ARCADIS

OHIO DEPARTMENT OF TRANSPORTATION

Safety Study

U.S. 422 at Rapids Road
Geauga County, Ohio

August 31, 2022

Safety Study

U.S. 422 at Rapids Road
Geauga County, Ohio

August 2022

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Executive Summary

The Ohio Department of Transportation (ODOT) retained Arcadis U.S., Inc. (Arcadis) to study safety and traffic operations at the intersection of U.S. Route 422 (U.S. 422) with Rapids Road in Geauga County, Ohio. The intersection is located approximately 14 miles east of the City of Solon and 6 miles west of the Village of Parkman. U.S. 422 is an east-west corridor that provides a connection between the cities of Cleveland and Warren. Rapids Road is a north-south corridor connecting U.S. 422 to State Route (SR) 87. The purpose of this safety study is to analyze existing safety conditions, predict future safety conditions, and develop safety improvements that will promote safe and efficient traffic operations now and in the future.

ODOT District 12 has been monitoring crashes and traffic operations at the intersection of U.S. 422 and Rapids Road for several years. A summary of the safety history is below:

- In 2014, ODOT completed the *GEA-422-10.93/13.31 Corridor Study,* which found that the intersection was ranked #60 on ODOT's safety priority list for rural intersections and recommended constructing a traffic signal and left turn lanes on U.S. 422.
- In 2015, following the recommendations from the *GEA-422-10.93/13.31 Corridor Study*, ODOT converted the signal to a traffic signal but did not build the left turn lanes.
- In 2017, ODOT completed the *GEA-422 (11.11-11.55) Abbreviated Safety Study,* which found that the intersection ranked #17 in 2015 (the same year the signal was constructed) and #82 in 2016 for rural intersections.
- In 2018 the intersection was ranked #161 on ODOT's safety priority list for rural intersections.
- In 2020 the intersection was ranked #165 on ODOT's safety priority list for rural intersections.
- In 2022, ODOT completed the *2022 GEA-422 Traffic Operations Assessment Systems Tool (TOAST) Study,* which provided TOAST scores for the intersection and identified an opportunity for improvements to safety, incident clearance time, volume per lane, and travel time.

The 2014, 2017, and 2022 studies identified rear-end crashes as the predominant crash type on U.S. 422 and recommended improving intersection sight distance, constructing left-turn lanes on U.S. 422, and interconnecting the traffic signals at Great Lake Parkway, Rapids Road, and SR 700.

Between 2019 and 2021, 16 crashes and 6 injuries occurred at the intersection of U.S. 422 and Rapids Road. Rear-end crashes were the most common crash type, accounting for 10 of the 16 crashes and all 6 injuries. All of the rear-end crashes occurred on U.S. 422. Given that most of the crashes were rear-end crashes on U.S. 422, proposed improvements include construction of left-turn lanes on U.S. 422 to provide storage for vehicles waiting to turn left during a green signal phase, reconstructing the traffic signal using mast arms, and implementing flashing yellow arrow (FYA) signal operation.

The benefit-cost ratio for the proposed improvements is 0.98. If implemented, these countermeasures are anticipated to provide a sufficient safety benefit to justify the cost of construction. According to ODOT's Economic Crash Analysis Tool (ECAT), the proposed improvements will reduce crashes by 3 per year.

1 Introduction

The Ohio Department of Transportation (ODOT) retained Arcadis U.S., Inc. (Arcadis) to study the overall safety and traffic operations of the intersection of U.S. Route 422 (U.S. 422) with Rapids Road in Geauga County, Ohio. The study area is located approximately 14 miles east of the City of Solon and 6 miles west of the Village of Parkman. The safety study included an analysis of the existing safety performance of the intersection; a traffic analysis of current intersection operations and future intersection operations (with no improvements and with implementation of proposed improvements); and a predictive safety analysis to quantify the safety benefits associated with the proposed improvements. This report presents the results of the safety study.

2 Purpose and Need

The purpose of this safety study is to analyze existing safety conditions, predict future safety conditions, and determine the potential safety benefit of proposed improvements.

The need for this study is demonstrated by the findings of three studies conducted by ODOT since 2014 that are described in Section 4. The intersection of U.S. 422 and Rapids Road has consistently appeared on ODOT's safety priority list for rural intersections since 2014 with rankings varying from #17 to #82. The most recent study, completed in 2022, provided Traffic Operations Assessment Systems Tool (TOAST) scores documenting safety, incident clearance times, volumes per lane, travel time performance, freight performance, bottlenecks, and secondary crashes.

Traffic congestion along U.S. 422 is a daily, ongoing issue. It is common for a queue of vehicles to develop on U.S. 422 because of the signal or when a westbound or eastbound traveling vehicle is stopped during a green signal phase while waiting to turn left onto Rapids Road. Therefore, ODOT is evaluating the potential safety and efficiency benefits of constructing left-turn lanes on U.S. 422.

3 Existing Conditions

U.S. 422 is an east-west principal arterial with a posted speed limit of 45 miles per hour (mph) and an average daily traffic (ADT) volume of approximately 16,000 vehicles per day (vpd), of which 10 to 12 percent is truck traffic. There is one 12-foot-wide lane in each direction, with 1-foot-wide paved shoulders adjacent to the travel lanes. The road is striped with centerline rumble stripes and edge lines. Rapids Road is a north-south local road with a posted speed limit of 55 mph and an ADT volume of 2,000 vpd, of which less than 1 percent is truck traffic. There is one 12-foot-wide lane in each direction, with a 1-foot-wide paved shoulder adjacent to the travel lanes. The intersection is signalized with no turn lanes. The signal heads are mounted to span wire. The signal operates using three phases: one phase for U.S. 422; one phase for Rapids Road; and a third short, protected eastbound left-turn phase during the p.m. peak hour, although there is no eastbound left-turn lane.

The pavement condition rating for U.S. 422 is 80, according to the ODOT Transportation Information Mapping System (TIMS). Lighting is present at the intersection. Utility poles are present in all four corners of the intersection. There are no pedestrian facilities (sidewalk, curb ramps, and crosswalks). The study area is illustrated on Figure 1.

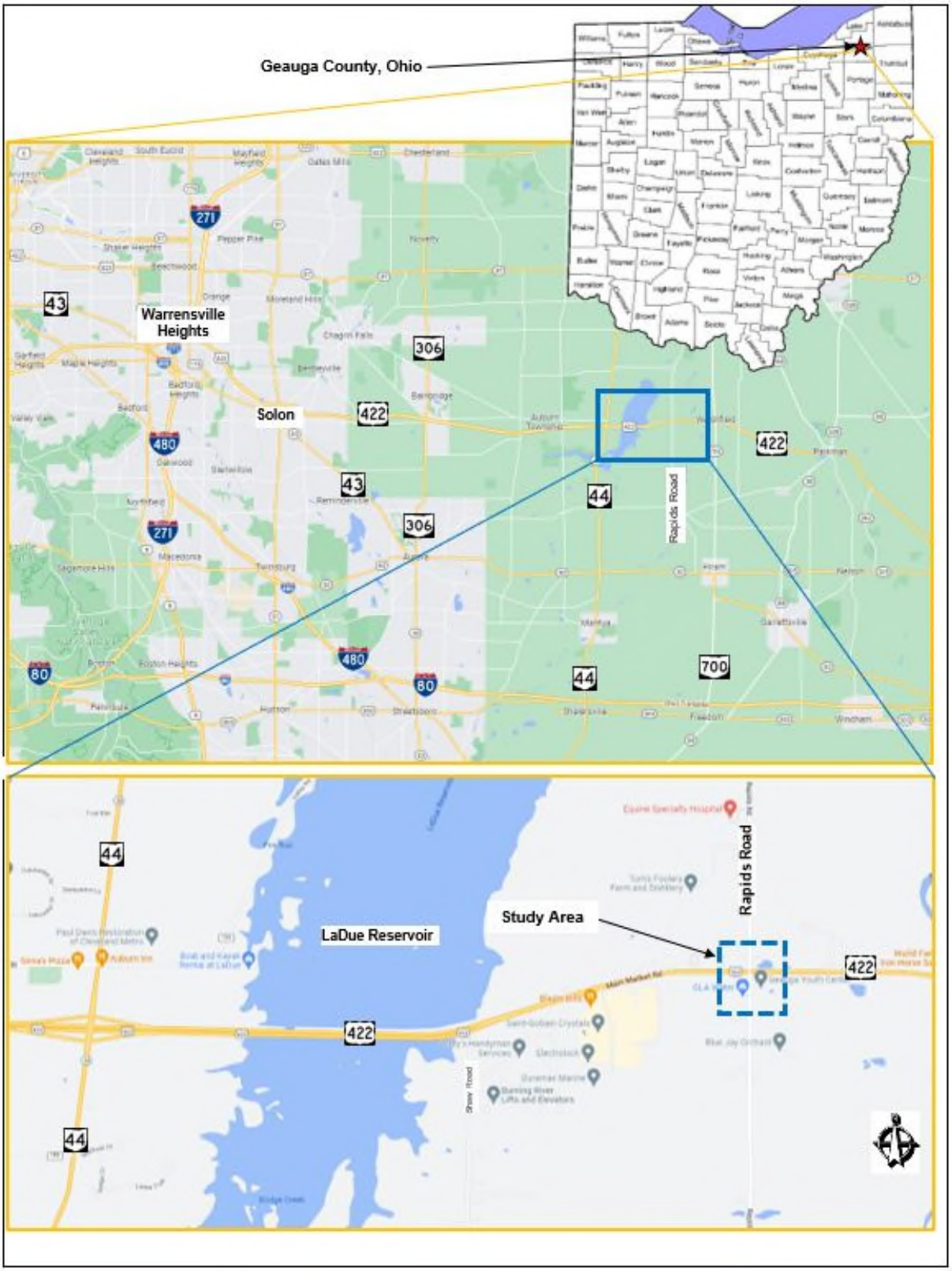

Figure 1. Study Area Map

A field visit was conducted on July 7, 2022, around 4:30 p.m. In addition, ODOT District 12 collected drone aerial video in August 2022. Observations of the study area during the field review are summarized as follows:

- Traffic volumes are high on U.S. 422 but relatively low on Rapids Road.

Figure 2. U.S. 422 Looking East

Figure 3. U.S. 422 Looking West

Figure 4. Rapids Road Looking North

Figure 5. Rapids Road Looking South

- A typical eastbound queue was seven to ten vehicles on U.S. 422 eastbound. However, at times the queue reached approximately 20 vehicles. The queue cleared during some signal phase but not each signal phase.

Figure 6. U.S. 422 Queues on the Eastbound Approach

- Vehicles queued on U.S. 422 behind a vehicle waiting to turn left were observed using the shoulder to bypass the left-turning vehicle.
- There are drainage ditches on all four sides of the intersection with a culvert that crosses beneath U.S. 422 on the west approach.
- A large number of single-unit trucks and semi-trucks were observed on U.S. 422.
- There is a slight downgrade on U.S. 422 west of the intersection.

4 Safety History

ODOT District 12 has been monitoring the crashes and traffic operations along U.S. 422, including the intersection of U.S. 422 and Rapids Road, for almost 10 years.

In 2014, ODOT District 12 conducted the *GEA-422-10.93/13.31 Corridor Study* to examine existing safety conditions and traffic operations along U.S. 422. The study identified several segments and intersections on ODOT's safety priority list including the intersection of U.S. 422 and Rapids Road, which ranked #60 for rural intersections. The study identified rear-end and angle crashes as the top two crash types and a failing level of service (LOS) on Rapids Road. The study recommendations included installing a new three-phase traffic signal, improving intersection sight distance, constructing left-turn lanes on U.S. 422, and interconnecting the new traffic signal with the traffic signals at Great Lake Parkway and State Route (SR) 700. ‘

In 2015, ODOT District 12 constructed a new traffic signal.

In 2017, ODOT District 12 conducted the *GEA-422 (11.11-11.55) Abbreviated Safety Study* to examine existing safety conditions and traffic operations along U.S. 422 including the Rapids Road intersection. The study found that the intersection of U.S. 422 at Rapids Road ranked #17 in 2015 (the year the traffic signal was constructed), and #82 in 2016 for rural intersections on ODOT's safety priority lists. The study recommendations included

installing a backplate on the traffic signal heads, installing a 40-mph advisory speed placard approaching the intersection, and constructing left-turn lanes on U.S. 422.

In 2018 the intersection was ranked #161 on ODOT's safety priority list for rural intersections.

In 2020 the intersection was ranked #165 on ODOT's safety priority list for rural intersections.

In 2022, ODOT District 12 conducted the *2022 GEA-422 TOAST Study* to examine existing safety conditions along U.S. 422 from Shaw Road to Rapids Road. The TOAST scores for the segment of U.S. 422 that includes the intersection with Rapids Road showed an opportunity for improvement in safety, incident clearance time, volume per lane, and travel time. Specific to the intersection at Rapids Road, the TOAST study recommendations included constructing left-turn lanes on U.S. 422 and interconnecting the traffic signals at Great Lakes Parkway, Rapids Road, and SR 700.

5 Crash Data

Crash data from 2019 to 2021 were provided by ODOT District 12 and analyzed using ODOT's Crash Analysis Module (CAM) Tool. A total of 16 crashes and 6 injuries occurred within the study area during the three-year period. Crash data for the study area were compared to statewide averages obtained from ODOT's CAM Tool.

5.1 Statewide Comparison

The frequency of crash types in the study area compared to statewide averages for rural roads on the state system is shown on Figure 7. As indicated on the figure, rear-end, right-turn, and injury crashes occur more frequently in the study area compared to statewide averages.

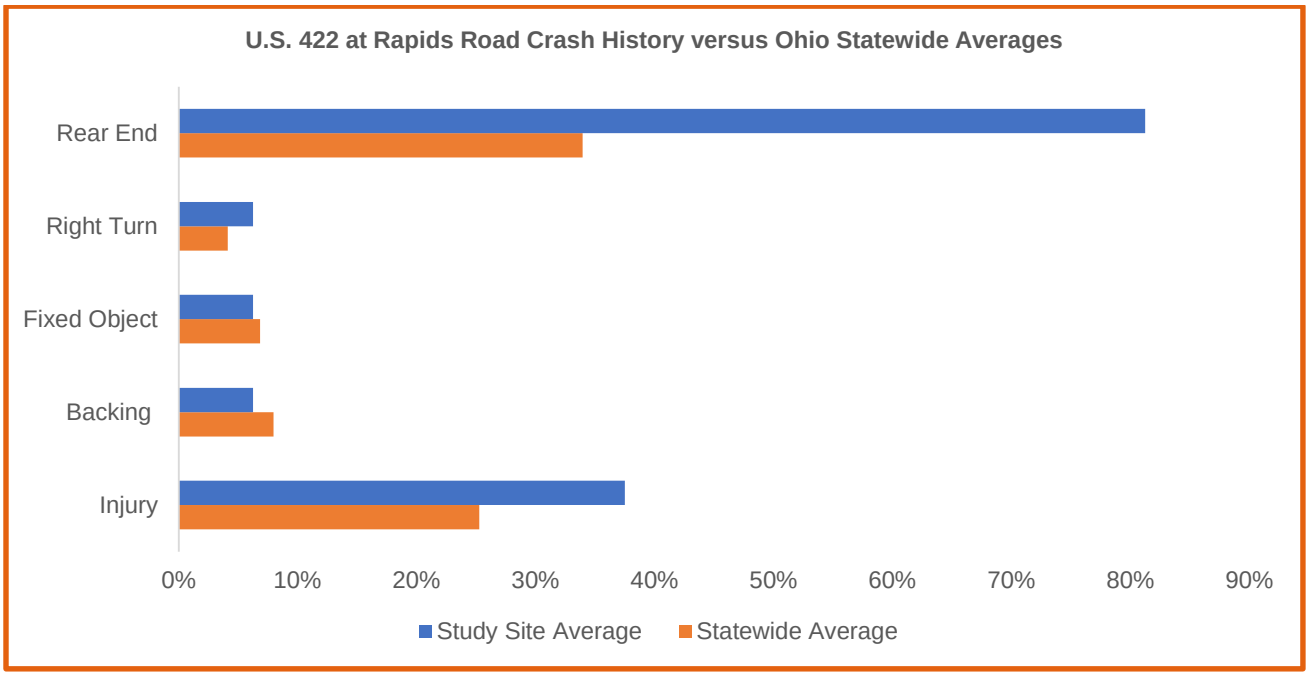

Figure 7. Crash History Compared to Statewide Averages

5.2 Crash Statistic Summary

Additional statistics based on the crash data are summarized in Table 1. As shown in the table, the most common crash type that occurred between 2019 and 2021 was rear-end crashes. None of the crashes resulted in a fatality. All six injuries were a result of rear-end crashes. Twelve crashes occurred on dry pavement, indicating that weather is not typically a contributing factor. Thirteen crashes occurred between 6 a.m. and 7 p.m., indicating that lighting is not typically a contributing factor. More detailed explanations of the crashes are provided following the table.

Table 1. Study Area Crash Statistics (2019 to 2021)

Crash Severity	Number	Percentage
Fatal Crash	0	0%
Injury Crash	6	38%
Property Damage Only (PDO) Crash	10	62%

Light Condition	Number	Percentage
Daylight	13	81%
Dark – Not Lighted	2	13%
Dawn/Dusk	1	6%

Type of Crash	Number	Percentage
Rear-End	13	82%
Fixed Object	1	6%
Backing	1	6%
Right-Turn	1	6%

Road Condition	Number	Percentage
Dry	12	75%
Wet	4	25%

Month	Number	Percentage
January	2	13%
February	3	19%
March	0	0%
April	2	13%
May	0	0%
June	1	6%
July	5	30%
August	1	6%
September	2	13%
October	0	0%
November	0	0%
December	0	0%

Contributing Factor	Number	Percentage
Followed too Closely/ACDA	13	69%
Failure to Control	1	6%
Other	1	6%
Left of Center	1	6%

Year	Crash	Percentage
2019	6	37%
2020	3	19%
2021	7	44%

Rear-End Crashes – Rear-end crashes accounted for approximately 82 percent of all crashes and 100 percent of all injuries. Ten of the 13 rear-end crashes were coded as rear-end crashes in TIMS. Two crashes that were coded as fixed object crashes were recoded as rear-end crashes because they were caused by eastbound vehicles striking the drainage ditch on the south side of U.S. 422 trying to avoid a rear-end crash. One crash that was coded as a sideswipe passing crash was recoded as a rear-end crash because it involved a motorcycle traveling westbound that swerved across the centerline to avoid a rear-end crash and sideswiped the vehicle it

was trying to avoid. All of the rear-end crashes occurred on U.S. 422. Assured clear distance or following too closely was the contributing factor in all of these crashes.

Fixed Object Crashes – After two of the fixed object crashes were recoded as rear-end crashes only, one fixed object crash remained in the dataset. This crash involved a vehicle traveling westbound that lost control in the intersection and struck a tree on the north side of U.S. 422 approximately 100 feet west of the intersection. This crash involved a drunk driver at 10.00 p.m. on a Saturday night.

Backing Crash – The backing crash occurred when two single-unit trucks traveling eastbound were stopped at the signal and the lead truck reversed to back out of the intersection.

Right-Turn Crash – This crash involved a vehicle traveling westbound that turned right and struck a southbound vehicle waiting at the traffic signal. This crash occurred in the snow on wet pavement.

A full printout from the ODOT CAM Tool is included in Appendix A and a crash diagram is included in Appendix B.

5.3 Crash Probable Causes

As indicated in Section 5, rear-end crashes accounted for the majority of the crashes that occurred in the study area between 2019 and 2021. Assured clear distance or following too closely was the contributing factor in most of these crashes. From a review of the OH-1 reports, it is difficult to discern whether a rear-end crash occurred because traffic was queued during a red signal phase or because traffic was queued during a green signal phase while the vehicle at the signal was waiting to turn left onto Rapids Road.

6 Proposed Improvements

Given that the majority of crashes in the study area are rear-end crashes on U.S. 422, the proposed countermeasure is to add eastbound and westbound left-turn lanes. The addition of left-turn lanes will minimize through-movement blockage by providing storage space on U.S. 422 for vehicles turning left. The traffic signal will be reconstructed using mast arms and flashing yellow arrow (FYA) signal operation will be implemented. A conceptual schematic of the proposed improvements is included in Appendix E.

The left-turn lane lengths proposed for the intersection of U.S. 422 and Rapids Road were calculated using guidance provided in the ODOT Location and Design (L&D) Manual, Volume 1. The L&D Manual provides guidelines to calculate the length of each turn lane based on traffic demand and degree of blockage caused by vehicles queued in the adjacent through lanes. The calculated length of each proposed left-turn lane is summarized in Table 2. The proposed turn lane length is 650 feet to comply with the recommendations for the maximum length of a turn lane in ODOT's L&D Manual, Volume 1.

Table 2. Calculated Left-Turn Lane Lengths

Movement	Approach Lane Configuration	Cycle Length (s)	Calculated Storage (feet)		Calculated Through Blockage (feet)		Proposed Turn Lane Length (feet)
			AM	PM	AM	PM	
EBL	L-TR	90	125	175	375	750	650
WBL	L-TR	90	125	125	775	450	650

The proposed length of each left-turn lane was not selected based on the calculated through blockage lengths in an effort to minimize impacts to adjacent properties and to reduce construction cost.

7 Capacity Analysis

A capacity analysis is the primary method for evaluating the efficiency of a roadway or intersection as it relates to vehicular traffic. The Highway Capacity Manual, published by the Transportation Research Board, outlines capacity analysis procedures and criteria for evaluating the operations of unsignalized and signalized intersections.[1] The criteria for evaluating the operation of an intersection are measured in terms of LOS, a qualitive measure, and control delay per vehicle. There are six levels of service, designated by the letters A through F. LOS A represents the best operating conditions, and LOS F represents the worst operating conditions. An overall intersection LOS of A through D is generally considered acceptable for ODOT projects. LOS criteria are listed in Table 3.

Table 3. Level of Service Criteria for Signalized Intersections

Level of Service	Signalized Intersection Delay (seconds)
A	≤ 10
B	> 10–20
C	> 20–35
D	> 35–55
E	> 55–80
F	> 80 or Volume-Capacity Ratio > 1.0

The existing conditions, no-build conditions, and build conditions capacity analyses were conducted using Highway Capacity Software (HCS).

7.1 Data Collection and Design Hourly Traffic Volumes

The traffic volume data necessary to complete the capacity analysis were obtained from two sources. ODOT District 12 collected turning movement count (TMC) data on June 2, 2022. The data captured the a.m. and p.m. peak hours, which are 6:15 a.m. to 7:15 a.m. and 4:45 p.m. to 5:45 p.m., respectively. The Northeast Ohio Areawide Coordinating Agency's (NOACA's) Travel Demand Model identified a 0.3 percent background linear growth rate.

To develop the a.m. and p.m. design hourly traffic volumes (DHV), the 2022 a.m. and p.m. peak hour TMCs were rounded up to the nearest five vehicles and forecasted to 2027 and 2047 using the 0.3 percent background linear growth rate provided by NOACA. The truck percentage on U.S. 422 is 10 percent eastbound and 12 percent

[1] Transportation Research Board. 2016. Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis.

westbound. Copies of the 2022 TMC data and the growth rate information provided by NOACA are included in Appendix C, along with 2022, 2027, and 2047 DHVs.

7.2 Existing Conditions Capacity Analysis

A traffic capacity analysis was conducted to evaluate the existing intersection operations. The analysis used the existing 90 second cycle length, the protected eastbound left-turn phase (without a dedicated left turn lane) during the p.m. peak hour, and the U.S. 422 phases set to max during the a.m. peak hour. The results of the analysis are presented in Table 4.

As shown in the table, overall, the intersection operates at LOS B in the a.m. and p.m. peak hours. Although the overall intersection LOS is acceptable, the 95th percentile queue is almost 300 feet long on U.S. 422 westbound during the a.m. peak hour and approximately 300 feet long on U.S. 422 eastbound during the p.m. peak hour. The HCS output is included in Appendix D.

Table 4. Existing Conditions (2022) Capacity Analysis Results

Intersection	Movement	AM			PM		
		LOS	Delay (seconds)	Average Queue Length (feet)	LOS	Delay (seconds)	Average Queue Length (feet)
U.S. 422 and Rapids Road	Eastbound	A	3.4	60	B	11.1	294
	Westbound	A	10.0	281	A	8.9	207
	Northbound	D	40.2	47	D	39.4	31
	Southbound	D	41.4	70	D	41.8	87
	Overall	B	10.5		B	12.6	

7.3 No-Build Conditions Capacity Analysis

A traffic capacity analysis was conducted to evaluate future intersection operations assuming no improvements are implemented based on traffic volumes forecasted to 2047. The analysis used the same signal timing as discussed in Section 7.2. The results of the analysis are presented in Table 5.

As shown in the table, overall, the intersection operates at LOS B in the a.m. and p.m. peak hours. The 95th percentile queue increases to 450 feet on U.S. 422 westbound during the a.m. peak hour and to almost 400 feet on U.S. 422 eastbound during the p.m. peak hour. Overall, traffic operations will deteriorate slightly as traffic volumes in the study area increase. The HCS output is included in Appendix D.

Table 5. No-Build Conditions (2047) Capacity Analysis Results

Intersection	Movement	AM			PM		
		LOS	Delay (seconds)	Average Queue Length (feet)	LOS	Delay (seconds)	Average Queue Length (feet)
U.S. 422 and Rapids Road	Eastbound	A	4.4	89	C	20.5	374
	Westbound	B	17.0	447	B	10.8	259
	Northbound	D	40.1	78	D	39.4	61
	Southbound	D	43.3	107	D	47.1	132
	Overall	B	16.0		B	19.8	

7.4 Build Conditions Capacity Analysis

A traffic capacity analysis was conducted to evaluate future intersection operations with the addition of the proposed left-turn lanes on U.S. 422. The analysis used the same signal timing as discussed in Section 7.2. The results of the analysis are presented in Table 6.

As shown in the table, the intersection operates at LOS B in the a.m. and p.m. peak hours and the overall delay decreases slightly. The 95th percentile queue on U.S. 422 westbound decreases approximately 50 feet during the a.m. peak hour and the 95th percentile queue on U.S. 422 eastbound decreases approximately 50 feet during the p.m. peak hour.

Table 6. Build Conditions (2047) Capacity Analysis Results

Intersection	Movement	AM			PM		
		LOS	Delay (seconds)	Average Queue Length (feet)	LOS	Delay (seconds)	Average Queue Length (feet)
U.S. 422 and Rapids Road	Eastbound Left	C	25.0	26	A	4.8	10
	Eastbound Through	A	3.7	71	B	12.8	338
	Westbound Left	A	4.1	<10	B	18.6	11
	Westbound Through	B	16.1	406	A	9.4	230
	Northbound	D	41.2	79	D	40.4	62
	Southbound	D	46.5	113	D	52.7	143
	Overall	B	15.9		B	14.9	

The HCS analysis results for 2047 are included in Appendix D.

8 Conceptual Estimate of Probable Cost

A conceptual estimate of probable cost to implement the proposed improvements was prepared using ODOT historical bid prices. The estimates include the cost for design, right-of-way, and construction. Estimated construction costs were developed using estimated quantities for items that would be needed for or impacted by implementation of the recommended improvements.

The following assumptions were utilized in developing the conceptual estimate of probable cost:

- Unit prices for all items were estimated based on ODOT's Historical Bid Data Item Search (2019-2022)
- A 30 percent design contingency was selected based on the Procedures for Budget Estimating.
- The rate of inflation was calculated using the ODOT Office of Estimating Fiscal Year 2023–2027 Business Plan Inflation Calculator. Based on a construction midpoint of June 2023, a 5 percent rate of inflation (to the assumed midpoint of construction) was assumed.

The total 2023 conceptual estimate of probable construction cost (with inflation) is $902,016. The total project cost includes $80,000 for preliminary engineering, 90,000 for final design, and $100,000 for right-of-way acquisition. Therefore, the total project cost is $1,202,016. A detailed cost estimate is included in Appendix F.

9 Safety Benefit

The safety benefit associated with the proposed improvements discussed in Section 8 was analyzed. The American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) is used to determine how an intersection is performing compared to similar locations.[2] It is also used to assess the safety benefits of proposed improvements. The HSM Part C discusses use of a predictive model for this type of analysis. The predictive method estimates the predicted crash frequency ($N_{predicted}$) together with observed crash frequency to estimate the expected crash frequency ($N_{expected}$). The difference between predicted and expected crash frequency is explained below.

$N_{predicted}$ is the anticipated (predicted) crash frequency, which describes how a location is expected to perform relative to similar sites. The calculation of $N_{predicted}$ uses Safety Performance Functions to determine a base condition and applies crash modification factors to account for site-specific features that differ from the base condition. The final value is multiplied by a calibration factor specific to Ohio to normalize the base condition. $N_{expected}$ is the estimated expected average crash frequency at a site for a given time period. The calculation of $N_{expected}$ uses the Empirical Bayes method to combine actual crash frequency with $N_{predicted}$. The difference between $N_{predicted}$ and $N_{expected}$ is the "expected excess crashes." If $N_{expected}$ is greater than $N_{predicted}$, the location may benefit from a safety improvement. If $N_{expected}$ is less than $N_{predicted}$, the site is experiencing fewer crashes than similar sites.

ODOT's Economic Crash Analysis Tool (ECAT) was used to calculate $N_{predicted}$ and $N_{expected}$. The existing conditions (traffic control, presence of a median, number of lanes, intersection control, lighting, presence of driveways) were input into ECAT. The proposed conditions match the existing conditions with the addition of an eastbound and a westbound left-turn lane to determine the reduction in crashes that can be expected and to

[2] AASHTO. 2010. Highway Safety Manual. First Edition.

perform a benefit-cost analysis for the proposed improvements. Complete ECAT results are included in Appendix G.

Table 7 presents a comparison of existing intersections ($N_{expected\ existing}$) to similar intersections ($N_{predicted\ existing}$) and to the proposed improvements ($N_{predicted\ proposed}$). The table shows that if the proposed improvements are implemented, the frequency of injury and PDO crashes is predicted to decrease and the overall crash frequency may decrease by three crashes per year.

Table 7. Proposed Improvements – ECAT Analysis Results Summary

Crashes	KA	B	C	O	Total
$N_{predicted}$ (Existing Conditions)	0.3	1.2	1.6	9.4	12.5
$N_{expected}$ (Existing Conditions)	0.3	1.0	1.3	6.8	9.4
$N_{Potential\ for\ Improvement}$ (Existing Conditions)	-0.1	-0.2	-0.3	-2.6	-3.1
$N_{predicted}$ (Proposed Conditions)	0.2	0.9	1.2	7.0	9.3

ODOT's ECAT was also used to compare the cost to construct the proposed improvements to the anticipated safety benefit. The results of the benefit-cost analysis are shown in Table 8.

Table 8. Proposed Improvements Benefit-Cost Summary

Value	Result
Expected Annual Crash Adjustment	3.23
Net Present Value of the Build Alternative	$1,202,016
Net Present Value of Safety Benefit	$1,453,785
Benefit-Cost Ratio	**0.98**

The proposed improvements show a benefit-cost ratio just below 1.

10 Conclusions and Recommendations

ODOT's ECAT was used to calculate the reduction in crashes that can be expected if eastbound and westbound left-turn lanes are constructed on U.S. 422 and to perform a benefit-cost analysis based on the safety benefit. A benefit-cost ratio greater than 1 indicates a positive return on investment.

The benefit-cost ratio for the proposed improvements is just below 1. If implemented, the proposed improvements are predicted to provide a sufficient safety benefit to justify the cost of construction. It is recommended that the proposed improvements be constructed.

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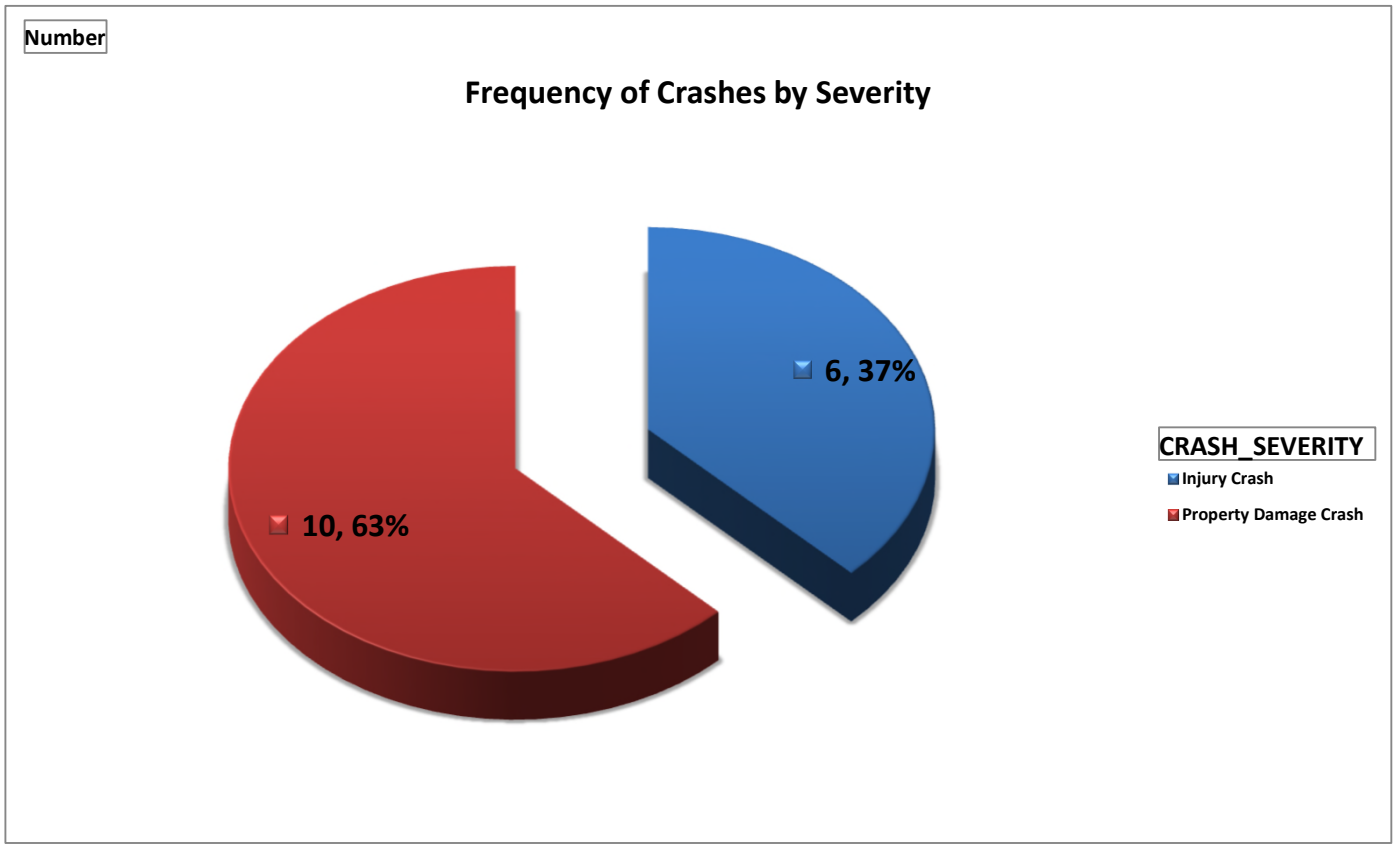
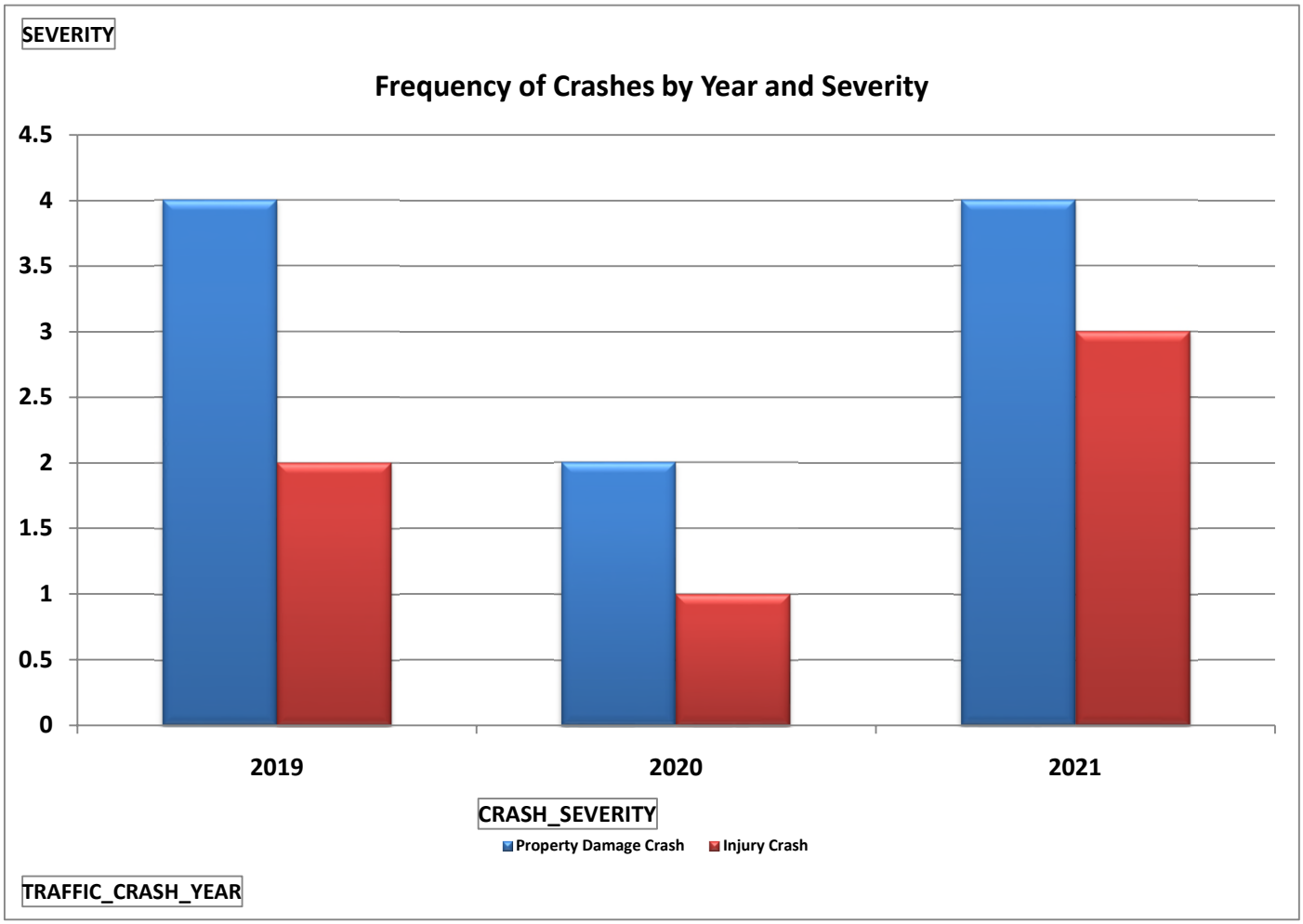
APPENDIX A

Crash Analysis Module Tool Results

US 422 at Rapids Road





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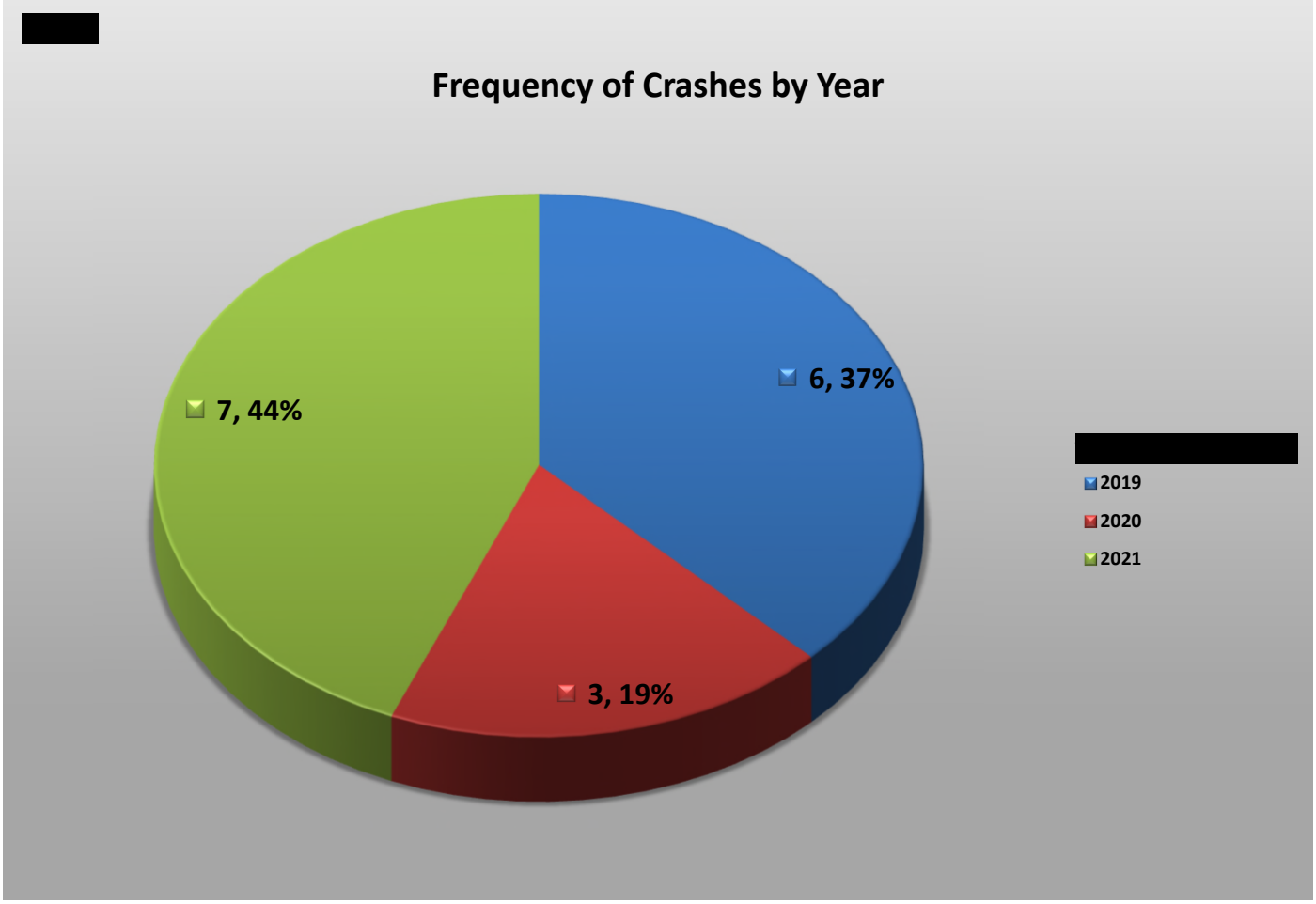

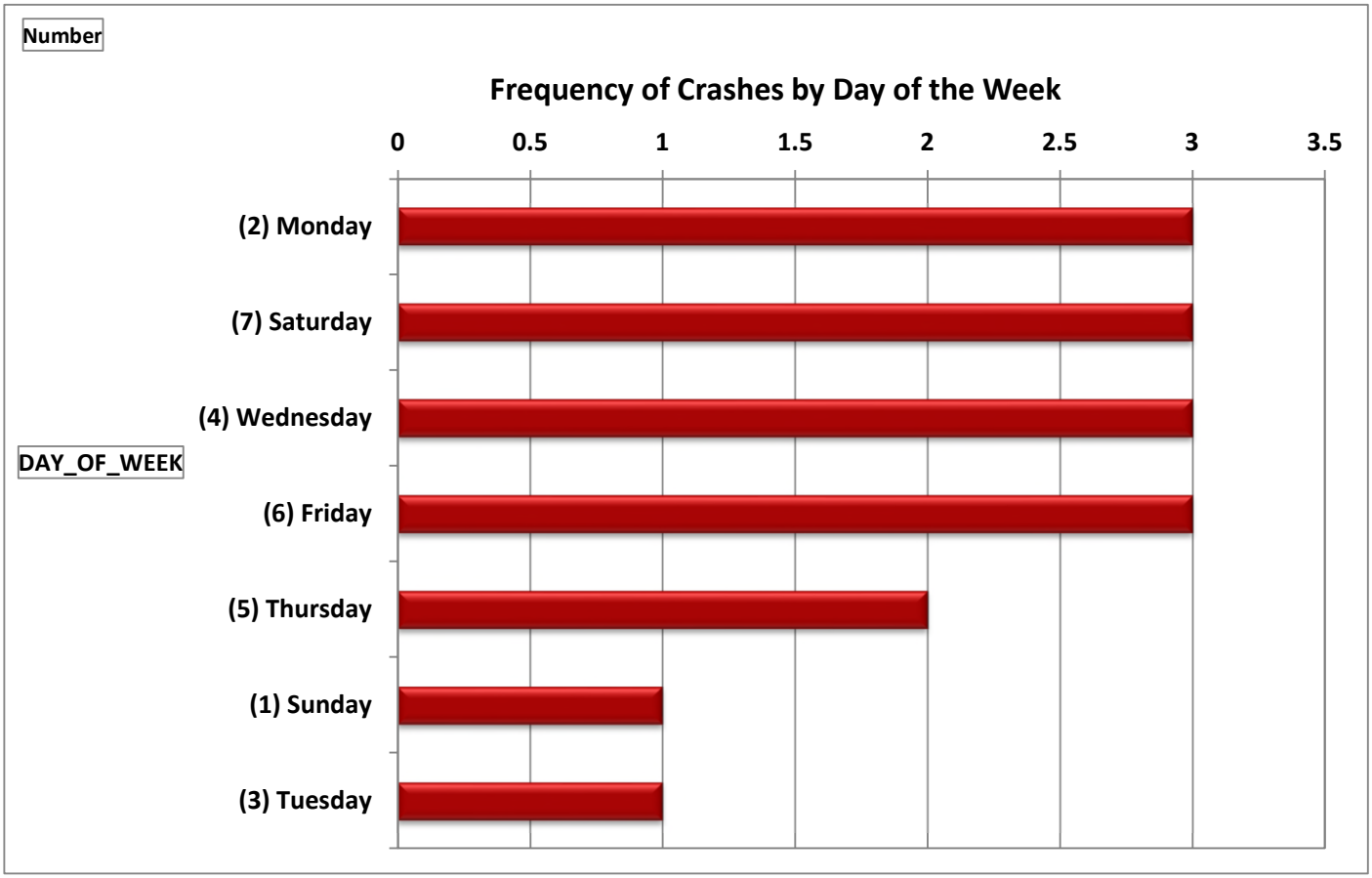

US 422 at Rapids Road

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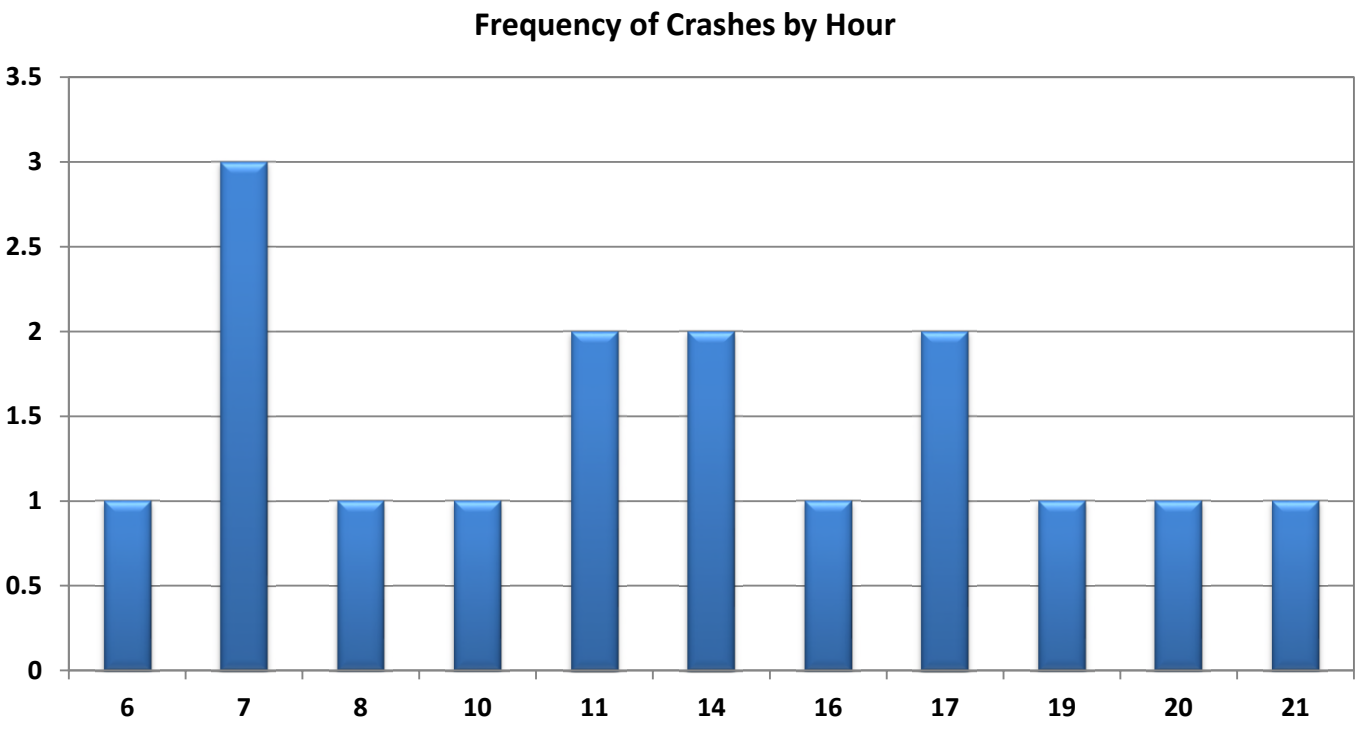

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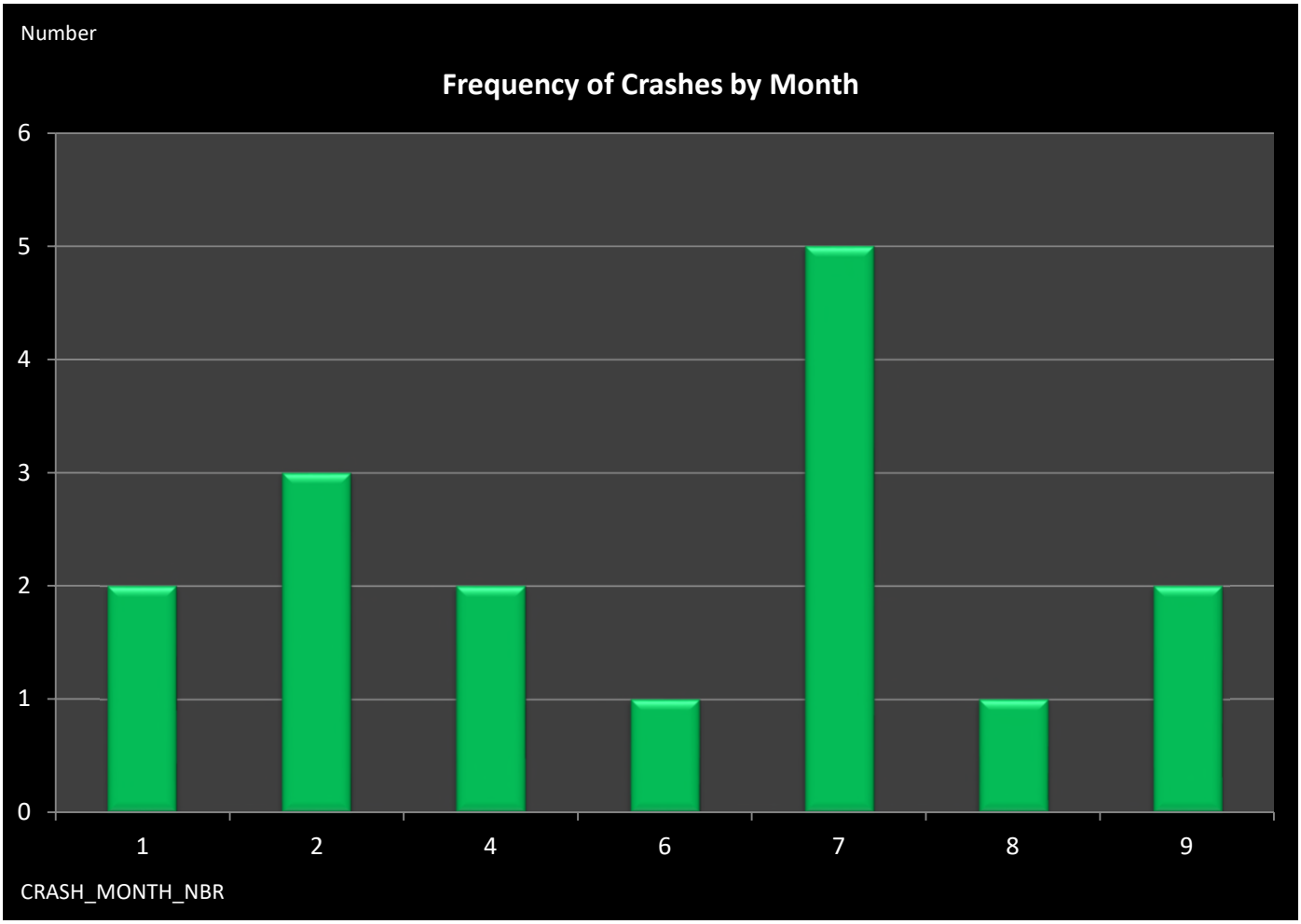
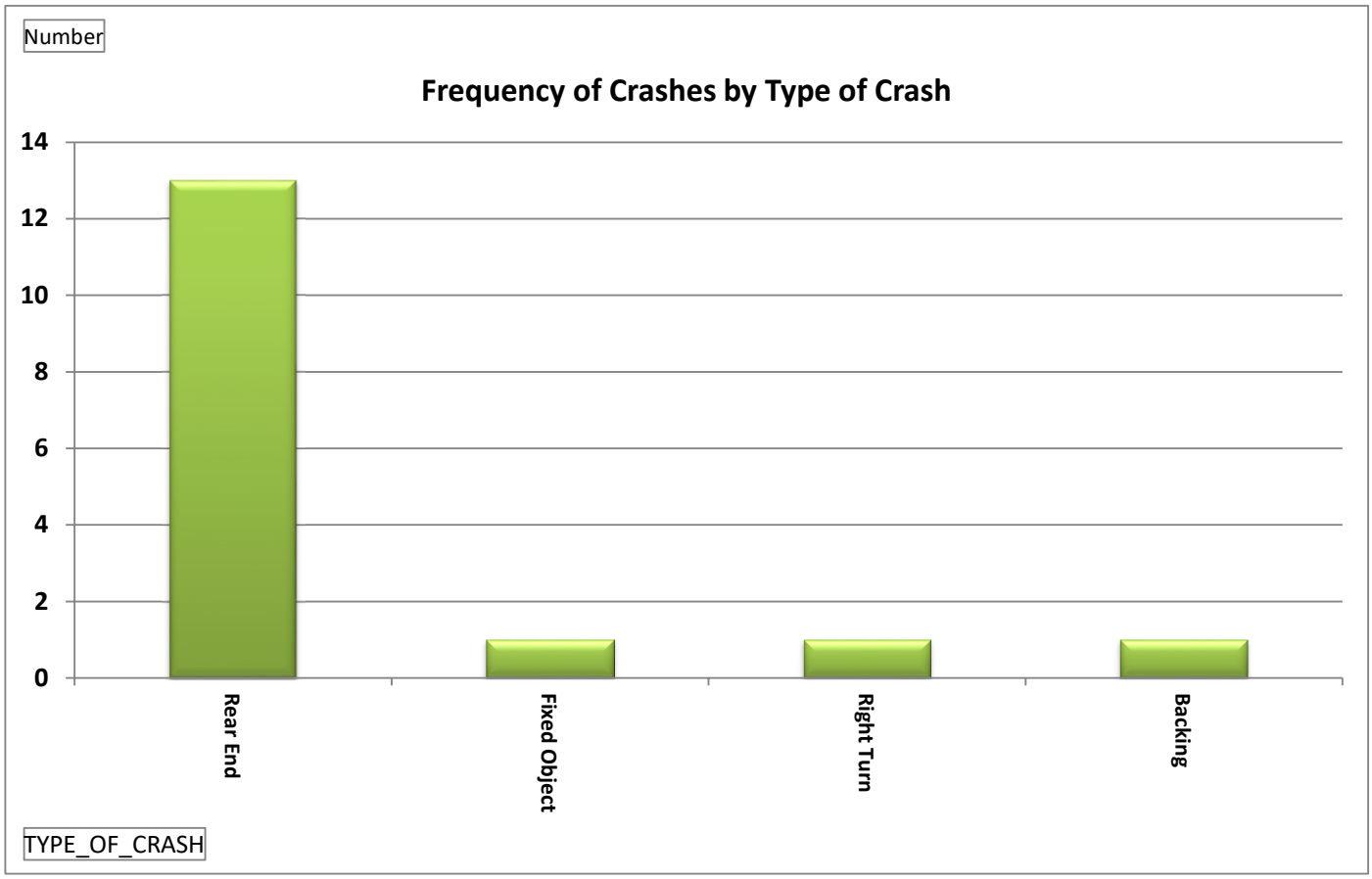
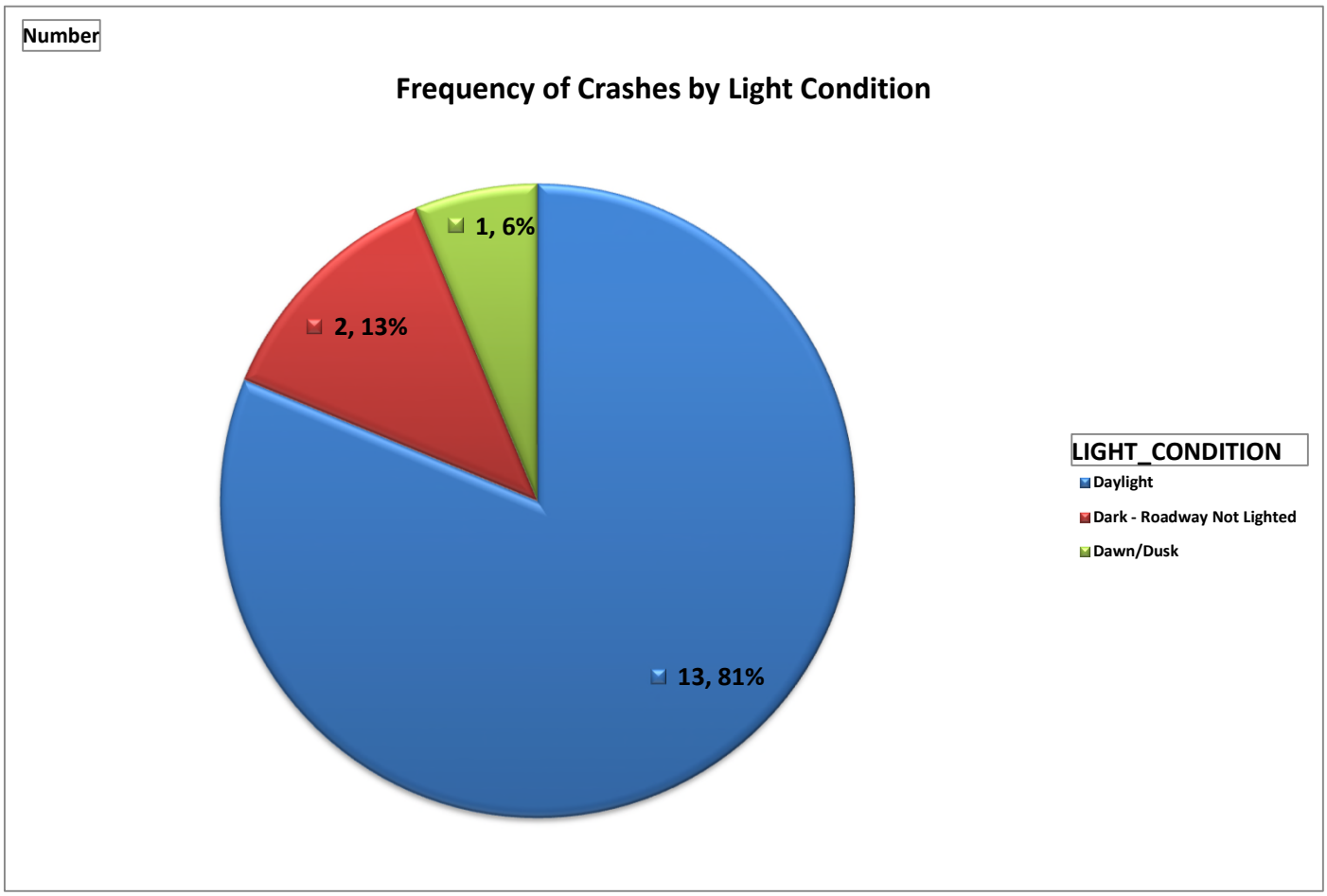
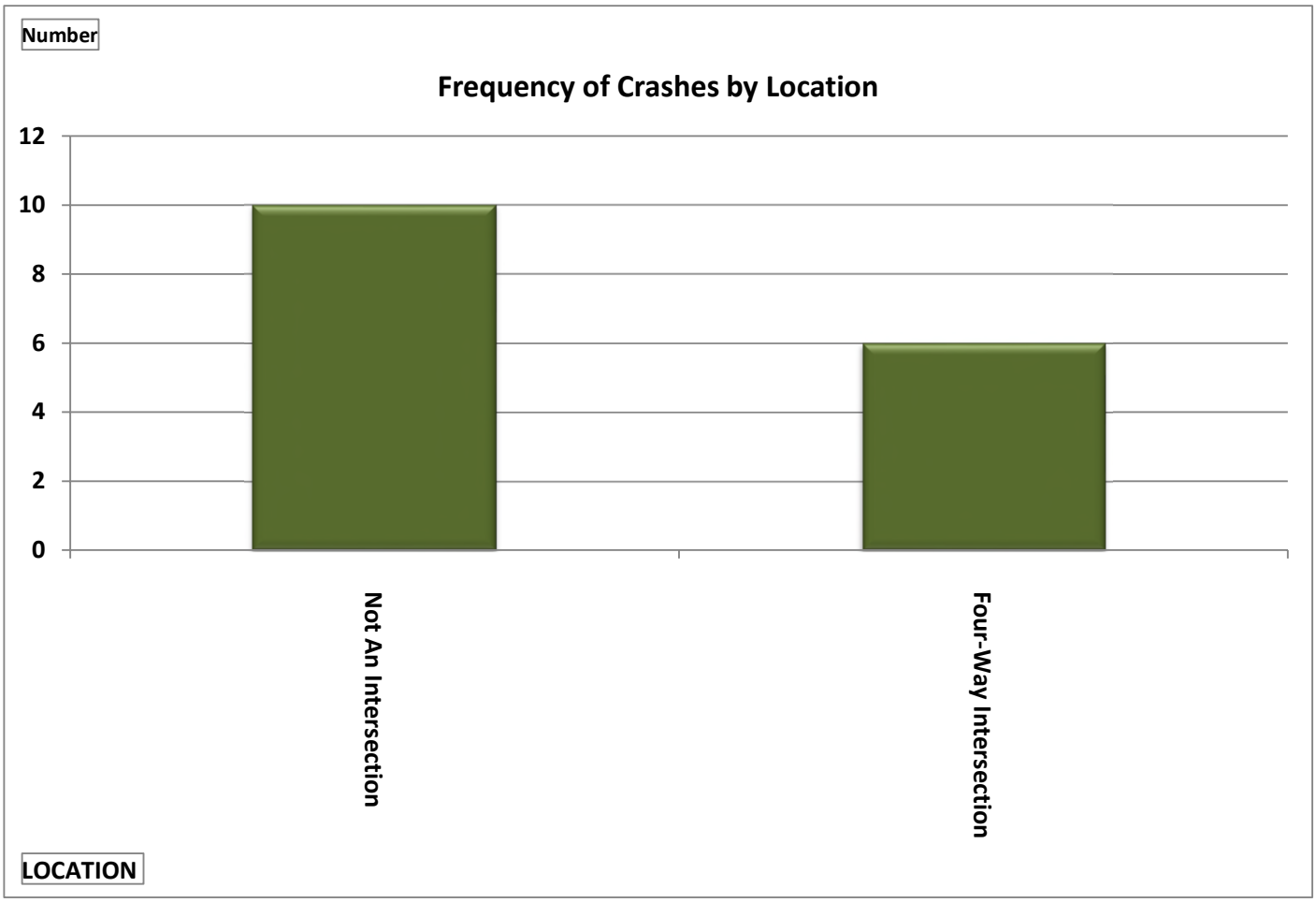


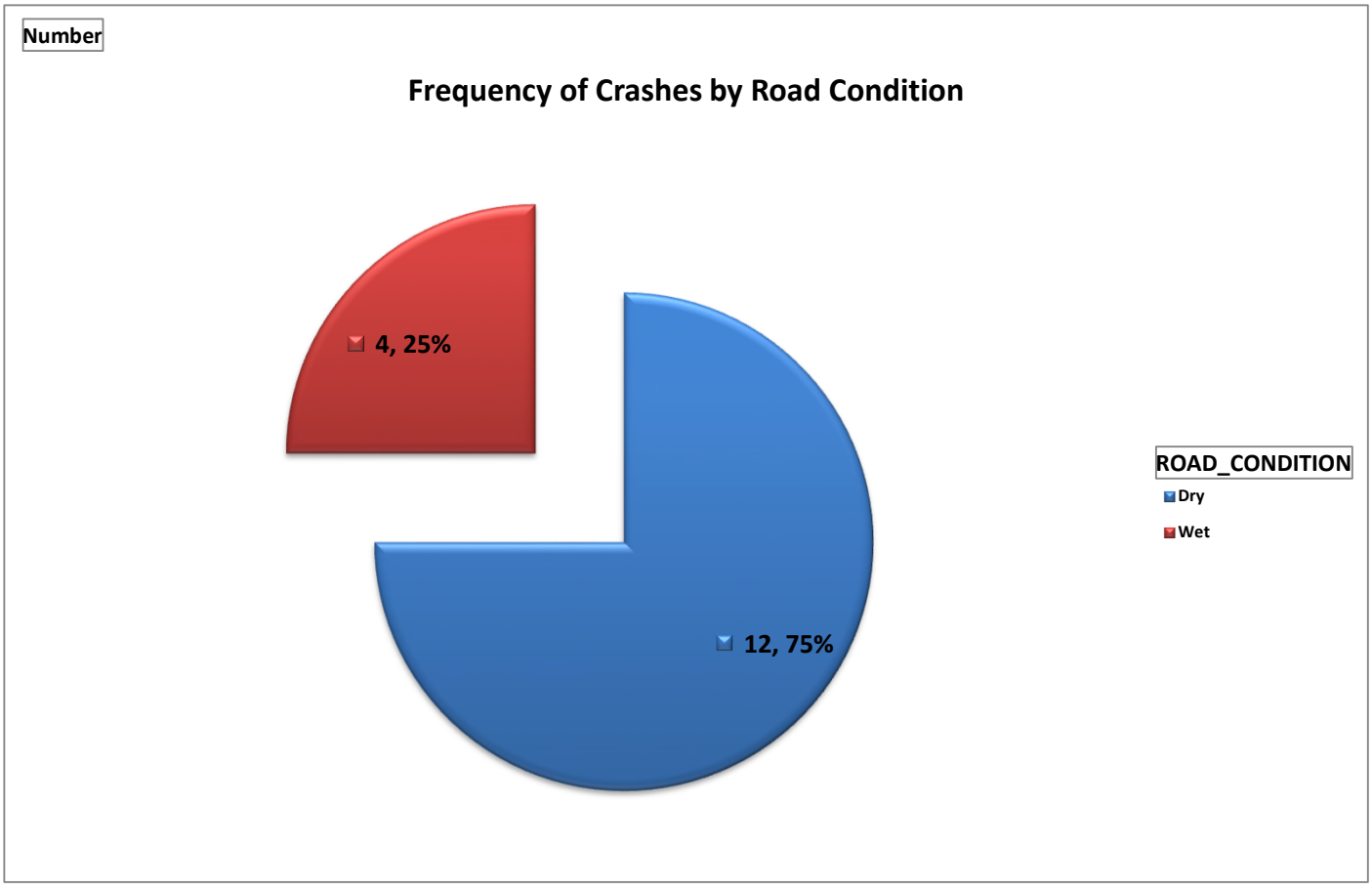
US 422 at Rapids Road



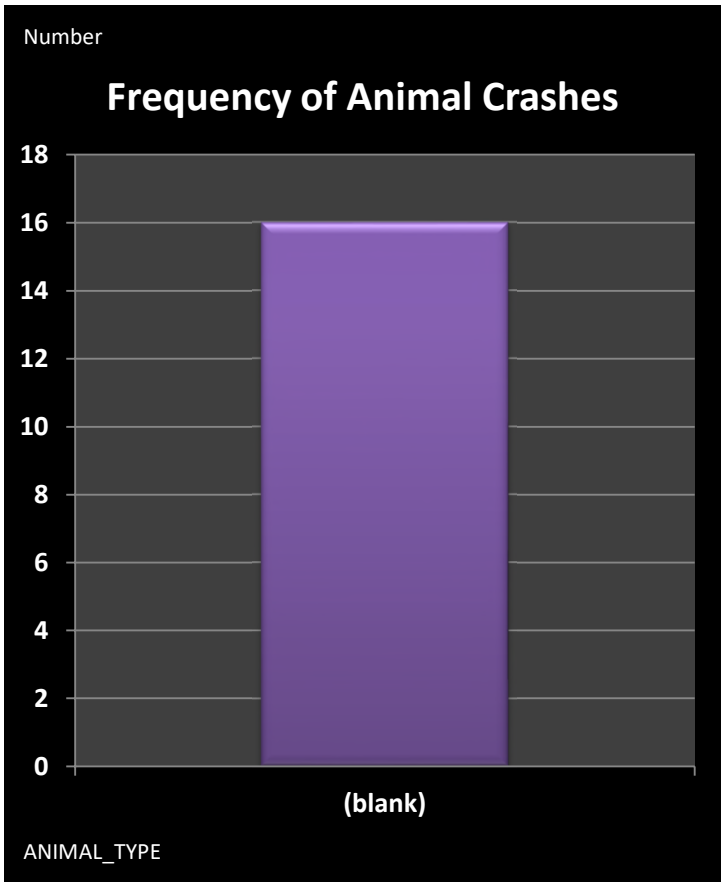


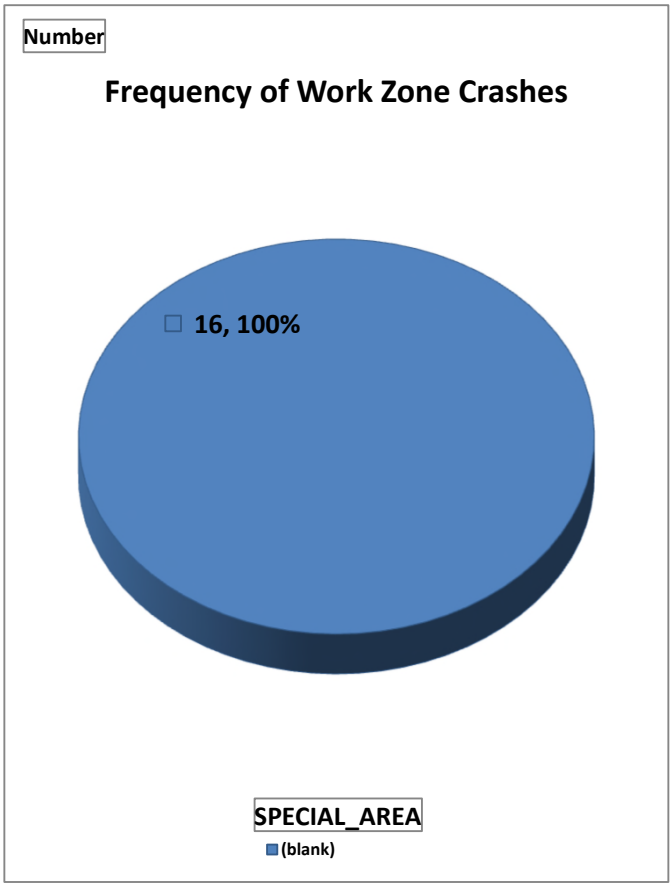
US 422 at Rapids Road

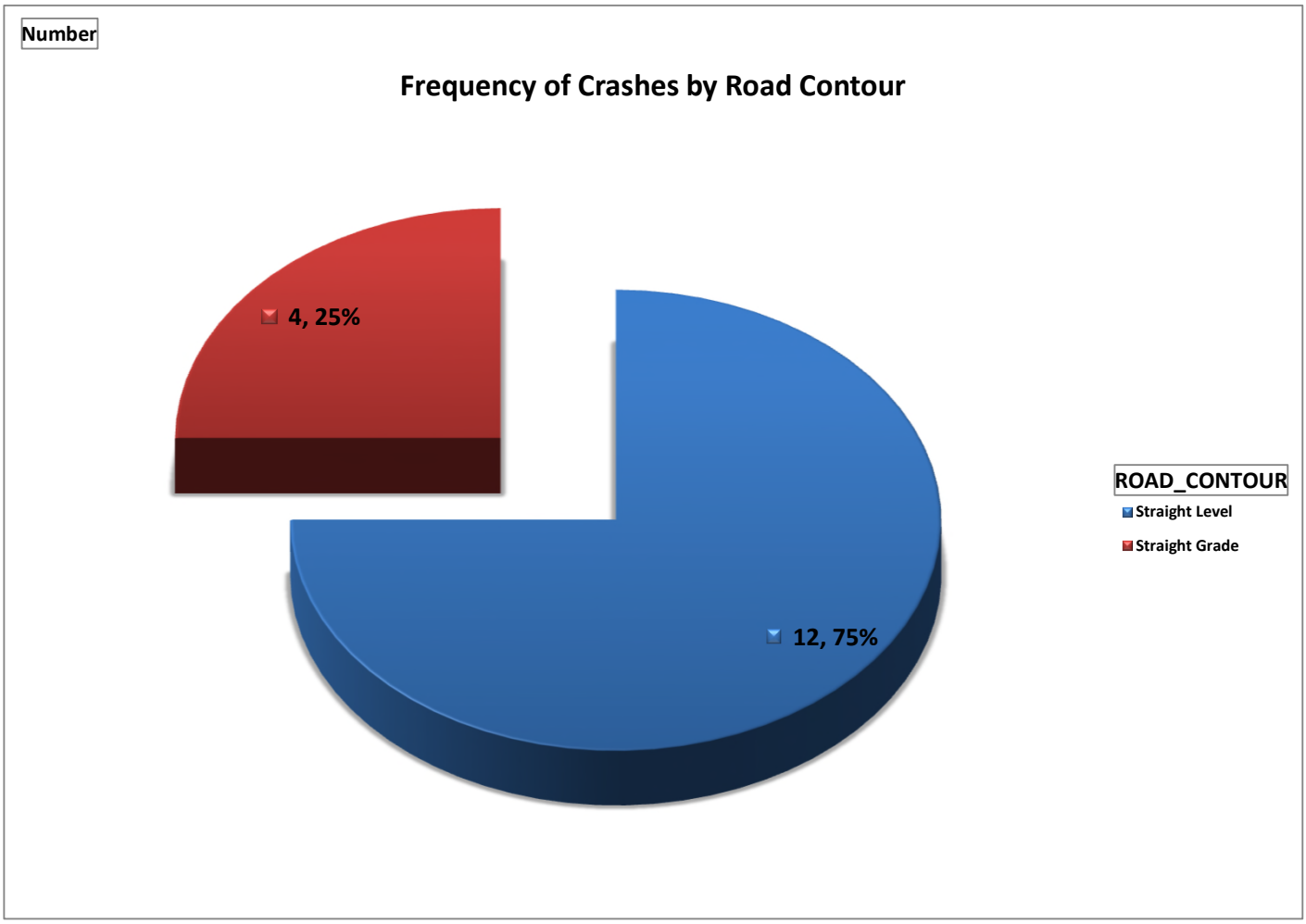




US 422 at Rapids Road

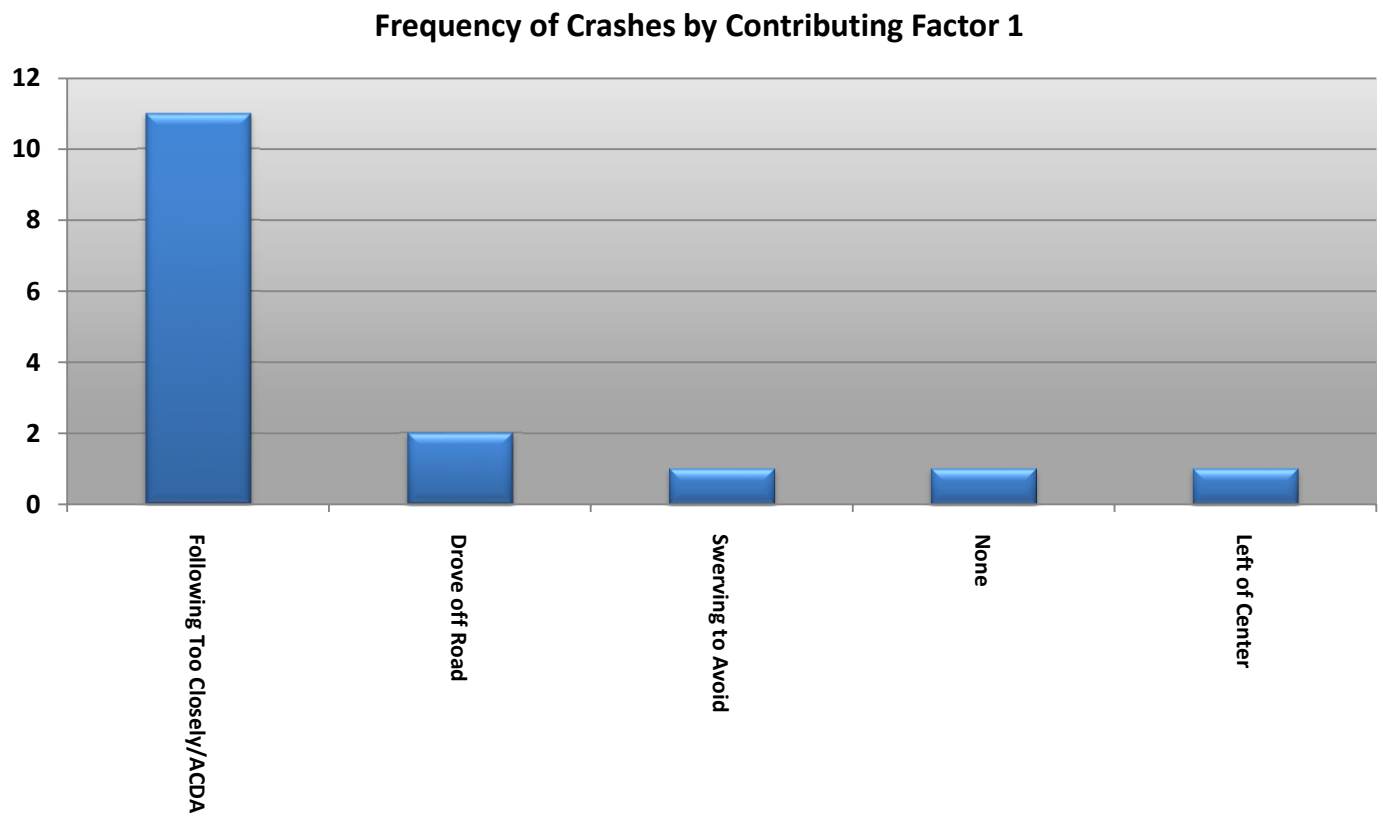






US 422 at Rapids Road

[redacted]



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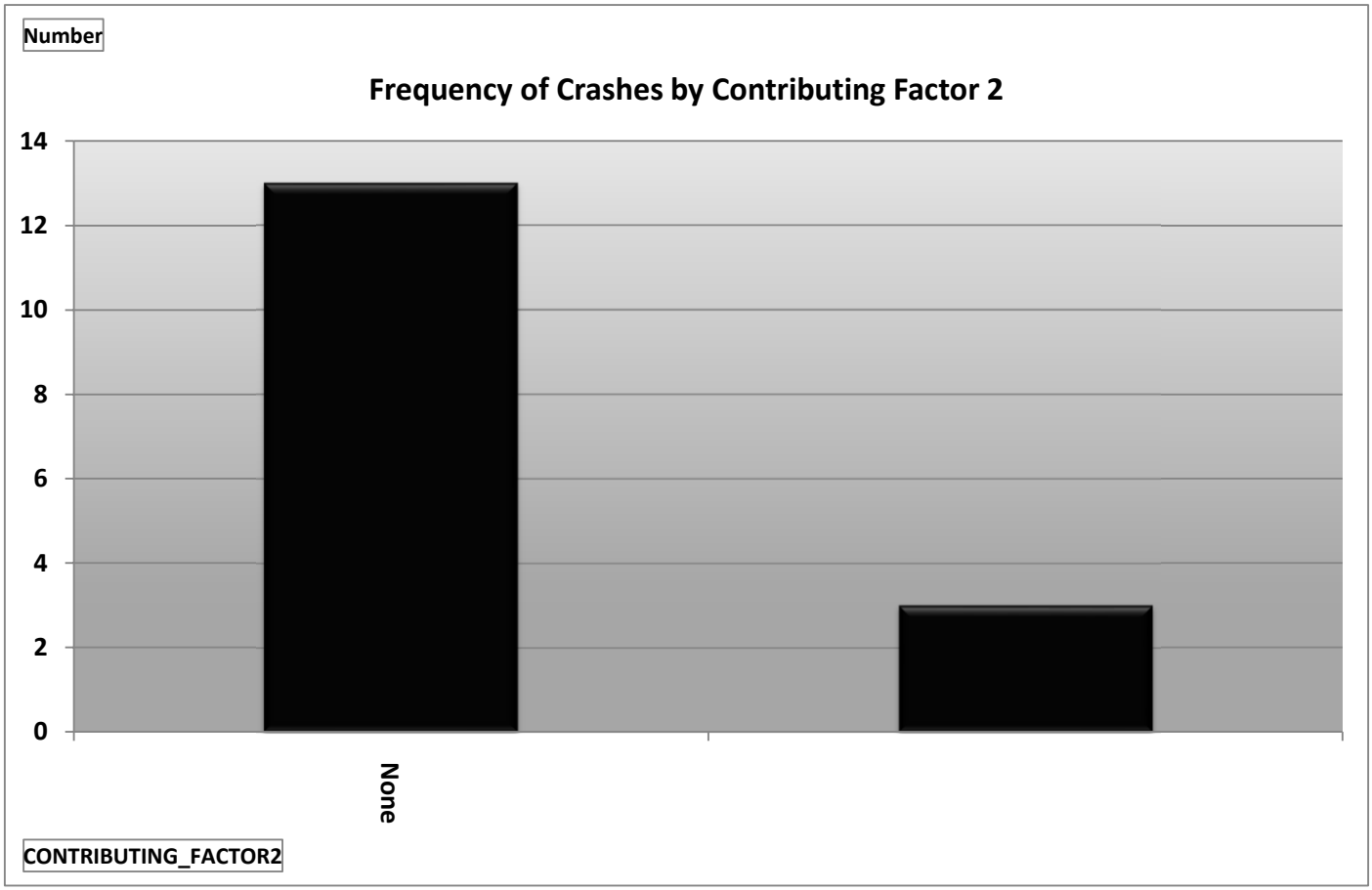
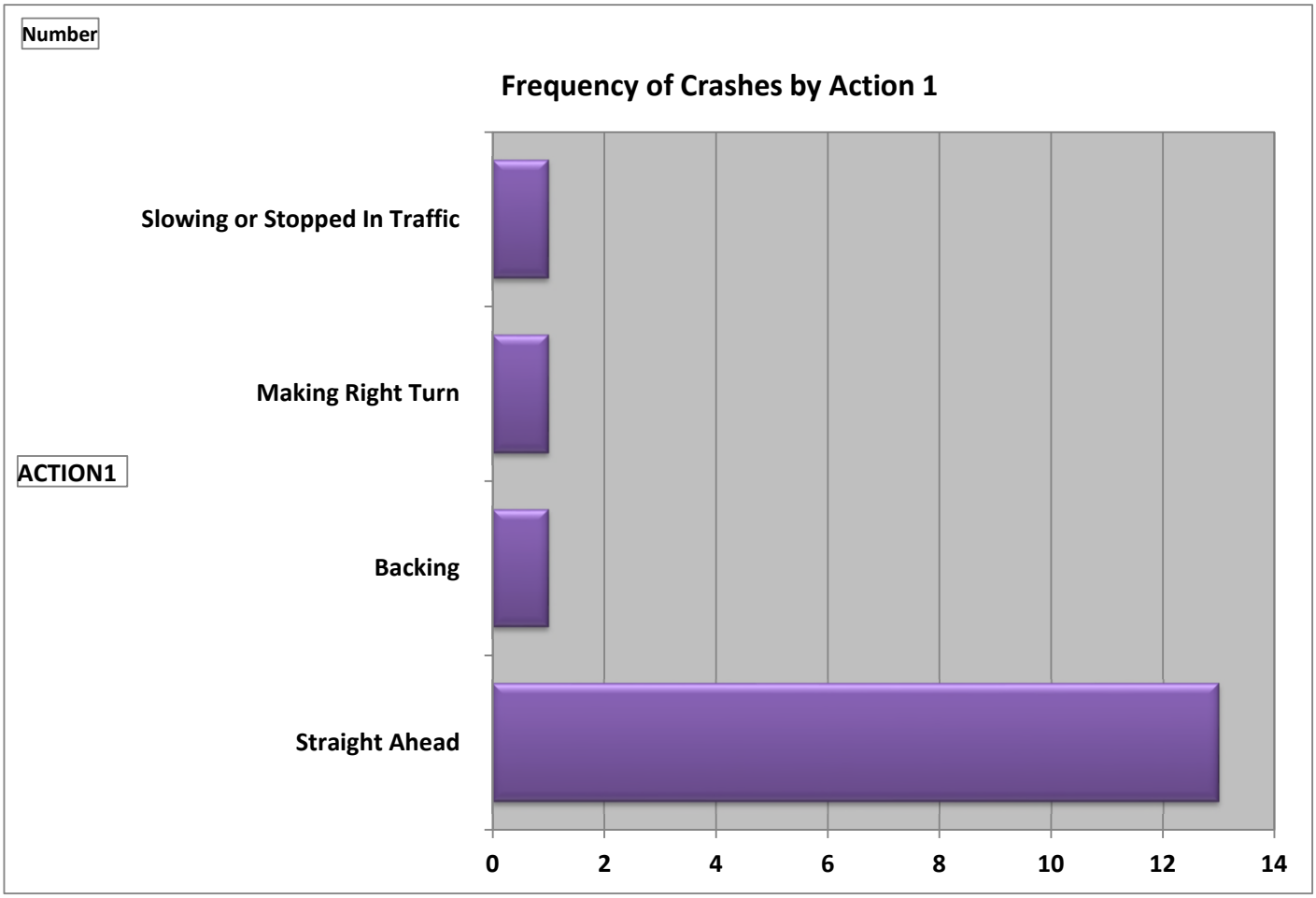
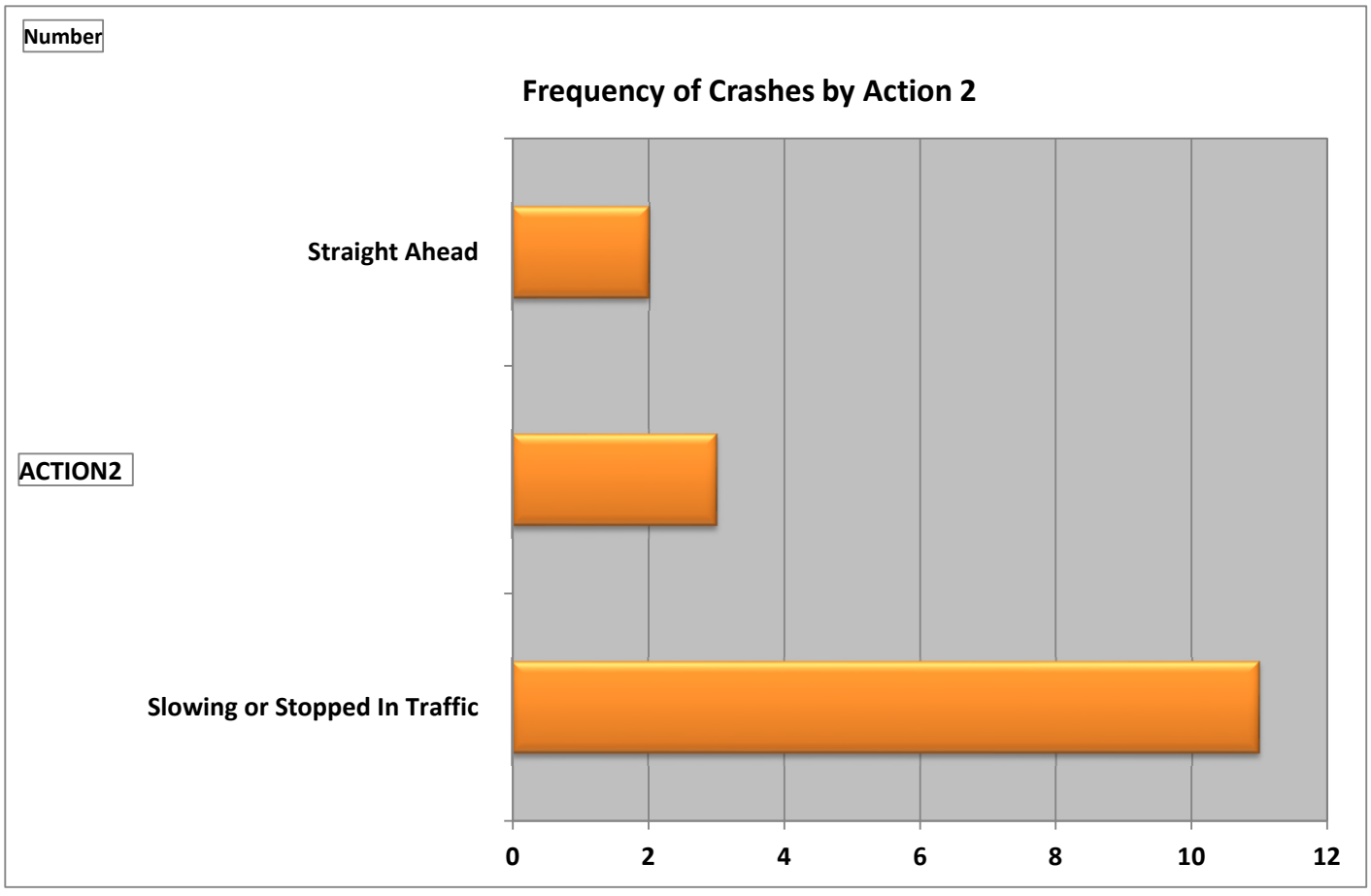
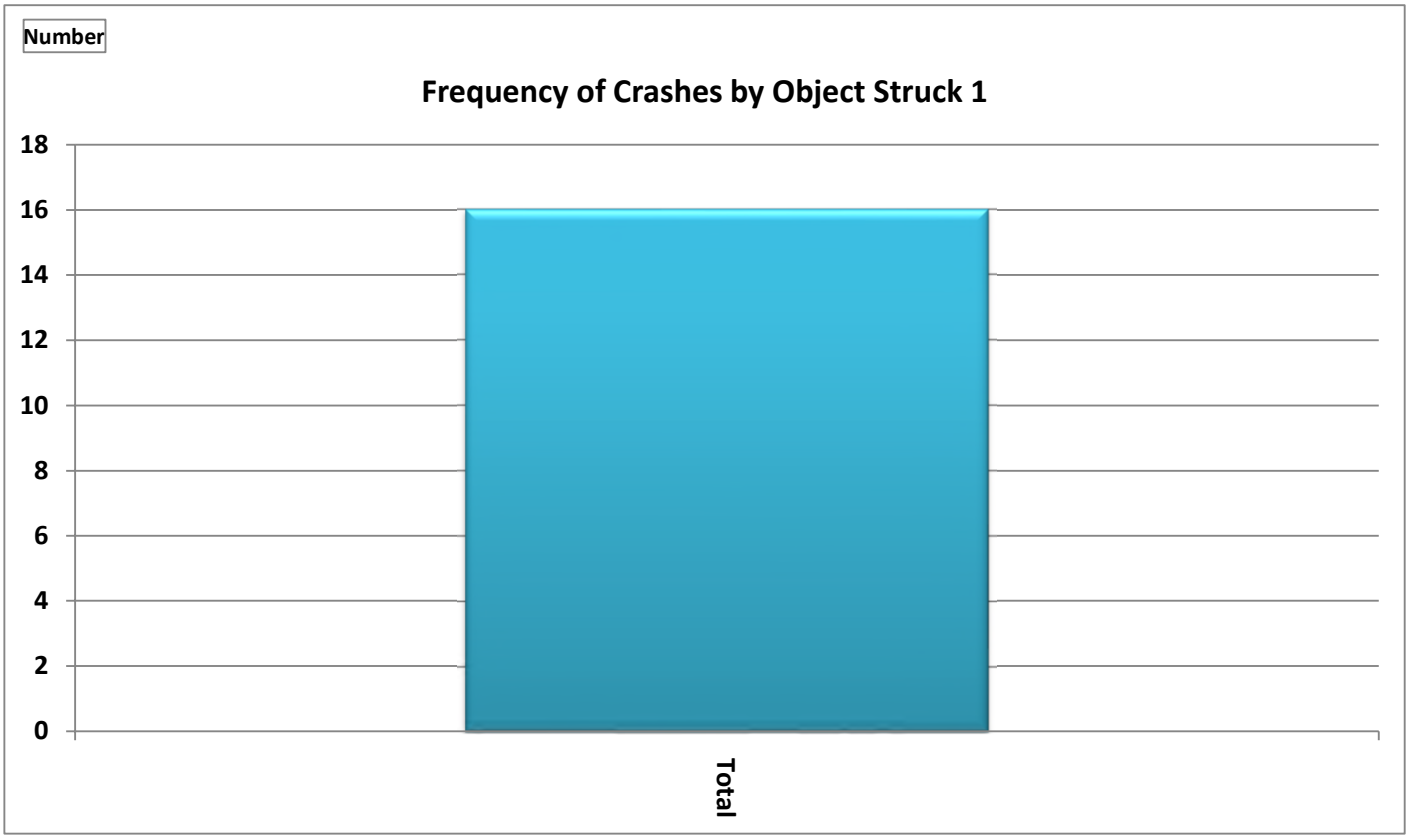


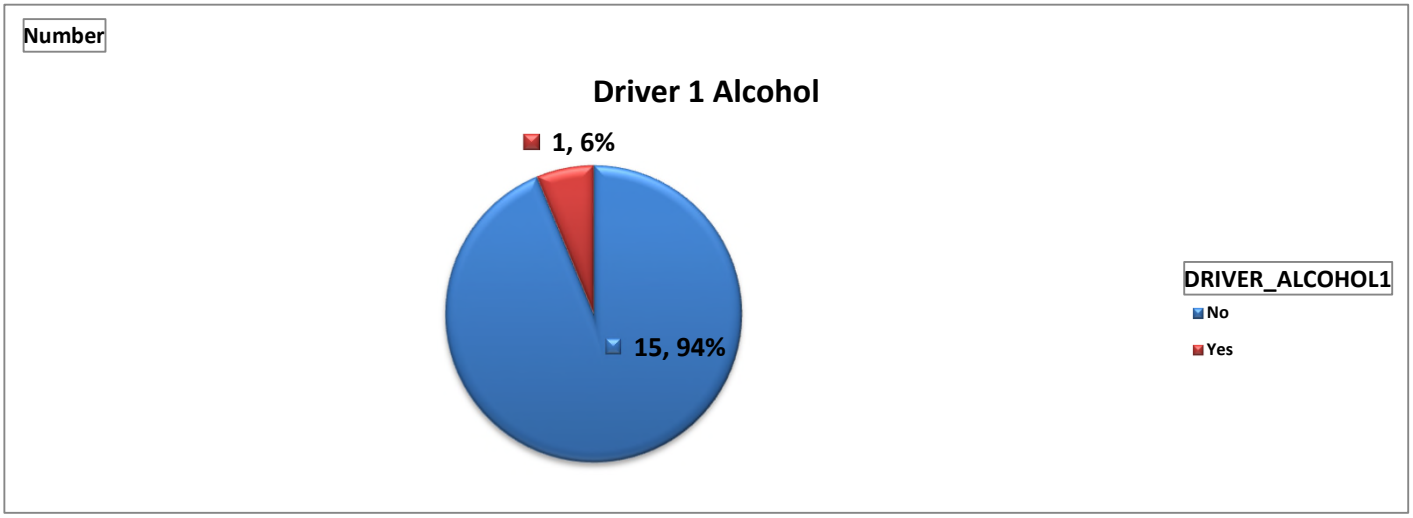
US 422 at Rapids Road

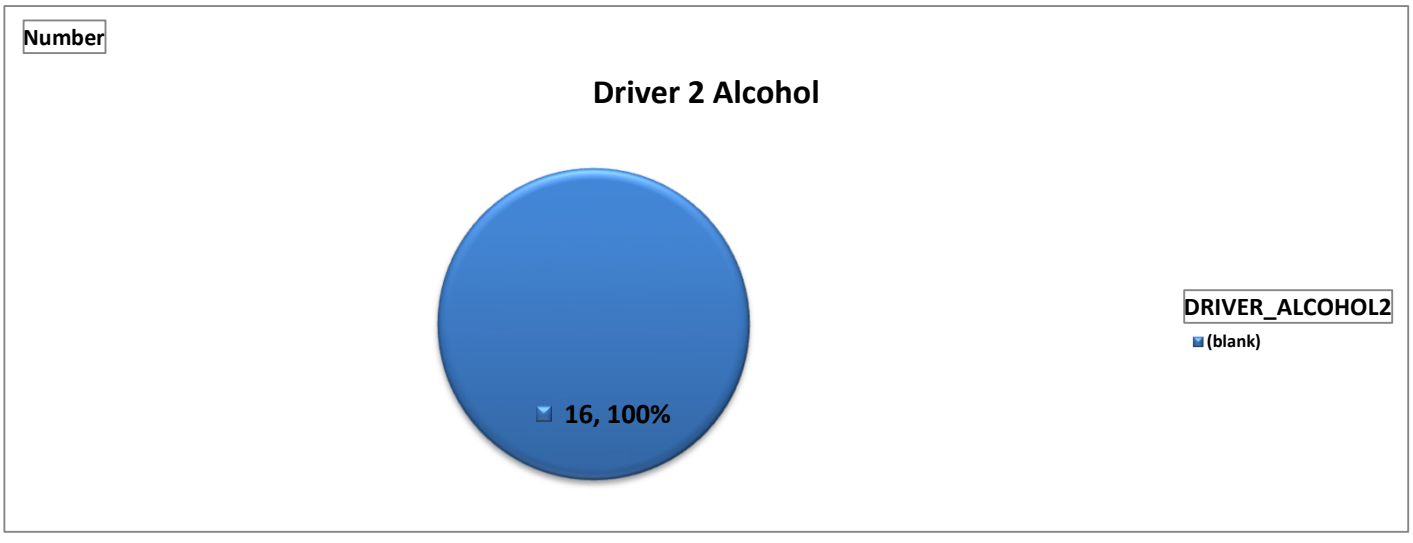




US 422 at Rapids Road







Select Site Type	Int/Rur; 4-leg signalized

Crash Severity	Site Average		Statewide Average
	Total (2019-2021)	Total (%)	Total (%)
Fatal Crash	0	0.00%	0.33%
Serious Injury Suspected Crash	1	6.25%	2.84%
Minor Injury Suspected Crash	2	12.50%	11.13%
Injury Possible Crash	3	18.75%	11.29%
Property-Damage-Only	10	62.50%	74.42%
Total	**16**		

Crashes by Crash Type				
	Total (%)		Fatal & All Injury (%)	
Crash Type	Site Average	Statewide Average	Site Average	Statewide Average
Unknown	0.00%	0.16%	0.00%	0.05%
Head On	0.00%	2.38%	0.00%	4.39%
Rear End	81.25%	33.94%	81.25%	32.42%
Backing	6.25%	7.97%	6.25%	0.61%
Sideswipe - Meeting	0.00%	0.67%	0.00%	0.44%
Sideswipe - Passing	0.00%	6.53%	0.00%	3.10%
Angle	0.00%	14.91%	0.00%	26.43%
Parked Vehicle	0.00%	3.06%	0.00%	0.85%
Pedestrian	0.00%	0.80%	0.00%	2.79%
Animal	0.00%	2.64%	0.00%	0.31%
Train	0.00%	0.04%	0.00%	0.00%
Pedalcycles	0.00%	0.42%	0.00%	0.99%
Other Non-Vehicle	0.00%	0.00%	0.00%	0.00%
Fixed Object	6.25%	6.85%	6.25%	5.03%
Other Object	0.00%	0.24%	0.00%	0.00%
Falling From Or In Vehicle	0.00%	0.00%	0.00%	0.00%
Overturning	0.00%	0.40%	0.00%	0.85%
Other Non-Collision	0.00%	0.69%	0.00%	0.31%
Left Turn	0.00%	14.18%	0.00%	19.22%
Right Turn	6.25%	4.12%	6.25%	2.21%

Crashes by Light Conditions				
	Total (%)		Fatal & All Injury (%)	
Light Conditions	Site Average	Statewide Average	Site Average	Statewide Average
Daylight	81.25%	75.64%	81.25%	74.97%
Dawn/Dusk	6.25%	4.86%	6.25%	4.39%
Dark - Lighted Roadway	0.00%	10.32%	0.00%	10.27%
Dark - Roadway Not Lighted	12.50%	7.93%	12.50%	9.32%
Dark - Unknown Roadway Lighting	0.00%	0.28%	0.00%	0.24%
Other / Unknown	0.00%	0.97%	0.00%	0.81%

Crashes by Road Conditions				
	Total (%)		Fatal & All Injury (%)	
Road Conditions	Site Average	Statewide Average	Site Average	Statewide Average
Dry	70.59%	74.05%	70.59%	76.43%
Wet	23.53%	19.52%	23.53%	19.86%
Snow	0.00%	4.39%	0.00%	2.76%
Ice	0.00%	1.27%	0.00%	0.54%
Sand, Mud, Dirt, Oil, Gravel	0.00%	0.04%	0.00%	0.10%
Water (Standing, Moving)	0.00%	0.02%	0.00%	0.00%
Slush	0.00%	0.19%	0.00%	0.14%
Other / Unknown	5.88%	0.52%	5.88%	0.17%

APPENDIX B

Crash Diagram

LEGEND

TYPES OF COLLISIONS

REAR END

FIXED OBJECT

BACKING

RIGHT TURN

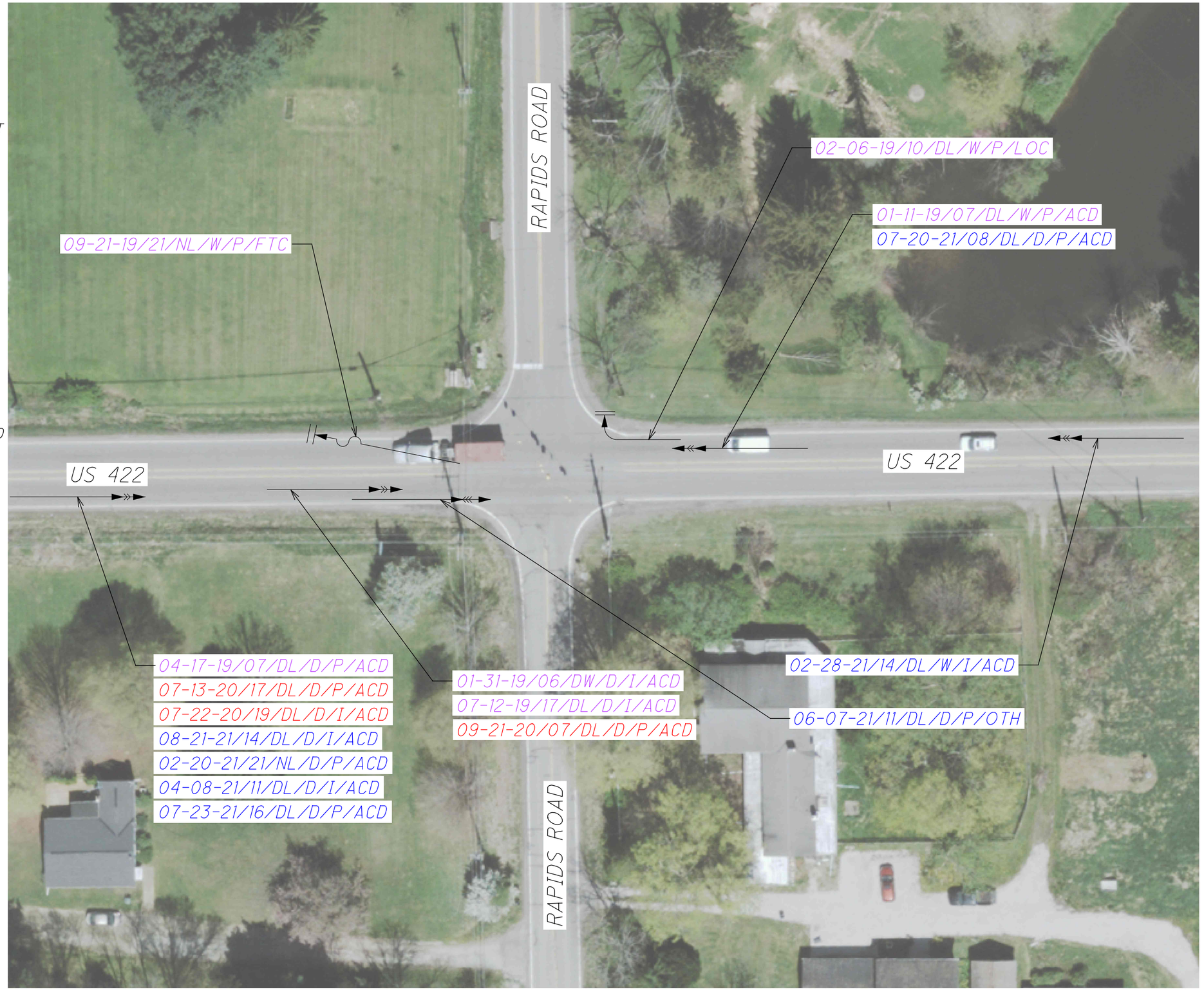
YEAR	LIGHT
2019	DL = DAYLIGHT
2020	LT = NIGHT LIGHTED
2021	NL = NIGHT NOT-LIGHTED
	DW = DAWN
	DK = DUSK

CONTRIBUTING FACTOR

ACD = ASSURED CLEAR DISTANCE
FTC = FAILURE TO CONTROL
LOC = LEFT OF CENTER
STA = SWERVING TO AVOID
OTH = OTHER

SEVERITY	ROAD
P = PROPERTY DAMAGE ONLY	D = DRY
I = INJURY	W = WET
F = FATALITY	S = SNOW
	I = ICE

DATE/HOUR/LIGHT/ROAD/
SEVERITY/CONTR FACTOR



NOT DRAW TO SCALE

CALCULATED QA
CHECKED JM

D12/D3 GES FY2022-2024 TRAFFIC
CRASH DIAGRAMS (2019-2021)

PID #115292

1-1

C:\Users\Qai\ARCADIS\D12 D3 GES FY2022:2024 Traffic - Documents\05 Project Execution\Task 1 - US

APPENDIX C

Traffic Volumes

APPENDIX C

Traffic Volumes - Turning Movement Counts

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Brian.Blayney@dot.state.oh.us
Office of Traffic Engineering

Count Name: GEA-422-11.56
Site Code:
Start Date: 06/02/2022

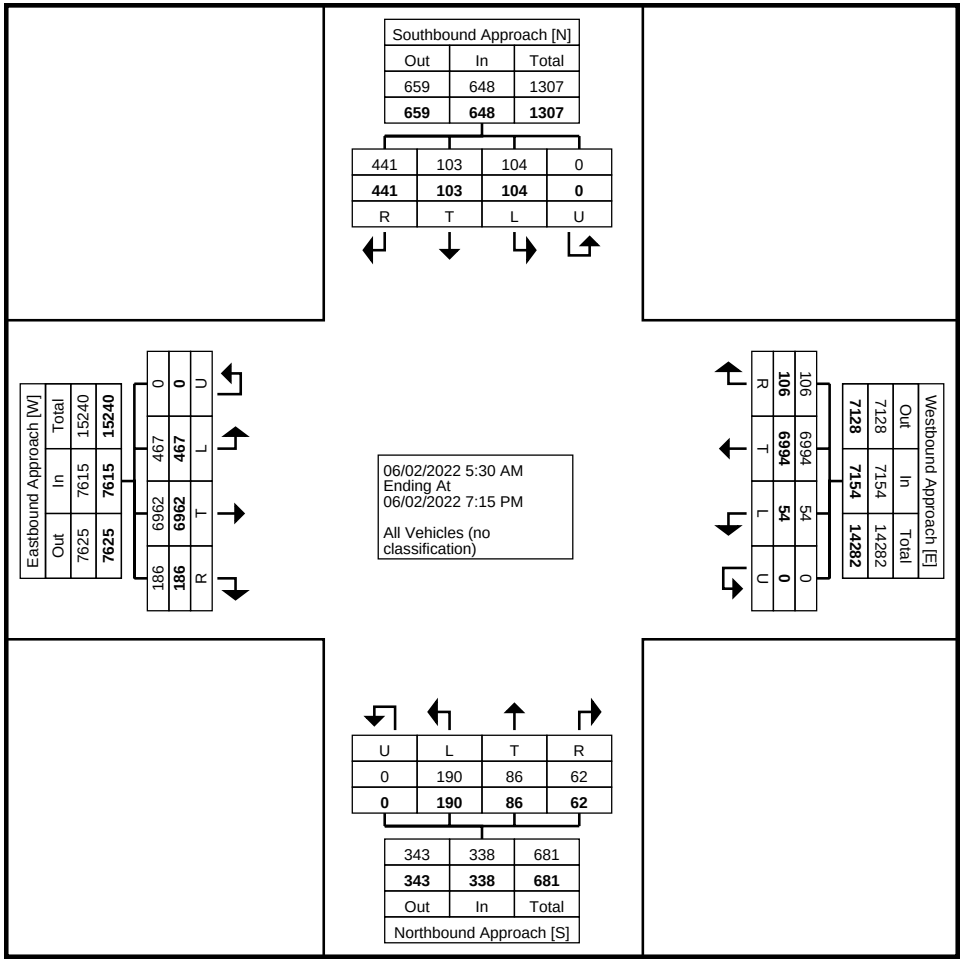
Turning Movement Data

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
5:30 AM	9	0	0	0	9	3	186	0	0	189	0	0	5	0	5	0	34	1	0	35	238
5:45 AM	8	0	0	0	8	6	174	0	0	180	1	2	7	0	10	0	64	1	0	65	263
Hourly Total	17	0	0	0	17	9	360	0	0	369	1	2	12	0	15	0	98	2	0	100	501
6:00 AM	6	0	0	0	6	0	180	0	0	180	2	1	11	0	14	1	101	1	0	103	303
6:15 AM	16	1	0	0	17	1	255	1	0	257	4	2	7	0	13	3	104	2	0	109	396
6:30 AM	17	1	0	0	18	2	250	0	0	252	0	2	10	0	12	1	77	1	0	79	361
6:45 AM	14	1	3	0	18	4	213	0	0	217	0	1	4	0	5	0	82	7	0	89	329
Hourly Total	53	3	3	0	59	7	898	1	0	906	6	6	32	0	44	5	364	11	0	380	1389
7:00 AM	4	0	0	0	4	0	194	1	0	195	0	1	8	0	9	3	109	6	0	118	326
7:15 AM	15	2	3	0	20	1	191	1	0	193	0	3	6	0	9	2	109	10	0	121	343
7:30 AM	15	3	2	0	20	6	207	0	0	213	1	4	5	0	10	1	92	9	0	102	345
7:45 AM	19	0	3	0	22	7	185	1	0	193	0	4	11	0	15	2	107	11	0	120	350
Hourly Total	53	5	8	0	66	14	777	3	0	794	1	12	30	0	43	8	417	36	0	461	1364
8:00 AM	16	1	0	0	17	0	187	0	0	187	0	3	7	0	10	1	105	9	0	115	329
8:15 AM	11	3	0	0	14	2	166	1	0	169	1	2	3	0	6	1	82	12	0	95	284
8:30 AM	11	3	3	0	17	1	169	0	0	170	0	0	5	0	5	2	92	11	0	105	297
8:45 AM	6	3	1	0	10	4	129	0	0	133	2	1	5	0	8	2	73	12	0	87	238
Hourly Total	44	10	4	0	58	7	651	1	0	659	3	6	20	0	29	6	352	44	0	402	1148
9:00 AM	8	0	1	0	9	0	100	1	0	101	0	1	3	0	4	4	90	11	0	105	219
9:15 AM	5	1	2	0	8	0	115	2	0	117	0	0	2	0	2	0	90	5	0	95	222
9:30 AM	4	0	1	0	5	3	110	0	0	113	0	2	1	0	3	1	91	5	0	97	218
9:45 AM	4	0	0	0	4	1	101	0	0	102	1	3	4	0	8	4	83	5	0	92	206
Hourly Total	21	1	4	0	26	4	426	3	0	433	1	6	10	0	17	9	354	26	0	389	865
10:00 AM	10	3	1	0	14	3	111	0	0	114	1	0	4	0	5	2	95	7	0	104	237
10:15 AM	4	1	3	0	8	1	105	2	0	108	4	1	2	0	7	1	74	6	0	81	204
10:30 AM	5	0	3	0	8	1	96	0	0	97	2	1	1	0	4	0	107	3	0	110	219
10:45 AM	7	0	0	0	7	3	84	1	0	88	0	1	5	0	6	0	84	6	0	90	191
Hourly Total	26	4	7	0	37	8	396	3	0	407	7	3	12	0	22	3	360	22	0	385	851
11:00 AM	5	2	1	0	8	3	90	2	0	95	1	2	1	0	4	4	106	8	0	118	225
11:15 AM	2	2	1	0	5	1	115	1	0	117	1	1	4	0	6	4	65	6	0	75	203
11:30 AM	4	0	1	0	5	3	92	2	0	97	3	2	4	0	9	4	94	7	0	105	216
11:45 AM	5	0	2	0	7	2	103	1	0	106	0	3	4	0	7	4	103	7	0	114	234
Hourly Total	16	4	5	0	25	9	400	6	0	415	5	8	13	0	26	16	368	28	0	412	878
12:00 PM	10	2	6	0	18	1	120	0	0	121	1	1	2	0	4	2	116	12	0	130	273
12:15 PM	9	0	0	0	9	3	115	1	0	119	0	3	5	0	8	4	114	8	0	126	262

12:30 PM	5	1	0	0	6	0	105	1	0	106	2	0	2	0	4	1	94	5	0	100	216
12:45 PM	10	2	3	0	15	1	109	2	0	112	1	1	4	0	6	5	91	8	0	104	237
Hourly Total	34	5	9	0	48	5	449	4	0	458	4	5	13	0	22	12	415	33	0	460	988
1:00 PM	5	2	0	0	7	0	130	0	0	130	0	0	2	0	2	3	115	10	0	128	267
1:15 PM	6	0	1	0	7	0	104	0	0	104	2	4	3	0	9	2	134	5	0	141	261
1:30 PM	10	2	0	0	12	0	132	1	0	133	2	2	1	0	5	3	135	8	0	146	296
1:45 PM	7	3	2	0	12	1	117	0	0	118	2	0	1	0	3	5	138	10	0	153	286
Hourly Total	28	7	3	0	38	1	483	1	0	485	6	6	7	0	19	13	522	33	0	568	1110
2:00 PM	8	1	0	0	9	3	134	3	0	140	0	0	0	0	0	4	152	10	0	166	315
2:15 PM	7	1	2	0	10	2	142	1	0	145	2	1	3	0	6	3	157	4	0	164	325
2:30 PM	7	4	5	0	16	0	115	1	0	116	3	2	4	0	9	7	172	8	0	187	328
2:45 PM	9	1	1	0	11	2	108	1	0	111	0	1	2	0	3	5	190	8	0	203	328
Hourly Total	31	7	8	0	46	7	499	6	0	512	5	4	9	0	18	19	671	30	0	720	1296
3:00 PM	6	5	2	0	13	3	98	2	0	103	0	1	1	0	2	4	211	14	0	229	347
3:15 PM	11	1	1	0	13	5	126	1	0	132	0	0	1	0	1	6	188	14	0	208	354
3:30 PM	6	4	2	0	12	2	99	3	0	104	2	1	1	0	4	3	221	13	0	237	357
3:45 PM	2	3	5	0	10	3	117	1	0	121	3	1	4	0	8	2	226	10	0	238	377
Hourly Total	25	13	10	0	48	13	440	7	0	460	5	3	7	0	15	15	846	51	0	912	1435
4:00 PM	9	4	7	0	20	1	108	3	0	112	2	3	3	0	8	5	214	25	0	244	384
4:15 PM	9	1	2	0	12	2	118	3	0	123	0	3	3	0	6	15	203	5	0	223	364
4:30 PM	3	9	4	0	16	1	104	0	0	105	0	5	1	0	6	10	183	17	0	210	337
4:45 PM	6	6	0	0	12	2	117	1	0	120	2	1	2	0	5	4	225	15	0	244	381
Hourly Total	27	20	13	0	60	6	447	7	0	460	4	12	9	0	25	34	825	62	0	921	1466
5:00 PM	8	2	5	0	15	0	108	1	0	109	2	5	0	0	7	10	226	18	0	254	385
5:15 PM	11	8	3	0	22	5	121	1	0	127	3	1	3	0	7	7	220	10	0	237	393
5:30 PM	11	2	8	0	21	5	116	2	0	123	3	1	3	0	7	8	180	17	0	205	356
5:45 PM	11	2	4	0	17	2	96	0	0	98	0	1	3	0	4	3	173	19	0	195	314
Hourly Total	41	14	20	0	75	12	441	4	0	457	8	8	9	0	25	28	799	64	0	891	1448
6:00 PM	7	2	4	0	13	1	102	1	0	104	1	2	2	0	5	8	167	8	0	183	305
6:15 PM	9	3	2	0	14	0	76	2	0	78	2	2	3	0	7	4	156	8	0	168	267
6:30 PM	6	3	2	0	11	2	81	2	0	85	2	1	2	0	5	2	133	5	0	140	241
6:45 PM	3	2	2	0	7	1	68	3	0	72	1	0	0	0	1	4	113	3	0	120	200
Hourly Total	25	10	10	0	45	4	327	8	0	339	6	5	7	0	18	18	569	24	0	611	1013
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	3	3
Grand Total	441	103	104	0	648	106	6994	54	0	7154	62	86	190	0	338	186	6962	467	0	7615	15755
Approach %	68.1	15.9	16.0	0.0	-	1.5	97.8	0.8	0.0	-	18.3	25.4	56.2	0.0	-	2.4	91.4	6.1	0.0	-	-
Total %	2.8	0.7	0.7	0.0	4.1	0.7	44.4	0.3	0.0	45.4	0.4	0.5	1.2	0.0	2.1	1.2	44.2	3.0	0.0	48.3	-
All Vehicles (no classification)	441	103	104	0	648	106	6994	54	0	7154	62	86	190	0	338	186	6962	467	0	7615	15755
% All Vehicles (no classification)	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Brian.Blayney@dot.state.oh.us
Office of Traffic Engineering

Count Name: GEA-422-11.56
Site Code:
Start Date: 06/02/2022



Turning Movement Data Plot

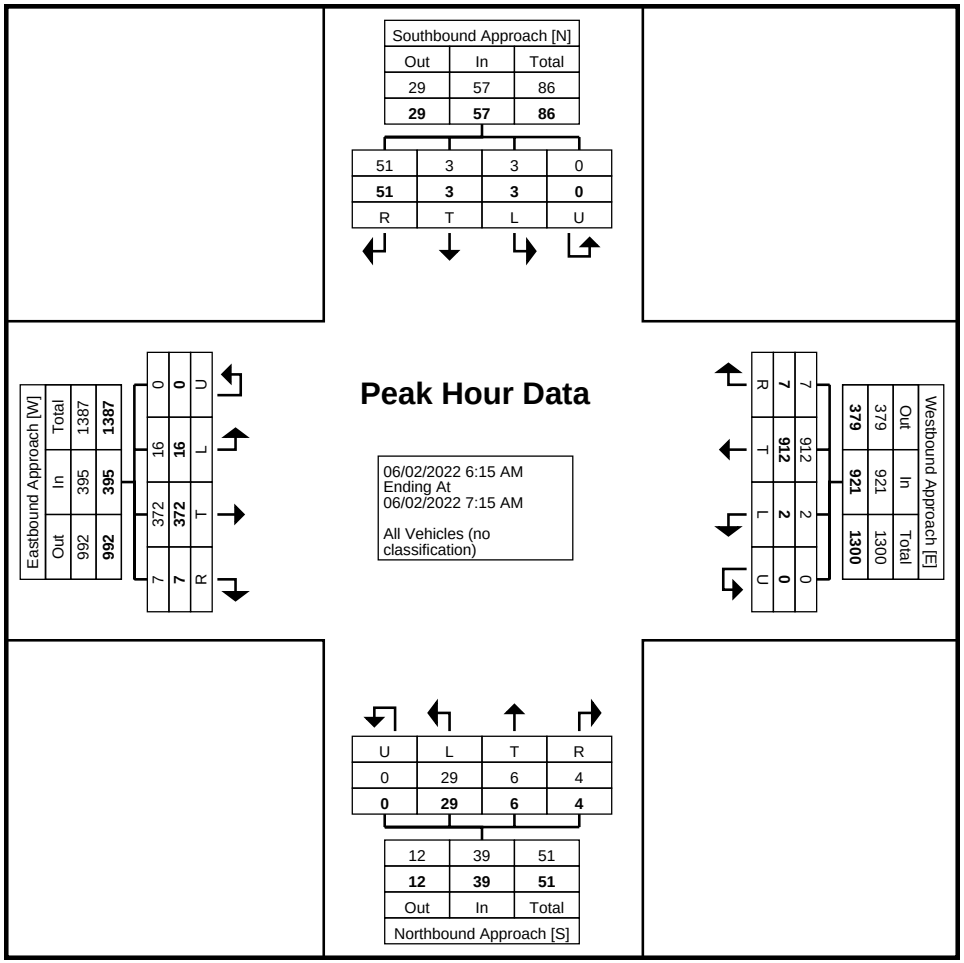
Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Brian.Blayney@dot.state.oh.us
Office of Traffic Engineering

Count Name: GEA-422-11.56
Site Code:
Start Date: 06/02/2022

Turning Movement Peak Hour Data (6:15 AM)

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
6:15 AM	16	1	0	0	17	1	255	1	0	257	4	2	7	0	13	3	104	2	0	109	396
6:30 AM	17	1	0	0	18	2	250	0	0	252	0	2	10	0	12	1	77	1	0	79	361
6:45 AM	14	1	3	0	18	4	213	0	0	217	0	1	4	0	5	0	82	7	0	89	329
7:00 AM	4	0	0	0	4	0	194	1	0	195	0	1	8	0	9	3	109	6	0	118	326
Total	51	3	3	0	57	7	912	2	0	921	4	6	29	0	39	7	372	16	0	395	1412
Approach %	89.5	5.3	5.3	0.0	-	0.8	99.0	0.2	0.0	-	10.3	15.4	74.4	0.0	-	1.8	94.2	4.1	0.0	-	-
Total %	3.6	0.2	0.2	0.0	4.0	0.5	64.6	0.1	0.0	65.2	0.3	0.4	2.1	0.0	2.8	0.5	26.3	1.1	0.0	28.0	-
PHF	0.750	0.750	0.250	0.000	0.792	0.438	0.894	0.500	0.000	0.896	0.250	0.750	0.725	0.000	0.750	0.583	0.853	0.571	0.000	0.837	0.891
All Vehicles (no classification)	51	3	3	0	57	7	912	2	0	921	4	6	29	0	39	7	372	16	0	395	1412
% All Vehicles (no classification)	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Brian.Blayney@dot.state.oh.us
Office of Traffic Engineering



Turning Movement Peak Hour Data Plot (6:15 AM)

Ohio Department of Transportation
1980 West Broad Street
Mail Stop 5160
Columbus, Ohio, United States 43223
+16147528099 Brian.Blayney@dot.state.oh.us
Office of Traffic Engineering

Count Name: GEA-422-11.56
Site Code:
Start Date: 06/02/2022

Turning Movement Peak Hour Data (4:45 PM)

Start Time	Southbound Approach					Westbound Approach					Northbound Approach					Eastbound Approach					
	Southbound					Westbound					Northbound					Eastbound					
	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
4:45 PM	6	6	0	0	12	2	117	1	0	120	2	1	2	0	5	4	225	15	0	244	381
5:00 PM	8	2	5	0	15	0	108	1	0	109	2	5	0	0	7	10	226	18	0	254	385
5:15 PM	11	8	3	0	22	5	121	1	0	127	3	1	3	0	7	7	220	10	0	237	393
5:30 PM	11	2	8	0	21	5	116	2	0	123	3	1	3	0	7	8	180	17	0	205	356
Total	36	18	16	0	70	12	462	5	0	479	10	8	8	0	26	29	851	60	0	940	1515
Approach %	51.4	25.7	22.9	0.0	-	2.5	96.5	1.0	0.0	-	38.5	30.8	30.8	0.0	-	3.1	90.5	6.4	0.0	-	-
Total %	2.4	1.2	1.1	0.0	4.6	0.8	30.5	0.3	0.0	31.6	0.7	0.5	0.5	0.0	1.7	1.9	56.2	4.0	0.0	62.0	-
PHF	0.818	0.563	0.500	0.000	0.795	0.600	0.955	0.625	0.000	0.943	0.833	0.400	0.667	0.000	0.929	0.725	0.941	0.833	0.000	0.925	0.964
All Vehicles (no classification)	36	18	16	0	70	12	462	5	0	479	10	8	8	0	26	29	851	60	0	940	1515
% All Vehicles (no classification)	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0	100.0	100.0	-	100.0	100.0

Ohio Department of Transportation
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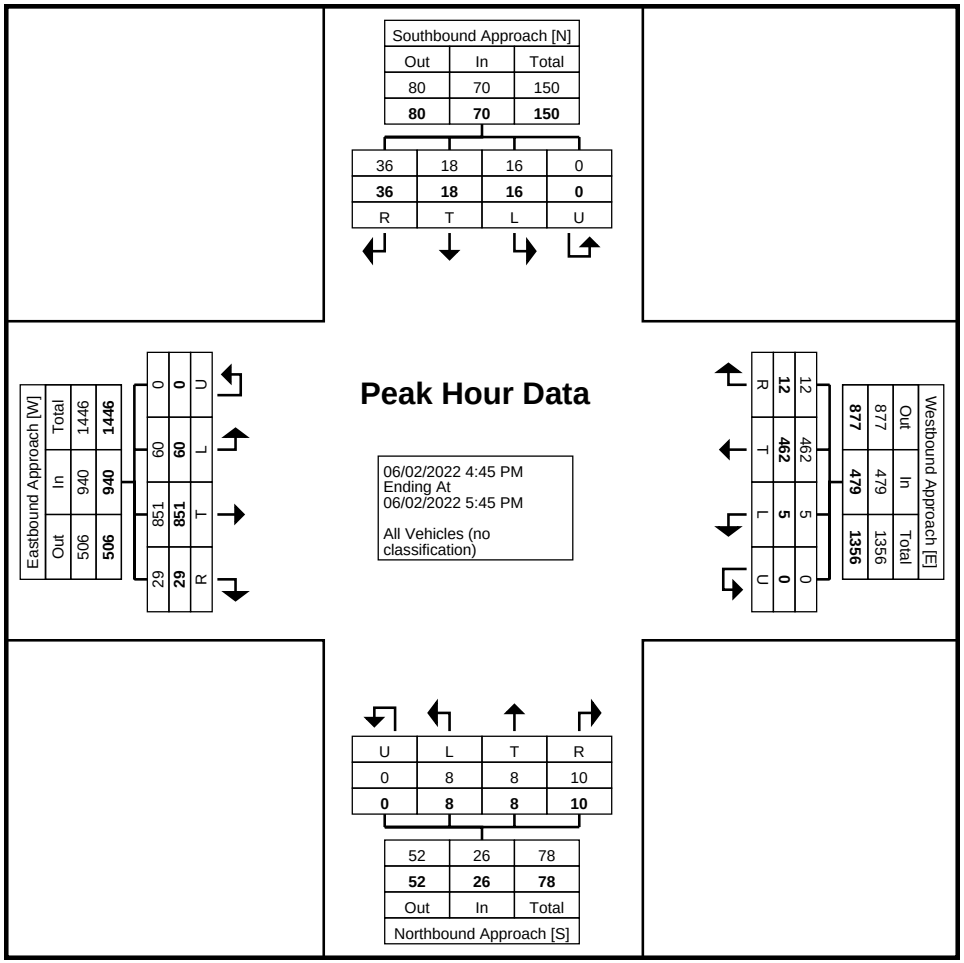
Office of Traffic Engineering

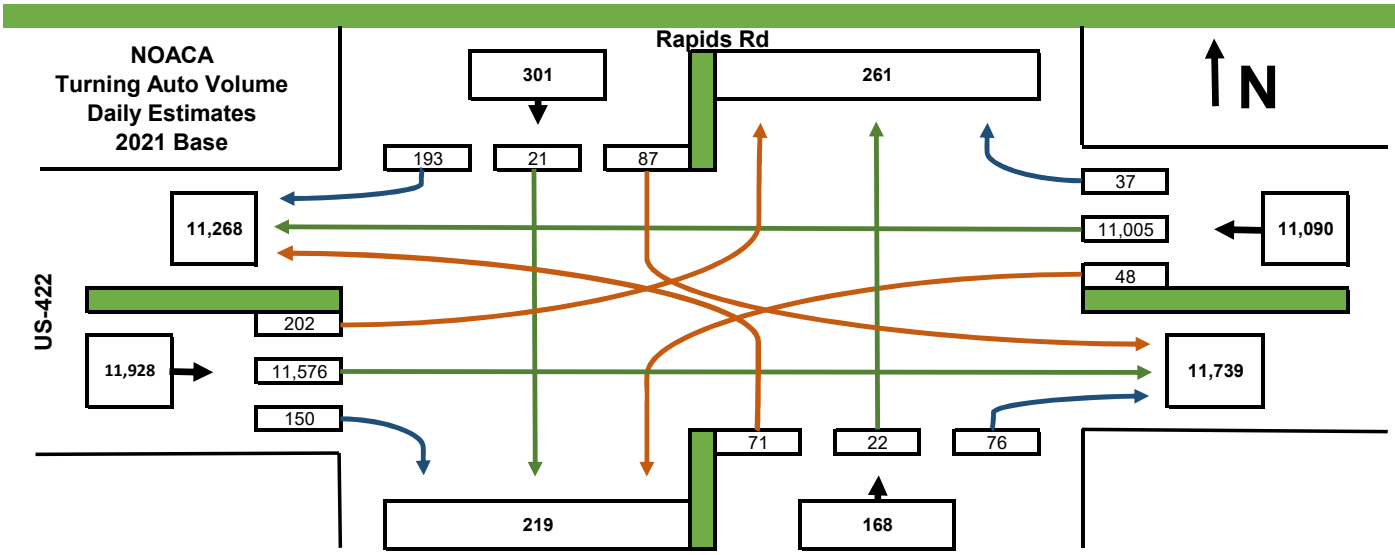
Count Name: GEA-422-11.56
Site Code:
Start Date: 06/02/2022

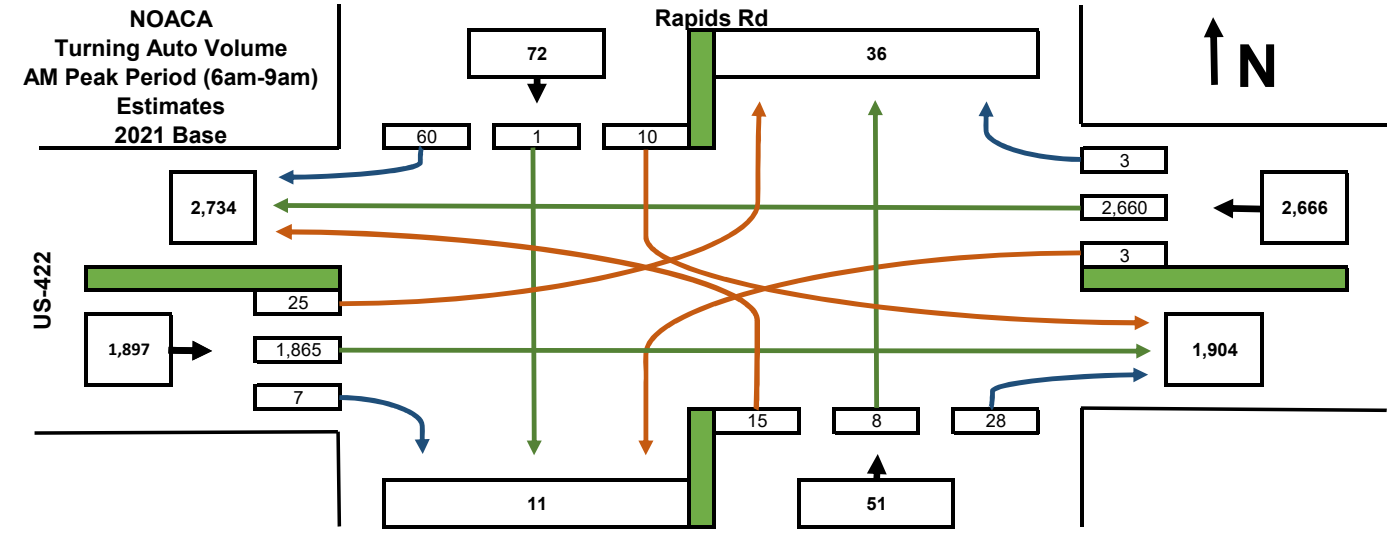


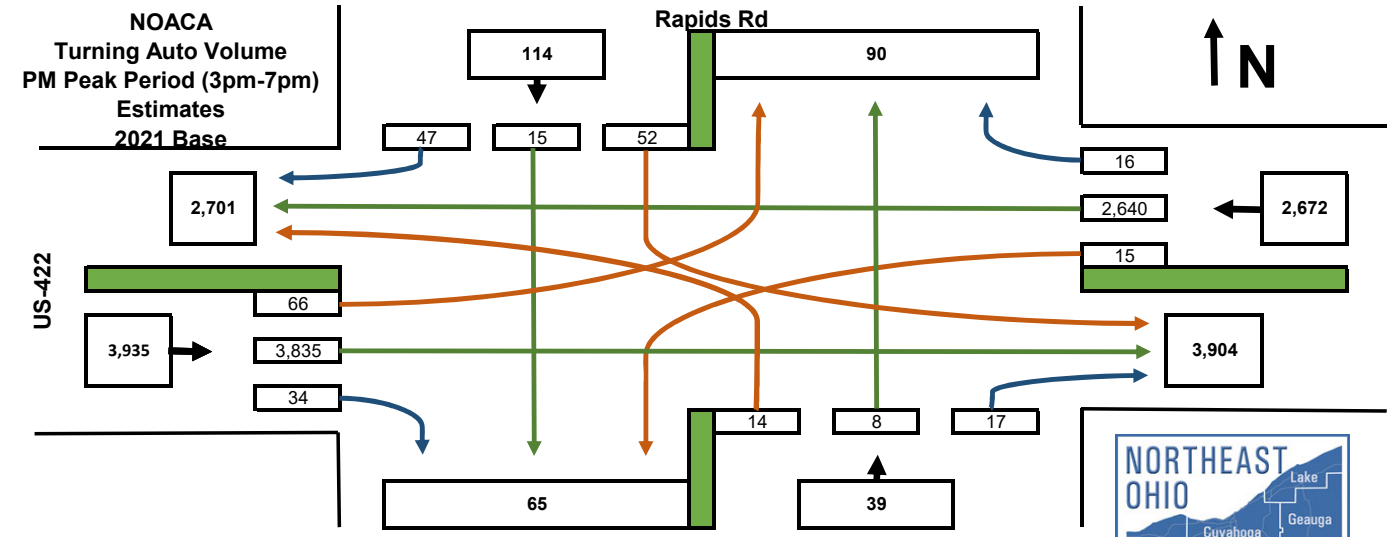
Turning Movement Peak Hour Data Plot (4:45 PM)

APPENDIX C

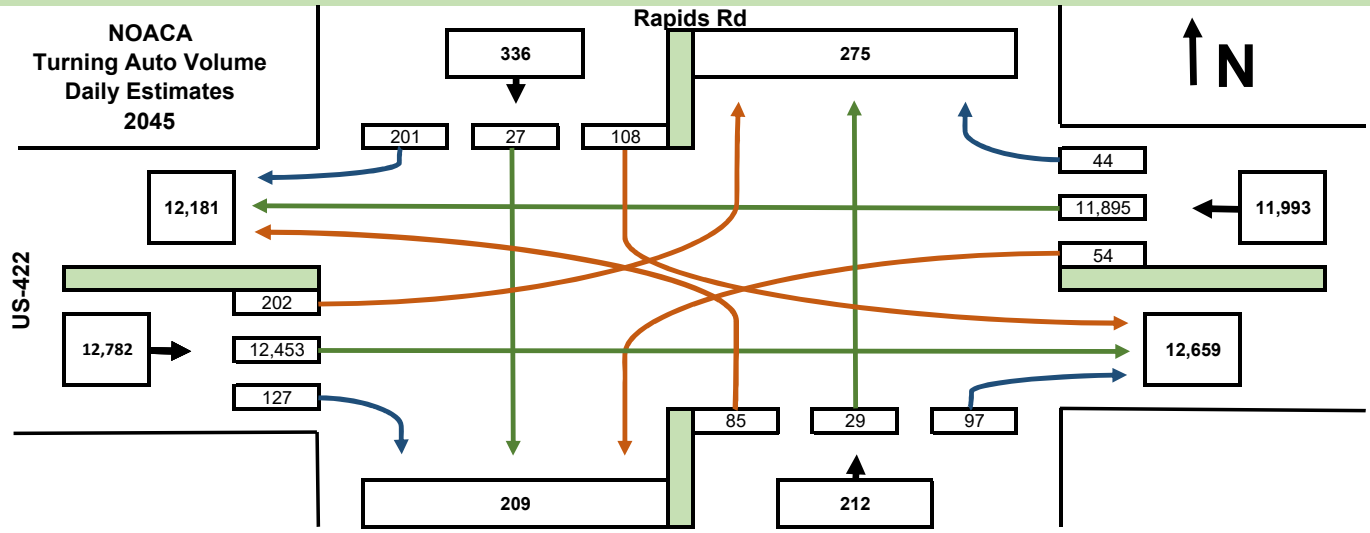
Traffic Volumes - NOACA Travel Demand Model Data

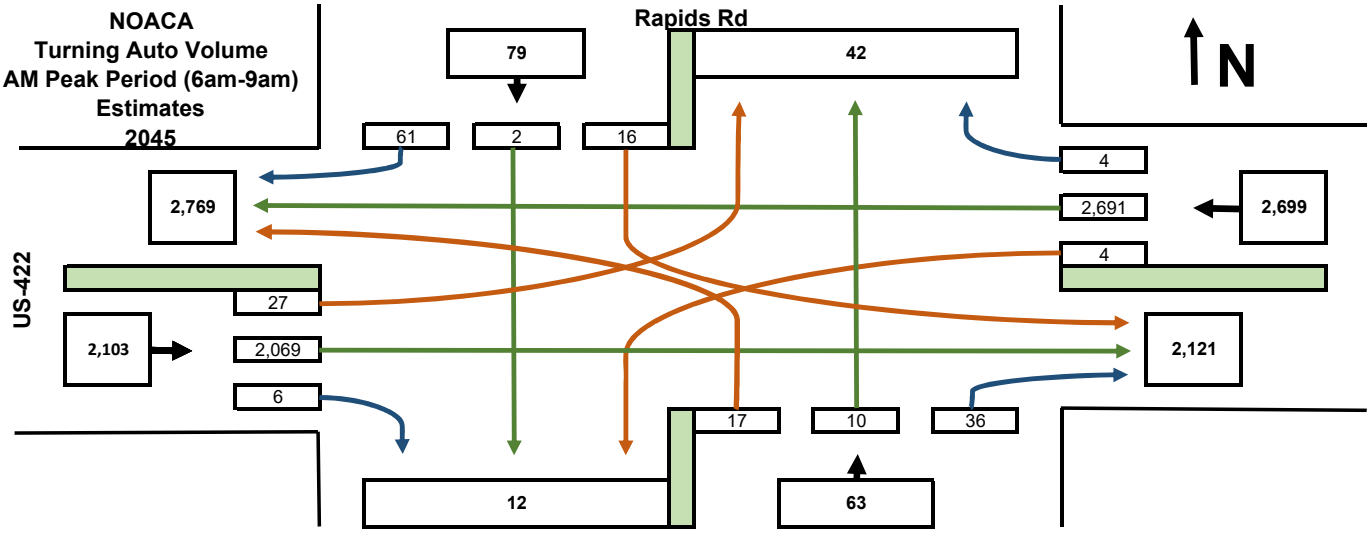


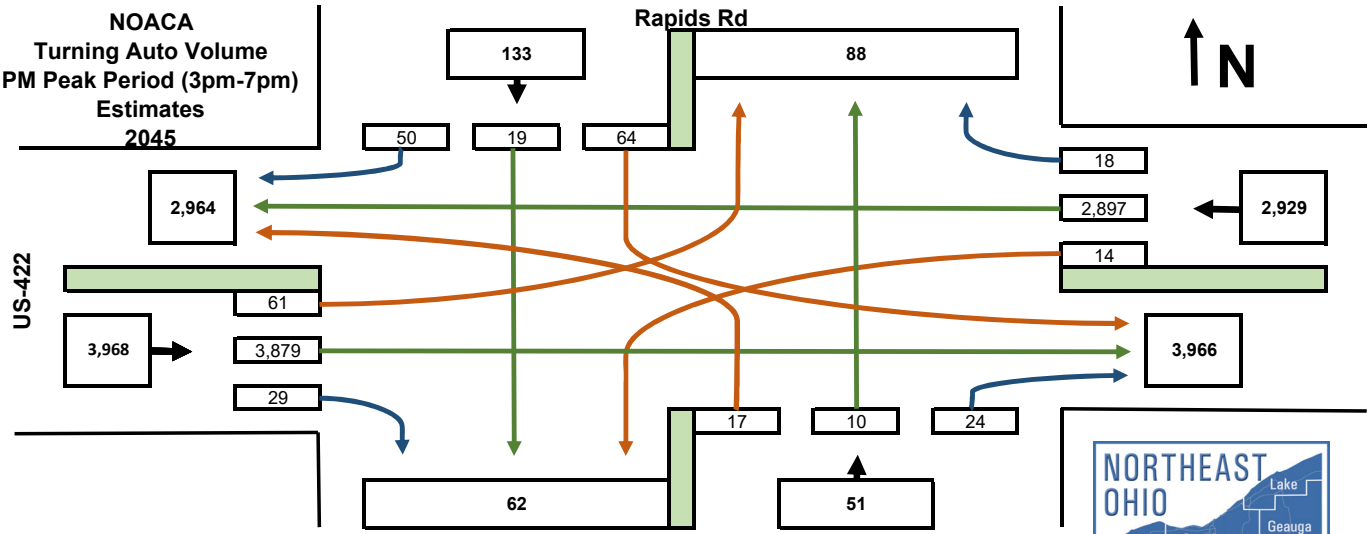




NORTHEAST OHIO AREAWIDE COORDINATING AGENCY
NOACA: Planning For Greater Cleveland







NORTHEAST OHIO AREAWIDE COORDINATING AGENCY
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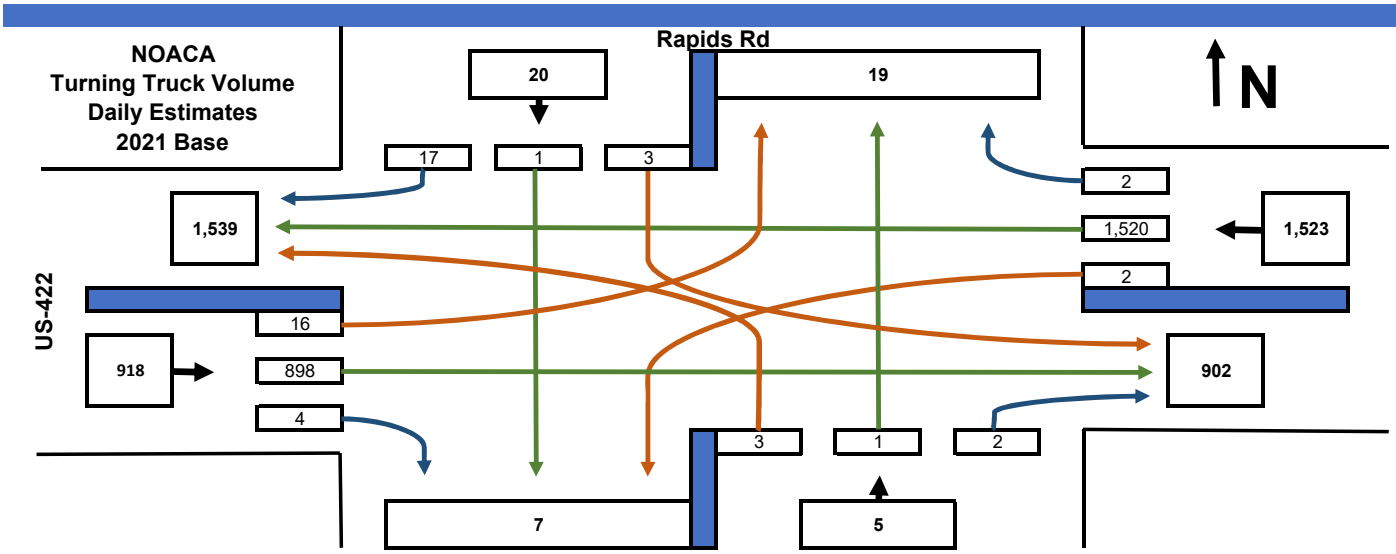

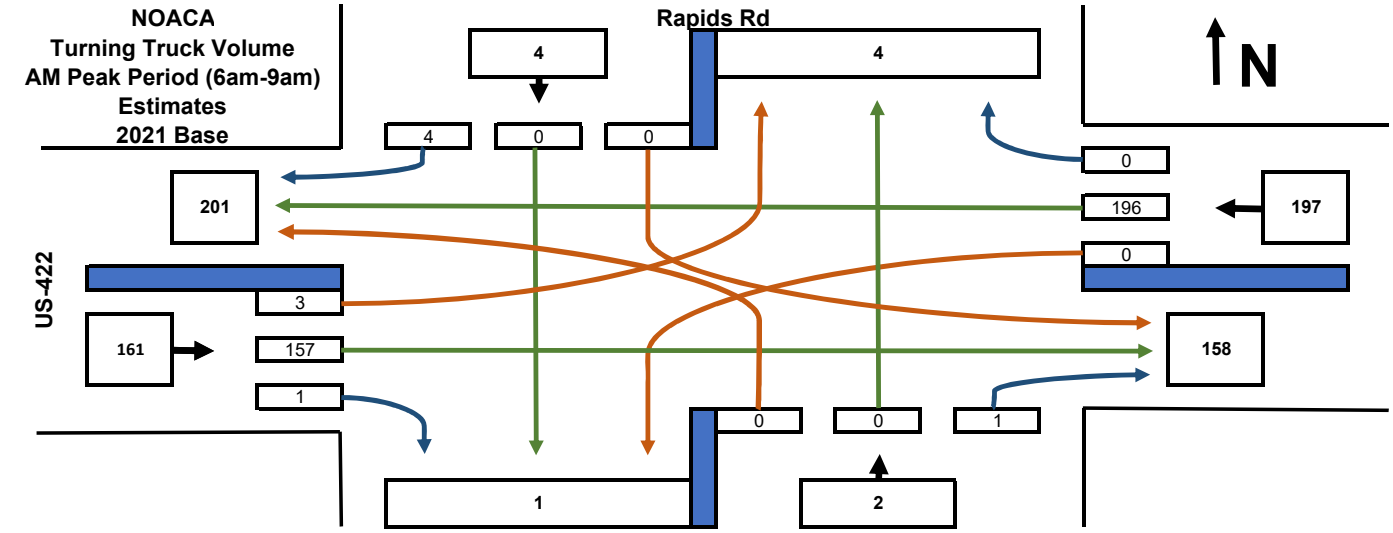

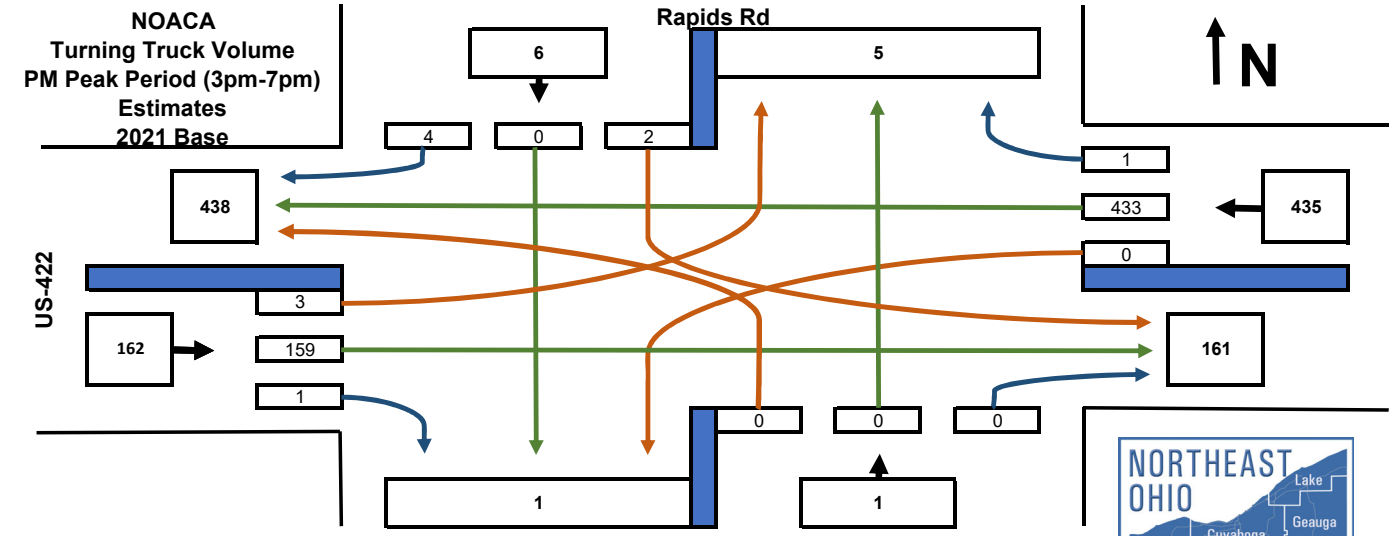

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY
Lake
Geauga
Cuyahoga
Lorain
Medina
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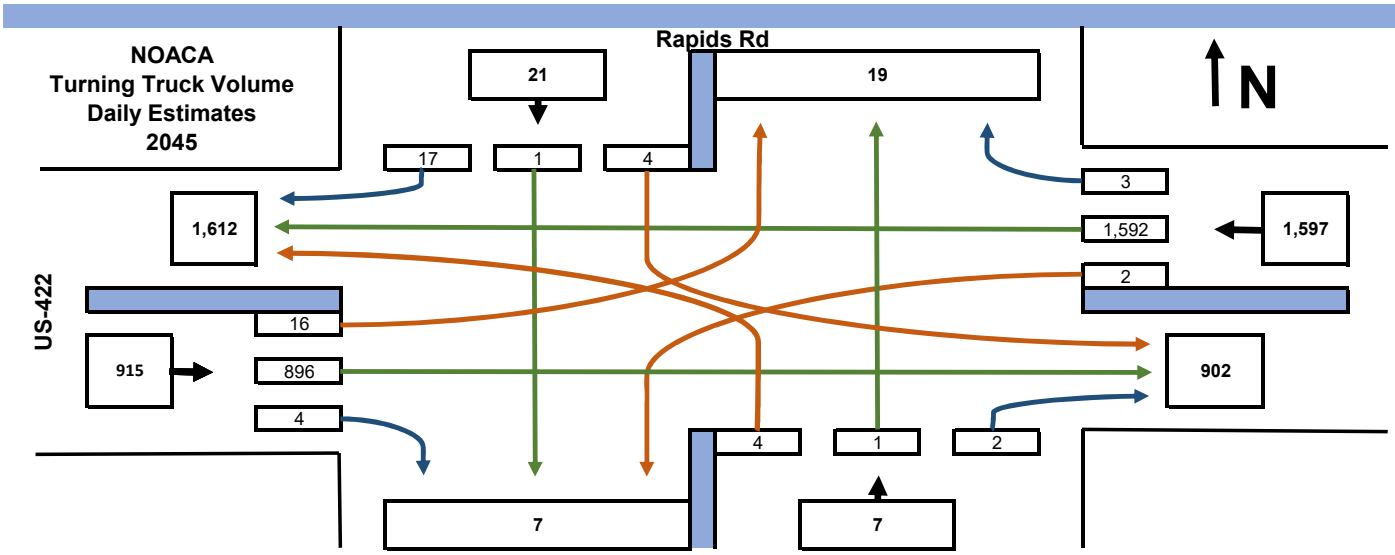

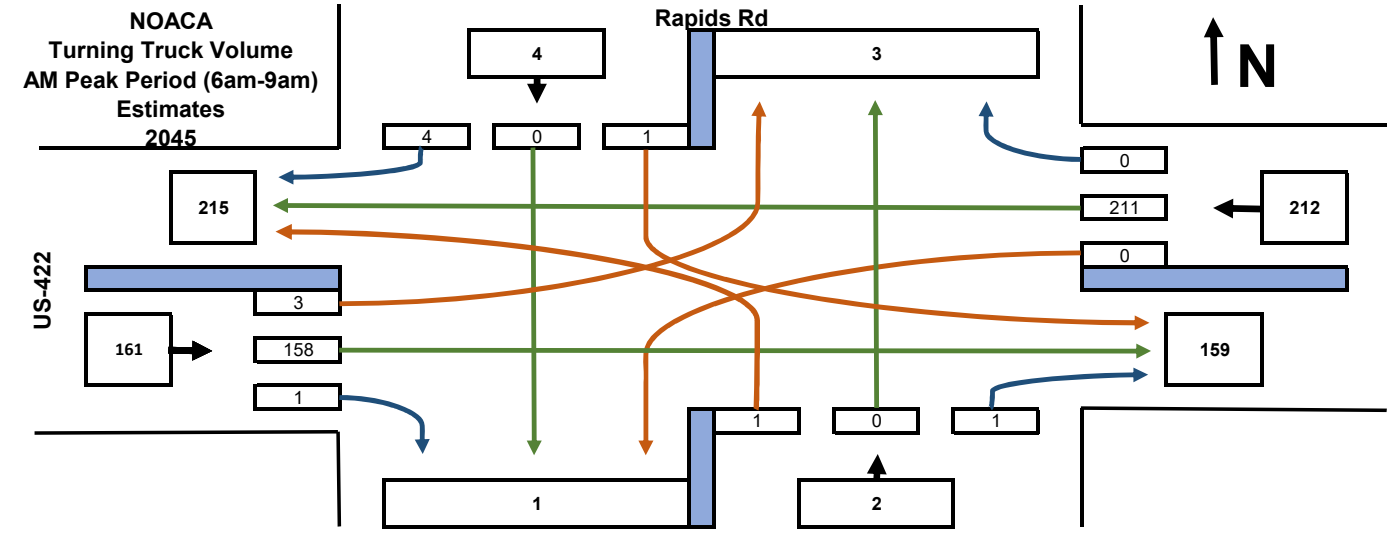

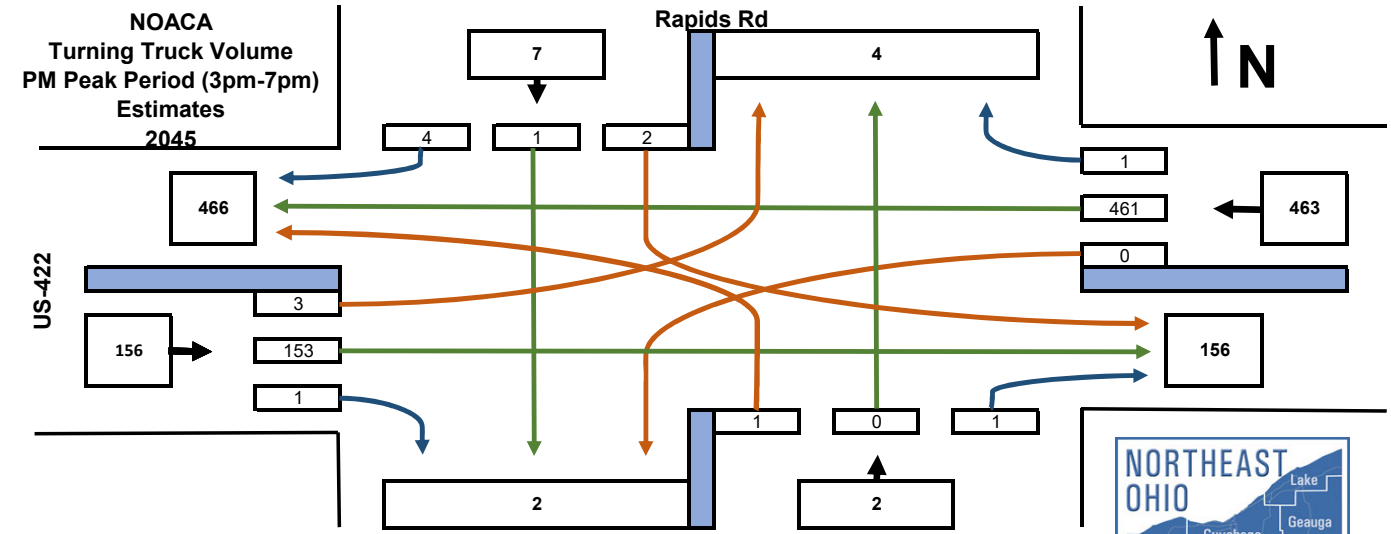

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY
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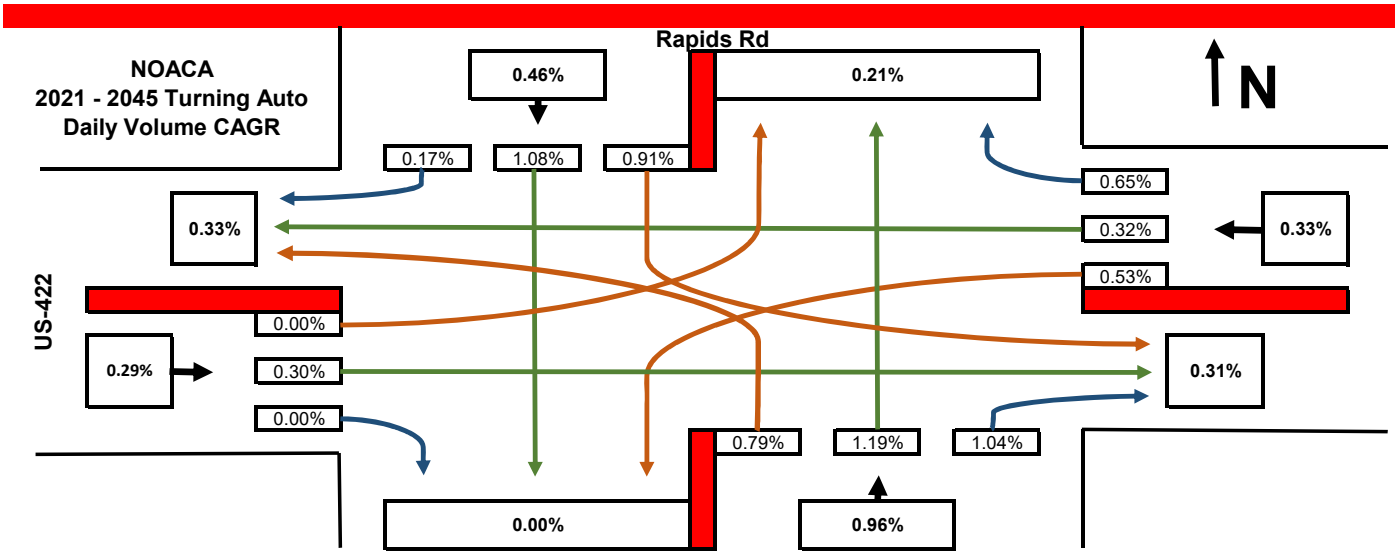
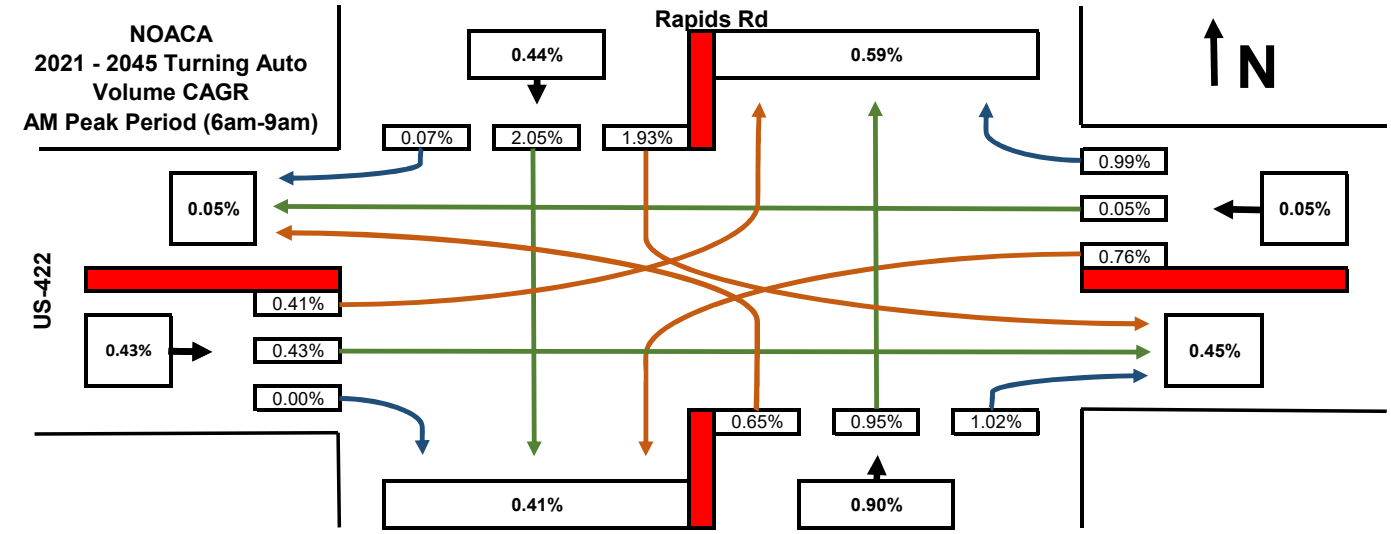
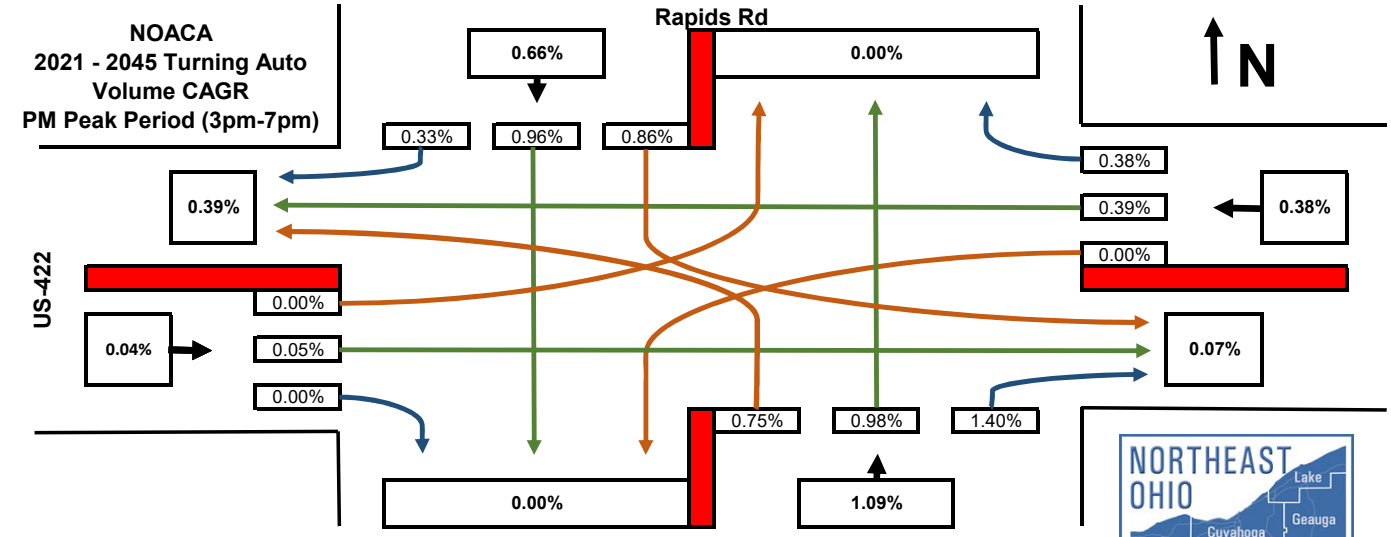
Geauga
Cuyahoga
Lorain
Medina







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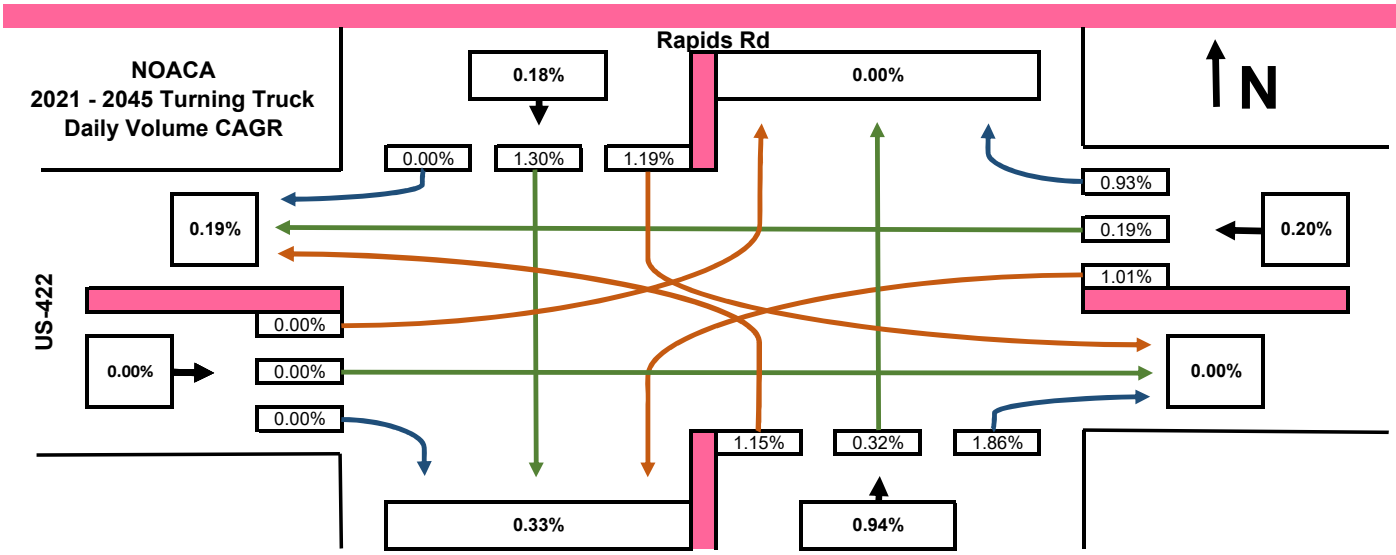
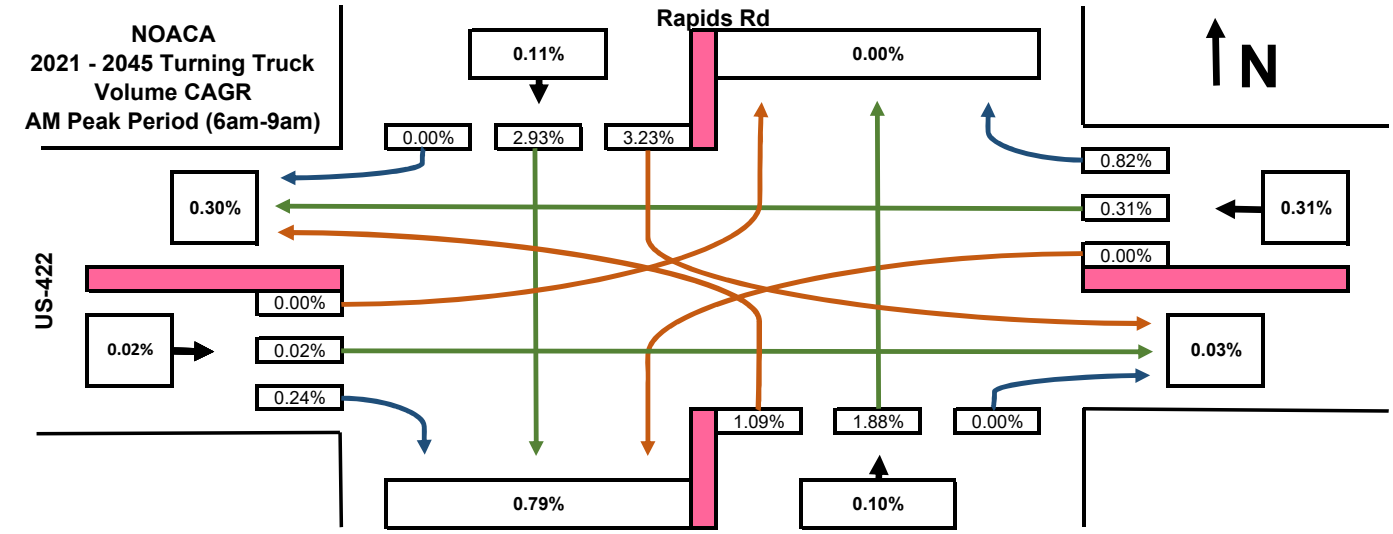
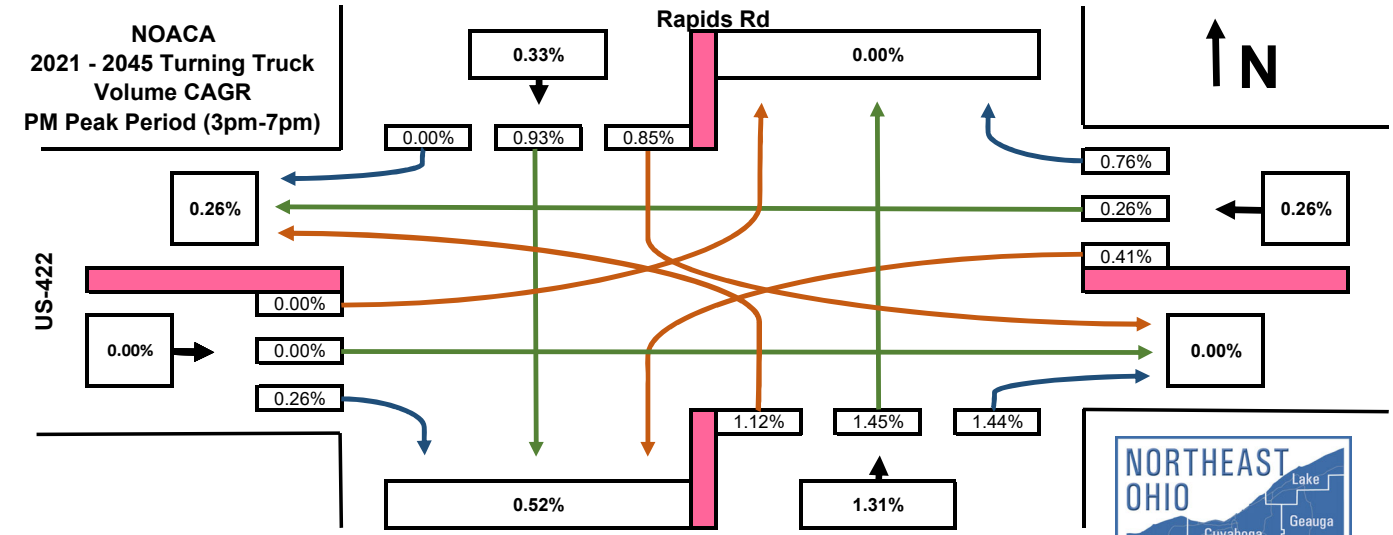






NORTHEAST OHIO AREAWIDE COORDINATING AGENCY
Lake
Geauga
Cuyahoga
Lorain
Medina
NOACA: Planning For Greater Cleveland

Maderia, Justin

From: Brian.Blayney@dot.ohio.gov
Sent: Wednesday, July 6, 2022 12:54 PM
To: Maderia, Justin; Anderson, Nora
Subject: RE: Traffic Count Data for GEA-422 and Rapids
Attachments: Bblayney_SegmentDetails_07062022124727.pdf

Justin,

I'm good with that. Just for fun, I ran this segment in TFMS. It returned a negative growth rate for cars, but a hefty 3.4% for trucks, which is kind of scary, there are already too many trucks on that road as it is.

I think 0.3% simple annual growth is a good middle of the road number to use for total volumes for all movements.

Brian

From: Maderia, Justin <Justin.Maderia@arcadis.com>
Sent: Wednesday, July 6, 2022 12:43 PM
To: Blayney, Brian <Brian.Blayney@dot.ohio.gov>; Anderson, Nora <nora.anderson@wsp.com>
Subject: RE: Traffic Count Data for GEA-422 and Rapids

Hi Brian,

I was able to access the MioVision video.

It looks like the NOACA data is providing a 0.3% background growth rate. We will use that and forecast the TMC data to 2047 for the HCS analysis.

Thanks!

Justin

Justin Maderia (he/him) PE, PTOE, PTP
Traffic and Safety Project Manager
Arcadis U.S., Inc.
1111 Superior Avenue, Suite 1300 | Cleveland, OH | 44114 | USA
T +1 216 298 5239
M +1 216 571 7416
www.arcadis.com

From: Brian.Blayney@dot.ohio.gov <Brian.Blayney@dot.ohio.gov>
Sent: Wednesday, July 6, 2022 9:02 AM
To: Anderson, Nora <nora.anderson@wsp.com>; Maderia, Justin <Justin.Maderia@arcadis.com>
Subject: Traffic Count Data for GEA-422 and Rapids

Hi Nora and Justin,

Here's the PDF report for Rapids. I believe I correctly shared the data with you in the MioVision portal. Let me know if you haven't received an invitation to view a shared count.

Brian

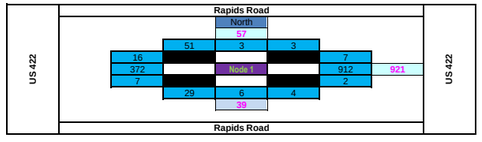
Brian Blayney, PE
District Traffic Planning Engineer
ODOT District 12: Cuyahoga, Geauga & Lake Counties
5500 Transportation Blvd., Garfield Heights, Ohio 44125
(p) 216.584.2108
transportation.ohio.gov

APPENDIX C

Traffic Volumes - Design Hourly Traffic Volumes

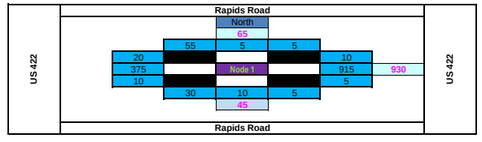
Year: 2022 Background Linear Growth Rate 0.3%

AM Peak Hour — **Raw TMC Data**



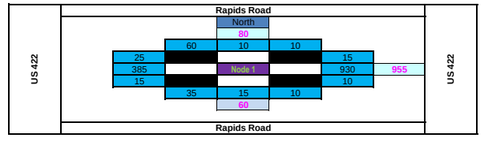
Year: 2022

2022 AM DHV



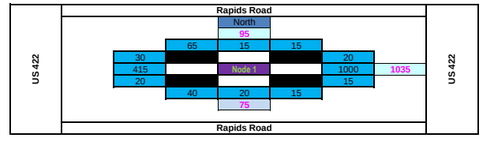
Year: 2027

2027 AM DHV

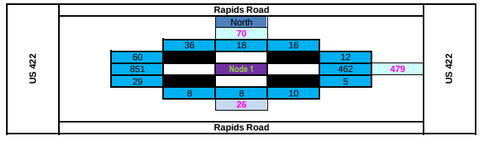


Year: 2047

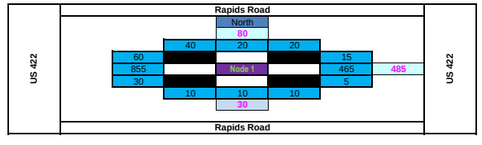
2047 AM DHV



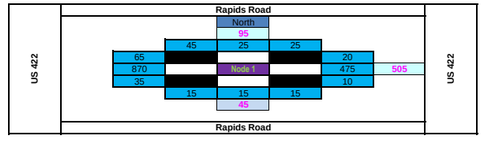
PM Peak Hour — **Raw TMC Data**



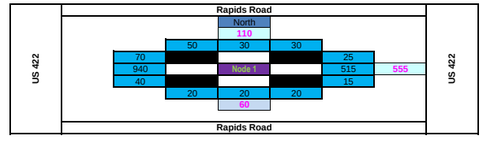
2022 AM DHV



2027 AM DHV



2047 AM DHV



APPENDIX D

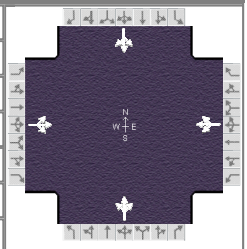
HCS Capacity Analysis

APPENDIX D

HCS Capacity Analysis - Existing & No-Build Conditions

HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2022	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2022 AM.xus		
Project Description	2022 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	20	375	10	5	915	10	30	10	5	5	5	55

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off

							1	2	3	4
Green	71.6	6.6	0.0	0.0	0.0	0.0	5	6	7	8
Yellow	5.2	3.6	0.0	0.0	0.0	0.0				
Red	1.5	1.5	0.0	0.0	0.0	0.0				

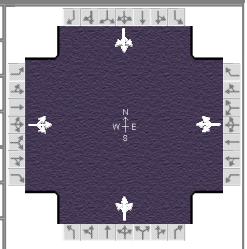
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		8.0		8.0		8.0		8.0
Phase Duration, s		78.3		78.3		11.7		11.7
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						4.8		6.3
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.95		0.95
Max Out Probability						0.90		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		440			1011			49			71	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1525			1582			1460			1448	
Queue Service Time (g_s), s		0.0			0.0			0.0			1.1	
Cycle Queue Clearance Time (g_c), s		7.0			32.8			2.8			4.3	
Green Ratio (*g/C*)		0.79			0.79			0.07			0.07	
Capacity (*c*), veh/h		1252			1296			175			150	
Volume-to-Capacity Ratio (*X*)		0.351			0.780			0.280			0.471	
Back of Queue (*Q*), ft/ln (95 th percentile)		60.1			281.3			46.4			69.7	
Back of Queue (*Q*), veh/ln (95 th percentile)		2.2			10.3			1.8			2.7	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		2.6			5.3			39.8			40.6	
Incremental Delay (d_2), s/veh		0.8			4.7			0.3			0.9	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		3.4			10.0			40.2			41.4	
Level of Service (LOS)		A			A			D			D	
Approach Delay, s/veh / LOS	3.4	A		10.0	A		40.2	D		41.4	D	
Intersection Delay, s/veh / LOS	10.5						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	1.21	A	2.16	B	0.57	A	0.60	A

HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District12	Time Period	PM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2022	Analysis Period	1> 4:45
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2022 PM.xus		
Project Description	2022 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	60	855	30	5	465	15	10	10	10	20	20	40

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off

							1	2	3	4
Green	7.0	60.3	6.8	0.0	0.0	0.0	5	6	7	8
Yellow	3.0	5.2	3.6	0.0	0.0	0.0				
Red	1.0	1.6	1.5	0.0	0.0	0.0				

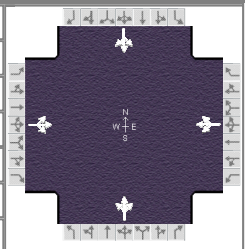
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6		8		4
Case Number	0.0	14.2		8.3		8.0		8.0
Phase Duration, s	11.0	78.1		67.1		11.9		11.9
Change Period, ($Y+R_c$), s	4.0	6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s	0.0	0.0		0.0		3.1		3.1
Queue Clearance Time (g_s), s						3.7		7.2
Green Extension Time (g_e), s	0.0	0.0		0.0		0.0		0.0
Phase Call Probability						0.95		0.95
Max Out Probability						0.13		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		1027			527			33			87	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1545			1570			1560			1484	
Queue Service Time (g_s), s		7.0			0.0			0.0			3.4	
Cycle Queue Clearance Time (g_c), s		34.8			14.9			1.7			5.2	
Green Ratio (*g/C*)		0.79			0.67			0.08			0.08	
Capacity (*c*), veh/h		1269			1092			171			162	
Volume-to-Capacity Ratio (*X*)		0.810			0.483			0.190			0.536	
Back of Queue (*Q*), ft/ln (95 th percentile)		293.6			207			30.4			86.6	
Back of Queue (*Q*), veh/ln (95 th percentile)		10.9			7.6			1.2			3.3	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		5.4			7.4			39.2			40.8	
Incremental Delay (d_2), s/veh		5.7			1.5			0.2			1.0	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		11.1			8.9			39.4			41.8	
Level of Service (LOS)		B			A			D			D	
Approach Delay, s/veh / LOS	11.1	B		8.9	A		39.4	D		41.8	D	
Intersection Delay, s/veh / LOS	12.6						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.64	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	2.18	B	1.36	A	0.54	A	0.63	A

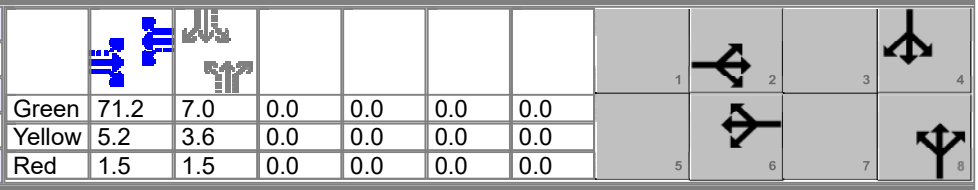
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2027	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2027 AM.xus		
Project Description	2027 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	25	385	15	10	930	15	35	15	10	10	10	60

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	71.2	7.0	0.0	0.0	0.0	0.0		
Yellow	5.2	3.6	0.0	0.0	0.0	0.0		
Red	1.5	1.5	0.0	0.0	0.0	0.0		

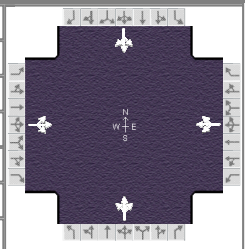
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		8.0		8.0		8.0		8.0
Phase Duration, s		77.9		77.9		12.1		12.1
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						5.7		7.1
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.98		0.98
Max Out Probability						1.00		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		462			1038			65			87	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1497			1577			1474			1485	
Queue Service Time (g_s), s		0.0			0.0			0.0			1.4	
Cycle Queue Clearance Time (g_c), s		7.6			36.0			3.7			5.1	
Green Ratio (*g/C*)		0.79			0.79			0.08			0.08	
Capacity (*c*), veh/h		1226			1287			177			160	
Volume-to-Capacity Ratio (*X*)		0.377			0.806			0.368			0.544	
Back of Queue (*Q*), ft/ln (95 th percentile)		67.7			313			62.3			86.4	
Back of Queue (*Q*), veh/ln (95 th percentile)		2.5			11.4			2.4			3.3	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		2.8			5.7			40.0			40.7	
Incremental Delay (d_2), s/veh		0.9			5.5			0.5			1.1	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		3.7			11.2			40.5			41.7	
Level of Service (LOS)		A			B			D			D	
Approach Delay, s/veh / LOS	3.7	A		11.2	B		40.5	D		41.7	D	
Intersection Delay, s/veh / LOS	11.9						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	1.25	A	2.20	B	0.60	A	0.63	A

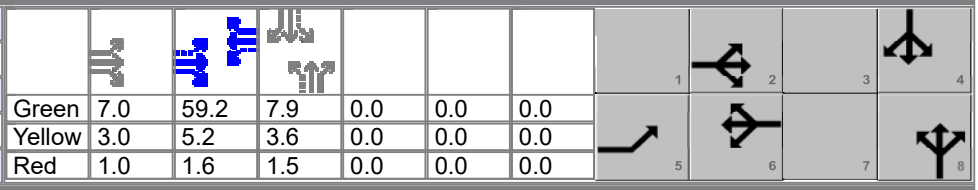
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District12	Time Period	PM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2027	Analysis Period	1> 4:45
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2027 PM.xus		
Project Description	2027 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	65	870	35	10	475	20	15	15	15	25	25	45

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	7.0	59.2	7.9	0.0	0.0	0.0
Yellow	3.0	5.2	3.6	0.0	0.0	0.0
Red	1.0	1.6	1.5	0.0	0.0	0.0

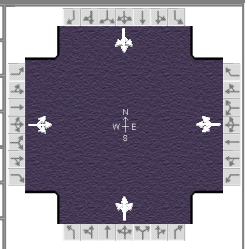
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6		8		4
Case Number	0.0	14.2		8.3		8.0		8.0
Phase Duration, s	11.0	77.0		66.0		13.0		13.0
Change Period, (*Y+R c*), s	4.0	6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s	0.0	0.0		0.0		3.1		3.1
Queue Clearance Time (*g s*), s						4.6		8.1
Green Extension Time (*g e*), s	0.0	0.0		0.0		0.0		0.0
Phase Call Probability						0.98		0.98
Max Out Probability						0.68		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		1054			549			49			103	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1538			1554			1556			1491	
Queue Service Time (*g s*), s		7.0			0.0			0.0			3.5	
Cycle Queue Clearance Time (*g c*), s		41.1			16.5			2.6			6.1	
Green Ratio (*g/C*)		0.78			0.66			0.09			0.09	
Capacity (*c*), veh/h		1245			1063			190			181	
Volume-to-Capacity Ratio (*X*)		0.847			0.516			0.258			0.570	
Back of Queue (*Q*), ft/ln (95 th percentile)		121.7			227.6			45.4			106.2	
Back of Queue (*Q*), veh/ln (95 th percentile)		4.5			8.3			1.8			4.1	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (*d 1*), s/veh		6.5			8.1			38.6			40.2	
Incremental Delay (*d 2*), s/veh		7.2			1.8			0.3			2.7	
Initial Queue Delay (*d 3*), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		13.7			9.9			38.9			42.9	
Level of Service (LOS)		B			A			D			D	
Approach Delay, s/veh / LOS	13.7	B		9.9	A		38.9	D		42.9	D	
Intersection Delay, s/veh / LOS	14.9						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.64	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	2.23	B	1.39	A	0.57	A	0.66	A

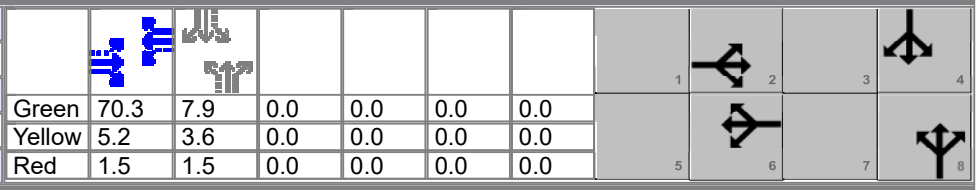
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2047	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2047 AM.xus		
Project Description	2047 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	30	415	20	15	1000	20	40	20	15	15	15	65

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	70.3	7.9	0.0	0.0	0.0	0.0		
Yellow	5.2	3.6	0.0	0.0	0.0	0.0		
Red	1.5	1.5	0.0	0.0	0.0	0.0		

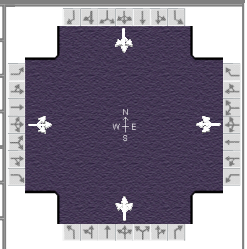
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		8.0		8.0		8.0		8.0
Phase Duration, s		77.0		77.0		13.0		13.0
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						6.7		8.0
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.99		0.99
Max Out Probability						1.00		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		505			1125			82			103	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1410			1573			1481			1504	
Queue Service Time (g_s), s		0.0			8.2			0.0			1.3	
Cycle Queue Clearance Time (g_c), s		9.1			49.2			4.7			6.0	
Green Ratio (*g/C*)		0.78			0.78			0.09			0.09	
Capacity (*c*), veh/h		1142			1267			191			178	
Volume-to-Capacity Ratio (*X*)		0.442			0.888			0.426			0.579	
Back of Queue (*Q*), ft/ln (95 th percentile)		88.8			446.8			77.9			106.9	
Back of Queue (*Q*), veh/ln (95 th percentile)		3.3			16.3			3.0			4.1	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		3.2			7.6			39.5			40.2	
Incremental Delay (d_2), s/veh		1.2			9.5			0.6			3.1	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		4.4			17.0			40.1			43.3	
Level of Service (LOS)		A			B			D			D	
Approach Delay, s/veh / LOS	4.4	A		17.0	B		40.1	D		43.3	D	
Intersection Delay, s/veh / LOS	16.0						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	1.32	A	2.34	B	0.62	A	0.66	A

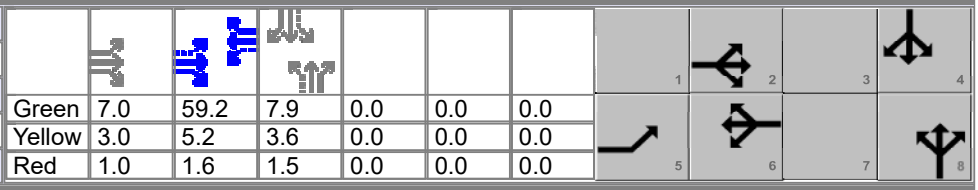
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District12	Time Period	PM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2047	Analysis Period	1> 4:45
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2047 PM.xus		
Project Description	2047 Existing Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	70	940	40	15	515	25	20	20	20	30	30	50

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	7.0	59.2	7.9	0.0	0.0	0.0
Yellow	3.0	5.2	3.6	0.0	0.0	0.0
Red	1.0	1.6	1.5	0.0	0.0	0.0

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6		8		4
Case Number	0.0	14.2		8.3		8.0		8.0
Phase Duration, s	11.0	77.0		66.0		13.0		13.0
Change Period, ($Y+R_c$), s	4.0	6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s	0.0	0.0		0.0		3.1		3.1
Queue Clearance Time (g_s), s						5.5		9.1
Green Extension Time (g_e), s	0.0	0.0		0.0		0.0		0.0
Phase Call Probability						0.99		0.99
Max Out Probability						1.00		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		1141			603			65			120	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1532			1538			1558			1504	
Queue Service Time (g_s), s		7.0			0.0			0.0			3.6	
Cycle Queue Clearance Time (g_c), s		56.7			19.2			3.5			7.1	
Green Ratio (*g/C*)		0.78			0.66			0.09			0.09	
Capacity (*c*), veh/h		1239			1053			190			183	
Volume-to-Capacity Ratio (*X*)		0.921			0.573			0.343			0.654	
Back of Queue (*Q*), ft/ln (95 th percentile)		373.7			258.8			61.3			132.3	
Back of Queue (*Q*), veh/ln (95 th percentile)		13.8			9.4			2.4			5.1	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		8.0			8.5			39.0			40.6	
Incremental Delay (d_2), s/veh		12.5			2.3			0.4			6.5	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		20.5			10.8			39.4			47.1	
Level of Service (LOS)		C			B			D			D	
Approach Delay, s/veh / LOS	20.5	C		10.8	B		39.4	D		47.1	D	
Intersection Delay, s/veh / LOS	19.8						B					

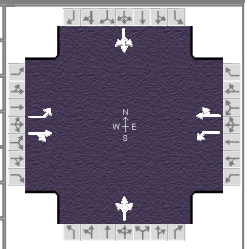
Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.64	B	1.72	B	1.72	B
Bicycle LOS Score / LOS	2.37	B	1.48	A	0.60	A	0.68	A

APPENDIX D

HCS Capacity Analysis - Build Conditions

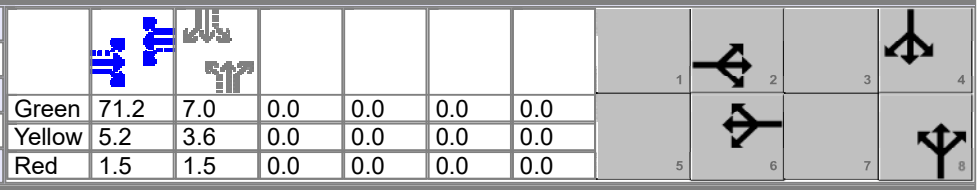
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2027	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2027 AM - LT.xus		
Project Description	2027 Build Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	25	385	15	10	930	15	35	15	10	10	10	60

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	71.2	7.0	0.0	0.0	0.0	0.0						
Yellow	5.2	3.6	0.0	0.0	0.0	0.0						
Red	1.5	1.5	0.0	0.0	0.0	0.0						

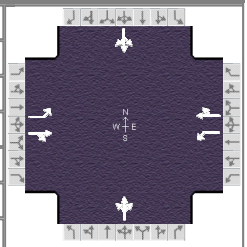
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		6.0		6.0		8.0		8.0
Phase Duration, s		77.9		77.9		12.1		12.1
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						5.8		7.1
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.98		0.98
Max Out Probability						1.00		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	27	435		11	1027			65			87	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	558	1603		969	1582			1474			1485	
Queue Service Time (g_s), s	2.8	7.0		0.3	34.9			0.0			1.4	
Cycle Queue Clearance Time (g_c), s	37.7	7.0		7.3	34.9			3.8			5.1	
Green Ratio (*g/C*)	0.79	0.79		0.79	0.79			0.08			0.08	
Capacity (*c*), veh/h	304	1267		770	1250			177			160	
Volume-to-Capacity Ratio (*X*)	0.089	0.343		0.014	0.821			0.368			0.544	
Back of Queue (*Q*), ft/ln (95 th percentile)	16.8	61.4		2.1	314.3			62.3			88.6	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.7	2.3		0.1	11.5			2.4			3.4	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	16.9	2.7		3.8	5.6			40.0			40.7	
Incremental Delay (d_2), s/veh	0.6	0.7		0.0	6.2			0.5			2.1	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0			0.0			0.0	
Control Delay (*d*), s/veh	17.5	3.4		3.8	11.8			40.5			42.8	
Level of Service (LOS)	B	A		A	B			D			D	
Approach Delay, s/veh / LOS	4.3	A		11.7	B		40.5	D		42.8	D	
Intersection Delay, s/veh / LOS	12.4						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.94	B	1.94	B
Bicycle LOS Score / LOS	1.25	A	2.20	B	0.60	A	0.63	A

HCS7 Signalized Intersection Results Summary

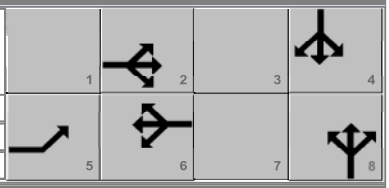
General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District12	Time Period	PM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2027	Analysis Period	1> 4:45
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2027 PM - LT.xus		
Project Description	2027 Build Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	65	870	35	10	475	20	15	15	15	25	25	45

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off

Green	5.8	61.3	7.0	0.0	0.0	0.0
Yellow	3.0	5.2	3.6	0.0	0.0	0.0
Red	1.0	1.6	1.5	0.0	0.0	0.0



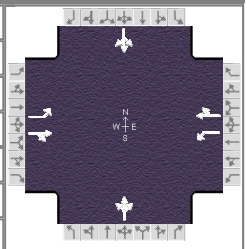
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6		8		4
Case Number	1.0	4.0		6.3		8.0		8.0
Phase Duration, s	9.8	77.9		68.1		12.1		12.1
Change Period, ($Y+R_c$), s	4.0	6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s	3.0	0.0		0.0		3.1		3.1
Queue Clearance Time (g_s), s	2.9					4.6		8.1
Green Extension Time (g_e), s	0.0	0.0		0.0		0.0		0.0
Phase Call Probability	0.83					0.98		0.98
Max Out Probability	0.05					0.73		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	71	984		11	538			49			103	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1667	1602		581	1575			1562			1498	
Queue Service Time (g_s), s	0.9	30.1		0.9	14.9			0.0			3.5	
Cycle Queue Clearance Time (g_c), s	0.9	30.1		21.2	14.9			2.6			6.1	
Green Ratio (*g/C*)	0.77	0.79		0.68	0.68			0.08			0.08	
Capacity (*c*), veh/h	642	1266		345	1073			175			167	
Volume-to-Capacity Ratio (*X*)	0.110	0.777		0.032	0.502			0.280			0.618	
Back of Queue (*Q*), ft/ln (95 th percentile)	7.6	271.8		5.7	203.8			46			112	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.3	10.1		0.2	7.4			1.8			4.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	4.3	5.1		13.6	7.0			39.5			41.0	
Incremental Delay (d_2), s/veh	0.0	4.7		0.2	1.7			0.3			5.0	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0			0.0			0.0	
Control Delay (*d*), s/veh	4.3	9.9		13.7	8.6			39.8			46.1	
Level of Service (LOS)	A	A		B	A			D			D	
Approach Delay, s/veh / LOS	9.5	A		8.7	A		39.8	D		46.1	D	
Intersection Delay, s/veh / LOS	12.3						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.63	B	1.94	B	1.94	B
Bicycle LOS Score / LOS	2.23	B	1.39	A	0.57	A	0.66	A

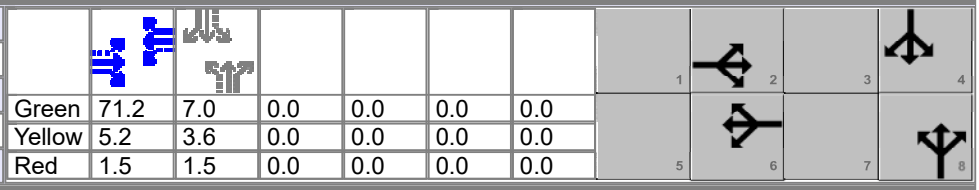
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2047	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2047 AM - LT.xus		
Project Description	2047 Build Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	30	415	20	15	1000	20	40	20	15	15	15	65

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	71.2	7.0	0.0	0.0	0.0	0.0						
Yellow	5.2	3.6	0.0	0.0	0.0	0.0						
Red	1.5	1.5	0.0	0.0	0.0	0.0						

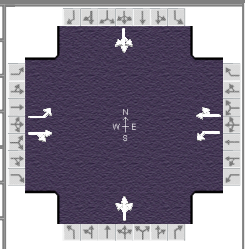
Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		6.0		6.0		8.0		8.0
Phase Duration, s		77.9		77.9		12.1		12.1
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						6.9		8.0
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.99		0.99
Max Out Probability						1.00		1.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	33	473		16	1109			82			103	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	516	1600		935	1581			1449			1526	
Queue Service Time (g_s), s	4.3	7.9		0.5	44.4			0.0			1.1	
Cycle Queue Clearance Time (g_c), s	48.7	7.9		8.4	44.4			4.9			6.0	
Green Ratio (*g/C*)	0.79	0.79		0.79	0.79			0.08			0.08	
Capacity (*c*), veh/h	233	1264		737	1249			174			165	
Volume-to-Capacity Ratio (*X*)	0.140	0.374		0.022	0.888			0.468			0.626	
Back of Queue (*Q*), ft/ln (95 th percentile)	25.6	70.6		3.4	405.8			79.2			112.6	
Back of Queue (*Q*), veh/ln (95 th percentile)	1.0	2.6		0.1	14.8			3.1			4.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	23.8	2.8		4.1	6.6			40.5			41.0	
Incremental Delay (d_2), s/veh	1.3	0.8		0.1	9.6			0.7			5.5	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0			0.0			0.0	
Control Delay (*d*), s/veh	25.0	3.7		4.1	16.2			41.2			46.5	
Level of Service (LOS)	C	A		A	B			D			D	
Approach Delay, s/veh / LOS	5.0	A		16.1	B		41.2	D		46.5	D	
Intersection Delay, s/veh / LOS	15.9						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.94	B	1.94	B
Bicycle LOS Score / LOS	1.32	A	2.34	B	0.62	A	0.66	A

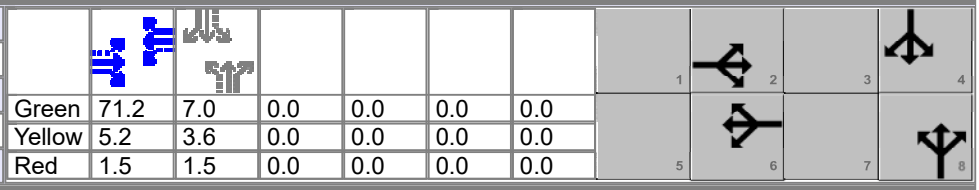
HCS7 Signalized Intersection Results Summary

General Information				Intersection Information	
Agency	Arcadis US Inc			Duration, h	0.250
Analyst	QAi	Analysis Date	5/26/2022	Area Type	Other
Jurisdiction	District 12	Time Period	AM Peak	PHF	0.92
Urban Street	US 422	Analysis Year	2047	Analysis Period	1> 6:15
Intersection	US422 at Rapids Road	File Name	US 422 at Rapids Road - 2047 AM - LT.xus		
Project Description	2047 Build Conditions				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	30	415	20	15	1000	20	40	20	15	15	15	65

Signal Information			
Cycle, s	90.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	No	Simult. Gap E/W	Off
Force Mode	Fixed	Simult. Gap N/S	Off



Green	71.2	7.0	0.0	0.0	0.0	0.0						
Yellow	5.2	3.6	0.0	0.0	0.0	0.0						
Red	1.5	1.5	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		6.0		6.0		8.0		8.0
Phase Duration, s		77.9		77.9		12.1		12.1
Change Period, ($Y+R_c$), s		6.8		6.8		5.1		5.1
Max Allow Headway (*MAH*), s		0.0		0.0		3.1		3.2
Queue Clearance Time (g_s), s						6.9		8.0
Green Extension Time (g_e), s		0.0		0.0		0.0		0.0
Phase Call Probability						0.99		0.99
Max Out Probability						1.00		1.00

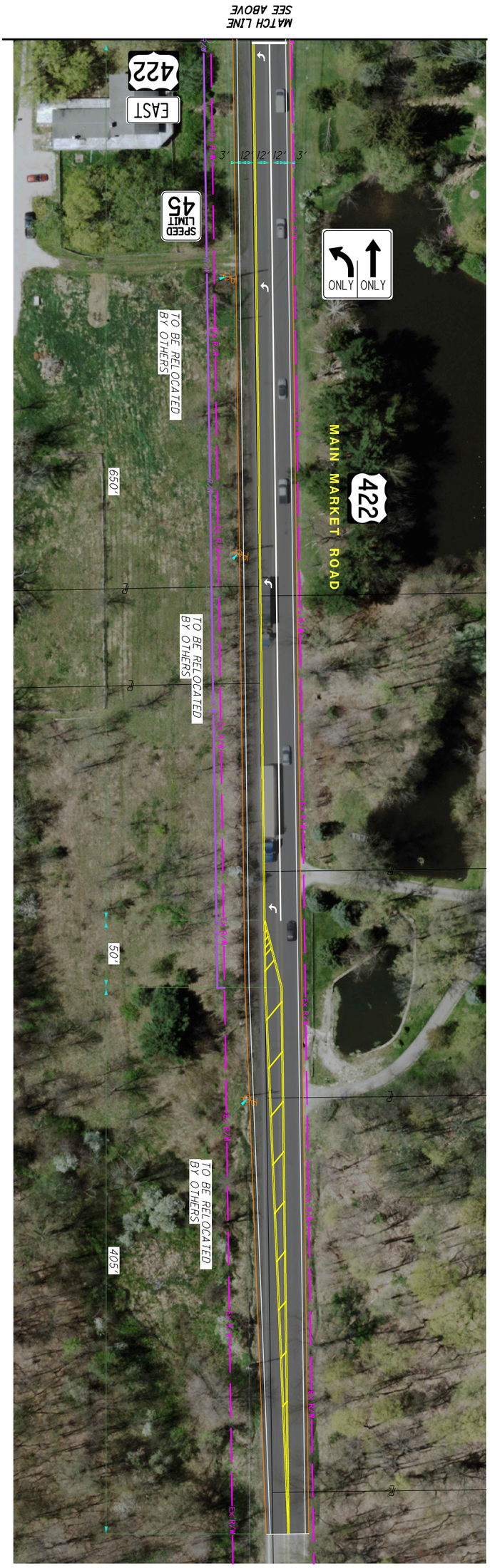
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	33	473		16	1109			82			103	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	516	1600		935	1581			1449			1526	
Queue Service Time (g_s), s	4.3	7.9		0.5	44.4			0.0			1.1	
Cycle Queue Clearance Time (g_c), s	48.7	7.9		8.4	44.4			4.9			6.0	
Green Ratio (*g/C*)	0.79	0.79		0.79	0.79			0.08			0.08	
Capacity (*c*), veh/h	233	1264		737	1249			174			165	
Volume-to-Capacity Ratio (*X*)	0.140	0.374		0.022	0.888			0.468			0.626	
Back of Queue (*Q*), ft/ln (95 th percentile)	25.6	70.6		3.4	405.8			79.2			112.6	
Back of Queue (*Q*), veh/ln (95 th percentile)	1.0	2.6		0.1	14.8			3.1			4.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	23.8	2.8		4.1	6.6			40.5			41.0	
Incremental Delay (d_2), s/veh	1.3	0.8		0.1	9.6			0.7			5.5	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0			0.0			0.0	
Control Delay (*d*), s/veh	25.0	3.7		4.1	16.2			41.2			46.5	
Level of Service (LOS)	C	A		A	B			D			D	
Approach Delay, s/veh / LOS	5.0	A		16.1	B		41.2	D		46.5	D	
Intersection Delay, s/veh / LOS	15.9						B					

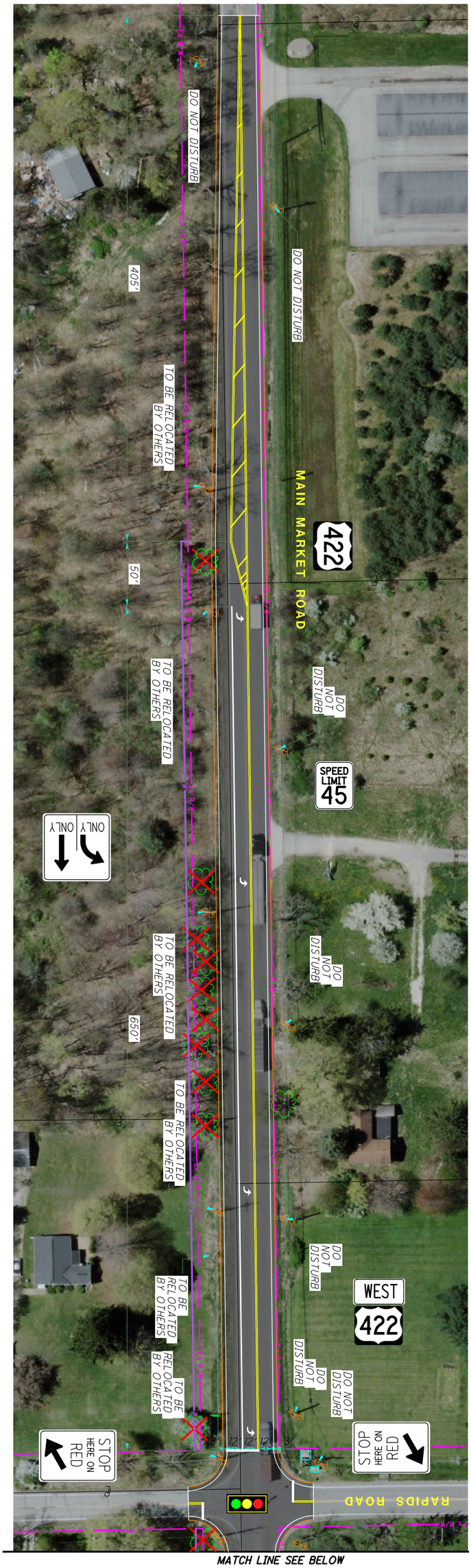
Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.60	B	1.60	B	1.94	B	1.94	B
Bicycle LOS Score / LOS	1.32	A	2.34	B	0.62	A	0.66	A

APPENDIX E

Conceptual Schematic of Proposed Countermeasure

CTY-RTE-SECTION





SHEET	TOTAL
1	1

PROJECT ID: 115292

REVIEWER: SMG 7-13-22

DESIGNER: TB

DESIGN AGENCY
ARCADIS
1111 SUPERIOR AVENUE SUITE 1300
CLEVELAND, OHIO 44114
(216) 781-6177
www.arcadis.com

US 422 AT RAPIDS ROAD SAFETY STUDY
CONCEPTUAL SCHEMATIC

HORIZONTAL SCALE IN FEET
0 40
20 80

APPENDIX F

Cost Estimate

PID 115292 - US 422 @ Rapids Rd.

Description	Qty	Unit	Unit Cost	Cost	Comment
CLEARING AND GRUBBING	1	LS	$20,000	$20,000	
PAVEMENT REMOVED, ASPHALT	2880	SY	$15	$43,200	
EXCAVATION	250	CY	$30	$7,500	
EMBANKMENT	250	CY	$30	$7,500	
PAVEMENT PLANING, ASPHALT CONCRETE	6371	SY	$5	$31,856	
SUBGRADE COMPACTION	3285	SY	$3	$9,855	
ASPHALT CONCRETE BASE, PG64-22	501	CY	$200	$100,167	
AGGREGATE BASE	521	CY	$75	$39,063	
ASPHALT CONCRETE SURFACE COURSE, TYPE 1, (448), PG64-	204	CY	$300	$61,163	
ASPHALT CONCRETE INTERMEDIATE COURSE, TYPE 1, (448)	285	CY	$250	$71,357	
SIGNAL SUPPORT, MISC.:New Signal w/ Mast Arms	1	EA	$250,000	$250,000	
SIGNING, MISC.: Signing and Striping	1	LS	$7,500	$7,500	
EROSION CONTROL	1000	EA	$1	$1,000	
MAINTAINING TRAFFIC	1	LS	$5,000	$5,000	
MOBILIZATION	1	LS	$10,000	$10,000	
CONSTRUCTION LAYOUT AND STAKING	1	LS	$3,000	$3,000	
SUBTOTAL				$668,160	
30% DESIGN CONTINGENCY				$200,448	
5% INFLATION				$33,408	2022 to 2023
GRAND TOTAL				$902,016	

APPENDIX G

Economic Crash Analysis Tool Results

Project Information

General Information

Project Name	D12 D3 GES FY2022-2024 Traffic	Contact Email	justin.maderia@arcadis.com
Project Description	Safety Study	Contact Phone	216-571-7416
Reference Number	PID #115292	Date Performed	8/12/2022
Analyst	Justin Maderia	Analysis Year	2047
Agency/Company	Arcadis		
Perform Benefit Cost Analysis?	Yes		

Do the proposed improvements fundamentally change the conditions of the base safety performance function (SPF), Or is crash data unavailable for the analysis condition, Or is only predicted (and not expected) analysis needed for the existing or proposed condition?	**Yes**

(Examples: unsignalized to signalized, undivided to divided, increase or decrease in the number of lanes, change the number of approaches to an intersection, significant realignment of the roadway)

If Yes, are you analyzing the existing or proposed conditions?	**Proposed**

Project Elements Description Table

Project Element ID (Must be Unique)	Site Type	Intersection Control Type	Location Information					
			NLFID	Begin Logpoint/ Intersection Midpoint	End Logpoint *(Leave blank for Intersection)*	Length (mi) OR Intersection Radius Buffer (mi)	Cross Route NLFID(s)	Common Name
US422; 11.562	Rural Two-Lane Two Way Intersection	Signalized	SGEAUS00422**C	11.562		0.05	CGEACR0000	US 422 at Rapids Road

Traffic Volume Growth Rate Calculation For Benefit Cost Analysis

	Year	AADT	
Present ADT (PADT)	2022	15,755	veh / day
Future ADT (FADT)	2047	18,170	veh / day
Annual Linear Growth Rate		0.0061	

Proposed Conditions: General Information and Data for Rural Two-Lane Two-Way Intersection

General Information		Location Information	
Analyst	Justin Maderia	Route	US422
Agency or Company	Arcadis	Logpoint	11.562
Date Performed	08/12/22	Common Name	US 422 at Rapids Road
Intersection	US422; 11.562	Analysis Year	2047
Signalized/Unsignalized	Signalized		

Input Data							Proposed Conditions	HSM Base Conditions
Intersection type (3ST, 4ST, 4SG)							4SG	--
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ =	25,200	(veh/day)				17,100	--
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ =	12,500	(veh/day)				1,070	--
Intersection skew angle (degrees) Skew Angle Help	Does skew differ for minor legs? Else, No.			Skew for Leg 1 (All):	0	Skew for Leg 2 (4ST only):	0	0
Number of signalized approaches with a left-turn lane (0, 1, 2, 3, 4)							2	0
Number of signalized approaches with a right-turn lane (0, 1, 2, 3, 4)							0	0
Intersection lighting (present/not present)							Present	Not Present
Calibration Factor, C_i							1.68	1.00
Locality:							State System	

Proposed Conditions: Crash Modification Factors (CMFs) for Rural Two-Lane Two-Way Intersection

(1) CMF for Intersection Skew Angle CMF_{1i} from Equations 10-22 or 10-23	(2) CMF for Left-Turn Lanes CMF_{2i} from Table 10-13	(3) CMF for Right-Turn Lanes CMF_{3i} from Table 10-14	(4) CMF for Lighting CMF_{4i} from Equation 10-24	(5) Combined CMF CMF_{COMB} (1)*(2)*(3)*(4)
1.0000	0.6700	1.0000	0.9999	0.6699

Proposed Conditions: Predicted Crash Summary for Rural Two-Lane Two-Way Intersection

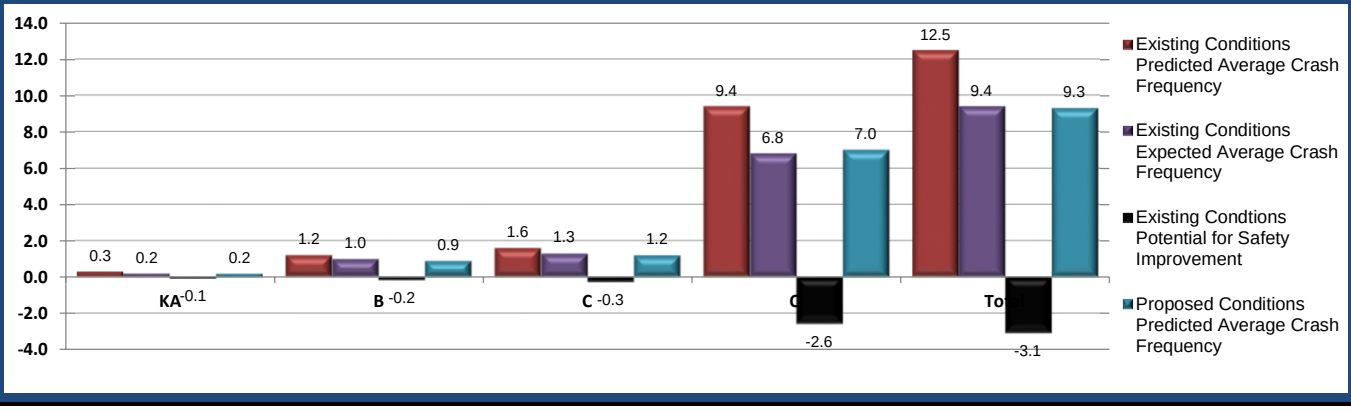
(1) Crash Severity Level	(2) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ from Equations 10-8, 10-9, or 10-10	(3) Overdispersion Parameter, k from Section 10.6.2	(4) Crash Severity Distribution from Table 10-5	(5) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ by Severity Distribution $(2)_{TOTAL}$ * (4)	(6) Combined CMFs from (5) of Worksheet 2B	(7) Calibration Factor, C_i	(8) Predicted average crash frequency, $N_{predicted\ int}$ (5)*(6)*(7)
Total	8.275	0.11	1.000	8.275	0.67	1.68	9.313
Fatal and Injury (FI)	--	--	0.249	2.057	0.67	1.68	2.315
Property Damage Only (PDO)	--	--	0.751	6.217	0.67	1.68	6.998

Project Safety Performance Report

General Information

Project Name	D12 D3 GES FY2022-2024 Traffic	Contact Email	justin.maderia@arcadis.com
Project Description	Safety Study	Contact Phone	216-571-7416
Reference Number	PID #115292	Date Performed	8/12/2022
Analyst	Justin Maderia	Analysis Year	2047
Agency/Company	Arcadis		

Summary of Anticipated Safety Performance of the Project (average crashes/year)



Project Summary Results (Without Animal Crashes)

	KA	B	C	O	Total
$N_{predicted}$ - Existing Conditions	0.2934	1.2471	1.5769	9.4224	12.5398
$N_{expected}$ - Existing Conditions	0.2425	1.0309	1.3032	6.8322	9.4088
$N_{potential\ for\ improvement}$ - Existing Conditions	-0.0509	-0.2162	-0.2737	-2.5902	-3.1310
$N_{predicted}$ - Proposed Conditions	0.2181	0.9262	1.1709	6.9979	9.3131

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Existing Conditions Project Element Predicted Crash Summary (Without Animal Crashes)

Project Element ID	Common Name	Crash Severity Level				
		KA	B	C	O	Total
US422; 11.562	US 422 at Rapids Road	0.2934	1.2471	1.5769	9.4224	12.5398

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Existing Conditions Project Element Expected Crash Summary (Without Animal Crashes)

Project Element ID	Common Name	Crash Severity Level				
		KA	B	C	O	Total
US422; 11.562	US 422 at Rapids Road	0.2425	1.0309	1.3032	6.8322	9.4088

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Existing Conditions Project Element Potential for Safety Improvement Summary (Without Animal Crashes)

Project Element ID	Common Name	Crash Severity Level				
		KA	B	C	O	Total
US422; 11.562	US 422 at Rapids Road	-0.0509	-0.2162	-0.2737	-2.5902	-3.131

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Proposed Conditions Project Element Predicted Crash Summary (Without Animal Crashes)

Project Element ID	Common Name	Crash Severity Level				
		KA	B	C	O	Total
US422; 11.562	US 422 at Rapids Road	0.2181	0.9262	1.1709	6.9979	9.3131

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Summary by Crash Type

Crash Type	Existing			Proposed
	Predicted Crash Frequency	Expected Crash Frequency	PSI	Expected Crash Frequency
Unknown	0.0166	0.0116	-0.0050	
Head On	0.1072	0.0753	-0.0319	
Rear End	6.4616	4.4208	-2.0408	
Backing	0.6987	0.4675	-0.2312	
Sideswipe - Meeting	0.2967	0.2032	-0.0935	
Sideswipe - Passing	1.0108	0.6817	-0.3291	
Angle	2.9674	2.0482	-0.9192	
Parked Vehicle	0.5471	0.3686	-0.1785	
Pedestrian	0.1361	0.0992	-0.0369	
Animal	0.0000	0.0000	0.0000	
Train	0.0000	0.0000	0.0000	
Pedalcycles	0.0903	0.0649	-0.0254	
Other Non-Vehicle	0.0000	0.0000	0.0000	
Fixed Object	0.9330	0.6388	-0.2942	
Other Object	0.0298	0.0200	-0.0098	
Overturning	0.0586	0.0414	-0.0172	
Other Non-Collision	0.0837	0.0568	-0.0269	
Left Turn	1.2309	0.8558	-0.3751	
Right Turn	0.0000	0.0000	0.0000	

Safety Benefit - Cost Analysis

General Information

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Select Site Types to be used in Benefit-Cost Analysis:

All Sites

Comments:

Countermeasure Service Lives, Costs, and Safety Benefits

Countermeasures	Service Life (Years)	Initial Cost of Countermeasure	Annual Maintenance & Energy Costs	Salvage Value	Net Present Cost of Countermeasure	Total Cost of Countermeasures	Summary of Annual Crash Modifications	Net Present Value of Safety Benefits
Eastbound and Westbound Left Turn Lane on US 422	25	$1,172,016.00	$0.00	$0.00	$1,172,016.00	$1,172,016.00	-3.227	$1,143,785
Site Characteristic Improvements (Please add description about improvements i.e. Lighting)					$0.00	$0.00		
Site Characteristic Improvements (Please add description about improvements i.e. Signal Phasing)					$0.00	$0.00		
Site Characteristic Improvements (Please add description about improvements i.e. Added Right Turn Lane)					$0.00	$0.00		
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
					$0.00	$0.00	0.000	$0
Totals		**$1,172,016.00**	**$0.00**	**$0.00**	**$1,172,016.00**	**$1,172,016.00**	**-3.227**	**$1,143,785**

Safety Benefit - Cost Analysis

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Benefit - Cost Calculator

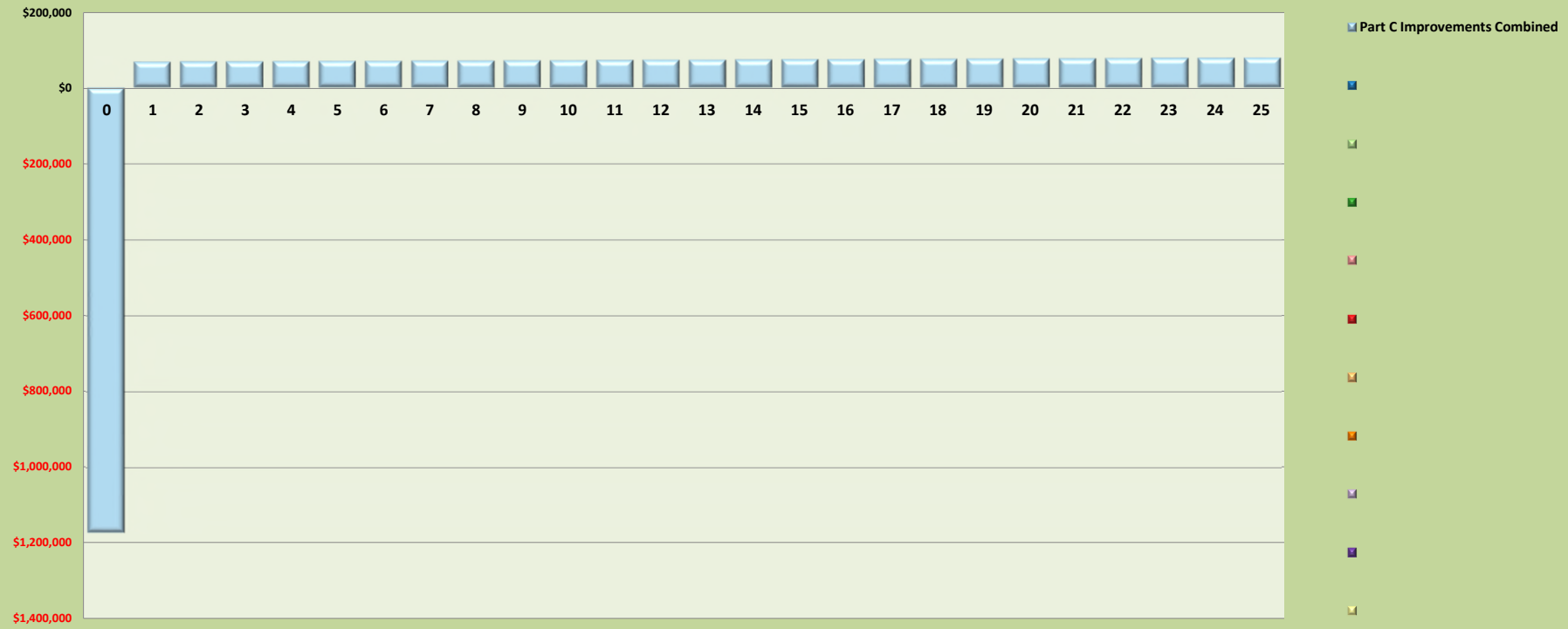
Net Present Value of Project	$1,172,016.00
Net Present Value of Safety Benefits	$1,143,785.12
Net Benefit	($28,230.88)
Benefit / Cost Ratio	0.98

Expected Annual Crash Adjustment

Number of Fatal & Incapacitating Injury Crashes	-0.075
Number of Injury Crashes	-0.802
Number of Total Crashes	-3.227

Comments:

Safety Benefits and Project Costs Combined Cash Flows By Countermeasure Per Year



Safety Benefit - Cost Analysis

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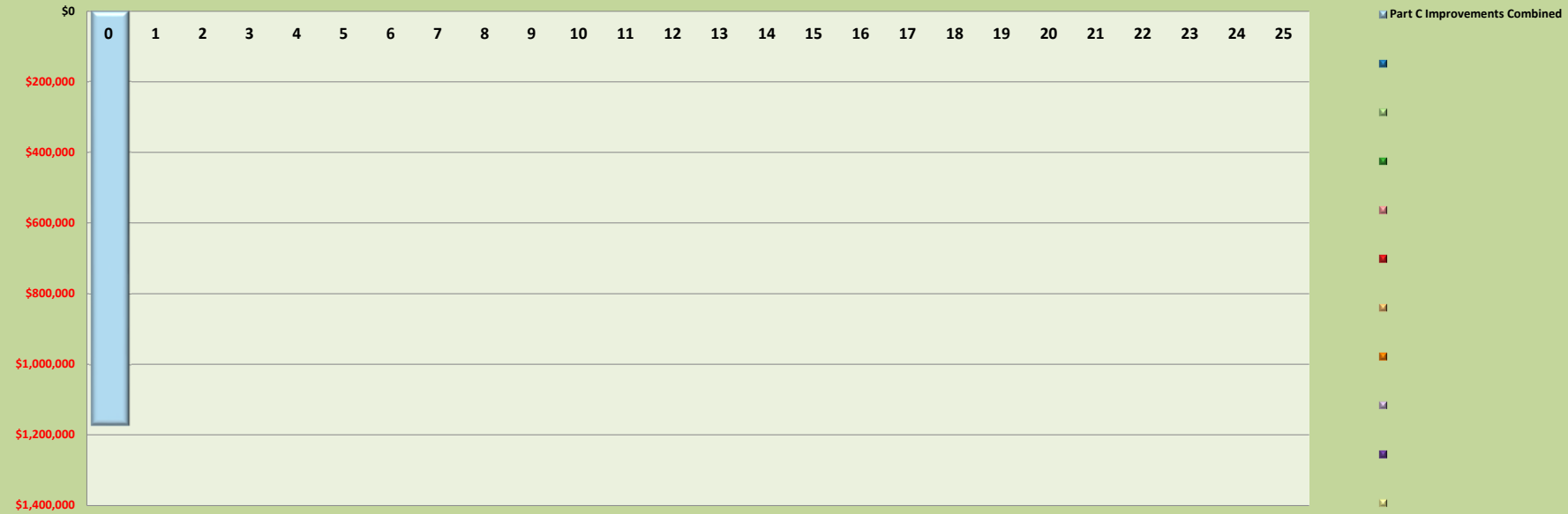
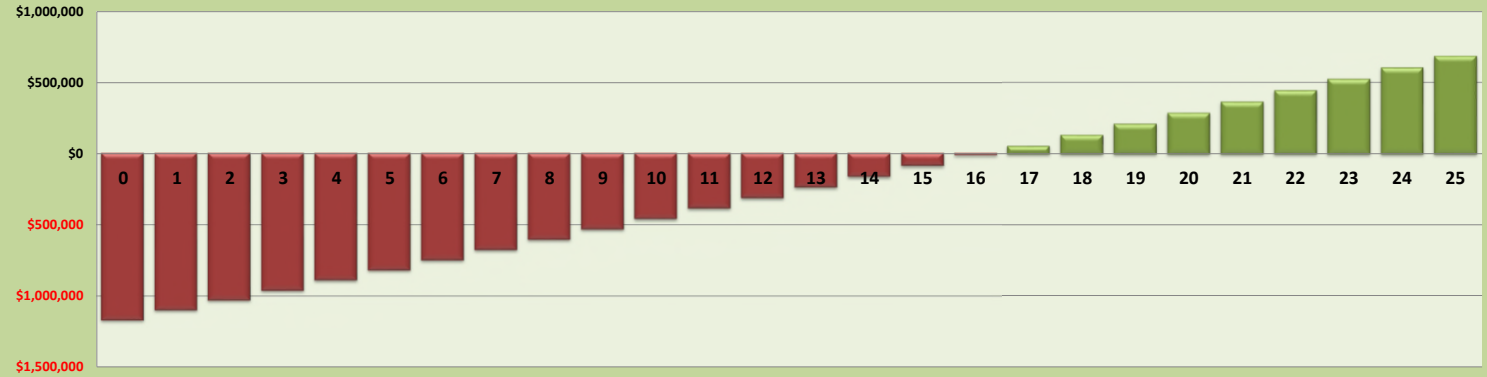
Project Costs Only Cash Flows By Countermeasure Per Year



Return on Investment (Safety Benefits and Project Investments)



First year to observe a positive return on investment: 2064 (17 years)

Percentage of Service Life to observe a continuous Positive Return on Investment: 36.00%