# Signal Operations
# L Street / Q Street
Project Report

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## Executive Summary

AECOM conducted a signal operations evaluation of multiple corridors as part of the City of Omaha Signal System Master Plan. This study included Data Collection, Signal Optimization, Implementation, Performance Evaluation and Safety Analysis.

The project area includes 52 intersections and two primary corridors, as listed below:

- L Street / Millard Avenue / Q Street between 90th / L Street to 180th / Q Street (23 intersections)
- 132nd Street / Millard Avenue / 144th Street between 132nd / Arbor Street to 144th / Stony Brook Boulevard (15 intersections, includes overlap with L / Millard / Q corridor). This corridor includes 5 signalized intersections, between 132nd / Arbor Street and 132nd / Grover Street, that were re-timed as part of the West Center Road project.

Other intersections included within this project are located along 168th Street, 156th Street, 144th Street, 96th Street, F Street, I Street, and Q Street.

Existing and proposed Synchro models were used to compare timing plan performance for the AM, Midday (MD), PM, and Offpeak (OP) analysis periods. Network performance measures including total delay, total stops, total travel time, and fuel consumed were analyzed and are summarized in **Table ES1**. This table includes all traffic movements at all 52 signal intersections and are based on Synchro model output.

***Table ES.1 Network Performance***

| Performance Measure | AM Peak (Plan 2) | | | MD Peak (Plan 1) | | |
|---|---|---|---|---|---|---|
| | Existing | Proposed | Delta | Existing | Proposed | Delta |
| Total Delay (hr) | 1,218 | 1,076 | -11.7% | 615 | 588 | -4.4% |
| Total Stops (#) | 71,935 | 75,332 | 4.7% | 55,169 | 53,599 | -2.8% |
| Total Travel Time (hr) | 2,288 | 2,091 | -8.6% | 1,483 | 1,420 | -4.2% |
| Average Speed (mph) | 19 | 20 | 5.3% | 24 | 24 | 0% |
| Fuel Consumed (gal) | 3,184 | 3,036 | -4.6% | 2,260 | 2,167 | -4.1% |
| **Performance Measure** | **PM Peak (Plan 3)** | | | **Off Peak (Plan 4)** | | |
| | **Existing** | **Proposed** | **Delta** | **Existing** | **Proposed** | **Delta** |
| Total Delay (hr) | 1,855 | 1,725 | -7.0% | 330 | 302 | -8.5% |
| Total Stops (#) | 93,489 | 93,657 | 0.2% | 37,251 | 34,670 | -6.9% |
| Total Travel Time (hr) | 3,138 | 2,955 | -5.8% | 968 | 914 | -5.6% |
| Average Speed (mph) | 17 | 17 | 0% | 27 | 27 | 0% |
| Fuel Consumed (gal) | 4,163 | 3,990 | -4.2% | 1,545 | 1,455 | -5.8% |

Travel time runs collected before new signal timings were implementation and after fine tuning was complete to document improvements for vehicles travelling along the corridors. Travel time was reduced was reduced by up to 2 minutes in the eastbound direction and 1 minute in the westbound direction along L Street / Millard Avenue / Q Street corridor. Along the Millard Avenue corridor travel time was reduced by up to 1.5 minutes in the southbound direction and 45 seconds in the northbound direction.

A benefit cost analysis was conducted to determine the return on investment for this project. There are typically two types of benefits associated with traffic signal retiming projects. First there are the user (direct) benefits that are determined by a reduction in travel time costs, operating costs, and crash costs. The second is societal (non-direct) benefits that include a reduction in air pollutants.

The City has developed a methodology, based on national / USDOT guidelines, to calculate the monetary benefit over the next five years. Based on this methodology, the monetary over the next years is anticipated to be **$25.4 million**. A breakdown of the project benefits for the various direct and non-direct benefits is shown in **Table ES.2**. The cost to complete this project was $205,139, yielding a **benefit/cost ratio of 124:1**.

***Table ES.2 Anticipated Project Benefits Over Five Years***

| Performance Measure | Project Benefit | Present Value |
|---|---|---|
| Delay Reduction | 669,694 hours | $18,947,051 |
| Fuel Consumption Reduction | 1,301,104 gallons | $2,667,263 |
| Emissions Reduction | 11,605 tons | $907,198 |
| Crash Reduction | 68 crashes | $2,903,079 |

# 1. Introduction

## 1.1 Project Overview and Background

The Omaha Signal Operations L Street/Q Street Project is part of a citywide effort to optimize traffic signals connected to the City of Omaha's fiber optic cable network, in order to improve traffic operations and progression throughout the City. The consultant, AECOM, has provided traffic engineering and analysis services for the fifty-two (52) traffic signals as part of this project. The primary purpose of this project was to first prepare optimized traffic signal timing plans and to then implement the optimized timing plans and document improvements to traffic operations resulting from the signal timing changes. This report describes in more detail the steps and processes followed throughout the project.

## 1.2 Signal Locations

The fifty-two traffic signals included in this project are primarily located along L Street and Q Street in southwest Omaha. Additional signals are located along corridors branching off of L Street and Q Street, including 168th Street, 156th Street, 144th Street, 96th Street, and Millard Avenue. **Table 1.1** identifies the signals included in this project. Additionally, the locations of the project traffic signals are shown in **Figure 1.1**. The colors shown in the map indicate the different Wapiti signal zones, with the circle symbols representing Wapiti signal locations and the square symbols representing Wapiti signal master controller locations. The green triangle symbols represent Maxtime signal locations.

***Table 1.1 List of L Street/Q Street Signal Operations Traffic Signals***

| No. | Signal ID | Intersection Name |
|---|---|---|
| 1 | 528 | 102 ST & L ST |
| 2 | 540 | 108 ST & L ST |
| 3 | 1101 | 111 ST & L ST |
| 4 | 553 | 119 CIR / I FRONTAGE RD & I ST |
| 5 | 560 | 120 ST & I ST |
| 6 | 561 | 120 ST & L ST |
| 7 | 1110 | 121 ST & I ST |
| 8 | 1003 | 126 PLZ & L ST |
| 9 | 1109 | 126 ST & I ST |
| 10 | 573 | 132 ST & F ST |
| 11 | 1005 | 132 ST & I ST |
| 12 | 575 | 132 ST / MILARD AVE & L ST / INDUSTRIAL RD |
| 13 | 580 | 133 ST & MILLARD AVE |
| 14 | 583 | 135 ST & MILLARD AVE |
| 15 | 651 | 136 ST / P ST & Q ST |
| 16 | 733 | 138 ST & INDUSTRIAL RD |
| 17 | 715 | 138 ST & MILLARD AVE / P ST |
| 18 | 585 | 138 ST & Q ST |
| 19 | 921 | 144 ST & HILLSDALE ST |
| 20 | 711 | 144 ST & L ST |
| 21 | 1095 | 144 ST & MILLARD AVE |
| 22 | 1068 | 144 ST & N ST |
| 23 | 607 | 144 ST & Q ST |
| 24 | 32 | 144 ST & STONEY BROOK BLVD / Y ST |
| 25 | 1094 | 144 ST & U ST |
| 26 | 1126 | 146 ST & STONEY BROOK BLVD |
| 27 | 923 | 153 ST & Q ST |
| 28 | 890 | 156 ST & F ST |
| 29 | 859 | 156 ST & OHERN ST |
| 30 | 673 | 156 ST & Q ST |
| 31 | 936 | 156 ST & ROLLING RIDGE RD |
| 32 | 1097 | 156 ST & STONY BROOK BLVD / S ST |
| 33 | 1084 | 165 ST & Q ST |
| 34 | 884 | 168 ST & PATTERSON ST |
| 35 | 746 | 168 ST & Q ST |
| 36 | 881 | 168 ST & ROLLING RIDGE ST |
| 37 | 838 | 168 ST & V ST |
| 38 | 773 | 172 ST &Q ST |
| 39 | 779 | 176 AVE & Q ST |
| 40 | 780 | 180 ST & Q ST |
| 41 | 797 | 87 ST & F ST |
| 42 | 804 | 90 ST & F ST |
| 43 | 502 | 90 ST & L ST |
| 44 | 713 | 96 ST & F ST |
| 45 | 714 | 96 ST & J ST |
| 46 | 515 | 96 ST & L ST |
| 47 | 517 | 96 ST & MOCKINGBIRD DR / N ST |
| 48 | 922 | BLACKWELL DR & Q ST |
| 49 | 1117 | HYVEE / 178 ST & Q ST |
| 50 | 697 | MILLARD AVE & Q ST |
| 51 | 33 | MILLARD AVE & U ST |
| 52 | 748 | MILLARD SOUTH HIGH & Q ST |

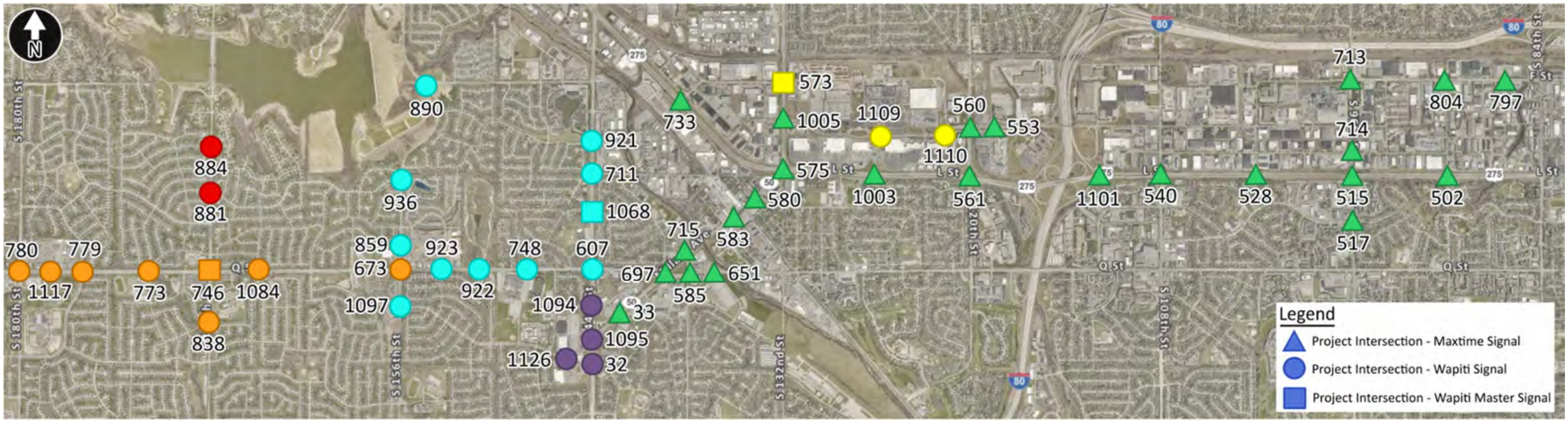



*Figure 1.1 Map of L Street/Q Street Signal Operations Traffic Signals*

# 2. Project Administration

## 2.1 Project Team

The project team consisted of representatives from multiple agencies. Representatives from all agencies collaborated throughout the project. Members of the project team included:

| Representative | Agency |
|---|---|
| Bryan Guy | City of Omaha (City Project Manager) |
| Nick Gordon | City of Omaha |
| Garret Schram | City of Omaha |
| Mark Horak | City of Omaha |
| Juan Pizano | City of Omaha |
| Jenna Habegger | Nebraska Department of Transportation |
| Daryl Taavola | AECOM (AECOM Project Manager) |
| Jim Kollbaum | AECOM |
| Ming-Shiun Lee | AECOM |
| Vanessa Nghiem | AECOM |
| Scott Laxton | AECOM |
| Ben Giese | AECOM |

## 2.2 Project Meetings

Ongoing project meetings were held throughout the entirety of the project. All project meetings were held virtually due to the ongoing COVID-19 pandemic. **Appendix A** includes meeting minutes from each of the project meetings. Project meetings held include:

- Kickoff Meeting – September 28th, 2020
- Progress Meeting – October 26th, 2020
- Progress Meeting – November 16th, 2020
- Progress Meeting – December 2nd, 2020
- Pre-Implementation Meeting – December 10th, 2020
- Progress Meeting – December 30th, 2020
- Implementation – January 21st, 2021
- Progress Meeting – February 18th, 2021
- Progress Meeting – March 24th, 2021
- Progress Meeting – April 13th, 2021

Following the project kickoff meeting, progress meetings were held to review project activities and discuss questions and concerns that arose throughout the project. A pre-implementation meeting was held to review and finalize the proposed signal timing changes. Following implementation, progress meetings were held to discuss observations post-implementation and potential necessary fine-tuning changes to signal timings.

# 3. Data Collection

## 3.1 Lane Configurations

The City of Omaha initially provided AECOM with Synchro models representing existing conditions of the signals included in the project area. AECOM completed field reviews of each intersection to confirm the existing lane configurations and geometric layouts and updated the Synchro models as necessary.

## 3.2 Turning Movement Counts

Turning movement counts were accessed from the City of Omaha online Traffic Counts Viewer application. The date of which the turning movement counts were recorded varied between 2015 and 2019. It should be noted that all counts were taken prior to the COVID-19 pandemic, which led to significantly decreased traffic volumes. Discussions between the City of Omaha and AECOM led to the determination that historic traffic volumes should be maintained and should not be factored to match 2020 (COVID) volumes. Turning movement counts were utilized to determine the peak hour traffic volumes input into Synchro models created for the optimized signal timings and day plan schedules.

## 3.3 24-Hour Traffic Volumes

Traffic volume data was collected using ADT tube counters at 3 locations for this project providing 24-hour, 7-day directional traffic volumes. The purpose of this data collection was to determine appropriate traffic growth factors that should be applied to the existing turn movement counts provided by the City. Counts were collected from Wednesday, October 28 to Tuesday, November 3, 2020 at representative locations along L Street, Q Street and Millard Avenue. Data from the Millard Avenue location is shown in **Exhibit 3.1**.

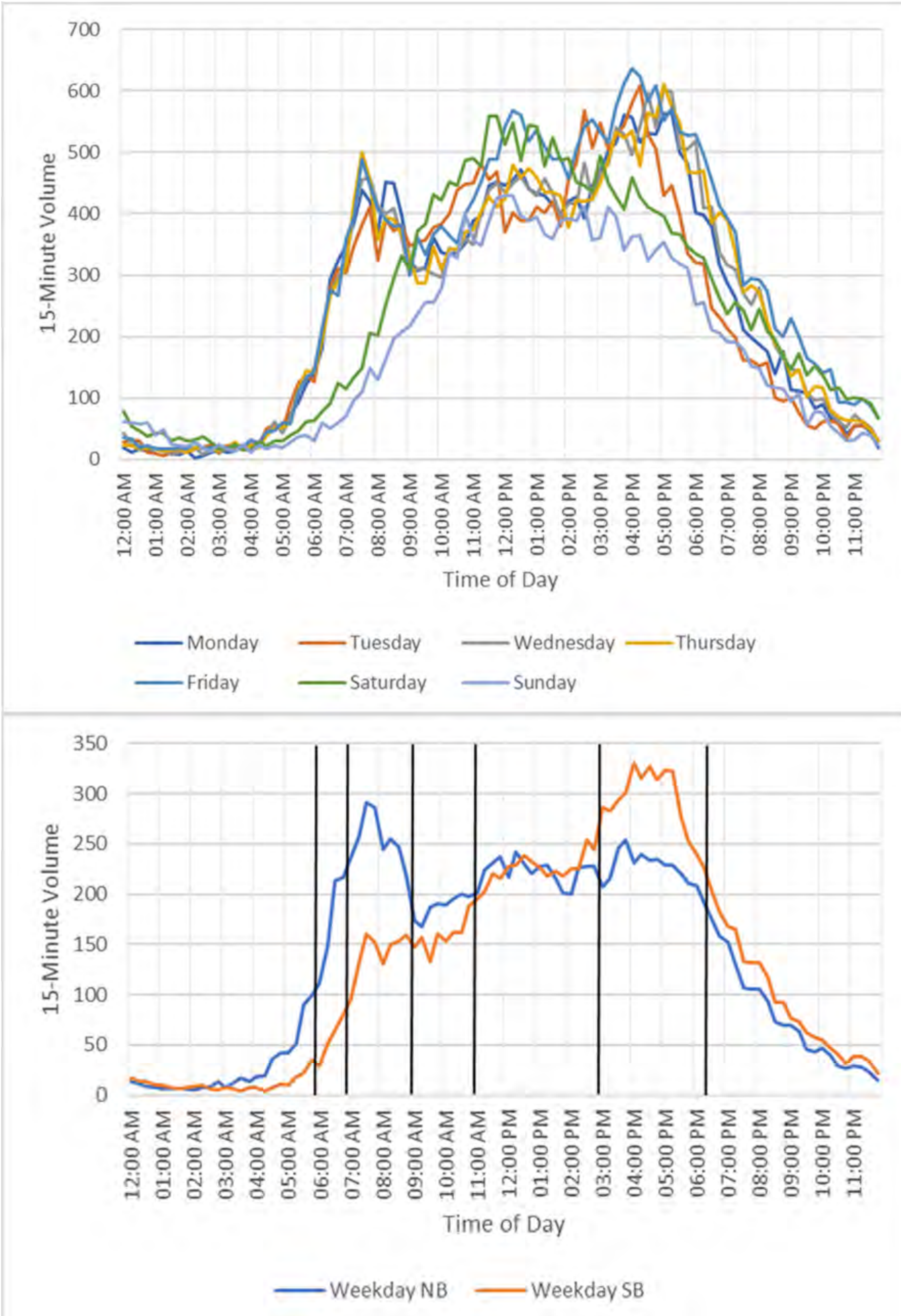
A comparison of the project 7-day count against the 2018 Metropolitan Area Planning Agency (MAPA) Daily Traffic Flow volumes is provided in **Table 3.1**. In general, the project 7-day counts were found to be about 20% lower than the 2018 MAPA (pre-COVID) volumes.

***Table 3.1 Comparison of 7-Day Average Daily Traffic Counts to 2018 MAPA AAWT Traffic Counts***

| | Location | | |
|---|---|---|---|
| **Daily Traffic Counts** | **East of 108th / L** | **East of 162nd / Q** | **North of 138th / Millard** |
| 7-Day Tube Counts | | | |
| Wed. (10-28-20) | 23,810 | 26,971 | 25,494 |
| Th (10-29-20) | 24,593 | 27,132 | 25,589 |
| Fri (10-30-20) | 26,205 | 30,106 | 28,658 |
| Sat (10-31-20) | 18,286 | 23,531 | 23,608 |
| Sun (11-1-20) | 12,528 | 17,670 | 17,620 |
| Mon (11-2-20) | 23,676 | 26,455 | 24,700 |
| Tue (11-3-20) | 23,769 | 24,744 | 23,829 |
| *Average (Tue - Th)* | 24,057 | 26,282 | 24,971 |
| MAPA AAWT (2018) | 29,400 | 35,900 | 30,800 |
| Delta | -5,343 | -9,618 | -5,829 |
| Delta % | -18% | -27% | -19% |

Note: AAWT = Annual Average Weekday Traffic

***Exhibit 3.1 7-Day Tube Counts for Millard Avenue (15-minute volume bins)***



A comparison of the 7-day project counts collected post-COVID against City / MAPA turning movement counts collected pre-COVID, shown in **Table 3.2**, found that the commuter traffic volumes in the project 7-day counts were typically 20-40% lower than the turning movement count volumes.

***Table 3.2 Comparison of 7-Day Tube Counts to Turning Movement Counts***

| Location / Direction | Peak Hour | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AM Peak | | | | MD Peak | | | | PM Peak | | | |
| | 7-Day [1] | TMC [2,3] | Delta | Delta % | 7-Day [1] | TMC [4] | Delta | Delta % | 7-Day [1] | TMC [5] | Delta | Delta % |
| East of 108th / L | | | | | | | | | | | | |
| EB | 636 | 1046 | -410 | -39% | 907 | 949 | -42 | -4% | 761 | 1209 | -448 | -37% |
| WB | 873 | 1166 | -293 | -25% | 928 | 960 | -32 | -3% | 1201 | 1624 | -423 | -26% |
| East of 162nd / Q | | | | | | | | | | | | |
| EB | 1323 | 2084 | -761 | -37% | 891 | 709 | 182 | 26% | 1015 | 1266 | -251 | -20% |
| WB | 750 | 851 | -101 | -12% | 987 | 763 | 224 | 29% | 1405 | 2180 | -775 | -36% |
| North of 138th / Millard | | | | | | | | | | | | |
| NB | 1064 | 1296 | -232 | -18% | 868 | 837 | 31 | 4% | 900 | 1018 | -118 | -12% |
| SB | 584 | 564 | 20 | 3% | 932 | 1024 | -92 | -9% | 1206 | 1499 | -293 | -20% |

Notes: 1 - 7-day counts match same hours as TMC and is the average of 24 hour counts collected Tuesday - Thursday
2 - TMC intersections are 102nd / L (528), 156th / Q (673), and 135th / Millard (583)
3 - TMC AM peaks for 102nd / L, 156th / Q, and 135th / Millard are all 7:30-8:30am
4 - TMC Off peaks for 102nd / L, 156th / Q, and 135th / Millard are all 2-3pm
5 - TMC PM peaks for 102nd / L is 4:30-5:30pm, 156th / Q is 5-6pm, and 135th / Millard is 4:45-5:45pm

In addition, collected 24-hour traffic volume data was assessed and compared to traffic count data available from nearby Wavetronix detector stations to allow the City to assess Wavetronix data collection accuracy. Specific sites are included below:

1. 24-Hour Traffic Volume Counts
    a. L Street – East of S. 108th Street
    b. Q Street – East of S. 162nd Street
    c. Millard Avenue – North of S. 138th Street

2. Traffic Volume Comparisons of 24-Hour Counts with Wavetronix Detector Counts
    a. L Street EB & WB – Between 102nd Street and 108th Street
    b. Millard Avenue NB & SB – Between 135th Street and 138th Street
        i. Note: No Wavetronix Data Available on Q Street

A comparison of the data obtained from the 24-hour counts and Wavetronix counts is summarized in **Table 3.3**. The data presented in this table is the total volume over the 7-day time period. The ratios between the two data sources varies considerably from 0.78 to 2.25. In general, the 24-hour counts tended to record higher traffic volumes than the Wavetronix detectors. The daily ratios were typically within 10% of the 7-day ratio. The traffic count and traffic volume comparison graphs are included in **Appendix B**.

*Table 3.3 Comparison of 7-Day Tube Counts to Wavetronix Counts*

| 24-Hour Count Segment | 24-Hour Count | Wavetronix Counts | | Ratio [a] | Ratio [b] |
|---|---|---|---|---|---|
| | | 102nd / L [a] | 108th / L [b] | | |
| L St (102-108th) EB | 69,055 | 36,034 | 30,740 | 1.92 | 2.25 |
| L St (102-108th) WB | 67,555 | 53,085 | 86,623 | 1.27 | 0.78 |
| **24-Hour Count Segment** | **24-Hour Count** | **Wavetronix Counts** | | **Ratio [a]** | **Ratio [b]** |
| | | **135th / Millard [a]** | **138th / Millard [b]** | | |
| Millard Ave (135-138) NB | 86,841 | | 45,323 | | 1.92 |
| Millard Ave (135-138) SB | 82,657 | 78,570 | 58,802 | 1.05 | 1.41 |

It should be noted that collected 24-hour volume data appears to be impacted due to different driving behaviors with COVID. For example, the Noon (lunch) hour counts were less than traffic counted during the 2-3 pm time period. As a result (and for the modeling input), 2-3 pm turn movement volumes were factored up by 5% and used for the Mid-Day peak period (Pattern 1, 11 am - 3pm). The AM peak (Pattern 2, 7-9 am) and PM peak (Pattern 3, 3–6:30 pm) turn movement counts were not applied a growth factor. The new Off peak (Pattern 4, 9-11 am & 6:30 pm-7 am) utilized turn movement count data from the 10-11 am time period.

### 3.4 "Before" Travel Time Runs

"Before", or existing, travel time runs were conducted by AECOM during the week of November 16th, 2020, along the corridor:

- 180th Street & Q Street to 90th Street & L Street via Millard Avenue

Five (5) runs were completed along the corridor in each direction for each signal timing period included in the project (AM Peak, Midday Peak, PM Peak, Offpeak, and Weekend). Travel time runs were collected using Tru-Traffic and each run was recorded using a dash-mounted camera. A summary of the L Street/Q Street corridor travel time runs is shown in **Table 3.4**. More information on travel time runs for each peak period is provided in **Appendix C**.

*Table 3.4 Summary of L Street/Q Street Corridor "Before" Travel Time Runs*

| Peak | Direction | # of Runs | Average | Std Dev | Avg Spd (mph) |
|---|---|---|---|---|---|
| AM 7-9am | EB | 6 | 13:13 | 1:44 | 35.0 |
| | WB | 4 | 15:29 | 1:19 | 29.9 |
| MD 11:30am-1pm | EB | 5 | 14:29 | 0:51 | 32.0 |
| | WB | 5 | 13:49 | 0:53 | 33.5 |
| PM 4-6pm | EB | 6 | 15:58 | 1:29 | 29.0 |
| | WB | 5 | 14:57 | 0:42 | 31.0 |
| Off Peak 1:30-3pm | EB | 5 | 13:35 | 0:50 | 34.1 |
| | WB | 5 | 13:51 | 0:49 | 33.4 |
| Weekend 11am-1pm | EB | 5 | 13:55 | 0:40 | 33.3 |
| | WB | 5 | 13:54 | 1:27 | 33.3 |

In addition to the L Street/Q Street travel time runs collected by AECOM, a separate consultant, Felsburg, Holt & Ullevig (FHU) collected "before" travel time runs along the corridor:

- 132nd Street & Arbor Street to 144th Street & Stony Brook Boulevard via Millard Avenue

This data collection was part of the West Center Road project, adjacent with the L Street/Q Street project. These "before" travel time runs were collected by FHU in early September 2020 and were collected in the same manner as the L Street/Q Street travel time runs as described previously. AECOM coordinated with FHU to retrieve and report on these travel time runs. The results are summarized in **Table 3.5.** More information on travel time runs for each peak period is provided in **Appendix C**.

*Table 3.5 Summary of 132nd Street/144th Street Corridor "Before" Travel Time Runs*

| Peak | Direction | # of Runs | Average | Std Dev | Avg Spd (mph) |
|---|---|---|---|---|---|
| AM 6:30-9am | SB | 7 | 8:25 | 0:51 | 20.7 |
| | NB | 7 | 6:46 | 0:21 | 25.7 |
| MD 11:30am-1:30pm | SB | 6 | 7:54 | 0:45 | 22.0 |
| | NB | 6 | 8:03 | 0:46 | 21.6 |
| PM 3:30-6pm | SB | 8 | 8:26 | 1:22 | 20.6 |
| | NB | 8 | 6:38 | 0:55 | 26.2 |
| Off Peak 9-11am | SB | 5 | 7:07 | 0:22 | 24.4 |
| | NB | 5 | 7:15 | 0:11 | 24.0 |
| Weekend 11am-3pm | SB | 12 | 7:30 | 0:45 | 23.2 |
| | NB | 12 | 7:49 | 0:43 | 22.2 |

# 4. Optimization

## 4.1 Traffic Analysis & Optimization Methodology

As previously mentioned, existing Synchro traffic models provided by the City were checked for geometry, timing and volume information. A fourth existing model was created based on factored volume information for the Midday time period. Proposed models were developed using the basic signal timing parameters specified by the City (see **Section 4.2**), with consideration of West Center Road timing adjacent to the project area. Proposed models were developed for AM, Midday, PM and Off-Peak time periods also using Synchro (Version 10). All models/Synchro files were submitted in separate attachments for the City's review.

Traffic operations analyses were conducted to determine the level of service (LOS). LOS is a qualitative rating system used to describe the efficiency of traffic operations at an intersection. Six LOS are defined, designated by letters A through F. LOS A represents the best operating conditions (no congestion), and LOS F represents the worst operating conditions (severe congestion).

LOS for intersections is determined by the average control delay per vehicle. The range of control delay for each LOS is different for signalized and unsignalized intersections. **Table 4.1** presents the LOS criteria for signalized intersections.

***Table 4.1 Signalized Intersection LOS Criteria***

| LOS | Control Delay per Vehicle (sec) |
|---|---|
| A | ≤ 10 |
| B | > 10 – 20 |
| C | > 20 - 35 |
| D | > 35 – 55 |
| E | > 55 – 80 |
| F | > 80 |

## 4.2 Basic Timing Parameters

Basic Signal Timing Parameters set forth by the City of Omaha were incorporated.

a. Minimum Greens: Minimum greens for coordinated phases are 20 seconds. Minimum greens for side street through movements are 10 seconds, or 8 seconds if volume is minimal. Minimum greens for left turns are 5 seconds.
b. Max I/II Intervals: Consultant will update max I/II values in all maxtime databases during implementation.
c. Passage: Passage intervals for all locations where Wavetronix Matrix detection is operational based on City-provided template has been updated.
d. Yellow Change, Red Clearance, Walk, and Pedestrian Clearance Intervals: Consultant updated intervals using City of Omaha methodologies and forms. Intersections requiring clearance interval updates are limited to the Wapiti locations. Additional information provided in section 4.3.
e. Minimum Splits (Models only): In optimized model files, once the above values were programmed, the minimum split value was updated such that the green interval for left turn splits is at least 7 seconds. Additionally, if pedestrian push buttons are available and the pedestrian phase is not on recall, the minimum green split and pedestrian phase (walk and don't walk) splits were compared

and if the values were within a few seconds then the minimum green was increased to accommodate the pedestrian timing. Finally, all min splits were rounded up to the nearest second.

### 4.3 Clearance Interval Evaluation

Clearance intervals at each of the Wapiti intersections within this project area were evaluated and updated based on the City of Omaha methodology. For each of the Wapiti intersections a drawing was developed showing all of the clearance distances and a spreadsheet was completed with the updated clearance interval calculations. **Appendix D** includes the aerial map drawings and clearance calculations.

### 4.4 Left Turn Phase Warrant Analysis

AECOM completed left turn phase warrant analyses using the methodology and resources provided by the City of Omaha. The City methodology takes into account left-turn traffic volume, opposing traffic volume, and delay in order to determine if a permitted-protected left turn phase is warranted at a project intersection. Only intersections with existing infrastructure capable of providing permitted-protected left turn phasing were analyzed. The results of this analysis are summarized in **Table 4.2**. "Enable" indicates that permitted-protected left turn phasing is active for the specific movement during the time period, while "Omit" indicates that permitted-only left turn phasing is provided. It should be noted that although some left turn movements did not meet left turn warrants, it is recommended they remain enabled due to special events and other unique circumstances. The full evaluation results of are included in **Appendix E**.

*Table 4.2 Left Turn Phase Analysis Summary*

| Intersection | Phase | Direction | Plan 1 MD | Plan 2 AM | Plan 3 PM | Plan 4 OP |
|---|---|---|---|---|---|---|
| (560) 120th St & I St | 3 | NBL | Enable | Enable | Enable | Enable |
| (560) 120th St & I St | 7 | SBL | Enable | Enable | Enable | Enable |
| (1110) 121st St & I St | 1 | WBL | Enable | Enable | Enable | Enable |
| (1110) 121st St & I St | 5 | EBL | Omit | Omit | Omit | Omit |
| (1005) 132nd St & I St | 1 | WBL | Enable | Enable | Enable | Enable |
| (1005) 132nd St & I St | 3 | NBL | Enable | Enable | Enable | Enable |
| (1005) 132nd St & I St | 7 | SBL | Enable | Enable | Enable | Enable |
| (715) 138th St & Millard Ave / P St | 3 | NBL | Omit | Omit | Enable | Omit |
| (715) 138th St & Millard Ave / P St | 7 | SBL | Enable | Enable | Enable | Enable |
| (585) 138th St & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (921) 144th St & Hillsdale St | 7 | SBL | Enable | Enable | Enable | Omit |
| (711) 144th St & L St | 7 | SBL | Enable | Enable | Enable | Enable |
| (607) 144th St & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (607) 144th St & Q St | 5 | EBL | Enable | Enable | Enable | Enable |
| (859) 156th St & Ohern St | 3 | NBL | Enable | Enable | Enable | Omit |
| (673) 156th St & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (673) 156th St & Q St | 5 | EBL | Enable | Enable | Enable | Enable |
| (773) 172nd St & Q St | 1 | WBL | Enable | Enable | Enable | Omit |
| (779) 176th Ave & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (780) 180th St & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (780) 180th St & Q St | 5 | EBL | Enable | Enable | Enable | Enable |
| (780) 180th St & Q St | 3 | NBL | Enable | Enable | Enable | Enable |
| (780) 180th St & Q St | 7 | SBL | Enable | Enable | Enable | Enable |
| (515) 96th St & L St | 3 | NBL | Enable | Enable | Enable | Enable |
| (515) 96th St & L St | 7 | SBL | Enable | Omit | Enable | Omit |
| (1117) HyVee / 178th St & Q St | 5 | EBL | Enable | Enable | Enable | Enable |
| (697) Millard Ave & Q St | 1 | WBL | Enable | Enable | Enable | Enable |
| (697) Millard Ave & Q St | 5 | EBL | Enable | Enable | Enable | Enable |
| (748) Millard South High & Q St | 1 | WBL | Enable | Enable | Enable | Enable |

## 4.5 Leading Pedestrian Interval Evaluation

The existing intersection turning movement counts were evaluated to determine if an intersection had at least 25 pedestrians in one hour. A total of 11 intersections were identified that meet that threshold. A leading pedestrian interval (LPI) spreadsheet was completed for 9 intersections, all of which were located near schools. A summary of the LPI analysis is provided in the table on next page.

*Table 4.3 Leading Pedestrian Interval Evaluation Summary*

| Intersection | Leg | Warrants Met? | LPI Recommended? | Notes |
|---|---|---|---|---|
| 144th / N | S | No | No | |
| 156th / Ohern | E | Yes | No | Field observations saw very little ped activity on east leg compared to the TMC data. Students primarily used south leg only and were escorted in a group by teachers. |
| 156th / Q | W | Yes | No | Field observations saw very little ped activity on all intersection legs compared to the TMC data. |
| 168th / Q | S | Yes | No | Field observations saw very little ped activity on all intersection legs compared to the TMC data. |
| 172nd / Q | W | Yes | No | Field observations saw significant ped activity for 3 signal cycles and very little afterwards. A crossing guard is present at the crosswalk in the west leg and no yield issues were observed. |
| 176th / Q | W | Yes | No | Field observations saw less ped activity compared to the TMC data. No yielding issues were observed. This crossing serves high school students. |
| 178th / Q | W | Yes | No | Field observations saw very little ped activity at this intersection compared to the TMC data. |
| Q / Blackwell | E | Yes | No | Field observations saw very little ped activity at this intersection compared to the TMC data. |
| Q / Millard South HS | W | Yes | No | Field observations saw significant ped activity for 3 signal cycles and very little afterwards. No yielding issues were observed. This crossing serves high school students. |

The summary spreadsheet and LPI spreadsheets are provided in **Appendix F**. The leading pedestrian interval spreadsheet (v2.2) was provided by the City of Omaha in a September 30, 2020 email.

### 4.6 Bicycle Timing Consideration

The field observations conducted for this project only found occasional bicyclists through the 52 study area intersections. The locations with more than a couple bicyclists were typically by schools including Millard West (176th & Q) and a couple of the elementary schools. There are no major multi-use trails with the study area. Due to the low bicycle volumes and lack of bicycle facilities it is recommended that bicycle timing strategies not be carried forward at this time.

### 4.7 Proposed Day Plan Schedules

The proposed day plan schedule was developed following the analysis of existing day plan schedules, 24-hour traffic count data, and observations made during the “before” travel time runs. See **Appendix G** for Comparison of Weekend and Weekday Time of Day Schedules and Cycle Lengths by intersection. Time of day plans summarized in **Table 4.4**.

*Table 4.4 Proposed Day Plan Summary*

| Existing | | | |
|---|---|---|---|
| Mon-Thu | Plan | Friday | Plan |
| 0:00 | 20 or 19 | 0:00 | 20 or 19 |
| 6:00 | 2 | 6:00 | 2 |
| 9:00 | 1 | 9:00 | 1 |
| 15:30 | 3 | 15:30 | 3 |
| 18:30 | 1 | 18:30 | 1 |
| 22:00 | 20 or 19 | 22:00 | 1 |
| Sat | Plan | Sun | Plan |
| 0:00 | 20 or 19 | 0:00 | 20 or 19 |
| 6:00 | 1 | 6:00 | 1 |
| | | 21:00 | 20 or 19 |

Plan 19 and 20 indicate FREE operation

| Proposed | | | |
|---|---|---|---|
| Mon-Thu | Plan | Friday | Plan |
| 0:00 | 20 or 19 | 0:00 | 20 or 19 |
| 6:00 | 4 | 6:00 | 4 |
| 7:00 | 2 | 7:00 | 2 |
| 9:00 | 4 | 9:00 | 4 |
| 11:00 | 1 | 11:00 | 1 |
| 15:00 | 3 | 15:00 | 3 |
| 18:30 | 4 | 18:30 | 4 |
| 22:00 | 20 or 19 | 22:00 | 4 |
| Sat | Plan | Sun | Plan |
| 0:00 | 20 or 19 | 0:00 | 20 or 19 |
| 6:00 | 20 | 6:00 | 20 |
| 7:00 | 4 | 8:00 | 4 |
| 10:00 | 1 | 11:00 | 1 |
| 18:30 | 4 | 17:00 | 4 |
| | | 22:00 | 20 or 19 |

## 4.8 Cycle Length Optimization by Pattern

Each model was optimized to determine a cycle length for each proposed pattern. Cycles of 60, 90, 120, or 150 seconds were used to allow for coordination of adjacent and crossing corridors in future phases. The existing and proposed weekday time of day schedules are provided in **Table 4.5 and 4.6**, respectively. The weekday and weekend time of day schedules are included in **Appendix G**.

### General Methodology

In each plan, the cycle lengths choices were narrowed to two choices based on existing cycle lengths as well as City preference of 30 sec increments. For Midday and Off Peak, 90 vs 120 was examined. For AM and PM, 120 and 150 were evaluated. In order to determine the best cycle length, Synchro manual optimization was used at a high level to compare performance index as well as the natural cycle length for the signals. For instance, in the AM plan, only a few larger intersections had a natural cycle length higher than 120, and even as a 150, it was difficult to achieve v/c ratio lower than 1 on some movements. The delay was not drastically different for a 150 vs 120, so 120 was selected as a more efficient cycle length for the majority of the intersections. The corridors were also looked at in logical segments, L Street was evaluated as the entire corridor, but also with a break at 132$^{nd}$ to evaluate if the same cycle length was appropriate both east and west of 132$^{nd}$. The same break point was used on Q Street. In the AM, Midday and Off Peak models, one cycle length was chosen for the whole system (with a few half cycles during the AM, MD and PM plans). In the PM Plan, L Street is 150 sec cycle length west of and along 132$^{nd}$ Street and 120 sec cycle length east of 132$^{nd}$ Street. Q Street is 150 sec cycle from 138$^{th}$ Street to the west and 120 secs cycle to the east.

Once cycle lengths were selected, each individual intersection was evaluated. Half cycles did not work well for progression along the main corridors of L, Q and 132$^{nd}$ Streets, but they were considered and used on many of the north/south streets. Once cycle lengths were determined, each intersection was individually optimized. Side street and left turn splits were reduced while maintaining a v/c ratio of at least 0.80 if possible. In many cases, the splits are less than pedestrian

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### *Table 4.5 Existing Weekday Time of Day Schedule*

12 am, 1 am, 2 am, 3 am, 4 am, 5 am, 6 am, 7 am, 8 am, 9 am, 10 am, 11 am, 12 pm, 1 pm, 2 pm, 3 pm, 4 pm, 5 pm, 6 pm, 7 pm, 8 pm, 9 pm, 10 pm, 11 pm, 12 pm

| | EXISTING SCHEDULES MONDAY - THURSDAY | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 651 | 136 ST/P ST & Q ST | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 585 | 138 ST & Q ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 697 | MILLARD AVE & Q ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 607 | 144 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 748 | MILLARD SOUTH HIGH & Q | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 922 | BLACKWELL DR & Q ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 923 | 153 ST & Q ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 673 | 156 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 1084 | 165 ST & Q ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 746 | 168 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 773 | 172 ST & Q ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 779 | 176 AVE & Q ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 1117 | HYVEE / 178 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 780 | 180 ST & Q ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | | |
| 502 | 90 ST & L ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | |
| 515 | 96 ST & L ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | |
| 528 | 102 ST & L ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | |
| 540 | 108 ST & L ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 1101 | 111 ST & L ST | 20 [FREE] | 2 [60] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 561 | 120 ST & L ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 1003 | 126 PLZ & L ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 575 | 132 ST / MILLARD AVE & L ST / INDUSTRIAL RD | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 733 | 138 ST & INDUSTRIAL RD | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 553 | 119 CIR / I FRONTAGE RD & I ST | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 560 | 120 ST & I ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 1110 | 121 ST & I ST | 33 [FLASH] | 20 [FREE] | | | | | |
| 1109 | 126 ST & I ST | 33 [FLASH] | 20 [FREE] | | | | | |
| 1005 | 132 ST & I ST | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 797 | 87 ST & F ST | 19 [FLASH] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | 19 [FLASH] |
| 804 | 90 ST & F ST | 19 [FLASH] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | 19 [FLASH] |
| 713 | 96 ST & F ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 20 [FREE] | | |
| 884 | 168 ST & PATTERSON ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 881 | 168 ST & ROLLING RIDGE S | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 746 | 168 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 838 | 168 ST & V ST | 33 [FLASH] | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | 33 [FLASH] |
| 890 | 156 ST & F ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 936 | 156 ST & ROLLING RIDGE F | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | 33 [FLASH] | |
| 859 | 156 ST & OHERN ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 673 | 156 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 1097 | 156 ST & STONY BROOK BLVD / S ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 33 [FLASH] | |
| 921 | 144 ST & HILLSDALE ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 33 [FLASH] | | |
| 711 | 144 ST & L ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 33 [FLASH] | | |
| 1068 | 144 ST & N ST | 33 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 33 [FLASH] | | |
| 607 | 144 ST & Q ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] |
| 1094 | 144 ST & U ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | |
| 1095 | 144 ST & MILLARD AVE | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | |
| 32 | 144 ST & STONEY BROOK BLVD / Y ST | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | |
| 1126 | 146 ST & STONEY BROOK BLVD | 20 [FREE] | 2 [120] | 20 [FREE] | 3 [120] | 20 [FREE] | | |
| 573 | 132 ST & F ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 1005 | 132 ST & I ST | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 575 | 132 ST / MILLARD AVE & L ST / INDUSTRIAL RD | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 580 | 133 ST & MILLARD AVE | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 583 | 135 ST & MILLARD AVE | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 715 | 138 ST & MILLARD AVE / F | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | | |
| 697 | MILLARD AVE & Q ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 33 | MILLARD AVE & U ST | 19 [FLASH] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 19 [FLASH] | |
| 1095 | 144 ST & MILLARD AVE | 20 [FREE] | 1 [90] | 2 [120] | 1 [90] | 3 [120] | 20 [FREE] | |
| 560 | 120 ST & I ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 561 | 120 ST & L ST | 20 [FREE] | 2 [120] | 1 [90] | 3 [120] | 1 [90] | 20 [FREE] | |
| 713 | 96 ST & F ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 20 [FREE] | | |
| 714 | 96 ST & J ST | 19 [FLASH] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 19 [FLASH] | |
| 515 | 96 ST & L ST | 20 [FREE] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 20 [FREE] | |
| 517 | 96 ST & MOCKINGBIRD DR / N ST | 19 [FLASH] | 2 [90] | 1 [90] | 3 [90] | 1 [90] | 19 [FLASH] | |

## *Table 4.6 Proposed Weekday Time of Day Schedule*

| | PROPOSED SCHEDULES MONDAY - THURSDAY | 12 am | 6 am | 7 am | 9 am | 11 am | 3 pm | 6 pm | 10 pm |
|---|---|---|---|---|---|---|---|---|---|
| 651 | 136 ST/P ST & Q ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 585 | 138 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 697 | MILLARD AVE & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 607 | 144 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 748 | MILLARD SOUTH HIGH & Q | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 922 | BLACKWELL DR & Q ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 923 | 153 ST & Q ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [60] | 3 [150] | 4 [90] | 33 [FLASH] |
| 673 | 156 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1084 | 165 ST & Q ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [60] | 3 [150] | 4 [90] | 33 [FLASH] |
| 746 | 168 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 773 | 172 ST & Q ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 779 | 176 AVE & Q ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 1117 | HYVEE / 178 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 780 | 180 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 502 | 90 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 20 [FREE] |
| 515 | 96 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 20 [FREE] |
| 528 | 102 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 20 [FREE] |
| 540 | 108 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 20 [FREE] |
| 1101 | 111 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [60] | 3 [120] | 4 [90] | 20 [FREE] |
| 561 | 120 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1003 | 126 PLZ & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 575 | 132 ST / MILLARD AVE & L ST / INDUSTRIAL RD | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 733 | 138 ST & INDUSTRIAL RD | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 553 | 119 CIR / I FRONTAGE RD & I ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 19 [FLASH] |
| 560 | 120 ST & I ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1110 | 121 ST & I ST | 33 [FLASH] | 20 [FREE] | | | | | | 33 [FLASH] |
| 1109 | 126 ST & I ST | 33 [FLASH] | 20 [FREE] | | | | | | 33 [FLASH] |
| 1005 | 132 ST & I ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 797 | 87 ST & F ST | 19 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [60] | 4 [90] 20 [FREE] | 19 [FLASH] |
| 804 | 90 ST & F ST | 19 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [60] | 4 [90] 20 [FREE] | 19 [FLASH] |
| 713 | 96 ST & F ST | 20 [FREE] | | | | | | | |
| 884 | 168 ST & PATTERSON ST | 33 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [60] | 3 [75] | 4 [90] | 33 [FLASH] |
| 881 | 168 ST & ROLLING RIDGE S | 33 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [60] | 3 [75] | 4 [90] | 33 [FLASH] |
| 746 | 168 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 838 | 168 ST & V ST | 33 [FLASH] | | 2 [60] | 4 [90] | 1 [60] | 3 [75] | 4 [90] | 33 [FLASH] |
| 890 | 156 ST & F ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 20 [FREE] |
| 936 | 156 ST & ROLLING RIDGE F | 33 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 33 [FLASH] |
| 859 | 156 ST & OHERN ST | 33 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 33 [FLASH] |
| 673 | 156 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1097 | 156 ST & STONY BROOK BLVD / S ST | 33 [FLASH] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 33 [FLASH] |
| 921 | 144 ST & HILLSDALE ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 711 | 144 ST & L ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 33 [FLASH] |
| 1068 | 144 ST & N ST | 33 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 33 [FLASH] |
| 607 | 144 ST & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1094 | 144 ST & U ST | 20 [FREE] | 4 [90] | 2 [60] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1095 | 144 ST & MILLARD AVE | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 32 | 144 ST & STONEY BROOK BLVD / Y ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 1126 | 146 ST & STONEY BROOK BLVD | 20 [FREE] | 4 [90] | 2 [60] | 20 [FREE] | | 3 [75] | 20 [FREE] | |
| 573 | 132 ST & F ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [75] | 4 [90] | 20 [FREE] |
| 1005 | 132 ST & I ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 575 | 132 ST / MILLARD AVE & L ST / INDUSTRIAL RD | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 580 | 133 ST & MILLARD AVE | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 583 | 135 ST & MILLARD AVE | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 715 | 138 ST & MILLARD AVE / F | 10 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 10 [FREE] |
| 697 | MILLARD AVE & Q ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 33 | MILLARD AVE & U ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 19 [FLASH] |
| 1095 | 144 ST & MILLARD AVE | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 560 | 120 ST & I ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 561 | 120 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [150] | 4 [90] | 20 [FREE] |
| 713 | 96 ST & F ST | 20 [FREE] | | | | | | | |
| 714 | 96 ST & J ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 19 [FLASH] |
| 515 | 96 ST & L ST | 20 [FREE] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 20 [FREE] |
| 517 | 96 ST & MOCKINGBIRD DR / N ST | 19 [FLASH] | 4 [90] | 2 [120] | 4 [90] | 1 [120] | 3 [120] | 4 [90] | 19 [FLASH] |

clearances where pedestrian buttons are available. Once the splits were optimized at each intersection, progression work began.

**Progression**

Each plan had different progression goals for the main corridors. In each model, progression on L and Q Streets was set first, then 132nd Street and 144th street. Finally, the remaining corridors were adjusted where possible within the offsets set at L and Q Streets. Intersections from the West Center Road System and other adjacent signals that are outside of the study area were included in the Synchro models in order to take into account traffic progression from one system to the next smoothly. Once the offsets were tweaked In Synchro, the timing was exported to Tru-Traffic for a more detailed look at the green bands for each corridor. This was also the best way to evaluate phase order and the impacts of phase order changes. Final adjustments were then exported back into Synchro. The time space diagrams for the major corridors from Tru-Traffic have been included in **Appendix H**.

**Plan Specific Goals**

*AM Plan* – Eastbound progression on L and Q Streets as well as northbound progression on 132nd Street were favored in the AM model to accommodate the peak direction traffic.
*Midday Plan* – Balanced progression in both directions was the goal for Midday model, with slight weighting to the westbound and southbound progression.
*PM Plan* – Westbound progression on L and Q Streets as well as Southbound progression on 132nd Street were favored in the PM model to accommodate the peak direction traffic.
*Off Peak* - Balanced progression in both directions was the goal for Off Peak model, with slight weighting to the eastbound and northbound progression as volumes were higher in those directions.

## 4.9 Sequence Summary

The key below, **Table 4.7**, was used as reference for phase order shown on the following page (**Table 4.8**). The phase order is shown for each time of day plan. Only intersections in which a change in sequence between existing and proposed are presented in **Table 4.8**.

***Table 4.7 Sequence Summary Key***

| Sequence | Ring | Phases | Sequence | Ring | Phases | Sequence | Ring | Phases | Sequence | Ring | Phases |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1,2,a,3,4,b | 5 | 1 | 1,2,a,3,4,b | 9 | 1 | 1,2,a,3,4,b | 13 | 1 | 1,2,a,3,4,b |
| | 2 | 5,6,a,7,8,b | | 2 | 6,5,a,7,8,b | | 2 | 5,6,a,8,7,b | | 2 | 6,5,a,8,7,b |
| 2 | 1 | 2,1,a,3,4,b | 6 | 1 | 2,1,a,3,4,b | 10 | 1 | 2,1,a,3,4,b | 14 | 1 | 2,1,a,3,4,b |
| | 2 | 5,6,a,7,8,b | | 2 | 6,5,a,7,8,b | | 2 | 5,6,a,8,7,b | | 2 | 6,5,a,8,7,b |
| 3 | 1 | 1,2,a,4,3,b | 7 | 1 | 1,2,a,4,3,b | 11 | 1 | 1,2,a,4,3,b | 15 | 1 | 1,2,a,4,3,b |
| | 2 | 5,6,a,7,8,b | | 2 | 6,5,a,7,8,b | | 2 | 5,6,a,8,7,b | | 2 | 6,5,a,8,7,b |
| 4 | 1 | 2,1,a,4,3,b | 8 | 1 | 2,1,a,4,3,b | 12 | 1 | 2,1,a,4,3,b | 16 | 1 | 2,1,a,4,3,b |
| | 2 | 5,6,a,7,8,b | | 2 | 6,5,a,7,8,b | | 2 | 5,6,a,8,7,b | | 2 | 6,5,a,8,7,b |

*Table 4.8 Sequence Summary*

| Intersection | Existing or Proposed | Plan 1 MIDDAY | Plan 2 AM | Plan 3 PM | Plan 4 Off Peak | Notes |
|---|---|---|---|---|---|---|
| 102 St & L St (528) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 5 | 1 | 5 | 1 | No Phases 3/7 |
| 108 St & L St (540) | Existing | 2 | 2 | 2 | 2 | |
| | Proposed | 5 | 2 | 2 | 1 | |
| 120 St & I St (560) | Existing | 1 | 9 | 1 | 1 | |
| | Proposed | 4 | 1 | 9 | 9 | |
| 120 St & L St (561) | Existing | 1 | 9 | 1 | 1 | |
| | Proposed | 9 | 1 | 10 | 9 | |
| 126 Plz & L St (1003) | Existing | 5 | 5 | 5 | 5 | |
| | Proposed | 5 | 5 | 1 | 5 | Phase 5 only |
| 132 St & I St (1005) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 1 | 3 | 1 | No Phases 5 |
| 132/Millard & L/Industrial (575) | Existing | 2 | 2 | 4 | 2 | |
| | Proposed | 1 | 2 | 2 | 9 | |
| 135 St & Millard Ave (583) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 1 | 9 | 1 | Phase 7 PM Plan only |
| 138 St & Industrial Rd (733) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 2 | 2 | 5 | 5 | No Phases 3/7 |
| 138 St & Millard Ave/P St (715) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 1 | 1 | 9 | Phase 3 Plan 3 only |
| 138 St & Q St (585) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 2 | 1 | 1 | Phase 1 only |
| 144 St & Millard Ave (1095) | Existing | 4 | 4 | 3 | 4 | |
| | Proposed | 2 | 4 | 4 | 2 | 2/6 Split phase |
| 144 St & Q St (607) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 1 | 9 | 9 | No Phase 1 Plan 4 |
| 144 St & Stony Brook/Y St (32) | Existing | 9 | 9 | 9 | 9 | |
| | Proposed | 9 | 9 | 3 | 9 | No Phase 1 |
| 156 St & Q St (673) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 9 | 1 | 1 | |
| 168 St & Patterson St (884) | Existing | 2 | 2 | 2 | 2 | |
| | Proposed | 1 | 1 | 1 | 1 | No LT Phases |
| 168 St & Q St (746) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 6 | 1 | 5 | |
| 90 St & L St (502) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 5 | 2 | 2 | No Phases 3/7 |
| 96 St & L St (515) | Existing | 1 | 1 | 1 | 1 | |
| | Proposed | 1 | 1 | 1 | 2 | No Phase 7 Plan 2,4 |
| Hyvee/178 St & Q St (1117) | Existing | 5 | 5 | 5 | 5 | |
| | Proposed | 5 | 5 | 1 | 1 | Phase 5 only |

# 5. Implementation

## 5.1 Controller Programming

After the basic timing parameters were updated, optimized signal timings were developed, and a day plan schedule was created. The proposed information was entered into the central signal management systems as a “Proposed” database version. Intelight controller data was entered into Intelight’s web based MaxView application and the Wapiti controller data was entered into Wapiti’s DOS based TrafficView application via remote access to each central system. For the Wapiti controllers, Force Off Diagrams provided by the City, were completed as well as Timing Change Forms that compared the existing data to the proposed data and changes noted by bolding and underlining the changes. Once the data was entered into their central management systems, the City was given an opportunity to review the information and provide comments where applicable. This effort was performed January 15th, 2021 and was completed on January 21st, 2021.

## 5.2 Implementation Day

Implementation began on February 1, 2021 at which point an upload of the existing data from the field was performed to ensure there were no changes between the data stored in the central systems. Any changes were presented to the City for validation. Following this effort, the databases were downloaded onsite from the City’s Signal Shop to each controller and AECOM staff were in the field making observations to confirm the basic timing programming was performing as expected.

## 5.3 Fine Tuning

Each new timing plan was observed at each intersection during its respective peak hour to ensure each phase split was appropriate for the traffic conditions present. The fine-tuning process began on February 3rd, 2021 and continued through Saturday, February 6th, 2021. The fine-tuning process involved a multi-day review including Saturday operations. If a movement or intersection was over capacity, split adjustments were made to manage queue spillback and blockage. The fine-tuning changes were made by AECOM staff within the central management systems. A log of the changes made are shown as **Figure 5.1**.

In addition to fine-tuning the splits, offset adjustments often have a larger effect on the performance of the network. Offsets were adjusted at the coordinated intersections by conducting travel time runs along the corridor. Travel time runs were conducted using TruTraffic (v10) in conjunction with a direct connected GPS unit which track the location of the test vehicle with the traffic signal system. This provides the user dynamic information about the performance of the traffic signal system. Results of the travel time runs under existing timings (the “before” runs) and implemented signal timings (the “after” runs) are discussed in the next section of this report.

### *Figure 5.1 – Fine Tune Log for L / Q St Signal Timing Implementation*

| Signal Operations L Street/Q Street<br>MAPA-5026(15) CN 22801, OPW 53797 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Intersection** | **Date** | **Pattern** | **Change From** | **Change To** | **Controller** | **Tru-Traffic** | **Synchro** | **FO Diagram** | **db** | **Timing Change Form** |
| 1068 - 144 St & N St | 2/4/2021 | 1 | OS 43 | OS 110 | x | x | x | x | x | x |
| 1068 - 144 St & N St | 2/4/2021 | 2 | OS 67 | OS 54 | x | x | x | x | x | x |
| 515 - 96 St & L St | 2/2/2021 | 2 | ph 3 21, ph 4 31 | ph 3 27, ph 4 25 | x | x | x | n/a | x | n/a |
| 560 - 120 St & I St | 2/2/2021 | 2 | OS 15 | OS 20 | x | x | x | n/a | x | n/a |
| 561 - 120 St & L St | 2/2/2021 | 2 | ph 3 13, ph 4 25 | ph 3 15, ph 4 23 | x | x | x | n/a | x | n/a |
| 580 - 133 St & Millard Ave | 2/2/2021 | 2 | OS 14 | OS 71 | x | x | x | n/a | x | n/a |
| 583 - 135 St & Millard Ave | 2/2/2021 | 2 | OS 17 | OS 24 | x | x | x | n/a | x | n/a |
| 713 - 96 St & F St | 2/2/2021 | 2 | OS 15 | OS 100 | x | x | x | n/a | x | n/a |
| 715 - 138 St/P St & Millard Ave | 2/2/2021 | 2 | OS 8 | OS 12 | x | x | x | n/a | x | n/a |
| 1068 - 144 St & N St | 2/4/2021 | 3 | OS 21 | OS 8 | x | x | x | x | x | x |
| 1095 - 144 St & Millard Ave | 2/2/2021 | 2 | leading 2/4/5/7 | leading 2/3/5/7 | x | x | x | x | x | x |
| 1095 - 144 St & Millard Ave | 2/2/2021 | 3 | OS 146 | OS 13 | x | x | x | x | x | x |
| 1095 - 144 St & Millard Ave | 2/2/2021 | 1 | OS 50 | OS 66 | x | x | x | x | x | x |
| 583 - 135 St & Millard Ave | 2/3/2021 | 1 | OS 104 | OS 92 | x | x | x | n/a | x | n/a |
| 651 - 136 St/P St & Q St | 2/3/2021 | 1 | OS 89 | OS 105 | x | x | x | n/a | x | n/a |
| 697 - Millard Ave & Q St | 2/3/2021 | 1 | Seq 1 | Seq 5 | x | x | x | n/a | x | n/a |
| 1003 - 126 Plz & L St | 2/3/2021 | 1 | OS 56 | OS 40 | x | x | x | n/a | x | n/a |
| 502 - 90 St & L St | 2/3/2021 | 3 | OS 92 | OS 87 | x | x | x | n/a | x | n/a |
| 585 - 138 St & Q St | 2/3/2021 | 3 | OS 25 | OS 2 | x | x | x | n/a | x | n/a |
| 651 - 136 St/P St & Q St | 2/3/2021 | 3 | OS 58 | OS 64 | x | x | x | n/a | x | n/a |
| 697 - Millard Ave & Q St | 2/3/2021 | 3 | seq 1 | seq 2 | x | x | x | n/a | x | n/a |
| 33 - Millard Ave & U St | 2/3/2021 | 4 | OS 24 | OS 72 | x | x | x | n/a | x | n/a |
| 502 - 90 St & L St | 2/3/2021 | 4 | OS 68, seq 2 | OS 21, seq 5 | x | x | x | n/a | x | n/a |
| 502 - 90 St & L St | 2/3/2021 | 4 | OS 21 | OS 26 | x | x | x | n/a | x | n/a |
| 561 - 120 St & L St | 2/3/2021 | 4 | OS 22 | OS 26 | x | x | x | n/a | x | n/a |
| 715 - 138 St & Millard Ave | 2/3/2021 | 4 | OS 72 | OS 76 | x | x | x | n/a | x | n/a |
| 1097 - 156 St & Stoney Brook | 2/1/2021 | 1 | OS 39 | OS 53 | x | x | x | x | x | x |
| 1117 - 178 St/Hyvee & Q St | 2/4/2021 | 3 | OS 119 | OS 128 | x | x | x | x | x | x |
| 713 - 96 St & F St | 2/4/2021 | | coordinated | free | x | x | x | n/a | x | n/a |
| 32 - 144 St & Stoney Brook | 2/4/2021 | 3 | patt 3, ph 5/6 20/39 | patt 3, ph 5/6 29/30 | x | x | x | x | x | x |
| 607 - 144 St & Q St | 2/2/2021 | 3 | OS 72 | OS 82 | x | x | x | x | x | x |
| 673 - 156 St & Q St | 2/1/2021 | 1 | Leading 3/8 | Leading 3/7 | x | x | x | x | x | x |
| 673 - 156 St & Q St | 2/2/2021 | 3 | OS 117 | OS 124 | x | x | x | x | x | x |
| 711 - 144 St & L St | 2/4/2021 | 2 | OS 73 | OS 97 | x | x | x | x | x | x |
| 746 - 168 St & Q St | 2/2/2021 | 3 | OS 73 | OS 78 | x | x | x | x | x | x |
| 780 - 180 St & Q St | 2/3/2021 | 1 | OS 25 | OS 32 | x | x | x | x | x | x |
| 780 - 180 St & Q St | 2/3/2021 | 4 | OS 75 | OS 82 | x | x | x | x | x | x |
| 890 - 156 St & F St | 2/4/2021 | 1 | OS 21 | OS 111 | x | x | x | x | x | x |
| 890 - 156 St & F St | 2/4/2021 | 2 | OS 14 | OS 30 | x | x | x | x | x | x |
| 921 - 144 St & Hillsdale St | 2/4/2021 | 1 | OS 21 | OS 69 | x | x | x | x | x | x |
| 921 - 144 St & Hillsdale St | 2/4/2021 | 2 | OS 83 | OS 64 | x | x | x | x | x | x |
| 921 - 144 St & Hillsdale St | 2/4/2021 | 3 | OS 133 | OS 103 | x | x | x | x | x | x |
| 936 - 156 St & Rolling Ridge Rd | 2/4/2021 | 1 | OS 18 | OS 113 | x | x | x | x | x | x |
| 748 - Millard South HS & Q | 2/19/2021 | 3 | splits 16/103/31/119/31 | splits 16/89/45/105/45 | x | x | x | x | x | x |
| 923 - 153rd St & Q | 3/29/2021 | 2 | OS 76 | OS 46 | x | x | x | x | x | x |
| 607 - 144 St & Q St | 4/19/2021 | 2 | OS 89 | OS 115 | x | x | x | x | x | x |

### 5.4 Public Comments

AECOM received one comment from the public following the fine-tuning effort that occurred during the week of February 1st, 2021. This was received by the City's Engineering staff and forwarded to the AECOM team.

- Q St & Millard South High School – A comment was received on February 18th, 2021, stating that the time available to leave Millard South High School parking lot in the afternoon was too short causing severe congestion and creating a danger to the students attempting to cross Q St. AECOM staff observed the operation in the field during the specified time to validate the citizen's complaint. It was determined to increase the split time and final observation was made to confirm the change performed as expected.

# 6. Performance Evaluation

## 6.1 Network Performance Measures

Overall network performance of the 52 intersections included in this project were analyzed to provide a comparison benchmark between the existing and proposed conditions. Network performance measures evaluated included total delay, total stops, total travel time, and fuel consumed. The results from the Synchro models for existing and proposed conditions for each plan are presented in Table 6.1.
A comparison of existing and proposed Synchro Network MOEs are included below by plan. Synchro output reports are provided in **Appendix I**.

***Table 6.1 Network Performance***

| Performance Measure | AM Peak (Plan 2) | | | MD Peak (Plan 1) | | |
|---|---|---|---|---|---|---|
| | Existing | Proposed | Delta | Existing | Proposed | Delta |
| Total Delay (hr) | 1,218 | 1,076 | -11.7% | 615 | 588 | -4.4% |
| Total Stops (#) | 71,935 | 75,332 | 4.7% | 55,169 | 53,599 | -2.8% |
| Total Travel Time (hr) | 2,288 | 2,091 | -8.6% | 1,483 | 1,420 | -4.2% |
| Average Speed (mph) | 19 | 20 | 5.3% | 24 | 24 | 0% |
| Fuel Consumed (gal) | 3,184 | 3,036 | -4.6% | 2,260 | 2,167 | -4.1% |
| **Performance Measure** | **PM Peak (Plan 3)** | | | **Off Peak (Plan 4)** | | |
| | **Existing** | **Proposed** | **Delta** | **Existing** | **Proposed** | **Delta** |
| Total Delay (hr) | 1,855 | 1,725 | -7.0% | 330 | 302 | -8.5% |
| Total Stops (#) | 93,489 | 93,657 | 0.2% | 37,251 | 34,670 | -6.9% |
| Total Travel Time (hr) | 3,138 | 2,955 | -5.8% | 968 | 914 | -5.6% |
| Average Speed (mph) | 17 | 17 | 0% | 27 | 27 | 0% |
| Fuel Consumed (gal) | 4,163 | 3,990 | -4.2% | 1,545 | 1,455 | -5.8% |

## 6.2 Intersection Performance Measures

Individual intersections were also analyzed by doing a comparison of the overall intersection delay for the existing and implemented conditions Synchro models. **Table 6.2** provides a summary of the number of intersection where delay decreased or increased. The delay values for each intersection are provided in **Table 6.3**.

***Table 6.2 Summary of Intersection Performance***

| Number of Intersections where: | Peak Period | | | |
|---|---|---|---|---|
| | AM | MD | PM | OP |
| Delay Decreased | 21 | 18 | 25 | 31 |
| Delay Increased ≤ 5 sec/veh | 20 | 26 | 19 | 17 |
| Delay Increased > 5 sec/veh | 11 | 8 | 8 | 1 |

There are a couple of primary reasons that the delay increased at some intersection. First, the overall cycle length was increased during a couple of the peak periods in order to increase progression band opportunities, but that can lead to increased delay for side streets and minor movements. Second, the programmed stops associated with corridor progression were updated and, in some cases, this impacted some intersections that were previously not programmed stops. Finally, the clearance intervals were increased and that can particularly impact intersections that are near or over capacity. Additional information on intersections that increased by more than 5 seconds is provided after the tables.

*Table 6.3 Individual Intersection Performance*

| Decrease > 5s | Decrease < 5s | No change | Increased < 5s | Increase > 5s |
|---|---|---|---|---|

| Intersection | AM | | Off Peak | | Mid Day | | PM | |
|---|---|---|---|---|---|---|---|---|
| | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS |
| 102 St & L St (528) | 11.5/B | 12.9/B | 7.8/A | 8.5/A | 8.8/A | 10.5/B | 18.0/B | 22.8/C |
| 108 St & L St (540) | 36.3/D | 41.3/D | 25.7/C | 25.3/C | 34.4/C | 38.6/D | 51.3/D | 40.7/D |
| 111 St & L St (1101) | 70.6/E | 35.3/D | 8.5/A | 8.8/A | 6.9/A | 8.1/A | 14.3/B | 17.8/B |
| 119 Cir / I Frontage Rd & I St (553) | 49.9/D | 3.1/A | 7.3/A | 7.8/A | 9.4/A | 10.1/B | 12.5/B | 9.6/A |
| 120 St & I St (560) | 66.1/E | 34.4/C | 21.6/C | 19.3/B | 36.3/D | 33.1/C | 62.5/E | 48.2/D |
| 120 St & L St (561) | 104.9/F | 68.3/E | 28.6/C | 25.4/C | 69.8/E | 35.6/D | 124.4/F | 79.9/E |
| 121 St & I St (1110) | 16.5/B | 5.3/A | 8.4/A | 7.8/A | 12.2/B | 13.2/B | 22.9/C | 14.5/B |
| 126 Plz & L St (1003) | 6.8/A | 8.7/A | 11.5/B | 8.0/A | 15.0/B | 14.0/B | 16.9/B | 17.3/B |
| 126 St & I St (1109) | 5.0/A | 9.3/A | 7.2/A | 5.6/A | 10.4/B | 6.9/A | 8.4/A | 7.9/A |
| 132 St & F St (573) | 6.6/A | 7.4/A | 5.4/A | 4.0/A | 9.0/A | 7.2/A | 15.7/B | 13.8/B |
| 132 St & I St (1005) | 19.2/B | 28.3/C | 19.1/B | 19.3/B | 24.6/C | 24.1/C | 36.8/D | 48.9/D |
| 132/Millard & L/Industrial (575) | 50.0/D | 43.5/D | 26.1/C | 21.1/C | 45.5/D | 42.1/D | 95.8/F | 77.1/E |
| 133 St & Millard Ave (580) | 13.0/B | 21.7/C | 7.3/A | 5.5/A | 7.9/A | 6.9/A | 9.1/A | 12.3/B |
| 135 St & Millard Ave (583) | 11.6/B | 11.5/B | 5.8/A | 10.0/A | 6.3/A | 8.0/A | 20.5/C | 15.0/B |
| 136 St/P St & Q St (651) | 6.8/A | 6.0/A | 4.4/A | 5.0/A | 4.6/A | 5.4/A | 6.6/A | 13.7/B |
| 138 St & Industrial Rd (733) | 13.8/B | 21.7/C | 9.8/A | 11.6/B | 12.0/B | 11.8/B | 18.6/B | 28.9/C |
| 138 St & Millard Ave/P St (715) | 25.6/C | 22.4/C | 16.8/B | 14.4/B | 20.7/C | 16.6/B | 64.8/E | 51.9/D |
| 138 St & Q St (585) | 13.3/B | 15.5/B | 11.3/B | 10.8/B | 12.3/B | 16.8/B | 18.4/B | 22.8/C |
| 144 St & Hillsdale St (921) | 6.3/A | 23.4/C | 5.2/A | 4.8/A | 5.4/A | 11.1/B | 6.5/A | 11.3/B |
| 144 St & L St (711) | 9.0/A | 16.1/B | 4.8/A | 6.3/A | 5.8/A | 6.7/A | 11.0/B | 13.0/B |
| 144 St & Millard Ave (1095) | 20.0/C | 11.9/B | 15.0/B | 13.5/B | 20.4/C | 24.8/C | 27.7/C | 33.3/C |
| 144 St & N St (1068) | 8.7/A | 12.3/B | 2.4/A | 2.4/A | 3.8/A | 5.1/A | 4.9/A | 3.7/A |
| 144 St & Q St (607) | 37.2/D | 37.1/D | 28.9/C | 22.7/C | 32.5/C | 37.2/D | 79.4/E | 83.1/F |
| 144 St & Stony Brook/Y St (32) | 28.8/C | 43.0/D | 16.6/B | 20.3/C | 24.9/C | 24.7/C | 28.8/C | 41.5/D |
| 144 St & U St (1094) | 2.6/A | 6.3/A | 2.1/A | 2.8/A | 2.2/A | 4.0/A | 5.5/A | 4.6/A |

### Table 6.3 Individual Intersection Performance (Continued)

| Decrease > 5s | Decrease < 5s | No change | Increased < 5s | Increase > 5s |
|---|---|---|---|---|

| Intersection | AM | | Off Peak | | Mid Day | | PM | |
|---|---|---|---|---|---|---|---|---|
| | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS | Existing Delay/LOS | Proposed Delay/LOS |
| 145 St & Stony Brook Blvd (1126) | 5.5/A | 5.0/A | 6.7/A | 6.4/A | 8.4/A | 6.4/A | 11.5/B | 8.2/A |
| 153 St & Q St (923) | 10.5/B | 10.1/B | 6.9/A | 6.6/A | 9.6/A | 8.1/A | 22.5/C | 17.5/B |
| 156 St & F St (890) | 5.6/A | 8.2/A | 7.9/A | 7.7/A | 10.6/B | 14.8/B | 22.8/C | 25.6/C |
| 156 St & Ohern St (859) | 7.3/A | 9.8/A | 6.4/A | 6.4/A | 4.8/A | 6.6/A | 12.5/B | 15.9/B |
| 156 St & Q St (673) | 50.4/D | 45.0/D | 16.5/B | 15.6/B | 18.8/B | 21.7/C | 64.3/E | 60.2/E |
| 156 St & Rolling Ridge Rd (936) | 12.7/B | 13.5/B | 5.2/A | 5.2/A | 5.2/A | 6.5/A | 6.9/A | 6.1/A |
| 156 St & Stony Brook/ S St (1097) | 15.7/B | 15.4/B | 7.6/A | 8.6/A | 7.6/A | 10.0/A | 21.5/C | 25.0/C |
| 165 St & Q St (1084) | 13.3/B | 14.0/B | 3.3/A | 2.9/A | 3.1/A | 5.8/A | 8.4/A | 6.1/A |
| 168 St & Patterson St (884) | 16.4/B | 20.0/B | 5.1/A | 14.2/B | 5.0/A | 18.2/B | 7.7/A | 12.0/B |
| 168 St & Q St (746) | 83.0/F | 89.4/F | 30.1/C | 25.6/C | 25.7/C | 33.7/C | 153.3/F | 163.1/F |
| 168 St & Rolling Ridge St (881) | 9.2/A | 20.9/C | 3.9/A | 2.6/A | 4.1/A | 3.6/A | 7.5/A | 6.9/A |
| 168 St & V St (838) | 17.6/B | 10.1/B | 4.1/A | 3.8/A | 4.7/A | 3.5/A | 8.5/A | 7.1/A |
| 172 St & Q St (773) | 16.7/B | 12.7/B | 3.9/A | 4.9/A | 5.6/A | 11.6/B | 15.5/B | 14.0/B |
| 176 Ave & Q St (779) | 16.0/B | 17.5/B | 6.8/A | 6.5/A | 8.1/A | 10.5/B | 17.4/B | 15.8/B |
| 180 St & Q St (780) | 32.9/C | 35.1/D | 18.3/B | 22.2/C | 19.5/B | 23.0/C | 33.2/C | 38.9/D |
| 87 St & F St (797) | 4.1/A | 9.7/A | 5.6/A | 7.3/A | 5.5/A | 5.4/A | 6.4/A | 9.7/A |
| 90 St & F St (804) | 9.0/A | 8.6/A | 6.5/A | 4.7/A | 5.6/A | 4.6/A | 4.9/A | 5.6/A |
| 90 St & L St (502) | 23.3/C | 26.7/C | 10.7/B | 13.4/B | 11.5/B | 17.2/B | 30.6/C | 27.9/C |
| 96 St & F St (713) | 12.0/B | 13.1/B | 14.6/B | 7.6/A | 17.2/B | 9.1/A | 16.8/B | 12.5/B |
| 96 St & J St (714) | 5.5/A | 5.7/A | 8.4/A | 8.3/A | 8.4/A | 10.1/B | 13.3/B | 13.8/B |
| 96 St & L St (515) | 32.9/C | 27.0/C | 22.9/C | 20.8/C | 25.8/C | 31.0/C | 54.7/D | 39.5/D |
| 96 St & Mockingbird Dr/N St (517) | 6.0/A | 13.0/B | 4.7/A | 5.8/A | 4.7/A | 9.0/A | 10.1/B | 9.5/A |
| Blackwell Dr & Q St (922) | 3.5/A | 3.7/A | 1.6/A | 2.9/A | 3.1/A | 3.7/A | 16.7/B | 23.5/C |
| Hyvee/178 St & Q St (1117) | 11.2/B | 8.4/A | 9.7/A | 8.2/A | 12.4/B | 11.7/B | 22.2/C | 22.9/C |
| Millard Ave & Q St (697) | 47.1/D | 28.4/C | 26.8/C | 17.8/B | 27.2/C | 37.2/D | 36.3/D | 38.6/D |
| Millard Ave & U St (33) | 5.5/A | 7.6/A | 5.1/A | 4.1/A | 6.6/A | 7.5/A | 8.3/A | 8.9/A |
| Millard South High & Q St (748) | 67.1/E | 68.7/E | 4.2/A | 2.8/A | 5.4/A | 13.2/B | 10.6/B | 22.3/C |

- 108th Street and L Street (AM) – Reduced green time for 108th Street to improve progression on L Street, overall intersection LOS remains acceptable.
- 132nd Street and I Street (AM) – Additional delay is due to increased side street split to cover pedestrian timings.
- 132nd Street and I Street (PM) – Increased cycle length resulted in additional delay for side street.
- 133rd Street and Millard Avenue (AM) – Additional delay is due to a small increase for side street split to provide more reliable operations.
- 136th St / P St and Q Street (PM) – Increased cycle length resulted in additional delay for side street.
- 138th Street and Industrial Road (AM) – Additional delay because this is a programmed stop during this time period.
- 138th Street and Industrial Road (PM) – Increased cycle length resulted in additional delay for side street.
- 144th Street and Hillsdale Street (AM) – Additional delay because this is a programmed stop during this time period.
- 144th Street and Hillsdale Street (MD) - Increased cycle length resulted in additional delay for side street.
- 144th Street and L Street (AM) - Additional delay is due to increased side street split to cover pedestrian timings.
- 144th Street and Stony Brook Boulevard (AM) – Reduced green time for Stony Brook to improve progression on 144th Street. Additional delay because this is a programmed stop during this during this time period.
- 144th Street and Stony Brook Boulevard (PM) - Increased cycle length resulted in additional delay for side street and 144th Street left-turn movements.
- 168th Street and Patterson Street (MD) – Intersection is half-cycled to reduce side street delay, but results in additional delay for NB / SB traffic.
- 168th Street and Patterson Street (OP) – Increased cycle length resulted in additional delay for side street.
- 168th Street and Q Street (AM) – Increased clearance values result in additional delay.
- 168th Street and Q Street (MD) – Increased clearance values result in additional delay.
- 168th Street and Q Street (PM) – Increased cycle length resulted in additional delay for side street. Increased clearance values also result in additional delay.
- 168th Street and Rolling Ridge Street (AM) – Intersection is half-cycled to reduce side street delay, but results in additional delay for NB / SB traffic.
- 172nd Street and Q Street (MD) – Increased cycle length resulted in additional delay for side street.

- 180th Street and Q Street (PM) – Increased cycle length resulted in additional delay for side street.
- Blackwell Drive and Q Street (PM) – Increased cycle length resulted in additional delay for side street. Additional delay for Q Street is due to increased side street split to cover pedestrian timings.
- Millard Avenue and Q Street (MD) – Increased cycle length resulted in additional delay for side street.
- Millard South High and Q Street (MD) – Increased cycle length resulted in additional delay for side street.
- Millard South High and Q Street (PM) – Increased cycle length resulted in additional delay for side street. Additional delay for Q Street is due to increased side street split to cover pedestrian timings.
- 87th Street and F Street (AM) - Intersection is half-cycled to reduce side street delay, but results in additional delay for EB / WB traffic.
- 90th Street and L Street (MD) - Increased cycle length resulted in additional delay for side street.
- 96th Street and L Street (MD) - Increased cycle length resulted in additional delay for side street.
- 96th Street and Mockingbird Drive (AM) – Increased cycle length resulted in additional delay for side street.

### 6.3 Corridor Performance Measures ("After" Travel Time Runs)

The "after" travel time runs were conducted by AECOM during the last week of February and first two weeks of March 2021, along the following corridors:

- 180th Street & Q Street to 90th Street & L Street via Millard Avenue
- 132nd Street & Arbor Street to 144th Street & Stony Brook Boulevard via Millard Avenue

A minimum of five (5) runs were completed along the corridor in each direction for each signal timing period included in the project (AM Peak, Midday Peak, PM Peak, Offpeak, and Weekend). Travel time runs were collected using Tru-Traffic and each run was recorded using a dash-mounted camera. A summary of the L Street/Q Street and Millard Ave corridor travel time runs are shown in **Figure 6.1** and **Figure 6.2**, respectively.

Travel time was reduced was reduced by up to 2 minutes in the eastbound direction and 1 minute in the westbound direction along L Street / Millard Avenue / Q Street corridor. Along the Millard Avenue corridor travel time was reduced by up to 1.5 minutes in the southbound direction and 45 seconds in the northbound direction.

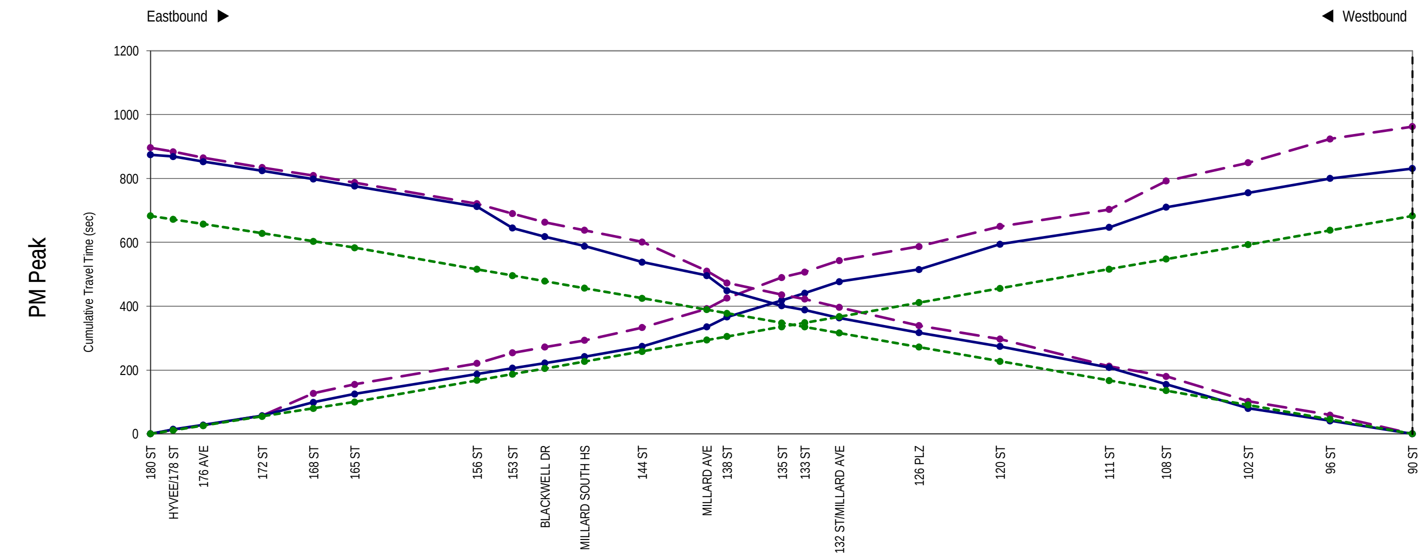
## Average Total Travel Time & Delay

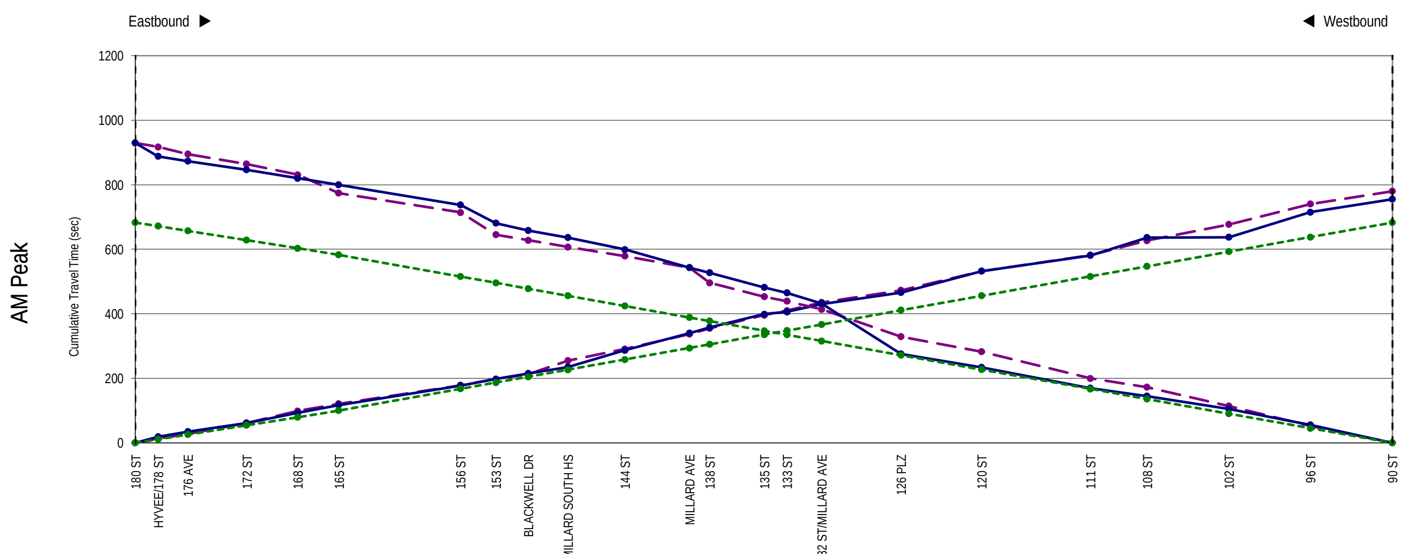
**Q ST/MILLARD AVE/L ST: 7.7 miles**

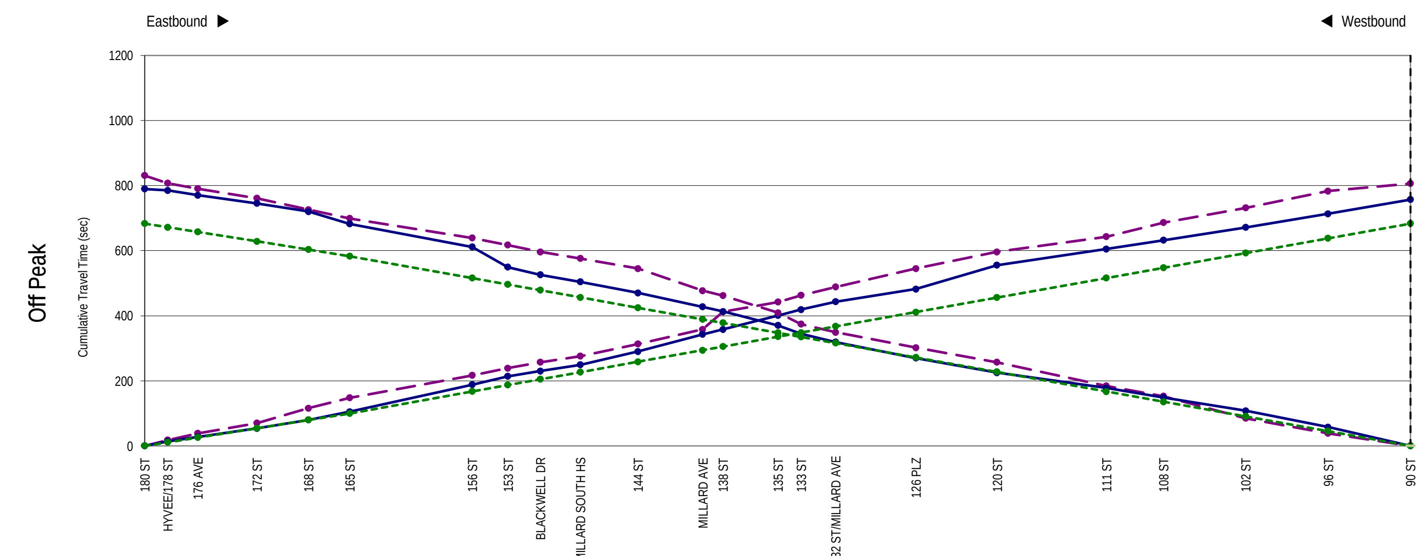
| | | AM | | MD | | PM | | Off peak | | Weekend | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) |
| Eastbound | Existing | 780 | 95 | 870 | 185 | 963 | 278 | 806 | 121 | 814 | 129 |
| | Implemented | 755 | 70 | 745 | 60 | 831 | 146 | 757 | 72 | 749 | 64 |
| | Difference | -25 | -25 | -125 | -125 | -132 | -132 | -49 | -49 | -65 | -65 |
| | % Difference | -3.2% | -26.3% | -14.4% | -67.6% | -13.7% | -47.5% | -6.1% | -40.5% | -8.0% | -50.4% |
| Westbound | Existing | 930 | 260 | 825 | 155 | 897 | 226 | 831 | 161 | 853 | 183 |
| | Implemented | 930 | 260 | 765 | 95 | 875 | 204 | 789 | 119 | 785 | 115 |
| | Difference | 0 | 0 | -60 | -60 | -22 | -22 | -42 | -42 | -68 | -68 |
| | % Difference | 0.0% | 0.0% | -7.3% | -38.7% | -2.5% | -9.7% | -5.1% | -26.1% | -8.0% | -37.2% |

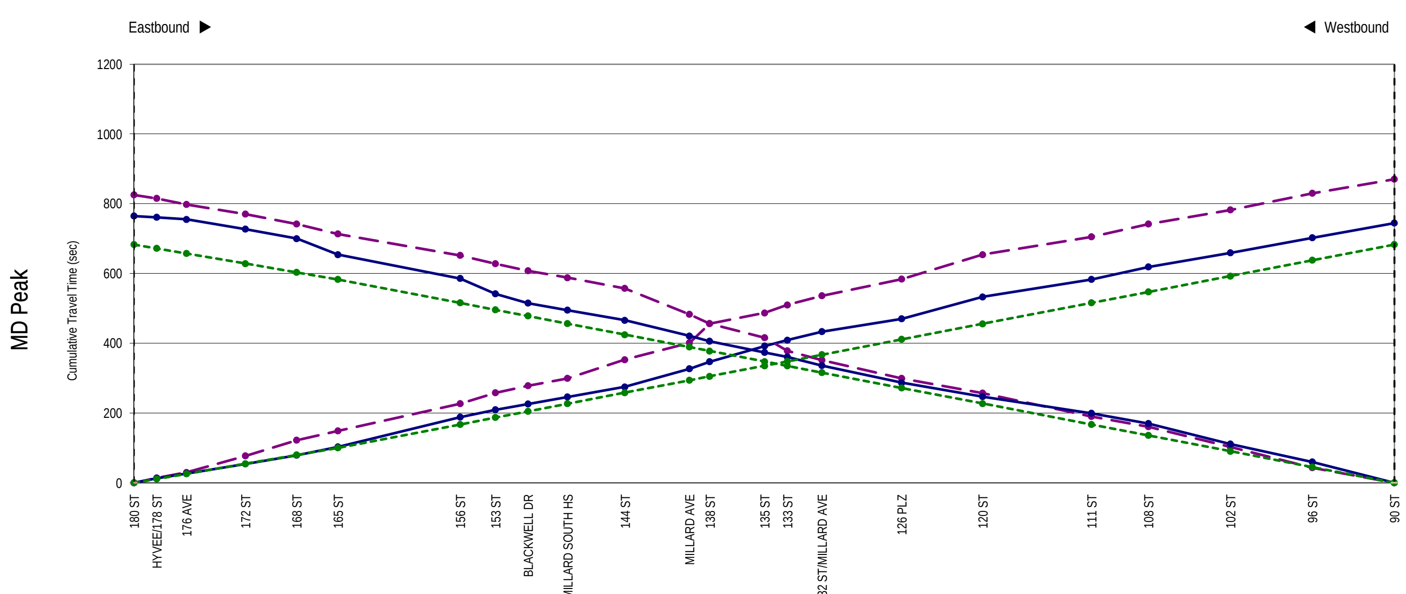
*Eastbound : Q ST & 180 ST to L ST & 90 ST*

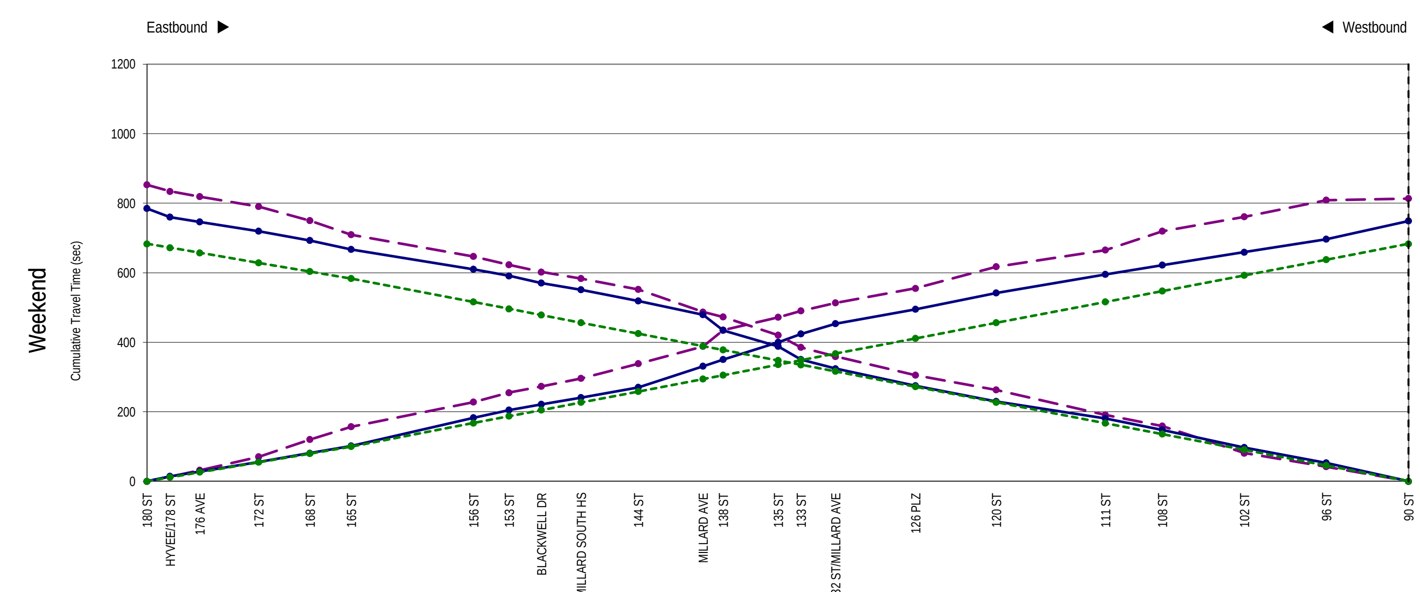
*Westbound : L ST & 90 ST to Q ST & 180 ST*




AECOM

Existing
Implemented
Free Flow

Figure 6.1

Average Travel Time & Delay

Q ST/MILLARD AVE/L ST

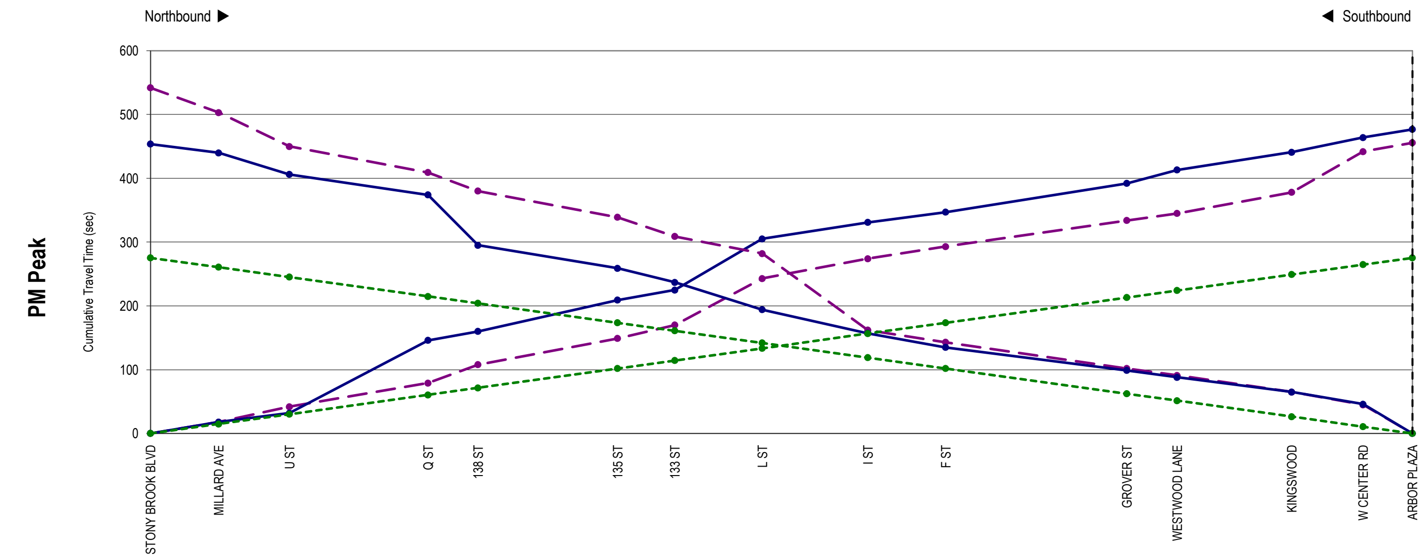
## Average Total Travel Time & Delay

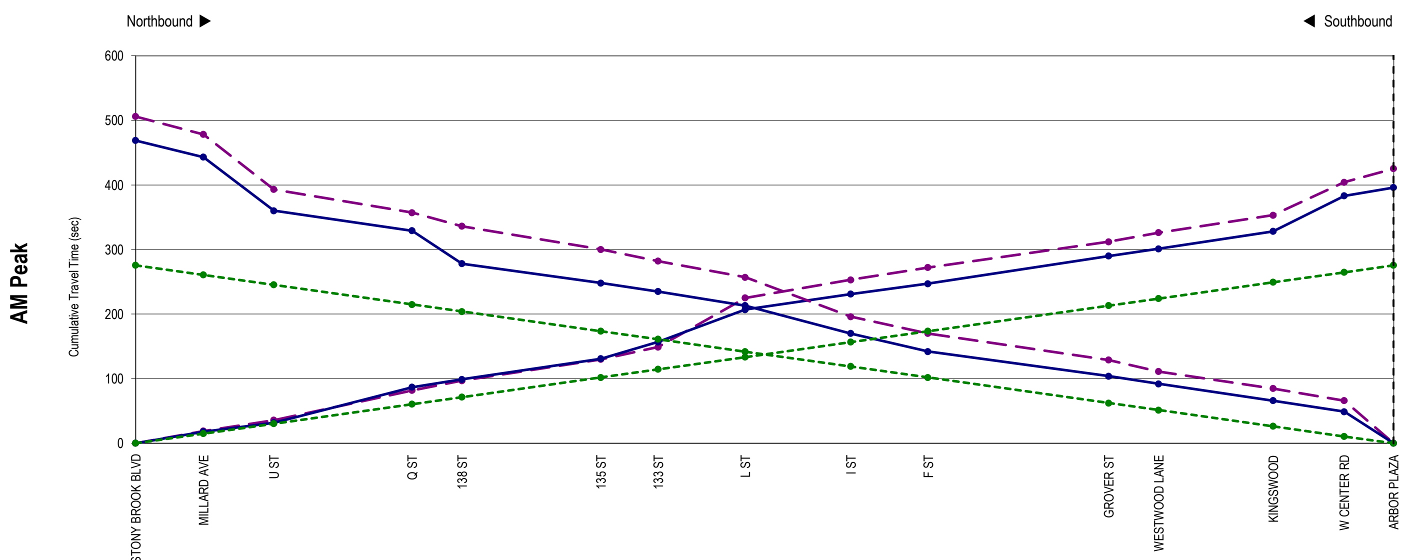
**MILLARD AVE/132 ST: 3.1 miles**

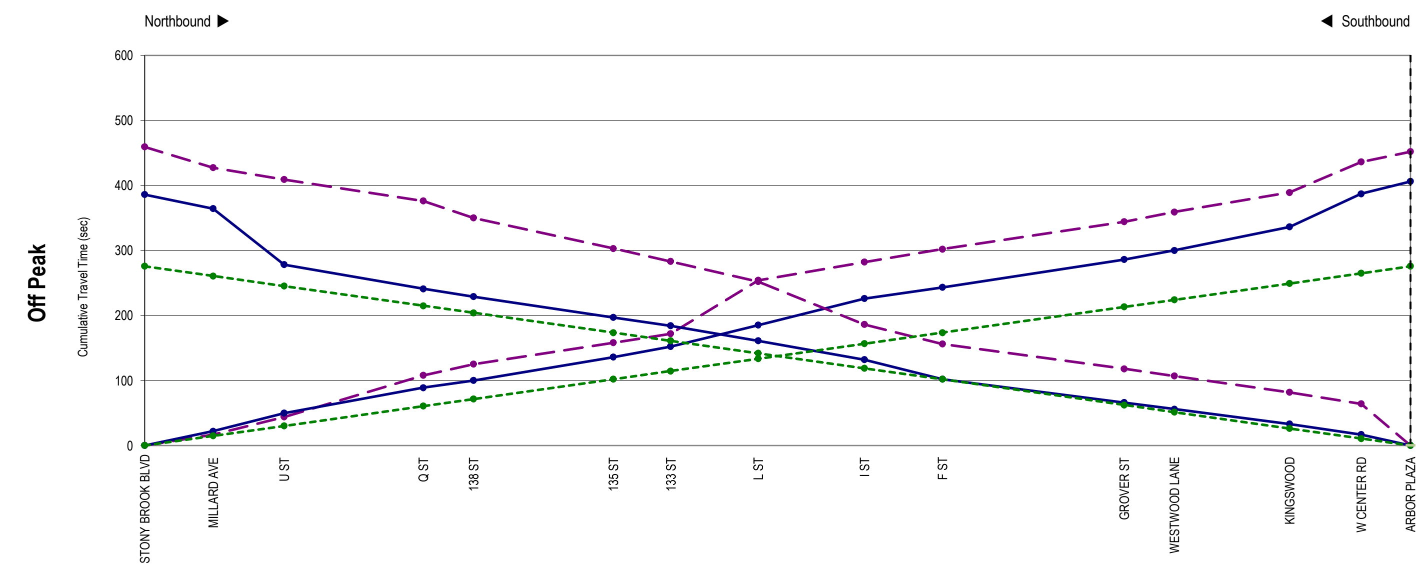
| | | AM | | MD | | PM | | Off peak | | Weekend | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) | Travel Time (s) | Delay (s) |
| Northbound | Existing | 425 | 151 | 499 | 226 | 456 | 183 | 452 | 178 | 526 | 252 |
| | Implemented | 396 | 122 | 515 | 242 | 477 | 204 | 406 | 132 | 502 | 228 |
| | Difference | -29 | -29 | 16 | 16 | 21 | 21 | -46 | -46 | -24 | -24 |
| | % Difference | -6.8% | -19.2% | 3.2% | 7.1% | 4.6% | 11.5% | -10.2% | -25.8% | -4.6% | -9.5% |
| Southbound | Existing | 506 | 230 | 508 | 232 | 542 | 268 | 459 | 184 | 516 | 241 |
| | Implemented | 469 | 193 | 454 | 178 | 454 | 180 | 386 | 111 | 476 | 201 |
| | Difference | -37 | -37 | -54 | -54 | -88 | -88 | -73 | -73 | -40 | -40 |
| | % Difference | -7.3% | -16.1% | -10.6% | -23.3% | -16.2% | -32.8% | -15.9% | -39.7% | -7.8% | -16.6% |

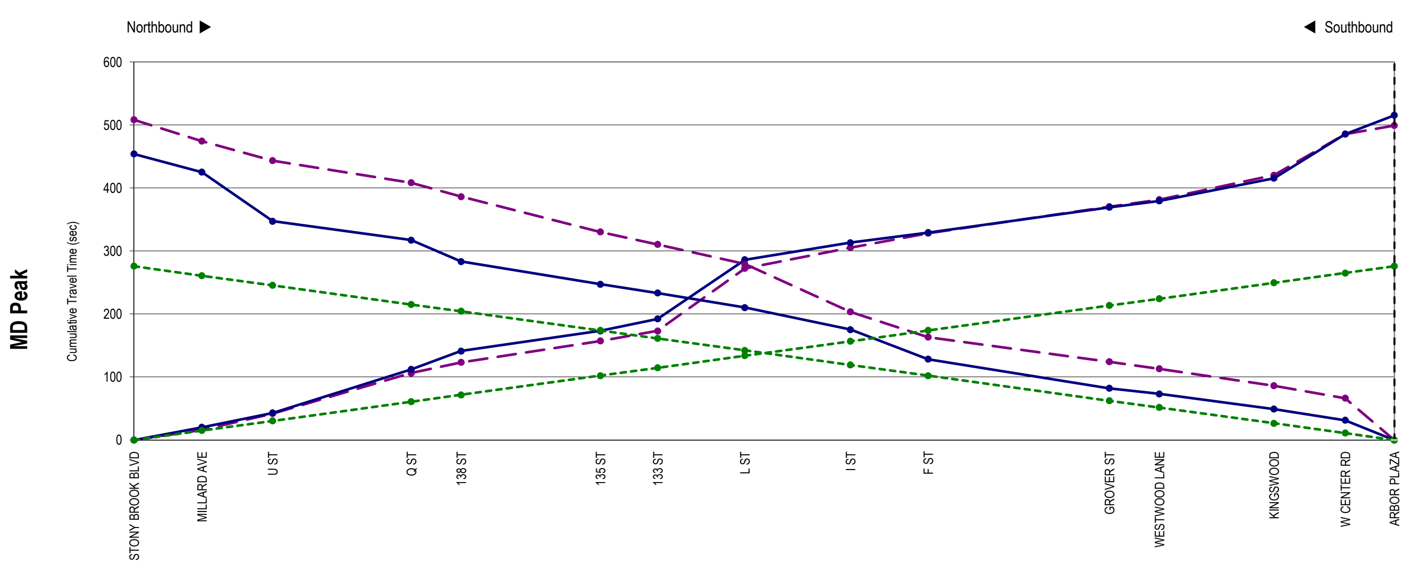
*Southbound : 132 ST & ARBOR PLAZA*

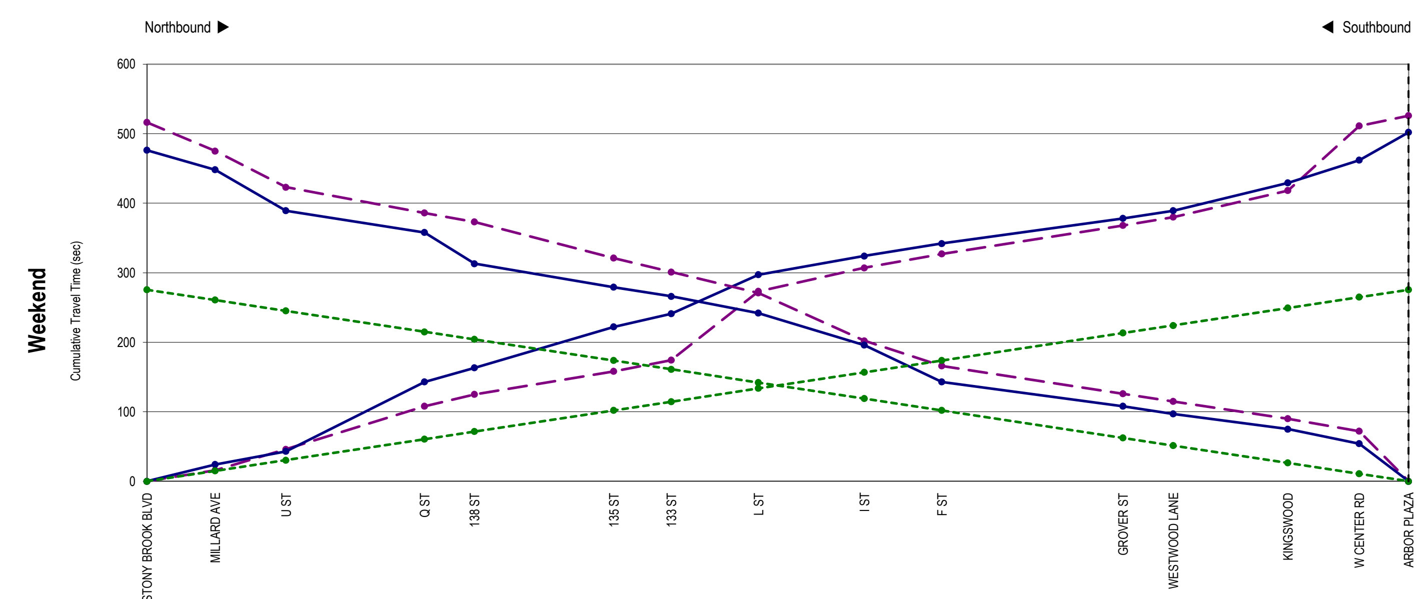
*Northbound: 144 ST & STONY BROOK BLVD*




AECOM

Existing
Implemented
Free Flow

Figure 6.2

Average Travel Time & Delay

MILLARD AVE/132 ST

During the after travel time runs there was a traffic lane closure on northbound Millard Avenue between 133rd and 135th Street for site redevelopment work. The eastbound L / Q Street and northbound Millard Avenue after runs were adjusted in the AM peak period to account for the extra delay caused by the lane closure.

It was determined by AECOM and the City that traffic volumes had likely increased since the "before" travel time runs were collected. As a result of this potential increase in traffic, the "after" travel time runs would show increased travel times (compared to the "before" travel time runs) despite the efforts to improve signal operations and reduce travel times through signal optimization. To determine if this increase in volume occurred, the City provided AECOM with additional Wavetronix data which was recorded around the same time that AECOM completed "after" travel time runs. This data was compared to the "before" Wavetronix traffic data, in a similar manner to the comparison of 24-hour tube counts to "before" Wavetronix data that was documented in Section 3. The results of this "before" and "after" traffic volume data, presented in **Table 6.6**, did not indicate a significant increase in traffic volumes. The difference in "before" and "after" travel time run data is attributed to general variation in daily traffic volumes. The data was further broken down into peak hour time periods (AM, PM & Midday); this breakdown further showed there was no significant difference in traffic volumes.

***Table 6.6 Comparison of "Before" & "After" Wavetronix Counts***

| Direction | "Before" Wavetronix Counts | | "After" Wavetronix Counts | | Ratio [a] | Ratio [b] |
|---|---|---|---|---|---|---|
| | 102nd / L [a] | 108th / L [b] | 102nd / L [a] | 108th / L [b] | | |
| EB | 36,034 | 30,740 | 34,083 | 30,966 | 0.946 | 1.007 |
| WB | 60,678 | 100,473 | 59,660 | 102,147 | 0.983 | 1.017 |
| **Direction** | **"Before" Wavetronix Counts** | | **"After" Wavetronix Counts** | | **Ratio [a]** | **Ratio [b]** |
| | **135th / Millard [a]** | **138th / Millard [b]** | **135th / Millard [a]** | **138th / Millard [b]** | | |
| NB | No Data | 45,323 | No Data | 44,239 | No Data | 0.976 |
| SB | 78,570 | 58,802 | 79,042 | 58,704 | 1.006 | 0.998 |

## 6.4 Benefit Cost Analysis (Timing)

A benefit cost analysis was conducted to determine the return on investment for this project. There are typically two types of benefits associated with traffic signal retiming projects. First there are the user (direct) benefits that are determined by a reduction in travel time costs, operating costs, and crash costs. The second is societal (non-direct) benefits that include a reduction in air pollutants.

The City has developed a methodology, based on national / USDOT guidelines, to calculate the monetary benefit over the next five years. Based on this methodology, the monetary over the next years is anticipated to be $25.4 million. A breakdown of the project benefits for the various direct and non-direct benefits is shown in **Table 6.7**. Detailed project benefit calculations are provided in **Appendix J**. The cost to complete this project was $205,139, yielding a benefit/cost ratio of 124:1.

*Table 6.7 Anticipated Project Benefits Over Five Years*

| Performance Measure | Project Benefit | Present Value |
|---|---|---|
| Delay Reduction | 669,694 hours | $18,947,051 |
| Fuel Consumption Reduction | 1,301,104 gallons | $2,667,263 |
| Emissions Reduction | 11,605 tons | $907,198 |
| Crash Reduction | 68 crashes | $2,903,079 |

## 6.5 Short Term Operations Recommendations

Based on field observations and review of available data a set of preliminary recommendations are offered for a few intersections, as listed below:

- 121st St / I St (1110) - for the northbound / southbound approaches the lane striping and markings are worn away and should be replaced. Work with private street owner to replace striping and markings.
- 126th St / I St (1109) - the traffic volumes along I St and the westbound left-turn may be approaching the threshold for providing protected / permissive left-turn signal operations. The left-turn warrant analysis, included in Appendix E, indicates the volume warrant is currently met during the PM peak hour. This movement should be monitored to determine if traffic delays or crash history warrant the future installation of a left-turn signal.
- 165th St / Q St (1084) - the northbound approach has two lanes, but has no lane striping or markings. Lane striping and markings should be installed.
- 168th St / V St (838) - the eastbound and westbound approaches each have two lanes, but has no lane striping or markings. Lane striping and markings should be installed.

# 7. Safety Analysis

## 7.1 Short Term Safety Recommendations

Based on field observations and review of available data a set of preliminary, short-term safety recommendations are offered for the following intersections. These are generally lower cost improvements and include:

- Install "Yield on FYA" signage for lagging left-turn phases. Signs would be installed at the following intersections / approaches:
    - 120th St / I St (560) – NB and SB
    - 132nd St / I St (1005) – NB
    - 135th St / Millard Ave (583) – SB
    - 138th St / Millard Ave (715) – SB
    - 138th St / Q St (585) - WB
- Develop FYA public outreach material that could be posted on the City's website.

## 7.2 Long Term Safety and Operational Recommendations

The purpose of the long-term safety analysis was to investigate and document potential safety improvements at three signalized intersections within the L Street/Q Street Signal Operations project area that have a history of safety issues and crashes. These intersections were selected by the City of Omaha and include:

- 144th Street and Q Street
- Millard Avenue and Q Street
- 120th Street and L Street

This analysis documents existing geometric and operational characteristics of the three intersections as well as the 5-year crash histories (2015-2019), provided by the City of Omaha. Existing conditions and crash histories were used to identify crash trends at each of the three intersections. These crash trends were then used to identify potential countermeasures which could be implemented to improve the safety at each intersection.

**Figure 7.1** shows the locations of the three study intersections.


*Figure 7.1 – Intersection Location Map of Safety Analysis Locations*

**Existing Conditions and Traffic Volumes**

The intersection of 144$^{th}$ Street and Q Street is a 4-leg signalized intersection, with 144$^{th}$ Street extending north-south and Q Street extending east-west. The 144$^{th}$ Street segment is a 4-lane divided arterial street with dedicated left-turn (dual) and right-turn (single) lanes for both the northbound and southbound approaches, while Q Street is a 4-lane divided arterial street with dedicated left-turn and right-turn lanes (both single) for the eastbound and westbound approaches. The intersection currently has protected left-turn signal phasing for the northbound/southbound approaches and protected/ permissive left-turn phasing for the eastbound/westbound approaches. The posted speed limit while traveling both northbound and southbound on 144$^{th}$ Street and approaching the Q Street intersection is 45 mph. The posted speed limit while traveling both eastbound and westbound on Q Street and approaching the 144$^{th}$ Street intersection is 40 mph.

The existing intersection layout is shown in **Figure 7.2**. Traffic volumes are shown in **Table 7.1**.

*Table 7.1 – Traffic Volume Turning Movement Counts (144$^{th}$ Street & Q Street)**

| | Time Period | EB (Q St) | | | WB (Q St) | | | NB (144$^{th}$ St) | | | SB (144$^{th}$ St) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | R | L | T | R | L | T | R | L | T | R |
| 144$^{th}$ Street & Q Street | AM Peak | 311 | 1540 | 208 | 17 | 690 | 184 | 151 | 698 | 29 | 239 | 550 | 229 |
| | Midday Peak | 167 | 542 | 141 | 24 | 789 | 158 | 195 | 553 | 37 | 153 | 540 | 250 |
| | PM Peak | 249 | 891 | 217 | 29 | 1514 | 162 | 402 | 783 | 43 | 260 | 743 | 439 |
| | Off Peak | 152 | 636 | 117 | 24 | 410 | 98 | 120 | 499 | 27 | 109 | 417 | 114 |

*Turning movement count data collected 04/11/2016

*Figure 7.2 – Existing Intersection Layout (144th Street & Q Street)*

The intersection of Millard Avenue and Q Street is a 4-leg signalized intersection, with Millard Avenue extending north-south and Q Street extending east-west. The Millard Avenue segment is a 4-lane divided arterial street with dedicated left-turn (single) and right-turn (single) lanes for both approaches, as are the two Q Street approaches. The intersection currently has permissive left-turn signal phasing for the northbound/southbound approaches and protected/permissive with flashing yellow arrow (FYA) left-turn phasing for the eastbound/westbound approaches. The southbound to westbound right turn is signalized and does not allow right turns on red. The posted speed limit for all four approaches at the Millard Avenue and Q Street intersection is 40 mph.

The existing intersection layout is shown in **Figure 7.3**. Traffic volumes are shown in **Table 7.2**.

*Table 7.2 – Traffic Volume Turning Movement Counts (Millard Avenue & Q Street)**

| | Time Period | EB (Q St) | | | WB (Q St) | | | NB (Millard Ave) | | | SB (Millard Ave) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | R | L | T | R | L | T | R | L | T | R |
| **Millard Avenue & Q Street** | AM Peak | 657 | 1232 | 30 | 124 | 608 | 8 | 9 | 601 | 289 | 12 | 289 | 242 |
| | Midday Peak | 269 | 429 | 21 | 186 | 526 | 9 | 12 | 378 | 159 | 23 | 384 | 372 |
| | PM Peak | 388 | 720 | 59 | 318 | 1084 | 12 | 13 | 424 | 200 | 20 | 657 | 617 |
| | Off Peak | 374 | 438 | 28 | 116 | 371 | 5 | 10 | 357 | 160 | 14 | 263 | 200 |

*Turning movement count data collected 11/03/2015


*Figure 7.3 – Existing Intersection Layout (Millard Avenue & Q Street)*

The intersection of 120th Street and L Street is a 4-leg signalized intersection, with 120th Street extending north-south and L Street extending east-west. The 120th Street segment is a 4-lane divided arterial street with dedicated left-turn (dual) and right-turn (single) lanes for both the northbound and southbound approaches, while L Street is a 6-lane divided highway with dedicated left-turn (dual) and right-turn lanes (single) for the eastbound and westbound approaches. The intersection currently has protected left-turn signal phasing for all four approaches. The posted speed limit while traveling both northbound and southbound on 120th Street and approaching the L Street intersection is 40 mph. The posted speed limit while traveling both eastbound and westbound on L Street and approaching the 120th Street intersection is 45 mph.

The existing intersection layout is shown in **Figure 7.4**. Traffic volumes are shown in **Table 7.3**.

*Table 7.3 – Traffic Volume Turning Movement Counts (120th Street & L Street)**

| | **Time Period** | **EB (L St)** | | | **WB (L St)** | | | **NB (120th St)** | | | **SB (120th St)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | R | L | T | R | L | T | R | L | T | R |
| **120th Street & L Street** | AM Peak | 291 | 2524 | 118 | 311 | 1827 | 242 | 238 | 584 | 876 | 192 | 343 | 80 |
| | Midday Peak | 122 | 1836 | 156 | 245 | 1657 | 187 | 182 | 340 | 672 | 285 | 367 | 157 |
| | PM Peak | 149 | 2432 | 232 | 306 | 2522 | 204 | 371 | 614 | 952 | 421 | 585 | 344 |
| | Off Peak | 124 | 1477 | 96 | 173 | 1181 | 137 | 152 | 343 | 396 | 154 | 230 | 71 |

*Turning movement count data collected 10/01/2018

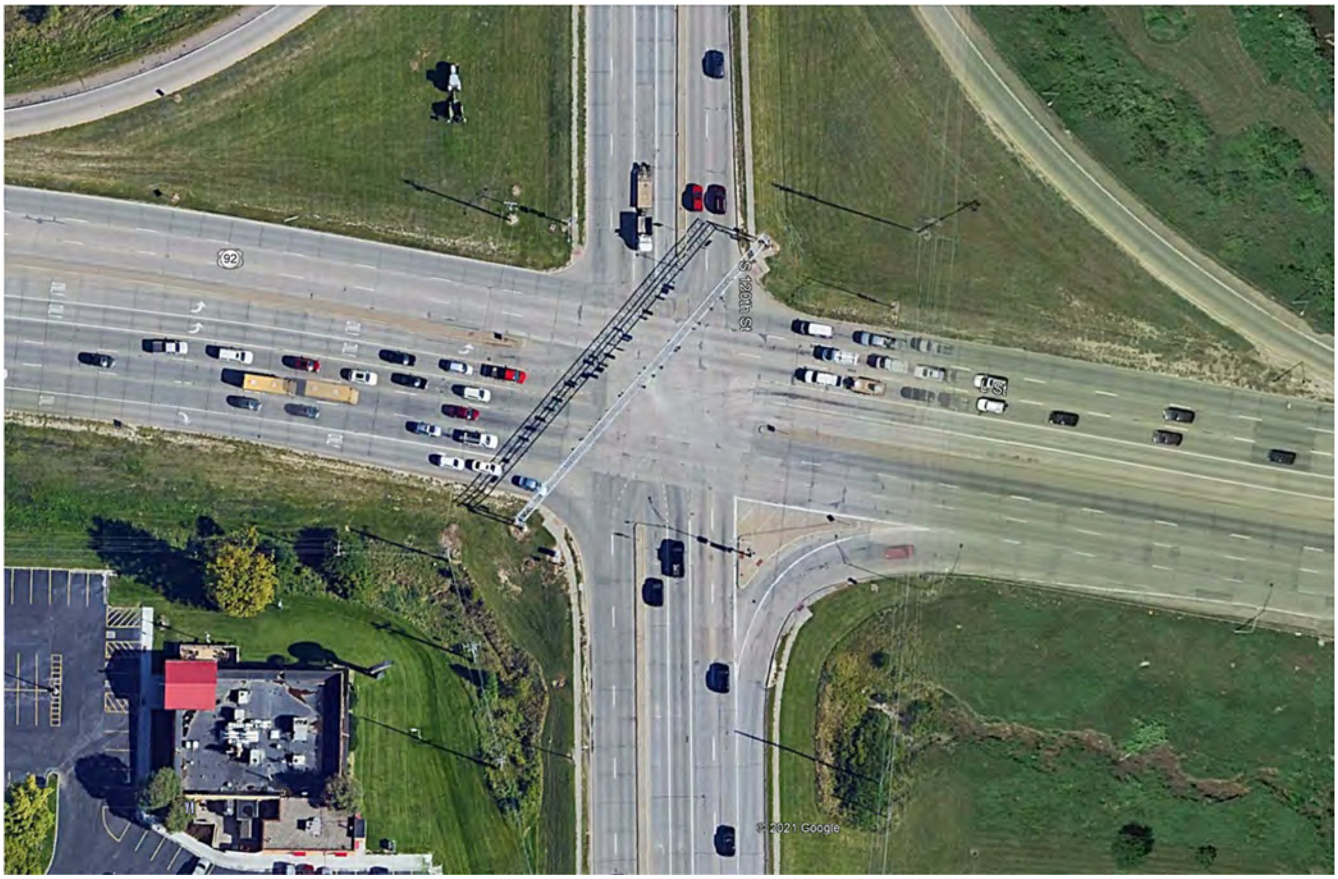



*Figure 7.4 – Existing Intersection Layout (120th Street & L Street)*

**Crash History and Analysis**
Crash data for the 144th Street and Q Street intersection was provided by the City of Omaha and included all crashes over a 5-year period from 2015-2019. Over the course of the study period, there were a total of 141 reported crashes. A detailed crash analysis was performed to identify any potential crash patterns at the intersection that may need further evaluation. Individual crashes were categorized using a series of parameters, which include the following:

- Crash Severity
- Crash Type by Movement Direction (at-fault vehicle)

The number of crashes by severity rank and crash types by movement direction are shown in **Tables 7.4** and **7.5**, respectively. A visualization of the crash history is provided as a crash diagram in **Appendix K**.

*Table 7.4 – Crash Severities by Year (144th Street & Q Street)*

| Year | Crash Severity | | | | | |
|---|---|---|---|---|---|---|
| | Fatal | Disabling Injury | Visible Injury | Possible Injury | Property Damage Only | Total Crashes |
| **2015** | 0 | 0 | 1 | 9 | 23 | **33** |
| **2016** | 0 | 0 | 4 | 8 | 20 | **32** |
| **2017** | 0 | 0 | 0 | 6 | 17 | **23** |
| **2018** | 0 | 0 | 1 | 7 | 19 | **27** |
| **2019** | 0 | 1 | 1 | 5 | 19 | **26** |
| **Total** | **0** | **1** | **7** | **35** | **98** | **141** |

*Table 7.5 – Crash Types by Movement (144th Street & Q Street)*

| Movement | Crash Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Angle | Left Turn | Rear End | Sideswipe | Head On | Bike/Ped | Other | Total |
| **NBL** | 1 | 2 | 1 | 2 | 0 | 0 | 0 | **6** |
| **NBT** | 5 | 0 | 12 | 0 | 0 | 0 | 0 | **17** |
| **NBR** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| **SBL** | 0 | 0 | 1 | 1 | 0 | 0 | 0 | **2** |
| **SBT** | 3 | 0 | 12 | 0 | 0 | 0 | 0 | **15** |
| **SBR** | 1 | 0 | 2 | 0 | 0 | 1 | 0 | **4** |
| **EBL** | 0 | 17 | 3 | 2 | 0 | 0 | 0 | **22** |
| **EBT** | 3 | 0 | 32 | 0 | 0 | 0 | 0 | **35** |
| **EBR** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **2** |
| **WBL** | 1 | 7 | 0 | 0 | 0 | 0 | 0 | **8** |
| **WBT** | 0 | 0 | 26 | 0 | 1 | 0 | 0 | **27** |
| **WBR** | 0 | 0 | 1 | 0 | 0 | 1 | 0 | **2** |
| **Total** | **15** | **26** | **91** | **5** | **1** | **2** | **1** | **141** |

After reviewing the crash data over the 5-year analysis period for the 144th Street and Q Street intersection, the following observations were made:

- The **Intersection Crash Rate** was **1.51** per million entering vehicles (MEV).
  - **City-wide Average Crash Rate for Principal Arterial Intersections: 0.93** MEV
- The **Intersection Severity Rate** was **2.07**.
- The **Intersection Crash Density** was **28.2** crashes per year.
- The most predominant crash type at the intersection was **Rear End (91)**.
  - Rear End crashes were found to be most frequently associated with the eastbound and westbound thru approaches (32 and 26, respectively).
  - Eastbound movements during the AM peak hour and westbound movements during the PM peak hour experience the longest queue lengths at the intersection; long queue lengths are a likely contributing factor to the rear end crash trend.
  - Field notes indicated that drivers have a tendency to speed when approaching the intersection, traveling westbound from the Millard Avenue & Q Street intersection.
- The other predominant crash type at the intersection was **Left Turn (26).**
  - Left Turn crashes were found to occur primarily at the eastbound (17) and westbound approaches (7).

- The seven (7) westbound left turn crashes initially appears to be a low number of total crashes; however, comparing the number of crashes to the low volume of westbound left turn vehicles indicates a high crash rate for this movement, which lead to the identification of this crash trend.
- Protected-permissive left turn signal phasing for the eastbound and westbound approaches may be a contributing factor.
- A downhill roadway grade in the opposing (westbound) approach reduces sight distance availability and creates a blind spot for drivers making eastbound left turn movements.
- Millard South High School is just west of the intersection and the eastbound left turn movement has high traffic volumes after school ends for the day.

Crash data for the Millard Avenue and Q Street intersection was provided by the City of Omaha and included all crashes over a 5-year period from 2015-2019. Over the course of the study period, there were a total of 157 reported crashes. A detailed crash analysis was performed to identify any potential crash patterns at the intersection that may need further evaluation. Individual crashes were categorized using a series of parameters, which include the following:

- Crash Severity
- Crash Type by Movement Direction (at-fault vehicle)

The number of crashes by severity rank and crash types by movement direction are shown in **Tables 7.6** and **7.7**, respectively. A visualization of the crash history is provided as a crash diagram in **Appendix K**.

***Table 7.6 – Crash Severities by Year (Millard Avenue & Q Street)***

| Year | Crash Severity | | | | | |
|---|---|---|---|---|---|---|
| | Fatal | Disabling Injury | Visible Injury | Possible Injury | Property Damage Only | Total Crashes |
| **2015** | 0 | 0 | 3 | 3 | 22 | **28** |
| **2016** | 0 | 1 | 2 | 9 | 25 | **37** |
| **2017** | 0 | 0 | 6 | 6 | 19 | **31** |
| **2018** | 0 | 1 | 1 | 4 | 24 | **30** |
| **2019** | 0 | 0 | 2 | 2 | 27 | **31** |
| **Total** | **0** | **2** | **14** | **24** | **117** | **157** |

*Table 7.7 – Crash Types by Movement (Millard Avenue & Q Street)*

| Movement | Crash Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Angle | Left Turn | Rear End | Sideswipe | Head On | Bike/Ped | Other | Total |
| **NBL** | 0 | 3 | 1 | 0 | 0 | 0 | 1 | **5** |
| **NBT** | 2 | 0 | 4 | 0 | 0 | 0 | 0 | **6** |
| **NBR** | 1 | 0 | 3 | 0 | 0 | 0 | 0 | **4** |
| **SBL** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| **SBT** | 4 | 0 | 5 | 2 | 0 | 0 | 0 | **11** |
| **SBR** | 0 | 0 | 19 | 0 | 0 | 0 | 1 | **20** |
| **EBL** | 0 | 22 | 4 | 0 | 0 | 0 | 0 | **26** |
| **EBT** | 3 | 0 | 41 | 2 | 0 | 0 | 1 | **47** |
| **EBR** | 1 | 0 | 1 | 1 | 0 | 0 | 0 | **3** |
| **WBL** | 0 | 20 | 2 | 0 | 0 | 0 | 0 | **22** |
| **WBT** | 3 | 0 | 9 | 1 | 0 | 0 | 0 | **13** |
| **WBR** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| **Total** | **14** | **45** | **89** | **6** | **0** | **0** | **3** | **157** |

After reviewing the crash data over the 5-year analysis period for the Millard Avenue and Q Street intersection, the following observations were made:

- The **Intersection Crash Rate** was **1.69** per million entering vehicles (MEV).
  - **City-wide Average Crash Rate for Principal Arterial Intersections: 0.93** MEV
- The **Intersection Severity Rate** was **2.31**.
- The **Intersection Crash Density** was **31.4** crashes per year.
- The most predominant crash type at the intersection was **Rear End (89)**.
  - Rear End crashes were found to be most frequently associated with the eastbound thru and the southbound right turn movements (41 and 19, respectively).
  - The southbound right turn movement prohibits drivers from making right turns on red, which may not be immediately recognized by drivers and potentially contribute to Rear End crashes when looking for gaps in westbound thru traffic.
  - Roadway geometry, including a significant downhill roadway grade and right curve when traveling eastbound and approaching the intersection, may contribute to higher numbers of eastbound Rear End crashes.
  - The eastbound left turn movement has very high traffic volumes, especially during peak hours, and the queue regularly extends out of the existing eastbound left turn storage into the eastbound through lane, which may also be a contributing factor to the eastbound rear end crash pattern
- The other predominant crash type at the intersection was **Left Turn (45)**.
  - Left Turn crashes were found to be most frequently associated with the eastbound and westbound left turn movements (22 and 20, respectively).
  - Flashing Yellow Arrow (FYA) left turn signal phasing for the eastbound and westbound approaches may be a contributing factor.
  - A slight roadway curve in the opposing (westbound) approach reduces sight distance availability for drivers making eastbound left turn movements.
  - Significant downhill roadway grade on eastbound approach could contribute to higher average vehicle speeds and inhibit ability for drivers making eastbound left turns to slow down to safe speeds.

- Significant downhill roadway grade on eastbound approach could contribute to higher average vehicle speeds for eastbound thru traffic and reduce time for drivers making westbound left turn movements to proceed safely through intersection.

The City of Omaha recently converted the southbound right turn movement from yield control to signal control, with no right turns on red allowed. In order to determine if the change in control impacted (positively or negatively) the crash trend associated southbound right turn movement, AECOM requested additional crash data, recorded prior to the change in control, from the City. The additional data showed that 71 southbound right turn crashes occurred between 2011 & 2014 (approximately 24 crashes per year) prior to the installation of a right turn signal. The crash data for this study showed 19 southbound right turn crashes between 2015 & 2019 (approximately 5 crashes per year) after the installation of the right turn signal. It was concluded that the conversion to signal control reduced the number of crashes associated with the southbound right turn movement by approximately 19 crashes per year. This conclusion was taken into consideration as potential safety improvements to the intersection were identified. The additional data provided by the City is included in **Appendix K**.

Crash data for the 120th Street and L Street intersection was provided by the City of Omaha and included all crashes over a 5-year period from 2015-2019. Over the course of the study period, there were a total of 164 reported crashes. A detailed crash analysis was performed to identify any potential crash patterns at the intersection that may need further evaluation. Individual crashes were categorized using a series of parameters, which include the following:

- Crash Severity
- Crash Type by Movement Direction (at-fault vehicle)

The number of crashes by severity rank and crash types by movement direction are shown in **Tables 7.8** and **7.9**, respectively. A visualization of the crash history is provided as a crash diagram in **Appendix K**.

***Table 7.8 – Crash Severities by Year (120th Street & L Street)***

| Year | Crash Severity | | | | | |
|---|---|---|---|---|---|---|
| | Fatal | Disabling Injury | Visible Injury | Possible Injury | Property Damage Only | Total Crashes |
| **2015** | 0 | 2 | 2 | 6 | 24 | **34** |
| **2016** | 0 | 0 | 1 | 5 | 13 | **19** |
| **2017** | 0 | 0 | 1 | 12 | 39 | **52** |
| **2018** | 0 | 0 | 2 | 5 | 20 | **27** |
| **2019** | 0 | 0 | 1 | 6 | 25 | **32** |
| **Total** | **0** | **2** | **7** | **34** | **121** | **164** |

*Table 7.9 – Crash Types by Movement (120th Street & L Street)*

| Movement | Crash Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Angle | Left Turn | Rear End | Sideswipe | Head On | Bike/Ped | Other | Total |
| **NBL** | 0 | 0 | 0 | 2 | 0 | 0 | 0 | **2** |
| **NBT** | 1 | 0 | 6 | 1 | 0 | 0 | 0 | **8** |
| **NBR** | 2 | 0 | 22 | 0 | 0 | 0 | 1 | **25** |
| **SBL** | 0 | 0 | 6 | 0 | 0 | 0 | 0 | **6** |
| **SBT** | 4 | 0 | 11 | 0 | 0 | 0 | 0 | **15** |
| **SBR** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **2** |
| **EBL** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| **EBT** | 5 | 0 | 36 | 3 | 0 | 0 | 1 | **45** |
| **EBR** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |
| **WBL** | 0 | 0 | 3 | 2 | 0 | 0 | 1 | **6** |
| **WBT** | 2 | 0 | 41 | 6 | 0 | 0 | 2 | **51** |
| **WBR** | 0 | 0 | 1 | 2 | 0 | 0 | 0 | **3** |
| **Total** | **15** | **0** | **128** | **16** | **0** | **0** | **5** | **164** |

After reviewing the crash data over the 5-year analysis period for the 120th Street and L Street intersection, the following observations were made:

- The **Intersection Crash Rate** was **0.88** per million entering vehicles (MEV).
  - **City-wide Average Crash Rate for Principle Arterial Intersections: 0.93** MEV
- The **Intersection Severity Rate** was **1.17**.
- The **Intersection Crash Density** was **32.8** crashes per year.
- The predominant crash type at the intersection was **Rear End (128)**.
  - Rear End crashes were found to be most frequently associated with the northbound right turn movement and the eastbound/westbound thru movements (22, 36 and 41, respectively).
  - Roadway type (US highway) and number of lanes (6 total, 3 thru lanes) for eastbound and westbound approaches may contribute to higher average vehicle speeds and a higher number of Rear End crashes for these approaches.
  - Roadway geometry, including a downhill roadway grade and right curve when traveling eastbound and approaching the intersection, may contribute to higher numbers of eastbound Rear End crashes.
  - Northbound right turn movement currently does not have any signalization/signage to aid drivers in making safer right turns (i.e. right turn signal head, "No Turn On Red" sign, etc.), which may contribute to higher numbers of Rear End crashes.

**Countermeasures**

After reviewing the crash data and crash trends identified previously, the following treatments were identified as potential countermeasures which would help to reduce the most frequent crash types at the intersection of 144th Street & Q Street and improve intersection safety:

A. Signal/progression optimization

B. Install Advance Warning System (AWS) / Advance Warning Flasher (AWF) at all approaches (144th Street & Q Street)

C. Install Dynamic Speed Feedback Sign (DSFS) at westbound approach (Q Street)

D. Install a second left turn lane, resulting in dual left turn lanes, at the eastbound approach (Q Street)

   a. Change left turn phasing from permitted/protected to protected only at both the eastbound and westbound approaches

**Table 7.10** summarizes the crash trend targeted by each identified potential countermeasure.

*Table 7.10 – Summary of Potential Countermeasures (144th Street & Q Street)*

| Potential Countermeasure | Crash Trend Targeted | Crash Reduction Factor (CRF) | Advance for Further Analysis? |
|---|---|---|---|
| A. | Rear End – All Approaches | 17 [1] | No |
| B. | Rear End – All Approaches | 18 [2] | No |
| C. | Rear End – Westbound Approach | 7 [3] | No |
| D. | Rear End & Left Turn – Eastbound Approach | 10 [4] | Yes |
| a. | Left Turn – Eastbound Approach | 42 [5] | Yes |

After further discussions on the crash data, crash trends, and preliminary potential countermeasures with the City, the following treatments were identified as the potential most effective treatments and advanced for further concept development and benefit-cost analysis at the 144th Street & Q Street intersection:

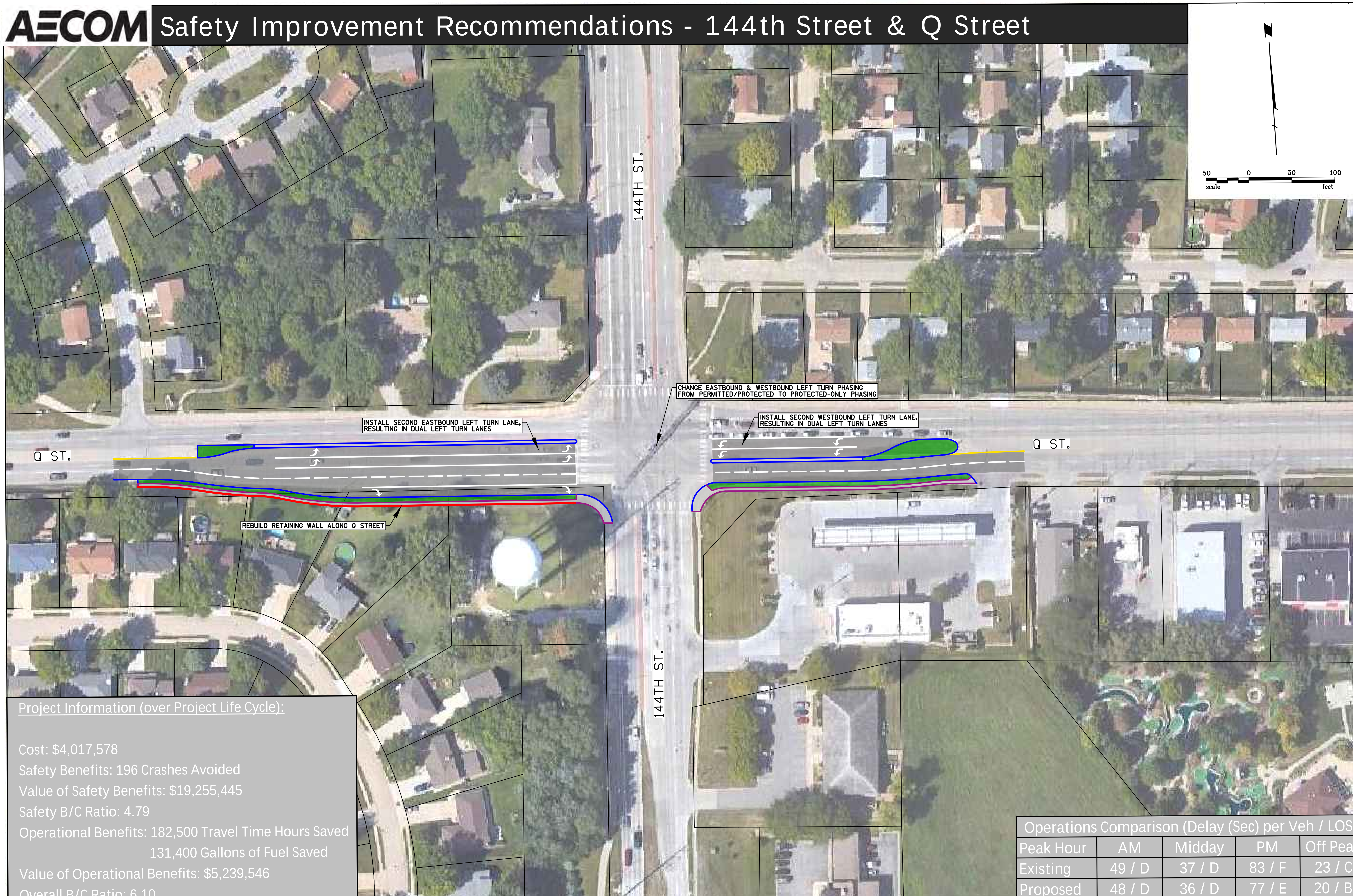
- Install a second left turn lane, resulting in dual left turn lanes, at the eastbound and westbound approaches.
- Change the eastbound & westbound left turn phasing from permitted/protected to protected only.
  - Due to the low westbound left turn movement volumes, it is feasible to implement protected-only left turn phasing for this movement as a near-term safety improvement without altering the geometry of the intersection.

A concept drawing of the proposed intersection layout is included in on the next page**.** This project is projected to cost approximately $3.3 million, as summarized in **Table 7.11.**

*Table 7.11 – Estimated Safety Improvement Project Cost (144th Street & Q Street)*

| Category | Estimated Cost |
|---:|---:|
| Grading | $446,382 |
| Surfacing | $730,706 |
| Signing, Striping, & Signals | $626,782 |
| **Construction Subtotal** | **$1,803,869** |
| Drainage (20%) | $360,774 |
| Contingency (25%) | $450,967 |
| **Construction Total** | **$2,615,611** |
| ROW (10%) | $261,561 |
| Utilities (10%) | $261,561 |
| Construction Engineering (8%) | $209,249 |
| **Total Construction Cost** | **$3,347,981** |

# Safety Improvement Recommendations - 144th Street & Q Street




Project Information (over Project Life Cycle):

Cost: $4,017,578
Safety Benefits: 196 Crashes Avoided
Value of Safety Benefits: $19,255,445
Safety B/C Ratio: 4.79
Operational Benefits: 182,500 Travel Time Hours Saved
131,400 Gallons of Fuel Saved
Value of Operational Benefits: $5,239,546
Overall B/C Ratio: 6.10

Operations Comparison (Delay (Sec) per Veh / LOS)

| Peak Hour | AM | Midday | PM | Off Peak |
|---|---|---|---|---|
| Existing | 49 / D | 37 / D | 83 / F | 23 / C |
| Proposed | 48 / D | 36 / D | 77 / E | 20 / B |

After reviewing the crash data and crash trends identified previously, the following treatments were identified as potential countermeasures which would help to reduce the most frequent crash types at the intersection of Millard Avenue & Q Street and improve intersection safety:

A. Signal/progression optimization
B. Install Advance Warning System (AWS) / Advance Warning Flasher (AWF) at eastbound approach (Q St) and southbound approach (Millard Avenue)
C. Install acceleration lane on Q Street for southbound right turn movement from Millard Avenue
    a. Extend southbound right turn lane storage length
D. Install a second right turn lane, resulting in dual right turn lanes, at the southbound approach (Millard Avenue)
E. Move local business access driveway at the eastbound approach (Q Street) to the west in order to increase the storage length for eastbound left turn movement
F. Install a second left turn lane, resulting in dual left turn lanes, at the eastbound and westbound approaches (Q Street)
    a. Change left turn phasing from permitted/protected to protected only at both the eastbound and westbound approaches

**Table 7.12** summarizes the crash trend targeted by each identified potential countermeasure.

*Table 7.12 – Summary of Potential Countermeasures (Millard Avenue & Q Street)*

| Potential Countermeasure | Crash Trend Targeted | Crash Reduction Factor (CRF) | Advance for Further Analysis? |
|---|---|---|---|
| A. | Rear End – All Approaches | 17 [1] | No |
| B. | Rear End – Eastbound & Southbound Approaches | 18 [2] | No |
| C. | Rear End – Southbound Approach | 26 [6] | No |
| a. | Rear End – Southbound Approach | 15 [6] | Yes |
| D. | Rear End – Southbound Approach | 4 [4] | Yes |
| E. | Rear End & Left Turn – Eastbound Approach | | Yes |
| F. | Rear End & Left Turn – Eastbound & Westbound Approaches | 10 [4] | Yes |
| a. | Left Turn – Eastbound & Westbound Approaches | 42 [5] | Yes |

After further discussions on the crash data, crash trends, and preliminary potential countermeasures with the City, the following treatments were identified as the potential most effective treatments and advanced for further concept development and benefit-cost analysis at the Millard Avenue & Q Street intersection:

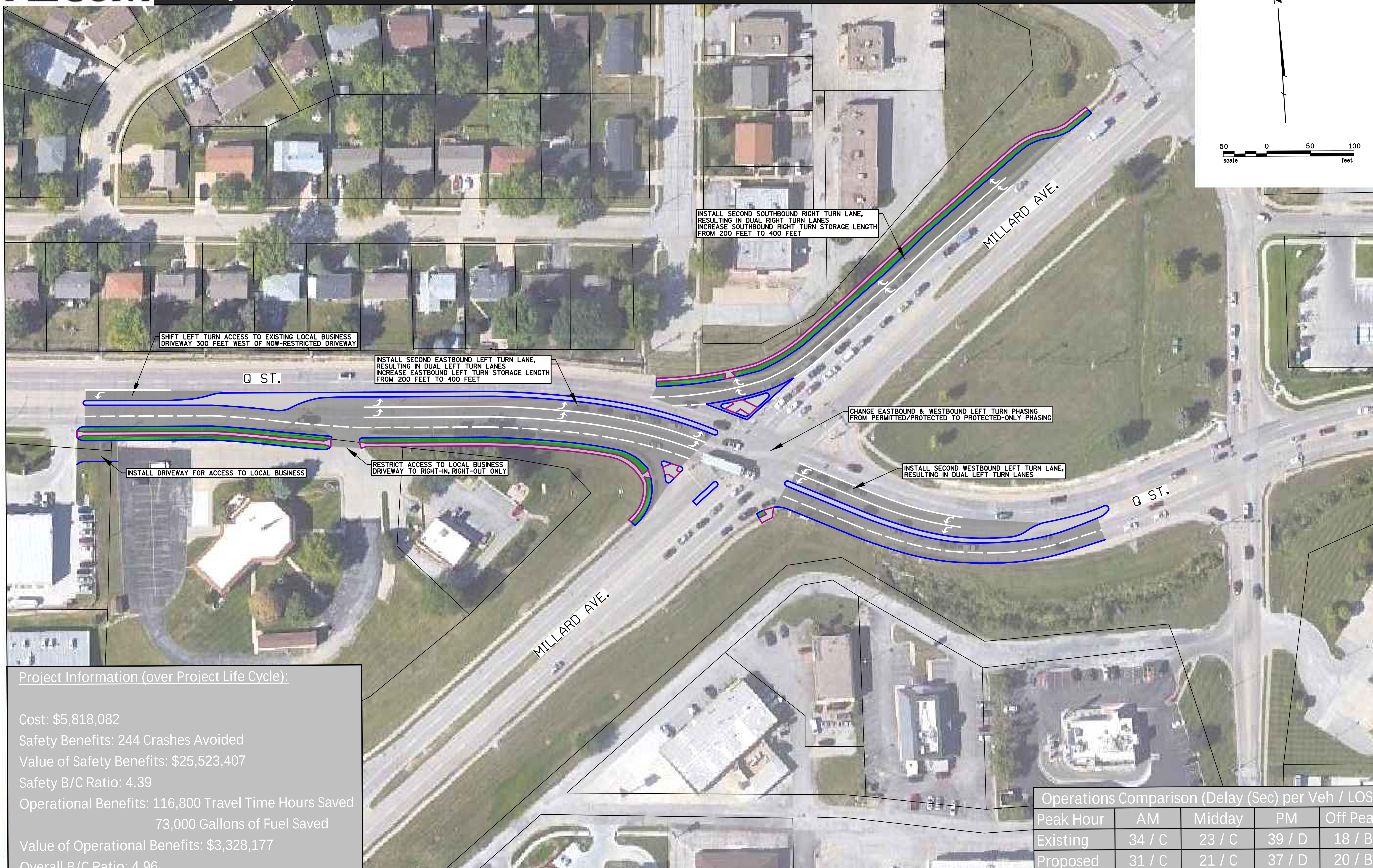
- Install a second left turn lane, resulting in dual left turn lanes, at the eastbound and westbound approaches and extend the eastbound left turn lane storage length from 200 feet to 400 feet.
- Change the eastbound & westbound left turn phasing from permitted/protected to protected only.
- Restrict access to the existing local business driveway along the eastbound approach on Q Street to right-in, right-out only. Shift the existing left turn lane into the existing local business driveway to an adjacent local business driveway located approximately 300 feet west of the existing driveway.
- Install a second right turn lane, resulting in dual right turn lanes, at the southbound approach. Extend the southbound right turn lane storage length from 200 feet to 400 feet.

A concept drawing of the proposed intersection layout is included on the next page**.** This project is projected to cost approximately $4.8 million, as summarized in **Table 7.13.**

***Table 7.13 – Estimated Safety Improvement Project Cost (Millard Avenue & Q Street)***

| Category | Estimated Cost |
|---:|---:|
| Grading | $520,255 |
| Surfacing | $1,458,668 |
| Signing, Striping, & Signals | $633,362 |
| **Construction Subtotal** | **$2,612,286** |
| Drainage (20%) | $522,457 |
| Contingency (25%) | $653,071 |
| **Construction Total** | **$3,787,814** |
| ROW (10%) | $378,781 |
| Utilities (10%) | $378,781 |
| Construction Engineering (8%) | $303,025 |
| **Total Construction Cost** | **$4,848,402** |

# Safety Improvement Recommendations - Millard Avenue & Q Street




Project Information (over Project Life Cycle):

Cost: $5,818,082
Safety Benefits: 244 Crashes Avoided
Value of Safety Benefits: $25,523,407
Safety B/C Ratio: 4.39
Operational Benefits: 116,800 Travel Time Hours Saved
73,000 Gallons of Fuel Saved
Value of Operational Benefits: $3,328,177
Overall B/C Ratio: 4.96

Operations Comparison (Delay (Sec) per Veh / LOS)

| Peak Hour | AM | Midday | PM | Off Peak |
|---|---|---|---|---|
| Existing | 34 / C | 23 / C | 39 / D | 18 / B |
| Proposed | 31 / C | 21 / C | 37 / D | 20 / B |

After reviewing the crash data and crash trends identified previously, the following treatments were identified as potential countermeasures which would help to reduce the most frequent crash types at the intersection of 144th St & Q St and improve intersection safety:

A. Signal/progression optimization

B. Install Advance Warning System (AWS) / Advance Warning Flasher (AWF) at eastbound and westbound approaches (L Street)

C. Install 5-section right turn signal head to make northbound right turn movement signalized, with overlaps and prohibit right turn on red

D. Install a second right turn lane, resulting in dual right turn lanes, at the northbound approach (120th Street)

E. Install a fourth through lane at the eastbound and westbound approaches (L Street)

F. Convert current intersection to Single Point Urban Interchange (SPUI)

**Table 7.14** summarizes the crash trend targeted by each identified potential countermeasure.

*Table 7.14 – Summary of Potential Countermeasures (120th Street & L Street)*

| Potential Countermeasure | Crash Trend Targeted | Crash Reduction Factor (CRF) | Advance for Further Analysis? |
|---|---|---|---|
| A. | Rear End – All Approaches | 17 [1] | No |
| B. | Rear End – Eastbound & Westbound Approaches | 18 [2] | No |
| C. | Rear End – Northbound Approach | 2 [7] | No |
| D. | Rear End – Northbound Approach | 4 [4] | Yes |
| E. | Rear End – Eastbound & Westbound Approaches | 25 [8] | Yes |
| F. | Rear End – Eastbound & Westbound Approaches | | No |

After further discussions on the crash data, crash trends, and preliminary potential countermeasures with the City, the following treatments were identified as the potential most effective treatments and advanced for further concept development and benefit-cost analysis at the 120th Street & L Street intersection:

- Install a second right turn lane, resulting in dual right turn lanes, at the northbound approach. Install pavement markings for the right turn lanes from the project intersection south to the intersection of 120th Street & M Street.
- Convert the existing eastbound right turn lane to a shared through/right turn lane, creating a fourth lane allowing through movements at the eastbound approach. Adjust the existing island at the northbound approach and pavement markings to create a receiving lane for this additional eastbound through movement.

  - o Install advance signage prior to (west of) the intersection to indicate to eastbound drivers the fourth through lane is intended for drivers traveling to I-80 westbound, west of the intersection.
- Install an additional westbound through lane on the north side of the intersection. Adjust the existing channelized westbound right turn lane to be a shared through/right turn lane, prior to westbound vehicles entering the main intersection. Adjust the existing channelized southbound right turn lane to install a new acceleration lane for southbound right-turning vehicles to merge into westbound traffic, past the main intersection.

A concept drawing of the proposed intersection layout is included on the next page. This project is projected to cost approximately $2.0 million, as summarized in **Table 7.15.**

***Table 7.15 – Estimated Safety Improvement Project Cost (120th Street & L Street)***

| Category | Estimated Cost |
|---:|---:|
| Grading | $458,683 |
| Surfacing | $588,897 |
| Signing, Striping, & Signals | $210,970 |
| **Construction Subtotal** | **$1,258,551** |
| Drainage (20%) | $251,710 |
| Contingency (25%) | $314,638 |
| **Construction Total** | **$1,824,898** |
| ROW (0%)* | *$0 |
| Utilities (5%) | $91,245 |
| Construction Engineering (8%) | $145,992 |
| **Total Construction Cost** | **$2,062,135** |

* No ROW costs are anticipated with this project

**References**

[1] http://www.cmfclearinghouse.org/detail.cfm?facid=6856
[2] http://www.cmfclearinghouse.org/detail.cfm?facid=4198
[3] https://www.fhwa.dot.gov/publications/research/safety/14020/14020.pdf
[4] https://www.in.gov/indot/files/CRF-CMF_Table.pdf
[5] http://www.cmfclearinghouse.org/detail.cfm?facid=340
[6] http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf
[7] http://www.cmfclearinghouse.org/detail.cfm?facid=5194
[8] http://www.cmfclearinghouse.org/detail.cfm?facid=8335

# Safety Improvement Recommendations - 120th Street & L Street


Project Information (over Project Life Cycle):

Cost: $2,474,562
Safety Benefits: 99 Crashes Avoided
Value of Safety Benefits: $8,081,939
Safety B/C Ratio: 3.27
Operational Benefits: 416,100 Travel Time Hours Saved
160,600 Gallons of Fuel Saved
Value of Operational Benefits: $11,631,348
Overall B/C Ratio: 7.97

Operations Comparison (Delay (Sec) per Veh / LOS)

| Peak Hour | AM | Midday | PM | Off Peak |
|---|---|---|---|---|
| Existing | 68 / E | 36 / D | 80 / E | 25 / C |
| Proposed | 58 / E | 36 / D | 69 / E | 25 / C |

### 7.3 Benefit Cost Analysis

The purpose of the benefit-cost analysis (BCA) is to measure the effectiveness of the previously identified projects based on the benefit-cost ratio, the estimated value of project benefits divided by the estimated project costs. A benefit-cost ratio greater than 1.0 indicates the projects benefits are projected to outweigh the projected project costs. Examples of benefits associated with a project include crashes avoided due to geometric and operational changes, operational improvements due to a reduction in traffic congestion, and fuel savings also attributed reduced traffic congestion. Examples of costs associated with a project include construction costs, maintenance costs, and operational costs.

Once crash trends and potential countermeasures were determined, as described in the previous section, crash reduction factors (CRF) were identified for each countermeasure in order to estimate the expected reduction in crashes (i.e. improvement to intersection safety) associated with each countermeasure. CRFs were accessed from CMF Clearinghouse, a web-based directory (http://www.cmfclearinghouse.org/) of professionally researched and reviewed CRFs, and the Federal Highway Administration (FHWA) Signalized Intersections Informational Guide, which also compiles professional research on safety treatments and their associated CRFs. When more than one CRF applied to a proposed countermeasure, a combined CRF was calculated. Individual CRFs, combined CRFs, and CRF references are included in **Appendix K**.

In order to monetarily quantify the expected benefit of avoided crashes, the FHWA provides an estimated cost associated with crashes, based on crash type, as shown in **Table 7.16.**

***Table 7.16 – FHWA Societal Cost of Traffic Accidents***

| Crash Type | Societal Cost |
|---|---|
| Right Angle | $103,180 |
| Rear End | $81,801 |
| Sideswipe (Same Direction) | $55,947 |
| Sideswipe (Opposite Direction) | $127,084 |
| Head On | $384,577 |
| Left Turn | $140,078 |
| Other | $28,738 |

A BCA was completed for each of the three safety analysis intersections. The cost estimate developed for each intersection includes the projected cost of all identified intersection improvements. When proposed intersection improvements targeted different crash trends on different approaches, separate CRFs (or combined CRFs) were utilized to determine the expected reduction in crashes.

The construction cost of the proposed intersection improvements at 144$^{th}$ Street and Q Street were estimated to be $3.2 million, with estimated maintenance costs over the 20-year project lifespan of $640,000. A weighted CRF of 57 was applied based on the proposed improvements at both the eastbound and westbound approaches. **Table 7.17** summarizes the proposed improvement project costs and benefits, over the 20-year project lifespan, and the B/C ratio. Full details from the BCA are included in **Appendix K**.

*Table 7.17 – Benefit-Cost Analysis (144th Street & Q Street)*

| Costs | | Benefits | |
|---|---|---|---|
| Total Construction Cost | $3,347,981 | Total Value of Avoided Crashes | $19,255,445 |
| Total Maintenance Cost | $669,596 | Total Value of Improved Operations | $5,239,546 |
| **Total Project Cost** | **$4,017,578** | **Total Value of Project Benefits** | **$24,494,991** |
| **Benefit-Cost Ratio** | | **6.10** | |

The construction cost of the proposed intersection improvements at Millard Avenue and Q Street were estimated to be $4.8 million, with estimated maintenance costs over the 20-year project lifespan of $970,000. A weighted CRF of 57 was applied based on the proposed improvements at both the eastbound and westbound approaches, while a weighted CRF of 18 was applied based on proposed improvements to the southbound approach. Additional safety benefits are expected from the proposed movement restriction and relocation at the local business driveway adjacent to the project intersection on the eastbound approach; however, no CRF applicable to this specific treatment could be identified. **Table 7.18** summarizes the proposed improvement project costs and benefits, over the 20-year project lifespan, and the B/C ratio. Full details from the BCA are included in **Appendix K**.

*Table 7.18 – Benefit-Cost Analysis (Millard Avenue & Q Street)*

| Costs | | Benefits | |
|---|---|---|---|
| Total Construction Cost | $4,848,402 | Total Value of Avoided Crashes | $25,523,407 |
| Total Maintenance Cost | $969,680 | Total Value of Improved Operations | $3,328,177 |
| **Total Project Cost** | **$5,818,082** | **Total Value of Project Benefits** | **$28,851,584** |
| **Benefit-Cost Ratio** | | **4.96** | |

The construction cost of the proposed intersection improvements at 120th Street & L Street were estimated to be $2.0 million, with estimated maintenance costs over the 20-year project lifespan of $412,000. A weighted CRF of 18 was applied based on the proposed improvements at the northbound approach, while a CRF of 25 was applied based on proposed improvements to the eastbound and westbound approaches. **Table 7.19** summarizes the proposed improvement project costs and benefits, over the 20-year project lifespan, and the B/C ratio. Full details from the BCA are included in **Appendix K**. Additionally, it was identified that safety and operations at this intersection would be greatly improved if the intersection were converted from a 4-leg signalized intersection to a Single Point Urban Interchange (SPUI). This recommendation is based on the high current traffic volumes and the adjacent roadway network. Additionally, the current intersection has an extensive amount of available right of way, which indicates minimal right of way costs would be expected and further supports the feasibility of a SPUI at this location. A detailed cost estimate was not completed for this recommendation, but the cost of converting an intersection to a SPUI typically ranges from $15 to $25 million.

*Table 7.19 – Benefit-Cost Analysis (120th Street & L Street)*

| Costs | | Benefits | |
|---|---|---|---|
| Total Construction Cost | $2,062,135 | Total Value of Avoided Crashes | $8,081,939 |
| Total Maintenance Cost | $412,427 | Total Value of Reduced Congestion | $11,631,348 |
| **Total Project Cost** | **$2,474,562** | **Total Value of Project Benefits** | **$19,713,286** |
| **Benefit-Cost Ratio** | | **7.97** | |

## Appendix A

Meeting Minutes

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## Appendix B

24-Hour Traffic Counts
and
Wavetronix Comparison

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# Appendix C

Travel Time Runs

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# Appendix D

Clearance Interval Calculations

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# Appendix E

Left Turn Phase Warrant Analysis

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# Appendix F

Leading Pedestrian Interval Evaluation

Summary Table and LPI Spreadsheets

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# Appendix G

Existing and Proposed Day Plan Schedules

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# Appendix H

Proposed Tru-Traffic Time Space Diagrams

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# Appendix I

Performance Measures

Synchro Output

# Appendix J

Benefit Cost Analysis

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# Appendix K

Safety Analysis Results