PHASE 2 TRAFFIC SIGNAL SYSTEM OPTIMIZATION

FEBRUARY 2019

PREPARED BY:

CITY OF LINCOLN NEBRASKA Traffic Engineering

IN COORDINATION WITH:

HDR FELSBURG HOLT & ULLEVIG olsson

GREEN LIGHT LINCOLN™

IT'S GO TIME

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This report documents the results of traffic engineering work completed for the Green Light Lincoln – Phase 2 Traffic Signal System Optimization project. Phase 2 builds upon work completed in Phase 1 which included over 120 traffic signals on or adjacent to nine corridors. Phase 2 addressed 115 additional traffic signals and the overlap of 34 Phase 1 signals. Twelve Phase 2 corridors were studied and evaluated for improved safety and traffic flow:

- S. 27th Street
- S. 40th Street
- S. 48th Street
- N. 48th Street
- S. 56th Street
- N. 70th Street
- A Street
- Old Cheney Road
- Pine Lake Road
- South Street
- Superior Street
- West O Street

The primary objective of the project was to prepare and implement optimized traffic signal timing plans along the study corridors and to quantify the resulting changes in traffic operations. These timing plans were developed based on a data collection effort, industry research, field observations, operational / safety review, and detailed traffic engineering which included utilizing a computerized software model (Synchro). Study corridors / intersections were evaluated for many variables to bring the timing plans into conformance with current best practices including proper time-of-day schedule, desirable left-turn phasing type, cycle length, phase splits, clearance intervals, and pedestrian walk and don't walk intervals.

The new timing plans were then implemented with the help of City of Lincoln Traffic Engineering staff and fine-tuned in the field over the course of several weeks to achieve optimal results. To confirm and quantify these results, performance measures were documented in the form of travel time studies which occurred both before and after the signal timing implementation and field fine-tuning tasks. Based on the "Before" and "After" data summarized, reductions in delay and fuel are estimated to save Lincoln motorists over 403,000 hours of delay and $8.9 million in time and fuel costs per year. These benefits are the direct result of improved traffic signal timings and equipment upgrades which achieved decreased travel time among users and vehicle fuel consumption savings. It should also be noted that these benefits were only quantified during eight hours of the day when field data was collected, and actual overall benefits are expected to be more significant. Additionally, the implementation of new timings also resulted in 21 countermeasures from the City of Lincoln 2012 and 2018 Crash Studies being implemented, which is expected to provide additional safety benefits to motorists along these corridors.

It is recommended to continue retiming efforts throughout the city and retime corridors every three to five years to further save Lincoln motorists time and money. This project alone produced a calculated benefit-to-cost ratio of 14:1 over the next five-year time frame.

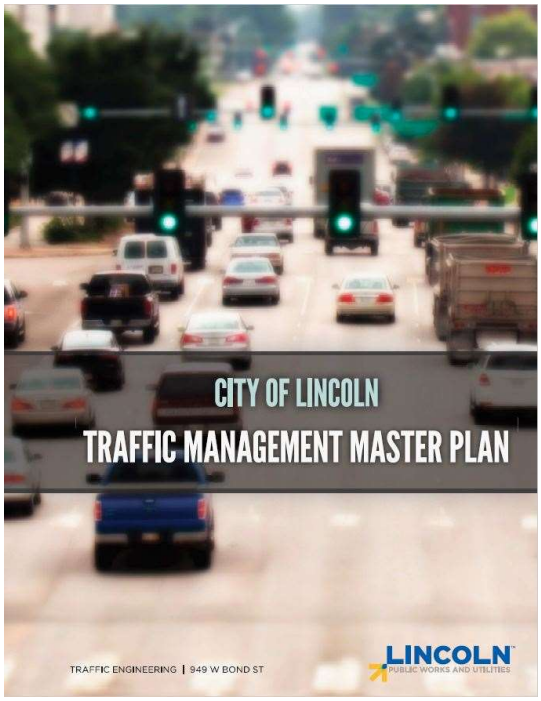
The report that follows documents in detail the Phase 2 Traffic Signal System Optimization objectives, processes, results, and benefits.

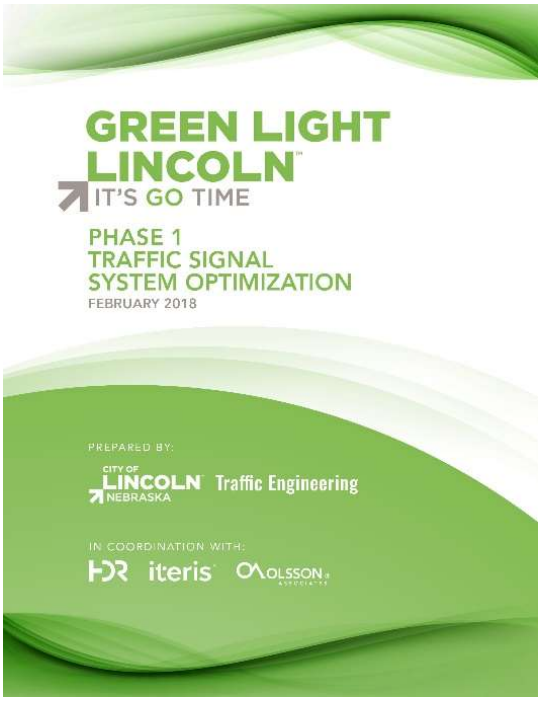
IT'S **GO** TIME!

1.0 INTRODUCTION

This traffic signal system optimization project (Green Light Lincoln – Phase 2) is a continuation of collaborative efforts from City of Lincoln Traffic Engineering, City leaders, contractors, and consultants to improve travel in the City of Lincoln. The Green Light Lincoln initiative originated from a recommendation of the City of Lincoln's *Traffic Management Master Plan* (TMMP); a document that has provided insight on the status of citywide traffic systems to the community and has also set the vision for the future of traffic engineering in Lincoln. Several key components of the TMMP, including this project, are being addressed under the Green Light Lincoln initiative.

Green Light Lincoln – Phase 1 was a monumental success and an award-winning endeavor. Phase 1 documented reductions in travel delay and fuel consumption which are estimated to save Lincoln motorists over 437,000 hours of delay and $8.8 million in time and fuel costs per year. Phase 2 builds upon this success to further improve mobility and safety for Lincoln motorists.





The overall purpose of this project was to prepare and implement optimized traffic signal timing plans along twelve signalized corridors, and to quantify and document the changes in traffic operations resulting from signal equipment upgrades and signal timing changes with "Before" and "After" performance measures.

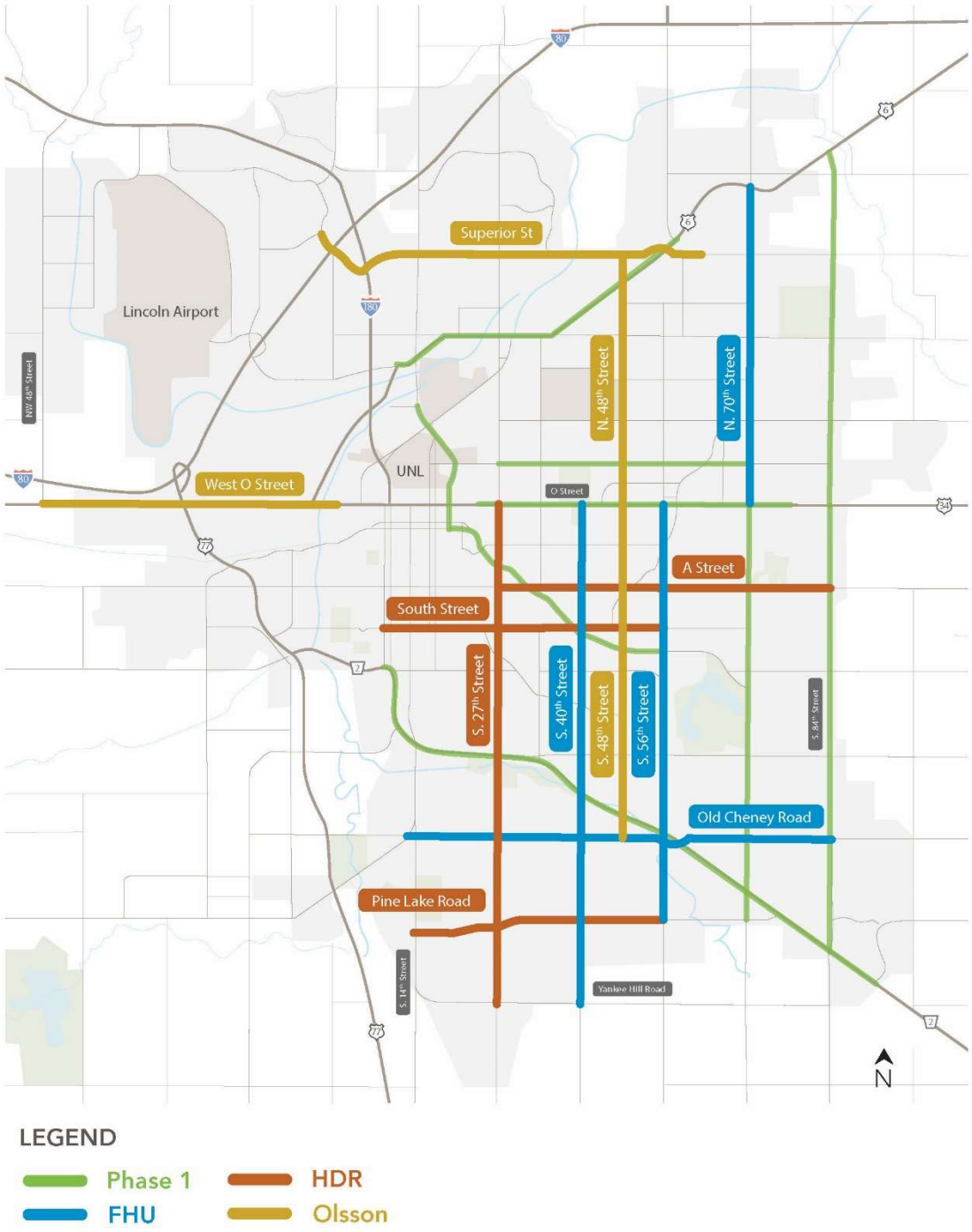
City forces and private contractors upgraded traffic signal controller cabinets, and fixed faulty detection in preparation for new signal timing plans. They also installed new signal heads, improved signal displays, and installed Flashing Yellow Arrow (FYA) indications to achieve uniformity across the city. Their collective efforts set the stage for the signal timing implementation portion of this project.

Three consultant teams were tasked with signal timing changes and performance measure documentation: HDR, Felsburg Holt & Ullevig / Albeck Gerken (FHU), and Olsson. Consultant teams were assigned the following corridors (consultant listed in parenthesis):

- S. 27th Street – Yankee Hill Road to O Street (HDR)
- S. 40th Street – Yankee Hill Road to Randolph Street (FHU)
- S. 48th Street – Old Cheney Road to O Street (Olsson)
- N. 48th Street – O Street to Superior Street (Olsson)
- S. 56th Street – Pine Lake Road to O Street (FHU)
- N. 70th Street – O Street to Cornhusker Highway (FHU)
- A Street – S. 27th Street to S. 84th Street (HDR)
- Old Cheney Road – Warlick Boulevard to S. 84th Street (FHU)
- Pine Lake Road – S. 14th Street to S. 56th Street (HDR)
- South Street – S. 9th Street to S. 56th Street (HDR)
- Superior Street – NW 1st Street & West Highland Boulevard to N. 62nd Street & Havelock Avenue (Olsson)
- West O Street – NW 48th Street to N. 1st Street (Olsson)

Figure 1 provides a map of the study corridors. A complete list of intersections per corridor is provided in **Appendix A**.

Figure 1: Study Corridors Map



2.0 Data Collection

Data collection and review efforts were completed for each study intersection. These efforts were dual-purposed. First, it yielded the characteristics and documentation necessary to perform calculations and support the development of new timing plans. Second, it provided the means to compare operations from updated conditions to baseline conditions.

2.1 City Provided Information

The City of Lincoln provided the following:

- City of Lincoln *Traffic Signal Timing Guidelines v2.0*
- City of Lincoln *2012 Crash Study*
- City of Lincoln *2018 Lincoln Crash Data Analysis*
- Existing timing plans via ATMS software (ACTRA)
- Synchro files
- Intersection Turning Movement Volumes (TMVs)
- 24-hour Traffic Volumes
- Pedestrian crossing distances (crosswalk lengths)
- Vehicle crossing distance (near to far side of intersection)

2.2 Consultant Collected Information

Consultants collected the following for each intersection:

- Intersection lane configuration / utilization
- Posted speed limits
- Distance between signalized intersections
- Intersection approach grades
- Turn restrictions
- Turn lane storage lengths
- Push button documentation
- Location of mast arm ends
- Intersection approach photographs
- Field observations of traffic operations
- Sight distance restrictions

2.3 Corridor Descriptions

Each corridor underwent detailed desktop reviews, field reviews at each intersection, and windshield reviews to observe and document corridor characteristics and operations. Characteristics of each study corridor are provided below.

S. 27th Street

The S. 27th Street corridor includes 21 traffic signals from Yankee Hill Road to O Street. The corridor is oriented in a north/south direction and is approximately 6.0 miles long with an average 24-hour volume of 22,000 vehicles.

S. 27th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- Yankee Hill Road to Ridge Line Drive – Four-lane divided
- Ridge Line Drive to Old Cheney Road – Five-lane with center turn lane
- Old Cheney Road to Nebraska Highway 2 – Four-lane divided
- Nebraska Highway 2 to South Street – Three-lane with center turn lane
- South Street to A Street – Four-lane undivided
- A Street to Capitol Pkwy – Four-lane divided
- Capitol Pkwy to Randolph Street – Four-lane undivided
- Randolph Street to O Street – Four-lane divided

The posted speed limit along the corridor is 45 mph south of Pine Lake Road, 40 mph between Pine Lake Road and Nebraska Highway 2, and 35 mph north of Nebraska Highway 2. The land use along S. 27th Street is a mix of residential and commercial/retail. Residential development abuts much of the S. 27th Street corridor north of Ridge Line Drive, particularly between major intersections. Commercial and retail development are located along S. 27th Street between Yankee Hill Road and Ridge Line Road, between Capitol Parkway and Randolph Street, and on the corners of major intersections with Nebraska Highway 2, Old Cheney Road, South Street, and O Street. Major attractions along S. 27th Street include SouthPointe Pavilions, Country Club of Lincoln, and Lincoln Children's Zoo.

S. 40th Street

The S. 40th Street corridor includes 14 signalized intersections from Yankee Hill Road to Randolph Street. The corridor is oriented in a north/south direction and is approximately 5.5 miles long with an average 24-hour volume of 19,000 vehicles.

S. 40th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- Yankee Hill Road to just north of Nebraska Highway 2 – Four-lane divided
- Just north of Nebraska Highway 2 to Locust Street – Two-lane
- Locust Street to just north of D Street – Three-lane with center turn lane
- Just north of D Street to Randolph Street – Two-lane

The posted speed limit along the S. 40th Street corridor is 45 mph south of Old Cheney Road, 40 mph between Old Cheney Road and Nebraska Highway 2, and 35 mph north of Nebraska Highway 2. The land use along S. 40th Street is a mix of residential and commercial. Retail and commercial buildings are located near intersections with Yankee Hill Road, Pine Lake Road, Old Cheney Road, Normal Boulevard, South Street, A Street, and Randolph Street. The corridor provides access to Lincoln Southeast High School and several churches.

S. 48th Street

The S. 48th Street corridor includes 15 traffic signals from Old Cheney Road to O Street. The corridor is oriented in a north/south direction and is approximately 4.0 miles long with an average 24-hour volume of 15,800 vehicles.

S. 48th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- Old Cheney Road to just south of Briarpark Drive / Rentworth Drive – Four-lane undivided
- Just south of, to just north of Briarpark Drive / Rentworth Drive – Five-lane with center turn lane
- Just north of Briarpark Drive / Rentworth Drive to just north of Nebraska Highway 2 – Four-lane divided
- Just north of Nebraska Highway 2 to just south of Van Dorn Street – Three-lane with center turn lane
- Just south of Van Dorn Street to Antelope Creek Road – Five-lane with center turn lane
- Antelope Creek Road to Glade Street – Four-lane divided
- Glade Street to M Street – Three-lane with center turn lane
- M Street to O Street – Four-lane divided

The posted speed limit along the corridor is 35 mph, except between Pioneers Boulevard and Calvert Street which is 25 mph. The land use along S. 48th Street is a mix of residential and commercial/retail alternating frequently. Distinct commercial/retail areas include: Old Cheney Road to Claire Avenue, Linden Street to Hillside Street, Van Dorn Street to Glade Street, and the immediate vicinities at Randolph Street and O Street. The corridor provides access to Union College, Bryan Medical Center East Campus, and Lefler Middle School.

N. 48th Street

The N. 48th Street corridor includes 13 signalized locations from O Street to Superior Street. The corridor is oriented in a north/south direction and is approximately 3.0 miles long with an average 24-hour volume of 19,700 vehicles.

N. 48th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- O Street to just north of R Street – Four-lane divided
- Just north of R Street to ½ way between R Street and Vine Street – Five-lane with center turn lane
- ½ way between R Street and Vine Street to Wilshire Boulevard – Four-lane divided
- Wilshire Boulevard to Dudley Street – Five-lane with center turn lane
- Dudley Street to Martin Street – Four-lane divided
- Martin Street to Garland Street – Four-lane undivided
- Garland Street to Walker Avenue – Four-lane divided
- Walker Avenue to Cleveland Avenue – Four-lane undivided
- Cleveland Avenue to Knox Street – Four-lane divided
- Knox Street to Superior Street – Three-lane with center turn lane

The posted speed limit along the corridor is 35 mph, except between Walker Avenue and Cleveland Avenue which is 25 mph. The land use along N. 48th Street is a generally commercial/retail with a pocket of residential (Adams Street to Fremont Street) and an area of light industrial (Fremont Street to Superior Street). In addition to the commercial/retail uses, the corridor is influenced by trip generators such as the University of Nebraska-Lincoln East Campus, Huntington Elementary School, Nebraska Wesleyan University, and Dawes Middle School.

S. 56th Street

The S. 56th Street corridor includes 14 signalized intersections from Pine Lake Road to O Street. The corridor is oriented in a north/south direction and is approximately 5.0 miles long with an average 24-hour volume of 23,000 vehicles near Nebraska Highway 2.

S. 56th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- Pine Lake Road to Elkcrest Drive – Four-lane divided
- Elkcrest Drive to Pawnee Street – Four-lane undivided (with left-turn lanes and northbound right-turn lane at the intersection with Pioneers Boulevard)
- Pawnee Street to Van Dorn Street – Four-lane divided
- Van Dorn Street to Lillibridge Street – Five-lane with center turn lane
- Lillibridge Street to Normal Boulevard – Four-lane divided
- Normal Boulevard to South Street – Four-lane undivided (two southbound lanes, center turn lane, and one northbound lane)
- South Street to Randolph Street – Three-lane with center turn lane
- North of Randolph Street – A one-way pair system is implemented, with S. 56th Street northbound and S. Cotner Boulevard southbound; both provide three lanes of traffic

The posted speed limit along the S. 56th Street corridor is 45 mph south of Old Cheney Road, 40 mph between Old Cheney Road to a point just north Van Dorn Street, and 35 mph north of Van Dorn Street. The land use along S. 56th Street is mainly residential, although there are major retail and commercial areas surrounding Pine Lake Road, Nebraska Highway 2, and O Street which influence several intersections on the corridor. Operations along S. 56th Street are highly influenced by several adjacent signals in the Nebraska Highway 2 commercial area.

N. 70th Street

The N. 70th Street corridor includes 10 signalized intersections from O Street to Cornhusker Highway. The corridor is oriented in a north/south direction and is approximately 3.9 miles long with an average 24-hour volume of 12,000 vehicles.

N. 70th Street includes a mix of the following cross-sections (listed south to north along the corridor):

- O Street to MoPac Trail – Four-lane divided
- MoPac Trail to Havelock Avenue – Three-lane with center turn lane
- Havelock Avenue to Cuming Street – Four-lane undivided
- Cuming Street to Cornhusker Highway – Four-lane divided

The posted speed limit along the N. 70th Street corridor is 35 mph. The land use along N. 70th Street is a mix of residential and commercial, with some retail and commercial buildings on the corner of major intersections. The area north of Havelock Avenue transitions to a primarily industrial land use. There is an active railroad crossing of the BNSF Railway just south of Cornhusker Highway. The corridor is influenced by Lincoln Northeast High School, Mickle Middle School, and commercial uses near O Street.

A Street

The A Street corridor includes 15 traffic signals from S. 27th Street to S. 84th Street. The corridor is oriented in an east/west direction and is approximately 4.0 miles long with an average 24-hour volume of 11,600 vehicles.

A Street includes a mix of the following cross-sections (listed west to east along the corridor):

- S. 27th Street to S. 40th Street – Three-lane with center turn lane
- S. 40th Street to S. 48th Street – Two-lane
- S. 48th Street to Twin Ridge Road – Three-lane with center turn lane
- Twin Ridge Road to S. 84th Street – Four-lane undivided

The posted speed limit along the corridor is 35 mph west of S. 70th Street and 40 mph east of S. 70th Street. The land use along A Street is a mix of residential, institutional, and commercial/retail. Residential development abuts much of the A Street corridor east of Capitol Parkway. Commercial and retail development are primarily located at the intersections with S. 33rd Street, S. 40th Street, and S. 70th Street. Major attractions and high traffic generators along A Street include the Lincoln Children's Zoo, Bryan Medical Center East Campus, Pius X Catholic High School, and Lincoln East High School.

Old Cheney Road

The Old Cheney Road corridor includes 15 signalized intersections from Warlick Boulevard to 84th Street. The corridor is oriented in an east/west direction and is approximately 5.1 miles long with an average 24-hour volume of 20,000 vehicles.

Old Cheney Road includes a mix of the following cross-sections (listed west to east along the corridor):

- Warlick Boulevard to S. 49th Street - Four-lane divided
- S. 49th Street to S. 53rd Street - Five-lane with center turn-lane
- S. 53rd Street to S. 62nd Street - Four-lane divided
- S. 62nd Street to just east of Pheasant Run Lane - Five-lane with center turn lane
- East of Pheasant Run Lane to S. 84th Street – Four-lane divided

The posted speed limit along the corridor is 35 mph west of S. 14th Street, 45 mph from S. 14th Street to S. 40th Street, 40 mph from S. 40th Street to S. 56th Street, 35 mph between S. 56th Street and Vandervoort Drive, and 45 mph east of Vandervoort Drive.

The land use along Old Cheney Road is residential and commercial. Commercial and office uses are present on the west end of the corridor from Warlick Boulevard to S. 16th Street, with retail and commercial areas surrounding S. 27th Street, S. 40th Street, Nebraska Highway 2, and S. 84th Street. Operations along Old Cheney Road are highly influenced by several adjacent signals in the Nebraska Highway 2 commercial area. The corridor also provides access to Lincoln Christian School and several churches. The Old Cheney Road corridor also includes the adjacent signalized intersection at:

- S. 14th Street & Brookridge Circle/S. 16th Street

Pine Lake Road

The Pine Lake Road corridor includes 10 traffic signals from S. 14th Street to S. 56th Street. The corridor is oriented in an east/west direction and is approximately 3.0 miles long with an average 24-hour volume of 19,000 vehicles. The cross-section for the corridor is four-lane divided.

The posted speed limit along the corridor is 40 mph west of S. 27th Street and 45 mph east of S. 27th Street. The land use along Pine Lake Road is a mix of commercial, retail and residential. Residential development along the Pine Lake Road corridor is most prominent between S. 32nd Street and S. 56th Street. Commercial and retail development are the primary land uses between S. 14th Street and S. 32nd Street, and near the intersection with S. 56th Street. Major attractions and high traffic generators along Pine Lake Road include Lincoln Southwest High School, Adams Elementary School, Scott Middle School, SouthPointe Pavilions, and Bryan Health Pine Lake Campus.

South Street

The South Street corridor includes 14 traffic signals from S. 9th Street to S. 56th Street. The corridor is oriented in an east/west direction and is approximately 3.4 miles long with an average 24-hour volume of 14,300 vehicles.

South Street includes a mix of the following cross-sections (listed west to east along the corridor):

- S. 9th Street to S. 41st Street – Four-lane undivided with medians at approaches to signalized intersections
- S. 41st Street to S. 56th Street – Three-lane with center turn lane

The posted speed limit along the corridor is 35 mph, except between S. 13th Street and S. 17th Street where it is 30 mph. The land use along South Street is predominantly residential east of S. 17th Street. Commercial and retail development are the primary land uses between S. 9th Street and S. 17th Street, and are also located near intersections with S. 27th Street and Normal Boulevard. Major attractions and high traffic generators along South Street include Saratoga Elementary School and Bryan Medical Center West Campus. The South Street corridor also included the adjacent pedestrian signal at:

- S. 13th Street & Saratoga Elementary School

Superior Street

The Superior Street (including Havelock Avenue) corridor includes 14 signalized locations from NW 1st Street & Highlands Boulevard to N. 62nd Street & Havelock Avenue. The corridor is oriented in an east/west direction and is approximately 4.8 miles long with an average 24-hour volume of 19,100 vehicles.

Superior Street includes a mix of the following cross-sections (listed west to east along the corridor):

- NW 1st Street & West Highland Boulevard to Touzalin Avenue (on Havelock Avenue) – Four-lane divided
- Havelock Avenue from Touzalin Avenue to N. 62nd Street – Two-lane

The posted speed limit along the corridor is 35 mph west of N. 1st Street, 40 mph between N. 1st Street and N. 27th Street, 45 mph between N. 27th Street and N. 48th Street, 40 mph between N. 48th Street and Cornhusker Highway, 35 mph between Cornhusker Highway and N. 60th Street, and 25 mph east of N. 60th Street. A multilane roundabout at N. 14th Street causes a break in signal progression due to the yield control operations. The corridor includes many adjacent land uses, including, schools, churches, residential, business and business centers, commercial, and industrial. The residential use is between N. 14th Street and N. 26th Street and homes do not have direct drive access to Superior Street, rather, they the backyards line the street ROW. Superior Street / Havelock Avenue provides access to I-180 and many schools and public uses such as: Parkview Christian School, Goodrich Middle School, Loren C Eisley Public Library, and Campbell Elementary School. The Superior Street / Havelock Avenue corridor also included the adjacent signalized intersection at:

- N. 14th Street & north of Superior Street (signalized pedestrian crossing)

West O Street

The West O Street corridor includes 8 signalized intersections from NW 48th Street to N. 1st Street. The corridor is oriented in an east/west direction and is approximately 3.5 miles long with an average 24-hour volume of 18,500 vehicles.

West O Street includes a mix of the following cross-sections (listed west to east along the corridor):

- NW 48th Street to NW 22nd Street, and just west and east of Sun Valley Boulevard – Four-lane divided
- NW 22nd Street to N. 1st Street (except at Sun Valley Boulevard) – Five-lane with center turn lane

The posted speed limit is 50 mph west of NW 27th Street, 45 mph between NW 27th Street and SW 13th Street, and 40 mph east of SW 13th Street. Land use along West O Street is predominantly commercial/retail and industrial. The corridor provides access to I-80, US-77, BNSF's Hobson Yard, and Downtown Lincoln.

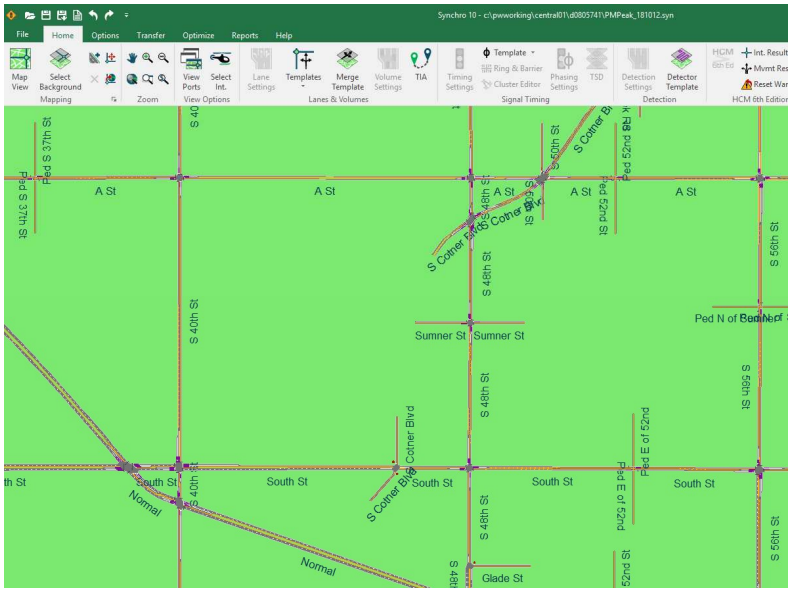
3.0 Traffic Signal System Optimization

This section discusses the development of optimized traffic signal timing plans and associated tasks for the project corridors. Specifically, existing timings were reviewed and included in the existing conditions Synchro model, then the project team developed optimized timings for each corridor by conducting analyses of the cycle length, phasing, and timing parameters described below. Optimized timings were developed for four time periods, which are:

- Morning (AM) peak period
- Midday (MD) period
- Afternoon (PM) peak period
- Off-peak (OP) period

3.1 Synchro Network Development

Base Synchro models developed by the City of Lincoln for the AM, MD, and PM peak periods were provided to the Consultants. These base Synchro models included changes that had been incorporated as part of Phase 1 of the Green Light Lincoln project. The Synchro models were reviewed by the Consultants to verify the accuracy of lane configurations, speed limits, turn restrictions, volume, and timing information utilizing the data provided by the City of Lincoln and collected in-field by the Consultants. Proposed changes were submitted to the City of Lincoln based on the review of intersection configuration data, count data, and timing permits.



The City of Lincoln incorporated the proposed changes for Phase 2 into the Synchro models. The MD Synchro model was then used by the Consultants as a base network to create the OP Synchro model for each of the study corridors. The City of Lincoln did not have turning movement volumes available for the OP hours at all study intersections. A factor to apply to MD volumes to generate OP volumes for use in developing OP signal timings was developed from 24-hour volumes at spot locations around the city. This resulted in a factor of 0.4 applied to the MD volumes to develop OP volumes. In general, the OP timing plans were primarily developed based on the intersection minimum cycle length requirements, as the OP timing plans are utilized during the low-volume hours (late-night/early-morning).

3.2 Operational Analysis

Prior to signal timing development, a review of operations was conducted to identify spot improvements at study intersections to be implemented with the new signal timings or considered for future implementation. The following sections provide a summary of the evaluation of operational characteristics for the study intersections along the project corridors. The operational analysis included review of movements that would benefit from the addition of exclusive turn lanes, review of left-turn storage bay lengths and vehicle queues, left-turn phasing analysis including the use of FYA indications, and operational deficiencies noted during field review.

3.2.1 Additional Auxiliary Lanes

A cursory review of the provided Synchro files was performed to note left-turn and right-turn movements where operations could be improved with the addition of an exclusive turn lane. Movements that were identified as benefiting from an exclusive turn lane and appear to have available right-of-way to accommodate the additional turn lane are shown in **Table 1**. These additional lanes should be considered during the planning of future improvements. The locations noted with an asterisk (*) in the "Additional Lane" column of **Table 1** require only pavement marking modifications. The remaining locations would require new pavement. There are several specific locations (listed in **Table 1**) where the addition of a right-turn lane would achieve operational benefits. As a general recommendation; exclusive right-turn lanes should be considered at every intersection approach along arterial streets to reduce the potential for rear-end collisions caused by turning traffic from the through travel lane. The addition of exclusive right-turn lanes should also consider potential impacts to cycle length to accommodate longer pedestrian intervals.

Table 1: Additional Auxiliary Lanes

Intersection	Additional Lane	Justification
NW 1st St & W. Highland Blvd	SB Right	Movement exceeds 100 vph.
N. 1st St & Superior St	EB Right	Movement exceeds 125 vph.
S. 27th St & Pine Lake Rd	EB Right	Movement exceeds 100 vph.
S. 27th St & Old Cheney Rd	NB Right	Movement exceeds 200 vph.
S. 27th St & Capitol Pkwy	WB Right	Movement exceeds 200 vph.
S. 27th St & O Street	NB/SB/EB/WB Right	Intersection and movements at capacity, all exceed or approach 100 vph, Crash Study recommendation.
S. 40th St & Old Cheney Rd	WB Left	Movement exceeds 300 vph; continue to monitor while delaying installation to avoid going to protected only operations.
S. 40th St & Normal Blvd	NB/EB/WB Right	Movements exceed 300 vph.
S. 40th St & Normal Blvd	NB Left	Movement exceeds 300 vph.
S. 48th St & Normal Blvd	EB/WB Right	Movements exceed 400 vph.
S. 48th St & Normal Blvd	NB Left	Movement exceeds 325 vph; continue to monitor delay and queues.

Table 1: Additional Auxiliary Lanes (Continued)

Intersection	Additional Lane	Justification
N. 48th St & St. Paul Ave	NB/SB Left	Exclusive lefts would reduce through movement delay.
N. 48th St & Fremont St	NB Right	Movement approaches 100 vph.
S. 56th St & Old Cheney Rd	EB Right	Movement exceeds 100 vph.
S. 56th St & Old Cheney Rd	NB Right	Movement exceeds 400 vph; continue to monitor while delaying installation as the traffic volumes should reduce once Pine Lake Road re-opens.
S. 56th St & Old Cheney Rd	WB Left	Movement exceeds 300 vph; continue to monitor while delaying installation as the traffic volumes should reduce once Pine Lake Road re-opens.
S. 56th St & Normal Blvd	EB Right	Movements exceed 300 vph.
S. 56th St & Normal Blvd	WB Right	Movements exceed 100 vph.
S. 56th St & South St	SB Through	Movement group with shared right-turn lane exceeds 800 vph.
S. 56th St & A Street	WB Right	Crash Study recommendation.
N. 70th St & Havelock Ave	EB Right	Movement exceeds 200 vph.
A Street & S. 84th St	NB Left	Movement exceeds 300 vph.
Old Cheney Rd & S. 14th St	EB Right	Movement exceeds 400 vph; continue to monitor while delaying installation as a project is underway to completely reconstruct the area.
Old Cheney Rd & S. 14th St	NB/WB Left	Movements exceed 300 vph; continue to monitor while delaying installation as a project is underway to completely reconstruct the area.
Old Cheney Rd & S. 48th St	EB Left	Movement exceeds 375 vph; continue to monitor delay and queues.
Old Cheney Rd & S. 70th St	EB Left*	Movement exceeds 300 vph; continue to monitor while delaying installation to avoid going to protected only operations.
Old Cheney Rd & S. 84th St	SB Left*	Movement exceeds 300 vph; continue to monitor while delaying installation to avoid going to protected only operations.
South St & Normal Blvd	EB/WB Right	Movements exceed 200 vph.
West O St & NW 20th St	WB Right	Movement exceeds 125 vph.

* Denotes where the additional lane can be provided by pavement marking modifications

3.2.2 Left-Turn Storage Length

During field observations, locations where turn bay length is not sufficient to store queued vehicles during peak volume times of the day were noted. Some of these locations have additional median length available upstream of the turn lane that could be used to extend the turn lane and reduce queues that spill into the adjacent lane. Locations where vehicles spilled out of the turn bay and into

the adjacent through traffic lane, which have additional median length available to lengthen the storage bay, are noted below:

- S. 27th Street & Pine Lake Road; WB Left-turn
- S. 27th Street & Capitol Parkway; EB Left-turn
- S. 40th Street & Old Cheney Road; WB Left-turn
- S. 48th Street & Normal Boulevard; NB Left-turn
  - This extension would result in restricted movements at Apple Creek Road and adjacent business drives
- S. 56th Street & Nebraska Highway 2; EB Left-turn
- A Street & S. 70th Street; WB Left-turn
- Old Cheney Road & Nebraska Highway 2; EB Left-turn
- Old Cheney Road & S. 70th Street; EB Left-turn
- Superior Street & N. 27th Street; EB Left-turn
- West O Street & Sun Valley Boulevard; EB Left-turn

The above list includes locations where the City of Lincoln should consider extending the turn bay storage length as part of future intersection improvement projects to prevent queue spillback into the adjacent through lane. These improvements would achieve safety and operational benefits.

3.2.3 Left-Turn Phasing

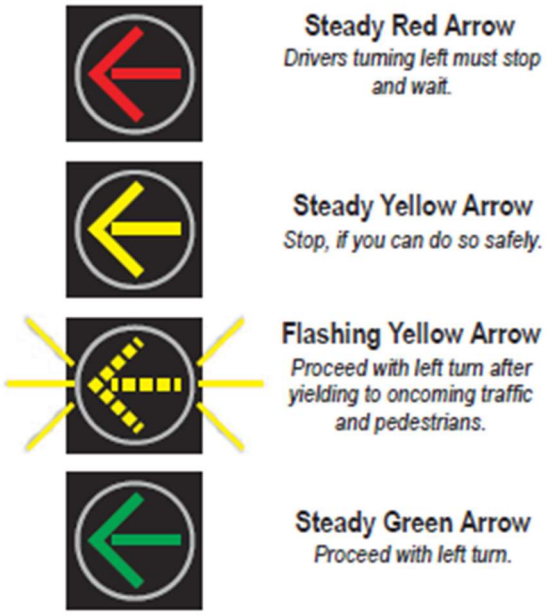
An analysis of left-turn phasing was conducted to determine the least restrictive level of control that could be used to operate left-turn movements efficiently and safely. This analysis was conducted based on the guidance provided in the City of Lincoln *Traffic Signal Timing Guidelines*. The results of the analysis were used to generate initial left-turn phasing that was implemented with the new signal timings. The implemented left-turn phasing was reviewed in the field and further adjusted as necessary.

3.2.4 Flashing Yellow Arrow (FYA) Analysis

The City of Lincoln is in the process of implementing FYA signal heads for left-turn movements throughout the city, where appropriate. Benefits of the FYA signal heads include:

- To enhance safety at Lincoln intersections
- Flexibility to use any type of left-turn operation (i.e., permissive, protected/permissive, protected) to improve overall traffic flow
- Provides an exclusive signal indication to left-turning motorists
- The ability to operate signals with lead/lag left-turn phasing without the safety concern of a yellow trap

In the past, the City of Lincoln had predominantly used dog-house (five-section) or three-section signal heads for left-turn movements. Dog-house signal heads were installed on the lane line between the exclusive left-turn lane and the adjacent through lane. Guidance in the Manual on Uniform Traffic Control Device (MUTCD) suggests that FYA signal heads should be installed over the center of the left-turn lane. Based on this criteria, field reviews were conducted at each intersection approach and noted the length of the mast arm.



The FYA analysis was done independently of the left-turn operation analysis to assess if the existing mast arms could accommodate the installation of FYA signal heads. In some instances, the FYA analysis indicated that some approaches are suitable for FYA while the operational analysis states that the movement should operate as protected only. Ultimately, the results of the left-turn operation analysis determined the operation of the left-turns at an intersection approach and the FYA analysis determined which approaches could have FYA signal heads installed.

3.2.5 Field Observations

Consultant staff were in the field on multiple occasions during this project. Those occasions included field review and inventory of study intersections, to conduct travel time studies, and as part of the implementation of the new timings. Additional operational notes from time in the field are noted below.

- Dense driveway access along A Street between S. 33rd Street and S. Cotner Boulevard create frequent slowing or stopping of through traffic, which can disrupt progression of traffic between traffic signals and create additional stops.
- Moderate pedestrian activity with push button actuation at the following signalized intersections results in signals periodically (sometimes frequently) operating in transition to get into coordinated time step with adjacent signals:
  - S. 27th Street & Capitol Parkway
  - S. 27th Street & Pine Lake Road
- S. 40th Street & South Street – Corridor operations could be improved if more strict access management could be implemented north of South Street and if the transitions for the crown of the street over South Street could be smoothed out to allow traffic on S. 40th Street to maintain their speed while driving through the intersection.
- S. 48th Street – Many LFR responses utilize this corridor due to proximity of Stations 6, 7, and Bryan Medical Center East Campus.

- S. 48th Street – Dense residential driveway spacing throughout the corridor and implications with garbage and mail trucks.
- S. 48th Street – It can be difficult during peak hours to find gaps to turn on to S. 48th Street in the five-lane section from Van Dorn Street to Antelope Creek Road.
- N. 48th Street – Increased delays were noted in the St Paul Avenue area where the street narrows to a 4-lane undivided section; left-turns can cause stand-still conditions.
- S. 56th Street & Calvert Street – Northbound and southbound left-turn movements do not have auxiliary left-turn lanes. This creates sight distance issues for left-turn traffic, increases the risk for rear-end collisions, and increases delay for through movement traffic. Right-of-way does not appear to be available to add the lanes, so this improvement would likely need to be part of a larger reconstruction project for S. 56th Street.
- S. 56th Street & Shady Creek Court – This intersection would operate more efficiently without split phasing. The City is currently in the process of redesigning this intersection to allow standard phasing.
- S. 56th Street & Old Cheney Road – This intersection is over-capacity during the PM peak period. The eastbound approach queue backs up to Queens Drive, the northbound approach queue extends just beyond Waltz Road in the outside lane, and the westbound left-turn queue extends beyond the capacity of the storage bay. Once Pine Lake Road is open again east of S. 56th Street the northbound right-turn and westbound left-turn volume should reduce. At this point the intersection should be revisited to adjust splits to account for the new traffic pattern.
- A Street & Normal Boulevard – Vehicles traveling through the intersection eastbound and westbound are impacted by left-turning vehicles from the through lane. As the left-turn vehicles wait for a gap in opposing traffic, eastbound and westbound through vehicles typically swerve around the left-turn vehicles. This is infrequent, as the eastbound and westbound left-turn movements have low volume.
- A Street at Lincoln East parking lot entrance (east of S. 70th Street) – Heavy eastbound left-turn traffic into the parking lot from the inside through lane during the AM peak hour causes stopped conditions in the inside eastbound through lane. This requires eastbound through traffic to use the outside through lane.
- A Street & S. 84th Street – Some northbound left-turning traffic avoid the northbound left-turn lane in the AM peak hour because of excessive queuing. These vehicles turn right onto A Street, make a U-turn just east of the intersection and then travel as a westbound through vehicle.
- Old Cheney Road between S. 56th Street and Nebraska Highway 2 – Corridor operations could be improved if more strict access management could be implemented in this area.
- Pine Lake Road & S. 40th Street – The eastbound left-turn lane occasionally spills out of the provided storage into the through lane. This is largely the result of Pine Lake Road closed east of S. 56th Street for construction. Once Pine Lake Road east of S. 56th Street is reopened, the queuing in the eastbound left-turn lane is expected to be reduced and accommodated within the provided storage lane.
- Pine Lake Road & S. 56th Street – The eastbound left-turn lane occasionally spills out of the provided storage into the through lane. This is largely the result of Pine Lake Road currently being closed east of S. 56th Street for construction. Once Pine Lake Road east of S. 56th Street

is reopened, the queuing in the eastbound left-turn lane is expected to be reduced and accommodated within the provided storage lane.

- Railroad preemption can cause random stops along N. 70th Street during train events.
- West O Street – Longer vehicle start up times due to heavy truck percentage.
- Intersection approach lane utilization at two-lane approaches heavily favors the inside through lane at locations with lane drops shortly downstream of study intersections. These intersection approaches include:
    - S. 27th Street & South Street – SB approach
    - S. 27th Street & Nebraska Highway 2 – NB approach
    - S. 40th Street & Nebraska Highway 2 – NB approach
    - S. 48th Street & Nebraska Highway 2 – NB approach
    - S. 48th Street & Van Dorn Street – SB approach
    - S. 48th Street & Normal Boulevard – NB approach
    - 48th Street & O Street – SB and WBL approaches
    - N. 48th Street & Holdrege Street – EB approach
    - N. 48th Street & Adams Street – NB approach
    - 70th Street & O Street – NB approach
    - N. 70th Street & Cornhusker Highway – EB approach
    - Old Cheney Road & Warlick Boulevard – WB approach
    - Old Cheney Road & S. 14th Street – WB approach
    - Old Cheney Road & S. 16th Street – WB approach
    - South Street & S. 9th Street – WB approach
    - Superior Street & Cornhusker Highway – EB approach

3.3 Intersection Crash Analysis

The City of Lincoln conducts periodic crash studies of intersections with high crash rates to identify potential safety improvements. As part of this project, the City of Lincoln *2012 Crash Study* and *2018 Lincoln Crash Data Analysis* were reviewed for recommendations specific to project intersections. A field review was conducted at those locations to determine if the recommendations had been implemented and if not, if they were still applicable. Findings from the field review were summarized and submitted to the City of Lincoln. The majority of countermeasures recommended from the crash studies at project intersections involve signal timing updates and/or phasing changes. Those countermeasures that involved signal timing related improvements were implemented as part of this project, which resulted in implementation of 21 countermeasures. The countermeasures implemented as part of this project are summarized in **Appendix B**.

3.4 Traffic Signal Timing Development

Traffic signal timing development was completed through multiple steps. This process included calculation or determination of intersection basic timing parameters (minimum green, yellow change, red clearance, walk, flashing don't walk, and vehicle recall), cycle lengths, splits, and offsets. Timings were then refined in the field based on observations of traffic operations. A brief overview on how these parameters were developed and modified is described in the following sections.

3.4.1 Basic Signal Timing Parameters

Basic timing parameters of minimum green, yellow change, red clearance, walk, flashing don't walk, and vehicle recall were evaluated based on information in the City of Lincoln *Traffic Signal Timing Guidelines*. Data collected from the intersection inventory and aerial photography were used to calculate these parameter values. Calculated values reflect current industry practices which are based on new research that is intended to improve the safety of intersection operations. The initial intersection calculation file for each intersection was submitted to the City of Lincoln for their review and approved prior to the development of optimized timing plans. The approved timing parameters were then coded into Synchro by the Consultants for use in creating the new timing plans. Final intersection basic signal timing parameters were submitted to the City of Lincoln with the final project deliverables.

3.4.2 Cycle Length

An optimum cycle length provides sufficient green time to efficiently serve all movements at an intersection while providing efficient flow of traffic along a corridor from one intersection to the next. Long cycle lengths generally accommodate efficient flow of traffic (progression), however, they generally cause greater delays for the minor street approaches. Short cycle lengths sometimes work well to reduce delay for minor street approaches, however, the progression along the corridor can be easily disrupted. An optimum cycle length balances these two considerations of delay and progression. Additionally, it is important to consider how selection of a cycle length at an intersection affects operations at adjacent intersections. System-wide coordination would be accomplished by using complimentary cycle lengths throughout the system or grouping of intersections. The optimum cycle length is the merging of the following factors:

- System-wide coordination
- Proximity of study corridors to other major corridors in the system
- Intersection vehicular demand (through and turning movements)
- Minimum cycle length
- Pedestrian and bicyclist volumes
- Overall intersection delay and level of service
- Intersection approach/movement delays
- Progression

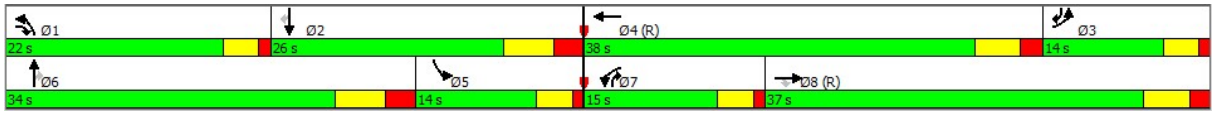
Various cycle lengths were considered and evaluated against the items listed above with consideration given to performance of existing cycle lengths. The selection of a standard cycle length for all the project corridors allows the potential for cross coordination of corridors that intersect each other. Ultimately, the cycle lengths selected for Phase 1 of Green Light Lincoln Traffic Signal Optimization project were also selected for the Phase 2 corridors due to the number of shared intersections with Phase 1. To reduce delay for minor street approaches, half cycle lengths were

considered at intersections where traffic volumes were light enough to maintain efficient progression with a shorter cycle length.

The existing cycle lengths varied within time-of-day plans but were generally similar to those ultimately selected for implementation. For the AM and PM peak periods, 120 seconds was selected for the cycle length. The MD period traffic volumes are less than the AM and PM peak hours, and thus a lower cycle length of 100 seconds was selected. The OP cycle length of 70 seconds was selected to keep the side street delay low during the late-night/early-morning hours when traffic volumes are lower.

3.4.3 Splits and Offsets

Synchro software was used to develop the initial proposed timing plans. Intersection splits and offsets were determined after model development and selection of proposed cycle lengths. Synchro provided initial splits and offsets for each intersection through its optimization function. From these initial



values, a review of each intersection's splits was conducted to make the most efficient use of the overall cycle length. Changes were made as necessary to satisfy system standards, lower intersection/movement delay and improve coordination along the corridors.

Intersection offsets were determined using a combination of Synchro and Tru-Traffic software. Coordination along the corridors was determined based on directional traffic flow trends by time-of-day with progression favored in the direction of travel having notably higher traffic volumes. In cases where traffic volumes were similar, the offsets were set to maximize traffic flow in both directions. Proposed timing plans were submitted to the City of Lincoln for review, discussion, revision, and approval prior to implementation.

3.4.4 Time-of-Day Schedule

A schedule was developed to operate the proposed timing plans based on patterns from 24-hour volumes throughout the city. **Figure 2** provides a graphical illustration of 24-hour volume data, which shows the variation in traffic volumes throughout the day used as the basis for developing the time-of-day schedule. The spikes seen in the AM and PM peak periods of the graph are typical of weekday traffic, as commuters are traveling to and from work. During these AM and PM peak periods, longer cycle lengths than those during the remainder of the day are typically needed to serve the increase in vehicle demand. To accommodate cross-coordination along intersecting corridors, a common time-of-day plan was selected for all study corridors. **Table 2** illustrates the implemented time-of-day schedule.

Figure 2: Weekday 24-Hour Count Data Graph

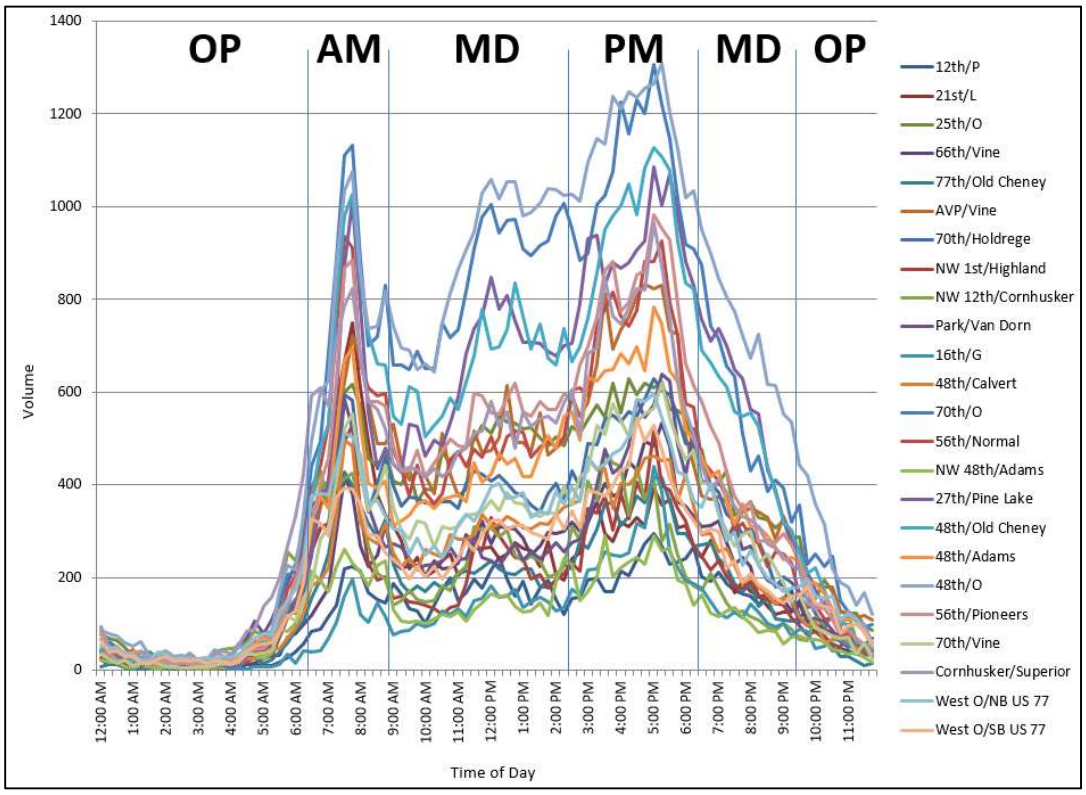


Table 2: Time-of-Day Schedule

Days	Timing Plan	Time-of-Day
Weekday	AM	6:30 AM – 9:00 AM
	MD	9:00 AM – 2:30 PM 6:30 PM – 9:30 PM
	PM	2:30 PM – 6:30 PM
	OP	9:30 PM – 6:30 AM
Weekend	MD	6:30 AM – 9:30 PM
	OP	9:30 PM – 6:30 AM

3.4.5 Implementation and Field Fine-Tuning

Implementation and field fine-tuning was conducted jointly by Consultant and City staff. This iterative process was conducted over several weeks allowing sufficient time to be dedicated to each corridor. The initial implementation and fine-tuning was completed in fall 2018. Fine-tuning continued in the weeks following the initial implementation to address operational deficiencies that were noted during monitoring of the new timings' operations and based on citizen comments.

Fine-tuning was conducted to further improve operations throughout the system. Movements found needing more time were addressed based on the tradeoff between improving the movement

operations and the impact to the overall coordination along the corridor. Offsets were adjusted along the corridors to improve progression based on field observations. In addition to the initial field observations, additional changes were made based on citizen comments received along the project corridors. Any revisions made during the fine-tuning process were recorded and revised in the Synchro and Tru-Traffic files. Final Synchro and Tru-Traffic files were submitted to the City of Lincoln with the final project deliverables.

4.0 Corridor Performance Evaluation

The study corridors were evaluated to determine the effectiveness of the retiming effort. The corridor evaluations consisted of comparing performance measures from "Before" and "After" studies conducted before and after implementation of new signal timings. This chapter provides details on the methodology used to evaluate corridor performance and the results of those evaluations.

4.1 Performance Evaluation Data

Travel time study data were used to calculate a variety of performance measures. Corridor performance results were based on data from "Before" and "After" travel time studies conducted for each study corridor. The corridor travel time studies occurred during multiple periods throughout the day for "Before" and "After" conditions of implementing the new signal timing plans. The periods for the travel time studies were:

- AM peak period – 7:00 AM – 8:30 AM (Weekday) – All study corridors
- Mid-morning (MM) period – 9:00 AM – 10:30 AM (Weekday) – All study corridors
- MD peak period – 11:15 AM – 1:00 PM (Weekday) – All study corridors
- Mid-afternoon (MA) period – 2:30 PM – 4:00 PM (Weekday) – All study corridors
- PM peak period – 4:00 PM – 6:00 PM (Weekday) – All study corridors
- Saturday/Sunday period – Varied by corridor
    - Saturday (SA) – 11:00 AM – 3:00 PM (Saturday) – S. 27th Street, S. 48th Street, N. 48th Street, S. 56th Street, S. 70th Street, Pine Lake Road, South Street, Superior Street, and West O Street
    - Sunday (SU) – 11:00 AM – 3:00 PM (Sunday) – S. 40th Street, A Street, and Old Cheney Road

The "Before" travel time studies were conducted in August/September 2018 prior to implementation of new signal timings. The "After" travel time studies were conducted in October/November 2018 after implementation and fine-tuning of new signal timings.

The travel time studies were conducted with a pilot vehicle traveling each study corridor for a minimum of five travel time runs for each time period of "Before" and "After" conditions. During these studies, travel time data was collected with Tru-Traffic software. Tru-Traffic, accompanied with a GPS device, is used to track a vehicle's position while it travels along a corridor. It records the position of the vehicle every second and uses that information, along with inputs on the locations of intersections, to calculate performance measures along the corridor.

4.2 Performance Measures

The following performance measures were identified to be reported for this project:

- **Travel Time** – The time to travel from one end of a study corridor to the other
- **Corridor Performance**
  - **Delay** – The amount of time corridor through traffic is slowed or stopped by traffic signals on a trip from one end of a study corridor to the other
  - **Stops** – The number stops experienced by through traffic on a study corridor on a trip from one end of a study corridor to the other
  - **Fuel Consumption** – The estimated amount of fuel consumed by through traffic on a trip from one end of a study corridor to the other
  - **Emissions** – The estimated emissions produced by through traffic on a trip from one end of a study corridor to the other

Performance measures were summarized for times of the day when travel time studies were completed. This means that benefits derived from the retiming effort are only reported for those hours during the day in which travel time studies were conducted. For the remaining hours of the day, it is expected that additional benefits are realized that are not reported in this study since travel studies were not collected during those times of day.

4.3 User Savings Analysis

The travel time performance measure was reported as the change in travel time between "Before" and "After" conditions by comparing the average time to travel from one end of a study corridor to the other end during the study periods. Travel time was extracted from the travel time run data in Tru-Traffic for each period of "Before" and "After" conditions. "Time" is of value to all people. A reduction in travel time, delay, and fuel consumption keep dollars in the pockets of motorists. These direct savings were tracked and quantified to determine community savings.

Corridor performance measures of delay, stops, fuel consumption, and emissions were calculated using output from Tru-Traffic travel time runs, year 2018 local demographics, and procedures outlined in the City of Lincoln *Traffic Signal Timing Guidelines v2.0*. Each of the corridor performance measures was reported as the change between "Before" and "After" conditions.

4.4 Summary of Performance Measures and User Savings

Results from the performance evaluation show that new signal timings along the 12 study corridors produced substantial benefits to the community. A summary of corridor-specific performance measures are provided below.

4.4.1 Travel Time Results

The average travel time change from "Before" to "After" conditions by time period are provided in **Table 3** for each study corridor. The travel times conducted after the new signal timings were implemented showed a decrease in travel times from the "Before" conditions for most corridor study periods. A total of 144 comparisons were made from "Before" to "After" conditions when considering

two directions of travel, during six time periods, and for 12 corridors. Of the 144 travel time comparisons, 127 showed a reduction in travel time when traveling from one end of the corridor to the other. It should be noted that most of the travel time comparisons that showed an increase in travel time with the new timings are relatively minor increases (less than 30 seconds). These increases could be attributed to enhanced safety treatments through updated pedestrian and vehicle clearance times at intersections included with the new signal timings.

For those travel time comparisons that showed an increase in travel time, some reasons for an increase include (but are not limited to):

- A change in signal progression to improve flow and reduce travel time in one direction resulted in an increase to travel time in the opposing direction.
- Progression needs of a crossing arterial with higher traffic volumes result in added delay of a study corridor at the crossing intersection.
- Increased pedestrian crossing times resulting in more likelihood for signals operating out of coordination for a period of time.
- Increased vehicle yellow change and all red times at select intersections.
- Consistent time of day plans along a corridor that reduce the likelihood of random progression through signals.
- Railroad preemption with greater impacts to "After" studies than "Before" studies.
- Day-to-day variation in traffic demand.

More detailed travel time results, showing the total corridor travel times with the travel time savings, is provided in **Appendix C**.

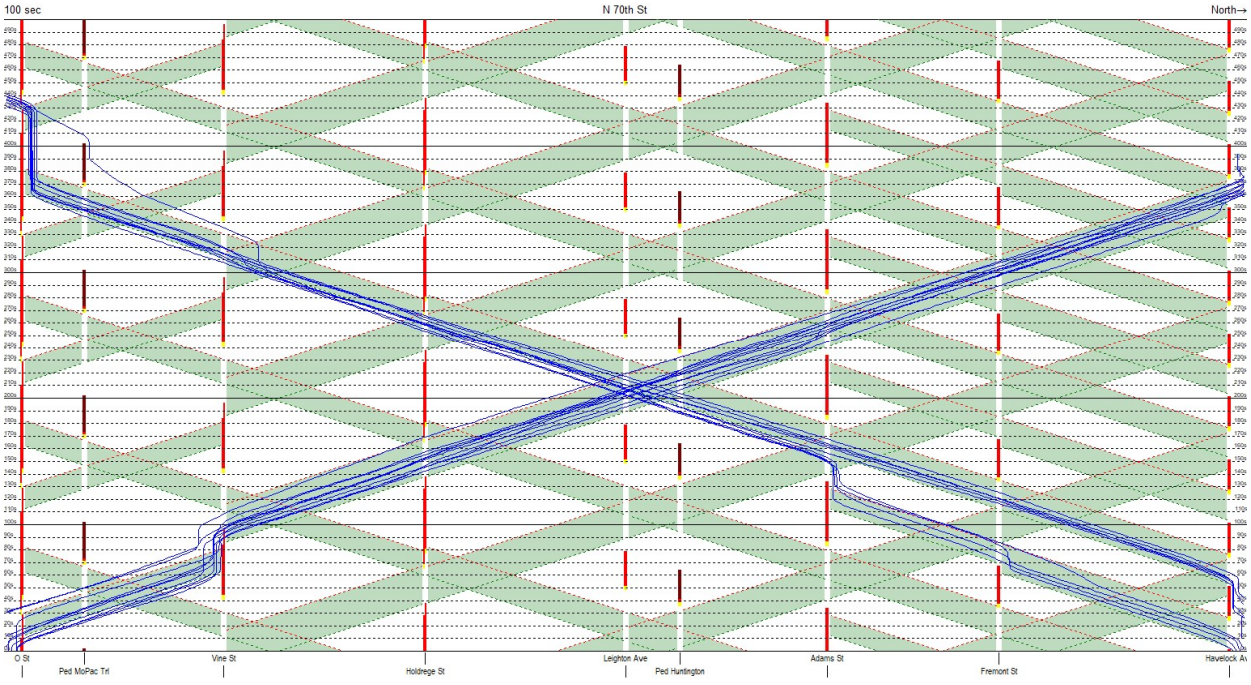


Table 3: Travel Time Comparison from "Before" to "After" Conditions

Corridor	Period	Travel Time Change (Min:Sec)[1]		
		NB/EB	SB/WB	Total
S. 27th Street (Yankee Hill Road – O Street)	AM	-1:20	-0:04	-1:24
	MM	-1:41	-2:06	-3:47
	MD	-1:37	-0:15	-1:52
	MA	-1:26	-1:10	-2:36
	PM	-0:19	-0:13	-0:32
	SA	-1:14	-1:25	-2:39
S. 40th Street (Yankee Hill Road – Randolph Street)	AM	-3:10	-0:36	-3:46
	MM	-1:27	-1:07	-2:34
	MD	-1:37	-0:44	-2:21
	MA	-1:56	-1:21	-3:17
	PM	-1:56	-1:21	-3:17
	SU	-1:51	-1:35	-3:26
S. 48th Street (Old Cheney Road – O Street)	AM	-1:00	-0:07	-1:07
	MM	-1:04	-0:53	-1:57
	MD	-1:41	-1:06	-2:47
	MA	-0:10	-1:53	-2:03
	PM	-0:51	0:01	-0:50
	SA	-2:04	-0:25	-2:29
N. 48th Street (O Street – Superior Street)	AM	-2:09	-0:15	-2:24
	MM	-0:49	-0:44	-1:33
	MD	-0:55	-0:13	-1:08
	MA	-0:50	-0:16	-1:06
	PM	-0:23	-0:14	-0:37
	SA	-1:34	-0:59	-2:33
S. 56th Street (Pine Lake Road – O Street)	AM	-3:36	-3:06	-6:42
	MM	-0:53	-0:10	-1:03
	MD	-2:13	-1:28	-3:41
	MA	-1:10	-0:54	-2:04
	PM	-1:19	-3:15	-4:34
	SA	-1:38	-1:47	-3:25
N. 70th Street (O Street – Havelock Avenue)	AM	0:11	-1:18	-1:07
	MM	-0:47	-1:12	-1:59
	MD	-1:26	-1:02	-2:28
	MA	-1:02	-0:48	-1:50
	PM	-3:13	-2:27	-5:40
	SA	-1:16	-0:54	-2:10

Corridor	Period	Travel Time Change (Min:Sec)[1]		
		NB/EB	SB/WB	Total
A Street (S. 27th Street – S. 84th Street)	AM	-2:17	-3:06	-5:23
	MM	-2:03	-1:44	-3:47
	MD	-2:38	-1:34	-4:12
	MA	-1:00	0:20	-0:40
	PM	-0:38	-1:24	-2:02
	SU	-1:03	-1:19	-2:22
Old Cheney Road (Warlick Boulevard – S. 84th Street)	AM	-1:04	0:24	-0:40
	MM	-0:22	-1:01	-1:23
	MD	-0:51	0:20	-0:31
	MA	-1:39	1:01	-0:38
	PM	-0:47	1:00	0:13
	SU	0:07	0:02	0:09
Pine Lake Road (S. 14th Street – S. 56th Street)	AM	-1:00	-0:14	-1:14
	MM	-0:57	-0:43	-1:40
	MD	0:04	0:03	0:07
	MA	-0:52	-0:13	-1:05
	PM	-0:27	0:07	-0:20
	SA	-1:11	-0:31	-1:42
South Street (S. 9th Street – S. 56th Street)	AM	-1:58	-1:15	-3:13
	MM	-0:33	-0:15	-0:48
	MD	-0:20	-0:16	-0:36
	MA	0:57	1:52	2:49
	PM	-0:27	-0:04	-0:31
	SA	-0:30	0:04	-0:26
Superior Street (NW 1st St & W. Highlands Blvd to N. 62nd St & Havelock Ave)	AM	-0:30	-1:16	-1:46
	MM	-1:50	-0:20	-2:11
	MD	-1:25	-0:02	-1:27
	MA	-1:21	-1:31	-2:52
	PM	-1:31	0:07	-1:24
	SA	-1:36	-1:59	-3:35
West O Street (NW 48th Street – N. 1st Street)	AM	-0:20	-0:40	-1:00
	MM	-0:26	-0:24	-0:50
	MD	-0:49	0:09	-0:40
	MA	-0:22	-0:36	-0:58
	PM	-0:22	-0:19	-0:41
	SA	-0:28	-0:37	-1:05

[1] Negative time values represent a decrease in travel time during the "After" condition as compared to the "Before" condition; Positive time values represent an increase in travel time during the "After" condition.

4.4.2 Corridor Performance Results

The total benefits to corridor performance from "Before" to "After" conditions are summarized in **Table 4**. The corridor performance results show sizable reductions for motorist delay, fuel consumption, stops, and emissions. The reductions to delay and fuel are estimated to save Lincoln motorists over 403,000 hours of delay and $8.9 million in user (time and fuel) costs per year. More detailed corridor performance measures, including a breakdown by study time period, are provided in **Appendix D**.

Table 4: Corridor Performance Results

Corridor	Annual Savings (From "Before" to "After" Conditions)				
	Delay (Veh-Hours)	Fuel (Gallons)	Stops (Million Veh-Stops)	Emissions (Kilograms)	User Savings[1] ($)
S. 27th Street (Yankee Hill Road – O Street)	42,900	56,600	2.7	5,600	$938,300
S. 40th Street (Yankee Hill Road – Randolph Street)	39,900	59,000	3.3	5,900	$888,200
S. 48th Street (Old Cheney Road – O Street)	33,700	43,300	2.9	4,300	$734,600
N. 48th Street (O Street – Superior Street)	34,800	45,800	2.9	4,600	$763,600
S. 56th Street (Pine Lake Road – O Street)	71,500	99,900	5.7	10,000	$1,576,900
N. 70th Street (O Street – Havelock Avenue)	45,000	60,900	3.7	6,100	$1,002,000
A Street (S. 27th Street – S. 84th Street)	29,400	50,000	3.8	5,000	$672,300
Old Cheney Road (Warlick Blvd – S. 84th Street)	9,100	6,500	-0.2	700	$184,000
Pine Lake Road (S. 14th Street – S. 56th Street)	21,700	39,300	1.8	3,900	$502,200
South Street (S. 9th Street – S. 56th Street)	9,100	7,900	0.2	800	$189,200
Superior Street (NW 1st St & W. Highlands Blvd to N. 62nd St & Havelock Ave)	47,600	41,000	0.8	4,100	$987,800
West O Street (NW 48th Street – N. 1st Street)	18,300	28,500	1.2	2,800	$420,500
TOTALS	403,000	538,700	29.0	53,800	$8,859,600

[1] Savings based on reductions in delay, fuel, and local demographic information.

4.5 Study Benefit-to-Cost

A benefit-to-cost analysis was completed for the overall study area to understand the return benefit based on City investment. The annual benefit of the project is estimated to be $8.9 million, as shown in **Table 4**. The costs for the project are outlined below:

- Consultant services = $ 700,800
- Equipment = $ 1,920,500
- Contractor services = $ 552,400
- Total = $ 3,173,700

The Federal Highway Administration (FHWA) recommends that signal timings be updated every three to five years. Based on the FHWA's recommendation, the quantified benefits are assumed to be realized each year for the next five years. The benefits over five years are expected to be $44.3 million.

The benefit-to-cost ratio is calculated to be 14:1. This shows a significant return on investment through delay and fuel savings to Lincoln motorists. Additionally, the reduction to stops and emissions (which were not monetized), provide a benefit to the air quality in Lincoln. Reduction in stops (also not monetized), is expected to provide added safety benefits by reducing crashes. Moreover, these savings are only inclusive for the portion of the day for which travel time data was collected. As a result, benefits are being experienced during other hours of the day and thus, the benefit-to-cost ratio is much greater than 14:1.

5.0 Summary/Conclusion

The overall purpose of this project was to prepare and implement optimized traffic signal timing plans along signalized corridors and to quantify the changes in traffic operations resulting from signal equipment upgrades and signal timing changes with "Before" and "After" performance measures. Travel time studies conducted after the new signal timings were implemented showed a decrease in travel times from the "Before" conditions for most corridor study periods. Additionally, updates to pedestrian and vehicle clearance times at study intersections enhance safety at these locations.

The reductions to delay incurred and fuel consumed are estimated to save Lincoln motorists over 403,000 hours of delay and 538,700 gallons of fuel per year, equating to $8.9 million annual user savings. The benefit-to-cost ratio over a five-year period (recommended period between retiming efforts) is 14:1. These savings are only inclusive for the portion of the day for which travel time data was collected. Thus, benefits are being experienced during other hours of the day. The implementation of new timings also resulted in 21 countermeasures from the *2012 Crash Study* and *2018 Crash Analysis* being implemented, which should provide additional safety benefits to Lincoln motorists.

A summary of benefits and costs for Phases 1 and 2 of the Traffic Signal System Optimization effort are shown in **Table 5**. Phase 2 resulted in similar benefits to those achieved with Phase 1. The biggest difference between Phases 1 and 2 was the higher project cost of Phase 2. The higher cost of Phase 2 was the result of having more total signals included in Phase 2 and more improvements/repairs to signal equipment.

Table 5: Summary of Benefits and Costs for Phases 1 and 2

Variable	Phase 1	Phase 2	Total of Phases 1 and 2
Annual Delay Savings (Veh-Hours)	437,200	403,000	840,200
Annual Fuel Savings (Gallons)	575,000	538,700	1,113,700
Annual User Savings[1] ($)	$8,766,200	$8,859,600	$17,625,800
Project Cost	$2,325,100	$3,173,700	$5,498,800
Benefit-to-Cost Ratio[2]	19:1	14:1	16:1

[1] Savings based on reductions in delay, fuel, and local demographic information.
[2] Benefits calculated for five years based on FHWA recommendation for signal retiming.

The next phase of Traffic Signal System Optimization (Phase 3) is slated for 2019 and will continue the effort to improve safety and mobility in Lincoln. It is recommended to continue retiming efforts throughout the city and retime corridors every three to five years to further save Lincoln motorists time and money throughout the city.

APPENDIX A

Corridor Intersection Lists

Study Corridor Intersections (Table 1 of 4)

S. 27th Street	S. 40th Street	S. 48th Street
O Street[1]	Randolph Street	Old Cheney Road[2]
M Street (Ped)[1]	D Street	Nebraska Highway 2[1]
J Street[1]	A Street[2]	N of Claire Avenue (Ped)
Randolph Street[1]	South Street[1,2]	Pioneers Boulevard
Capitol Parkway[1]	Normal Boulevard[1]	Prescott Avenue
A Street[2]	Van Dorn Street	Calvert Street
Summer Street (Ped)	Pioneers Boulevard	Van Dorn Street
South Street[2]	Nebraska Highway 2[1]	Normal Boulevard[1]
Sheridan Boulevard	Wildbriar Lane	South Street[2]
Van Dorn Street	Old Cheney Road[2]	Sumner Street
Woods Boulevard[1]	Duxhall Drive	S. Cotner Boulevard
Nebraska Highway 2[1]	Pine Lake Road[2]	A Street[2]
Tipperary Trail	Grainger Parkway	S of Valley Road (Ped)
Jameson N	Yankee Hill Road	Randolph Street
Old Cheney Road[2]		
Ridge Line Road		
Southridge Road		
Pine Lake Road[2]		
Porter Ridge Road		
Grainger Parkway		
Yankee Hill Road		

[1] Phase 1 Intersection
[2] Phase 2 Intersection on multiple corridors

Study Corridor Intersections (Table 2 of 4)

N. 48th Street	S. 56th Street	N. 70th Street
O Street[1]	O Street[1]	Cornhusker Highway
Target Drive[1]	Randolph Street	Havelock Avenue
R Street[1]	A Street[2]	Fremont Street
Vine Street[1]	Sumner Street (Ped)	Adams Street
Orchard Street (Ped)	South Street[2]	Huntington Avenue (Ped)
Holdrege Street	Normal Boulevard[1]	Leighton Avenue
Leighton Avenue	Van Dorn Street	Holdrege Street
Ped at Huntington Avenue	Calvert Street	Vine Street[1]
St Paul Avenue	Pioneers Boulevard	Mopac Trail (Ped)
Adams Street	Elkcrest Drive	O Street[1]
Fremont Street	Shady Creek Court[1]	
Cornhusker Highway[1]	Nebraska Highway 2[1]	
Superior Street[2]	Old Cheney Road[1,2]	
	Pine Lake Road[2]	

[1] Phase 1 Intersection
[2] Phase 2 Intersection on multiple corridors

Study Corridor Intersections (Table 3 of 4)

A Street	Old Cheney Road	Pine Lake Road
S. 27th Street[2]	Warlick Boulevard	S. 14th Street
Rock Island Trail (Ped)	S. 14th Street	S. 20th Street
Normal Boulevard[1]	S. 16th Street	Scott Middle School (Ped)
S. 33rd Street[1]	Tipperary Trail/Norman Road	Ridge Road
S. 37th Street (Ped)	The Knolls (Ped)	S. 27th Street[2]
S. 40th Street[2]	S. 27th Street[2]	S. 29th Street
S. 48th Street[2]	S. 34th Street	S. 32nd Street
S. 50th Street/S. Cotner Boulevard	S. 40th Street[2]	S. 40th Street[2]
S. 52nd Street (Ped)	S. 48th Street[2]	Beaver Creek Lane
S 56th Street[2]	S. 56th Street[1,2]	S. 56th Street[2]
Pius X High School (Ped)	Nebraska Highway 2[1]	
S. 70th Street[1]	Vandervoort Drive[1]	
Regency Drive (Ped)	S. 70th Street[1]	
Cottonwood Drive (Ped)	S. 77th Street	
S. 84th Street[1]	S. 84th Street[1]	
	Adjacent Intersection	
	Brookridge Circle / S. 16th Street	

[1] Phase 1 Intersection
[2] Phase 2 Intersection on multiple corridors

Study Corridor Intersections (Table 4 of 4)

South Street	Superior Street	West O Street
S. 9th Street	NW 1st Street & W. Highland Boulevard / Highland Circle	NW 48th Street
S. 10th Street	N. 1st Street/Campers Circle	US-77 SB Ramp
S. 13th Street	I-180 SB Ramp	US-77 NB Ramp
S. 16th Street	I-180 NB Ramp	NW 20th Street
S. 17th Street	Ped E of N. 14th Street	Capitol Beach Boulevard
S. 20th Street (Ped)	N. 20th Street	NW Roundhouse Drive
S. 27th Street[2]	N. 27th Street	Sun Valley Boulevard
S. 31st Street (Ped)	Industrial Avenue	N. 1st Street
Rock Island Trail (Ped)	N. 33rd Street	
S. 33rd Street	N. 48th Street[2]	
Normal Boulevard[1]	Cornhusker Highway[1]	
S. 40th Street[1,2]	Havelock Avenue & Touzalin Avenue	
S. 48th Street[2]	Havelock Avenue & N. 62nd Street	
S. 52nd Street (Ped)	**Adjacent Intersections**	
S. 56th Street[2]	N. 14th Street N of Superior Street (Ped)	
Adjacent Intersection		
S. 13th Street & Saratoga Elementary (Ped)		

[1] Phase 1 Intersection
[2] Phase 2 Intersection on multiple corridors

APPENDIX B

Implemented 2012 Crash Study & 2018 Crash Analysis Countermeasures

Implemented 2012 Crash Study & 2018 Crash Analysis Countermeasures

Intersection	Crash Pattern	Countermeasure	Phase 2 Improvement
S. 27th Street & Pine Lake Road	N/A	Review and update signal timings	Signal timings updated
S. 27th Street & Old Cheney Road	N/A	Review and update signal timings	Clearance intervals updated, Signal timings reviewed and updated
S. 27th Street & South Street	N/A	Review and update signal timings	Signal timings updated
S. 27th Street & A Street	N/A	Review and update signal timings	Signal timings updated
		FYA including 4-section head on poles	FYA installed on all approaches
S. 40th Street & Old Cheney Road	N/A	Review and update signal timings	Clearance intervals updated, Signal timings reviewed and updated
S. 40th Street & Normal Blvd	NB Rear End	Review signal timing clearance intervals	Clearance intervals updated
S. 48th Street & South Street	SB Rear End	Review signal timing clearance intervals	Clearance intervals updated
S. 48th Street & A Street	SB Rear End	Review and update signal timings	Updated signal timings
S. 48th Street & Randolph Street	SB Rear End	Update signal timing to improve coordination	Coordination improved with new timings
N. 48th Street & R Street	Rear End	Review and update signal timings	Updated signal timings
N. 48th Street & Holdrege Street	SB Rear End	Review signal timing clearance intervals	Clearance intervals updated
N. 48th Street & Adams Street	Left-turns	Review Signal Timing Clearance Intervals, install FYA	Clearance intervals updated, FYAs installed
N. 48th Street & Fremont Street	Bike/Ped	Update signal displays	Updated signal displays
N. 70th Street & Vine Street	EB & NB Rear Ends	Review signal timing clearance intervals	Clearance intervals updated
N. 70th Street & Holdrege Street	N/A	Review and update signal timings. Monitor recent conversion to FYA	Clearance intervals updated, Signal timings reviewed and updated. Too recent to review crash history since FYA conversion
A Street & S. Cotner Boulevard & S. 50th Street	WB Rear End	Review signal timing clearance intervals	Clearance intervals updated
A Street & S. 56th Street	Right Angle	Review signal timing clearance intervals	Clearance intervals updated
South Street & S. 20th Street	Right Angle and Rear End	Review signal timing clearance intervals	Clearance intervals updated
Superior Street & N. 27th Street	Rear End	Review and update signal timings	Updated signal timings
Pine Lake Road & S. 40th Street	All Crash Patterns	Review signal timing clearance intervals	Clearance intervals updated

APPENDIX C

Travel Time Results

Travel Time Results 1 of 2

Corridor	Period	Travel Time (Min:Sec)						Travel Time Change (Min:Sec)[1]		
		"Before"			"After"					
		NB/EB	SB/WB	Total	NB/EB	SB/WB	Total	NB/EB	SB/WB	Total
S. 27th Street (Yankee Hill Road – O Street)	AM	16:29	13:12	29:41	15:09	13:08	28:17	-1:20	-0:04	-1:24
	MM	14:16	13:27	27:43	12:35	11:21	23:56	-1:41	-2:06	-3:47
	MD	14:56	13:13	28:09	13:19	12:58	26:17	-1:37	-0:15	-1:52
	MA	17:09	14:05	31:14	15:43	12:55	28:38	-1:26	-1:10	-2:36
	PM	16:10	15:42	31:52	15:51	15:29	31:20	-0:19	-0:13	-0:32
	SA	14:29	13:56	28:25	13:15	12:31	25:46	-1:14	-1:25	-2:39
S. 40th Street (Yankee Hill Road – Randolph Street)	AM	15:31	14:18	29:49	12:21	13:42	26:03	-3:10	-0:36	-3:46
	MM	13:10	12:28	25:38	11:43	11:21	23:04	-1:27	-1:07	-2:34
	MD	13:25	12:12	25:37	11:48	11:28	23:16	-1:37	-0:44	-2:21
	MA	14:49	15:15	30:04	12:52	13:53	26:45	-1:56	-1:21	-3:17
	PM	14:49	15:15	30:04	12:52	13:53	26:45	-1:56	-1:21	-3:17
	SU	13:48	12:16	26:04	11:57	10:41	22:38	-1:51	-1:35	-3:26
S. 48th Street (Old Cheney Road – O Street)	AM	12:42	10:42	23:24	11:42	10:35	22:17	-1:00	-0:07	-1:07
	MM	10:55	11:20	22:15	9:51	10:27	20:18	-1:04	-0:53	-1:57
	MD	11:17	11:50	23:07	9:36	10:44	20:20	-1:41	-1:06	-2:47
	MA	12:10	14:09	26:19	12:00	12:16	24:16	-0:10	-1:53	-2:03
	PM	12:34	13:32	26:06	11:43	13:33	25:16	-0:51	0:01	-0:50
	SA	11:50	10:56	22:46	9:46	10:31	20:17	-2:04	-0:25	-2:29
N. 48th Street (O Street – Superior Street)	AM	9:20	8:22	17:42	7:11	8:07	15:18	-2:09	-0:15	-2:24
	MM	8:24	7:55	16:19	7:35	7:11	14:46	-0:49	-0:44	-1:33
	MD	8:35	8:15	16:50	7:40	8:02	15:42	-0:55	-0:13	-1:08
	MA	9:23	10:31	19:54	8:33	10:15	18:48	-0:50	-0:16	-1:06
	PM	8:59	10:28	19:27	8:36	10:14	18:50	-0:23	-0:14	-0:37
	SA	7:56	8:46	16:42	6:22	7:47	14:09	-1:34	-0:59	-2:33
S. 56th Street (Pine Lake Road – O Street)	AM	16:19	13:42	30:01	12:42	10:36	23:18	-3:36	-3:06	-6:42
	MM	11:39	11:15	22:54	10:46	11:04	21:50	-0:53	-0:10	-1:03
	MD	13:03	11:55	24:58	10:50	10:27	21:17	-2:13	-1:28	-3:41
	MA	12:43	13:43	26:26	11:33	12:49	24:22	-1:10	-0:54	-2:04
	PM	13:58	16:14	30:12	12:39	12:58	25:37	-1:19	-3:15	-4:34
	SA	11:45	12:02	23:47	10:07	10:15	20:22	-1:38	-1:47	-3:25
N. 70th Street (O Street – Havelock Avenue)	AM	6:47	7:55	14:42	6:57	6:38	13:35	0:11	-1:18	-1:07
	MM	6:38	7:33	14:11	5:52	6:22	12:14	-0:47	-1:12	-1:59
	MD	7:11	7:39	14:50	5:46	6:37	12:23	-1:26	-1:02	-2:28
	MA	8:20	8:54	17:14	7:18	8:06	15:24	-1:02	-0:48	-1:50
	PM	10:08	10:01	20:09	6:54	7:34	14:28	-3:13	-2:27	-5:40
	SA	7:07	7:28	14:35	5:52	6:34	12:26	-1:16	-0:54	-2:10

[1] Negative time values represent a decrease in travel time during the "After" condition; Positive time values represent an increase in travel time during the "After" condition.

Travel Time Results 2 of 2

Corridor	Period	Travel Time (Min:Sec)						Travel Time Change (Min:Sec)[1]		
		"Before"			"After"					
		NB/EB	SB/WB	Total	NB/EB	SB/WB	Total	NB/EB	SB/WB	Total
A Street (S. 27th Street – S. 84th Street)	AM	13:32	12:22	25:54	11:15	9:16	20:31	-2:17	-3:06	-5:23
	MM	10:27	11:05	21:32	8:24	9:21	17:45	-2:03	-1:44	-3:47
	MD	11:12	11:02	22:14	8:34	9:28	18:02	-2:38	-1:34	-4:12
	MA	12:28	11:35	24:03	11:28	11:55	23:23	-1:00	0:20	-0:40
	PM	11:50	13:18	25:08	11:12	11:54	23:06	-0:38	-1:24	-2:02
	SU	9:35	10:32	20:07	8:32	9:13	17:45	-1:03	-1:19	-2:22
Old Cheney Road (Warlick Boulevard – S. 84th Street)	AM	13:46	12:02	25:48	12:42	12:26	25:08	-1:04	0:24	-0:40
	MM	10:47	10:44	21:31	10:25	9:43	20:08	-0:22	-1:01	-1:23
	MD	11:14	10:16	21:30	10:23	10:36	20:59	-0:51	0:20	-0:31
	MA	12:10	13:02	25:12	10:31	14:03	24:34	-1:39	1:01	-0:38
	PM	14:29	13:25	27:54	13:41	14:26	28:07	-0:47	1:00	0:13
	SU	10:28	10:18	20:46	10:35	10:20	20:55	0:07	0:02	0:09
Pine Lake Road (S. 14th Street – S. 56th Street)	AM	7:38	6:03	13:41	6:38	5:49	12:27	-1:00	-0:14	-1:14
	MM	6:04	5:50	11:54	5:07	5:07	10:14	-0:57	-0:43	-1:40
	MD	6:06	5:58	12:04	6:10	6:01	12:11	0:04	0:03	0:07
	MA	6:34	6:40	13:14	5:42	6:27	12:09	-0:52	-0:13	-1:05
	PM	6:35	6:11	12:46	6:08	6:18	12:26	-0:27	0:07	-0:20
	SA	6:30	6:02	12:32	5:19	5:31	10:50	-1:11	-0:31	-1:42
South Street (S. 9th Street – S. 56th Street)	AM	10:58	10:47	21:45	9:00	9:32	18:32	-1:58	-1:15	-3:13
	MM	8:07	8:37	16:44	7:34	8:22	15:56	-0:33	-0:15	-0:48
	MD	8:27	8:40	17:07	8:07	8:24	16:31	-0:20	-0:16	-0:36
	MA	9:22	8:22	17:44	10:19	10:14	20:33	0:57	1:52	2:49
	PM	11:39	10:00	21:39	11:12	9:56	21:08	-0:27	-0:04	-0:31
	SA	8:22	8:02	16:24	7:52	8:06	15:58	-0:30	0:04	-0:26
Superior Street (NW 1st St & W. Highlands Blvd to N. 62nd St & Havelock Ave)	AM	10:55	9:41	20:36	10:25	8:25	18:50	-0:30	-1:16	-1:46
	MM	9:55	8:55	18:50	8:05	8:35	16:40	-1:50	-0:20	-2:11
	MD	9:55	8:46	18:41	8:30	8:44	17:14	-1:25	-0:02	-1:27
	MA	10:45	10:51	21:36	9:24	9:20	18:44	-1:21	-1:31	-2:52
	PM	10:49	9:09	19:58	9:18	9:16	18:34	-1:31	0:07	-1:24
	SA	10:06	10:55	21:01	8:30	8:56	17:26	-1:36	-1:59	-3:35
West O Street (NW 48th Street – N. 1st Street)	AM	5:21	5:54	11:15	5:01	5:14	10:15	-0:20	-0:40	-1:00
	MM	5:27	5:20	10:47	5:01	4:56	9:57	-0:26	-0:24	-0:50
	MD	5:37	5:17	10:54	4:48	5:26	10:14	-0:49	0:09	-0:40
	MA	5:31	5:23	10:54	5:09	4:47	9:56	-0:22	-0:36	-0:58
	PM	5:57	5:17	11:14	5:35	4:58	10:33	-0:22	-0:19	-0:41
	SA	5:38	5:37	11:15	5:10	5:00	10:10	-0:28	-0:37	-1:05

[1] Negative time values represent a decrease in travel time during the "After" condition; Positive time values represent an increase in travel time during the "After" condition.

APPENDIX D

Corridor Performance Measures

Travel Time Run System Evaluation

S. 27th Street from Yankee Hill Road to O Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
S. 27th Street	AM	6,036	15%	14,356	1%	4,460	3%	310,177	3%	60,349	3%	71,882	3%
	MM	12,396	42%	836,401	33%	16,536	11%	1,158,914	11%	225,483	11%	268,607	11%
	MD	6,452	22%	520,619	21%	9,685	7%	674,231	7%	131,220	7%	156,270	7%
	MA	9,551	21%	551,242	16%	11,519	6%	805,022	6%	156,625	6%	186,544	6%
	PM	-1,812	-3%	146,639	3%	2,138	1%	148,111	1%	28,786	1%	34,296	1%
	SA	10,236	30%	621,213	21%	12,272	8%	855,962	8%	166,525	8%	198,390	8%
	Total	42,859	18%	2,690,469	14%	56,609	5%	3,952,416	5%	768,988	5%	915,990	5%

Delay Reduction Per Year (hours)	42,859
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.32
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$787,684**
Fuel Consumption Reduction per Year (Gallons)	56,609
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$150,581**
Total Savings per Year	**$938,265**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

S. 40th Street from Yankee Hill Road to Randolph Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
S. 40th Street	AM	12,827	35%	895,199	36%	19,025	16%	1,328,234	16%	258,434	16%	307,807	16%
	MM	2,077	19%	254,143	28%	3,477	7%	243,736	7%	47,418	7%	56,468	7%
	MD	3,387	19%	387,426	26%	5,051	6%	350,096	6%	68,090	6%	81,116	6%
	MA	5,966	21%	430,076	22%	8,617	9%	603,186	9%	117,366	9%	139,800	9%
	PM	8,447	13%	595,882	14%	12,512	6%	874,048	6%	170,070	6%	202,602	6%
	WE	7,172	34%	722,467	38%	10,358	11%	724,589	11%	140,941	11%	167,939	11%
	Total	39,876	23%	3,285,193	26%	59,040	10%	4,123,889	10%	802,319	10%	955,732	10%

Delay Reduction Per Year (hours)	39,876
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.28
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$731,169**
Fuel Consumption Reduction per Year (Gallons)	59,040
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$157,046**
Total Savings per Year	**$888,215**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

S. 48th Street from Old Cheney Road to O Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
S. 48th Street	AM	4,393	17%	314,114	17%	5,087	6%	358,087	6%	69,652	6%	82,997	6%
	MM	4,462	27%	261,049	20%	5,141	8%	358,002	8%	69,636	8%	82,949	8%
	MD	8,985	35%	686,079	31%	10,973	12%	765,844	12%	149,017	12%	177,524	12%
	MA	6,146	17%	614,466	22%	7,728	7%	541,159	7%	105,251	7%	125,418	7%
	PM	1,536	3%	40,763	1%	645	0%	47,606	0%	9,224	0%	11,009	0%
	SA	8,170	32%	1,014,125	37%	13,686	14%	955,677	14%	185,952	14%	221,478	14%
	Total	33,692	19%	2,930,596	21%	43,261	8%	3,026,375	8%	588,732	8%	701,376	8%

Delay Reduction Per Year (hours)	33,692
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.32
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$619,552**
Fuel Consumption Reduction per Year (Gallons)	43,261
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$115,073**
Total Savings per Year	**$734,625**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

N. 48th Street Performance Measures

Travel Time Run System Evaluation

N. 48th Street from O Street to Superior Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
N. 48th Street	AM	6,641	32%	271,048	16%	6,829	9%	476,485	9%	92,684	9%	110,454	9%
	MM	4,941	39%	285,566	24%	5,295	9%	370,318	9%	72,053	9%	85,827	9%
	MD	4,634	25%	593,443	33%	6,987	9%	485,403	9%	94,445	9%	112,483	9%
	MA	3,833	11%	53,030	2%	3,386	3%	237,624	3%	46,222	3%	55,054	3%
	PM	3,553	8%	844,071	22%	7,984	5%	555,458	5%	108,057	5%	128,736	5%
	SA	11,188	52%	898,186	41%	15,350	17%	1,073,530	17%	208,874	17%	248,768	17%
	Total	34,790	23%	2,945,344	22%	45,832	8%	3,198,817	8%	622,334	8%	741,322	8%

Delay Reduction Per Year (hours)	34,790
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.37
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$641,688**
Fuel Consumption Reduction per Year (Gallons)	45,832
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$121,912**
Total Savings per Year	**$763,600**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

S. 56th Street from Pine Lake Road to O Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
S. 56th Street	AM	22,524	43%	1,755,408	46%	32,628	21%	2,279,986	21%	443,609	21%	528,384	21%
	MM	2,290	17%	496,098	40%	5,430	8%	379,091	8%	73,740	8%	87,849	8%
	MD	9,669	37%	873,247	43%	14,089	13%	984,249	13%	191,510	13%	228,119	13%
	MA	3,457	10%	131,982	6%	3,152	3%	221,350	3%	43,081	3%	51,275	3%
	PM	21,729	26%	1,421,150	26%	27,027	11%	1,892,354	11%	368,206	11%	438,574	11%
	WE	11,841	45%	1,046,739	53%	17,555	16%	1,226,326	16%	238,618	16%	284,211	16%
	Total	71,510	30%	5,724,625	34%	99,880	12%	6,983,357	12%	1,358,763	12%	1,618,411	12%

Delay Reduction Per Year (hours)	71,510
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.28
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$1,311,206**
Fuel Consumption Reduction per Year (Gallons)	99,880
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$265,681**
Total Savings per Year	**$1,576,887**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

N. 70th Street Performance Measures

Travel Time Run System Evaluation

N. 70th Street from O Street to Havelock Avenue
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
N. 70th Street	AM	3,563	30%	265,778	26%	4,792	9%	335,754	9%	65,326	9%	77,834	9%
	MM	3,011	48%	238,021	45%	4,096	14%	286,936	14%	55,812	14%	66,515	14%
	MD	5,475	52%	465,683	52%	7,287	16%	510,372	16%	99,299	16%	118,291	16%
	MA	4,437	26%	481,729	40%	6,812	13%	477,131	13%	92,872	13%	110,583	13%
	PM	23,146	55%	1,446,613	51%	27,747	25%	1,939,940	25%	377,426	25%	449,579	25%
	WE	5,405	49%	831,293	70%	10,192	20%	709,530	20%	138,029	20%	164,403	20%
	Total	45,038	43%	3,729,117	47%	60,926	17%	4,259,663	17%	828,763	17%	987,206	17%

Delay Reduction Per Year (hours)	45,038
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.54
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$839,919**
Fuel Consumption Reduction per Year (Gallons)	60,926
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$162,064**
Total Savings per Year	**$1,001,982**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

A Street from S. 27th Street to S. 84th Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
A Street	AM	9,396	43%	704,023	51%	12,332	18%	862,238	18%	167,784	18%	199,848	18%
	MM	4,066	49%	397,789	57%	5,793	16%	403,506	16%	78,537	16%	93,539	16%
	MD	4,957	47%	498,058	56%	7,410	16%	519,506	16%	101,072	16%	120,382	16%
	MA	1,170	5%	591,981	32%	5,336	7%	372,242	7%	72,424	7%	86,225	7%
	PM	6,842	20%	1,051,980	39%	12,816	11%	896,074	11%	174,373	11%	207,677	11%
	SU	2,933	32%	506,854	52%	6,323	13%	441,875	13%	85,987	13%	102,419	13%
	Total	29,364	29%	3,750,687	45%	50,011	13%	3,495,440	13%	680,179	13%	810,090	13%

Delay Reduction Per Year (hours)	29,364
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.30
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$539,264**
Fuel Consumption Reduction per Year (Gallons)	50,011
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$133,031**
Total Savings per Year	**$672,295**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Old Cheney Road Performance Measures

Travel Time Run System Evaluation

Old Cheney Road from Warlick Boulevard to S. 84th Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
Old Cheney Road	AM	1,921	5%	-332,721	-15%	-1,010	-1%	-70,210	-1%	-13,659	-1%	-16,272	-1%
	MM	3,361	28%	269,058	24%	5,090	8%	354,430	8%	68,977	8%	82,142	8%
	MD	2,096	11%	183,241	11%	2,878	3%	203,383	3%	39,595	3%	47,115	3%
	MA	2,033	7%	143,117	8%	3,452	3%	242,753	3%	47,223	3%	56,252	3%
	PM	-548	-1%	-519,248	-13%	-5,194	-2%	-362,784	-2%	-70,586	-2%	-84,082	-2%
	WE	218	1%	57,200	4%	1,331	1%	89,149	1%	17,306	1%	20,634	1%
	Total	9,081	6%	-199,353	1%	6,546	2%	456,721	2%	88,856	2%	105,788	2%

Delay Reduction Per Year (hours)	9,081
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.28
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$166,565**
Fuel Consumption Reduction per Year (Gallons)	6,546
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$17,412**
Total Savings per Year	**$183,976**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

Pine Lake Road from S. 14th Street to S. 56th Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
Pine Lake Road	AM	5,208	30%	412,507	31%	8,515	12%	596,536	12%	116,078	12%	138,252	12%
	MM	3,842	47%	312,154	39%	6,791	14%	474,293	14%	92,273	14%	109,960	14%
	MD	-1,018	-9%	22,905	2%	921	1%	66,452	2%	12,930	2%	15,424	2%
	MA	5,210	29%	487,981	30%	9,016	11%	631,174	11%	122,805	11%	146,284	11%
	PM	3,351	13%	259,815	13%	5,986	5%	423,310	5%	82,336	5%	98,136	5%
	SA	5,095	37%	290,534	26%	8,112	11%	568,464	11%	110,614	11%	131,747	11%
	Total	21,687	24%	1,785,896	23%	39,341	9%	2,760,228	9%	537,036	9%	639,802	9%

Delay Reduction Per Year (hours)	21,687
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.28
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$397,552**
Fuel Consumption Reduction per Year (Gallons)	39,341
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$104,648**
Total Savings per Year	**$502,200**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Travel Time Run System Evaluation

South Street from S. 9th Street to S. 56th Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
South Street	AM	9,736	37%	756,264	35%	12,650	16%	884,462	16%	172,117	16%	204,994	16%
	MM	1,665	16%	-92,771	-10%	691	1%	47,383	1%	9,208	1%	11,011	1%
	MD	1,171	12%	204,557	19%	2,230	5%	156,404	5%	30,416	5%	36,239	5%
	MA	-6,409	-43%	-709,450	-61%	-10,267	-16%	-719,276	-16%	-139,954	-16%	-166,709	-16%
	PM	1,544	4%	116,027	4%	1,776	2%	124,562	2%	24,263	2%	28,855	2%
	SA	1,343	13%	-61,485	-5%	790	1%	56,909	1%	11,024	1%	13,187	1%
	Total	9,050	10%	213,142	4%	7,869	3%	550,445	3%	107,073	3%	127,578	3%

Delay Reduction Per Year (hours)	9,050
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.50
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$168,295**
Fuel Consumption Reduction per Year (Gallons)	7,869
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$20,932**
Total Savings per Year	**$189,227**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

Superior Street Performance Measures

Travel Time Run System Evaluation

Superior Street from NW 1st St & W. Highlands Blvd to N. 62nd St & Havelock Ave
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
Superior Street	AM	6,095	26%	38,781	2%	4,286	4%	297,703	4%	57,945	4%	68,990	4%
	MM	4,753	58%	256,982	30%	5,486	9%	381,943	9%	74,317	9%	88,551	9%
	MD	3,853	35%	260,871	21%	4,811	6%	334,535	6%	65,095	6%	77,498	6%
	MA	12,815	43%	466,232	19%	13,101	10%	917,449	10%	178,485	10%	212,636	10%
	PM	6,296	21%	-874,294	-42%	-3,140	-2%	-219,972	-2%	-42,787	-2%	-51,031	-2%
	SA	13,803	64%	670,093	35%	16,432	15%	1,150,656	15%	223,850	15%	266,698	15%
	Total	47,615	39%	818,665	10%	40,976	6%	2,862,315	6%	556,904	6%	663,342	6%

Delay Reduction Per Year (hours)	47,615
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.38
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$878,802**
Fuel Consumption Reduction per Year (Gallons)	40,976
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$108,996**
Total Savings per Year	**$987,798**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.

West O Street Performance Measures

Travel Time Run System Evaluation

West O Street from NW 48th Street to 1st Street
Comparison of Before and After Travel Time Runs

Traffic Signal System Optimization Project - Phase 2
Project number: 702961

	Period	Delay Saved Veh-Hrs/Yr	Reduction Delay %	Stops Saved Veh-Stops/Yr	Reduction Stops %	Fuel Saved Gal/Yr	Reduction Fuel %	Carbon Monoxide Emissions Saved grams/Yr	Reduction Carbon Monoxide %	Nitrogen Oxides Emissions Saved grams/Yr	Reduction Nitrogen Oxides %	Volatile Oxygen Compounds Emissions Saved grams/Yr	Reduction Volatile Oxygen %
West O Street	AM	3,030	53%	245,283	46%	5,655	10%	396,270	10%	77,115	10%	91,846	10%
	MM	2,039	61%	137,776	40%	3,184	8%	224,754	8%	43,738	8%	52,064	8%
	MD	2,352	48%	6,089	2%	2,105	4%	146,127	4%	28,451	4%	33,863	4%
	MA	3,594	71%	413,459	75%	6,955	12%	484,890	12%	94,358	12%	112,353	12%
	PM	3,094	34%	192,716	25%	4,988	5%	347,477	5%	67,595	5%	80,563	5%
	SA	4,186	61%	197,600	39%	5,658	9%	396,531	10%	77,126	10%	91,853	10%
	Total	18,294	53%	1,192,922	40%	28,545	8%	1,996,049	8%	388,384	8%	462,543	8%

Delay Reduction Per Year (hours)	18,294
Value of Travel Time Savings ($/Hour) (Personal Travel)	$14.44
Value of Travel Time Savings ($/Hour) (Business Travel)	$28.87
Value of Travel Time Savings ($/Hour) (Truck Travel)	$28.55
Cost per Hour of Delay	$15.69
Average Vehicle Occupancy	1.2
Cost Saving per Year of Delay Reduction	**$344,550**
Fuel Consumption Reduction per Year (Gallons)	28,545
Cost of Fuel per Gallon	$2.66
Cost Saving per Year for Fuel Consumption Reduction	**$75,929**
Total Savings per Year	**$420,479**

Note: Total savings reported represent annual savings during the periods of travel time run data collection only. Savings outside of the times of day for which travel time run data was collected are not reported and would be in addition to those reported.