Traffic Impact Study

Prepared for submittal to:

CITY OF Billings

for the project:

Trailhead Commercial Subdivision

on behalf of:

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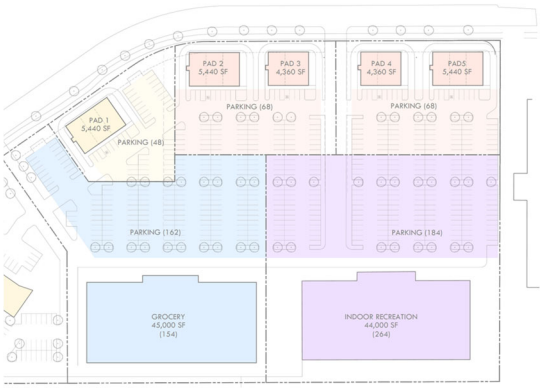

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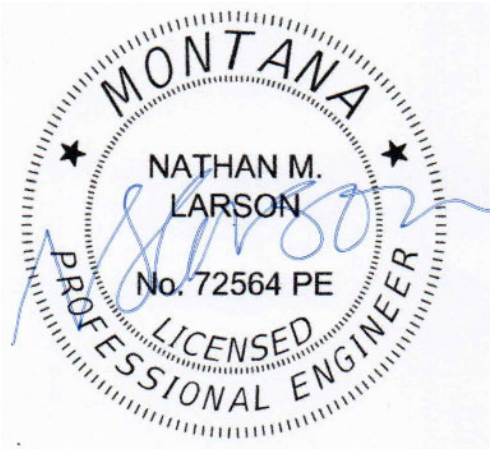

PTOE #1185, certified in 2003

December 2025

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APPENDICES

1 INTRODUCTION

This report documents the Traffic Impact Study (TIS) conducted for the Trailhead Commercial Subdivision project in south central Billings. This is a working title for the project, and it could change before final occupancy. The TIS documented here was conducted in accord with the guidelines indicated in the City of Billings Code of Ordinances Section 23-406, subsection (b), part (4) as updated May 19, 2025. This report also documents other study elements specified in the City's TIS checklist as well as intersection improvement cost-share calculations.

The need for a traffic study is met by this project's trip generation characteristics. This study has been prepared by a professional engineer licensed in good standing in Montana with experience and training in the field of traffic and transportation engineering. This study's author and signatory is also a professional traffic operations engineer.

1.1 PROJECT SITE AND STUDY AREA

The project site is shown in **Exhibit 1** along with the intersections studied. The existing study intersections were identified during preapplication review with City of Billings staff as:

1. Mullowney Lane/King Avenue at I-90 Business/Laurel Road
2. Mullowney Lane at I-90 Ramps
3. Mullowney Lane at Midland Road
4. South Billings Boulevard at Midland Road

For the sake of brevity from here forward in the body of this report, existing intersections are generally referred to only by their distinguishing street names (e.g., "Mullowney at Midland"). There is one existing driveway and one new/consolidated driveway that will be used by project traffic. These have been examined for the future "Total Traffic" scenario. In this report, these are referred to as the West access and the East access. Both were analyzed for future conditions with the project (the Total Traffic scenario), but because they are simple driveways they were not considered in cost share calculations.

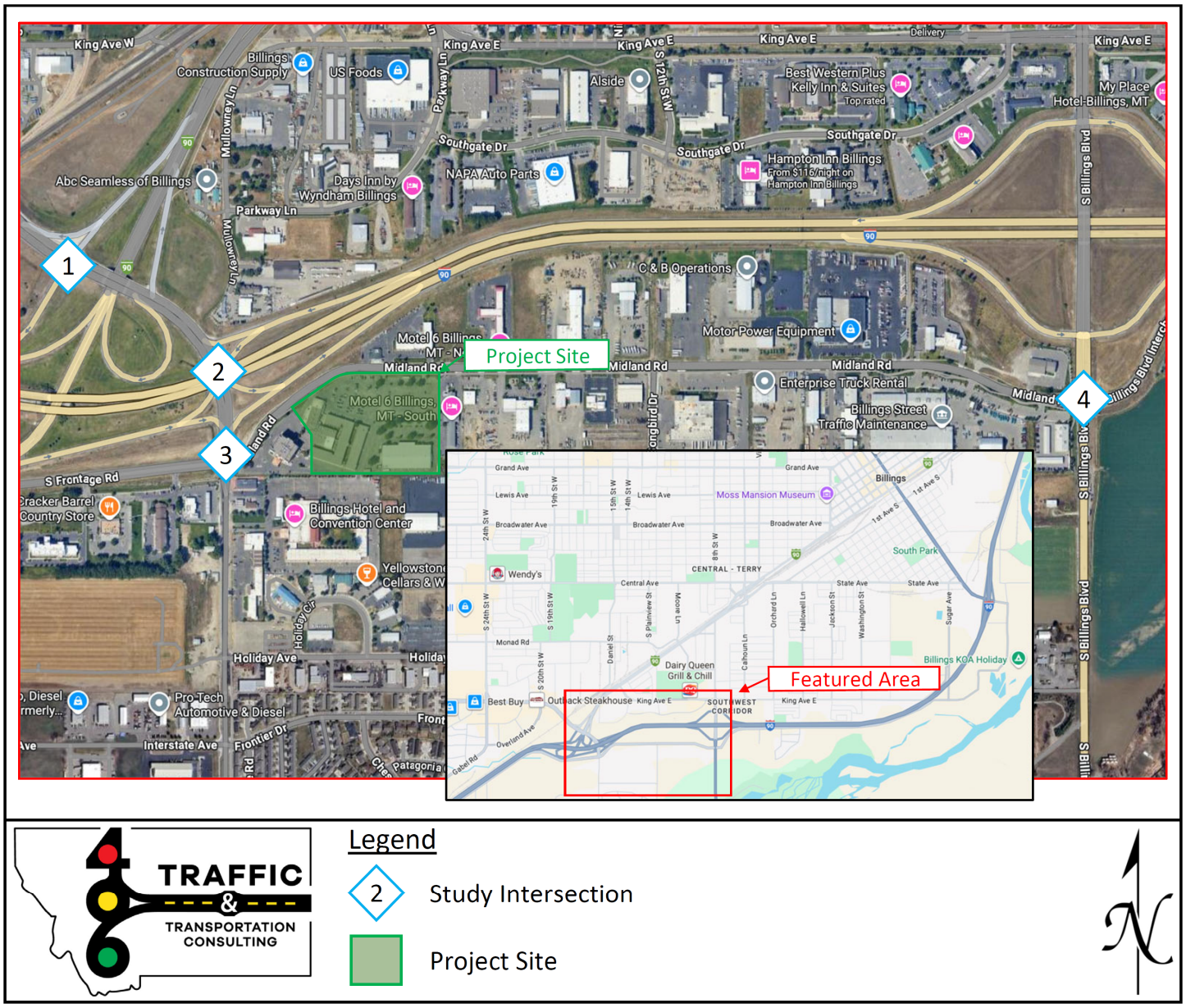
Midland is considered to be oriented east-west for the purpose of this report despite a prominent curve on the east leg of its intersection with Mullowney. The West access to the project site is on this curve, but with Midland considered east-west, the access is described here as a north-south facility.

1.2 LAND USES AND PHASING

The site was unused when this study began. The project will cover the whole site and will consist of seven commercial structures (6 new and one existing building not in use): two larger buildings and five outparcel pad sites. The two larger buildings are proposed to be a newly-constructed grocery store of 44,000 square feet (SF) and a re-used existing building that will house an indoor multi-purpose recreation center of similar size. Each of the five pad sites are expected to have 2-3 tenants and are being designed to include a simple drive-through lane/window that wraps around the building. Only the complete buildout of both uses is considered, so there is only one phase of the project for traffic impact analysis purposes.

Exhibit 2 shows the Trailhead Commercial Subdivision site plan on which the analysis here is based. It includes the proposed building footprints, adjacent street, access points, on-site circulation, drive-through lanes, parking, and limited landscaping features. Note that this site plan should be considered illustrative for the purpose of this traffic study, and a more detailed and/or higher-resolution one has been (or will be) provided separately by the applicant. The existing hotel west of this commercial site is not part of the project.

Exhibit 1. Overall Site Location and Study Intersections

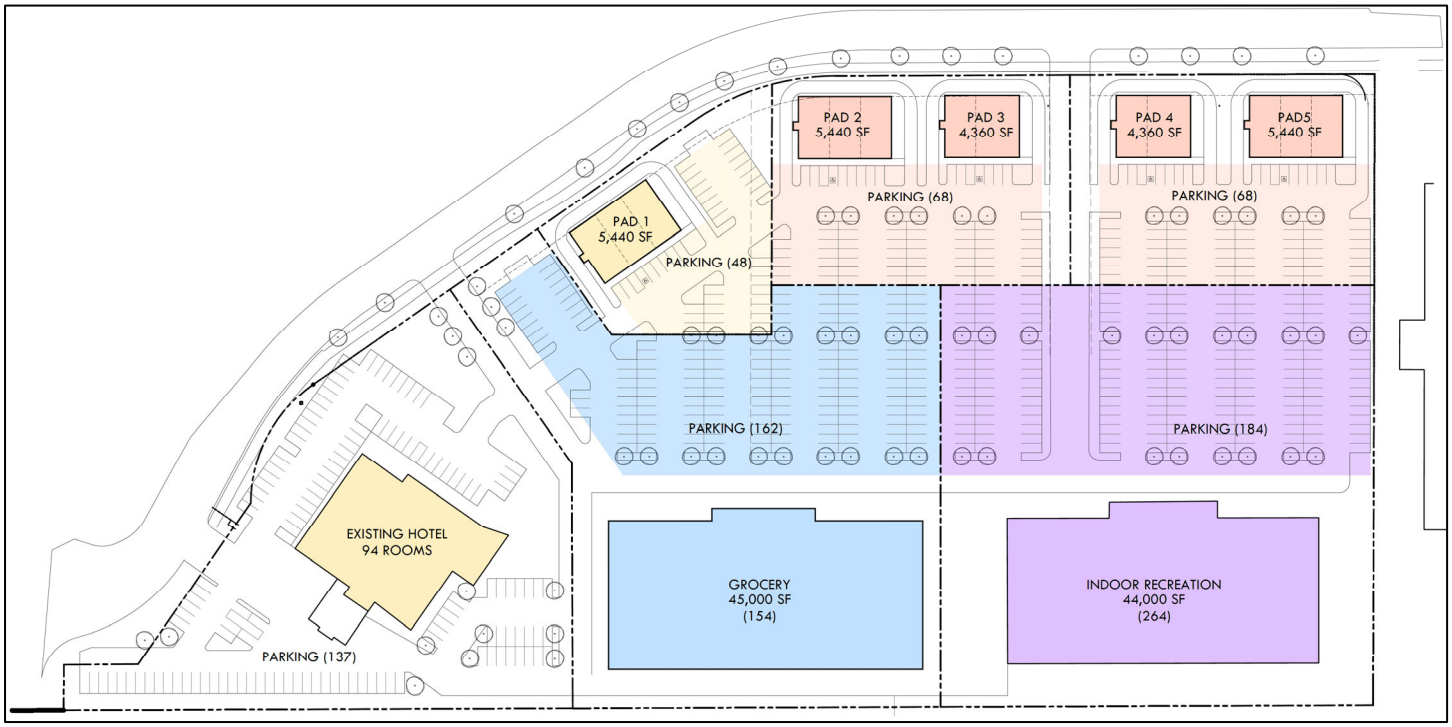


1.3 Analysis Methods and References

Raw field traffic counts were gathered by 406 Traffic. These raw counts were then adjusted slightly for this TIS based on 2025 City of Billings annualization factors prior to their use in impact analysis. Existing signal phasing and timing information was provided by MDT and City of Billings staff.

Trip generation rates, or equations as applicable, are from the Institute of Transportation Engineers (ITE) Trip Generation suite's 12th edition. ITE trip generation data, when aggregated across enough varied sites, produce both simple average rates and best-fit equations, either linear or logarithmic, to help the analyst derive proper estimates for their situation. Equations are generally preferred over rates, especially for larger sites where trip generation per unit of land use can diminish with increasing project size. General ITE guidance calls for the use of the fitted curve equation when the data set for the land use type in question is comprised of studies from 20 or more separate sites and when the equation produces a correlation coefficient (R^2) of 0.75 or higher, with 1.0 being the best possible fit. More information about trip generation is provided in Chapter 3.

Exhibit 2. Site Plan



Excerpted from: Performance Engineering/Collaborative Design Architects, 9/15/2025

Operational performance was analyzed at the study intersections through the use of the industry-standard methods presented in the USDOT's Highway Capacity Manual (HCM), published in its modern form as Transportation Research Board Special Report 209. Synchro Studio 12 was employed as both a data repository and a capacity analysis tool, with reports for each intersection generated using Synchro's application of the assumptions of the HCM's 7th edition, the most recent available at the time of this study.

The HCM methodology for intersection capacity analysis produces delay estimates for each turning movement (or "lane group" when multiple turning movements operate from the same lane). These delay estimates are assigned Level of Service (LOS) grades that range from A (best) to F (worst), as indicated in **Exhibit 3**. It's also important to note that for unsignalized intersections with only side-street under Stop sign control, LOS for the intersection is often represented by the LOS for the worst lane group. The Trailhead site's access points fall under this category.

Exhibit 3. Intersection LOS Criteria

	Delay Range (seconds/vehicle) by Control Type		
LOS	**Unsignalized**	**Signalized**	**Description**
A	0 to 10.0	0 - 10.0	Free flow
B	10.1 to 15.0	10.1 to 20.0	Stable flow (slight delays)
C	15.1 to 25.0	20.1 to 35.1	Stable flow (acceptable delays)
D	25.1 to 35.0	35.1 to 55.0	Approaching unstable flow
E	35.1 to 50.0	55.1 to 80.0	Unstable flow
F	50.1 or more	80.1 or more	Forced flow (congested, queues fail to clear)

Source: HCM 7th Edition

Operations impacts are determined by how peak hour LOS relates to acceptability standards. In general, Billings employs a LOS standard of C or better. When LOS without the project (the "Background" condition) is D or worse, an operations impact is defined when the project would increase delay.

MDT auxiliary turn lane analysis was not conducted for this project for the following reasons:

- All four existing study intersections are already signalized;
- Midland is a lower-speed collector, rather than the type of rural highway for which the MDT process was developed;
- Midland already has a continuous center turn lane to serve traffic entering the site; and
- The site driveways are located somewhat close together.

2 EXISTING AND BACKGROUND CONDITIONS

2.1 STREETS AND INTERSECTIONS

Note that for the purpose of this traffic study report, the dividing line between Mullowney Lane and King Avenue is the I-90 SPUI intersection (Intersection 2). There are currently no dedicated bicycle facilities in the study area.

Mullowney Lane is a north-south Collector in the Billings 2023 Long Range Transportation Plan (LRTP) with a speed limit of 35 mph. It has two travel lanes in each direction in the study area with a single left turn lane in each direction (a 5-lane section) at the Midland intersection. About 400-500 feet south of the Midland intersection, Mullowney transitions down to a three-lane section, with one lane in each direction and a center turn lane. There is a sidewalk along the east side of Mullowney from the Midland intersection to the north.

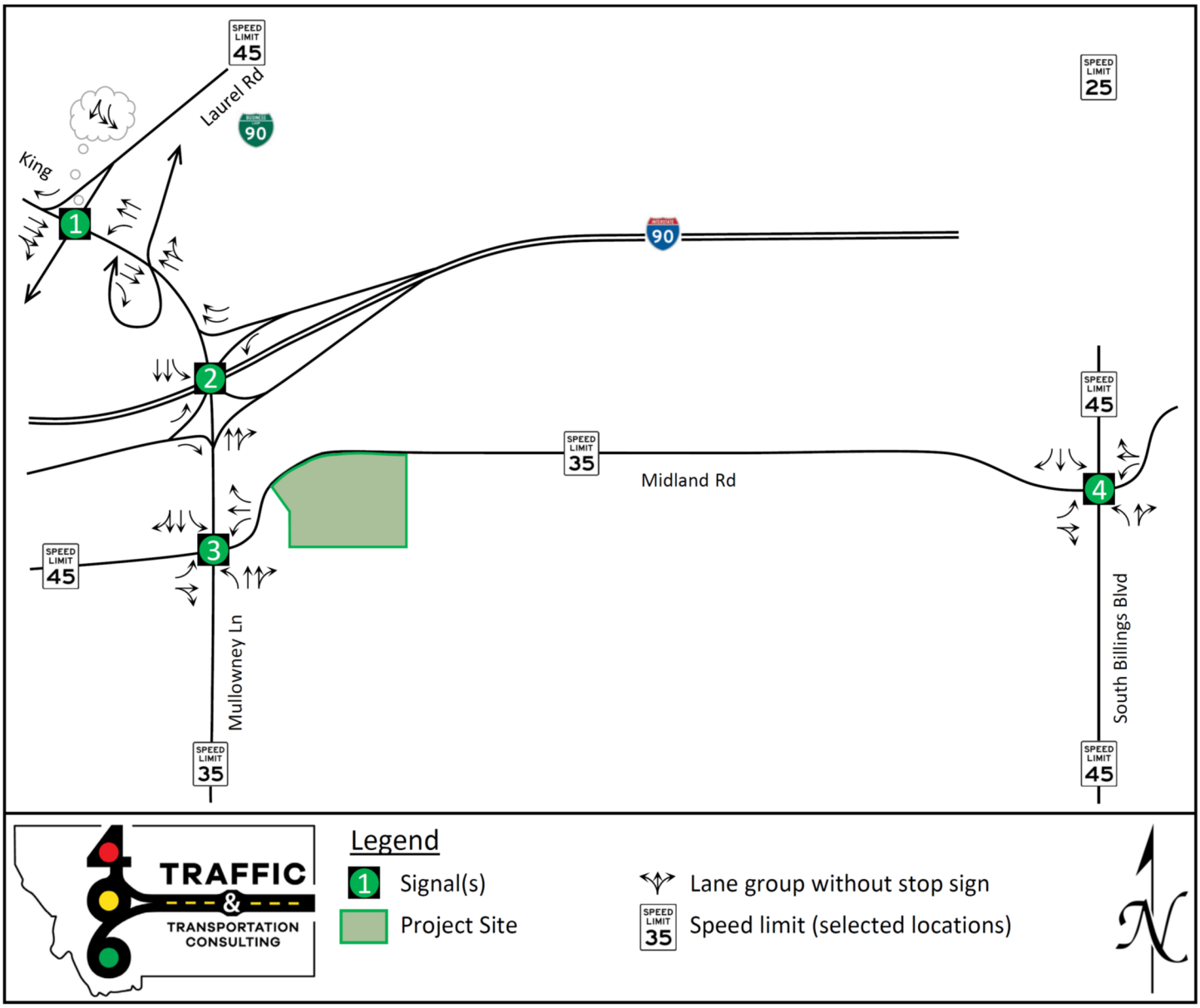
King Avenue is a northwest-southeast principal arterial in the study area with two through travel lanes northbound, two or three travel lanes southbound, and a speed limit of 35 mph. King Avenue's primary function in the study area is to connect ramps to and from both I-90 and Laurel Road to the major commercial corridor to the northwest. There is a sidewalk on the east (northeast) side of King in the study area.

Midland Road is an east-west Minor Arterial with one travel lane in each direction, a continuous center turn lane, and a speed limit of 35 mph. Midland connects a mix of low-density commercial and municipal uses to two of southern Billings' major north-south routes. Sidewalks run along both sides of the street between Mullowney and South Billings Boulevard. MET Transit runs its *Route 19 – Midtown* buses along Mullowney and Midland with hourly service on weekdays. In the study area, this route serves four fixed bus stop locations on Midland in each direction, with one of these near the proposed project's east access. East of South Billings Boulevard and west of Mullowney Lane, this facility is an MDT one simply signed as "Frontage Road", but those parts are only relevant in the context of intersection analysis, and so are not described separately here.

South Billings Boulevard is a north-south Principal Arterial with one travel lane in each direction approaching its Midland Road intersection and a speed limit of 45 mph. North of Midland it connects travelers to I-90 and the neighborhoods of south Billings. South of Midland it provides access to limited low-density commercial and municipal uses and crosses the Yellowstone River. South Billings Boulevard has a sidewalk along its west side south of the Midland intersection.

All four study existing intersections are signalized. **Exhibit 4** shows traffic control and lane arrangements schematically at each existing intersection, as well as posted speed limits on selected road segments.

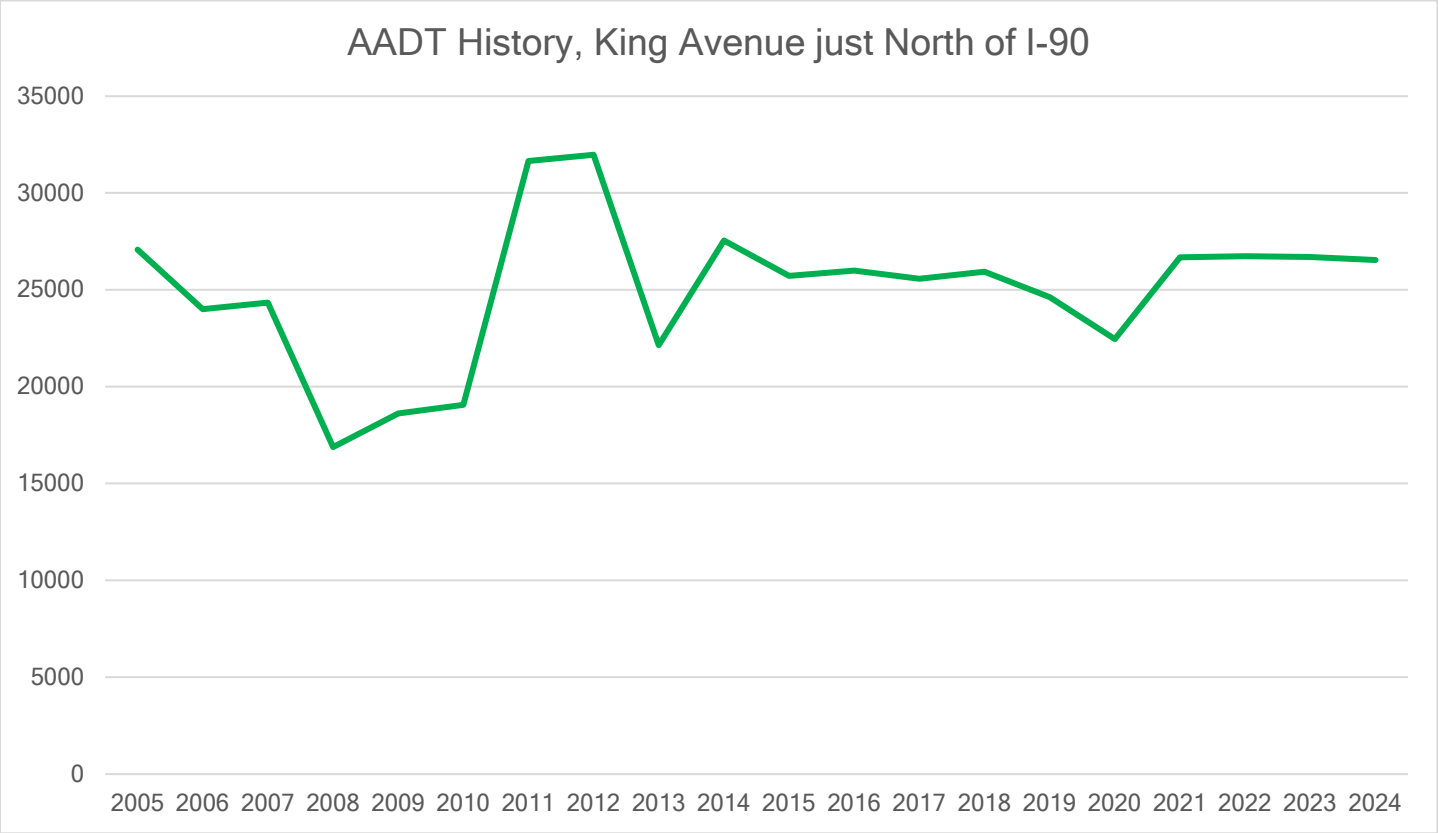
Exhibit 4. Existing Road and Intersection Basics



2.2 HISTORICAL TRAFFIC VOLUMES

Daily traffic information was gathered from the Montana Department of Transportation's (MDT) public-facing data resource, the Traffic Count Database System, which compiles data from thousands of counting stations across Montana. At these stations, the MDT either collects or estimates traffic counts from which annualized average daily traffic (AADT) is computed. For this report, AADT data from the counting station on Mullowney/King between I-90 and Laurel Road was used. Of the MDT count stations in the study area, this station's location would be used by the most project traffic. These data were examined over the past 20 years for a historical perspective. The historical AADT volumes are shown in **Exhibit 5**.

Exhibit 5. Historical Daily Traffic Volumes



The COVID-19 pandemic appears to have strongly influenced traffic volumes in 2020, but volume recovered quickly in the following year. Traffic volume on King has largely plateaued and even saw a slight decrease in 2024, unrelated to the pandemic. Based on the historical growth trend, it was assumed that there will be no growth in background traffic volumes between 2025 and this project's buildout year of 2028.

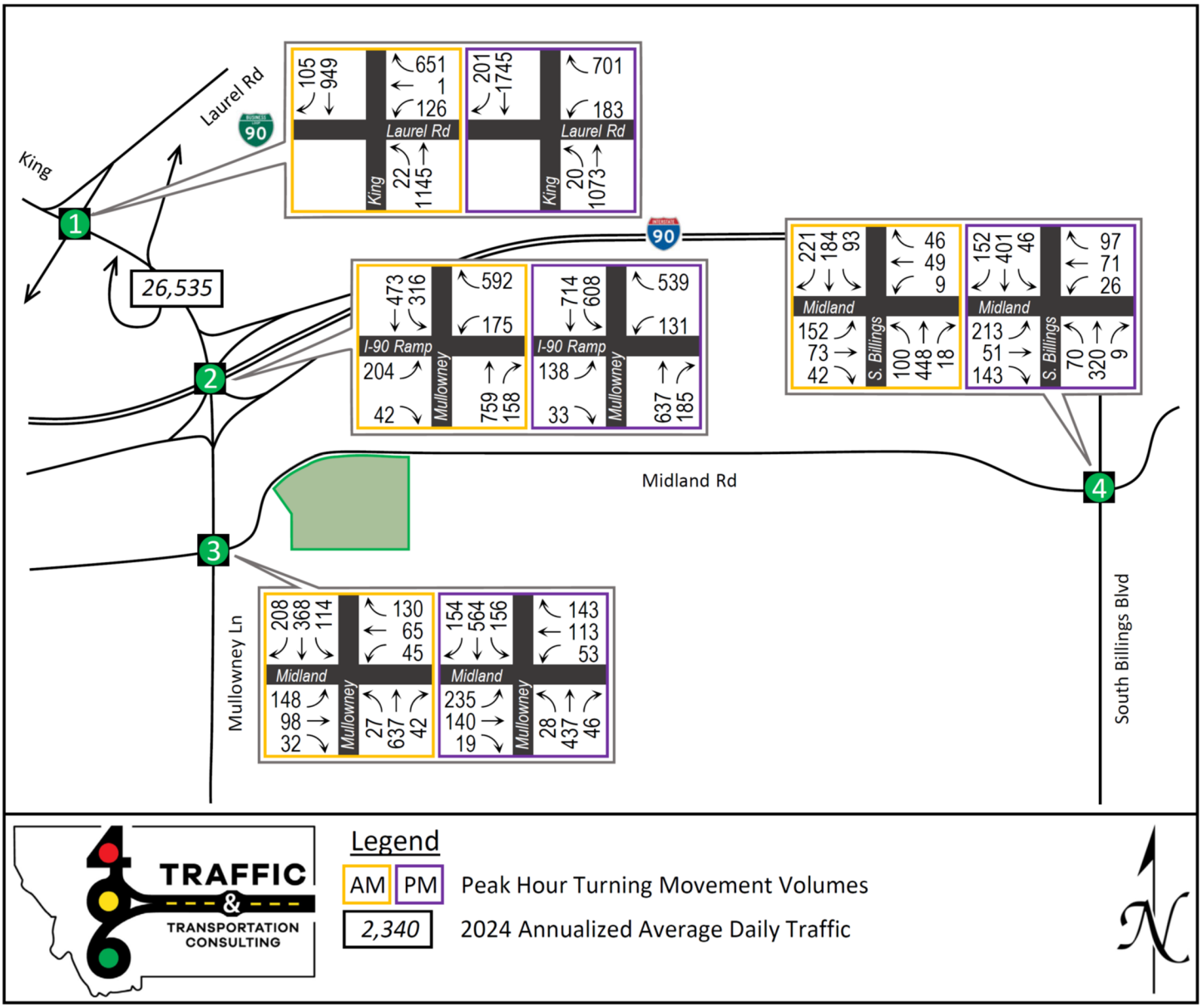
2.3 Recent Traffic Counts

Three of the four study intersections were studied between 4-6 p.m. and between 7-9 a.m. on November 3 and 4, 2025, respectively. At Intersection 1, Laurel Road at King, volumes were adapted from a TIS conducted in 2023 for a nearby site, provided by City of Billings staff. To estimate volumes there, peak-hour turning movement ratios from the previous study were applied to 2025 field volumes counted on the north leg at intersection 2. These volumes also reflect the ramps between Intersections 1 and 2 that send traffic on to Laurel Road.

All of the new counts were conducted using StreetLogic CountCam4 cameras, and they were summarized for analysis in 15-minute increments. Based on total entering volume (TEV), the study area's AM peak hour was identified from these counts as starting at 7:15 a.m. The PM peak hour was estimated to have started at 4:30 p.m. along Mullowney/King and at 4:45 at Intersection 4. The existing count information at each of the four existing study intersections is provided in **Appendix A**.

Counts at the four study intersections were adjusted for seasonal variation using the City's seasonal adjustment factors, or annualization factors, last updated in February 2025. These factors vary by month and day of the week, but not by functional classification as the MDT seasonal adjustment factors do. All of the raw counts were multiplied by Billings' annualization factor for a Tuesday or Wednesday in November, which is 1.01. Existing annualized traffic volumes based on the traffic counts are shown in **Exhibit 6**. Note that because traffic growth has been flat (zero) as documented in the previous subsection, these are also the Background scenario traffic volumes against which project traffic impacts were measured.

Exhibit 6. Existing (Background) Traffic Volumes



3 PROJECT TRIP GENERATION AND DISTRIBUTION

3.1 TRIP GENERATION

Trip generation rates, or equations as applicable, are from the Institute of Transportation Engineers (ITE) Trip Generation suite's 12th edition. ITE trip generation data, when aggregated across enough varied sites, produce both simple average rates and best-fit equations, either linear or logarithmic, to help the analyst derive proper estimates for their situation. Equations are generally preferred over rates, especially for larger sites where trip generation per unit of land use often diminishes with increasing project size.

The proposed grocery store, ITE 850, is a common use with solid data. The other co-anchor for the site, the indoor recreation center, is similar to the ITE land use Multipurpose Recreation Center (code 435). ITE's description indicates that based on the sites studied, a facility to which its rates can apply should contain at least two of the following six elements:

- Mini-golf
- Driving range
- Batting cages
- Video arcade
- Bumper boats
- Go-kart track

ITE also indicates that such facilities customarily have a snack bar or limited restaurant, and that the sites studied range in size from about 20,000 to 60,000 square feet. Such facilities typically attract scheduled family parties and co-worker events. While no specific tenant for this use has been revealed to the design team at the time of this TIS, the nature of the building and a potential model location in another state indicates that the recreation center will have a primary focus on a broad range of arcade, tavern-style, and prize games, with space expected to be dedicated to additional similar and more modern activities such as axe-throwing. A key feature of such facilities is that they are not open during the morning peak, and ITE does not have AM peak data for this land use.

Land use for the site's five outparcels was divided into three types. Because each of the five buildings would contain a wraparound drive-through element, two of them were assumed to have part of their space dedicated to coffee/donut shops (or similar) and the other three were assumed to be food establishments. Coffee/donut establishments could be those that are primarily for coffee, primarily for baked items, or something else such as specialty soda beverages. All of these were assumed to have the trip generation patterns covered by ITE land use 937. The restaurant uses are expected to be most consistent with ITE's description for 934 – Fast Food Restaurant with Drive-Through Window, though they will be smaller than most such sites included by ITE and more likely to be occupied by specialized tenants. Content/theme examples from potential model sites located elsewhere include sandwiches, pizza, and fried chicken.

After the coffee/donut and fast food uses associated with drive-through space, the remaining eight spaces with considerably less projected tenant information were grouped into a more standard retail/shopping center use. These tenants could include many types of small stores, service businesses (e.g., mobile phone, nail salon, or insurance office), and a small specialty restaurant, bakery, or coffee shop without a drive-through lane.

Three types of adjustments to trip generation were considered for this project, per guidance in ITE's Trip Generation Handbook. Each is described separately.

First, a discount is sometimes taken to reflect internal capture where multiple uses are present in a single project site. This discount reflects the tendency for a user to visit more than one part of the site in a single trip. Examples of this could include a patron of both a store and a restaurant located on the site, or an employee on one part of the site who commutes by car visiting a coffee shop on another part of the site on the way to or from their car. Due to both the large number of separate tenants on the site and the scarcity of similar commercial sites in this part of South Billings, the potential for internal capture is expected to be relatively high. An internal capture discount of 20% was applied for this project.

Second, a modal adjustment can be taken if a site is clearly served by robust high-capacity transit and one or more of its land uses by their nature serve a customer base inclined to use transit to get there, or if the potential land use mix and walk/bike network are likely to lead to nonmotorized trips, either internal or external. No modal discount was applied for the following three reasons: (a) no such transit network is present near this site, (b) facilities for nonmotorized access are limited in and around the study area are limited, and (c) few land uses such as offices and residences that would produce potential walk trips are close to the project site. The only prominent potential sources of such trips are lodging properties east and west of the site along Midland.

Finally, some land uses attract trips that were already using the adjacent or nearby road network by virtue of improved convenience over a similar site that could have been used before. These are called "pass-by" and "diverted-linked" trips. Pass-by trips are those on streets bordering the site, while diverted-linked trips are those that might go slightly out of their way to stop at the establishment on their way to their destination. ITE has compiled pass-by data from studies of over two dozen land uses. All but the Indoor Recreation Center have ITE pass-by data that yield average percentages used in this study. Diverted-linked trips were not estimated for

this study, in part because ITE has no studies of this type for the land uses proposed. Note that pass-by trips still turn into and out of the site driveways, but they are part of background traffic at other intersections. Pass-by reductions are applied after the internal capture discount mentioned above. **Exhibit 7** shows trip generation details for the project.

Exhibit 7. Trip Generation

	Daily	AM Peak Hour	PM Peak Hour
Multipurpose Recreational Facility – X = 45,000 square feet (45.0 ksf)			
ITE Land Use 435 rate:	T = 29.78 (X) [1]	N/A	T = 3.44 (X)
Peak hour in/out split			56% / 44%
Gross trips	1,310		151
Net after internal capture (20%)	1,048		121 68 in / 53 out)
Pass-by reduction (none)			
Net primary trips	1,048		121 (68 in / 53 out)
Strip Retail Plaza (under 40,000 square feet) – X = 16,100 square feet (16.1 ksf)			
ITE Land Use 822 rate:	T = 54.45 (X)	T = 3.93 (X)	T = 6.29 (X)
Peak hour in/out split		55% / 45%	50% / 50%
Gross trips	877	63	101
Net after internal capture (20%)	702	50 (28 in / 22 out)	81 (41 in / 40 out)
Pass-by reduction (40%)	- 281	- 20	- 32
Net primary trips	421	30 (17 in / 13 out)	49 (25 in / 24 out)
Supermarket – X = 44,000 square feet (44.0 ksf)			
ITE Land Use 850 rate:	T = 92.29 (X)	T = 2.95 (X)	T = 8.79 (X)
Peak hour in/out split		59% / 41%	50% / 50%
Gross trips	4,153	133	396
Net after internal capture (20%)	3,322	106 (63 in / 43 out)	317 (159 in / 158 out)
Pass-by reduction	- 797	- 27	- 76
Net primary trips	2,525	81 (47 in / 33 out)	241 (121 in / 120 out)
Fast-Food Restaurant with Drive-Through Window – X = 5,370 square feet (5.37 ksf)			
ITE Land Use 934 rate:	T = 467.48 (X)	T = 44.61 (X)	T = 33.03 (X)
Peak hour in/out split		51% / 49%	52% / 48%
Gross trips	2,511	240	177
Net after internal capture (20%)	2,009	192 (98 in / 94 out)	142 (74 in, 68 out)
Pass-by reduction (50%)	- 1004	- 96	- 71
Net primary trips	1005	96 (49 in / 47 out)	71 (37 in / 34 out)
Coffee/Donut Shop with Drive-Through Window – X = 3,560 square feet (3.56 ksf)			
ITE Land Use 937 rate:	T = 600.50 (X)	T = 85.41 (X)	T = 39.00 (X)
Peak hour in/out split		51% / 49%	50% / 50%
Gross trips	2,136	304	139
Net after internal capture (20%)	1,709	243 (124 in / 119 out)	111 (56 in / 55 out)
Pass-by reduction (82%)	- 1,401	- 199	- 91
Net primary trips	308	44 (22 in / 22 out)	20 (10 in / 10 out)
Net after internal capture, all uses[2]	**8,790**	**591 (313 in / 278 out)**	**772 (398 in / 374 out)**
Net primary trips, all uses[3]	**5,307**	**251 (136 in / 115 out)**	**502 (261 in / 241 out)**

Source: ITE Trip Generation, 12th Edition.

1. Daily rate, not present in ITE data, was assumed based on Daily-to-PM ratio for Strip Retail

2. Total project-generated traffic assigned at site driveway locations

3. Total project-generated traffic assigned at external street intersections

3.2 Trip Distribution and Assignment

Trip distribution was estimated for the streets surrounding the project site in percentages that add to 100%. Farther from the site, traffic eventually disperses in smaller percentages to/from other routes. Most project-generated traffic is expected to be oriented west of the site. Trip distribution and assignment percentages are shown in **Exhibit 8**. These percentages were assumed to be the same for all uses. Trips reflected as peak hour intersection and site driveway turning movement volumes and the daily link volume on King are shown in **Exhibit 9**, and the total volumes are shown in **Exhibit 10**.

Exhibit 8. Trip Distribution Percentages for Site Trips

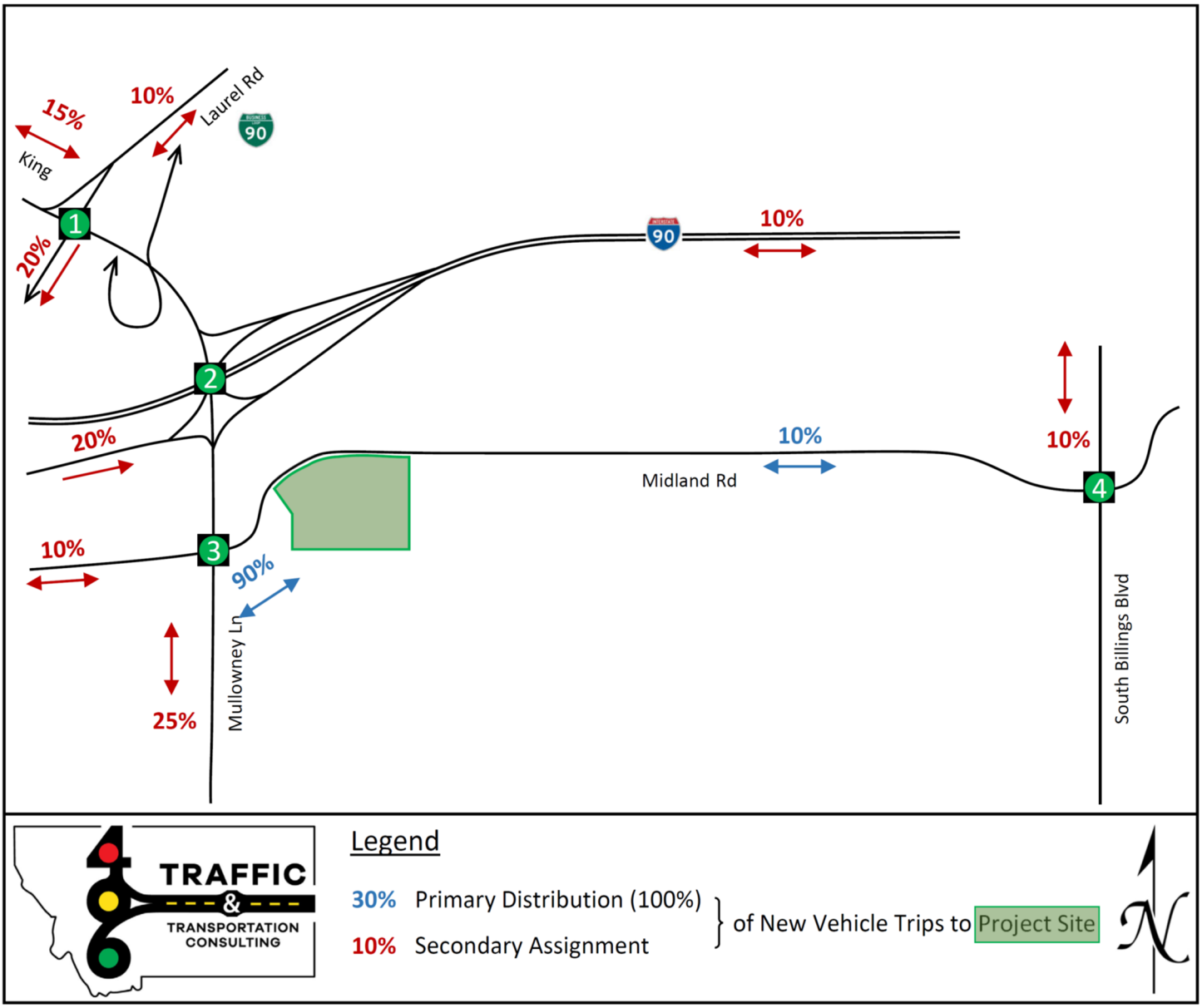


Exhibit 9. Assignment of Site Trips

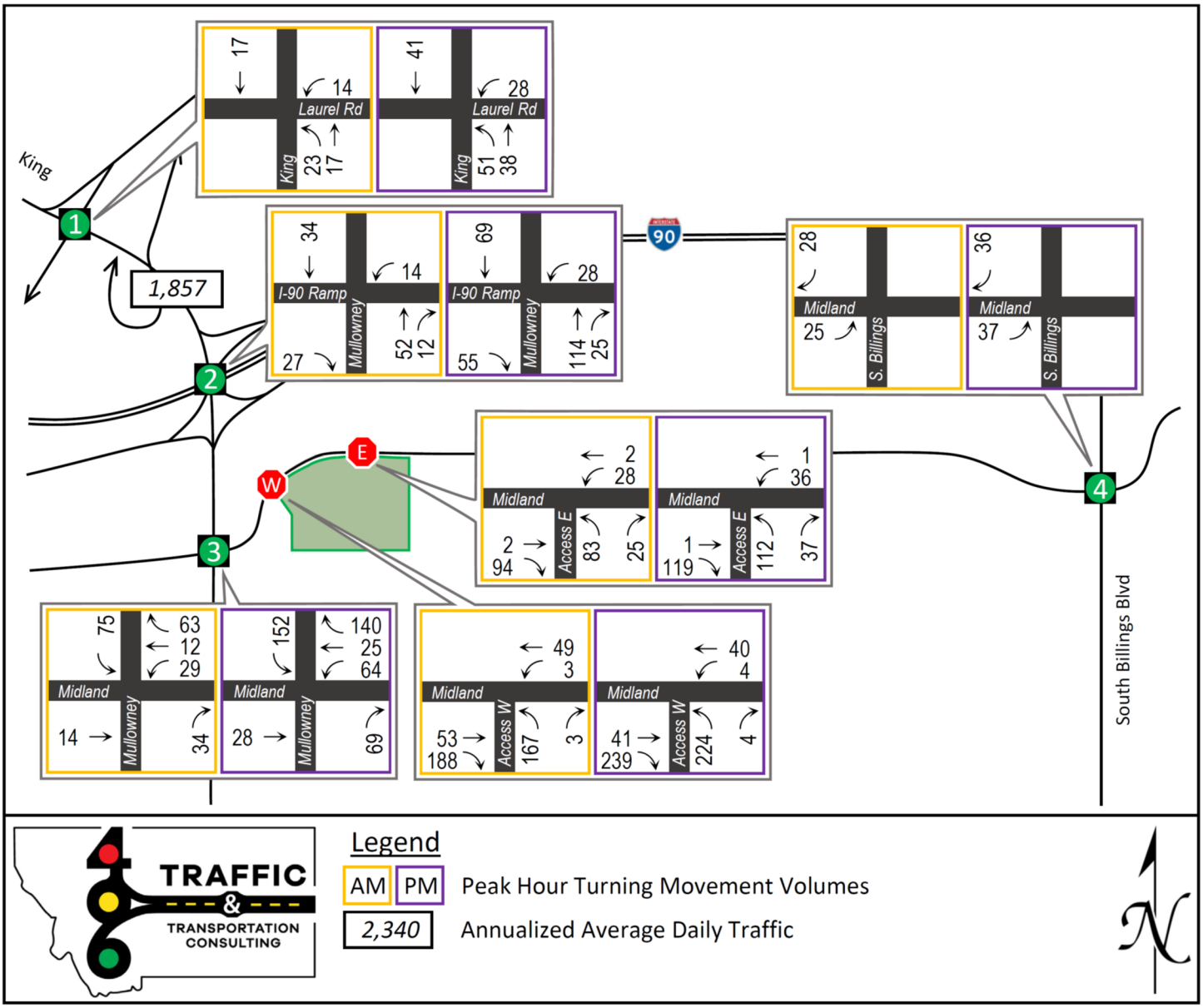
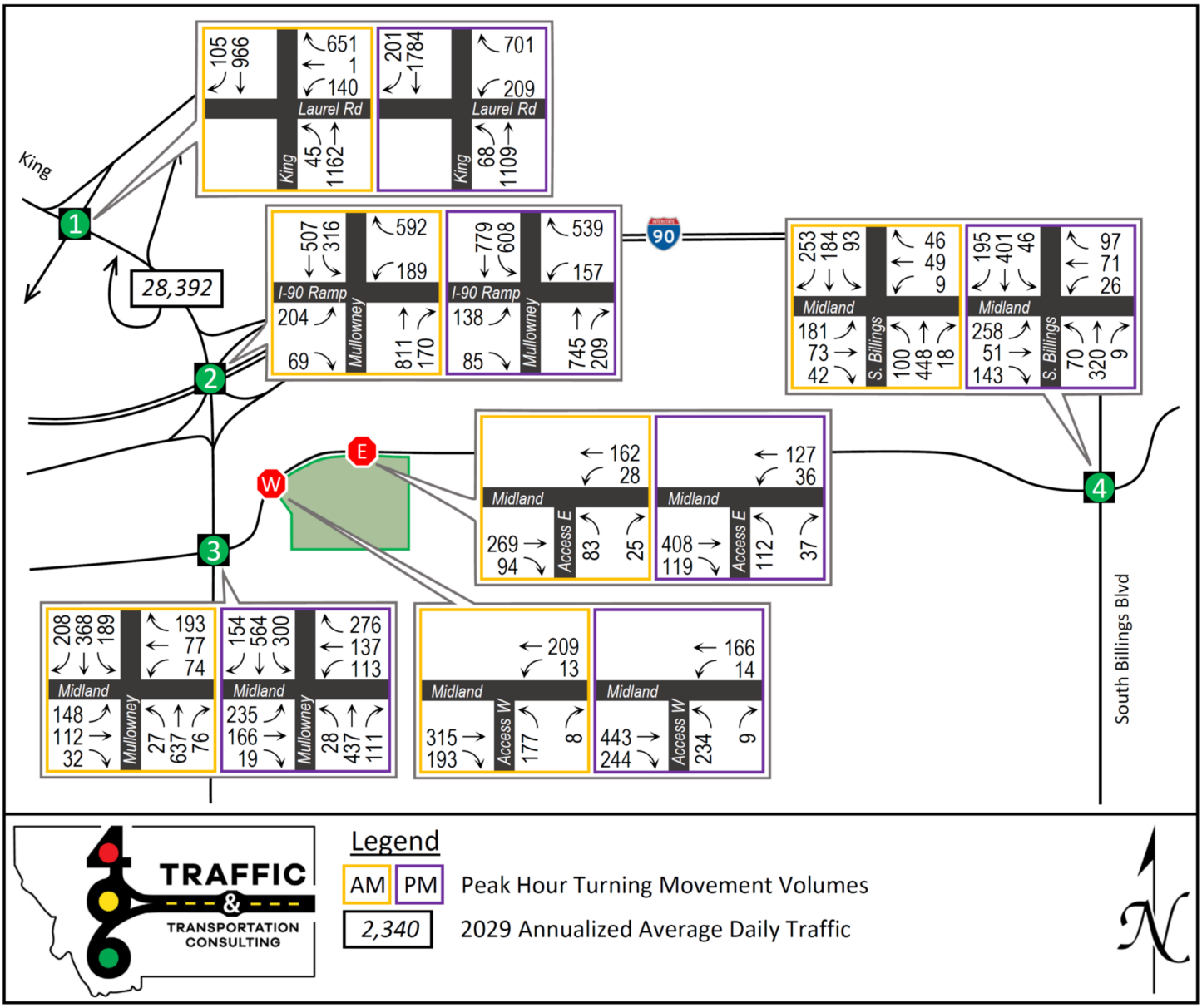


Exhibit 10. Total Traffic Volumes



4 CAPACITY ANALYSIS

4.1 INTERSECTIONS

The project driveways were not subject to analysis under the background condition because they handle only a very small amount of turning traffic for existing land uses. Peak hour volumes are low for two reasons: (a) the Trailhead Inn's other access to Midland Road is closer to the Mullowney intersection where the strong majority of traffic is oriented and (b) hotels and casinos tend to have low amounts of traffic spread throughout the day. The peak hour intersection Level of Service (LOS) and delay results with and without the project are shown in **Exhibit 11**. Analysis software results are provided in Appendix B.

Exhibit 11. Intersection LOS and Delay with and without the Project

	Intersection	Traffic Control	LOS (delay, in seconds/vehicle) Background	Total Traffic
AM Peak Hour	1. King at Laurel Road	Signal	A (3.7)	A (3.9)
	2. Mullowney at I-90 Ramps	Signal	C (28.0)	C (32.2)
	3. Mullowney at Midland	Signal	B (12.9)	B (14.7)
	4. South Billings Blvd at Midland	Signal	B (17.1)	B (17.9)
	5. West Site Driveway Access	TWSC*	N/A	C (22.2)*
	6. East Site Driveway Access	TWSC*	N/A	B (14.6)*
PM Peak Hour	1. King at Laurel Road	Signal	A (5.1)	A (5.6)
	2. Mullowney at I-90 Ramps	Signal	C (24.1)	C (30.8)
	3. Mullowney at Midland	Signal	B (17.6)	B (19.7)
	4. South Billings Blvd at Midland	Signal	B (19.7)	C (20.7)
	5. West Site Driveway Access	TWSC*	N/A	E (42.4)*
	6. East Site Driveway Access	TWSC*	N/A	C (19.0)*

* *TWSC LOS reported only for the worst lane group, which is the northbound (exit) left at both site driveways.*

All signalized intersections would operate at LOS C or better in both peaks with or without the project with the data and assumptions documented in this study. At the driveways only delay for the northbound approach is shown. The northbound King Avenue left turn at Intersection 1 (traffic getting on to I-90 westbound) would continue to operate at LOS A, with or without the project. The only LOS challenge for the study area is that with 90% of traffic leaving the site destined to the west on Midland, much of that traffic would turn left at the West Driveway, which results in sufficient delay for that one movement to exceed the LOS C standard in the PM peak hour. The movement would operate at LOS E, with Synchro reporting a 95th-percentile queue length of just under 6 vehicles (approximately 130-140 feet). This queue would extend back into the site but would not affect street operations and is not expected to affect internal site circulation for most of the peak hour. Analysis software results are provided in Appendix B. No impact mitigation is recommended at this time.

4.2 Drive-Through Lane Analysis

The drive-through lanes for the five outparcels were analyzed for queue storage sufficiency based on fundamental traffic flow principles, limited information from studies and inquiries at other restaurants and coffee shops, and field-based assumptions about vehicle mix and driver behavior.

Assumptions

Quantitative analysis of queuing relies on the assumption that arrivals are generally random. Average rates reflect the fact that despite the nearby signal on Midland leading to some potential platooning, traffic could arrive from any direction. The arrival and service rates for drive-through queue lane operation were gathered separately for the two outparcel uses (fast-food and coffee/donut shop), and an adjustment factor was applied to reflect that based on the example and model indicated by the applicant, the style of building proposed here, with multiple tenants, is not typically occupied by food/beverage companies with very high-volume drive-through activity. Arrival rates from the AM peak hour condition was used for this analysis because it has the higher traffic generation quantities for the food/beverage uses.

The service rate represents the amount of time spent at the pick-up window, which will also be used for in-person payments, and is also sometimes called the “window time.” An advance order menu board/microphone is expected be available on the east side of the buildings for drive-through patrons. Orders are also expected to be taken in advance via online/mobile apps. App-based pickup, through such services as DoorDash and Uber Eats, have not been directly predicted as a proportion of orders, but increasing use of such services in the restaurant/coffee shop industry, along with a strong trend of lower use of cash and physical card transactions, is believed to provide support for the use of a window time assumption of 2 minutes for food businesses and 0.8 minutes for the coffee/donut shop-based ones.

For storage capacity, the amount of space available for queued vehicles, including the one being served at the pick-up window, is estimated to be about 230 feet. This distance is measured along the center of the drive-through lane from (a) several feet ahead of the pick-up window location such that the driver is positioned at the window to (b) the beginning of the drive-through lane. Factors that govern how many vehicles fit in this space include vehicle mix (especially as it relates to light trucks), vehicle length, and separation of stopped vehicles in queue. Most passenger vehicles and pickup trucks are nominally 15-18 feet long, and bumper spacing for stopped vehicles in a drive-through lane is often in the 3- to 5-foot range (slightly shorter than for vehicles stopped in traffic). The analysis documented here is based on these assumptions, which indicate that 230 feet is enough space to store 12 vehicles. This assumption also accounts for the fact that the last vehicle in the queue doesn't need separation space behind it before encroaching on the crosswalk.

Finally, the definition of adequacy used here is a minimum probability of 95% that the vehicle queue, at any given time that peak-hour arrival rates exist, will fit within the available storage. In other words, the success threshold is when the probability of 12 or fewer vehicles being queued is 95% or greater.

Methodology

Foundational traffic flow theory has a well-developed set of mathematical relationships that allow the estimation of queue characteristics, similar to the estimation of average intersection delay. To apply these here, relevant information is adapted from the text *Traffic Flow Fundamentals* (Adolf D. May, Simon & Schuster, 1990), where Chapter 12, section 3 covers Stochastic Queuing Analysis.

In the context of queuing analysis, traffic intensity is directly analogous to the commonly computed parameter "volume/capacity ratio." This variable is assigned the letter ρ (rho), and it is the only one necessary, other than the number of vehicles that can fit in the space available, to analyze the drive-through lane in question. Importantly, as with arrivals, the service time for queued vehicles at the window can also be considered random for the purposes of this analysis. These rates in simple queueing are commonly assumed to follow a Poisson distribution, not a Normal distribution.

The applicable mathematical relationship here is the probability of a specific number of vehicles in queue (or fewer). The equation for this probability is:

$$P(n) = \rho^n(1 - \rho)$$

where $P(n)$ = probability of exactly n vehicles in the drive-through lane, and
ρ = traffic intensity (arrival rate/service rate)

The traffic intensity (ρ) value here is arrival rate divided by the service rate. The addition of successive probabilities for specific numbers of vehicles results in the cumulative probability that a queue will be equal to or less than the highest of those values at any given time.

Application

The results of the drive-through lane's relevant cumulative queue probability calculations are shown in **Exhibit 12**.

Exhibit 12. Drive-Through Queue Analysis

	Fast Food (ITE 934)		Coffee/Donut (ITE 937)	
ρ (arrival / service rate):	*22.1 vph / 30 vph = 0.74*		*58.1 vph / 75 vph = 0.78*	
Probability of *n* vehicles:	Exactly	At Least	Exactly	At Least
n = 0	26.3%	26.3%	22.5%	22.5%
n = 1	19.4%	45.7%	17.4%	39.9%
n = 2	14.3%	60.0%	13.5%	53.4%
n = 3	10.5%	70.5%	10.5%	63.9%
n = 4	7.8%	78.3%	8.1%	72.0%
n = 5	5.7%	84.0%	6.3%	78.3%
n = 6	4.2%	88.2%	4.9%	83.2%
n = 7	3.1%	91.3%	3.8%	87.0%
n = 8	2.3%	93.6%	2.9%	89.9%
n = 9	1.7%	**95.3%**	2.3%	92.2%
n = 10	1.2%	**96.5%**	1.8%	94.0%
n = 11	0.9%	**97.4%**	1.4%	**95.4%**
n = 12	0.7%	**98.1%**	1.1%	**96.5%**

The accepted design confidence level, or cumulative probability threshold, is 95%. For both types of land uses examined the expected traffic would be storable in the drive-through space available under the estimated peak traffic arrival rate at this confidence level.

5 COST PARTICIPATION

New project trips identified in this report are subject to examination under the City's cost participation program to the extent that they would travel through the two studied intersections on Midland. At Intersections 1 and 2, the need, scope, and timing of capacity improvements are controlled by MDT, so they are not covered here. Critical traffic shares that drive cost participation are subject to waiver if they fall below 2%. Right turns are not considered.

Exhibit 13 shows the incremental intersection cost participation for the new trips associated with each of the two project phases and the cost share calculation. As shown in the table, neither of the intersections examined would qualify for the "sub-2%" waiver.

Exhibit 13. Intersection Cost Participation

	Critical Volume %		
Intersection	**AM**	**PM**	**Highest**
3. Mullowney at Midland	9.8%	19.2%	19.2%
4. South Billings Blvd at Midland	2.1%	3.1%	3.1%
		Total:	**22.3%**
		x $450,000	**$100,350**

For both intersections, the PM peak hour critical-pair traffic volume would exceed that of the AM peak hour. The details of these cost calculations are provided in Appendix C.

This concludes the Trailhead Commercial Subdivision TIS.

Appendix A: Raw Traffic Count Data for Intersections

Project **Trailhead Commercial Subdivision**

Intersection **1. King Avenue at Laurel Road/I-90 Business WB**

AM Count **Adapted/Factored from adjacent intersection (see report text)**

PM Count **Adapted/Factored from adjacent intersection (see report text)**

	King Avenue Southbound				Laurel Road/Business 90 Westbound				King Avenue Northbound				N/A Eastbound			
Start Time	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U
7:15 AM	15	188		0	142	1	28			240	3	0				
7:30 AM	22	257		0	169	0	30			284	5	0				
7:45 AM	23	275		0	197	0	40			365	9	1				
8:00 AM	27	220		0	137	0	27			245	5	0				
4:30 PM	44	396		0	171	0	20			279	10	0				
4:45 PM	54	410		0	168	0	43			260	8	0				
5:00 PM	56	489		0	169	0	68			265	1	2				
5:15 PM	45	433		0	186	0	50			258	1	0				

Project **Trailhead Commercial Subdivision**

Intersection **2. King Avenue/Mullowney Lane at I-90 Ramps (SPUI)**

AM Count **November 4, 2025; 7-9 a.m.**

PM Count **November 3, 2025, 4-6 p.m.**

	King Avenue Southbound				I-90 Off Westbound				Mullowney Lane Northbound				I-90 Off Eastbound			
Start Time	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U
7:00 AM		74	57	0	88		32	0	31	136		0	10		35	
7:15 AM		98	75	0	141		42	0	48	171		0	12		44	
7:30 AM		130	78	1	147		48	0	36	207		0	4		54	
7:45 AM		138	83	0	179		55	0	44	203		0	19		57	
8:00 AM		102	77	0	119		28	0	28	170		0	7		47	
8:15 AM		112	87	0	99		31	0	37	111		0	8		39	
8:30 AM		104	67	0	107		24	0	15	130		0	5		27	
8:45 AM		99	67	0	93		16	0	27	116		0	10		35	
4:00 PM		145	148	0	113		27	1	30	165		0	6		38	
4:15 PM		151	144	1	119		24	0	26	140		0	11		36	
4:30 PM		167	139	0	123		28	0	48	180		0	12		37	
4:45 PM		194	142	0	130		31	0	51	137		0	8		32	
5:00 PM		173	165	0	143		37	0	47	165		0	4		40	
5:15 PM		173	156	0	138		34	0	37	149		0	9		28	
5:30 PM		169	116	0	116		29	0	25	120		0	6		46	
5:45 PM		122	107	0	118		31	0	20	110		0	4		47	

Project **Trailhead Commercial Subdivision**
Intersection **3. Mullowney Lane at Midland Road**
AM Count **November 4, 2025; 7-9 a.m.**
PM Count **November 3, 2025, 4-6 p.m.**

	Mullowney Lane Southbound				Midland Road Westbound				Mullowney Lane Northbound				Frontage Road Eastbound			
Start Time	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U
7:00 AM	27	73	16	0	24	18	10	0	9	131	8	0	2	12	12	0
7:15 AM	47	76	29	0	33	16	8	0	13	159	6	0	7	19	27	1
7:30 AM	59	98	25	0	32	22	13	0	8	179	10	0	10	19	32	0
7:45 AM	74	100	38	0	35	16	11	0	8	167	2	0	9	24	45	0
8:00 AM	26	90	21	0	29	10	13	0	13	126	9	0	6	35	43	0
8:15 AM	33	84	34	0	17	18	4	0	7	107	6	0	3	35	24	0
8:30 AM	45	62	26	0	25	16	7	0	11	93	4	0	3	14	27	0
8:45 AM	30	71	23	1	34	16	11	0	13	80	7	0	1	16	28	0
4:00 PM	26	109	42	1	34	17	9	0	19	116	8	0	6	31	44	0
4:15 PM	27	124	34	1	24	32	7	0	9	98	4	0	2	33	43	0
4:30 PM	35	136	35	1	44	29	12	0	18	119	11	0	5	32	64	0
4:45 PM	36	143	51	3	25	22	16	0	11	115	6	0	3	32	45	0
5:00 PM	47	130	36	1	45	33	11	0	9	96	6	0	6	41	70	0
5:15 PM	34	149	32	1	28	28	13	0	8	103	5	0	5	34	54	0
5:30 PM	29	152	22	1	25	16	12	0	7	87	5	0	5	18	32	0
5:45 PM	23	111	22	1	16	16	14	0	4	87	6	0	10	10	26	0

Project **Trailhead Commercial Subdivision**
Intersection **4. Midland Road at South Billings Boulevard**
Start Time **November 4, 2025; 7-9 a.m.**
Site Code **November 3, 2025, 4-6 p.m.**

	South Billings Blvd Southbound				Frontage Road Westbound				South Billings Blvd Northbound				Midland Road Eastbound			
Start Time	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U	Right	Thru	Left	U
7:00 AM	36	31	19	0	4	12	3	0	6	93	20	0	6	13	29	0
7:15 AM	44	34	31	1	16	17	2	0	5	117	26	0	8	18	36	0
7:30 AM	71	36	19	0	11	12	2	0	4	148	32	0	10	10	33	0
7:45 AM	74	53	25	0	9	11	2	0	5	102	30	0	11	17	42	0
8:00 AM	30	59	17	0	10	9	3	0	4	77	11	0	13	27	39	0
8:15 AM	29	73	20	0	14	10	3	0	5	52	13	0	14	21	36	0
8:30 AM	20	55	9	0	13	13	1	0	5	97	15	0	20	19	41	0
8:45 AM	36	54	11	0	17	18	3	0	4	101	26	1	14	9	38	0
4:00 PM	38	102	10	0	26	15	10	0	3	74	17	0	29	21	65	0
4:15 PM	39	85	12	1	22	16	6	0	2	88	12	0	29	28	60	0
4:30 PM	29	97	14	0	17	12	4	0	2	79	16	0	27	30	71	0
4:45 PM	42	90	14	0	18	20	6	0	4	79	12	0	37	17	54	0
5:00 PM	27	92	10	0	37	21	9	0	2	79	24	0	51	16	73	0
5:15 PM	44	109	12	0	31	17	9	0	1	90	22	0	30	7	51	0
5:30 PM	37	106	10	0	10	12	2	0	2	69	11	0	24	10	33	0
5:45 PM	23	86	8	0	10	5	2	0	2	50	14	0	15	5	30	0

Appendix B: Intersection Analysis Software Output

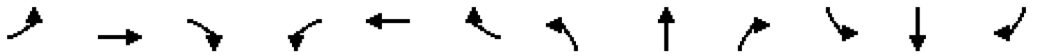
Scenario sequence:

Background AM

Background PM

Total Traffic AM

Total Traffic PM



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	126	1	0	22	1145	0	0	949	105
Future Volume (veh/h)	0	0	0	126	1	0	22	1145	0	0	949	105
Initial Q (Qb), veh				0	0	0	0	0	0	0	0	0
Lane Width Adj.				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)				1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach					No			No			No	
Adj Sat Flow, veh/h/ln				1709	1709	0	1709	1709	0	0	1709	1709
Adj Flow Rate, veh/h				155	0	0	27	1396	0	0	1157	128
Peak Hour Factor				0.82	0.82	0.82	0.82	0.82	0.82	0.92	0.82	0.82
Percent Heavy Veh, %				3	3	0	3	3	0	0	3	3
Cap, veh/h				244	128		399	2594	0	0	3405	377
Arrive On Green				0.08	0.00	0.00	1.00	1.00	0.00	0.00	0.80	0.80
Sat Flow, veh/h				3255	1709	0	427	3333	0	0	4417	471
Grp Volume(v), veh/h				155	0	0	27	1396	0	0	844	441
Grp Sat Flow(s),veh/h/ln				1628	1709	0	427	1624	0	0	1555	1624
Q Serve(g_s), s				3.7	0.0	0.0	0.5	0.0	0.0	0.0	6.0	6.0
Cycle Q Clear(g_c), s				3.7	0.0	0.0	6.5	0.0	0.0	0.0	6.0	6.0
Prop In Lane				1.00		0.00	1.00		0.00	0.00		0.29
Lane Grp Cap(c), veh/h				244	128		399	2594	0	0	2484	1297
V/C Ratio(X)				0.63	0.00		0.07	0.54	0.00	0.00	0.34	0.34
Avail Cap(c_a), veh/h				1420	746		399	2594	0	0	2484	1297
HCM Platoon Ratio				1.00	1.00	1.00	1.33	1.33	1.00	1.00	1.00	1.00
Upstream Filter(I)				1.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00
Uniform Delay (d), s/veh				35.9	0.0	0.0	0.3	0.0	0.0	0.0	2.2	2.2
Incr Delay (d2), s/veh				2.7	0.0	0.0	0.3	0.8	0.0	0.0	0.4	0.7
Initial Q Delay(d3), s/veh				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln				1.5	0.0	0.0	0.0	0.3	0.0	0.0	0.9	1.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh				38.7	0.0	0.0	0.6	0.8	0.0	0.0	2.6	2.9
LnGrp LOS				D			A	A			A	A
Approach Vol, veh/h					155			1423			1285	
Approach Delay, s/veh					38.7			0.8			2.7	
Approach LOS					D			A			A	

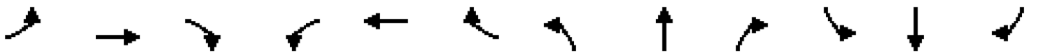
Timer - Assigned Phs	2			6		8						
Phs Duration (G+Y+Rc), s	68.9			68.9		11.1						
Change Period (Y+Rc), s	5.0			5.0		5.1						
Max Green Setting (Gmax), s	35.0			35.0		34.9						
Max Q Clear Time (g_c+I1), s	8.5			8.0		5.7						
Green Ext Time (p_c), s	12.6			10.0		0.5						

Intersection Summary		
HCM 7th Control Delay, s/veh	3.7	
HCM 7th LOS	A	

Notes

User approved volume balancing among the lanes for turning movement.

Unsignalized Delay for [WBR] is excluded from calculations of the approach delay and intersection delay.



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	204	0	0	175	0	592	0	759	0	316	473	0
Future Volume (vph)	204	0	0	175	0	592	0	759	0	316	473	0
Ideal Flow (vphpl)	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Storage Length (ft)	0		0	300		0	0		0	550		0
Storage Lanes	1		0	1		2	0		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1583	0	0	1599	0	2517	0	3228	0	1614	3228	0
Flt Permitted	0.950			0.950						0.138		
Satd. Flow (perm)	1583	0	0	1599	0	2517	0	3228	0	234	3228	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						426						
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		500			500			550			656	
Travel Time (s)		9.7			9.7			10.7			12.8	
Peak Hour Factor	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Heavy Vehicles (%)	5%	2%	2%	4%	2%	4%	2%	3%	2%	3%	3%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	234	0	0	201	0	680	0	872	0	363	544	0
Turn Type	Prot			Prot		Over		NA		pm+pt	NA	
Protected Phases	7			3		1		2		1	6	
Permitted Phases										6		
Detector Phase	7			3		1		2		1	6	
Switch Phase												
Minimum Initial (s)	5.0			5.0		5.0		5.0		5.0	5.0	
Minimum Split (s)	14.6			14.6		10.7		23.7		10.7	23.7	
Total Split (s)	35.0			35.0		20.0		25.0		20.0	45.0	
Total Split (%)	43.8%			43.8%		25.0%		31.3%		25.0%	56.3%	
Maximum Green (s)	25.4			25.4		14.4		19.4		14.4	39.4	
Yellow Time (s)	3.6			3.6		3.6		3.6		3.6	3.6	
All-Red Time (s)	6.0			6.0		2.0		2.0		2.0	2.0	
Lost Time Adjust (s)	0.0			0.0		0.0		0.0		0.0	0.0	
Total Lost Time (s)	9.6			9.6		5.6		5.6		5.6	5.6	
Lead/Lag						Lead		Lag		Lead		
Lead-Lag Optimize?						Yes		Yes		Yes		
Vehicle Extension (s)	3.0			3.0		3.0		3.0		3.0	3.0	
Recall Mode	None			None		None		C-Max		None	C-Max	
Walk Time (s)								7.0			7.0	
Flash Don't Walk (s)								11.0			11.0	
Pedestrian Calls (#/hr)								0			0	
Act Effct Green (s)	17.1			17.1		18.8		23.3		47.7	47.7	
Actuated g/C Ratio	0.21			0.21		0.24		0.29		0.60	0.60	
v/c Ratio	0.69			0.59		0.74		0.93		0.78	0.28	
Control Delay (s/veh)	39.4			34.7		16.2		43.0		29.5	10.1	
Queue Delay	0.0			0.0		0.0		0.0		0.0	0.0	
Total Delay (s/veh)	39.4			34.7		16.2		43.0		29.5	10.1	
LOS	D			C		B		D		C	B	
Approach Delay (s/veh)		39.4			20.4			43.0			17.8	
Approach LOS		D			C			D			B	

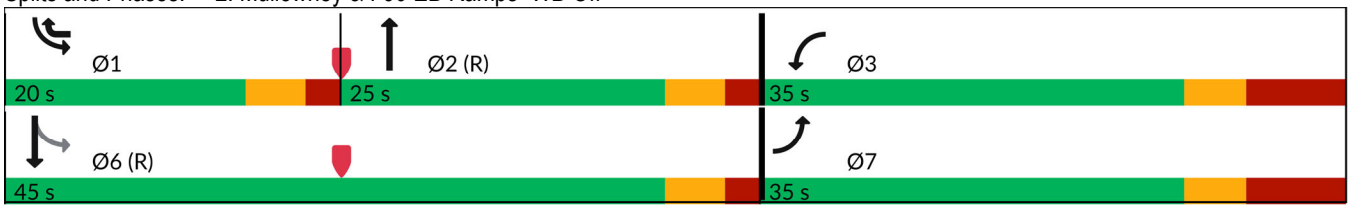
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Length 50th (ft)	109			91		57		~271		121	73	
Queue Length 95th (ft)	158			136		127		#348		#280	128	
Internal Link Dist (ft)		420			420			470			576	
Turn Bay Length (ft)				300						550		
Base Capacity (vph)	502			507		918		939		464	1926	
Starvation Cap Reductn	0			0		0		0		0	0	
Spillback Cap Reductn	0			0		0		0		0	0	
Storage Cap Reductn	0			0		0		0		0	0	
Reduced v/c Ratio	0.47			0.40		0.74		0.93		0.78	0.28	

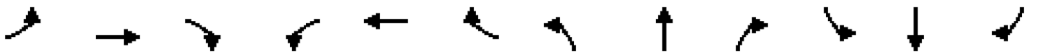
Intersection Summary			
Area Type:	Other		
Cycle Length: 80			
Actuated Cycle Length: 80			
Offset: 3 (4%), Referenced to phase 2:NBT and 6:SBTL, Start of Green			
Natural Cycle: 90			
Control Type: Actuated-Coordinated			
Maximum v/c Ratio: 0.93			
Intersection Signal Delay (s/veh): 28.0		Intersection LOS: C	
Intersection Capacity Utilization 71.4%		ICU Level of Service C	
Analysis Period (min) 15			

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 2: Mullowney & I-90 EB Ramps+WB Off

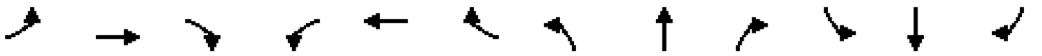




Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	148	98	32	45	65	130	27	637	42	114	368	208
Future Volume (veh/h)	148	98	32	45	65	130	27	637	42	114	368	208
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1641	1641	1641	1668	1668	1668	1723	1723	1723	1709	1709	1709
Adj Flow Rate, veh/h	164	109	36	50	72	144	30	708	47	127	409	231
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	8	8	8	6	6	6	2	2	2	3	3	3
Cap, veh/h	293	257	85	257	364	308	525	1719	114	481	1317	736
Arrive On Green	0.22	0.22	0.22	0.22	0.22	0.22	0.55	0.55	0.55	0.12	1.00	1.00
Sat Flow, veh/h	1110	1181	390	1204	1668	1414	789	3115	207	1628	2009	1122
Grp Volume(v), veh/h	164	0	145	50	72	144	30	372	383	127	330	310
Grp Sat Flow(s),veh/h/ln	1110	0	1571	1204	1668	1414	789	1637	1685	1628	1624	1507
Q Serve(g_s), s	11.3	0.0	6.4	3.0	2.8	7.1	1.4	10.5	10.5	2.5	0.0	0.0
Cycle Q Clear(g_c), s	14.2	0.0	6.4	9.3	2.8	7.1	1.4	10.5	10.5	2.5	0.0	0.0
Prop In Lane	1.00		0.25	1.00		1.00	1.00		0.12	1.00		0.74
Lane Grp Cap(c), veh/h	293	0	342	257	364	308	525	903	930	481	1065	988
V/C Ratio(X)	0.56	0.00	0.42	0.19	0.20	0.47	0.06	0.41	0.41	0.26	0.31	0.31
Avail Cap(c_a), veh/h	535	0	685	519	728	617	525	903	930	617	1065	988
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.94	0.94
Uniform Delay (d), s/veh	31.3	0.0	26.9	31.0	25.6	27.2	8.3	10.4	10.4	6.5	0.0	0.0
Incr Delay (d2), s/veh	1.7	0.0	0.8	0.4	0.3	1.1	0.2	1.4	1.3	0.3	0.7	0.8
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	2.9	0.0	2.3	0.9	1.1	2.4	0.2	3.6	3.7	0.7	0.2	0.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	33.0	0.0	27.8	31.3	25.8	28.3	8.6	11.8	11.7	6.8	0.7	0.8
LnGrp LOS	C		C	C	C	C	A	B	B	A	A	A
Approach Vol, veh/h		309			266			785			767	
Approach Delay, s/veh		30.6			28.2			11.6			1.7	
Approach LOS		C			C			B			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	8.3	49.2		22.5		57.5		22.5				
Change Period (Y+Rc), s	3.6	5.0		5.1		5.0		5.1				
Max Green Setting (Gmax), s	11.4	20.0		34.9		35.0		34.9				
Max Q Clear Time (g_c+I1), s	4.5	12.5		16.2		2.0		11.3				
Green Ext Time (p_c), s	0.2	2.8		1.3		4.4		1.0				

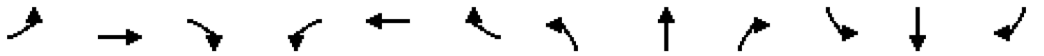
Intersection Summary												
HCM 7th Control Delay, s/veh			12.9									
HCM 7th LOS			B									



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	152	73	42	9	49	46	100	448	18	93	184	221
Future Volume (veh/h)	152	73	42	9	49	46	100	448	18	93	184	221
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1559	1559	1559	1532	1532	1532	1695	1695	1695	1668	1668	1668
Adj Flow Rate, veh/h	165	79	46	10	53	50	109	487	20	101	200	240
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	14	14	14	16	16	16	4	4	4	6	6	6
Cap, veh/h	294	217	126	274	170	160	552	800	33	418	1024	868
Arrive On Green	0.23	0.23	0.23	0.23	0.23	0.23	0.49	0.49	0.49	0.06	0.61	0.61
Sat Flow, veh/h	1169	924	538	1125	725	684	934	1617	66	1589	1668	1414
Grp Volume(v), veh/h	165	0	125	10	0	103	109	0	507	101	200	240
Grp Sat Flow(s),veh/h/ln	1169	0	1462	1125	0	1409	934	0	1683	1589	1668	1414
Q Serve(g_s), s	10.9	0.0	5.7	0.6	0.0	4.8	5.3	0.0	17.4	2.3	4.2	6.3
Cycle Q Clear(g_c), s	15.7	0.0	5.7	6.3	0.0	4.8	5.3	0.0	17.4	2.3	4.2	6.3
Prop In Lane	1.00		0.37	1.00		0.49	1.00		0.04	1.00		1.00
Lane Grp Cap(c), veh/h	294	0	343	274	0	331	552	0	832	418	1024	868
V/C Ratio(X)	0.56	0.00	0.36	0.04	0.00	0.31	0.20	0.00	0.61	0.24	0.20	0.28
Avail Cap(c_a), veh/h	510	0	614	482	0	592	552	0	832	526	1024	868
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	31.8	0.0	25.6	28.3	0.0	25.3	11.6	0.0	14.6	10.4	6.8	7.2
Incr Delay (d2), s/veh	1.7	0.0	0.6	0.1	0.0	0.5	0.8	0.0	3.3	0.3	0.4	0.8
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	3.0	0.0	1.9	0.2	0.0	1.5	1.1	0.0	6.3	0.7	1.3	1.6
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	33.4	0.0	26.3	28.3	0.0	25.8	12.4	0.0	17.9	10.7	7.2	8.0
LnGrp LOS	C		C	C		C	B		B	B	A	A
Approach Vol, veh/h		290			113			616			541	
Approach Delay, s/veh		30.3			26.0			17.0			8.2	
Approach LOS		C			C			B			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	9.6	45.3		25.2		54.8		25.2				
Change Period (Y+Rc), s	5.1	5.7		6.4		5.7		6.4				
Max Green Setting (Gmax), s	9.9	19.3		33.6		34.3		33.6				
Max Q Clear Time (g_c+I1), s	4.3	19.4		17.7		8.3		8.3				
Green Ext Time (p_c), s	0.1	0.0		1.1		1.8		0.5				

Intersection Summary												
HCM 7th Control Delay, s/veh			17.1									
HCM 7th LOS			B									



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	183	0	0	20	1073	0	0	1745	201
Future Volume (veh/h)	0	0	0	183	0	0	20	1073	0	0	1745	201
Initial Q (Qb), veh				0	0	0	0	0	0	0	0	0
Lane Width Adj.				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)				1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach					No			No			No	
Adj Sat Flow, veh/h/ln				1736	1736	0	1736	1736	0	0	1736	1736
Adj Flow Rate, veh/h				197	0	0	22	1154	0	0	1876	216
Peak Hour Factor				0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.93	0.93
Percent Heavy Veh, %				1	1	0	1	1	0	0	1	1
Cap, veh/h				297	156		212	2587	0	0	3383	387
Arrive On Green				0.09	0.00	0.00	1.00	1.00	0.00	0.00	0.78	0.78
Sat Flow, veh/h				3307	1736	0	198	3386	0	0	4471	493
Grp Volume(v), veh/h				197	0	0	22	1154	0	0	1371	721
Grp Sat Flow(s),veh/h/ln				1654	1736	0	198	1650	0	0	1580	1648
Q Serve(g_s), s				4.6	0.0	0.0	2.2	0.0	0.0	0.0	13.2	13.5
Cycle Q Clear(g_c), s				4.6	0.0	0.0	15.7	0.0	0.0	0.0	13.2	13.5
Prop In Lane				1.00		0.00	1.00		0.00	0.00		0.30
Lane Grp Cap(c), veh/h				297	156		212	2587	0	0	2478	1292
V/C Ratio(X)				0.66	0.00		0.10	0.45	0.00	0.00	0.55	0.56
Avail Cap(c_a), veh/h				1443	757		212	2587	0	0	2478	1292
HCM Platoon Ratio				1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00
Upstream Filter(I)				1.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00
Uniform Delay (d), s/veh				35.2	0.0	0.0	1.7	0.0	0.0	0.0	3.3	3.3
Incr Delay (d2), s/veh				2.6	0.0	0.0	1.0	0.6	0.0	0.0	0.9	1.7
Initial Q Delay(d3), s/veh				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln				1.9	0.0	0.0	0.1	0.2	0.0	0.0	2.3	2.8
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh				37.8	0.0	0.0	2.7	0.6	0.0	0.0	4.2	5.1
LnGrp LOS				D			A	A			A	A
Approach Vol, veh/h					197			1176			2092	
Approach Delay, s/veh					37.8			0.6			4.5	
Approach LOS					D			A			A	

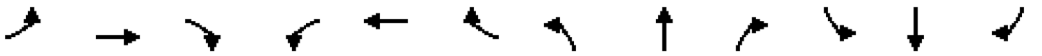
Timer - Assigned Phs	2			6		8						
Phs Duration (G+Y+Rc), s	67.7			67.7		12.3						
Change Period (Y+Rc), s	5.0			5.0		5.1						
Max Green Setting (Gmax), s	35.0			35.0		34.9						
Max Q Clear Time (g_c+I1), s	17.7			15.5		6.6						
Green Ext Time (p_c), s	8.4			14.4		0.7						

Intersection Summary		
HCM 7th Control Delay, s/veh	5.1	
HCM 7th LOS	A	

Notes

User approved volume balancing among the lanes for turning movement.

Unsignalized Delay for [WBR] is excluded from calculations of the approach delay and intersection delay.

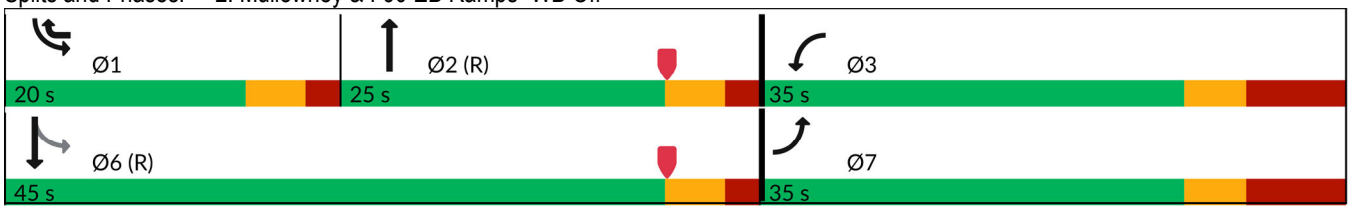


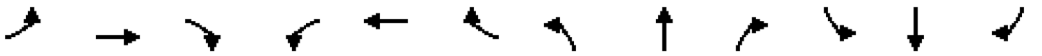
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	138	0	0	131	0	539	0	637	0	608	714	0
Future Volume (vph)	138	0	0	131	0	539	0	637	0	608	714	0
Ideal Flow (vphpl)	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Storage Length (ft)	0		0	300		0	0		0	550		0
Storage Lanes	1		0	1		2	0		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1583	0	0	1599	0	2517	0	3292	0	1646	3292	0
Flt Permitted	0.950			0.950						0.166		
Satd. Flow (perm)	1583	0	0	1599	0	2517	0	3292	0	288	3292	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						561						
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		500			500			550			656	
Travel Time (s)		9.7			9.7			10.7			12.8	
Peak Hour Factor	0.96	0.92	0.92	0.96	0.92	0.96	0.92	0.96	0.92	0.96	0.96	0.92
Heavy Vehicles (%)	5%	2%	2%	4%	2%	4%	2%	1%	2%	1%	1%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	144	0	0	136	0	561	0	664	0	633	744	0
Turn Type	Prot			Prot		Over		NA		pm+pt	NA	
Protected Phases	7			3		1		2		1	6	
Permitted Phases										6		
Detector Phase	7			3		1		2		1	6	
Switch Phase												
Minimum Initial (s)	5.0			5.0		5.0		5.0		5.0	5.0	
Minimum Split (s)	14.6			27.6		10.7		25.0		10.7	25.0	
Total Split (s)	35.0			35.0		20.0		25.0		20.0	45.0	
Total Split (%)	43.8%			43.8%		25.0%		31.3%		25.0%	56.3%	
Maximum Green (s)	25.4			25.4		14.4		19.4		14.4	39.4	
Yellow Time (s)	3.6			3.6		3.6		3.6		3.6	3.6	
All-Red Time (s)	6.0			6.0		2.0		2.0		2.0	2.0	
Lost Time Adjust (s)	0.0			0.0		0.0		0.0		0.0	0.0	
Total Lost Time (s)	9.6			9.6		5.6		5.6		5.6	5.6	
Lead/Lag						Lead		Lag		Lead		
Lead-Lag Optimize?						Yes		Yes		Yes		
Vehicle Extension (s)	3.0			3.0		3.0		3.0		3.0	3.0	
Recall Mode	None			None		None		C-Max		None	C-Max	
Walk Time (s)				7.0				7.0			7.0	
Flash Don't Walk (s)				11.0				11.0			11.0	
Pedestrian Calls (#/hr)				0				0			0	
Act Effct Green (s)	12.6			12.6		27.2		19.4		52.2	52.2	
Actuated g/C Ratio	0.16			0.16		0.34		0.24		0.65	0.65	
v/c Ratio	0.58			0.54		0.46		0.83		0.98	0.35	
Control Delay (s/veh)	39.8			38.3		3.5		32.8		46.9	7.0	
Queue Delay	0.0			0.0		0.0		0.0		0.0	0.0	
Total Delay (s/veh)	39.8			38.3		3.5		32.8		46.9	7.0	
LOS	D			D		A		C		D	A	
Approach Delay (s/veh)		39.8			10.3			32.8			25.3	
Approach LOS		D			B			C			C	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Length 50th (ft)	68			63		0		175		260	104	
Queue Length 95th (ft)	115			110		39		#258		#539	136	
Internal Link Dist (ft)		420			420			470			576	
Turn Bay Length (ft)				300						550		
Base Capacity (vph)	502			507		1226		798		649	2148	
Starvation Cap Reductn	0			0		0		0		0	0	
Spillback Cap Reductn	0			0		0		0		0	0	
Storage Cap Reductn	0			0		0		0		0	0	
Reduced v/c Ratio	0.29			0.27		0.46		0.83		0.98	0.35	

Intersection Summary			
Area Type:	Other		
Cycle Length: 80			
Actuated Cycle Length: 80			
Offset: 26.4 (33%), Referenced to phase 2:NBT and 6:SBTL, Start of Yellow			
Natural Cycle: 90			
Control Type: Actuated-Coordinated			
Maximum v/c Ratio: 0.98			
Intersection Signal Delay (s/veh): 24.1		Intersection LOS: C	
Intersection Capacity Utilization 81.3%		ICU Level of Service D	
Analysis Period (min) 15			
# 95th percentile volume exceeds capacity, queue may be longer.			
Queue shown is maximum after two cycles.			

Splits and Phases: 2: Mullowney & I-90 EB Ramps+WB Off





Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	235	140	19	53	113	143	28	437	46	156	564	154
Future Volume (veh/h)	235	140	19	53	113	143	28	437	46	156	564	154
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1682	1682	1682	1709	1709	1709	1750	1750	1750	1709	1709	1709
Adj Flow Rate, veh/h	245	146	20	55	118	149	29	455	48	162	588	160
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	5	5	5	3	3	3	0	0	0	3	3	3
Cap, veh/h	371	449	62	372	530	449	271	759	80	580	1422	386
Arrive On Green	0.31	0.31	0.31	0.31	0.31	0.31	0.25	0.25	0.25	0.50	1.00	1.00
Sat Flow, veh/h	1086	1448	198	1210	1709	1448	725	3036	319	1628	2524	685
Grp Volume(v), veh/h	245	0	166	55	118	149	29	248	255	162	378	370
Grp Sat Flow(s),veh/h/ln	1086	0	1646	1210	1709	1448	725	1663	1693	1628	1624	1586
Q Serve(g_s), s	17.3	0.0	6.2	2.9	4.1	6.3	2.5	10.5	10.6	0.0	0.0	0.0
Cycle Q Clear(g_c), s	21.4	0.0	6.2	9.1	4.1	6.3	2.5	10.5	10.6	0.0	0.0	0.0
Prop In Lane	1.00		0.12	1.00		1.00	1.00		0.19	1.00		0.43
Lane Grp Cap(c), veh/h	371	0	511	372	530	449	271	416	423	580	915	894
V/C Ratio(X)	0.66	0.00	0.33	0.15	0.22	0.33	0.11	0.60	0.60	0.28	0.41	0.41
Avail Cap(c_a), veh/h	508	0	718	524	746	632	271	416	423	580	915	894
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.93	0.93
Uniform Delay (d), s/veh	28.4	0.0	21.2	24.7	20.4	21.2	23.4	26.5	26.5	13.1	0.0	0.0
Incr Delay (d2), s/veh	2.0	0.0	0.4	0.2	0.2	0.4	0.8	6.2	6.2	0.2	1.3	1.3
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	4.3	0.0	2.2	0.8	1.6	2.1	0.5	4.7	4.8	1.4	0.3	0.3
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	30.4	0.0	21.5	24.8	20.7	21.6	24.2	32.7	32.7	13.3	1.3	1.3
LnGrp LOS	C		C	C	C	C	C	C	C	B	A	A
Approach Vol, veh/h		411			322			532			910	
Approach Delay, s/veh		26.8			21.8			32.2			3.4	
Approach LOS		C			C			C			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	25.1	25.0		29.9		50.1		29.9				
Change Period (Y+Rc), s	5.0	* 5		5.1		5.0		5.1				
Max Green Setting (Gmax), s	12.0	* 20		34.9		35.0		34.9				
Max Q Clear Time (g_c+I1), s	2.0	12.6		23.4		2.0		11.1				
Green Ext Time (p_c), s	0.3	1.8		1.5		5.2		1.3				

Intersection Summary												
HCM 7th Control Delay, s/veh			17.6									
HCM 7th LOS			B									

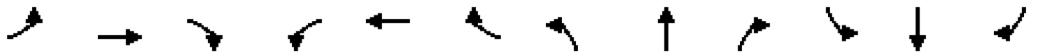
Notes

* HCM 7th computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	213	51	143	26	71	97	70	320	9	46	401	152
Future Volume (veh/h)	213	51	143	26	71	97	70	320	9	46	401	152
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1723	1723	1723	1709	1709	1709	1709	1709	1709	1723	1723	1723
Adj Flow Rate, veh/h	237	57	159	29	79	108	78	356	10	51	446	169
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	3	3	3	3	3	3	2	2	2
Cap, veh/h	368	130	364	337	213	291	367	678	19	412	887	752
Arrive On Green	0.33	0.33	0.33	0.33	0.33	0.33	0.41	0.41	0.41	0.04	0.51	0.51
Sat Flow, veh/h	1196	401	1120	1156	654	894	801	1654	46	1641	1723	1460
Grp Volume(v), veh/h	237	0	216	29	0	187	78	0	366	51	446	169
Grp Sat Flow(s),veh/h/ln	1196	0	1521	1156	0	1548	801	0	1701	1641	1723	1460
Q Serve(g_s), s	15.2	0.0	8.9	1.6	0.0	7.4	5.6	0.0	12.9	1.3	13.6	5.1
Cycle Q Clear(g_c), s	22.6	0.0	8.9	10.6	0.0	7.4	10.8	0.0	12.9	1.3	13.6	5.1
Prop In Lane	1.00		0.74	1.00		0.58	1.00		0.03	1.00		1.00
Lane Grp Cap(c), veh/h	368	0	495	337	0	503	367	0	697	412	887	752
V/C Ratio(X)	0.64	0.00	0.44	0.09	0.00	0.37	0.21	0.00	0.52	0.12	0.50	0.22
Avail Cap(c_a), veh/h	482	0	639	446	0	650	367	0	697	547	887	752
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	29.4	0.0	21.2	25.4	0.0	20.7	19.0	0.0	17.7	12.7	12.7	10.6
Incr Delay (d2), s/veh	1.9	0.0	0.6	0.1	0.0	0.5	1.3	0.0	2.8	0.1	2.0	0.7
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	4.2	0.0	3.0	0.4	0.0	2.5	1.1	0.0	5.0	0.4	4.9	1.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	31.3	0.0	21.8	25.5	0.0	21.2	20.3	0.0	20.6	12.9	14.7	11.3
LnGrp LOS	C		C	C		C	C		C	B	B	B
Approach Vol, veh/h		453			216			444			666	
Approach Delay, s/veh		26.8			21.8			20.5			13.7	
Approach LOS		C			C			C			B	

Timer - Assigned Phs		2		4	5	6		8				
Phs Duration (G+Y+Rc), s		47.6		32.4	8.4	39.2		32.4				
Change Period (Y+Rc), s		6.4		6.4	5.0	6.4		6.4				
Max Green Setting (Gmax), s		33.6		33.6	10.0	18.6		33.6				
Max Q Clear Time (g_c+I1), s		15.6		24.6	3.3	14.9		12.6				
Green Ext Time (p_c), s		2.9		1.4	0.0	0.9		1.0				

Intersection Summary												
HCM 7th Control Delay, s/veh			19.7									
HCM 7th LOS			B									



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	140	1	0	45	1162	0	0	966	105
Future Volume (veh/h)	0	0	0	140	1	0	45	1162	0	0	966	105
Initial Q (Qb), veh				0	0	0	0	0	0	0	0	0
Lane Width Adj.				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)				1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach					No			No			No	
Adj Sat Flow, veh/h/ln				1709	1709	0	1709	1709	0	0	1709	1709
Adj Flow Rate, veh/h				172	0	0	55	1417	0	0	1178	128
Peak Hour Factor				0.82	0.82	0.82	0.82	0.82	0.82	0.92	0.82	0.82
Percent Heavy Veh, %				3	3	0	3	3	0	0	3	3
Cap, veh/h				265	139		388	2573	0	0	3385	368
Arrive On Green				0.08	0.00	0.00	1.00	1.00	0.00	0.00	0.79	0.79
Sat Flow, veh/h				3255	1709	0	418	3333	0	0	4426	464
Grp Volume(v), veh/h				172	0	0	55	1417	0	0	858	448
Grp Sat Flow(s),veh/h/ln				1628	1709	0	418	1624	0	0	1555	1626
Q Serve(g_s), s				4.1	0.0	0.0	1.3	0.0	0.0	0.0	6.3	6.3
Cycle Q Clear(g_c), s				4.1	0.0	0.0	7.6	0.0	0.0	0.0	6.3	6.3
Prop In Lane				1.00		0.00	1.00		0.00	0.00		0.29
Lane Grp Cap(c), veh/h				265	139		388	2573	0	0	2464	1288
V/C Ratio(X)				0.65	0.00		0.14	0.55	0.00	0.00	0.35	0.35
Avail Cap(c_a), veh/h				1420	746		388	2573	0	0	2464	1288
HCM Platoon Ratio				1.00	1.00	1.00	1.33	1.33	1.00	1.00	1.00	1.00
Upstream Filter(I)				1.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00
Uniform Delay (d), s/veh				35.6	0.0	0.0	0.4	0.0	0.0	0.0	2.4	2.4
Incr Delay (d2), s/veh				2.7	0.0	0.0	0.8	0.9	0.0	0.0	0.4	0.7
Initial Q Delay(d3), s/veh				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln				1.7	0.0	0.0	0.1	0.3	0.0	0.0	1.0	1.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh				38.3	0.0	0.0	1.1	0.9	0.0	0.0	2.8	3.1
LnGrp LOS				D			A	A			A	A
Approach Vol, veh/h					172			1472			1306	
Approach Delay, s/veh					38.3			0.9			2.9	
Approach LOS					D			A			A	

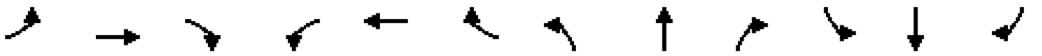
Timer - Assigned Phs	2			6		8						
Phs Duration (G+Y+Rc), s	68.4			68.4		11.6						
Change Period (Y+Rc), s	5.0			5.0		5.1						
Max Green Setting (Gmax), s	35.0			35.0		34.9						
Max Q Clear Time (g_c+I1), s	9.6			8.3		6.1						
Green Ext Time (p_c), s	13.1			10.2		0.6						

Intersection Summary		
HCM 7th Control Delay, s/veh	3.9	
HCM 7th LOS	A	

Notes

User approved volume balancing among the lanes for turning movement.

Unsignalized Delay for [WBR] is excluded from calculations of the approach delay and intersection delay.



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	204	0	0	189	0	592	0	811	0	316	507	0
Future Volume (vph)	204	0	0	189	0	592	0	811	0	316	507	0
Ideal Flow (vphpl)	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Storage Length (ft)	0		0	300		0	0		0	550		0
Storage Lanes	1		0	1		2	0		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1583	0	0	1599	0	2517	0	3228	0	1614	3228	0
Flt Permitted	0.950			0.950						0.138		
Satd. Flow (perm)	1583	0	0	1599	0	2517	0	3228	0	234	3228	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						424						
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		500			500			550			656	
Travel Time (s)		9.7			9.7			10.7			12.8	
Peak Hour Factor	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Heavy Vehicles (%)	5%	2%	2%	4%	2%	4%	2%	3%	2%	3%	3%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	234	0	0	217	0	680	0	932	0	363	583	0
Turn Type	Prot			Prot		Over		NA		pm+pt	NA	
Protected Phases	7			3		1		2		1	6	
Permitted Phases										6		
Detector Phase	7			3		1		2		1	6	
Switch Phase												
Minimum Initial (s)	5.0			5.0		5.0		5.0		5.0	5.0	
Minimum Split (s)	14.6			14.6		10.7		23.7		10.7	23.7	
Total Split (s)	35.0			35.0		20.0		25.0		20.0	45.0	
Total Split (%)	43.8%			43.8%		25.0%		31.3%		25.0%	56.3%	
Maximum Green (s)	25.4			25.4		14.4		19.4		14.4	39.4	
Yellow Time (s)	3.6			3.6		3.6		3.6		3.6	3.6	
All-Red Time (s)	6.0			6.0		2.0		2.0		2.0	2.0	
Lost Time Adjust (s)	0.0			0.0		0.0		0.0		0.0	0.0	
Total Lost Time (s)	9.6			9.6		5.6		5.6		5.6	5.6	
Lead/Lag						Lead		Lag		Lead		
Lead-Lag Optimize?						Yes		Yes		Yes		
Vehicle Extension (s)	3.0			3.0		3.0		3.0		3.0	3.0	
Recall Mode	None			None		None		C-Max		None	C-Max	
Walk Time (s)								7.0			7.0	
Flash Don't Walk (s)								11.0			11.0	
Pedestrian Calls (#/hr)								0			0	
Act Effct Green (s)	17.1			17.1		18.8		23.3		47.7	47.7	
Actuated g/C Ratio	0.21			0.21		0.24		0.29		0.60	0.60	
v/c Ratio	0.69			0.64		0.74		0.99		0.78	0.30	
Control Delay (s/veh)	39.4			36.6		16.3		55.8		29.8	10.1	
Queue Delay	0.0			0.0		0.0		0.0		0.0	0.0	
Total Delay (s/veh)	39.4			36.6		16.3		55.8		29.8	10.1	
LOS	D			D		B		E		C	B	
Approach Delay (s/veh)		39.4			21.2			55.8			17.7	
Approach LOS		D			C			E			B	

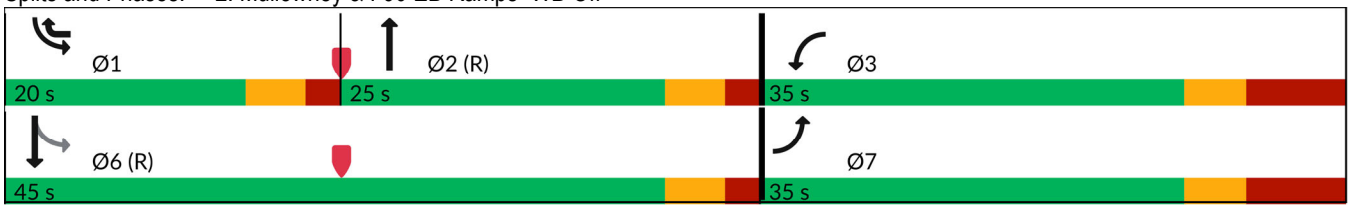
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Length 50th (ft)	109			99		57		~305		122	79	
Queue Length 95th (ft)	158			147		127		#383		#278	138	
Internal Link Dist (ft)		420			420			470			576	
Turn Bay Length (ft)				300						550		
Base Capacity (vph)	502			507		916		939		464	1926	
Starvation Cap Reductn	0			0		0		0		0	0	
Spillback Cap Reductn	0			0		0		0		0	0	
Storage Cap Reductn	0			0		0		0		0	0	
Reduced v/c Ratio	0.47			0.43		0.74		0.99		0.78	0.30	

Intersection Summary			
Area Type:	Other		
Cycle Length: 80			
Actuated Cycle Length: 80			
Offset: 3 (4%), Referenced to phase 2:NBT and 6:SBTL, Start of Green			
Natural Cycle: 90			
Control Type: Actuated-Coordinated			
Maximum v/c Ratio: 0.99			
Intersection Signal Delay (s/veh): 32.2		Intersection LOS: C	
Intersection Capacity Utilization 73.0%		ICU Level of Service C	
Analysis Period (min) 15			

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 2: Mullowney & I-90 EB Ramps+WB Off



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	148	112	32	74	77	193	27	637	76	189	368	208
Future Volume (veh/h)	148	112	32	74	77	193	27	637	76	189	368	208
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1641	1641	1641	1668	1668	1668	1723	1723	1723	1709	1709	1709
Adj Flow Rate, veh/h	164	124	36	82	86	214	30	708	84	210	409	231
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	8	8	8	6	6	6	2	2	2	3	3	3
Cap, veh/h	291	289	84	269	395	335	489	1490	177	468	1279	715
Arrive On Green	0.24	0.24	0.24	0.24	0.24	0.24	0.51	0.51	0.51	0.14	1.00	1.00
Sat Flow, veh/h	1028	1222	355	1187	1668	1414	789	2947	349	1628	2009	1122
Grp Volume(v), veh/h	164	0	160	82	86	214	30	393	399	210	330	310
Grp Sat Flow(s),veh/h/ln	1028	0	1577	1187	1668	1414	789	1637	1660	1628	1624	1507
Q Serve(g_s), s	12.2	0.0	6.9	5.0	3.3	10.9	1.6	12.5	12.5	4.7	0.0	0.0
Cycle Q Clear(g_c), s	15.5	0.0	6.9	11.9	3.3	10.9	1.6	12.5	12.5	4.7	0.0	0.0
Prop In Lane	1.00		0.22	1.00		1.00	1.00		0.21	1.00		0.74
Lane Grp Cap(c), veh/h	291	0	373	269	395	335	489	828	839	468	1034	960
V/C Ratio(X)	0.56	0.00	0.43	0.30	0.22	0.64	0.06	0.47	0.48	0.45	0.32	0.32
Avail Cap(c_a), veh/h	496	0	688	506	728	617	489	828	839	559	1034	960
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.93	0.93
Uniform Delay (d), s/veh	30.8	0.0	25.9	31.0	24.6	27.5	10.2	12.9	12.9	8.1	0.0	0.0
Incr Delay (d2), s/veh	1.7	0.0	0.8	0.6	0.3	2.0	0.2	1.9	1.9	0.6	0.8	0.8
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	2.9	0.0	2.5	1.4	1.3	3.7	0.3	4.5	4.6	1.3	0.2	0.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	32.5	0.0	26.7	31.6	24.8	29.5	10.4	14.8	14.8	8.7	0.8	0.8
LnGrp LOS	C		C	C	C	C	B	B	B	A	A	A
Approach Vol, veh/h		324			382			822			850	
Approach Delay, s/veh		29.7			28.9			14.6			2.7	
Approach LOS		C			C			B			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	10.5	45.5		24.0		56.0		24.0				
Change Period (Y+Rc), s	3.6	5.0		5.1		5.0		5.1				
Max Green Setting (Gmax), s	11.4	20.0		34.9		35.0		34.9				
Max Q Clear Time (g_c+I1), s	6.7	14.5		17.5		2.0		13.9				
Green Ext Time (p_c), s	0.2	2.4		1.4		4.4		1.4				

Intersection Summary	
HCM 7th Control Delay, s/veh	14.7
HCM 7th LOS	B

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	177	73	42	9	49	46	100	448	18	93	184	249
Future Volume (veh/h)	177	73	42	9	49	46	100	448	18	93	184	249
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1559	1559	1559	1532	1532	1532	1695	1695	1695	1668	1668	1668
Adj Flow Rate, veh/h	192	79	46	10	53	50	109	487	20	101	200	271
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	14	14	14	16	16	16	4	4	4	6	6	6
Cap, veh/h	320	236	138	300	185	175	520	765	31	392	989	838
Arrive On Green	0.26	0.26	0.26	0.26	0.26	0.26	0.47	0.47	0.47	0.06	0.59	0.59
Sat Flow, veh/h	1169	924	538	1125	725	684	908	1617	66	1589	1668	1414
Grp Volume(v), veh/h	192	0	125	10	0	103	109	0	507	101	200	271
Grp Sat Flow(s),veh/h/ln	1169	0	1462	1125	0	1409	908	0	1683	1589	1668	1414
Q Serve(g_s), s	12.6	0.0	5.6	0.6	0.0	4.7	5.7	0.0	18.2	2.4	4.4	7.7
Cycle Q Clear(g_c), s	17.3	0.0	5.6	6.1	0.0	4.7	5.7	0.0	18.2	2.4	4.4	7.7
Prop In Lane	1.00		0.37	1.00		0.49	1.00		0.04	1.00		1.00
Lane Grp Cap(c), veh/h	320	0	374	300	0	360	520	0	797	392	989	838
V/C Ratio(X)	0.60	0.00	0.33	0.03	0.00	0.29	0.21	0.00	0.64	0.26	0.20	0.32
Avail Cap(c_a), veh/h	512	0	614	484	0	592	520	0	797	499	989	838
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	30.9	0.0	24.2	26.7	0.0	23.9	12.6	0.0	15.9	11.4	7.5	8.2
Incr Delay (d2), s/veh	1.8	0.0	0.5	0.0	0.0	0.4	0.9	0.0	3.9	0.3	0.5	1.0
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	8.4	0.0	1.8	0.2	0.0	1.5	1.1	0.0	6.8	0.7	1.4	2.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	32.7	0.0	24.7	26.8	0.0	24.3	13.5	0.0	19.7	11.7	8.0	9.2
LnGrp LOS	C		C	C		C	B		B	B	A	A
Approach Vol, veh/h		317			113			616			572	
Approach Delay, s/veh		29.5			24.5			18.6			9.2	
Approach LOS		C			C			B			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	9.6	43.6		26.9		53.1		26.9				
Change Period (Y+Rc), s	5.1	5.7		6.4		5.7		6.4				
Max Green Setting (Gmax), s	9.9	19.3		33.6		34.3		33.6				
Max Q Clear Time (g_c+I1), s	4.4	20.2		19.3		9.7		8.1				
Green Ext Time (p_c), s	0.1	0.0		1.1		1.9		0.5				

Intersection Summary	
HCM 7th Control Delay, s/veh	17.9
HCM 7th LOS	B

Intersection	
Int Delay, s/veh	4.5

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	315	193	13	209	177	8
Future Vol, veh/h	315	193	13	209	177	8
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	300	-	0	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	342	210	14	227	192	9

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	552	0	703	447
Stage 1	-	-	-	-	447	-
Stage 2	-	-	-	-	255	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1018	-	404	611
Stage 1	-	-	-	-	644	-
Stage 2	-	-	-	-	787	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1018	-	398	611
Mov Cap-2 Maneuver	-	-	-	-	398	-
Stage 1	-	-	-	-	644	-
Stage 2	-	-	-	-	776	-

Approach	EB	WB	NB
HCM Ctrl Dly, s/v	0	0.5	21.71
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	398	611	-	-	1018	-
HCM Lane V/C Ratio	0.483	0.014	-	-	0.014	-
HCM Ctrl Dly (s/v)	22.2	11	-	-	8.6	-
HCM Lane LOS	C	B	-	-	A	-
HCM 95th %tile Q(veh)	2.5	0	-	-	0	-

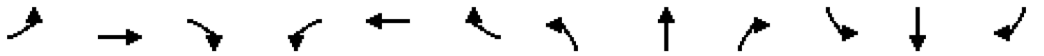
Intersection	
Int Delay, s/veh	2.6

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	269	94	28	162	83	25
Future Vol, veh/h	269	94	28	162	83	25
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	300	-	0	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	292	102	30	176	90	27

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	395	0	580	343
Stage 1	-	-	-	-	343	-
Stage 2	-	-	-	-	237	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1164	-	476	699
Stage 1	-	-	-	-	718	-
Stage 2	-	-	-	-	802	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1164	-	464	699
Mov Cap-2 Maneuver	-	-	-	-	464	-
Stage 1	-	-	-	-	718	-
Stage 2	-	-	-	-	781	-

Approach	EB	WB	NB
HCM Ctrl Dly, s/v	0	1.2	13.64
HCM LOS			B

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	464	699	-	-	1164	-
HCM Lane V/C Ratio	0.195	0.039	-	-	0.026	-
HCM Ctrl Dly (s/v)	14.6	10.4	-	-	8.2	-
HCM Lane LOS	B	B	-	-	A	-
HCM 95th %tile Q(veh)	0.7	0.1	-	-	0.1	-



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	209	0	0	68	1109	0	0	1784	201
Future Volume (veh/h)	0	0	0	209	0	0	68	1109	0	0	1784	201
Initial Q (Qb), veh				0	0	0	0	0	0	0	0	0
Lane Width Adj.				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)				1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach					No			No			No	
Adj Sat Flow, veh/h/ln				1736	1736	0	1736	1736	0	0	1736	1736
Adj Flow Rate, veh/h				225	0	0	73	1192	0	0	1918	216
Peak Hour Factor				0.93	0.93	0.93	0.93	0.93	0.92	0.92	0.93	0.93
Percent Heavy Veh, %				1	1	0	1	1	0	0	1	1
Cap, veh/h				329	173		203	2554	0	0	3350	374
Arrive On Green				0.10	0.00	0.00	1.00	1.00	0.00	0.00	0.77	0.77
Sat Flow, veh/h				3307	1736	0	190	3386	0	0	4482	483
Grp Volume(v), veh/h				225	0	0	73	1192	0	0	1397	737
Grp Sat Flow(s),veh/h/ln				1654	1736	0	190	1650	0	0	1580	1649
Q Serve(g_s), s				5.3	0.0	0.0	14.3	0.0	0.0	0.0	14.3	14.6
Cycle Q Clear(g_c), s				5.3	0.0	0.0	28.9	0.0	0.0	0.0	14.3	14.6
Prop In Lane				1.00		0.00	1.00		0.00	0.00		0.29
Lane Grp Cap(c), veh/h				329	173		203	2554	0	0	2447	1277
V/C Ratio(X)				0.68	0.00		0.36	0.47	0.00	0.00	0.57	0.58
Avail Cap(c_a), veh/h				1443	757		203	2554	0	0	2447	1277
HCM Platoon Ratio				1.00	1.00	1.00	1.33	1.33	1.00	1.00	1.00	1.00
Upstream Filter(I)				1.00	0.00	0.00	1.00	1.00	0.00	0.00	1.00	1.00
Uniform Delay (d), s/veh				34.8	0.0	0.0	3.4	0.0	0.0	0.0	3.7	3.7
Incr Delay (d2), s/veh				2.5	0.0	0.0	4.9	0.6	0.0	0.0	1.0	1.9
Initial Q Delay(d3), s/veh				0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln				2.2	0.0	0.0	0.5	0.2	0.0	0.0	2.7	3.2
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh				37.3	0.0	0.0	8.3	0.6	0.0	0.0	4.6	5.6
LnGrp LOS				D			A	A			A	A
Approach Vol, veh/h					225			1265			2134	
Approach Delay, s/veh					37.3			1.1			5.0	
Approach LOS					D			A			A	

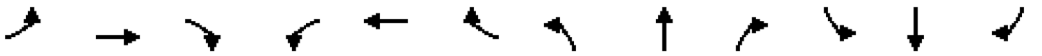
Timer - Assigned Phs	2			6		8						
Phs Duration (G+Y+Rc), s	66.9			66.9		13.1						
Change Period (Y+Rc), s	5.0			5.0		5.1						
Max Green Setting (Gmax), s	35.0			35.0		34.9						
Max Q Clear Time (g_c+I1), s	30.9			16.6		7.3						
Green Ext Time (p_c), s	3.1			13.9		0.8						

Intersection Summary	
HCM 7th Control Delay, s/veh	5.6
HCM 7th LOS	A

Notes

User approved volume balancing among the lanes for turning movement.

Unsignalized Delay for [WBR] is excluded from calculations of the approach delay and intersection delay.



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	138	0	0	157	0	539	0	745	0	608	779	0
Future Volume (vph)	138	0	0	157	0	539	0	745	0	608	779	0
Ideal Flow (vphpl)	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
Storage Length (ft)	0		0	300		0	0		0	550		0
Storage Lanes	1		0	1		2	0		0	1		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1583	0	0	1599	0	2517	0	3292	0	1646	3292	0
Flt Permitted	0.950			0.950						0.160		
Satd. Flow (perm)	1583	0	0	1599	0	2517	0	3292	0	277	3292	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)						561						
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		500			500			550			656	
Travel Time (s)		9.7			9.7			10.7			12.8	
Peak Hour Factor	0.96	0.92	0.92	0.96	0.92	0.96	0.92	0.96	0.92	0.96	0.96	0.92
Heavy Vehicles (%)	5%	2%	2%	4%	2%	4%	2%	1%	2%	1%	1%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	144	0	0	164	0	561	0	776	0	633	811	0
Turn Type	Prot			Prot		Over		NA		pm+pt	NA	
Protected Phases	7			3		1		2		1	6	
Permitted Phases										6		
Detector Phase	7			3		1		2		1	6	
Switch Phase												
Minimum Initial (s)	5.0			5.0		5.0		5.0		5.0	5.0	
Minimum Split (s)	14.6			27.6		10.7		25.0		10.7	25.0	
Total Split (s)	35.0			35.0		20.0		25.0		20.0	45.0	
Total Split (%)	43.8%			43.8%		25.0%		31.3%		25.0%	56.3%	
Maximum Green (s)	25.4			25.4		14.4		19.4		14.4	39.4	
Yellow Time (s)	3.6			3.6		3.6		3.6		3.6	3.6	
All-Red Time (s)	6.0			6.0		2.0		2.0		2.0	2.0	
Lost Time Adjust (s)	0.0			0.0		0.0		0.0		0.0	0.0	
Total Lost Time (s)	9.6			9.6		5.6		5.6		5.6	5.6	
Lead/Lag						Lead		Lag		Lead		
Lead-Lag Optimize?						Yes		Yes		Yes		
Vehicle Extension (s)	3.0			3.0		3.0		3.0		3.0	3.0	
Recall Mode	None			None		None		C-Max		None	C-Max	
Walk Time (s)				7.0				7.0			7.0	
Flash Don't Walk (s)				11.0				11.0			11.0	
Pedestrian Calls (#/hr)				0				0			0	
Act Effct Green (s)	13.5			13.5		26.3		19.4		51.3	51.3	
Actuated g/C Ratio	0.17			0.17		0.33		0.24		0.64	0.64	
v/c Ratio	0.54			0.61		0.47		0.97		1.01	0.38	
Control Delay (s/veh)	37.1			39.9		3.7		51.5		55.4	7.7	
Queue Delay	0.0			0.0		0.0		0.0		0.0	0.0	
Total Delay (s/veh)	37.1			39.9		3.7		51.5		55.4	7.7	
LOS	D			D		A		D		E	A	
Approach Delay (s/veh)		37.1			11.9			51.5			28.6	
Approach LOS		D			B			D			C	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Queue Length 50th (ft)	67			77		0		210		~275	123	
Queue Length 95th (ft)	113			127		40		#327		#557	159	
Internal Link Dist (ft)		420			420			470			576	
Turn Bay Length (ft)				300						550		
Base Capacity (vph)	502			507		1204		798		627	2110	
Starvation Cap Reductn	0			0		0		0		0	0	
Spillback Cap Reductn	0			0		0		0		0	0	
Storage Cap Reductn	0			0		0		0		0	0	
Reduced v/c Ratio	0.29			0.32		0.47		0.97		1.01	0.38	

Intersection Summary			
Area Type:	Other		
Cycle Length: 80			
Actuated Cycle Length: 80			
Offset: 26.4 (33%), Referenced to phase 2:NBT and 6:SBTL, Start of Yellow			
Natural Cycle: 90			
Control Type: Actuated-Coordinated			
Maximum v/c Ratio: 1.01			
Intersection Signal Delay (s/veh): 30.8		Intersection LOS: C	
Intersection Capacity Utilization 85.7%		ICU Level of Service E	
Analysis Period (min) 15			

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 2: Mullowney & I-90 EB Ramps+WB Off

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	235	166	19	113	137	276	28	437	111	300	564	154
Future Volume (veh/h)	235	166	19	113	137	276	28	437	111	300	564	154
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1682	1682	1682	1709	1709	1709	1750	1750	1750	1709	1709	1709
Adj Flow Rate, veh/h	245	173	20	118	143	288	29	455	116	312	588	160
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Percent Heavy Veh, %	5	5	5	3	3	3	0	0	0	3	3	3
Cap, veh/h	365	523	60	406	604	511	271	657	166	484	1314	357
Arrive On Green	0.35	0.35	0.35	0.35	0.35	0.35	0.25	0.25	0.25	0.42	1.00	1.00
Sat Flow, veh/h	934	1480	171	1181	1709	1448	725	2628	665	1628	2524	685
Grp Volume(v), veh/h	245	0	193	118	143	288	29	287	284	312	378	370
Grp Sat Flow(s),veh/h/ln	934	0	1651	1181	1709	1448	725	1663	1630	1628	1624	1586
Q Serve(g_s), s	20.1	0.0	6.9	6.5	4.7	12.8	2.5	12.5	12.7	2.9	0.0	0.0
Cycle Q Clear(g_c), s	24.8	0.0	6.9	13.4	4.7	12.8	2.5	12.5	12.7	2.9	0.0	0.0
Prop In Lane	1.00		0.10	1.00		1.00	1.00		0.41	1.00		0.43
Lane Grp Cap(c), veh/h	365	0	583	406	604	511	271	416	408	484	845	826
V/C Ratio(X)	0.67	0.00	0.33	0.29	0.24	0.56	0.11	0.69	0.70	0.64	0.45	0.45
Avail Cap(c_a), veh/h	442	0	720	504	746	632	271	416	408	484	845	826
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.91	0.91
Uniform Delay (d), s/veh	27.0	0.0	19.0	23.8	18.3	20.9	23.4	27.2	27.3	18.2	0.0	0.0
Incr Delay (d2), s/veh	3.0	0.0	0.3	0.4	0.2	1.0	0.8	9.0	9.5	2.7	1.6	1.6
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	4.3	0.0	2.4	1.8	1.8	4.2	0.5	5.7	5.7	3.7	0.4	0.4
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	30.0	0.0	19.3	24.2	18.5	21.9	24.2	36.2	36.8	20.9	1.6	1.6
LnGrp LOS	C		B	C	B	C	C	D	D	C	A	A
Approach Vol, veh/h		438			549			600			1060	
Approach Delay, s/veh		25.3			21.5			35.9			7.3	
Approach LOS		C			C			D			A	

Timer - Assigned Phs	1	2		4		6		8				
Phs Duration (G+Y+Rc), s	21.6	25.0		33.4		46.6		33.4				
Change Period (Y+Rc), s	5.0	* 5		5.1		5.0		5.1				
Max Green Setting (Gmax), s	12.6	* 20		34.9		35.0		34.9				
Max Q Clear Time (g_c+I1), s	14.9	14.7		26.8		2.0		15.4				
Green Ext Time (p_c), s	0.6	1.7		1.5		5.2		2.1				

Intersection Summary	
HCM 7th Control Delay, s/veh	19.7
HCM 7th LOS	B

Notes

* HCM 7th computational engine requires equal clearance times for the phases crossing the barrier.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	250	51	143	26	71	97	70	320	9	46	401	188
Future Volume (veh/h)	250	51	143	26	71	97	70	320	9	46	401	188
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Lane Width Adj.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1723	1723	1723	1709	1709	1709	1709	1709	1709	1723	1723	1723
Adj Flow Rate, veh/h	278	57	159	29	79	108	78	356	10	51	446	209
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Percent Heavy Veh, %	2	2	2	3	3	3	3	3	3	2	2	2
Cap, veh/h	406	142	395	374	231	315	328	632	18	376	839	711
Arrive On Green	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.38	0.38	0.04	0.49	0.49
Sat Flow, veh/h	1196	401	1120	1156	654	894	772	1654	46	1641	1723	1460
Grp Volume(v), veh/h	278	0	216	29	0	187	78	0	366	51	446	209
Grp Sat Flow(s),veh/h/ln	1196	0	1521	1156	0	1548	772	0	1701	1641	1723	1460
Q Serve(g_s), s	17.8	0.0	8.6	1.6	0.0	7.1	6.2	0.0	13.6	1.4	14.3	6.9
Cycle Q Clear(g_c), s	24.9	0.0	8.6	10.1	0.0	7.1	12.2	0.0	13.6	1.4	14.3	6.9
Prop In Lane	1.00		0.74	1.00		0.58	1.00		0.03	1.00		1.00
Lane Grp Cap(c), veh/h	406	0	537	374	0	546	328	0	650	376	839	711
V/C Ratio(X)	0.69	0.00	0.40	0.08	0.00	0.34	0.24	0.00	0.56	0.14	0.53	0.29
Avail Cap(c_a), veh/h	486	0	639	452	0	650	328	0	650	511	839	711
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	28.2	0.0	19.5	23.3	0.0	19.1	21.3	0.0	19.4	14.1	14.2	12.3
Incr Delay (d2), s/veh	3.1	0.0	0.5	0.1	0.0	0.4	1.7	0.0	3.5	0.2	2.4	1.0
Initial Q Delay(d3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	5.0	0.0	2.8	0.4	0.0	2.4	1.2	0.0	5.4	0.5	5.3	2.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d), s/veh	31.3	0.0	20.0	23.4	0.0	19.4	23.0	0.0	22.9	14.3	16.6	13.3
LnGrp LOS	C		C	C		B	C		C	B	B	B
Approach Vol, veh/h		494			216			444			706	
Approach Delay, s/veh		26.4			20.0			23.0			15.5	
Approach LOS		C			B			C			B	

Timer - Assigned Phs	2	4	5	6	8
Phs Duration (G+Y+Rc), s	45.4	34.6	8.4	37.0	34.6
Change Period (Y+Rc), s	6.4	6.4	5.0	6.4	6.4
Max Green Setting (Gmax), s	33.6	33.6	10.0	18.6	33.6
Max Q Clear Time (g_c+I1), s	16.3	26.9	3.4	15.6	12.1
Green Ext Time (p_c), s	3.0	1.3	0.0	0.7	1.0

Intersection Summary	
HCM 7th Control Delay, s/veh	20.7
HCM 7th LOS	C

Intersection	
Int Delay, s/veh	9.2

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	443	244	14	166	234	9
Future Vol, veh/h	443	244	14	166	234	9
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	300	-	0	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	482	265	15	180	254	10

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	747	0	825	614
Stage 1	-	-	-	-	614	-
Stage 2	-	-	-	-	211	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	862	-	342	492
Stage 1	-	-	-	-	540	-
Stage 2	-	-	-	-	824	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	862	-	336	492
Mov Cap-2 Maneuver	-	-	-	-	336	-
Stage 1	-	-	-	-	540	-
Stage 2	-	-	-	-	810	-

Approach	EB	WB	NB
HCM Ctrl Dly, s/v	0	0.72	41.32
HCM LOS			E

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	336	492	-	-	862	-
HCM Lane V/C Ratio	0.756	0.02	-	-	0.018	-
HCM Ctrl Dly (s/v)	42.4	12.5	-	-	9.3	-
HCM Lane LOS	E	B	-	-	A	-
HCM 95th %tile Q(veh)	5.9	0.1	-	-	0.1	-

Intersection	
Int Delay, s/veh	3.4

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	408	119	36	127	112	37
Future Vol, veh/h	408	119	36	127	112	37
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	300	-	0	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	443	129	39	138	122	40

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	573	0	724	508
Stage 1	-	-	-	-	508	-
Stage 2	-	-	-	-	216	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1000	-	392	565
Stage 1	-	-	-	-	604	-
Stage 2	-	-	-	-	820	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1000	-	377	565
Mov Cap-2 Maneuver	-	-	-	-	377	-
Stage 1	-	-	-	-	604	-
Stage 2	-	-	-	-	788	-

Approach	EB	WB	NB
HCM Ctrl Dly, s/v	0	1.93	17.26
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	377	565	-	-	1000	-
HCM Lane V/C Ratio	0.323	0.071	-	-	0.039	-
HCM Ctrl Dly (s/v)	19	11.9	-	-	8.7	-
HCM Lane LOS	C	B	-	-	A	-
HCM 95th %tile Q(veh)	1.4	0.2	-	-	0.1	-

Appendix C: Intersection Cost Participation Calculations

City of Billings Intersection Cost Participation Worksheet: Trailhead Commercial

Shading Key: **No such movement** | **Movement has no project traffic in either peak**

3: Mullowney at Midland

Lane Group (**critical**)	Lanes	AM Peak Hour Vproject	AM Peak Hour Per Lane	PM Peak Hour Vproject	PM Peak Hour Per Lane
EB T	1	**14**	**14**	**26**	**26**
WB L	1	**29**	**29**	**60**	**60**
WB T	1	12	12	24	24
EB L					
NB T					
SB L	1	**75**	**75**	**144**	**144**
SB T					
NB L					
Project **Critical** Lane Volume			**118**		**230**
Critical Lane Capacity			1200		1200
% Increase			9.8%		19.2%
Max % Increase			19.2%		

4: S. Billings Blvd at Midland

Lane Group (**critical**)	Lanes	AM Peak Hour Vproject	AM Peak Hour Per Lane	PM Peak Hour Vproject	PM Peak Hour Per Lane
EB T					
WB L					
WB T					
EB L	1	**25**	**25**	**37**	**37**
NB T					
SB L					
SB T					
NB L					
Project **Critical** Lane Volume			**25**		**37**
Critical Lane Capacity			1200		1200
% Increase			2.1%		3.1%
Max % Increase			3.1%		