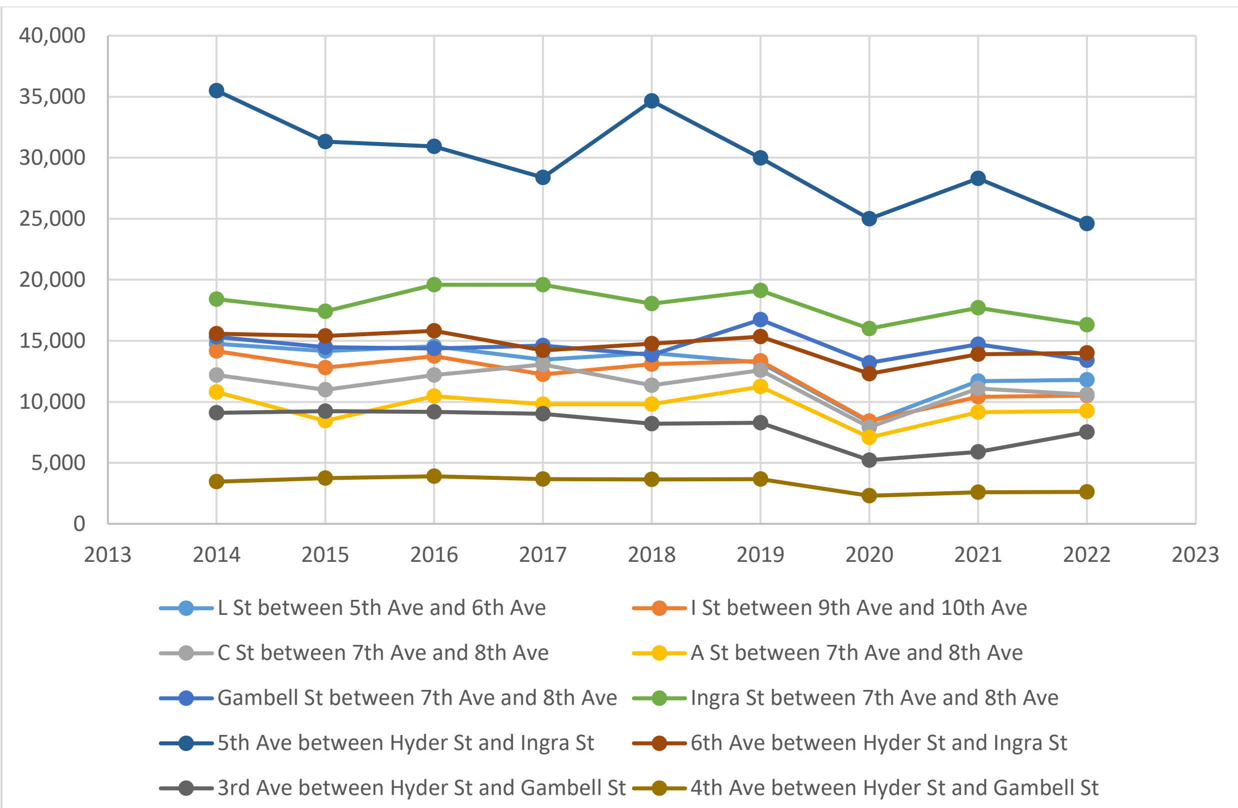


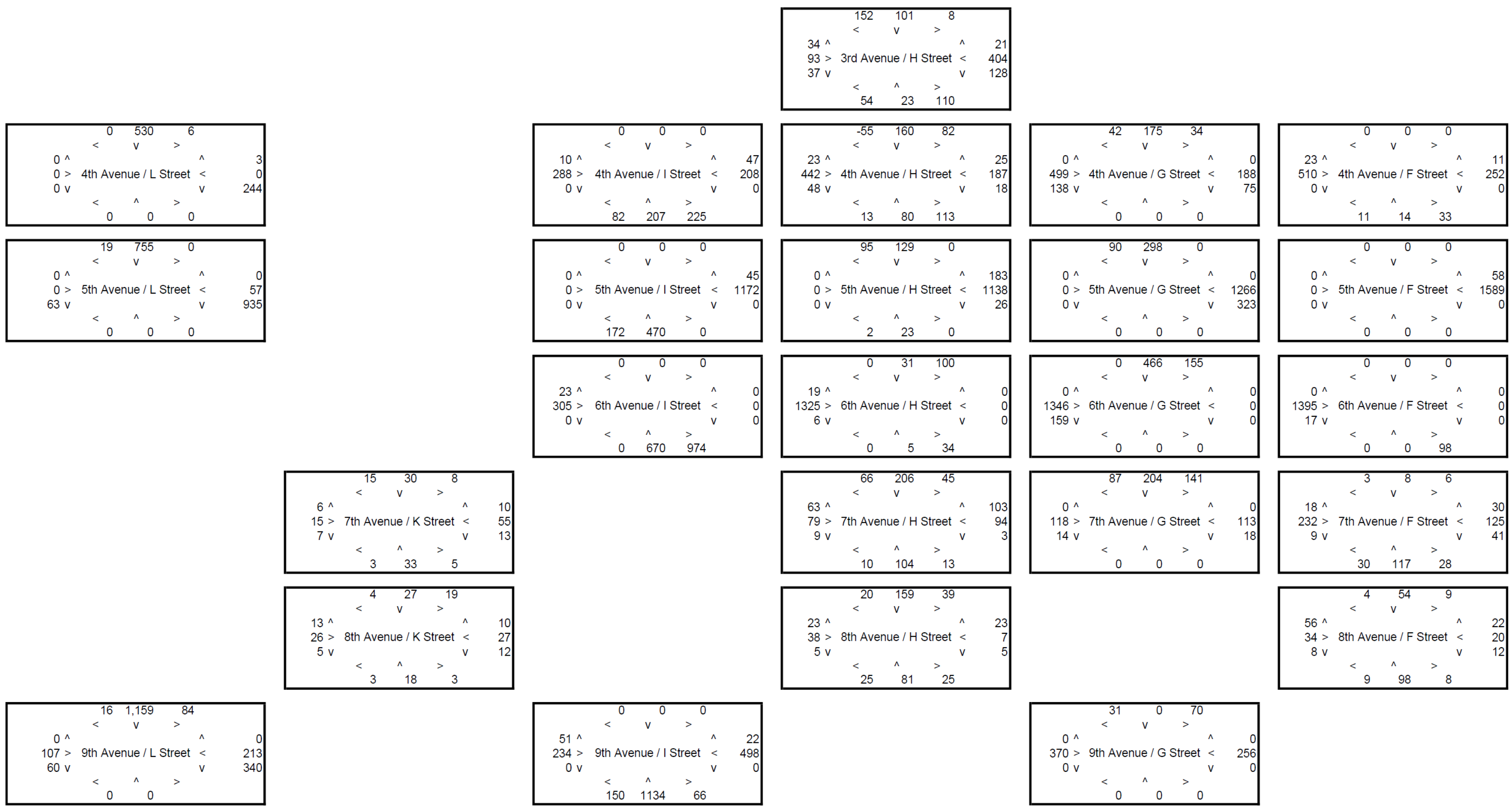
Figure 13. Summary of Traffic Volumes on Couplet Roads in Downtown Anchorage

Freight vehicles and buses are a feature of Anchorage's fleet. Vehicle classification data is not available at most DOT&PF data collection points downtown Anchorage; the classification percentage of 6% heavy vehicles used for this study come from the continuous count stations on A Street and on Minnesota.

Intersection analysis was completed using Trafficware Synchro 11, a software program that implementsHighway Capacity Manual (HCM) methodology for calculating operational metrics for vehicles and other modes of travel. HCM methods use equations to estimate operational metrics based on user volumes and travel way characteristics. For signalized intersections, signal timings must be known or estimated. The MOA provided the existing signal timings. Because downtown signals don't follow NEMA phasing, the analysis uses the HCM 2000 method. Later versions of the HCM have a different analysis methodology that requires the signal timing to use NEMA phasing.

For existing conditions, adjusted TMVs were input into Synchro and analyzed using the signal timings as provided by the MOA. For future conditions, signal splits were optimized using the Offset Optimization tool in Synchro. Future signal cycle lengths we kept at 80 seconds.

Future PM TMVs L Street Through F Street



Future PM TMVs E Street Through Barrow Street

	37 0 244	
	< v >	
10 ^		^ 22
197 >	3rd Avenue / E Street	< 425
0 v		v 0
	< ^ >	
	276 112 82	

	105 723 0	
	< v >	
0 ^		^ 0
0 >	3rd Avenue / C Street	< 469
431 v		v 432
	< ^ >	
	0 0 0	

	0 0 0	
	< v >	
0 ^		^ 138
0 >	3rd Avenue / A Street	< 666
0 v		v 0
	< ^ >	
	109 662 0	

	0 0 0	
	< v >	
160 ^		^ 108
383 >	4th Avenue / E Street	< 175
0 v		v 0
	< ^ >	
	88 202 101	

	0 0 0	
	< v >	
0 ^		^ 0
484 >	4th Avenue / D Street	< 249
0 v		v 0
	< ^ >	
	34 0 50	

	116 1,181 289	
	< v >	
0 ^		^ 0
372 >	4th Avenue / C Street	< 133
162 v		v 6
	< ^ >	
	0 0 0	

	= 0 0	
	< v >	
63 ^		^ 0
538 >	4th Avenue / A Street	< 0
0 v		v 0
	< ^ >	
	94 708 307	

	0 0 0	
	< v >	
0 ^		^ 69
0 >	5th Avenue / E Street	< 1391
0 v		v 0
	< ^ >	
	256 322 0	

	0 0 0	
	< v >	
0 ^		^ 84
0 >	5th Avenue / D Street	< 1460
0 v		v 0
	< ^ >	
	0 0 0	

	77 1,169 0	
	< v >	
0 ^		^ 0
0 >	5th Avenue / C Street	< 1348
0 v		v 566
	< ^ >	
	0 0 0	

	20 4 0	
	< v >	
0 ^		^ 60
0 >	5th Avenue / B Street	< 1778
0 v		v 13
	< ^ >	
	81 14 0	

	= 0 0	
	< v >	
0 ^		^ 183
0 >	5th Avenue / A Street	< 1670
0 v		v 0
	< ^ >	
	176 812 0	

	0 0 0	
	< v >	
155 ^		^ 0
1338 >	6th Avenue / E Street	< 0
0 v		v 0
	< ^ >	
	0 400 228	

	0 0 0	
	< v >	
0 ^		^ 0
1646 >	6th Avenue / D Street	< 0
13 v		v 0
	< ^ >	
	0 0 81	

	0 1,615 258	
	< v >	
0 ^		^ 0
1285 >	6th Avenue / C Street	< 0
136 v		v 0
	< ^ >	
	0 0 0	

	0 0 0	
	< v >	
154 ^		^ 0
1446 >	6th Avenue / A Street	< 0
0 v		v 0
	< ^ >	
	0 1011 363	

	0 0 0	
	< v >	
100 ^		^ 143
252 >	7th Avenue / E Street	< 132
0 v		v 0
	< ^ >	
	64 385 123	

	8 80 8	
	< v >	
12 ^		^ 10
200 >	7th Avenue / D Street	< 171
163 v		v 79
	< ^ >	
	96 57 108	

	49 1,705 34	
	< v >	
0 ^		^ 0
145 >	7th Avenue / C Street	< 211
171 v		v 57
	< ^ >	
	0 0 0	

	11 15 11	
	< v >	
17 ^		^ 9
17 >	7th Avenue / Barrow Street	< 9
17 v		v 9
	< ^ >	
	5 17 5	

	31 256 35	
	< v >	
34 ^		^ 42
57 >	8th Avenue / D Street	< 22
4 v		v 5
	< ^ >	
	2 185 7	

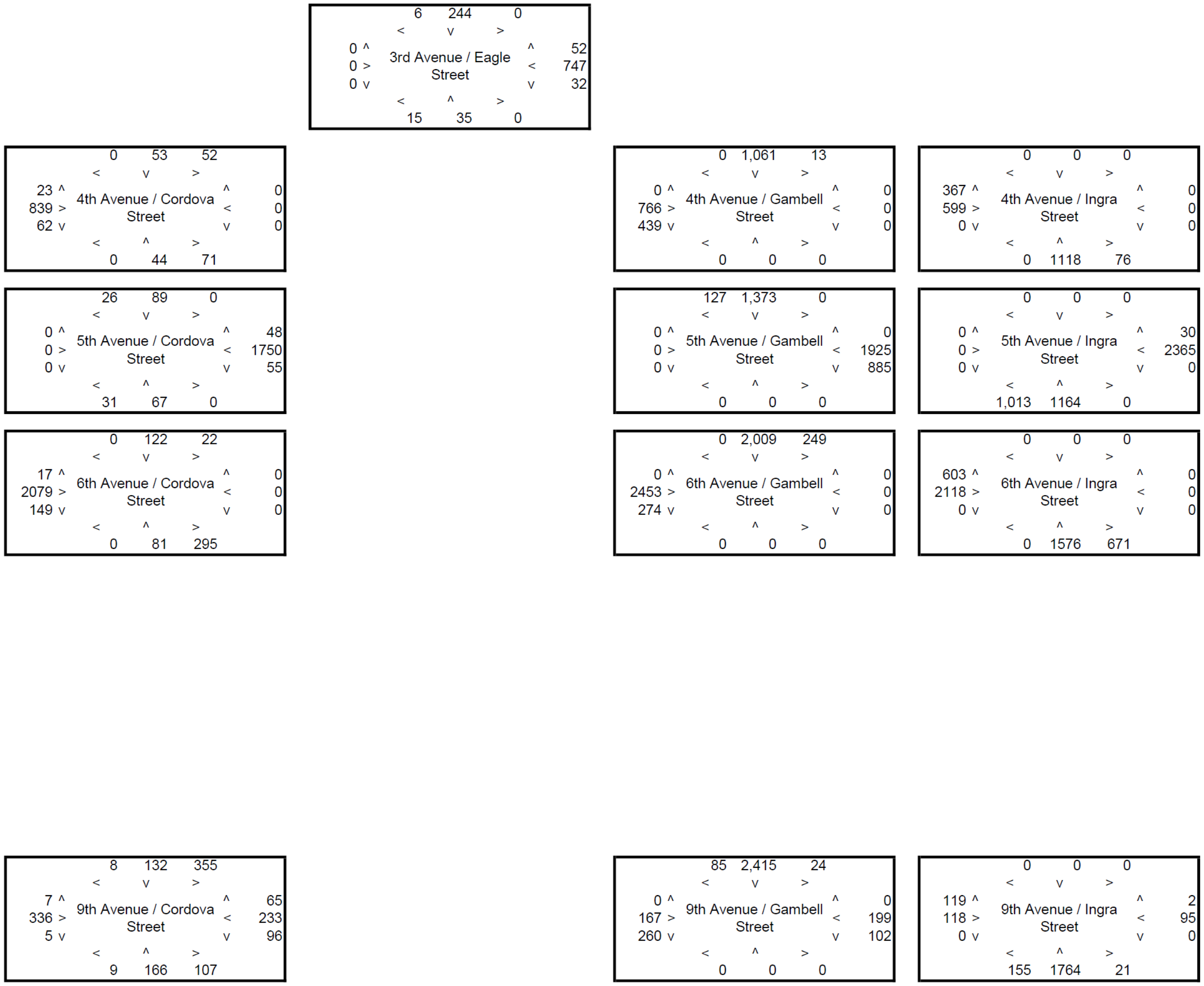
	16 7 18	
	< v >	
15 ^		^ 9
9 >	8th Avenue / Barrow Street	< 4
11 v		v 13
	< ^ >	
	5 3 5	

	0 0 0	
	< v >	
41 ^		^ 152
442 >	9th Avenue / E Street	< 294
98 v		v 118
	< ^ >	
	9 326 14	

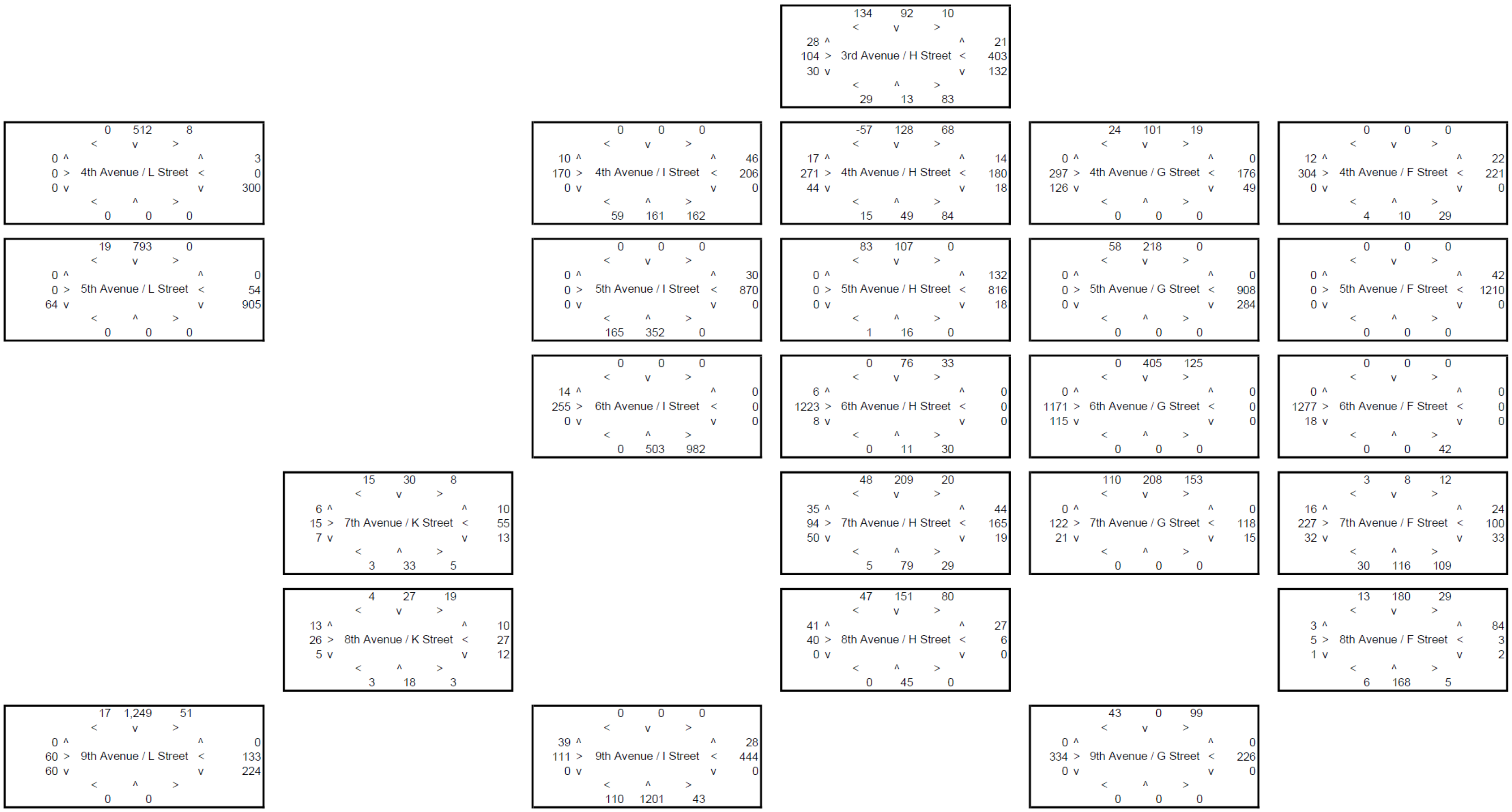
	28 1,458 73	
	< v >	
0 ^		^ 0
242 >	9th Avenue / C Street	< 221
197 v		v 157
	< ^ >	
	0 0 0	

	0 0 0	
	< v >	
37 ^		^ 29
279 >	9th Avenue / A Street	< 285
0 v		v 0
	< ^ >	
	148 1499 93	

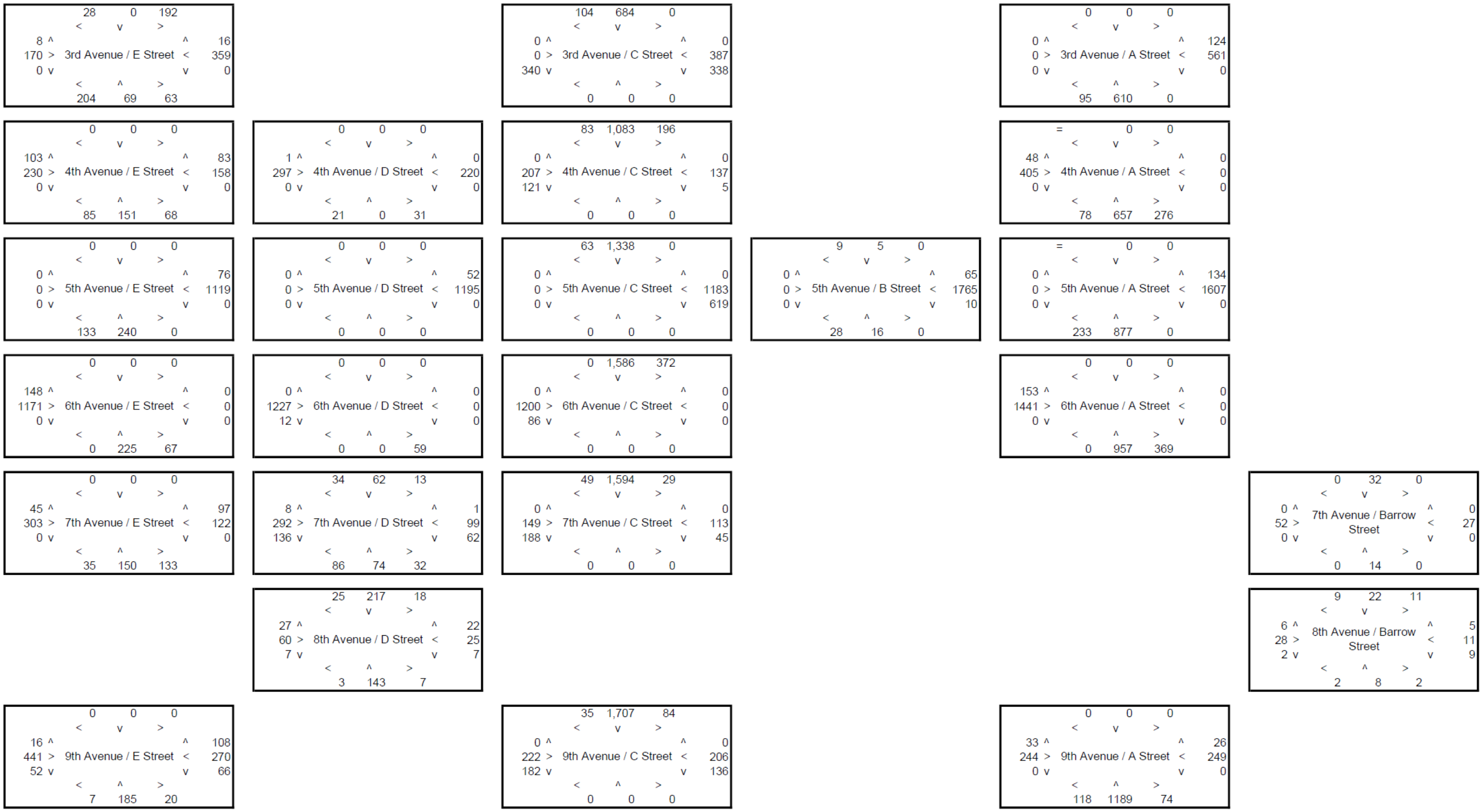
Future PM TMVs Cordova Street through Ingra Street



Existing PM TMVs L Street Through F Street



Existing PM TMVs E Street Through Barrow Street



Existing PM TMVs Cordova Street through Ingra Street

Intersection	Top <	Top v	Top >	Left ^	Left >	Left v	Right ^	Right <	Right v	Bottom <	Bottom ^	Bottom >
3rd Avenue / Eagle Street	4	133	0	0	0	0	33	645	24	10	17	0
4th Avenue / Cordova Street	0	44	41	19	636	52	0	0	0	0	43	65
4th Avenue / Gambell Street	0	739	47	0	473	51	0	0	0	0	0	0
4th Avenue / Ingra Street	0	0	0	233	478	0	0	0	0	0	621	53
5th Avenue / Cordova Street	22	74	0	0	0	0	44	1540	48	28	64	0
5th Avenue / Gambell Street	70	720	0	0	0	0	0	1861	820	0	0	0
5th Avenue / Ingra Street	0	0	0	0	0	0	56	2544	0	528	1057	2
6th Avenue / Cordova Street	0	74	48	37	1685	34	0	0	0	0	55	84
6th Avenue / Gambell Street	0	1,409	131	0	1734	257	0	0	0	0	0	0
6th Avenue / Ingra Street	0	0	0	253	1646	0	0	0	0	0	1334	1048
9th Avenue / Cordova Street	13	86	77	6	264	13	6	159	26	30	73	47
9th Avenue / Gambell Street	68	1,912	24	0	165	187	0	134	68	0	0	0
9th Avenue / Ingra Street	0	0	0	115	97	0	2	79	0	146	1874	19

Appendix B: Speed Limit Reduction Studies

Summary

Reducing vehicle speeds can increase safety for all road users, especially vulnerable road users. Speed limit reduction case studies from six cities were reviewed. In most cases, cities lowered speed limits, installed new speed limit signs, and publicized the change through public awareness campaigns, but many did not implement physical traffic calming road design changes. These actions were a part of each city's Vision Zero initiative to reduce fatal and severe injury crashes.

Most of the studies found that there were benefits (or potential benefits) to vulnerable road users due to reductions in vehicle speeds, especially a reduction in the number of vehicles traveling at higher speeds. Nevertheless, speed limit reductions were not uniform across all roadways.

Seattle, Washington

To eliminate traffic fatalities and serious injuries, the Seattle City Council revised municipal codes in 2016 to lower default residential street speed limits from 25 mph to 20 mph and arterial street speed limits from 30 mph to 25 mph. This initiative began in the downtown area and later expanded to include urban villages. By 2020, Seattle Department of Transportation (SDOT) had installed new speed limit signs on over 90 miles of arterial streets, at ¼ mile increments, and planned to extend this to an additional 270 miles by May 2021.

A 2020 SDOT study across five urban centers revealed reductions in driver speeds, total crashes, and injury crashes after the speed limit reduction. Median driver speeds, 85th percentile speeds and driver speeds above 40 mph were reduced by 9.9%, 7.1%, and 54.1% respectively. Total crashes were reduced by 22% and injury crashes decreased by 18%. These results indicate that lowering speed limits, even without additional marketing campaigns or enforcement, can effectively decrease driver speeds and enhance overall road safety.

Boston, Massachusetts

Boston lowered urban speed limits from 30 mph to 25 mph under its Vision Zero program. Boston's initiative resulted in a 29.3% reduction in the odds of drivers traveling over 35 mph. The initiative not only improved road safety but also collected growing community support, leading the Boston City Council to consider further reducing the speed limit to 20 mph and expanding the city's 20 mph Neighborhood Slow Street Zones.

Cambridge, Massachusetts

In March 2016, Cambridge City Council adopted Vision Zero and implemented measures to reduce speed limits from 25 mph to 20 mph on most local-access streets to enhance safety. Signs were installed at the entrance of each street and at intersections with major roads, ensuring that drivers were informed of the new speed limits.

A speed study on Broadway Street found that the implementation of the lower speed limit, coupled with clear signage and public awareness campaigns, resulted in a significant reduction in the 85th percentile speed from 29.3 mph to 25.9 mph. On Hampshire Street, similar actions led to a decrease in the 85th percentile speed from 27.9 mph to 25.1 mph. Additionally, the Cambridge Police Department employed a data-driven approach to enforcement, targeting areas with high crash rates and conducting proactive enforcement based on detailed crash analyses.

New York, New York
In New York, New York a multi-faceted approach was taken to increase traffic safety. In 2014 the Department of Citywide Administrative Services installed red light cameras and speed cameras at key intersections resulting in a 31% decrease in pedestrian injuries and 20% decline in all injury crashes. In addition, the citywide speed limit was reduced from 30 mph to 25 mph, increasing pedestrian crash survival rates from 20% to 30%. Additionally, penalties were implemented for dangerous driving, such as making it a misdemeanor to harm pedestrians or cyclists due to negligence, has aimed to deter reckless behavior effectively.

Additionally, the installation of new crosswalks, extended medians, and clearer lane designations have effectively reduced injury crashes by up to 63% at treated intersections. The introduction of traffic signal strategies, such as leading pedestrian intervals and coordinated arterial signal timing, has contributed to a safer traffic environment by minimizing speeding and intersection conflicts. As a result of these multifaceted approaches, fatalities at locations where major engineering changes were implemented since 2005 have decreased by 34%.

Portland, Oregon
In January 2018, Portland Bureau of Transportation (PBOT) implemented a speed limit reduction on residential streets from 25 mph to 20 mph. The initiative was supported by a comprehensive public awareness campaign known as "20 Is Plenty," which included extensive signage updates and community outreach efforts.

Before-and-after observations at 58 locations indicated average speeds were essentially unchanged (21.6 mph before the change and 21.7 mph post-implementation). However, the likelihood that vehicles would be driving above the speed limit was reduced significantly, with a 50% reduced likelihood of a vehicle driving at above 35 mph on the residential streets. Statistical models confirmed these reductions were significant, accounting for factors such as time-of-day, day-of-week, vehicle type, and roadway characteristics.

Minneapolis, Minnesota
In 2021 Minnesota Department of Transportation (MnDOT) lowered the default speed limit on most city streets from 30 mph to 20 mph, with select streets posted at 25 mph, 30 mph, or 35 mph. Driver speed data was collected before changes were implemented in summer 2020 and shortly after the implementation in June 2022. Mean driver speeds decreased at most locations.

The analysis indicated a general trend toward lower speeds, but the impact was not uniform across all locations: some locations experienced minimal changes in speeds or even increases in mean speeds. The data were collected shortly after the signs were installed, potentially not allowing enough time for drivers to adjust their behavior. Driver behavior may have also been influenced by other external factors such as construction.

Appendix C: Transit Road Design Changes

In-lane Stops

Sidewalk Stops: At an in-lane sidewalk stop, buses stop in a travel lane or bus lane adjacent to the curb. Stopping in-lane reduces passenger delay, increases transit reliability, and reduces wear on transit vehicles. Converting existing pull-outs into in-lane sidewalk stops can improve pedestrian space. In-lane sidewalk stops a0re effective on streets with low to moderate transit frequency and speeds of 30 mph or lower. In-lane sidewalk stops are a cost-effective treatment at locations where changes are not required to the existing sidewalk. This treatment is recommended for use on streets where pedestrian space and accessibility can be enhanced, as well as in constrained conditions where street width prevents separate bike and transit facilities, necessitating a shared bus-bike lane.

Figure 14. Boarding Island Constructed with Zicla© Blocks in Bellevue, WA (Source Google Maps)

Challenges include causing traffic to queue behind stopped transit vehicles in mixed traffic without dedicated lanes and creating safety hazards on two-lane, two-way streets when vehicles attempt to overtake stopped buses. Ensuring enough space for stop amenities without obstructing the accessible boarding area or pedestrian flow can be difficult on narrow sidewalks.

Side Boarding Islands: Side boarding islands (Figure 14) are installed at locations with protected bike lanes. Raised platforms are installed separated from sidewalks, creating a protected bike lane for the length of the platform. Pedestrians will cross the bike lane to board the bus, creating a conflict point between pedestrians and bicycles.

Queue Jumps

Queue jumps enable buses to bypass other vehicles at signalized intersections (Figure 15) using a leading bus interval or active signal priority. Queue jumps reduce bus delay, enhance schedule reliability, and improve overall transit performance by enabling buses to bypass congestion. Queue jumps can include a near-side or far-side stop, or it can be configured without a bus stop, depending on intersection dynamics and traffic conditions.

Queue jumps are effective at signalized intersections with low to moderate bus frequencies and high peak-hour traffic volumes, where they can enhance operational efficiency without compromising intersection safety.

Challenges associated with queue jump lanes are the need for adequate space for dedicated transit lanes and intersection modifications, potential impacts on right-turning traffic, and coordination with pedestrian movements.

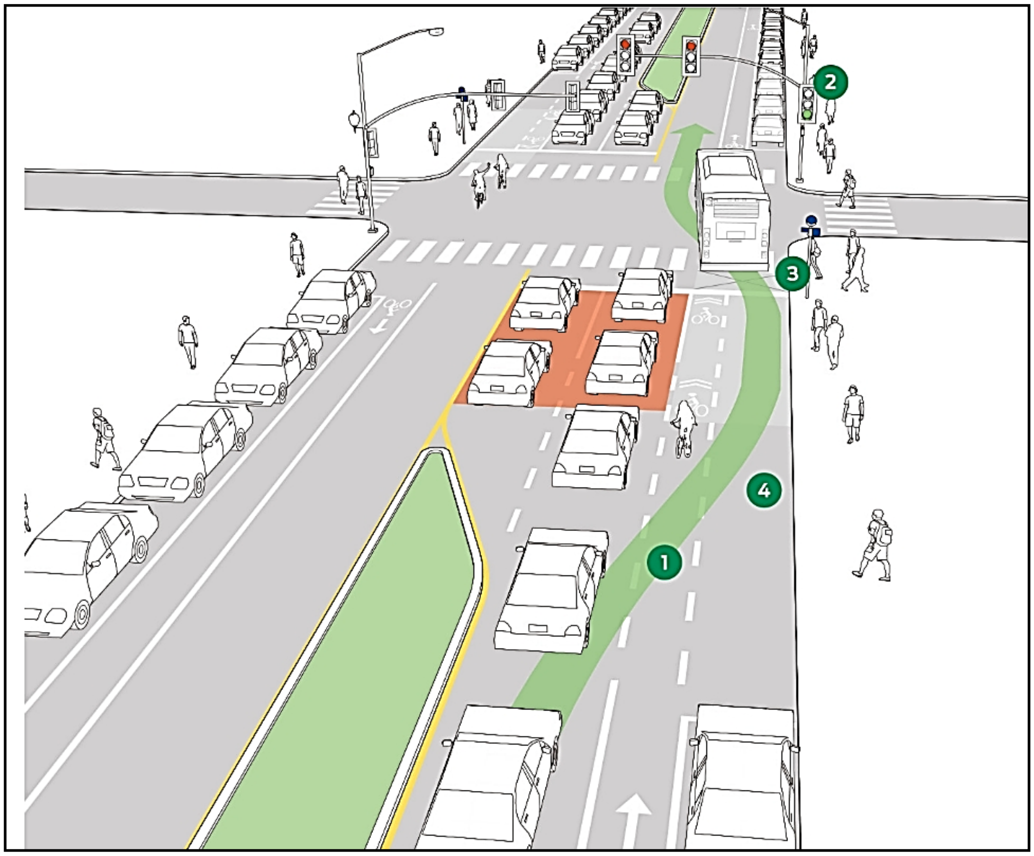


Figure 15. Example of a Queue Jump. (Source ---)

Bus-only lanes

Bus-only lanes are lanes or segments of lanes exclusively for use by buses. Bus-only lanes allow buses to bypass congested areas streamlining operations and improving reliability. They are most effective in urban centers with high transit demand, on corridors prone to peak-hour congestion, and on major transportation routes connecting key districts. Signage, lane markings, and enforcement inform and reinforce an understanding of the use of the bus lane for general purpose drivers. Bus-lane restrictions may be time-of-day dependent.

Bus-only lanes may be obstructed by uninformed drivers. Community outreach programs and regular enforcement can improve compliance to bus-lane restrictions. More sophisticated strategies may be implemented if non-compliance persists.

Bus-Bike Lanes

Shared bus-bike lanes provide a dual-purpose solution for integrating buses and bicycles on low-speed urban streets. They are typically found on two-way streets with curbside or offset bus lanes. By allowing cyclists to pass buses only at stops and encouraging buses to stay behind cyclists, these lanes enhance safety and reduce conflicts. They improve transit service reliability by minimizing delays caused by interactions between buses and bicycles. As seen in Figure 16, combined bus and bike lanes are wide enough for bikers to feel comfortable on the road.

Bus-bike lanes do not offer the same level of comfort as dedicated bikeways, especially during peak hours or on routes with high bus volumes and speeds. The interaction between buses and bicycles requires careful management to ensure smooth operation and minimize potential conflicts. Effective design includes clear pavement markings and signage to designate lanes for exclusive bus and bike use, along with appropriate lane widths that accommodate both modes safely, especially at bus stops where interactions are most frequent.

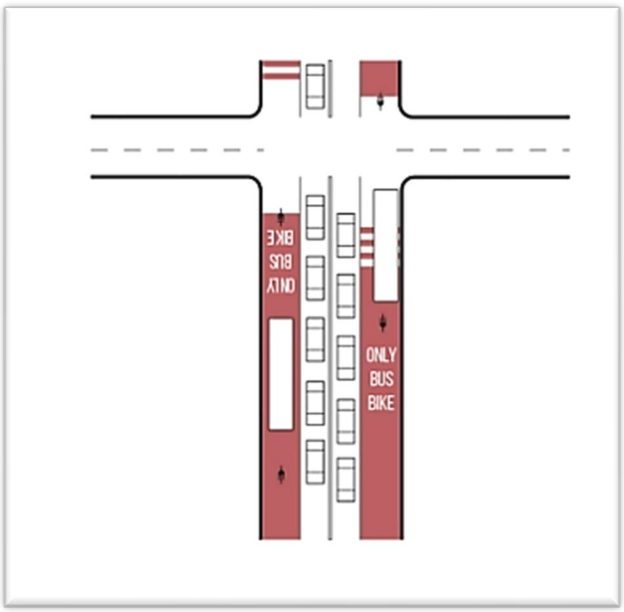


Figure 16 Bus-Bike Lane.

Transit Signal Priority

Transit Signal Priority (TSP) tools (illustrated in Figure 17) adjust traffic signal timing to prioritize transit vehicles, reducing delays and improving reliability. Techniques such as green extension, red truncation, and phase insertion optimize traffic flow for buses at intersections; TSP is particularly beneficial on corridors with long signal cycles or high transit demand. Benefits include significant reductions in transit delay—up to 50% at targeted intersections—and improved travel time reliability, which is especially crucial where signal delays contribute significantly to overall transit delay. Implementing TSP requires coordination between transit agencies and signal operators, ensuring effective use of on-board and wayside technology to prioritize buses without affecting other traffic or pedestrians.

Challenges with TSP include potential delays for cross-street traffic and the need for sufficient bus volumes to justify implementation. It is most beneficial where transit vehicles can reliably reach intersections, supported by adequate detection systems and operational agreements. Locations ideal for TSP deployment include corridors with frequent bus service and intersections prone to transit delays due to signal phasing or traffic congestion. Proper planning and integration with existing signal systems and transit operations are essential for maximizing TSP effectiveness and minimizing impacts on overall traffic flow.

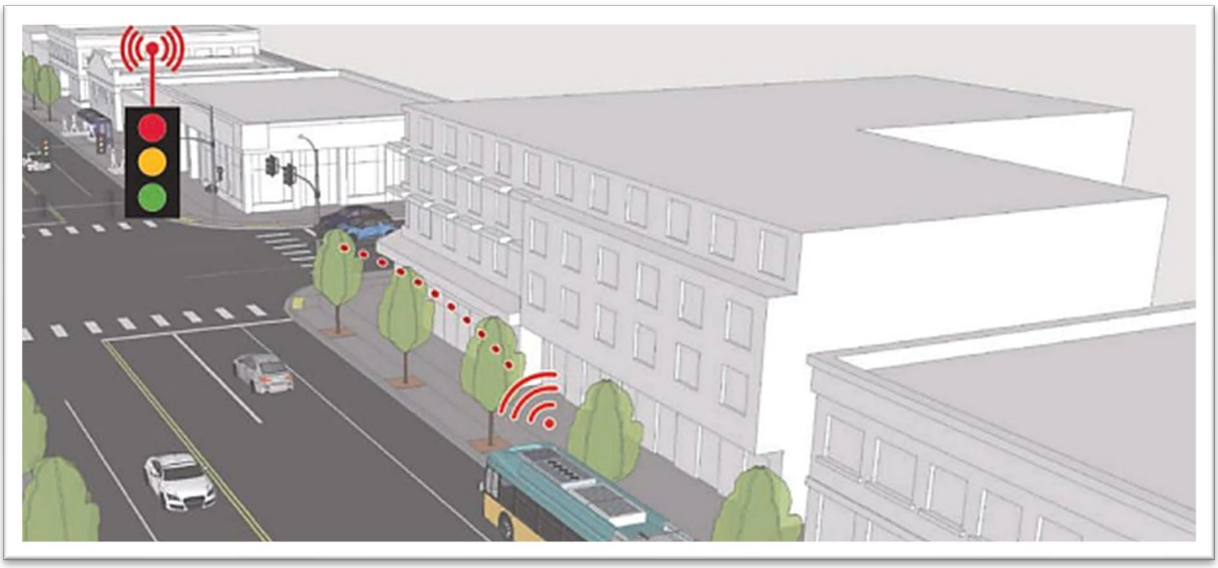


Figure 17 Transit Signal Priority, bus signaling to traffic light