THE UNIVERSITY OF IOWA
IOWA INITIATIVE
FOR SUSTAINABLE COMMUNITIES

FINAL DELIVERABLE

Title	North Liberty Traffic Impact Study
Completed By	Angela Skonicki, Sean Moriarty, and Momen Mokhtar
Date Completed	May 2023
UI Department	Department of Civil and Environmental Engineering
Course Name	Project Design and Management CEE:4850
Instructor	Paul Hanley
Community Partners	City of North Liberty

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a community engagement program at the University of Iowa. IISC partners with rural and urban communities across the state to develop projects that university students and IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

Research conducted by faculty, staff, and students of The University of Iowa exists in the public domain. When referencing, implementing, or otherwise making use of the contents in this report, the following citation style is recommended:

> [Student names], led by [Professor's name]. [Year]. [Title of report]. Research report produced through the Iowa Initiative for Sustainable Communities at the University of Iowa.

This publication may be available in alternative formats upon request.

Iowa Initiative for Sustainable Communities
The University of Iowa
347 Jessup Hall
Iowa City, IA, 52241
Phone: 319.335.0032
Email: iisc@uiowa.edu
Website: http://iisc.uiowa.edu/

The University of Iowa prohibits discrimination in employment, educational programs, and activities on the basis of race, creed, color, religion, national origin, age, sex, pregnancy, disability, genetic information, status as a U.S. veteran, service in the U.S. military, sexual orientation, gender identity, associational preferences, or any other classification that deprives the person of consideration as an individual. The University also affirms its commitment to providing equal opportunities and equal access to University facilities. For additional information contact the Office of Equal Opportunity and Diversity, (319) 335-0705.

TRAFFIC IMPACT STUDY

Prepared for the City of North Liberty, Iowa

Prepared by Angela Skonicki, Sean Moriarty,
and Momen Mokhtar
College of Engineering
University of Iowa

May 2023

Table of Contents

I. EXECUTIVE SUMMARY, CONCLUSIONS & RECOMMENDATIONS

North Liberty, Iowa, is a rapidly growing city with increasing traffic demands. The city has experienced substantial traffic growth in recent years, which has put a strain on the transportation system. To address the growing traffic issues, the city has been working to improve its transportation infrastructure and develop new strategies to manage congestion. One of the ways the city has addressed traffic growth was by investing in new roads and intersections to improve traffic flow. The city has also worked on expanding its public transportation options, such as bus and bike lanes, to reduce reliance on cars.

To further enhance the transportation system, the city has worked with neighboring communities to coordinate and integrate their transportation plans. By working together, the city and its neighbors seeks to create a comprehensive transportation network to serve the needs of the entire region.

The city has also engaged with the community to gather input on transportation issues and to identify opportunities for improvement. Through public meetings and surveys, the city has gained a better understanding of the transportation needs of its residents and businesses. This information had been used to develop a comprehensive transportation plan that would guide the city's efforts to improve the transportation system over the next decade.

The City of North Liberty has requested a traffic impact study for the intersection of Penn Street and Ranshaw Way, situated close to Pacha Parkway and Community Drive. During the development of Pacha Parkway and Community Drive, it was not anticipated that the growth of the town would result in significant traffic issues.

However, the westbound traffic during the morning rush hour heading toward the interstate has increased. Specifically, between 7 to 9 AM, traffic is observed to congest beyond Community Drive and Pacha Parkway, causing long delays for westbound traffic. As the city grows, there will be more development on the east side; therefore, the congested traffic is expected to worsen.

To address the city’s concerns about this traffic congestion, we set up traffic counters to collect traffic information. With the current traffic counts, we built a simulation model to investigate different traffic scenarios along both Ranshaw and Penn corridors. We then analyzed the results and prepared a traffic impact study detailing our findings and recommendations.

Due to the presence of landscaping at the intersection, any structural improvements to the area will be costly. Moreover, the city is not looking to change the geometry of any of the roads or add a roundabout. They are looking for a low-cost solution.

We are proposing the City of North Liberty implement a short-term solution to alleviate current delays and improve traffic flow at the intersection. Specifically, we suggest adjusting the timing and phasing of the signal lights to address the current concerns. This solution will improve the

level of service of the westbound approach while maintaining the existing level of service for the other directions. It was projected that this solution would be effective for four years.

In the long-term, we propose widening Penn Street by adding an extra through lane. This addition will anticipate an increase in the level of service of the intersection from a C to a B.

Our final submittals to the city of North Liberty includes a traffic impact study, Synchro model showing different traffic scenarios, and other design documents to the City of North Liberty engineer by May 12, 2023. The total cost of the design is estimated to be around $275.

II. DESIGN SERVICES

▪ PROJECT SCOPE

The aim of this project is to address the issue of traffic congestion on Penn St in North Liberty, IA, particularly in the westbound direction during the morning peak (7-9 AM) toward Interstate 380. The project involves conducting a traffic impact study for the intersection of Penn Street and Ranshaw Way in North Liberty, Iowa.

Our team conducted a thorough study and some of the tasks completed include:

- Traffic data collection: Traffic counters were used to collect traffic data and determine turning movements at the intersection during peak and off-peak hours.
- Traffic simulation modeling: Several traffic simulation models were developed using the collected data to simulate different traffic scenarios along both Ranshaw and Penn corridors. Scenarios included: existing conditions scenario, adjusted signal timing and phasing scenario, and a widening scenario.
- Traffic analysis: The simulation results were analyzed to identify the root causes of congestion and delays at the intersection.
- Recommendations development: Short-term and long-term recommendations were developed to alleviate congestion and improve traffic flow at the intersection.
- Design documents: Design documents were prepared, including a traffic impact study, Synchro model showing different traffic scenarios, and other design documents.
- Cost estimation: The total cost of the design, including the short-term and long-term solutions, was estimated.

Overall, the project aims to provide the City of North Liberty with a comprehensive traffic impact study, recommendations for short- and long-term solutions, and design documents to help the city alleviate congestion and improve traffic flow at the intersection of Penn Street and Ranshaw Way.

▪ WORK PLAN

The project period for this project spanned from February 6, 2023, to May 5, 2023. During the week of February 6-10, 2023, the client was presented with the project proposal. Once the proposal was accepted, research and design work commenced for the corridor in the City of North Liberty. Traffic counters were installed along the two corridors of the focus area, and the resulting counts were used to generate a Synchro model to simulate traffic congestion. The model was used to evaluate different signal and phasing timings for the intersection and to simulate the intersection's configuration with an additional westbound through lane. Improvement plans for the intersection were developed based on the findings of the model. Plans were developed for the potential construction of the additional through lane, which included the removal of items and the relocation of utilities. Draft submissions of the design drawings, design report, and poster were completed by April 7, 2023. The project's final design report, design drawings, and poster will be submitted to the City of North Liberty on May 12th, 2023.

▪ METHODS & DESIGN GUIDES

In the analysis process, the project team utilized the existing timing and phasing provided by the City of North Liberty as well as turning movement data collected at the intersection to construct a Synchro model. This model was developed to accurately replicate the existing conditions, providing a basis for evaluating the current traffic conditions at the intersection. The team then developed multiple Synchro models to simulate different timing and phasing scenarios, evaluating which scenarios would best alleviate congestion and improve traffic flow at the intersection.

Additionally, the project team developed a scenario that included widening Penn Street to add an additional through lane. The proposed lane would stretch approximately one mile from Community Drive to Jones Blvd. To evaluate the different scenarios, the team applied the capacity analysis procedures outlined in the Highway Capacity Manual within the Synchro Software. Key factors such as level of service, delay, and total cycle length were analyzed to determine which solution best met the project's criteria.

During the design process, the team utilized AutoCAD to design the intersection geometry, with reference to design manuals including SUDAS and Iowa Code of Ordinances. The Iowa DOT design manual was also used as a reference for the project's design drawings.

III. ANALYSIS OF EXISITING CONDITIONS & CONSTRAINTS

The intersection is presently occupied by commercial structures located at the northwest, northeast, and southeast corners. North Liberty is a growing community with a mix of residential and commercial areas. Traffic congestion is most pronounced during morning and afternoon peak hours. Ranshaw Way currently features two through lanes in both northbound and southbound directions, as well as a separate northbound through right lane and southbound through right lane as shown in figure 1. For northbound and southbound traffic, there are dedicated left-turn lanes. Penn Street features a left turn lane, a through lane, and a right turn lane in the eastbound direction, while the westbound direction has a through right turn lane and a left turn lane. The intersection is controlled by a multi-phase signal that enables protected and permitted left turns onto Ranshaw Way, as well as the same for cars turning onto Penn Street.

Figure 1: Current layout of intersection

The westbound geometry of Penn Street widens to three lanes and subsequently narrows to two lanes as shown in figure 2. This configuration features a right turn lane, a through lane, and a left turn lane. At the unsignalized intersection of Community Drive and Penn Street, there exists an eastbound left turn lane. Morning commuters are observed using this eastbound left turn lane as a continuation of the westbound left turn lane intended for Ranshaw Way.

Figure 2: East leg of Penn Street.

TRAFFIC DATA

The Iowa Department of Transportation's most recent traffic data dates back to 2017. Figure 3 illustrates the annual average daily traffic (AADT) and turning movement counts for that year, as obtained from the Iowa DOT's interactive map website. To obtain an approximate current value, this data was projected into five-year values using a growth rate of 1.5% provided by the Johnson County MPO. Subsequently, these values were used and inputted into Synchro to investigate the current traffic conditions.

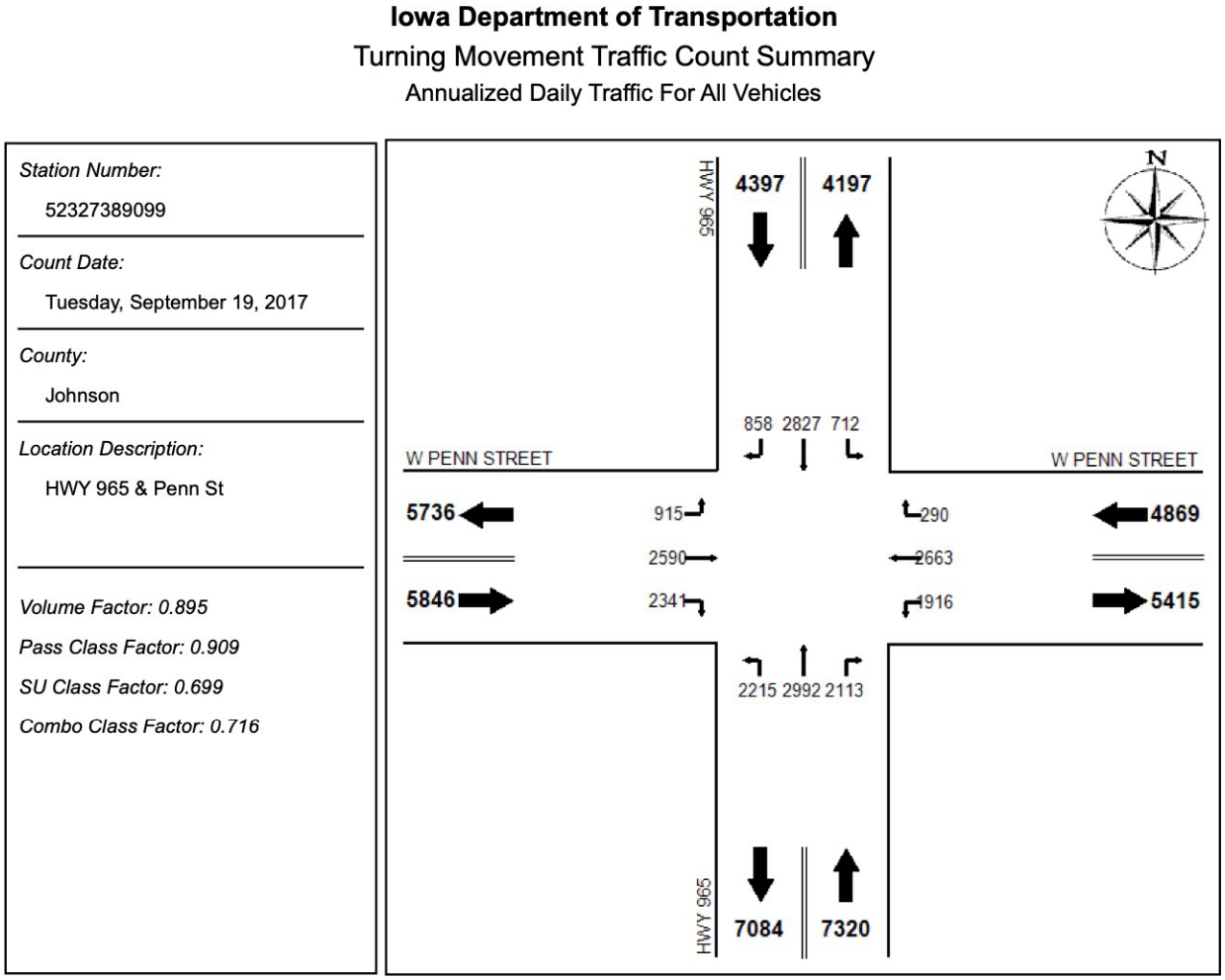


Figure 3: AADT & Turning movement traffic count summary.

		N Leg			E leg			S Leg			W Leg		
		L	T	R	L	T	R	L	T	R	L	T	R
AM Peak	7:00	137	404	115	193	330	14	233	196	69	82	181	192
PM Peak	17:00	90	309	81	153	244	24	234	397	220	96	386	272

Figure 4: AM & PM Peak for the Ranshaw & Penn intersection.

CRASH HISTORY

A report was produced using the Iowa Crash Analysis (ICAT) provided by the Iowa Department of Transportation, covering the past decade, and encompassing various types of accidents that occurred within a 200-foot radius of the intersection being studied.

To analyze when most accidents occurred within the week and time of day, the table below was considered, with accidents during morning and evening peaks highlighted in green and yellow, respectively. This data can be used to compare with future data after the implementation of the design alternatives, to determine the effectiveness of the changes made and identify any safety concerns.

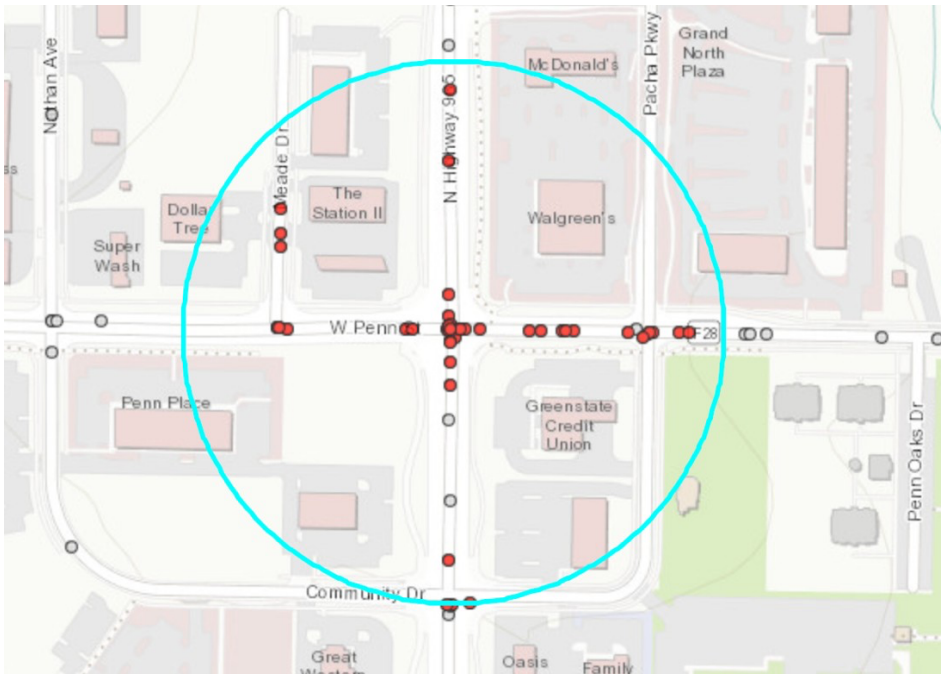


Figure 5: Area of study for the crash report.

Time of Day/Day of Week														
Day of Week	12 AM to 2 AM	2 AM to 4 AM	4 AM to 6 AM	6 AM to 8 AM	8 AM to 10 AM	10 AM to Noon	Noon to 2 PM	2 PM to 4 PM	4 PM to 6 PM	6 PM to 8 PM	8 PM to 10 PM	10 PM to 12 AM	Not reported	Total
Sunday	0	0	0	0	0	1	1	0	0	2	0	0	0	4
Monday	0	0	0	4	1	0	0	0	6	1	1	0	0	13
Tuesday	0	0	0	3	0	1	0	1	4	2	0	0	0	11
Wednesday	0	0	0	0	4	1	0	1	2	4	2	0	0	14
Thursday	0	0	0	2	2	2	1	3	3	0	1	0	0	14
Friday	0	0	0	1	2	0	5	2	3	2	0	0	0	15
Saturday	0	0	0	0	1	2	2	0	2	5	0	0	0	12
Total	0	0	0	10	10	7	9	7	20	16	4	0	0	83

Figure 6: Time of Day/Day of Week of accidents.

The majority of the accidents resulted in property damage, followed by possible or unknown crashes, and suspected minor injuries. No fatalities have been reported in this area over the past decade. Charts below illustrate the types and severity of crashes in different years. Additional information regarding the crashes can be found in the appendix of the report.

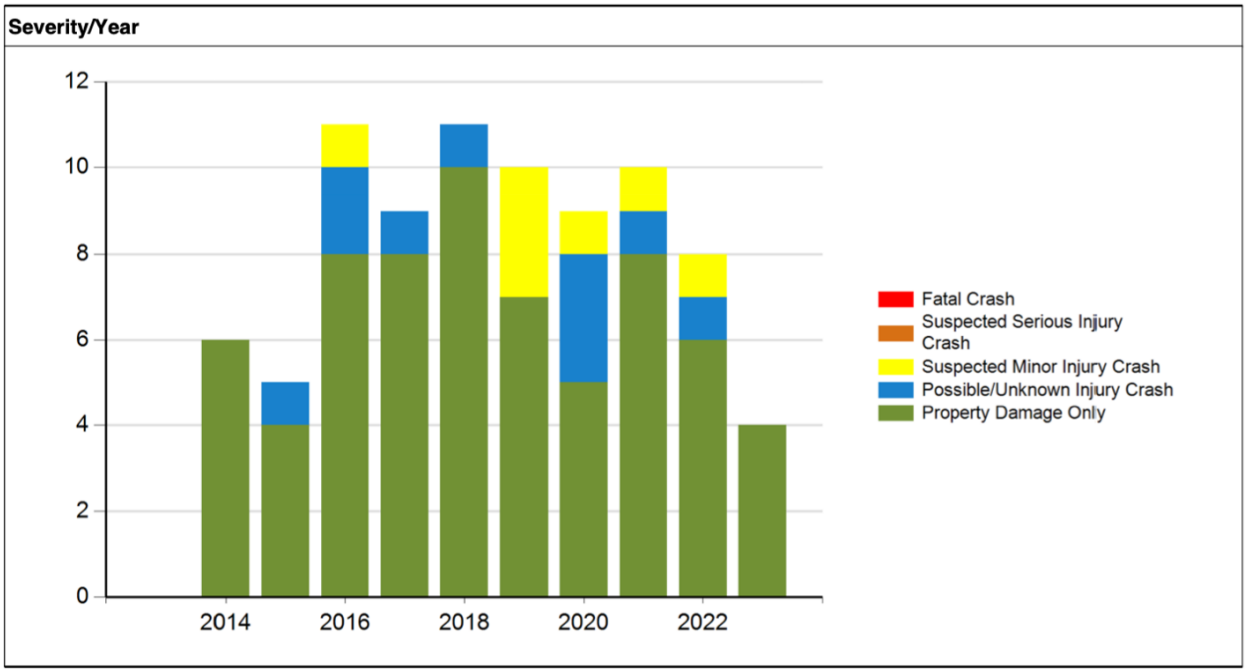


Figure 7: Types of crashes in different years.

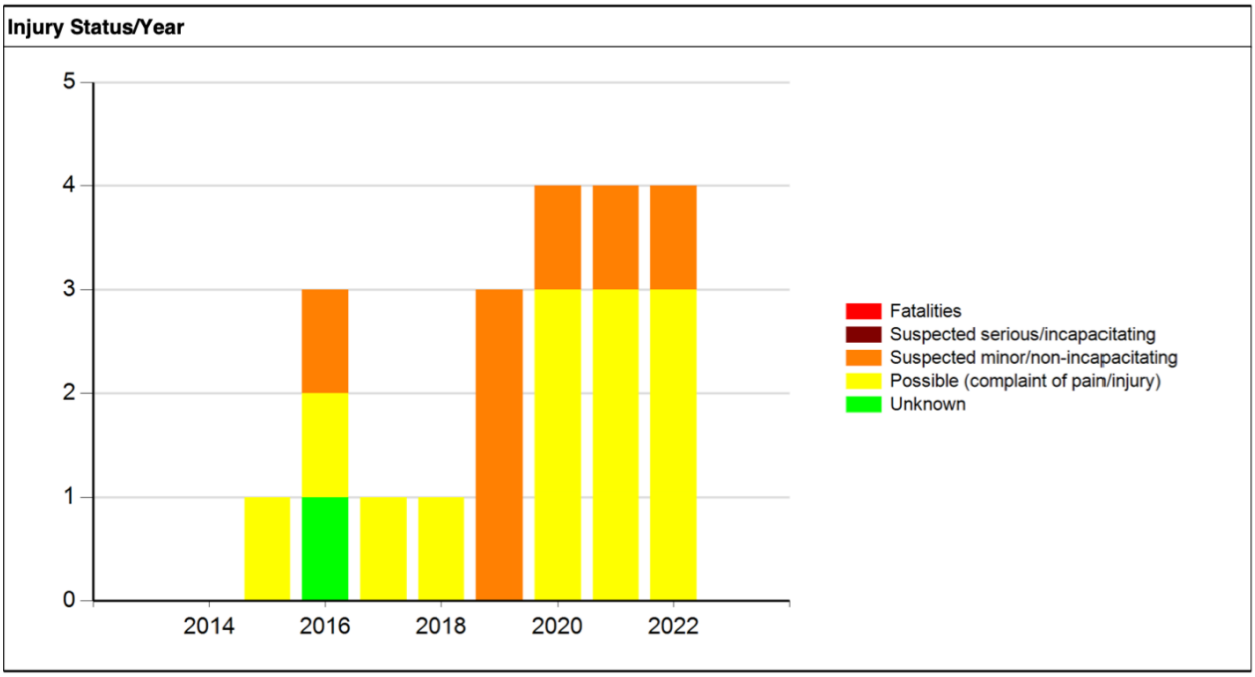


Figure 8: Injury status in different years.

CHALLENGES & IMPACTS

A major constraint for this project was that the client wanted a low-cost solution. The client also specified that they preferred that the current intersection does not get fully reconstructed. It is a relatively new build, and there is landscaping surrounding the intersection. Removing that landscaping will increase the cost of the project.

Another challenge that came with this project is the small distance between multiple intersections. There are less than 350 feet between Ranshaw Way and the next intersection with Community Drive heading eastbound. This limited right of way in intersections can pose a challenge for road design and improvement projects such as widening lanes or adding turn lanes. Also, the process of acquiring right of way can be time-consuming and expensive, and there may be resistance from property owners or other stakeholders. Instead, alternative solutions such as traffic signal optimization, intelligent transportation systems, or roundabouts were considered to improve traffic flow and safety. It is important to weigh the trade-offs of all altnertives in order to determine the best solution.

Improving traffic congestion in North Liberty, Iowa, would have a significant impact on various aspects of society. Here are a few key societal impacts to consider:

- Population Characteristics: Reducing traffic congestion leads to more efficient travel times for residents, allowing them to spend more time at work, school, or with their families. This could also attract new residents to the city, as a well-functioning transportation system is a desirable feature for many people.
- Community and Institutional Structures: By improving the transportation system, the city could foster better relationships between businesses, schools, and other institutions. This could lead to increased economic development and a more vibrant community.
- Individual and Family Changes: Improved traffic flow would result in less time spent sitting in traffic, reducing stress levels, and increasing overall quality of life for residents.
- Personal and Property Rights: By reducing traffic congestion, the city would be promoting individual freedom and the right to travel freely and efficiently. Additionally, reducing traffic would also decrease the likelihood of accidents, protecting personal safety and property rights.
- Community Resources: A well-functioning transportation system is a valuable resource for the entire community. It allows residents to access essential services such as healthcare, education, and employment more easily, and it attracts new businesses, which can provide economic opportunities and increase the tax base.

In conclusion, improving traffic congestion in North Liberty, Iowa, would have far-reaching impacts on various aspects of society, including population characteristics, community and institutional structures, individual and family changes, personal and property rights, and community resources.

IV. PROPOSED DEVELOPMENT

The population of North Liberty is expected to more than double by 2050, according to the Johnson County MPO. It is also expected that by 2050 there will be an increase in commercial density along Ranshaw Way and Penn Street. While this project is projected to be implemented in the near future, the intersection is being designed to withstand expected future development.

The same growth factor of 1.5% that was used by the MPO to forecast future growth is being applied in our analysis. It is assumed that there are no large developments planned in the immediate vicinity of the intersection, which justifies the use of the overall growth factor as a reasonable approximation.

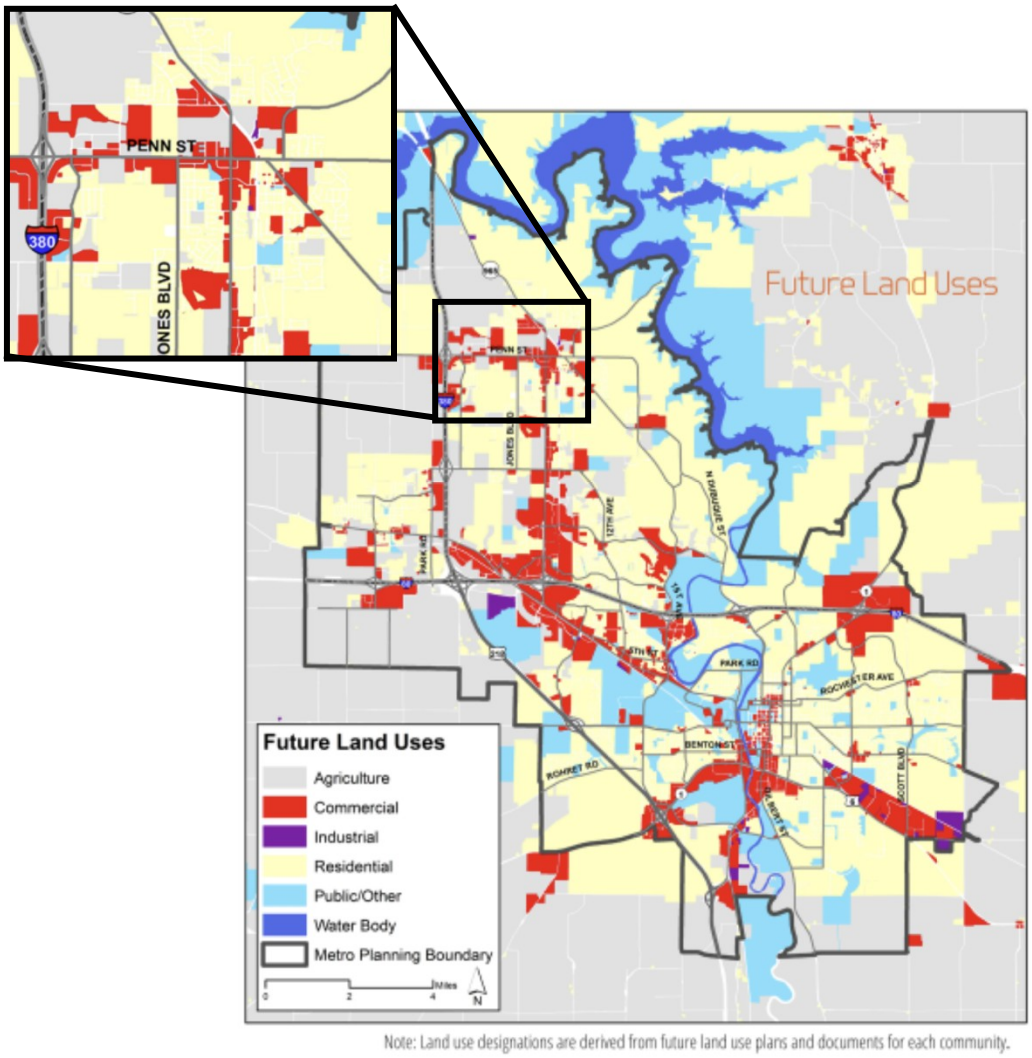


Figure 9: Projected land uses for Johnson County

V. ANALYSIS OF FUTURE CONDITIONS & ALTERNATIVE DESIGNS

▪ TRIP GENERATION

The Johnson County Metropolitan Planning Organization (MPO) has conducted a trip generation analysis for the area of North Liberty, using a growth multiplier of 1.5% to estimate the future growth of the area. This analysis takes into account both residential and commercial growth in the area. The growth factor of 1.5% was utilized in Synchro software to forecast and assess the long-term sustainability of alternative 1.

It's important to note that the proposed design that is being considered for North Liberty is not going to change any of the trip generation models that the MPO has generated. Instead, the goal of the design is to improve the existing traffic flow in the area.

▪ TRIP DISTRIBUTION

Similarly to the trip generation, the Johnson County MPO has conducted a trip distribution analysis based on the area's existing conditions. This analysis takes into account factors such as the location of employment centers, residential areas, and other regional activity centers.

The proposed design for North Liberty is not going to change the trip distribution pattern that was modeled by the MPO. Instead, the design is focused on improving traffic flow and reducing congestion on Penn Street, a major corridor in the area.

Given that the proposed design is not going to change any of the existing trip distribution patterns, it is reasonable to assume that the trip distribution modeled by the MPO will still be valid for the future. This means that the same trip distribution pattern that was used by the MPO can be used to model future trip patterns in the area.

▪ CAPACITY ANALYSIS

Utilizing Synchro, a capacity analysis was preformed using the Highway Capacity Manual's procedures for the existing conditions, below is a capacity analysis table summarizing the critical movement results.

The level of service (LOS) for the approach to the intersection varies across the different directions. Specifically, the LOS for the eastbound approach is C, for the westbound approach is D, for the northbound approach is B, and for the southbound approach is C as illustrated in figure 10.

The LOS is a measure that describes the operating conditions of a roadway, considering various factors such as speed, travel time, maneuverability, delay, and safety. The LOS is rated on a scale of A to F, with A being the best and F being the worst.

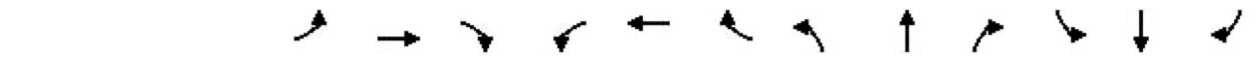
The intersection currently operates at a level of service C. According to the FHWA (Federal Highway Administration), level of service C is generally considered an acceptable level of service for urban roads during peak hours. It represents a relatively free-flowing traffic condition with moderate speeds, some delays, and moderate capacity utilization. However, there may be some degree of queuing or waiting time during peak traffic periods.

The variation in the level of service (LOS) observed between the different directions, may be attributed to several contributing factors. These factors may include disparities in traffic volume between the directions or a potential inadequacy in lane capacity to accommodate the traffic volume.

In scenarios where the traffic volume in the westbound direction is comparatively higher than that in the east, north and southbound directions, congestion and delays may arise, ultimately leading to a lower LOS. Conversely, the lower volume of traffic in the northbound direction may facilitate a smoother flow of traffic, reducing congestion and, in turn, contributing to a higher LOS.

Moreover, the adequacy of lane capacity is also an essential factor to consider when analyzing the LOS of an intersection. If the lane capacity in the east and westbound directions is inadequate to handle the higher volume of traffic, this may lead to more congestion and delays, ultimately reducing the LOS. In contrast, if the lane capacity in the north and southbound directions is sufficient, this may contribute to a more seamless flow of traffic, leading to a higher LOS.

Overall, the current LOS of the intersection suggests that there is some room for improvement. If the traffic flow continues to increase, the LOS may deteriorate further, resulting in longer travel times and greater delays.



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Total Split (s)	40.0	75.0	75.0	35.0	40.0		30.0	50.0		10.0	50.0	
Total Split (%)	21.1%	39.5%	39.5%	18.4%	21.1%		15.8%	26.3%		5.3%	26.3%	
Maximum Green (s)	34.5	69.0	69.0	29.5	34.0		24.5	44.0		4.5	44.0	
Yellow Time (s)	3.5	4.0	4.0	3.5	4.0		3.5	4.0		3.5	4.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)	5.5	6.0	6.0	5.5	6.0		5.5	6.0		5.5	6.0	
Lead/Lag	Lead	Lag	Lag	Lead	Lag		Lead	Lag		Lead	Lag	
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Recall Mode	None	None	None	None	None		None	Max		None	Max	
Walk Time (s)		7.0	7.0		7.0			7.0			7.0	
Flash Dont Walk (s)		11.0	11.0		11.0			11.0			11.0	
Pedestrian Calls (#/hr)		0	0		0			0			0	
Act Effct Green (s)	32.4	22.6	22.6	37.1	24.9		64.1	53.7		49.5	44.4	
Actuated g/C Ratio	0.28	0.20	0.20	0.32	0.22		0.55	0.46		0.43	0.38	
v/c Ratio	0.28	0.51	0.31	0.37	0.78		0.30	0.13		0.14	0.24	
Control Delay	28.8	47.4	9.0	29.6	57.4		15.4	15.7		16.1	25.7	
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	28.8	47.4	9.0	29.6	57.4		15.4	15.7		16.1	25.7	
LOS	C	D	A	C	E		B	B		B	C	
Approach Delay		31.2			49.0			15.5			23.9	
Approach LOS		C			D			B			C	

Intersection Signal Delay: 30.6 Intersection LOS: C

Figure 10: Ranshaw & Penn intersection capacity analysis.

ALTERNATIVE DESIGNS

Alternative 1: Short-term Solution:

The proposed solution for addressing the congestion on the westbound Penn Street involves the modification of the signal phasing and timing, which was determined using the Highway Capacity Manual's procedures in Synchro. The changes include a cycle length of 140 seconds and breaking up the phases, as illustrated in figure 11 on the next page. The modifications allow eastbound traffic, both through and left, to move separately then followed by a new phase of westbound through and left doing the same. Meanwhile, the phasing for north and southbound traffic remains unchanged but with new timing adjustments. On the following page, Figure 12 displays the red and yellow durations, as well as the minimum and maximum splits.

The left-turning lanes from these directions will remain permitted and protected and will adjust according to the current traffic as the signal system at the intersection is an uncoordinated actuated system that adjusts the timings based on real-time traffic data collected from the sensors and detectors.

These adjustments have resulted in significant improvements, including an increase in the westbound approach level of service from D to C. Additionally, the signal delay at the intersection has been reduced to 26.0 seconds compared to the existing conditions delay of 30.6 seconds. This alternative design was forecasted and found to be suitable for four years.

Overall, the proposed short-term solution shows promise in addressing the congestion issue on westbound Penn Street, reducing travel times for drivers, and minimizing the risk of accidents due to traffic delays. These changes may be temporary, but they can offer significant benefits while the City of North Liberty considers long-term solutions such as road widening.

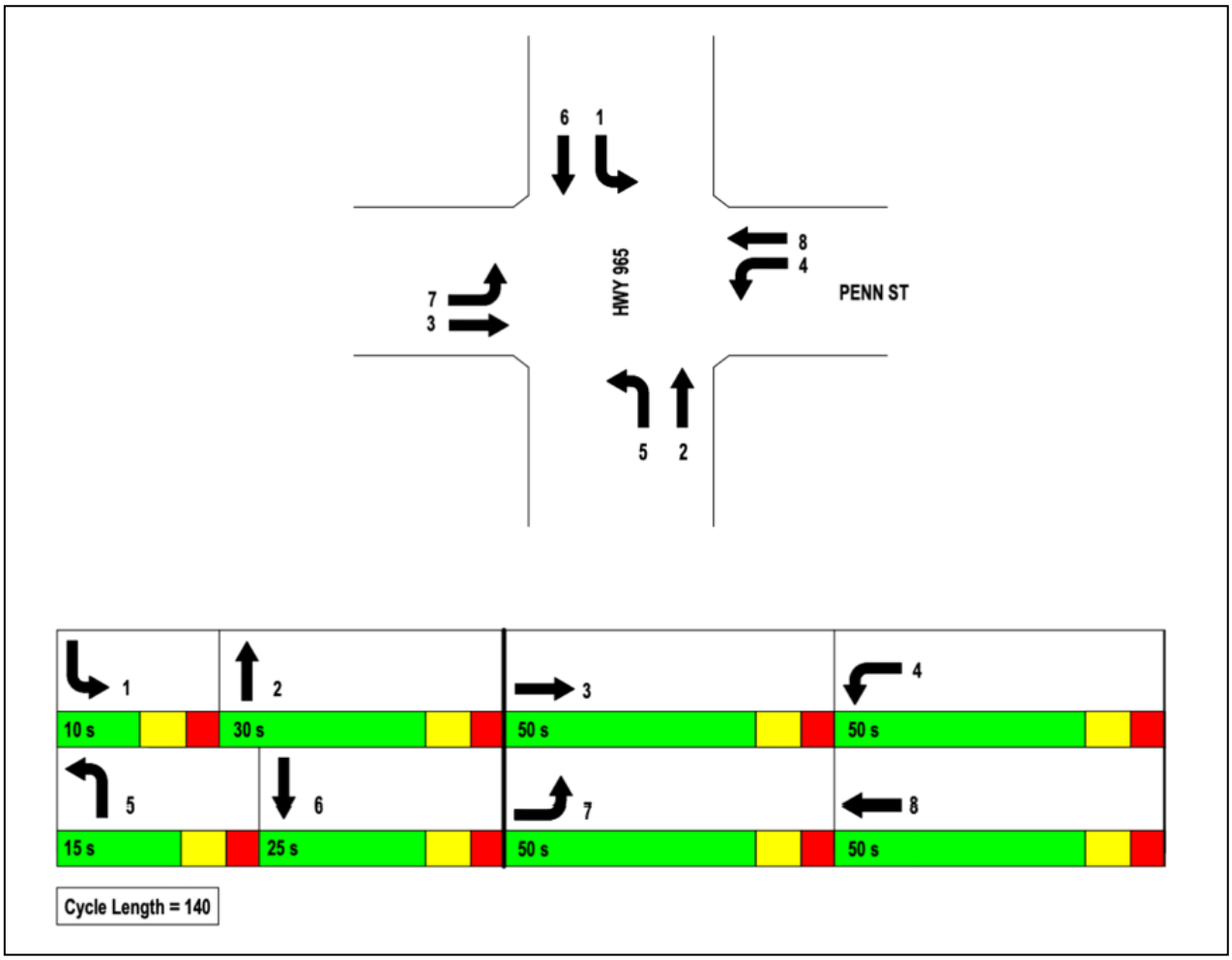


Figure 11: Phasing and Timing Plan.

PHASING SETTINGS	1-SBL	2-NBTL	3-EBTL	4-WBL	5-NBL	6-SBTL	7-EBL	8-WBTL
Minimum Initial (s)	2.5	10.0	20.0	6.0	4.5	10.0	6.0	20.0
Minimum Split (s)	8.0	30.0	50.0	50.0	10.0	25.0	50.0	40.0
Maximum Split (s)	10.0	30.0	50.0	50.0	15.0	25.0	50.0	50.0
Yellow Time (s)	3.5	4.0	4.0	4.0	3.5	4.0	4.0	4.0
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Figure 12: Phasing and Timing Plan.

- **Alternative 2: Long-term Solution:**

The long-term solution we considered to address the congestion on the westbound Penn Street involves widening Penn Street on the north side of the street. The specific stretch that we propose to widen is from Community Drive to Jones Boulevard to allow for more lanes traveling westbound. This would add a 12-foot lane starting at Community Drive and going to Jones Blvd about a half-mile west. The widening would increase the level of service of the intersection from a C to a B, which is a significant improvement. However, the intersection will have to undergo major construction, even though it was constructed only a few years ago. All the decorative corners that are currently in place would have to be removed and replaced, and additional right of way would need to be acquired.

We suggest taking six feet of right-of-way on the north and south sides of Penn Street. This will allow for the addition of the 12-foot lane. The new lane configuration is a left turn, a through lane, and then a through lane that doubles as a right-turn lane. The left-turn lane will be able to keep its same shape because it currently has enough storage capacity.

While the long-term solution requires significant construction, it would provide a substantial increase in the intersection's level of service. The additional lane capacity would allow for more efficient traffic flow, particularly during peak hours when traffic is heavy. This solution would accommodate the growth of the city and new developments that are anticipated in the future. The widening of Penn Street would ensure that the intersection remains functional and able to handle increased traffic volumes for many years to come.

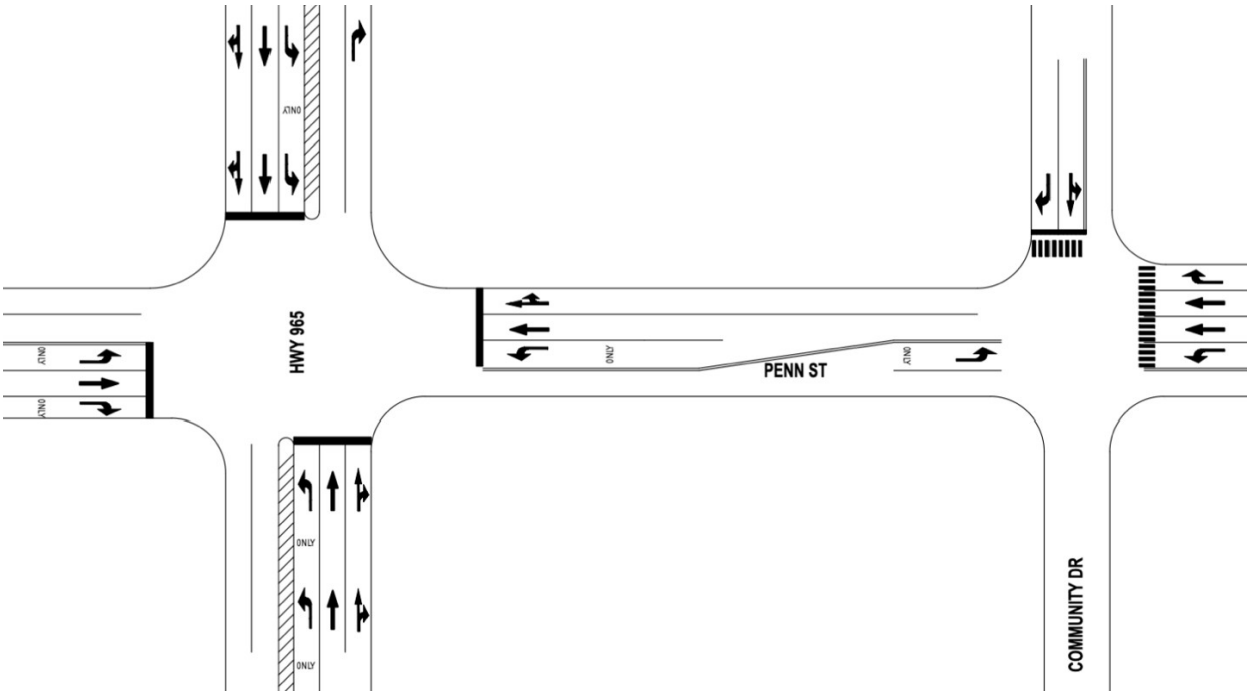


Figure 13: Widening the right of way alternative illustration.

VI. ENGINEER'S COST ESTIMATE

The cost of implementing the short-term solution of adjusting the signal timing and phasing is expected to be approximately $275, as indicated in figure 14. The estimate comprises the labor cost required for modifying the programming, which is projected to take around five hours to complete.

The long-term solution that involves widening Penn Street was estimated to cost $356,000. The cost estimate is based on unit prices sourced from the Iowa DOT, as well as averaged Right of Way prices based on land value and acreage. Additionally, a future cost analysis was conducted, which projected that the project cost would rise to around $640,000 in 10 years, as shown in figure 15.

COST ESTIMATES FOR SIGNAL TIMING & PHASING				
ITEM	**LABOR COST PER HOUR**	**HOURS**	**MULTIPLIER**	**TOTAL COST**
Programming New Timing & Phasing	$22.00	5	2.5	$275.00

Figure 14: Signal timing & phasing cost estimate.

COST ESTIMATES FOR WIDENING			
ITEM	**UNIT PRICE**	**QUANTITY**	**TOTAL COST**
Roadway Excavation (C.Y)	$166.47	544	$90,559.68
HMA 6" (ton)	$92.94	475	$44,146.50
Removal special (ft^2)	$30.00	4700	$141,000.00
Backfill 8" (C.Y)	$200.00	311	$62,200.00
Right of way (acre)	$14,116.00	0.573	$8,088.51
Relocation of Utilities	-	-	$10,000.00
Total	-	-	**$356,000.00**
Cost in 10 Years	-	-	**$637,600.00**

Figure 15: Widening Cost Estimates.

VII. CONCLUSIONS & RECOMMENDATIONS/ FINAL DESIGN

North Liberty is currently experiencing traffic congestion and safety concerns during morning rush hour due to increased westbound traffic towards the interstate. This congestion is causing a lack of space for southbound vehicles on Ranshaw Way, leading to delays and potentially unsafe conditions. Additionally, the city's growth and future development on the east side will exacerbate existing traffic issues.

Our recommendation to the City of North Liberty is to implement alternative 1 as a short-term solution to address the current congestion on westbound Penn Street. To alleviate the issue, we suggest changing the current signal phasing and timing to a cycle length of 140-seconds and adjusting the phasing as provided in the Synchro report. This solution can improve the westbound approach level of service from D to C. According to our forecasts, the intersection's overall level of service will remain at level C for the next three years with this solution.

Implementing alternative 1 as a short-term solution to address the current congestion on westbound Penn Street and changing the signal phasing and timing can offer several benefits. First, it can help reduce the travel time for drivers and ease the traffic congestion, thereby improving the overall driving experience for commuters. Additionally, it can potentially reduce the likelihood of accidents caused by traffic congestion and delays.

Considering the city's growth and expected developments, we also recommend widening Penn Street as a long-term solution. This solution can significantly improve the intersection's level of service from C to B.

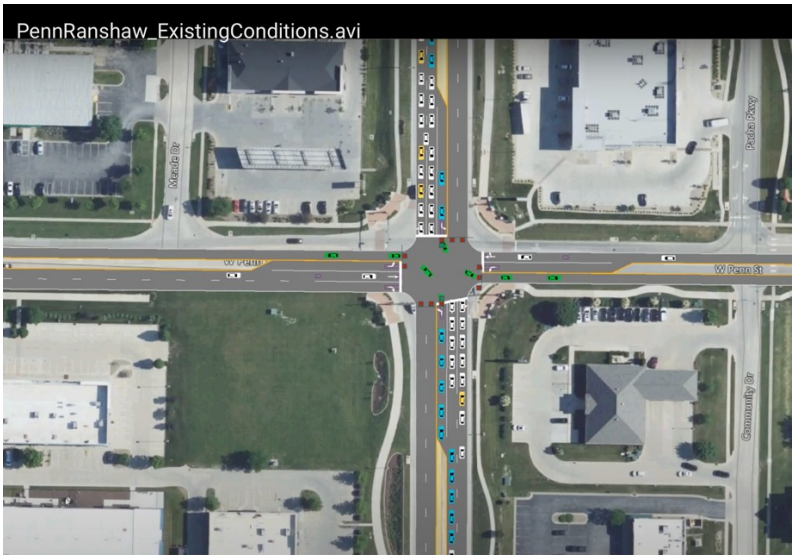
This approach can offer several significant benefits. It can increase the road's capacity, allowing for more vehicles to travel simultaneously, reducing the likelihood of traffic congestion and delays. Additionally, it can significantly enhance the traffic flow and driving experience for commuters. Overall, both short-term and long-term solutions can provide significant benefits to the City of North Liberty and its residents by enhancing road capacity and improving traffic flow.

The proposed development complies with all operational and safety standards as it seeks to enhance traffic flow and reduce congestion, thereby improving safety for road users. These measures will help mitigate the current traffic issues and improve traffic flow during peak hours, ensuring safe and efficient movement of vehicles.

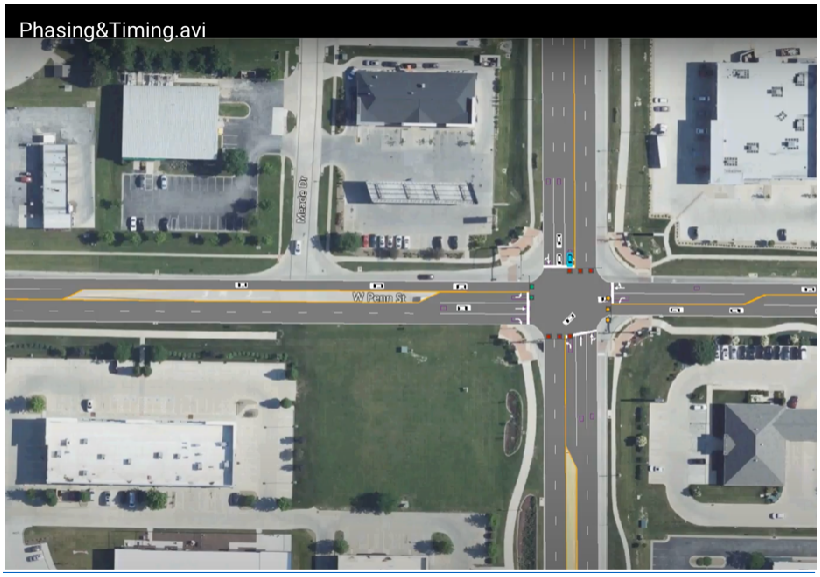
VIII. APPENDIX A: Simulations & References

The links below are for a Synchro Simulation of the existing conditions and alternative 1.

https://drive.google.com/file/d/1weaeIFGhWrQmHKdIJ-EqrHXkSFO_GCUI/view?usp=share_link



https://drive.google.com/file/d/1anpFXVbmNquKd7cbG3Ed0efhTiEFKpCr/view?usp=sharing



MPO long term transportation plan

https://www.iowa-city.org/WebLink/DocView.aspx?id=2066659&dbid=0&repo=CityofIowaCity&cr=1

IX. APPENDIX B: Introductions & Qualifications

We are a team of civil engineering students from the University of Iowa in the capstone design class. Our focus areas are transportation, and general practice. Our team is comprised of three members: Angela Skonicki (project manager), Sean Moriarty, and Momen Mokhtar. Our substantive work will focus on the area of transportation by evaluating and designing of a corridor improvement master plan around the intersection of Ranshaw Way and Penn St, North Liberty, IA.

Angela Skonicki has worked with Ciorba as a summer Roadway Intern. She was involved with analyzing a traffic study for York Road in Chicago. Another major project she worked on was the Wheeling Road expansion in Wheeling, IL. She was heavily involved in phase one of that project. This included being involved with a public meeting to inform community members of plans and get their opinions. She also worked on many other road improvements plans over the summer. She gained experience in planning and designing roadways.

Sean Moriarty has worked with F.H. Paschen for three years. He has been involved with a capital improvement project of an elementary school in Chicago, IL. He also worked on several school renovation projects. Most recently, he worked on a flood control project for the Metropolitan Water Reclamation District of Greater Chicago in the summer of 2022. During that summer he also had exposure to Illinois Tollway Projects in Justice, IL. In working for F.H. Paschen, he gained valuable experience in the construction industry with knowledge of estimating, project management, and construction software.

Momen Mokhtar has worked with HR Green for the past two years. He has been involved in roadway design projects including 1st Avenue and I-80 diverging diamond interchange, Josephville road reconstruction in Missouri, and 6th Avenue corridor study in Des Moines, and a TEAP Study for the City of Afton in Iowa. Working alongside other HR Green staff, he gained a knowledge of reading plans, designing horizonal elements using MicroStation, and performing traffic related tasks. Momen has also interned with Wight & Company, Inc. in Chicago for the summer of 2021, mainly doing inspections of several CDOT resurfacing projects across the city.

X. APPENDIX C: Existing Conditions - Synchro Report

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Future Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	150		0	120		0	0		0
Storage Lanes	1		1	1		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	1.00	0.95	0.95
Frt			0.850		0.994			0.956			0.975	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1863	1583	1770	1852	0	1770	3383	0	1770	3451	0
Flt Permitted	0.304			0.462			0.483			0.623		
Satd. Flow (perm)	566	1863	1583	861	1852	0	900	3383	0	1160	3451	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			126		1			37			12	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		701			360			468			721	
Travel Time (s)		15.9			8.2			10.6			16.4	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	72	184	126	135	300	12	180	145	61	75	264	54
Shared Lane Traffic (%)												
Lane Group Flow (vph)	72	184	126	135	312	0	180	206	0	75	318	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2		1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru		Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100		20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6		20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	pm+pt	NA	Perm	pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2			6		
Detector Phase	7	4	4	3	8		5	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	6.0	6.0	4.0	6.0		6.0	10.0		4.0	10.0	
Minimum Split (s)	40.0	75.0	75.0	40.0	40.0		40.0	50.0		35.0	50.0	

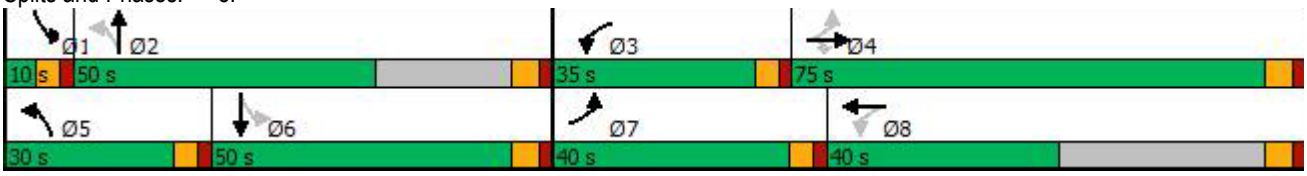
Educational Use Only

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Total Split (s)	40.0	75.0	75.0	35.0	40.0		30.0	50.0		10.0	50.0	
Total Split (%)	21.1%	39.5%	39.5%	18.4%	21.1%		15.8%	26.3%		5.3%	26.3%	
Maximum Green (s)	34.5	69.0	69.0	29.5	34.0		24.5	44.0		4.5	44.0	
Yellow Time (s)	3.5	4.0	4.0	3.5	4.0		3.5	4.0		3.5	4.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)	5.5	6.0	6.0	5.5	6.0		5.5	6.0		5.5	6.0	
Lead/Lag	Lead	Lag	Lag	Lead	Lag		Lead	Lag		Lead	Lag	
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Recall Mode	None	None	None	None	None		None	Max		None	Max	
Walk Time (s)		7.0	7.0		7.0			7.0			7.0	
Flash Dont Walk (s)		11.0	11.0		11.0			11.0			11.0	
Pedestrian Calls (#/hr)		0	0		0			0			0	
Act Effct Green (s)	32.4	22.6	22.6	37.1	24.9		64.1	53.7		49.5	44.4	
Actuated g/C Ratio	0.28	0.20	0.20	0.32	0.22		0.55	0.46		0.43	0.38	
v/c Ratio	0.28	0.51	0.31	0.37	0.78		0.30	0.13		0.14	0.24	
Control Delay	28.8	47.4	9.0	29.6	57.4		15.4	15.7		16.1	25.7	
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	28.8	47.4	9.0	29.6	57.4		15.4	15.7		16.1	25.7	
LOS	C	D	A	C	E		B	B		B	C	
Approach Delay		31.2			49.0			15.5			23.9	
Approach LOS		C			D			B			C	
90th %ile Green (s)	12.1	30.4	30.4	15.7	34.0		19.4	58.9		4.5	44.0	
90th %ile Term Code	Gap	Hold	Hold	Gap	Max		Gap	Hold		Max	MaxR	
70th %ile Green (s)	10.5	26.3	26.3	13.2	29.0		15.9	55.4		4.5	44.0	
70th %ile Term Code	Gap	Hold	Hold	Gap	Gap		Gap	Hold		Max	MaxR	
50th %ile Green (s)	9.4	22.8	22.8	11.6	25.0		13.8	53.3		4.5	44.0	
50th %ile Term Code	Gap	Hold	Hold	Gap	Gap		Gap	Hold		Max	MaxR	
30th %ile Green (s)	8.3	19.6	19.6	10.2	21.5		11.8	51.3		4.5	44.0	
30th %ile Term Code	Gap	Hold	Hold	Gap	Gap		Gap	Hold		Max	MaxR	
10th %ile Green (s)	6.7	15.3	15.3	8.3	16.9		9.1	48.6		4.5	44.0	
10th %ile Term Code	Gap	Hold	Hold	Gap	Gap		Gap	Hold		Max	MaxR	
Queue Length 50th (ft)	36	123	0	70	219		63	36		25	80	
Queue Length 95th (ft)	73	211	52	124	345		124	69		58	141	
Internal Link Dist (ft)		621			280			388			641	
Turn Bay Length (ft)	100			150			120					
Base Capacity (vph)	565	1121	1003	533	1034		686	1905		519	1332	
Starvation Cap Reductn	0	0	0	0	0		0	0		0	0	
Spillback Cap Reductn	0	0	0	0	0		0	0		0	0	
Storage Cap Reductn	0	0	0	0	0		0	0		0	0	
Reduced v/c Ratio	0.13	0.16	0.13	0.25	0.30		0.26	0.11		0.14	0.24	

Intersection Summary		
Area Type:	Other	
Cycle Length: 190		
Actuated Cycle Length: 115.7		
Natural Cycle: 205		
Control Type: Actuated-Uncoordinated		
Maximum v/c Ratio: 0.78		
Intersection Signal Delay: 30.6		Intersection LOS: C

90th %ile Actuated Cycle: 132.5
70th %ile Actuated Cycle: 122.4
50th %ile Actuated Cycle: 115.2
30th %ile Actuated Cycle: 108.6
10th %ile Actuated Cycle: 99.7

Splits and Phases: 3:



XI. APPENDIX C: Alternative 1 (Short-term Solution) - Synchro Report

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Future Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	150		0	120		0	0		0
Storage Lanes	1		1	1		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	1.00	0.95	0.95
Frt			0.850		0.994			0.956			0.975	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1863	1583	1770	1852	0	1770	3383	0	1770	3451	0
Flt Permitted	0.645			0.645			0.434			0.623		
Satd. Flow (perm)	1201	1863	1583	1201	1852	0	808	3383	0	1160	3451	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			126		2			40			14	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		701			360			468			721	
Travel Time (s)		15.9			8.2			10.6			16.4	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	72	184	126	135	300	12	180	145	61	75	264	54
Shared Lane Traffic (%)												
Lane Group Flow (vph)	72	184	126	135	312	0	180	206	0	75	318	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2		1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru		Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100		20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6		20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	pm+pt	NA	Perm	pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	7	3		4	8		5	2		1	6	
Permitted Phases	3		3	8			2			6		
Detector Phase	7	3	3	4	8		5	2		1	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		4.5	10.0		2.5	10.0	
Minimum Split (s)	50.0	50.0	50.0	50.0	40.0		10.0	30.0		8.0	25.0	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Total Split (s)	50.0	50.0	50.0	50.0	50.0		15.0	30.0		10.0	25.0	
Total Split (%)	35.7%	35.7%	35.7%	35.7%	35.7%		10.7%	21.4%		7.1%	17.9%	
Maximum Green (s)	44.0	44.0	44.0	44.0	44.0		9.5	24.0		4.5	19.0	
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0		3.5	4.0		3.5	4.0	
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0		2.0	2.0		2.0	2.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0		5.5	6.0		5.5	6.0	
Lead/Lag	Lead	Lead	Lead	Lag	Lag		Lead	Lag		Lead	Lag	
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Recall Mode	None	None	None	None	None		None	Max		None	Max	
Walk Time (s)	7.0	7.0	7.0	7.0	7.0			7.0			7.0	
Flash Dont Walk (s)	11.0	11.0	11.0	11.0	11.0			11.0			11.0	
Pedestrian Calls (#/hr)	0	0	0	0	0			0			0	
Act Effct Green (s)	13.7	13.7	13.7	20.8	20.8		34.4	26.5		24.2	19.2	
Actuated g/C Ratio	0.17	0.17	0.17	0.26	0.26		0.43	0.33		0.31	0.24	
v/c Ratio	0.27	0.57	0.33	0.33	0.64		0.39	0.18		0.19	0.38	
Control Delay	31.4	38.1	8.5	28.6	34.0		18.6	18.2		17.8	27.0	
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	31.4	38.1	8.5	28.6	34.0		18.6	18.2		17.8	27.0	
LOS	C	D	A	C	C		B	B		B	C	
Approach Delay		27.1			32.3			18.4			25.2	
Approach LOS		C			C			B			C	
90th %ile Green (s)	12.4	20.0	20.0	18.0	25.6		9.5	24.0		4.5	19.0	
90th %ile Term Code	Gap	Gap	Gap	Hold	Gap		Max	MaxR		Max	MaxR	
70th %ile Green (s)	10.2	15.6	15.6	15.7	21.1		9.5	24.0		4.5	19.0	
70th %ile Term Code	Gap	Gap	Gap	Hold	Gap		Max	MaxR		Max	MaxR	
50th %ile Green (s)	8.8	13.5	13.5	13.7	18.4		9.5	24.0		4.5	19.0	
50th %ile Term Code	Gap	Gap	Gap	Hold	Gap		Max	MaxR		Max	MaxR	
30th %ile Green (s)	7.6	11.5	11.5	12.0	15.9		9.5	24.0		4.5	19.0	
30th %ile Term Code	Gap	Gap	Gap	Hold	Gap		Max	MaxR		Max	MaxR	
10th %ile Green (s)	0.0	8.9	8.9	7.7	22.6		9.5	34.0		0.0	19.0	
10th %ile Term Code	Skip	Gap	Gap	Gap	Hold		Max	Hold		Skip	MaxR	
Queue Length 50th (ft)	31	85	0	56	142		54	31		21	66	
Queue Length 95th (ft)	70	155	44	107	237		118	66		56	120	
Internal Link Dist (ft)		621			280			388			641	
Turn Bay Length (ft)	100			150			120					
Base Capacity (vph)	990	1042	941	1104	1036		466	1157		388	843	
Starvation Cap Reductn	0	0	0	0	0		0	0		0	0	
Spillback Cap Reductn	0	0	0	0	0		0	0		0	0	
Storage Cap Reductn	0	0	0	0	0		0	0		0	0	
Reduced v/c Ratio	0.07	0.18	0.13	0.12	0.30		0.39	0.18		0.19	0.38	

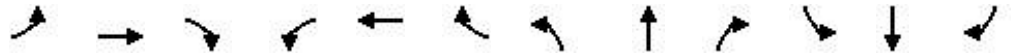
Intersection Summary			
Area Type:	Other		
Cycle Length: 140			
Actuated Cycle Length: 79.3			
Natural Cycle: 140			
Control Type: Actuated-Uncoordinated			
Maximum v/c Ratio: 0.64			
Intersection Signal Delay: 26.0		Intersection LOS: C	
Intersection Capacity Utiliz ation 58.1%		ICU Level of Service B	
Analysis Period (min) 15			

90th %ile Actuated Cycle: 90
70th %ile Actuated Cycle: 83.3
50th %ile Actuated Cycle: 79.2
30th %ile Actuated Cycle: 75.5
10th %ile Actuated Cycle: 68.6

Splits and Phases: 3:

XII. APPENDIX C: Alternative 1 (4 Year Forecast) - Synchro Report

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Future Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	150		0	120		0	0		0
Storage Lanes	1		1	1		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	1.00	0.95	0.95
Frt			0.850		0.994			0.956			0.974	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1863	1583	1770	1852	0	1770	3383	0	1770	3447	0
Flt Permitted	0.421			0.580			0.224			0.554		
Satd. Flow (perm)	784	1863	1583	1080	1852	0	417	3383	0	1032	3447	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			202		1			40			14	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		701			360			468			721	
Travel Time (s)		15.9			8.2			10.6			16.4	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92
Growth Factor	160%	160%	160%	160%	160%	160%	160%	160%	160%	160%	160%	160%
Adj. Flow (vph)	115	294	202	216	480	19	288	231	97	120	423	87
Shared Lane Traffic (%)												
Lane Group Flow (vph)	115	294	202	216	499	0	288	328	0	120	510	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2	1	1	2		1	2		1	2	
Detector Template	Left	Thru	Right	Left	Thru		Left	Thru		Left	Thru	
Leading Detector (ft)	20	100	20	20	100		20	100		20	100	
Trailing Detector (ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Position(ft)	0	0	0	0	0		0	0		0	0	
Detector 1 Size(ft)	20	6	20	20	6		20	6		20	6	
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Queue (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 1 Delay (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	pm+pt	NA	Perm	pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	7	3		4	8		5	2		1	6	
Permitted Phases	3		3	8			2			6		
Detector Phase	7	3	3	4	8		5	2		1	6	
Switch Phase												
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0		4.5	10.0		2.5	10.0	



Intersection Signal Delay: 41.9 Intersection LOS: D ICU Level of Service D

											SBT	SBR
Minimum Split (s)	50.0	50.0	50.0	50.0	50.0	10.0	30.0	8.0	25.0			
Total Split (s)	50.0	50.0	50.0	50.0	50.0	15.0	30.0	10.0	25.0			
Total Split (%)	35.7%	35.7%	35.7%	35.7%	35.7%	10.7%	21.4%	7.1%	17.9%			
Maximum Green (s)	44.0	44.0	44.0	44.0	44.0	9.5	24.0	4.5	19.0			
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	3.5	4.0	3.5	4.0			
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0			
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Total Lost Time (s)	6.0	6.0	6.0	6.0	6.0	5.5	6.0	5.5	6.0			
Lead/Lag	Lead	Lead	Lead	Lag	Lag	Lead	Lag	Lead	Lag			
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0			
Recall Mode	None	None	None	None	None	None	Max	None	Max			
Walk Time (s)	7.0	7.0	7.0	7.0	7.0		7.0		7.0			
Flash Dont Walk (s)	11.0	11.0	11.0	11.0	11.0		11.0		11.0			
Pedestrian Calls (#/hr)	0	0	0	0	0		0		0			
Act Effct Green (s)	21.6	21.6	21.6	32.1	32.1	34.4	24.3	24.3	19.3			
Actuated g/C Ratio	0.22	0.22	0.22	0.33	0.33	0.36	0.25	0.25	0.20			
v/c Ratio	0.39	0.71	0.40	0.42	0.81	1.02	0.37	0.41	0.73			
Control Delay	35.9	45.4	7.1	29.3	41.0	90.0	29.6	32.3	44.5			
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
Total Delay	35.9	45.4	7.1	29.3	41.0	90.0	29.6	32.3	44.5			
LOS	D	D	A	C	D	F	C	C	D			
Approach Delay		31.0			37.5		57.9		42.1			
Approach LOS		C			D		E		D			
90th %ile Green (s)	17.0	30.0	30.0	31.0	44.0	9.5	24.0	4.5	19.0			
90th %ile Term Code	Gap	Gap	Gap	Hold	Max	Max	MaxR	Max	MaxR			
70th %ile Green (s)	14.2	25.3	25.3	26.6	37.7	9.5	24.0	4.5	19.0			
70th %ile Term Code	Gap	Gap	Gap	Hold	Gap	Max	MaxR	Max	MaxR			
50th %ile Green (s)	12.3	22.5	22.5	22.4	32.6	9.5	24.0	4.5	19.0			
50th %ile Term Code	Gap	Gap	Gap	Hold	Gap	Max	MaxR	Max	MaxR			
30th %ile Green (s)	10.2	18.0	18.0	19.4	27.2	9.5	24.0	4.5	19.0			
30th %ile Term Code	Gap	Gap	Gap	Hold	Gap	Max	MaxR	Max	MaxR			
10th %ile Green (s)	7.7	13.8	13.8	15.5	21.6	9.5	24.0	4.5	19.0			
10th %ile Term Code	Gap	Gap	Gap	Hold	Gap	Max	MaxR	Max	MaxR			
Queue Length 50th (ft)	58	166	0	100	276	~141	76	50	152			
Queue Length 95th (ft)	117	279	56	169	422	#354	141	114	#276			
Internal Link Dist (ft)		621			280		388		641			
Turn Bay Length (ft)	100			150		120						
Base Capacity (vph)	814	856	837	919	852	282	878	293	696			
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0			
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0			
Storage Cap Reductn	0	0	0	0	0	0	0	0	0			
Reduced v/c Ratio	0.14	0.34	0.24	0.24	0.59	1.02	0.37	0.41	0.73			

Intersection Summary

Area Type: Other Control Type: Actuated-Uncoordinated

Cycle Length: 140

Actuated Cycle Length: 96.9

Natural Cycle: 150

Maximum v/c Ratio: 1.02

Analysis Period (min) 15
90th %ile Actuated Cycle: 113
70th %ile Actuated Cycle: 103.9
50th %ile Actuated Cycle: 96.9
30th %ile Actuated Cycle: 89.4
10th %ile Actuated Cycle: 81.3
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3:

XIII. APPENDIX C: Alternative 2 (Long-term Solution) - Synchro Report

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Future Volume (vph)	66	169	116	124	276	11	180	133	56	69	243	50
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	300		150	150		0	120		0	0		0
Storage Lanes	1		1	1		0	1		0	1		0
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	1.00	1.00	1.00	1.00	0.95	0.95	1.00	0.95	0.95	1.00	0.95	0.95
Frt			0.850		0.994			0.956			0.975	
Flt Protected	0.950			0.950			0.950			0.950		
Satd. Flow (prot)	1770	1863	1583	1770	3518	0	1770	3383	0	1770	3451	0
Flt Permitted	0.562			0.469			0.531			0.623		
Satd. Flow (perm)	1047	1863	1583	874	3518	0	989	3383	0	1160	3451	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)			182		8			61			40	
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		701			360			468			721	
Travel Time (s)		15.9			8.2			10.6			16.4	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	72	184	126	135	300	12	196	145	61	75	264	54
Shared Lane Traffic (%)												
Lane Group Flow (vph)	72	184	126	135	312	0	196	206	0	75	318	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		12			12			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA	Perm	pm+pt	NA		pm+pt	NA		pm+pt	NA	
Protected Phases		4		3	8		5	2		1	6	
Permitted Phases	4		4	8			2			6		
Minimum Split (s)	20.0	20.0	20.0	9.5	20.0		9.5	20.0		9.5	20.0	
Total Split (s)	20.0	20.0	20.0	9.5	29.5		10.0	20.9		9.6	20.5	
Total Split (%)	33.3%	33.3%	33.3%	15.8%	49.2%		16.7%	34.8%		16.0%	34.2%	
Maximum Green (s)	16.0	16.0	16.0	5.0	25.5		5.5	16.9		5.1	16.5	
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5		3.5	3.5		3.5	3.5	
All-Red Time (s)	0.5	0.5	0.5	1.0	0.5		1.0	0.5		1.0	0.5	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.5	4.0		4.5	4.0		4.5	4.0	
Lead/Lag	Lag	Lag	Lag	Lead			Lead	Lag		Lead	Lag	
Lead-Lag Optimize?	Yes	Yes	Yes	Yes			Yes	Yes		Yes	Yes	
Walk Time (s)	5.0	5.0	5.0		5.0			5.0			5.0	
Flash Dont Walk (s)	11.0	11.0	11.0		11.0			11.0			11.0	
Pedestrian Calls (#/hr)	0	0	0		0			0			0	
Act Effct Green (s)	16.0	16.0	16.0	25.0	25.5		21.9	16.9		21.1	16.5	
Actuated g/C Ratio	0.27	0.27	0.27	0.42	0.42		0.36	0.28		0.35	0.28	
v/c Ratio	0.26	0.37	0.23	0.31	0.21		0.45	0.21		0.16	0.33	
Control Delay	20.4	20.6	2.4	13.2	11.1		15.3	12.1		11.3	16.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	20.4	20.6	2.4	13.2	11.1		15.3	12.1		11.3	16.1	
LOS	C	C	A	B	B		B	B		B	B	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Approach Delay		14.5			11.7			13.6			15.2	
Approach LOS		B			B			B			B	
Queue Length 50th (ft)	20	54	0	29	34		43	20		15	41	
Queue Length 95th (ft)	51	102	17	60	57		81	43		36	71	
Internal Link Dist (ft)		621			280			388			641	
Turn Bay Length (ft)	300		150	150			120					
Base Capacity (vph)	279	496	555	438	1499		432	996		459	978	
Starvation Cap Reductn	0	0	0	0	0		0	0		0	0	
Spillback Cap Reductn	0	0	0	0	0		0	0		0	0	
Storage Cap Reductn	0	0	0	0	0		0	0		0	0	
Reduced v/c Ratio	0.26	0.37	0.23	0.31	0.21		0.45	0.21		0.16	0.33	

Intersection Summary			
Area Type:	Other		
Cycle Length: 60			
Actuated Cycle Length: 60			
Offset: 0 (0%), Referenced to phase 2:NBTL, Start of Green			
Natural Cycle: 60			
Control Type: Pretimed			
Maximum v/c Ratio: 0.45			
Intersection Signal Delay: 13.7		Intersection LOS: B	
Intersection Capacity Utilization 47.8%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 3:

XIV. APPENDIX D: Crash Data

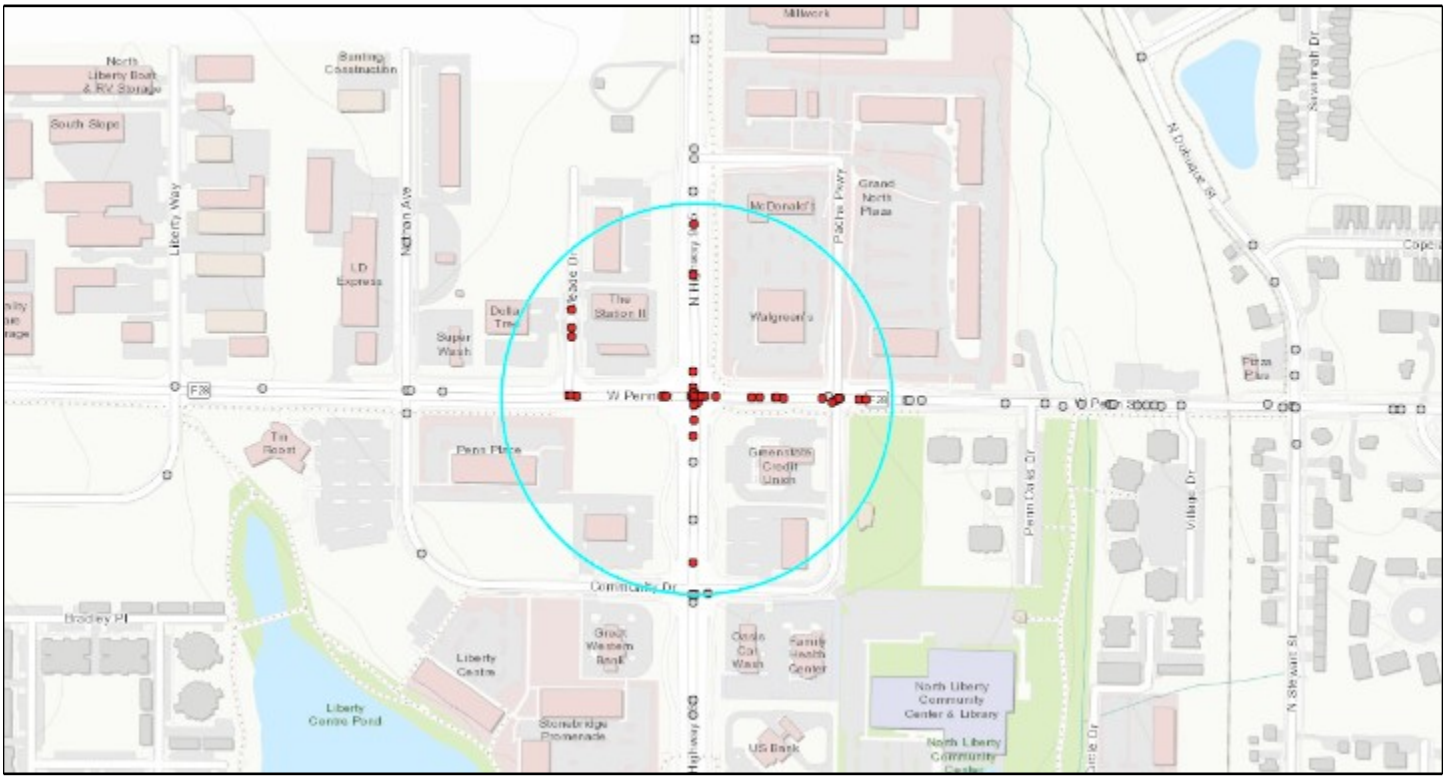
Iowa Crash Analysis Tool
Quick Report
2014-2023

Crash Severity	83
Fatal Crash	0
Suspected Serious Injury Crash	0
Suspected Minor Injury Crash	7
Possible/Unknown Injury Crash	10
Property Damage Only	66

Injury Status Summary	21
Fatalities	0
Suspected serious/incapacitating	0
Suspected minor/non-incapacitating	7
Possible (complaint of pain/injury)	13
Unknown	1

Property/Vehicles/Occupants	
Property Damage Total (dollars):	490,133.00
Average (per crash dollars):	5,905.22
Total Vehicles:	166.00
Average (per crash):	2.00
Total Occupants:	214.00
Average (per crash):	2.58

Average Severity	
Fatalities/Fatal Crash:	0.00
Fatalities/Crash:	0.00
Injuries/Crash:	0.24
Major Injuries/Crash:	0.00
Minor Injuries/Crash:	0.08
Possible/Unknown Injuries/Crash:	0.16



Major Cause			83
Animal	0	Ran traffic signal	7
Ran stop sign	1	Failed to yield to emergency vehicle	0
FTYROW: At uncontrolled intersection	0	FTYROW: Making right turn on red signal	1
FTYROW: From stop sign	7	FTYROW: From yield sign	0
FTYROW: Making left turn	10	FTYROW: From driveway	1
FTYROW: From parked position	0	FTYROW: To pedestrian	2
FTYROW: Other	0	Drove around RR grade crossing gates	0
Disregarded RR Signal	0	Crossed centerline (undivided)	0
Crossed median (divided)	0	Traveling wrong way or on wrong side of road	2
Aggressive driving/road rage	0	Driving too fast for conditions	1
Exceeded authorized speed	0	Improper or erratic lane changing	0
Operating vehicle in an reckless, erratic, ca...	2	Followed too close	20
Passing: On wrong side	0	Passing: Where prohibited by signs/markings	1
Passing: With insufficient distance/inadequa...	0	Passing: Through/around barrier	0
Passing: Other passing	0	Made improper turn	3
Driver Distraction: Manual operation of an e...	0	Driver Distraction: Talking on a hand-held d...	1
Driver Distraction: Talking on a hands free ...	0	Driver Distraction: Adjusting devices (radio...	0
Driver Distraction: Other electronic device ...	0	Driver Distraction: Passenger	2
Driver Distraction: Unrestrained animal	0	Driver Distraction: Reaching for object(s)/f...	0
Driver Distraction: Inattentive/lost in thou...	3	Driver Distraction: Other interior distracti...	5
Driver Distraction: Exterior distraction	2	Ran off road - right	0
Ran off road - straight	0	Ran off road - left	0
Lost control	0	Swerving/Evasive Action	1
Over correcting/over steering	0	Failed to keep in proper lane	0
Failure to signal intentions	0	Traveling on prohibited traffic way	0
Vehicle stopped on railroad tracks	0	Other: Vision obstructed	0
Other: Improper operation	0	Other: Disregarded warning sign	0
Other: Disregarded signs/road markings	0	Other: Illegal off-road driving	0
Downhill runaway	0	Separation of units	0
Towing improperly	0	Cargo/equipment loss or shift	0
Equipment failure	0	Oversized load/vehicle	0
Other: Getting off/out of vehicle	0	Failure to dim lights/have lights on	0
Improper backing	0	Improper starting	0
Illegally parked/unattended	0	Driving less than the posted speed limit	0
Operator inexperience	2	Other	2
Unknown	2	Not reported	0
Other: No improper action	5		

Time of Day/Day of Week

Day of Week	12 AM to 2 AM	2 AM to 4 AM	4 AM to 6 AM	6 AM to 8 AM	8 AM to 10 AM	10 AM to Noon	Noon to 2 PM	2 PM to 4 PM	4 PM to 6 PM	6 PM to 8 PM	8 PM to 10 PM	10 PM to 12 AM	Not reported	Total
Sunday	0	0	0	0	0	1	1	0	0	2	0	0	0	4
Monday	0	0	0	4	1	0	0	0	6	1	1	0	0	13
Tuesday	0	0	0	3	0	1	0	1	4	2	0	0	0	11
Wednesday	0	0	0	0	4	1	0	1	2	4	2	0	0	14
Thursday	0	0	0	2	2	2	1	3	3	0	1	0	0	14
Friday	0	0	0	1	2	0	5	2	3	2	0	0	0	15
Saturday	0	0	0	0	1	2	2	0	2	5	0	0	0	12
Total	0	0	0	10	10	7	9	7	20	16	4	0	0	83

Manner of Crash Collision	83
Non-collision (single vehicle)	5
Head-on (front to front)	2
Rear-end (front to rear)	40
Angle, oncoming left turn	10
Broadside (front to side)	18
Sideswipe, same direction	5
Sideswipe, opposite direction	2
Rear to rear	0
Rear to side	0
Not reported	0
Other	1
Unknown	0

Surface Conditions	83
Dry	73
Wet	7
Ice/frost	1
Snow	2
Slush	0
Mud, dirt	0
Water (standing or moving)	0
Sand	0
Oil	0
Gravel	0
Not reported	0
Other	0
Unknown	0

Fixed Object Struck			166
Bridge overhead structure	0	Bridge pier or support	0
Bridge/bridge rail parapet	0	Curb/island/raised median	0
Ditch	1	Embankment	0
Ground	0	Culvert/pipe opening	0
Guardrail - face	0	Guardrail - end	0
Concrete traffic barrier (median or right sid...	0	Other traffic barrier	0
Cable barrier	0	Impact attenuator/crash cushion	0
Utility pole/light support	1	Traffic sign support	2
Traffic signal support	0	Other post/pole/support	0
Fire hydrant	0	Mailbox	0
Tree	0	Landscape/shrubbery	0
Snow bank	0	Fence	0
Wall	0	Building	0
Other fixed object	0	None (no fixed object struck)	162

Driver Age/Driver Gender					
Driver Age - 5 year Bins	Female	Male	Not reported	Unknown	**Total**
< 14	0	0	0	0	0
= 14	0	0	0	0	0
= 15	0	0	0	0	0
= 16	1	2	0	0	3
= 17	0	2	0	0	2
= 18	4	2	0	0	6
= 19	3	2	1	0	6
= 20	2	3	0	0	5
>= 21 and <= 24	8	9	0	0	17
>= 25 and <= 29	9	16	0	0	25
>= 30 and <= 34	13	5	2	0	20
>= 35 and <= 39	11	9	1	0	21
>= 40 and <= 44	7	6	0	0	13
>= 45 and <= 49	5	6	0	0	11
>= 50 and <= 54	2	8	0	0	10
>= 55 and <= 59	3	3	0	0	6
>= 60 and <= 64	3	3	0	0	6
>= 65 and <= 69	3	1	0	0	4
>= 70 and <= 74	6	0	0	0	6
>= 75 and <= 79	0	0	0	0	0
>= 80 and <= 84	0	1	0	0	1
>= 85 and <= 89	1	0	0	0	1
>= 90 and <= 94	0	0	0	0	0
>= 95	0	0	0	0	0
Not reported	0	0	0	0	0
Unknown	0	0	2	0	2
Total	81	78	6	0	165

Drug/Alcohol Related	**83**
Drug	0
Alcohol (< Statutory)	0
Alcohol (Statutory)	1
Drug and Alcohol (< Statutory)	0
Drug and Alcohol (Statutory)	0
Refused	1
Under Influence of Alcohol/Drugs/Medications	0
None Indicated	81

Alcohol Test Given	**166**
None	160
Blood	0
Urine	0
Breath	1
Vitreous	0
Refused	1
Not reported	4

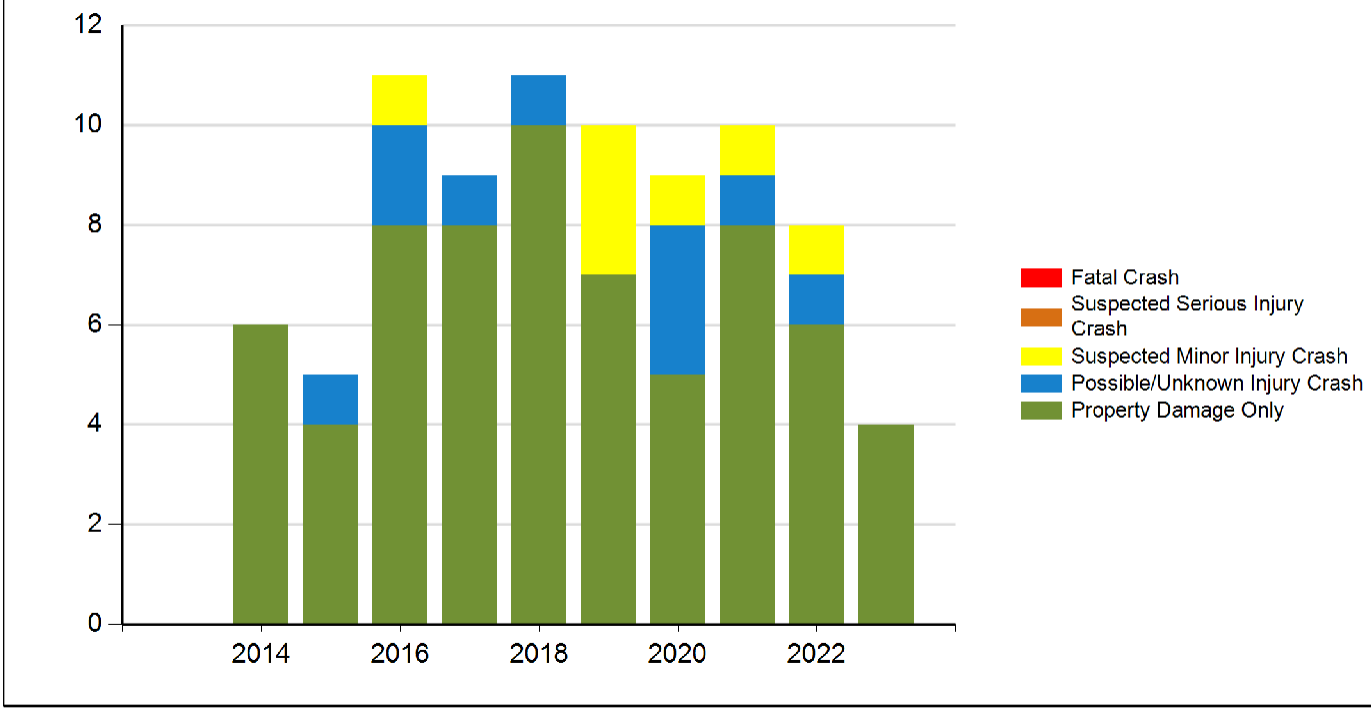
Drug Test Given	**166**
None	162
Blood	0
Urine	0
Breath	0
Vitreous	0
Refused	0
Not reported	4

Drug Test Result	**154**
Negative	0
Cannabis	0
Central Nervous System depressants	0
Central Nervous System stimulants	0
Hallucinogens	0
Inhalants	0
Narcotic Analgesics	0
Dissociative Anesthetic (PCP)	0
Prescription Drug	0
Not reported	154
Other	0

Crash Severity - Annual

Crash Year	Fatal Crash	Suspected Serious Injury Crash	Suspected Minor Injury Crash	Possible/Unknown Injury Crash	Property Damage Only	**Total**
2013	0	0	0	0	0	0
2014	0	0	0	0	6	6
2015	0	0	0	1	4	5
2016	0	0	1	2	8	11
2017	0	0	0	1	8	9
2018	0	0	0	1	10	11
2019	0	0	3	0	7	10
2020	0	0	1	3	5	9
2021	0	0	1	1	8	10
2022	0	0	1	1	6	8
2023	0	0	0	0	4	4
Total	0	0	7	10	66	83

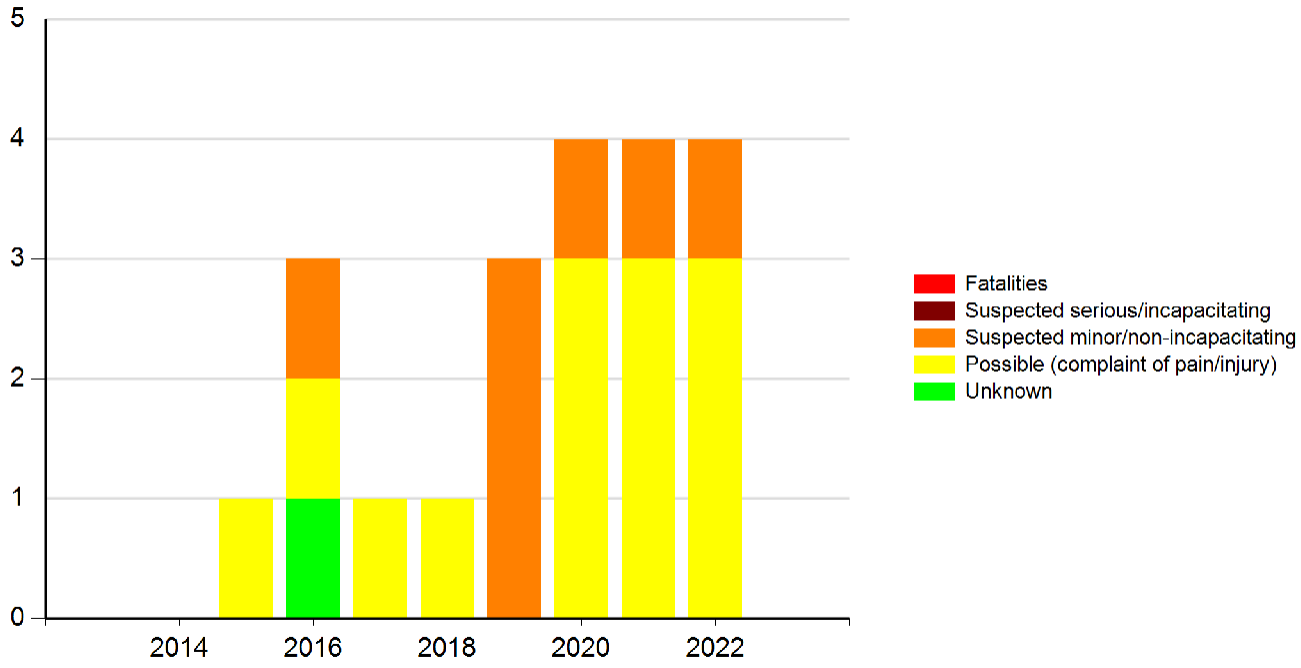
Severity/Year



Injury Status - Annual

Crash Year	Fatalities	Suspected serious/incapacitating	Suspected minor/non-incapacitating	Possible (complaint of pain/injury)	Unknown	Total
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	1	0	1
2016	0	0	1	1	1	3
2017	0	0	0	1	0	1
2018	0	0	0	1	0	1
2019	0	0	3	0	0	3
2020	0	0	1	3	0	4
2021	0	0	1	3	0	4
2022	0	0	1	3	0	4
2023	0	0	0	0	0	0
Total	0	0	7	13	1	21

Injury Status/Year



Meeting the following criteria

Jurisdiction: Statewide
Year: 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023
Map Selection: Yes
Filter: None

Analyst Information

Momen Mokhtar