City of McAllen Signal Study
Final Report

McAllen, Texas

Prepared for:

City of McAllen
210 N. 20th Street
McAllen, Texas 78501

Prepared by:

Kimley-Horn and Associates, Inc.

July 25, 2008

KHA # 068583000

Kimley-Horn
and Associates, Inc.

Kimley-Horn and Associates, Inc.

Table of Contents

List of Figures

Kimley-Horn and Associates, Inc.

List of Tables

Technical Appendices

Appendix A – Intersection Geometry

Appendix B – Traffic Counts
- Turning-movement counts
- 24-hour counts and speed data

Appendix C – Synchro 6.0 HCM Analysis
- AM Highway Capacity Manual analysis
- PM Highway Capacity Manual analysis

Appendix D – Time-space Diagrams
- AM Time-space diagrams
- PM Time-space diagrams

Appendix E – Alternative Analysis
- Intersection Improvement Geometry
- Time Benefit Calculations
- Opinion of Probabale Cost Worksheets

Executive Summary

Kimley-Horn and Associates, Inc. performed a comprehensive traffic study for the City of McAllen, Texas. The project includes developing a coordinated timing plan for 125 intersections in the city and identifying operational deficiencies at 22 intersections and recommending improvements.

The City of McAllen roadway network can be divided into 12 corridors: seven running north-south and five running east-west. The lengths of the corridors range from 2.2 miles to six miles with average signal spacing from five to two signals per mile. Most corridors have two lanes in each direction and a continuous center-turn lane or left-turn bays at signalized intersections.

The existing roadway conditions, measured with existing delays, travel times, and Level of Service (LOS), are presented here as the base condition. These measures lay the groundwork for improvement of the system through coordinated timing and intersection modifications.

Cycle lengths, timing patterns, and controller offsets were selected for the morning, afternoon and off peak periods to obtain progression in all study corridors. These updated timing plans were entered into the City's closed loop software program and lab tested prior to field implementation. Following this, the timing plans were then downloaded to each of the intersections in the field, along with an updated clock setting.

Fine tuning of the signal network was conducted over a two week period, with offsets and phase splits being adjusted as needed.

1. Introduction

1.1. Project Overview

Kimley-Horn and Associates, Inc. is performing a comprehensive traffic study for the City of McAllen, Texas. The purpose of the project is to study the major corridors in the city and to suggest methods to reduce travel times, congestion, and preventable accidents. The first portion of this study focused on developing a coordinated timing plan for 12 corridors in the city. This task required data collection, the development and analysis of baseline Synchro models, and optimization of the Synchro models. The final portion of the study reviews individual intersections, identifies deficiencies, and recommends improvements. For this task, the intersections were modeled with HCS+™ software, concept sketches of the proposed improvements were made, and a benefit-cost analysis was performed for each intersection.

The existing roadway conditions, measured with existing delays, travel times, and Level of Service (LOS), are presented in the report as the base condition. These measures lay the groundwork for improvement of the system through coordinated timing and intersection modifications.

Cycle lengths, timing patterns, and controller offsets were selected for the morning, afternoon and off peak periods to obtain progression in all study corridors. These updated timing plans were entered into the City's closed loop software program and lab tested prior to field implementation. Following this, the timing plans were then downloaded to each of the intersections in the field, along with an updated clock setting.

Fine tuning of the signal network was conducted over a two week period, with offsets and phase splits being adjusted as needed.

1.2. Network Description

The City of McAllen network is bound by Ware Road to the west, McColl Street to the east, and Trenton Road to the north. On the south side US 83 forms the general boundary although the study includes some intersections which are further to the south. As the streets in McAllen follow a grid pattern, the entire network has been divided into 12 corridors running east-west and north-south, which contain 125 intersections, as shown in **Figure 1-1**. There are seven north-south corridors and five running east-west. These are listed below in **Table 1-1**.

The lengths of the corridors range from 2.2 miles (29th Street) to six miles (10th Street) with average signal spacing from five to two signals per mile. Most corridors have two lanes in each direction and a continuous center turn lane or left-turn bays at signalized intersections. The speed limits in the network vary from 30 mph to 55 mph. Only a small stretch of corridor between Dove Avenue and Nolana on McColl Road has a speed of 55 mph. The network also has several school zones where the speed limits are lower during certain times of the day.

The existing traffic signals at the intersections are deployed by either mast-arms or span-wires. Some segments of the network have coordinated signal timing plans with the cycle lengths varying between 66 seconds and 120 seconds with the majority at 90 and 100 seconds.

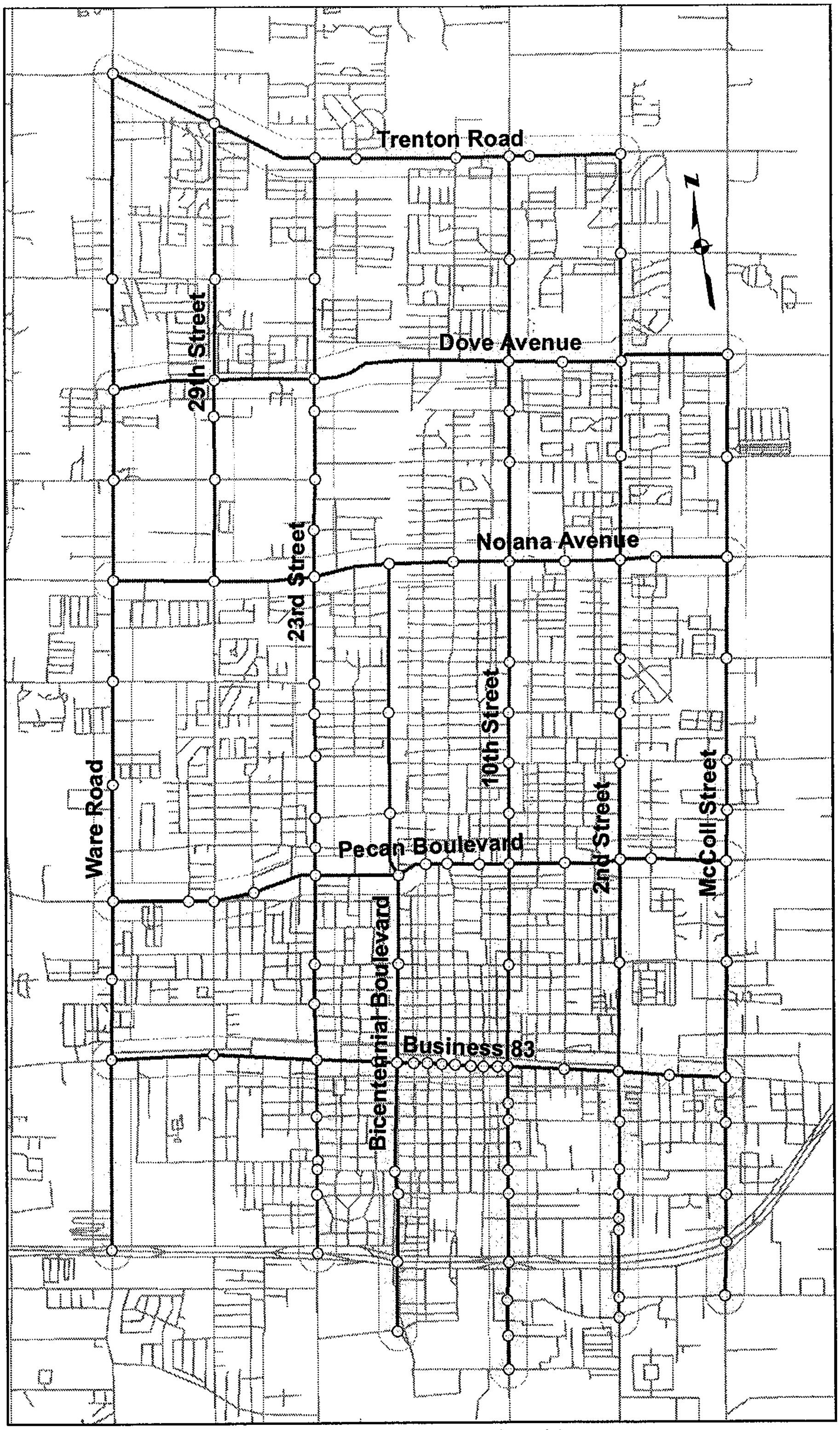

Figure 1-1: Project Corridors

Table 1-1: Corridor Statistics

	Extent		Length	No.	Signal Spacing (mi)		
	North	South	(mi)	Signals	Average	Min	Max
N-S Corridors							
Ware Rd.	Trenton	US 83	5.8	11	0.5	0.44	1.00
29th Street	Trenton	Nolana	2.2	6	0.4	0.19	0.73
23rd Street	Trenton	US 83	5.4	20	0.3	0.13	0.60
Bicentennial	Trenton	Uvalde	3.8	10	0.4	0.12	0.75
10th Street	Trenton	Wichita	6.0	20	0.3	0.09	1.00
2nd Street	Trenton	Savannah	5.7	17	0.3	0.11	0.53
McColl Street	Dove	Ridge	4.7	13	0.4	0.22	0.58
	Extent		Length	No.	Signal Spacing (mi)		
	West	East	(mi)	Signals	Average	Min	Max
E-W Corridors							
Trenton Road	Ware	2nd Street	2.6	8	0.3	0.10	0.57
Dove Avenue	Ware	McColl	3.1	7	0.4	0.27	0.98
Nolana Avenue	Ware	McColl	3.1	10	0.3	0.17	0.51
Pecan Blvd.	Ware	McColl	3.1	14	0.2	0.11	0.41
Business 83	Ware	McColl	3.1	17	0.2	0.06	0.52

2. Data Collection

2.1. Intersection Geometry

Prior to conducting field visits, draft intersection layouts were created from aerial imagery. Discrepancies with actual field conditions were noted during the visits. The following information was verified at each intersection: number of lanes per approach, movement designations (i.e., left only, left/straight, straight only, straight/right, right only, or left/straight/right), turn bays, and other information pertinent to the accurate modeling of signal operations (e.g., "free" right-turn movements). The sketches in **Appendix A** show the final intersection geometries used in the baseline Synchro files.

2.2. Turning Movement Counts

Turning movement counts for the weekday AM and PM peak periods were collected at 105 intersections by Kimley-Horn's subconsultants. Volumes were provided for two hours during each period, from 7:00 AM to 9:00 AM in the morning and from 4:00 PM to 6:00 PM in the evening. The City of McAllen provided 10-minute counts for an additional 20 intersections. For these intersections, peak-period hourly volumes were extrapolated using peak-hour factors from adjacent intersections.

All of the turning movement counts were made on a Tuesday, Wednesday, or Thursday to capture typical traffic conditions. The raw turning movement count data are provided in tabular form in **Appendix B**. In some instances these volumes may vary from those used in the Synchro models due to calibrations made for volume balancing.

2.3. 24-hour Counts

Directional daily traffic volumes were collected by Kimley-Horn's subconsultants on the same 25 segments in the network. These are included in **Appendix B**. They were used generate approach volumes to verify peak hour counts, identify directionality (see **Table 2-1**), and determine appropriate hours for timing plans. As expected, most corridors experience a nearly 50/50 split over the course of a day.

2.4. 85th-Percentile Speeds

Along with 24-hour traffic volume counts, speed data was collected on 25 segments in the network. The City of McAllen also provided 85th percentile speed data from a TxDOT speed study. The comparison of the 85-precentile speeds with the posted speed limits is presented in **Table 2-2**. The segments with a difference between the actual speed and posted speed of five or more miles per hour are noted in bold. In some instances, it may be appropriate to use the 85th percentile speed for modeling purposes.

Table 2-1: Traffic Volume Directionality

Street	North / East Limit	South / West Limit	Directional Split		
			7:00 AM	5:00 PM	Daily
23rd Street	Business 83	US 83	52/48	49/51	52/48
Bicentennial Blvd.	Nolana Avenue	Harvey Avenue	50/50	46/54	48/52
	Business 83	US 83	49/51	56/44	48/52
10th Street	Dallas Avenue	Dallas Avenue	58/42	47/53	53/47
	Pecan Blvd.	Bus. 83	15/85	48/52	53/47
	Jackson Avenue	US 83	60/40	53/47	56/44
	US 83	Wichita Avenue	26/74	53/47	50/50
2nd. Street	Dove Avenue	Nolana Avenue	33/67	57/43	52/48
	Nolana Avenue	Pecan Blvd.	40/60	55/45	51/49
	Pecan Blvd.	US 83	42/58	54/46	50/50
	US 83	Savannah Avenue	62/38	47/53	53/47
McColl Road	Dove Avenue	Nolana Avenue	41/59	50/50	50/50
	Nolana Avenue	Pecan Blvd.	39/61	44/56	44/56
	Pecan Blvd.	US 83	51/49	45/55	49/51
Trenton Road	23rd Street	29th Street	75/25	55/45	52/48
	10th Street	23rd Street	70/30	44/56	51/49
	2nd Street	10th Street	64/36	47/53	53/47
Nolana Avenue	10th Street	23rd Street	50/50	48/52	49/51
	2nd Street	10th Street	55/45	53/47	56/44
Pecan Blvd.	23rd Street	Ware Road	30/70	58/42	49/51
	10th Street	23rd Street	45/55	51/49	49/51
	2nd Street	10th Street	46/54	46/54	49/51
	McColl Road	2nd Street	65/35	65/35	58/42
Business 83	Ware Road	10th Street	54/46	48/52	48/52
	10th Street	McColl Road	33/67	51/49	57/43

Table 2-2: 85th-Percentile Speeds

Street	North / East Limit	South / West Limit	Posted Speed Limit	85th Percentile Speed	Difference (Actual – Posted)
Ware Road	Trenton Road	US 83	50	50	0
23rd Street	Trenton Road	Dove Avenue	45	45	-1
	Dove Avenue	Pecan Blvd.	40	42	2
	Pecan Blvd.	Bus. 83	30	37	7
	Business 83	US 83	30	29	-2
Bicentennial Blvd.	Nolana Avenue	Harvey Avenue	45	40	-6
	Business 83	US 83	40	42	2
10th Street	Trenton Road	Dove Avenue	50	50	0
	Dove Avenue	Esperanza Avenue	40	41	1
	Dallas Avenue	Dallas Avenue	30	33	3
	Pecan Blvd.	Bus. 83	30	42	12
	Jackson Avenue	US 83	30	34	4
	US 83	Wichita Avenue	30	35	5
2nd Street	Dove Avenue	Nolana Avenue	45	45	-1
	Nolana Avenue	Pecan Blvd.	45	46	1
	Pecan Blvd.	US 83	45	47	2
	US 83	Savannah Avenue	40	36	-4
McColl Road	Dove Avenue	Nolana Avenue	45	45	0
	Nolana Avenue	Pecan Blvd.	45	39	-7
	Pecan Blvd.	US 83	45	43	-3
Trenton Road	23rd Street	29th Street	45	44	-2
	10th Street	23rd Street	45	45	-1
	2nd Street	10th Street	40	45	5
Nolana Avenue	10th Street	23rd Street	40	45	5
	2nd Street	10th Street	40	41	1
Pecan Blvd.	23rd Street	Ware Road	35	47	12
	10th Street	23rd Street	30	35	5
	2nd. St	10th Street	35	35	-1
	McColl Road	2nd Street	35	38	3
Business 83	Ware Road	10th Street	45	40	-5
	10th Street	McColl Road	30	42	12

2.5. *Existing Signal Operations*

2.5.1. Signal Timing and Phasing

The City of McAllen provided information on existing signal timing plans and phasing for all of the signalized intersections in the network. This information included phase sequences and controller timing parameters, such as minimums, maximums, yellows, all-reds, walks, pedestrian clearances, and recalls.

2.5.2. Existing Coordination Timing

The City of McAllen also provided information on existing coordination parameters, including cycle lengths, splits, and offsets.

2.5.3. Signal Hardware

Data on the existing signal hardware, including signal heads, pedestrian signals, and vehicle detectors, was provided by the City of McAllen.

2.5.4. Communications

Prior to this study, the traffic signal communication network consisted mainly of spread spectrum radio using the Streetwise closed loop software. Currently the system is not operational as crucial repeaters were removed due to water tower repairs. Even after these repeaters are replaced, it is likely that there will be a need for additional repeaters and radios to maintain existing coordination. In addition, several additional on-street signal master controllers may be required to maintain coordination along the various corridors.

3. Existing Conditions Traffic Analysis

3.1. Traffic Modeling Process

Analysis of existing traffic conditions was conducted using the Synchro 6™ modeling software. Synchro 6™ is a software package for modeling and optimizing traffic signal timings. Synchro implements the methods of the 2000 Highway Capacity Manual and includes capacity analysis, coordination analysis, and a graphical interface for developing time-space diagrams.

The existing conditions model was developed using existing traffic counts, lane geometries, traffic control, and signal timing. This model was compared to observed conditions and calibrated to match. It is intended to be used as a base against which to measure the impact of future scenarios with optimized, coordinated signal timing plans.

3.2. Level of Service Evaluations

All capacity analyses were conducted with the Synchro 6™ software package using the associated Highway Capacity Manual (HCM) reporting module for the signalized intersections. These capacity analyses were expressed in the form of average delay and Level of Service.

Level of Service, which is a measure of the degree of congestion and/or delay, ranges from Level of Service (LOS) A (free flowing) to LOS F (congested, forced flow condition). It is generally accepted practice to consider LOS D as the minimal acceptable level of traffic operations in an urban environment. A description of each operational state for both unsignalized and signalized intersections is presented in **Table 3-1**. Analysis results for each intersection along the corridor are provided in **Table 3-2**.

Table 3-1: Definition of Level of Service for Signalized and Unsignalized Intersections

LOS	Average Control Delay per Vehicle (sec/veh)		Description
	Signalized	Unsignalized	
A	≤ 10	≤ 10	No delays at intersections with continuous flow traffic. Uncongested operations; high frequency of long gaps available for all left and right turning traffic; no observable queues.
B	> 10 and ≤ 20	> 10 and ≤ 15	
C	> 20 and ≤ 35	> 15 and ≤ 25	Moderate delays at intersections with satisfactory to good traffic flow. Light congestion; infrequent backups on critical approaches.
D	> 35 and ≤ 55	> 25 and ≤ 35	Increased probability of delays along every approach. Significant congestion on critical approaches, but intersection functional. No long standing lines formed.
E	> 55 and ≤ 80	> 35 and ≤ 50	Heavy traffic flow condition. Heavy delays probable. No available gaps for cross-street traffic or main street turning traffic. Limit of stable flow.
F	> 80	> 50	Unstable traffic flow. Heavy congestion. Traffic moves in forced flow condition. Average delays greater than one minute highly probable. Total breakdown.

Table 3-2: Signalized Intersection Levels of Service for Existing Conditions

Intersection	AM Peak		PM Peak	
	Delay	LOS	Delay	LOS
Trenton Road & Ware Road	21.8	C	25.5	C
Trenton Road & 29th Street	16.0	B	16.1	B
Trenton Road & 23rd Street	35.9	D	29.9	C
Trenton Road & 21st Street	27.8	C	29.1	C
Trenton Road & Main Street	12.5	B	25.0	C
Trenton Road & 10th Street	48.2	D	54.1	D
Trenton Road & 8th Street	26.4	C	24.8	C
Trenton Road & 2nd Street	31.4	C	36.0	D
Lark Avenue & Ware Road	33.1	C	29.4	C
Lark Avenue & 29th Street	30.7	C	26.2	C
Lark Avenue & 23rd Street	27.5	C	19.1	B
Martin Avenue & 2nd Street	**115.3**	**F**	9.8	A
Dove Avenue & Ware Road	23.6	C	20.8	C
Dove Avenue & 29th Street	42.1	D	**71.3**	**E**
Dove Avenue & 23rd Street	41.9	D	44.7	D
Dove Avenue & 10th Street	50.1	D	44.0	D
Dove Avenue & 6th Street	8.4	A	9.8	A
Dove Avenue & 2nd Street	21.7	C	21.1	C
Dove Avenue & McColl Road	30.8	C	46.9	D
Zinnia Avenue & 29th Street	12.5	B	11.1	B
Industrial & 23rd Street	4.4	A	7.3	A
Zinnia Avenue & 10th Street	24.2	C	22.8	C
Buddy Owens Blvd & Ware Road	32.8	C	26.1	C
Buddy Owens Blvd & 29th Street	34.2	C	35.6	D
Buddy Owens Blvd & 23rd Street	5.4	A	4.8	A
Violet Avenue & 10th Street	6.4	A	10.8	B
Violet Avenue & 2nd Street	36.7	D	34.8	C
Violet Avenue & McColl Road	20.0	C	15.9	B
Primrose Avenue & 23rd Street	13.1	B	8.6	A
Nolana Avenue & Ware Road	25.5	C	26.4	C
Nolana Avenue & 29th Street	32.1	C	33.7	C
Nolana Avenue & 23rd Street	**75.9**	**E**	50.3	D
Nolana Avenue & Bicentennial	22.6	C	17.6	B
Nolana Avenue & Main	19.7	B	21.7	C
Nolana Avenue & 10th Street	32.5	C	44.2	D
Nolana Avenue & 6th Street	17.9	B	11.6	B
Nolana Avenue & 2nd Street	32.1	C	32.1	C
Nolana Avenue & 1st Street	16.7	B	27.0	C
Nolana Avenue & McColl Road	32.3	C	31.7	C
Daffodil Avenue & Ware Road	36.1	D	23.5	C
Daffodil Avenue & 23rd Street	11.1	B	9.3	A
Fern Avenue & 10th Street	21.9	C	18.1	B
Fern Avenue & 2nd Street	6.9	A	7.3	A
Fern Avenue & McColl Road	15.5	B	13.2	B
Harvey Avenue & 23rd Street	12.0	B	11.1	B
Harvey Avenue & Bicentennial	21.0	C	22.9	C
Harvey Avenue & 10th Street	23.2	C	20.2	C
Harvey Avenue & 2nd Street	23.3	C	17.5	B
La Vista Avenue & 23rd Street	39.3	D	38.6	D
La Vista Avenue & 10th Street	23.8	C	23.8	C

Table 3-2a: Signalized Intersection Levels of Service for Existing Conditions (continued)

Intersection	AM Peak		PM Peak	
	Delay	LOS	Delay	LOS
La Vista Avenue & 2nd Street	35.5	D	19.8	B
La Vista Avenue & McColl Road	14.6	B	12.5	B
Vine & Ware Road	9.6	A	11.3	B
Tamarack Avenue & 23rd Street	44.2	D	35.3	D
Tamarack Avenue & Bicentennial	26.6	C	29.6	C
Tamarack Avenue & 10th	11.4	B	12.2	B
Tamarack & McColl Road	9.6	A	4.6	A
Quince & 23rd Street	27.4	C	21.3	C
Pecan Boulevard & Ware Road	25.4	C	26.3	C
Pecan Boulevard & 31st Street	12.6	B	11.7	B
Pecan Boulevard & 29th Street	5.6	A	11.1	B
Pecan Boulevard & 27th Street	32.4	C	30.6	C
Pecan Boulevard & 23rd Street	16.8	B	18.8	B
Pecan Boulevard & Bicentennial	21.4	C	27.7	C
Pecan Boulevard & 16th	11.8	B	11.9	B
Pecan Boulevard & Main	6.5	A	5.2	A
Pecan Boulevard & 12th Street	27.1	C	54.2	D
Pecan Boulevard & 10th Street	29.2	C	40.6	D
Pecan Boulevard & 6th Street	22.8	C	20.6	C
Pecan Boulevard & 2nd Street	34.8	C	22.0	C
Pecan Boulevard & 1st Street	45.7	D	18.7	B
Pecan Boulevard & McColl Road	33.8	C	48.8	D
Gumwood Avenue & Ware Road	14.1	B	9.2	A
Hackberry Avenue & 23rd Street	26.7	C	23.7	C
Hackberry Avenue & Bicentennial	14.6	B	28.7	C
Hackberry Avenue & 10th Street	34.3	C	32.1	C
Hackberry Avenue & 2nd Street	27.2	C	29.6	C
Hackberry Avenue & McColl Road	19.8	B	19.9	B
Ebony Avenue & 23rd Street	5.6	A	4.8	A
Business 83 & Ware Road	**71.1**	**E**	26.7	C
Business 83 & 29th Street	36.0	D	**65.0**	**E**
Business 83 & 23rd Street	**75.2**	**E**	**122.5**	**F**
Business 83 & 20th Street	5.3	A	7.5	A
Business 83 & Bicentennial	29.3	C	34.8	C
Business 83 & 17th Street	5.7	A	11.0	B
Business 83 & 16th Street	7.2	A	10.9	B
Business 83 & 15th Street	12.2	B	14.9	B
Business 83 & Main	7.4	A	14.9	B
Business 83 & Broadway	10.8	B	13.8	B
Business 83 & 12th Street	5.4	A	13.0	B
Business 83 & 11th Street	1.9	A	3.4	A
Business 83 & 10th Street	25.9	C	31.9	C
Business 83 & 6th Street	6.3	A	7.9	A
Business 83 & 2nd Street	26.8	C	30.7	C
Business 83 & Cynthia Street	5.2	A	1.7	A
Business 83 & McColl Road	32.9	C	26.0	C
Dallas Avenue & 23rd Street	23.0	C	26.9	C
Chicago Avenue & 10th Street	5.8	A	8.8	A

Table 3-2b: Signalized Intersection Levels of Service for Existing Conditions (continued)

Intersection	AM Peak Delay	AM Peak LOS	PM Peak Delay	PM Peak LOS
Dallas Avenue & 10th Street	3.2	A	4.5	A
Dallas Avenue & 10th Street	8.5	A	6.4	A
Dallas Avenue & 2nd Street	15.1	B	8.8	A
Dallas Avenue & McColl Road	7.1	A	8.4	A
Galveston Avenue & 23rd Street	28.0	C	47.2	D
Houston Avenue & 23rd Street	29.6	C	38.7	D
Houston Avenue & Bicentennial	24.5	C	32.7	C
Houston Avenue & 10th Street	12.9	B	15.6	B
Houston Avenue & 2nd Street	6.5	A	12.6	B
Jackson Avenue & 23rd Street	18.0	B	16.1	B
Jackson Avenue & Bicentennial	28.2	C	38.8	D
Jackson Avenue & 10th Street	22.8	C	34.8	C
Jackson Avenue & 2nd Street	16.8	B	25.0	C
Jackson Avenue & McColl Road	19.5	B	23.3	C
Lindberg & 2nd Street	14.9	B	20.0	B
US 83 Frontage Road & 2nd Street	8.2	A	15.7	B
US 83 WBFR & Ware Road	42.2	D	36.0	D
US 83 EBFR & Ware Road	36.6	D	40.0	D
US 83 WBFR & 23rd Street	42.7	D	37.0	D
US 83 EBFR & 23rd Street	28.1	C	33.8	C
US 83 WBFR & Bicentennial	10.4	B	8.6	A
US 83 WBFR & 10th Street	29.2	C	46.9	D
US 83 EBFR & 10th Street	39.4	D	38.4	D
US 83 WBFR & McColl Road	32.6	C	40.8	D
US 83 EBFR & McColl Road	37.4	D	48.5	D
Savannah Avenue & 10th Street	8.7	A	11.1	B
Ridge Road & 2nd Street	18.5	B	30.5	C
Ridge Road & McColl Road	20.5	C	24.3	C
Savannah Avenue & 2nd Street	20.1	C	27.6	C
Uvalde Avenue & Bicentennial	26.6	C	23.1	C
Uvalde Avenue & 10th Street	10.9	B	16.2	B
Wichita Avenue & 10th Street	30.7	C	31.3	C

Most of the study intersections are currently operating at an acceptable LOS. There are three intersections performing at LOS E in the AM peak and two during the PM peak. Only one intersection in each of the AM and PM peaks is operating at LOS F. For the few at LOS E and below, it is possible that enhancements to the intersection would eliminate the issue.

3.3. Measures of Effectiveness

The traffic signal timing and analysis model used for this study produces estimates of performance, or measures of effectiveness (MOEs). The following MOEs were calculated for existing conditions:

- Average Signal Delay
- Arterial Travel Time
- Average Arterial Speed
- Cycle Length (sec)
- Green Bands (sec)
- Level of Service

A summary of existing arterial conditions is provided in **Table 3-3**. Time-space diagrams and Highway Capacity Manual (HCM) analysis output from Synchro are included in **Appendices C and D**. The time-space diagrams illustrate the extent to which coordination may be lacking across the system.

Most corridors are also operating at an acceptable LOS. Only 29th Street and 23rd Street experience LOS E or F. The remaining corridors are at LOS C or D. Signal coordination should benefit all corridors.

It should be noted that the model assumes that these signals are operating with functional vehicle detectors and are able to adjust their timings to address variations in traffic flow. Field reconnaissance and discussions with city staff revealed that, at any given time, a number of loop detectors might be broken due to street maintenance activities or age. Assuming that vehicle detection issues are not a problem at critical intersections, it appears that intersection capacity is not a considerable issue at most of the intersections in the City of McAllen. For those that do not have sufficient capacity, potential improvements will be identified in a future task of the study.

From the time-space diagrams, it appears that some progression timing is present on a few of the study corridors. During the optimization phase of this study, efforts will be directed towards selecting cycle lengths, timing patterns, and controller offsets to obtain progression in all study corridors.

Table 3-3: Existing System MOEs – N/S Streets

Arterial	MOE	Northbound AM	Northbound PM	Southbound AM	Southbound PM
Ware Road	Signal Delay (min)	5.7	5.3	7.4	5.0
	Travel Time (min)	13.9	13.4	15.7	13.2
	Arterial Speed (mph)	26.1	27.0	23.5	28.0
	Arterial LOS	D	C	D	C
29th Street	Signal Delay (min)	0.5	0.6	0.8	3.2
	Travel Time (min)	0.8	0.9	1.2	3.6
	Arterial Speed (mph)	8.8	7.7	8.0	2.7
	Arterial LOS	**E**	**E**	**F**	**F**
23rd Street	Signal Delay (min)	8.2	13.0	10.0	10.1
	Travel Time (min)	18.8	23.3	20.5	20.3
	Arterial Speed (mph)	17.9	14.4	16.4	16.6
	Arterial LOS	D	**E**	**E**	**E**
Bicentennial	Signal Delay (min)	3.4	4.8	3.0	3.8
	Travel Time (min)	9.7	10.3	9.1	9.2
	Arterial Speed (mph)	24.1	20.7	25.1	22.9
	Arterial LOS	C	D	C	C
10th Street	Signal Delay (min)	8.2	9.1	8.6	9.7
	Travel Time (min)	19.6	20.5	20.0	21.1
	Arterial Speed (mph)	18.6	17.9	18.5	17.5
	Arterial LOS	C	D	C	D
2nd Street	Signal Delay (min)	6.5	6.6	7.0	5.9
	Travel Time (min)	15.8	15.9	16.3	15.2
	Arterial Speed (mph)	22.4	22.4	21.8	23.3
	Arterial LOS	C	C	D	C
McColl Street	Signal Delay (min)	6.2	5.3	5.3	6.1
	Travel Time (min)	13.9	13.0	12.9	13.7
	Arterial Speed (mph)	20.8	22.3	22.4	21.2
	Arterial LOS	D	C	C	D

Table 3-4: Existing System MOEs – E/W Streets

Arterial	MOE	Eastbound AM	Eastbound PM	Westbound AM	Westbound PM
Trenton Road	Signal Delay (min)	3.6	3.7	3.5	4.1
	Travel Time (min)	8.5	8.3	8.2	8.6
	Arterial Speed (mph)	20.3	20.6	21.1	20.0
	Arterial LOS	D	D	D	D
Dove Avenue	Signal Delay (min)	4.6	3.1	3.4	6.2
	Travel Time (min)	9.6	8.2	8.6	11.3
	Arterial Speed (mph)	20.0	23.6	22.8	17.3
	Arterial LOS	D	C	C	D
Nolana Avenue	Signal Delay (min)	5.8	4.8	4.4	4.7
	Travel Time (min)	11.1	10.1	9.7	10.0
	Arterial Speed (mph)	17.4	19.1	19.8	19.2
	Arterial LOS	D	D	D	D
Pecan Boulevard	Signal Delay (min)	5.6	5.3	5.0	5.5
	Travel Time (min)	12.6	12.0	11.9	12.1
	Arterial Speed (mph)	15.9	16.7	16.7	16.4
	Arterial LOS	D	D	D	D
Business 83	Signal Delay (min)	3.5	4.4	4.1	4.7
	Travel Time (min)	9.8	10.6	10.4	11.1
	Arterial Speed (mph)	19.7	18.1	18.5	17.4
	Arterial LOS	C	C	C	D

4. Signal Coordination

Providing smooth, continuous platoon progression by optimizing the timing of coordinated signal systems is regarded as one of the most cost-effective traffic management actions to reduce stops, delays, fuel consumption and exhaust emissions. Some of the advantages of traffic signal system coordination are as follows:

- Higher speed of progression and fewer stops alleviate spill-over queues.
- Smoother traffic operation increases capacity, decreases energy consumption, and reduces air pollution.
- By reducing stops at red lights, signal coordination encourages drivers to maintain a uniform speed thereby reducing overall speed variations.
- A greater proportion of traffic will tend to remain on the arterial street system instead of using parallel minor streets; and
- Preventing the queue of vehicles at one intersection from extending back and interfering with upstream traffic.

In a progressive system, the green displays are staggered in relation to each other according to the desired road speed. This system works effectively with unequal block length and unequal splits. A time-space diagram for the intersections helps to visualize the progress in both directions.

The complexity of this system arises from allocating the splits for the best coordination. For unevenly spaced intersections, a compromise has to be made between the two directions. This system can be used to favor one direction over the other, e.g. inbound flow in the morning peak at the expense of the fewer vehicles traveling in the opposite direction, and vice versa in the evening peak. Adequate two-way progressions can be implemented for certain combinations of cycle length, block spacing and platoon speed (progressive speed).

4.1. Signal Coordination Concepts

4.1.1. Intersection Spacing and Travel Speeds

Intersection spacing and travel speeds are critical when setting up coordinated signal timing plans. The amount of time it takes to travel from one intersection to the next has a direct bearing on the calculation of signal offsets needed to obtain progression. For vehicle progression, it is desirable to have uniform spacing of signals along a corridor.

4.1.2. Flow Patterns and Directionality

Traffic flow patterns vary by time of day. Green band widths are typically adjusted to favor the heaviest direction of travel while not completely sacrificing progression for the other direction

4.1.3. Signal Timing Intervals (Splits)

In a coordinated system, all signals have the same cycle length. These cycles are made up of intervals, or splits. Some of these intervals are predetermined (e.g. minimum green, yellow change, all red, pedestrian clearance) and others are variable and may depend on traffic demand and time-of-day. The predetermined intervals may mandate how the rest of the signal cycle time is allocated.

The sum of the green, yellow, and all red intervals typically defines an individual phase split. A split is then the segment of the cycle length allocated to each phase that may occur (expressed in percent or seconds). The primary considerations that must be given to vehicle split times are as follows:

- The phase duration must be no shorter than some absolute minimum time, such as five to seven seconds of green plus the required clearance interval. If pedestrians may be crossing with this phase, their crossing time should be considered and included in the maximum phase length to prevent signal from going out of coordination.
- A phase must be long enough to avoid over-saturating any approach associated with it. Too short a time will cause frequent cycle failures where traffic fails to clear completely during its phase, whereas too long a time will result in longer queues and side street delays.
- A phase length must not be so long that green time is wasted and vehicles on other approaches are delayed needlessly.
- Phase lengths should be properly designed to efficiently balance the cycle time available among the several phases, not just "equitably" between, say, north-south and east-west.

4.1.4. Cycle Length

The cycle length is the total time to complete one sequence of signalization around an intersection. A common cycle length is generally used at all intersections in a coordinated signal system.

Short cycle lengths typically yield the best performance in terms of providing the lowest overall average delay provided the capacity of the cycle to pass vehicles is not exceeded. The cycle length, however, must allow adequate time for vehicular and pedestrian movements. Longer cycles are used during peak periods to provide more green time for the major street, to permit larger platoons in the peak direction, and/or to reduce the number of starting delays. For progressive signal spacing, it is typically best to have a cycle length that is a direct multiple of the travel time between signalized intersections.

4.1.5. Left Turn Phases

The order in which traffic movements are served can greatly affect the progression of vehicles through a corridor. By changing the order in which a protected left turn phase comes up, it is possible to adjust the start of green for the through movement. In addition, whether a left turn is permissive, protected, or both can reduce the number of phases required in a given cycle. This can provide additional green time to the main street phase, possibly creating a larger green band on the arterial.

Certain situations exist where safety considerations may preclude the use of permissive left turns. In these cases, left turns should be restricted to the exclusive left turn phases. Such situations include:

- Intersection approaches where accident experience or traffic conflict criteria is used as the basis for installing separate left turn phasing.
- Intersections where the horizontal or vertical alignment of the road does not allow the left turning driver adequate sight distance to judge whether or not a gap in on-coming traffic is long enough to safely complete his turn.
- High-speed and/or multilane approaches may make it difficult for left turning drivers to judge gaps in oncoming traffic. Such locations should be evaluated on an individual basis.
- Unusual geometric or traffic conditions may complicate the driver's task and necessitate the prohibition of permissive left turns. An example of such conditions is an approach where dual left turns are provided.

4.1.6. Amber Trap & Dallas Phasing

Lead/lag operation should not be used unless the leading left turn is protected-only. Otherwise, motorists turning left during the permissive period could encounter a phenomenon called the left-turn amber trap. This occurs when a motorist turning left during the permissive green period sees all the thru-movement signals on their approach turn yellow and thinks that the opposing thru-traffic is also stopping. However, in reality, the opposing thru-traffic still has the green ball that is running concurrently with the lagging left phase. This set of circumstances could trick the motorist into turning left into an oncoming vehicle. For this reason, lead/lag phasing cannot safely be used if the lead left-turn phase has a permissive interval unless Dallas Phasing is used.

One option that allows protected and permissive left turns for leading left turns is commonly called "Dallas Phasing". Section 4D.06.C.2.(c) of the 2006 Texas MUTCD states that

> *"If the CIRCULAR GREEN and CIRCULAR YELLOW signal indications in the left-turn signal face are visibility-limited from the adjacent through movement, the left-turn signal face shall not be required to simultaneously display the same color of circular signal indication as the signal faces for the adjacent through movement."*

This allows a louvered green ball for the left turn phase to be wired to an overlap that mirrors the opposing through movement indications. When the adjacent through lane goes to a red ball indication, the left turn continues to see a green ball. This alerts the left turning drive that the opposing green is still on and they need to yield to opposing drivers. It is important to use an overlap phase, instead of wiring directly to the opposing green ball, in order to maintain proper operations of the conflict monitoring device within the signal controller cabinet.

4.1.7. Offsets

Offset is a key parameter for signal system coordination, as it is the time relationship of green-start for the major street at each of the intersections. Offsets usually are referenced to one intersection (e.g. the first intersection in the system). Proper determination and application of intersection offsets provide for the efficient movement of platoons through multiple intersections during the green indication. Properly timed offsets can significantly reduce delay and improve driver satisfaction with the system timing.

4.1.8. Platooning

A traffic signal compresses random vehicle flow into a series of well-defined platoons. After a platoon leaves the signal, it gradually disperses until the flow becomes random again. Fewer vehicles benefit from the available green once the platoon has dispersed because where no more green can be added to allow for the expansion, the last vehicles are left behind. In this situation, an offset that cuts off the stragglers and leaves them to wait for the next green is more detrimental than an offset that stops the leading vehicles, allows the stragglers to catch up, and compresses the platoon into its original length. The more rapidly platoons disperse, the sooner and more often they have to be stopped and compressed.

4.2. Methodology

This section of the report describes the process that was adopted in coordinating the traffic signals in the City of McAllen. Peak period traffic models of the entire network were created using the traffic modeling software Synchro 6™. As the traffic volumes and the direction of the traffic flow during the morning peak-period differs from the evening peak-period, different base models were developed and calibrated for the two rush-hour periods. City staff was regularly consulted throughout the process. They provided valuable input on cycle lengths, corridor priorities, and left turn treatments.

4.2.1. Cycle Length Determination

The first step was to determine the best common cycle length for the entire network. As a preliminary step cycles from 80 to 120 at 10-second intervals were tested on several of the corridors in the network to determine the cycle length that yielded the best results. The analysis showed ideal cycle lengths to be either 90 seconds or 100 seconds. Based on conclusions with the City staff, the protected phase of the left-turn movements needed to be a minimum of 15 seconds long. After accounting for left turns, the 90 second cycle was not long enough to provide enough green time to major arterial movements at the intersections. As a result, a cycle length of 100 seconds was chosen for all the intersections in the network.

4.2.2. Corridor Priority

The city was divided into 12 corridors shown in **Table 4-1**. Each route was assigned a priority based on input from City staff and the volume of traffic each carried. When developing timing plans for a grid network, the goal is to achieve interlocking coordination. North-south and east-west streets were analyzed incrementally, based on each corridor's priority.

Table 4-1: Priority of Corridors

Corridors	Priority	Extent North	Extent South	No. of Signals
N-S Corridors				
2^{nd} Street	1	Trenton Road	Savannah Avenue	17
McColl Street	2	Dove Avenue	Ridge Road	13
10^{th} Street	3	Trenton Road	Wichita Avenue	20
Ware Rd.	4	Trenton Road	US 83	11
Bicentennial	5	Trenton Road	Uvalde Avenue	10
23^{rd} Street	6	Trenton Road	US 83	20
29^{th} Street	7	Trenton Road	Nolana Avenue	6
		Extent West	Extent East	No. of Signals
E-W Corridors				
Nolana Avenue	1	Ware Road	McColl Road	10
Business 83	2	Ware Road	McColl Road	17
Trenton Road	3	Ware Road	2^{nd} Street	8
Dove Avenue	4	Ware Road	McColl Road	7
Pecan Blvd.	5	Ware Road	McColl Road	14

4.2.3. Green Bands

After a common cycle length was adopted for all the intersections, we started adjusting green splits and their offsets to widen the green bands. A green band is the window of time available for vehicles to travel through several intersections, without having to stop at the intersection. Each of the twelve corridors was worked upon separately, and the widest possible green bands were obtained in both directions (north and south or east and west). After the maximum possible progression was obtained on one corridor, the offsets for intersections on that corridor were held constant. The same process was repeated for the next corridor while keeping all the earlier corridor intersections fixed.

In a coordinated progression, green bands are obtained by adjusting the offsets of successive intersections such that the downstream intersection turns green in the time the platoon arrives. While it is desirable to have progression through as many intersections as possible, a green band over a long distance may not be very effective due to platoon dispersal. Therefore, in order to regroup and compress the platoon, the vehicles need to be stopped at some of the intersections. Some of the guiding philosophies adopted in this study for obtaining progression are as follows:

- An east-west corridor was followed by a north-south corridor. For instance, Nolana Avenue was the first corridor to be coordinated, followed by 2nd Street. After a corridor was coordinated, the next perpendicular corridor was coordinated around offsets of the intersection common to both the corridors.
- Breaks in progression and stopping of the traffic, where necessary, was done at a major arterial rather than a minor collector street.
- The breaks in progression are not necessarily at the same intersections for both directions. For instance, the westbound traffic on Trenton Road starting at 2nd

Street have to make a stop at 10th Street, whereas the eastbound traffic stop at 23rd Street and flow through 10th Street.

- At several intersections an increase in green band for one direction came at the expense of decreasing green band for the opposite direction. In such cases the directional nature of traffic volumes was observed and the direction with a higher traffic volume was allocated extra green time, with small decrease to the opposite direction.
- In cases where the minor street at an intersection carried very little traffic, their green times were reduced and added to the major street, if the overall corridor's green band improved.

4.2.4. Left-Turns

As directed by City of McAllen staff, all left-turning movements have been allocated a minimum split of 15 seconds. Currently, all the intersections allow only leading left-turns. However, it was observed at several intersections that staggering (lead-lagging) the left-turn movements yielded better progression on the major arterials. As many travelers may be unfamiliar with the concept of lagging left-turns, we have proposed lead-lags in ten intersections. Some of the factors that were considered while deciding lead-lag left turns are as follows:

- An intersection was considered for lead-lag only when it increased the green band considerably.
- Dallas phasing was used at intersections where left turns are staggered.
- In order to employ Dallas phasing, the leading left-turn is wired to the opposing movements via an overlap. This can be done only if the controller has additional free load switches. A list of intersections was made listing the number of free available load switches.
- In Dallas phasing, louvers are installed on the signal heads for the leading left-turn movement to prevent traffic on the adjacent lanes from seeing the left-turn signal. It is very difficult to put louvers on a signal head which is suspended by span-wires as, strong winds may cause the span signal heads to sway making it difficult to observe the signal head with louvers. Therefore, only those intersections that have their signals on mast arms were considered for lagging left turns.
- The lead-lag phase order was maintained for both the morning and evening peak-periods.
- Only intersections with a left-turn bay for the left movements were considered for lead-lag.

Table 4-2 lists the intersections where lead-lag was employed. This table also shows the phases that lead and lag.

Table 4-2: Intersections with Lead-Lag Left Turns

Intersection	Direction	Lead Phase	Lag Phase
Trenton & 23rd Street	East – West	3	7
Trenton & 8th Street	East – West	5	1
Trenton & 2nd Street	North – South	3	7
Pecan Blvd & 31st Street	East – West	5	1
23rd Street & Tamarack Avenue	North – South	5	1
10th Street & Harvey Avenue	North – South	1	5
10th Street & Tamarack Avenue	North – South	1	5
10th Street & Hackberry Avenue	North – South	1	5
Business 83 & 17th Street	East – West	1	5
10th Street & Uvalde	North – South	2	1

4.2.5. Pedestrian Clearance

The intersections were checked to ensure that the pedestrian walk and clearance time, amber time and all-red time combined together were not greater than the maximum split for the phase that allowed pedestrian movement. However, at some of the intersections adjusting the splits to accommodate pedestrian movement across the major arterial led to an increase in the splits for the minor arterial, thereby, worsening the progression along the main corridor. The City staff proposed that the pedestrian volumes were not high enough to warrant a high split time and, therefore, the split time was given to the major arterial. These intersections are likely to go out of coordination for some cycle lengths when a pedestrian call is made.

4.2.6. Measures of Effectiveness

To evaluate the proposed timings, measures of effectiveness (MOEs) were compared to those from the existing conditions. The MOEs that were compared include signal delay, travel time, arterial speed and level of service. These are presented in the following section.

4.3. Results

A summary of the results are presented in this section. The morning and evening peak-period models were developed independently while maintaining the order of lead-lag left turns. The morning progression segments are shown in **Figure 4-1 and Figure 4-2**. The corresponding maps for the evening peak-period are shown in **Figure 4-3 and Figure 4-4**. On the corridors that have more closely spaced intersections, the goal is to get progression through most of the intersections. From the figures it can be seen that, on average, the proposed coordination plans provides progression through three to four intersections at a time. Moreover, as the priority of the corridor increases, the progression improves.

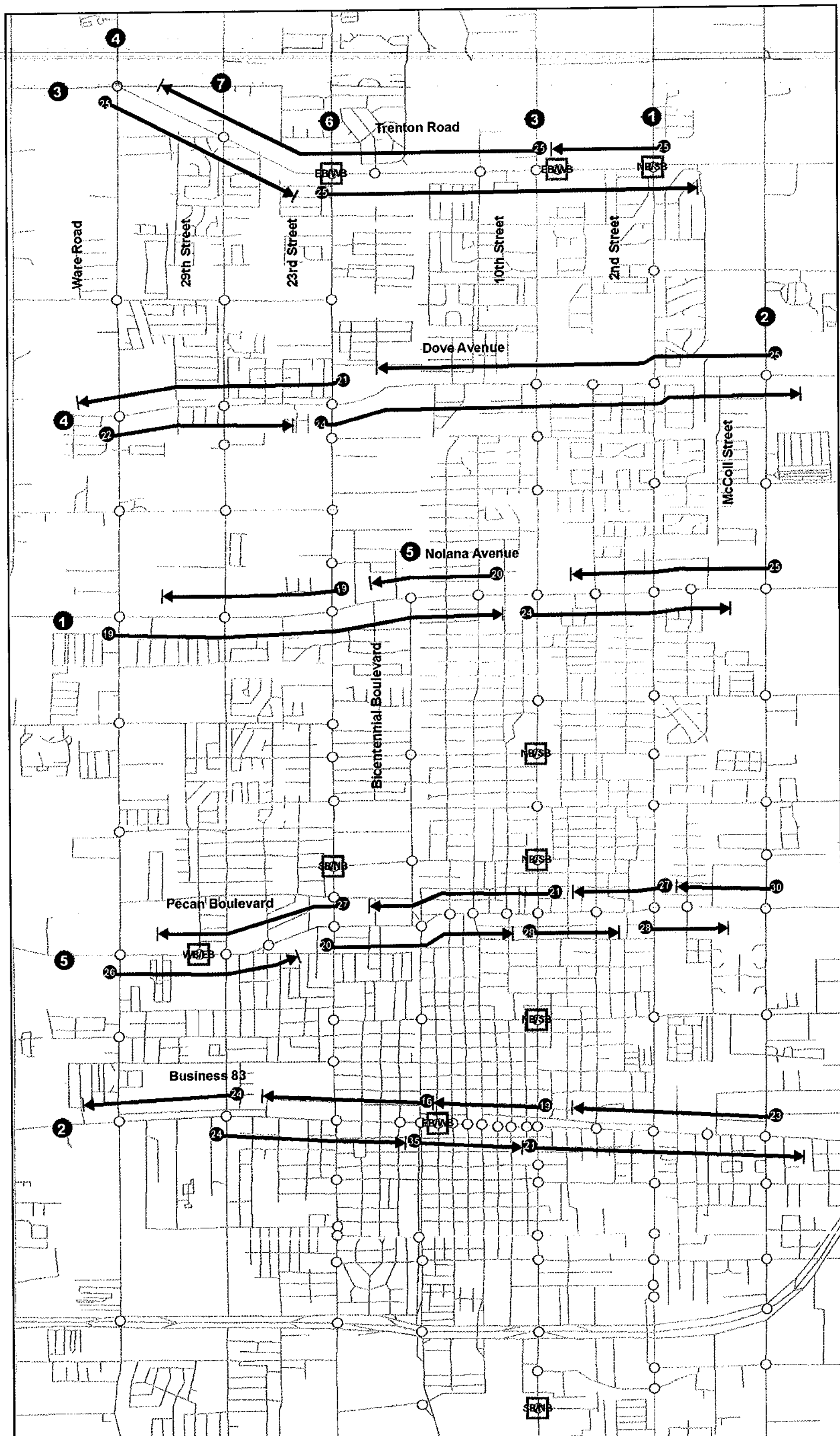

Figure 4-1: AM Peak Period Eastbound and Westbound Progressions

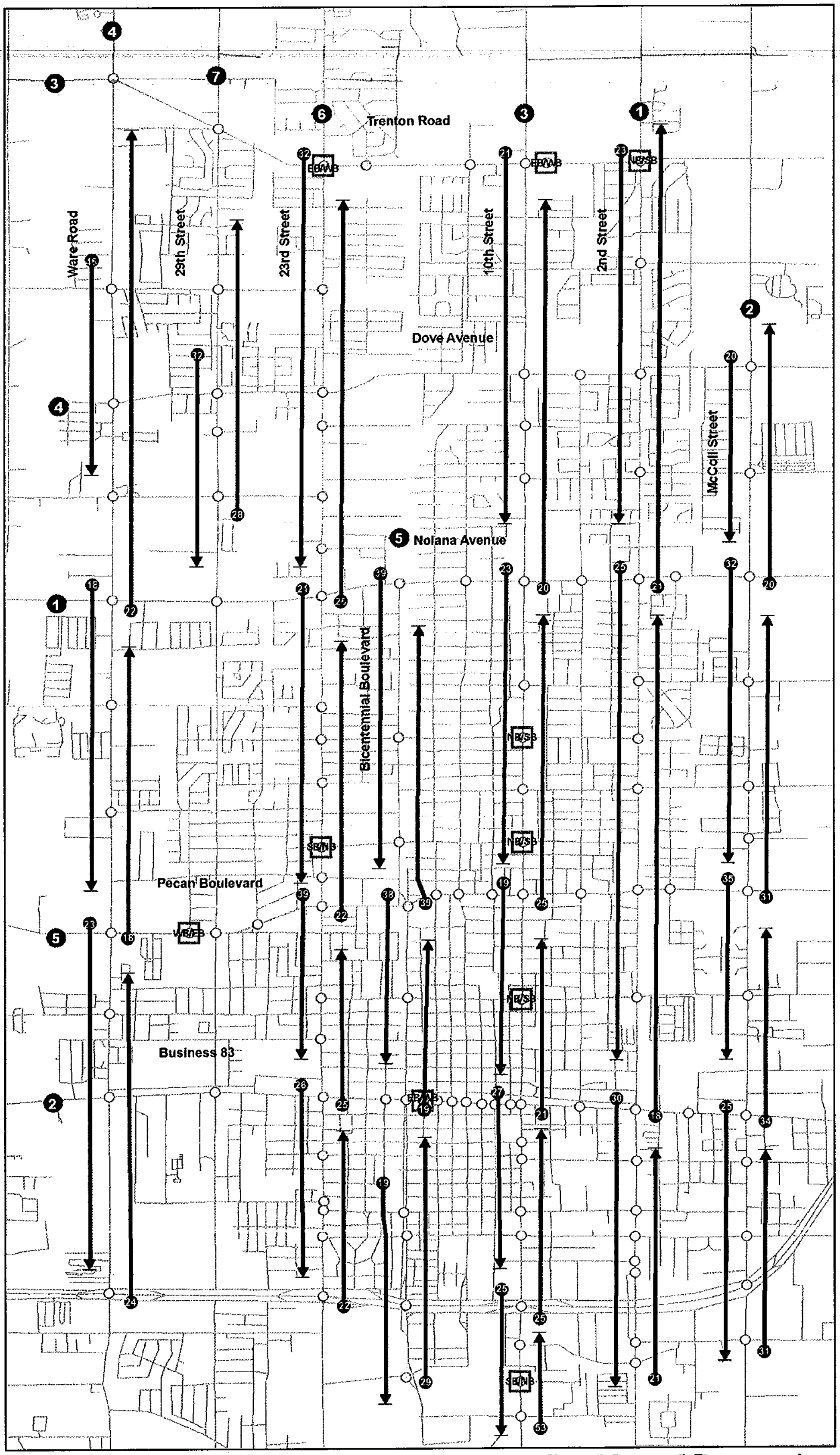

Figure 4-2: AM Peak Period Northbound and Southbound Progressions

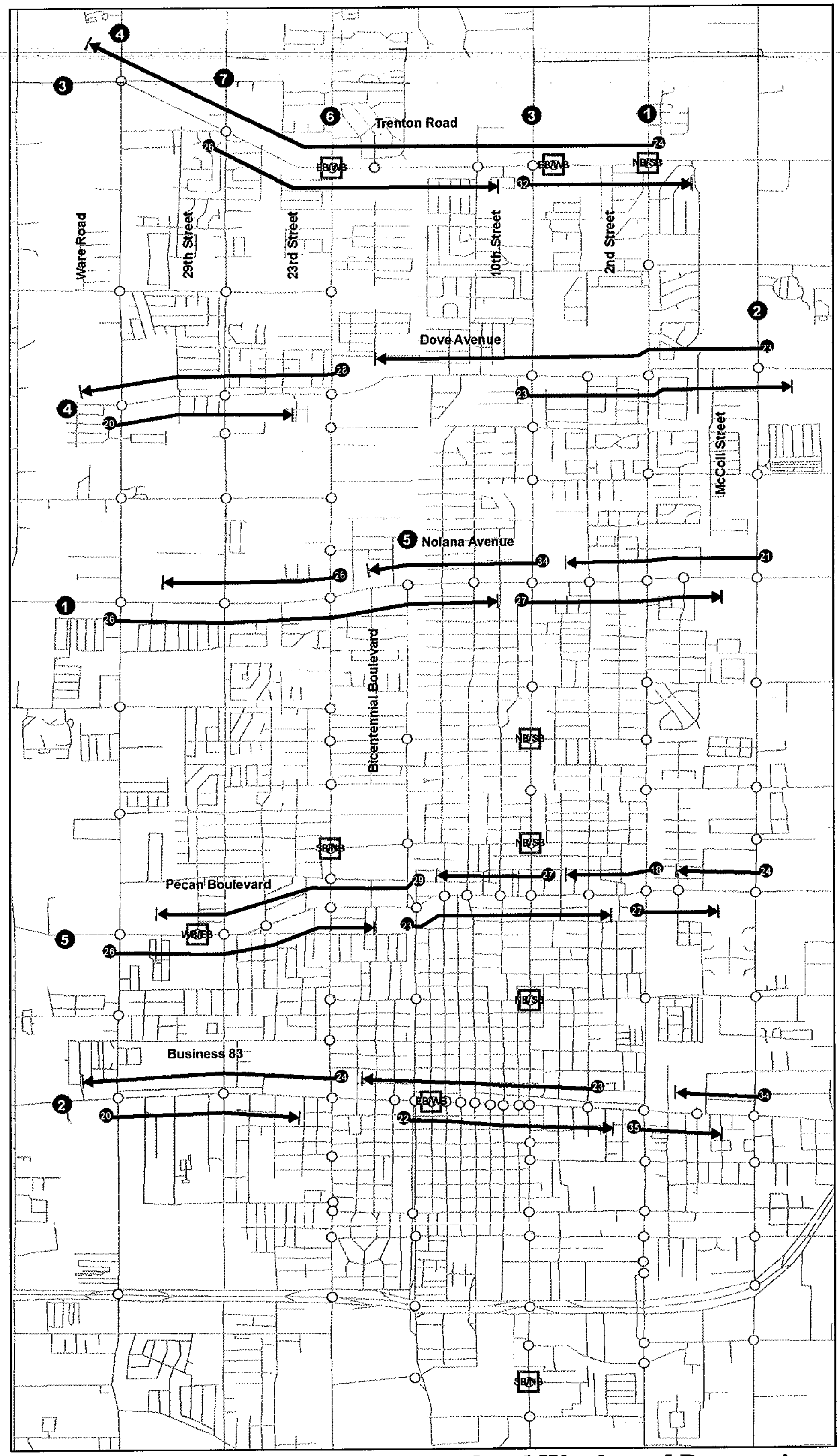

Figure 4-3: PM Peak Period Eastbound and Westbound Progressions

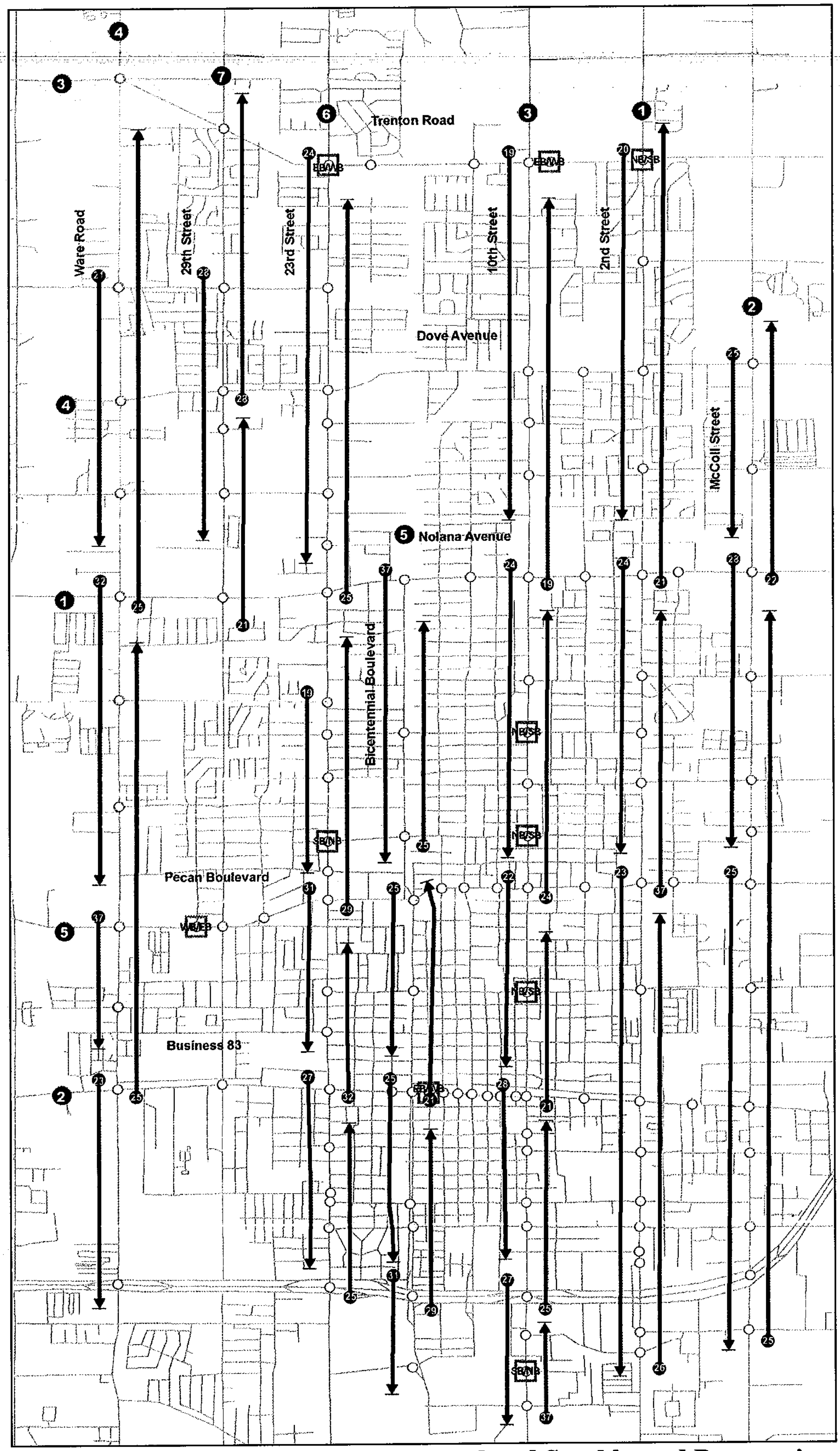

Figure 4-4: PM Peak Period Northbound and Southbound Progressions

For some of the intersections it was not possible to have adequate progression in both directions due to intersection spacing. Therefore, instead of trying to have some progression in each direction, the direction with heavier traffic flow was chosen and enough green time was allocated to that phase to ensure acceptable progression in one direction only. For instance, on Ware Road the AM peak-period model proposes a progression in the northbound direction with a green band of 22 seconds from Nolana and stopping at Lark, but no progression was obtained between these intersections in the southbound direction.

It was observed that lead-lagging the left turn movements improved progression and the green bands on several arterials. It is felt that the progression could have been improved on most of the corridors if the left-turn movement had been staggered on more intersections. However, due to absence of free load switches in the controllers, and span wire signal head suspension, it was not possible to lead-lag at many of the intersections.

Tables 4-3 through 4-6 show the measures of effectiveness comparison between the existing conditions and the proposed signal timing plan for all of the study corridors. **Table 4-7** shows a comparison of the network wide improvements, along with the annual delay savings associated with the improved timing plans.

Table 4-3: MOE Comparison AM Peak, North-South Corridors

Arterial	MOE	North		South		Total		Change	
		Ex.	Opt.	Ex.	Opt.	Ex.	Opt.	Value	%
Ware	Running Time (min)	8.3	8.3	8.4	8.4	16.7	16.7	-	-
	Signal Delay (min)	5.7	4.1	8.9	5.0	14.6	9.1	-5.5	-38%
	Travel Time (min)	14.1	12.4	17.3	13.4	31.4	25.9	-5.5	-18%
	Arterial Speed (mph)	25.7	29.1	21.3	27.5	23.5	28.3	4.8	20%
	Arterial LOS	D	C	D	C	D	C	Better	
29th Street	Running Time (min)	4.9	4.9	4.7	4.7	9.6	9.6	-	-
	Signal Delay (min)	2.2	1.7	2.5	2.0	4.7	3.7	-1.1	-23%
	Travel Time (min)	7.1	6.5	7.2	6.7	14.3	13.3	-1.1	-7%
	Arterial Speed (mph)	20.9	22.7	19.9	21.4	20.4	22.1	1.7	8%
	Arterial LOS	C	C	C	C	C	C	Same	
23rd Street	Running Time (min)	10.5	10.5	10.5	10.5	21.0	21.0	-	-
	Signal Delay (min)	8.1	5.2	10.0	5.3	18.2	10.6	-7.6	-42%
	Travel Time (min)	18.7	15.8	20.5	15.8	39.2	31.6	-7.6	-19%
	Arterial Speed (mph)	18.0	21.3	16.4	21.3	17.2	21.3	4.1	24%
	Arterial LOS	D	C	E	D	D	D	Same	
Bicentennial	Running Time (min)	6.3	6.3	6.1	6.1	12.4	12.4	-	-
	Signal Delay (min)	3.4	3.4	3.0	2.9	6.4	6.2	-0.2	-3%
	Travel Time (min)	9.7	9.7	9.1	9.0	18.8	18.7	-0.2	-1%
	Arterial Speed (mph)	24.1	24.1	25.1	25.4	24.6	24.8	0.1	1%
	Arterial LOS	C	C	C	C	C	C	Same	
10th Street	Running Time (min)	11.4	11.4	11.4	11.4	22.8	22.8	-	-
	Signal Delay (min)	8.0	4.9	8.4	5.6	16.4	10.5	-5.9	-36%
	Travel Time (min)	19.4	16.3	19.8	17.0	39.3	33.4	-5.9	-15%
	Arterial Speed (mph)	18.8	22.4	18.6	21.7	18.7	22.1	3.3	18%
	Arterial LOS	C	C	C	C	C	C	Same	
2nd Street	Running Time (min)	9.3	9.3	9.3	9.3	18.6	18.6	-	-
	Signal Delay (min)	6.5	4.7	7.0	5.5	13.5	10.2	-3.3	-24%
	Travel Time (min)	15.8	14.0	16.3	14.8	32.1	28.8	-3.3	-10%
	Arterial Speed (mph)	22.4	25.4	21.8	24.0	22.1	24.7	2.6	12%
	Arterial LOS	C	C	D	C	C	C	Same	
McColl	Running Time (min)	7.7	7.7	7.6	7.6	15.3	15.3	-	-
	Signal Delay (min)	6.2	3.6	5.3	4.1	11.5	7.7	-3.9	-34%
	Travel Time (min)	13.9	11.3	12.9	11.7	26.9	23.0	-3.9	-14%
	Arterial Speed (mph)	20.8	25.7	22.4	24.7	21.6	25.2	3.6	17%
	Arterial LOS	D	C	C	C	D	C	Better	

Table 4-4: MOE Comparison AM Peak, East-West Corridors

Arterial	MOE	East		West		Total		Change	
		Ex.	Opt.	Ex.	Opt.	Ex.	Opt.	Value	%
Trenton	Running Time (min)	4.8	4.8	4.7	4.7	9.5	9.5	-	-
	Signal Delay (min)	3.7	2.3	3.2	2.1	7.0	4.3	-2.7	-38%
	Travel Time (min)	8.6	7.1	7.9	6.8	16.5	13.9	-2.7	-16%
	Arterial Speed (mph)	20.0	24.2	21.7	25.5	20.9	24.9	4.0	19%
	Arterial LOS	D	C	D	C	D	C	Better	
Dove	Running Time (min)	5.1	5.1	5.1	5.1	10.2	10.2	-	-
	Signal Delay (min)	4.6	3.4	3.4	2.0	8.0	5.4	-2.6	-33%
	Travel Time (min)	9.6	8.4	8.6	7.2	18.2	15.6	-2.6	-14%
	Arterial Speed (mph)	20.0	22.8	22.8	27.2	21.4	25.0	3.6	17%
	Arterial LOS	D	C	C	C	D	C	Better	
Nolana	Running Time (min)	5.3	5.3	5.3	5.3	10.6	10.6	-	-
	Signal Delay (min)	5.8	4.1	4.4	3.0	10.2	7.1	-3.1	-31%
	Travel Time (min)	11.1	9.4	9.7	8.3	20.8	17.7	-3.1	-15%
	Arterial Speed (mph)	17.4	20.6	19.8	23.2	18.6	21.9	3.3	18%
	Arterial LOS	D	D	D	C	D	D	Same	
Pecan	Running Time (min)	7.0	7.0	6.8	6.8	13.8	13.8	-	-
	Signal Delay (min)	5.6	4.7	5.1	3.8	10.7	8.5	-2.2	-21%
	Travel Time (min)	12.6	11.6	11.9	10.6	24.5	22.3	-2.2	-9%
	Arterial Speed (mph)	16.0	17.2	16.6	18.6	16.3	17.9	1.6	10%
	Arterial LOS	D	D	D	C	D	D	Same	
Business 83	Running Time (min)	6.2	6.2	6.3	6.3	12.6	12.6	-	-
	Signal Delay (min)	3.5	3.4	4.1	3.5	7.6	6.9	-0.7	-9%
	Travel Time (min)	9.8	9.7	10.4	9.8	20.2	19.5	-0.7	-3%
	Arterial Speed (mph)	19.7	19.8	18.5	19.7	19.1	19.8	0.6	3%
	Arterial LOS	C	C	C	C	C	C	Same	

Table 4-5: MOE Comparison PM Peak, North-South Corridors

Arterial	MOE	North		South		Total		Change	
		Ex.	Opt.	Ex.	Opt.	Ex.	Opt.	Value	%
Ware	Running Time (min)	8.1	8.1	8.2	8.2	16.3	16.3	-	-
	Signal Delay (min)	7.8	3.9	5.3	3.7	13.0	7.6	-5.4	-41%
	Travel Time (min)	15.8	12.0	13.5	12.0	29.3	24.0	-5.4	-18%
	Arterial Speed (mph)	22.8	30.2	27.4	30.8	25.1	30.5	5.4	22%
	Arterial LOS	D	C	C	C	D	C	Better	
29th Street	Running Time (min)	4.7	4.7	4.6	4.6	9.4	9.4	-	-
	Signal Delay (min)	2.2	1.8	2.2	1.9	4.4	3.7	-0.7	-17%
	Travel Time (min)	6.9	6.5	6.8	6.5	13.8	13.0	-0.7	-5%
	Arterial Speed (mph)	21.3	22.8	21.1	22.1	21.2	22.5	1.3	6%
	Arterial LOS	C	C	C	C	C	C	Same	
23rd Street	Running Time (min)	10.3	10.3	10.2	10.2	20.5	20.5	-	-
	Signal Delay (min)	13.1	6.3	10.1	5.1	23.1	11.4	-11.7	-51%
	Travel Time (min)	23.3	16.6	20.3	15.3	43.6	31.9	-11.7	-27%
	Arterial Speed (mph)	14.4	20.3	16.6	22.0	15.5	21.2	5.7	36%
	Arterial LOS	E	D	E	D	E	D	Better	
Bicentennial	Running Time (min)	5.5	6.0	5.4	5.8	10.9	11.9	-	-
	Signal Delay (min)	4.8	3.9	3.8	2.6	8.6	6.6	-2.0	-23%
	Travel Time (min)	10.3	10.0	9.2	8.5	19.5	18.5	-1.0	-5%
	Arterial Speed (mph)	20.6	23.5	22.9	26.9	21.8	25.2	3.5	16%
	Arterial LOS	D	C	C	C	D	C	Better	
10th Street	Running Time (min)	11.4	11.4	11.4	11.4	22.8	22.8	-	-
	Signal Delay (min)	9.2	6.6	9.7	6.5	18.8	13.0	-5.8	-31%
	Travel Time (min)	20.5	18.0	21.1	17.9	41.6	35.8	-5.8	-14%
	Arterial Speed (mph)	17.8	20.4	17.5	20.7	17.7	20.6	2.9	16%
	Arterial LOS	D	C	D	C	D	C	Better	
2nd Street	Running Time (min)	9.3	9.3	9.3	9.3	18.6	18.6	-	-
	Signal Delay (min)	6.6	4.1	5.9	5.7	12.5	9.8	-2.7	-22%
	Travel Time (min)	15.9	13.4	15.2	15.0	31.1	28.4	-2.7	-9%
	Arterial Speed (mph)	22.4	26.5	23.3	23.7	22.9	25.1	2.3	10%
	Arterial LOS	C	C	C	C	C	C	Same	
McColl	Running Time (min)	7.7	7.7	7.6	7.6	15.3	15.3	-	-
	Signal Delay (min)	5.3	3.2	6.1	4.1	11.4	7.4	-4.0	-35%
	Travel Time (min)	13.0	10.9	13.7	11.7	26.7	22.7	-4.0	-15%
	Arterial Speed (mph)	22.3	26.5	21.2	24.7	21.8	25.6	3.9	18%
	Arterial LOS	C	C	D	C	D	C	Better	

Table 4-6: MOE Comparison PM Peak, East-West Corridors

Arterial	MOE	East Ex.	East Opt.	West Ex.	West Opt.	Total Ex.	Total Opt.	Change Value	Change %
Trenton	Running Time (min)	4.6	4.6	4.5	4.5	9.1	9.1	-	-
	Signal Delay (min)	3.6	2.4	3.8	2.2	7.4	4.6	-2.8	-38%
	Travel Time (min)	8.2	7.1	8.4	6.7	16.5	13.7	-2.8	-17%
	Arterial Speed (mph)	21.0	24.3	20.6	25.8	20.8	25.1	4.3	20%
	Arterial LOS	D	C	D	C	D	C	Better	
Dove	Running Time (min)	5.1	5.1	5.1	5.1	10.2	10.2	-	-
	Signal Delay (min)	3.1	2.5	6.2	2.8	9.3	5.3	-4.0	-43%
	Travel Time (min)	8.2	7.6	11.3	7.9	19.5	15.5	-4.0	-20%
	Arterial Speed (mph)	23.5	25.3	17.2	24.6	20.4	25.0	4.6	23%
	Arterial LOS	C	C	D	C	D	C	Better	
Nolana	Running Time (min)	5.3	5.3	5.3	5.3	10.6	10.6	-	-
	Signal Delay (min)	4.8	4.0	4.7	3.4	9.5	7.4	-2.1	-22%
	Travel Time (min)	10.1	9.3	10.0	8.7	20.1	18.0	-2.1	-11%
	Arterial Speed (mph)	19.1	20.9	19.2	22.0	19.2	21.5	2.3	12%
	Arterial LOS	D	D	D	C	D	D	Same	
Pecan	Running Time (min)	6.8	6.8	6.6	6.6	13.4	13.4	-	-
	Signal Delay (min)	5.2	3.2	5.5	4.4	10.7	7.6	-3.1	-29%
	Travel Time (min)	12.0	10.0	12.1	11.0	24.1	21.0	-3.1	-13%
	Arterial Speed (mph)	16.8	20.2	16.3	17.9	16.6	19.1	2.5	15%
	Arterial LOS	D	C	D	D	D	C	Better	
Business 83	Running Time (min)	6.2	6.2	6.3	6.3	12.6	12.6	-	-
	Signal Delay (min)	4.4	3.6	4.7	4.1	9.1	7.7	-1.4	-15%
	Travel Time (min)	10.6	9.8	11.1	10.5	21.7	20.3	-1.4	-6%
	Arterial Speed (mph)	18.1	19.6	17.4	18.4	17.8	19.0	1.3	7%
	Arterial LOS	C	C	D	C	D	C	Better	

Table 4-7: MOE Comparison, Network Wide

MOE	AM Peak Existing	AM Peak Optimized	PM Peak Existing	PM Peak Optimized
Total Network Delay Per Vehicle (sec / veh)	28	19	26	18
Total Network Delay (hrs)	2213	1562	2403	1740
Stops / Vehicle	0.61	0.53	0.63	0.52
Average Speed (mph)	19	23	20	23
Total Travel Time (hr)	4468	3818	4941	4278
Daily Savings	$18,368		$18,706	
Annual Savings	$ 4,591,991		$ 4,676,636	
Total Annual Savings	$9,268,627			

To calculate a daily benefit in dollars, the two peaks hour benefits are added and multiplied by 1.5 to account for off-peak benefits. This number is then multiplied by an assumed value of time ($18.81/hour, derived from the Texas Transportation Institute and adjusted using the Consumer Price Index). Assuming there are 250 weekdays in a year, the annual benefit is calculated from the daily benefit.

5. Alternative Analysis

This task includes studying network deficiencies at the intersection level and providing recommended improvements. Of the 125 project intersections, up to 22 are to be selected for analysis. This report documents the process of intersection identification and selection and the determination of ideal enhancements.

The optimized Synchro plans are used as the base condition for the alternatives analysis. Intersection deficiencies were determined by LOS for the entire intersection or by movement and by field observances. The selected 22 intersections were then modeled in HCS+™. The LOS values varied slightly between these two software packages. Modifications to signal timing and lane assignments and additions of right- or left-turn lanes were considered for operational improvements. The benefits to each intersection were determined by comparing the before and after delay calculations from the HCS+™ software. A benefit-cost analysis was used to determine a priority for the recommendations.

5.1. Intersection Selection

Intersection LOS and delay for all 125 intersections were obtained from the optimized Synchro models. These are listed in **Table 5-1** in order of decreasing delay. A map of the selected intersections is displayed in **Figure 5-1**. All intersections at LOS D overall or worse in either peak hour were selected for the alternatives analysis. For intersections operating at LOS C, those with individual approaches at LOS E were also included. Other intersections were included because one movement operated at an unacceptable LOS or the possibility of removing split phasing was feasible. Additional intersections recommended by City staff were also investigated for possible inclusion in this study.

Once the 22 intersections were selected, a site visit was made to collect information on existing utilities. Quantity estimates were prepared to determine probable costs for recommended intersection improvements. The results of this investigation can be seen in the figures of each intersection in **Appendix E**.

Certain constraints limited the possible recommendations. Most notably, railroad utilities and existing irrigation standpipes were avoided. Adding new pavement was recommended only when it would improve operations, especially if it would require purchasing additional Right-of-Way (ROW). If possible, the lanes were re-striped to fit new lanes on existing pavement.

Table 5-1: Overall Intersection LOS after Coordination Optimization

Intersection	AM	Approach				PM	Approach			
		EB	WB	NB	SB		EB	WB	NB	SB
Lark Avenue & Ware Road	E	F	F	C	C	C	D	E	B	C
Business 83 & 23rd	D	C	C	E	D	E	C	C	F	F
Nolana Avenue & 23rd	D	E	D	D	E	D	D	D	C	C
Trenton Road & 10th	D	D	C	D	D	D	D	D	D	D
Dove Avenue & 10th	D	F	B	B	C	C	D	C	C	B
Pecan Boulevard & McColl Street	D	D	C	C	D	C	D	D	C	D
Daffodil Avenue & Ware Road	D	D	D	C	D	B	D	D	B	B
Business 83 & 10th	C	C	C	D	D	D	B	C	E	E
Business 83 & 29th	C	C	C	C	D	D	C	C	C	E
Nolana Avenue & 10th	C	C	B	B	D	D	D	D	C	D
Nolana Avenue & 2nd Street	C	C	C	D	D	C	C	C	C	C
Pecan Boulevard & 2nd Street	C	E	D	C	B	C	B	D	C	C
Dove Avenue & 23rd	C	D	C	C	C	C	C	C	D	C
Nolana Avenue & Ware Road	C	C	C	D	C	C	C	C	C	C
US 83 EBFR & Ware Road	C	D	A	D	B	C	D	A	C	A
Nolana Avenue & 29th Street	C	C	C	D	C	C	B	C	D	B
Trenton Road & Ware Road	C	D	D	A	C	C	C	B	D	C
Pecan Boulevard & Bicentennial	C	C	B	C	D	C	C	C	B	B
Lark Avenue & 29th Street	C	D	C	B	C	C	D	C	A	C
Buddy Owens Blvd & 29th Street	C	D	C	B	C	C	C	D	B	C
Business 83 & Ware Road	C	C	C	C	C	C	C	B	C	D
Jackson Avenue & Bicentennial	C	D	D	D	A	C	D	D	C	A
Houston Avenue & Bicentennial	C	E	D	B	D	C	D	D	A	C
Nolana Avenue & McColl Street	C	C	C	C	D	C	C	C	D	C
Buddy Owens Blvd & Ware Road	C	D	D	B	C	C	C	C	B	B
Pecan Boulevard & Ware Road	C	C	D	D	B	C	C	C	B	B
Hackberry Avenue & 10th	C	D	D	B	C	C	D	D	C	B
Harvey Avenue & Bicentennial	C	D	E	A	C	C	D	D	B	B
Dove Avenue & McColl Street	C	B	C	C	D	C	B	D	C	D
Pecan Boulevard & 10th	C	D	B	C	B	C	C	C	C	C
US 83 WBFR & 10th	C	A	C	A	D	C	A	D	A	E
Pecan Boulevard & 6th	C	C	B	D	D	C	B	C	D	D
Tamarack Avenue & Bicentennial	C	C	C	C	C	C	C	D	C	C
Trenton Road & 29th Street	C	C	C	B	C	C	C	C	B	B
Business 83 & McColl Street	C	C	D	B	B	C	C	C	B	C
Zinnia Avenue & 10th	C	D	C	B	B	C	D	C	C	B
US 83 EBFR & McColl Street	C	C	A	C	A	C	D	A	C	A
Uvalde Avenue & Bicentennial	C	C	D	A	B	C	C	D	B	B
US 83 EBFR & 10th	C	C	A	C	A	C	C	A	C	A
Business 83 & Bicentennial	C	C	C	B	B	C	B	C	D	C
Trenton Road & 2nd Street	C	B	C	B	C	C	B	C	B	C
Business 83 & 2nd Street	C	B	B	C	C	C	C	C	C	C
Nolana Avenue & Bicentennial	C	B	B	F		B	B	A	C	
La Vista Avenue & 2nd Street	C	C	D	C	C	B	C	D	B	B
Martin Avenue & 2nd Street	C	B	C	C	C	B	D	D	A	A

Note: Intersections selected for alternative analysis are bold.

Table 5-1a: Overall Intersection LOS after Coordination Optimization (continued)

Intersection	AM	Approach				PM	Approach			
		EB	WB	NB	SB		EB	WB	NB	SB
US 83 WBFR & Ware Road	C	A	D	A	C	B	A	D	A	B
La Vista Avenue & 23rd	C	D	C	B	B	B	D	C	A	A
Dove Avenue & Ware Road	C	**D**	B	B	B	B	C	B	B	B
Pecan Boulevard & 1st	C	C	C	D	D	A	A	A	D	D
US 83 EBFR & 23rd	B	C	A	C	A	C	C	A	C	A
Jackson Avenue & 10th	B	D	D	B	A	C	D	C	B	B
Savannah Avenue & 2nd Street	B	D	C	B	A	C	D	C	B	B
Ridge Road & 2nd Street	B	C	D	B	B	C	C	D	C	B
Dove Avenue & 29th Street	B	B	B	C	B	C	C	C	C	B
Hackberry Avenue & Bicentennial	**B**	**D**	**D**	**A**	**A**	**C**	**E**	**D**	**A**	**B**
Lindberg & 2nd Street	B	C		A	B	C	C		A	D
US 83 WBFR & 23rd	B	A	C	A	C	B	A	C	A	C
Violet Avenue & McColl Street	B	D	C	B	B	B	D	C	B	B
Trenton Road & 23rd	B	A	B	C	C	B	A	B	C	C
Harvey Avenue & 10th	**B**	**E**	**D**	**A**	**A**	**B**	**D**	**C**	**A**	**A**
Nolana Avenue & Main	B	B	A	D	D	B	B	A	D	D
Wichita Avenue & 10th	B	C	D	A	A	B	C	D	B	A
Jackson Avenue & McColl Street	B	D	D	B	A	B	D	D	B	B
Pecan Boulevard & 23rd	B	B	B	B	B	B	B	B	D	B
Hackberry Avenue & McColl Street	B	D	D	B	B	B	D	D	B	A
Ridge Road & McColl Street	B	D	D	B	B	B	D	C	B	A
Jackson Avenue & 2nd Street	B	C	D	B	A	B	D	D	B	A
US 83 WBFR & McColl Street	B	A	D	A	C	B	A	C	A	B
Violet Avenue & 2nd Street	B	D	C	A	B	B	C	C	A	B
Dove Avenue & 2nd Street	B	B	B	B	C	B	B	B	B	C
Houston Avenue & 10th	B	D	D	A	A	B	D	D	A	A
Pecan Boulevard & 31st Street	B	A	A	D	D	B	A	B	D	D
La Vista Avenue & McColl Street	B	D	C	A	B	B	D	C	A	B
Houston Avenue & 23rd	B		C	C	A	B		C	C	A
Lark Avenue & 23rd	B	C		A	B	B	C		A	A
Hackberry Avenue & 2nd Street	B	C	C	B	A	B	C	C	A	B
Fern Avenue & McColl Street	B	D	D	A	A	B	D	D	B	C
La Vista Avenue & 10th	B	D	B	A	A	B	D	C	A	A
Tamarack Avenue & 23rd	**B**	**D**	**E**	**A**	**A**	**B**	**D**	**D**	**A**	**B**
Fern Avenue & 10th	B	D	C	A	A	B	D	C	A	A
Nolana Avenue & 6th	B	A	A	D	D	B	A	A	D	C
Tamarack Avenue & 10th	B	D	D	A	A	B	D	C	A	A
Trenton Road & Main Street	B	A	A	D	C	B	B	A	D	C
US 83 WBFR & Bicentennial	B		D	A	A	B		D	A	A
Dove Avenue & 6th Street	B	A	A	**D**	**D**	B	A	A	**D**	**D**
Trenton Road & 8th Street	B	A	A	D	D	A	A	A	D	D
Galveston Avenue & 23rd	B	C		A	B	A	C		A	B
Gumwood Avenue & Ware Road	B	D	D	A	B	A	D	D	A	A

Note: Intersections selected for alternative analysis are bold.

Table 5-1b: Overall Intersection LOS after Coordination Optimization (continued)

Intersection	AM	Approach				PM	Approach			
		EB	WB	NB	SB		EB	WB	NB	SB
Pecan Boulevard & 27th	B	A	A	D	D	A	A	A	D	D
Trenton Road & 21st	B	A	A	C	D	A	A	A	D	D
Harvey Avenue & 2nd Street	B	D		A	A	A	D		A	A
Quince & 23rd	B	C	D	A	A	A	C	D	A	A
Pecan Boulevard & 16th	B	A	A	D	D	A	A	A	D	D
Houston Avenue & 2nd Street	A	D	D	A	B	B	D	D	A	A
US 83 Frontage Road & 2nd Street	A	A		B	B	B	A		B	C
Business 83 & Main	A	A	A	D	D	B	B	A	D	C
Business 83 & 16th	A	A	A	D	D	B	A	A	D	C
Uvalde Avenue & 10th	A	D	D	A	A	B	D	D	A	A
Harvey Avenue & 23rd	A	D	C	A	A	A	D	D	A	A
Daffodil Avenue & 23rd	A	D		A	A	A	D		A	A
Dallas Avenue & 2nd Street	A	D	B	A	A	A	D	D	A	A
Pecan Boulevard & Main	A	A	A	D	D	A	A	A	D	D
Dallas Avenue & McColl Street	A	D	D	A	A	A	D	D	A	A
Dallas Avenue & 10th	A		D	A	A	A		D	A	A
Business 83 & 6th Street	A	A	A	D	D	A	A	A	D	D
Tamarack & McColl Street	A	D		A	A	A	D		A	A
Vine & Ware Road	A	D	D	A	A	A	C	D	A	A
Business 83 & 17th	A	A	A	A	D	A	A	A	A	D
Pecan Boulevard & 12th	A	A	A	D	D	A	A	A	D	D
Zinnia Avenue & 29th Street	A		D	A	A	A		D	A	A
Ebony Avenue & 23rd	A	D	D	A	A	A	D	D	A	A
Violet Avenue & 10th	A		D	A	A	A		D	A	A
Hackberry Avenue & 23rd	A		D	A	A	A		D	A	A
Business 83 & 12th	A	A	A	D	D	A	A	A	D	C
Chicago Avenue & 10th	A	D	D	A	A	A	D	D	A	A
Savannah Avenue & 10th	A	A	D	A	A	A	A	D	A	A
Business 83 & 20th	A	A	A	D	D	A	A	A	D	D
Business 83 & Cynthia Street	A	A	A	D		A	A	A	D	
Pecan Boulevard & 29th	A	A	A	D	D	A	A	A	C	D
Dallas Avenue & 23rd	A	D	D	A	A	A	D	D	A	A
Fern Avenue & 2nd Street	A		D	A	A	A		D	A	A
Business 83 & 15th	A	A	A	A	D	A	A	A	A	D
Buddy Owens Blvd & 23rd	A	D		A	A	A	D		A	A
Nolana Avenue & 1st Street	A	A	A	D	D	A	A	A	D	C
Business 83 & Broadway	A	A	A	A	D	A	A	A	A	D
Industrial & 23rd	A	D	D	A	A	A	D	D	A	A
Jackson Avenue & 23rd	A		D	A	A	A		D	A	A
Primrose Avenue & 23rd	A		D	A	A	A		D	A	A
Dallas Avenue & 10th	A	D		A	A	A	D		A	A
Business 83 & 11th	A	A	A	D	D	A	A	A	D	D

Note: Intersections selected for alternative analysis are bold.

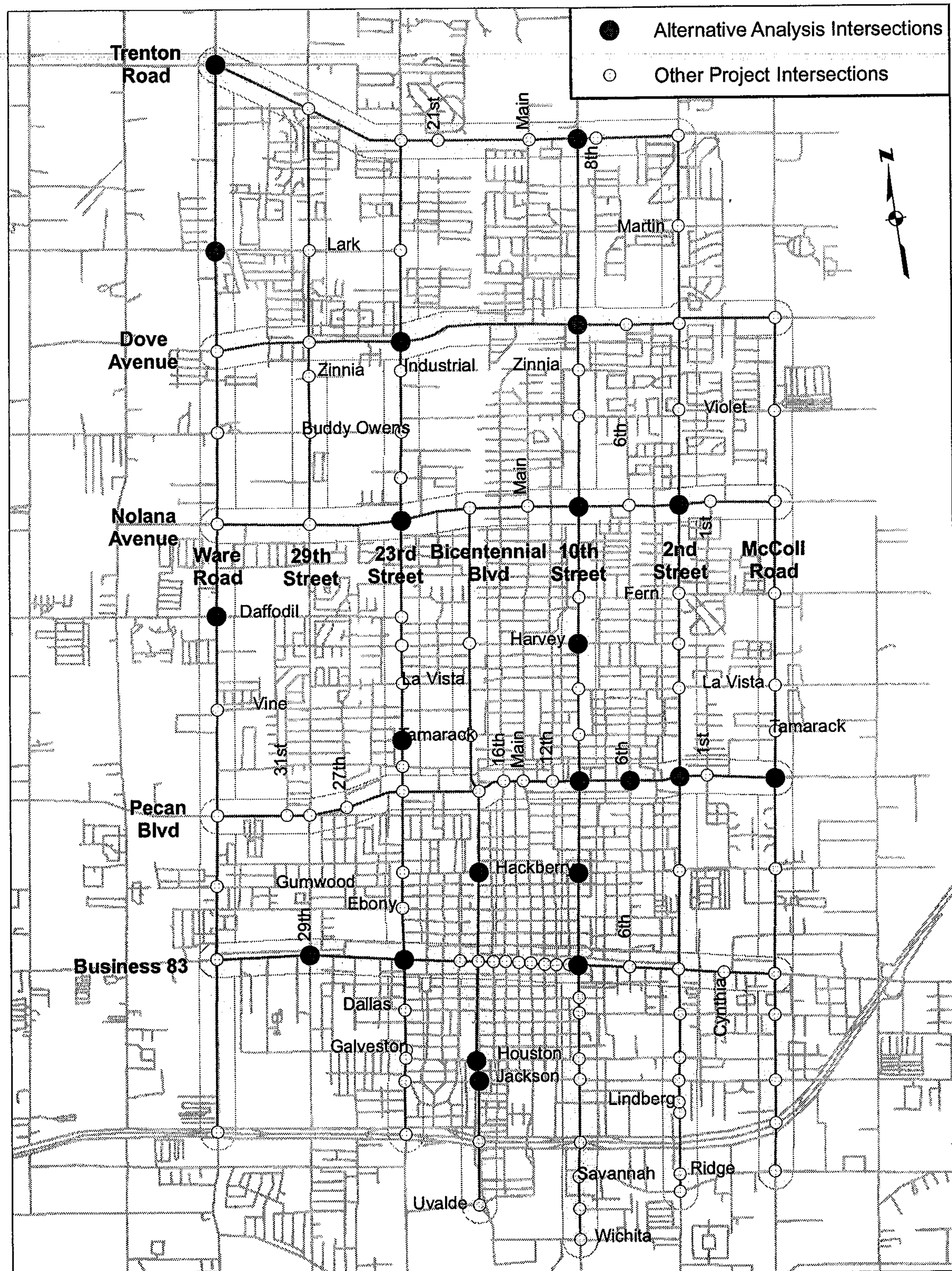

Figure 5-1: Intersections Selected for Alternatives Analysis

5.2. Proposed Improvements

The 22 selected intersections are discussed in this section with a description of the existing conditions and proposed improvements. The improvement is quantified in delay reduction (sec/veh) as computed with HCS+™. These numbers were used to calculate benefit in Section 5.3.

5.2.1. Auburn & Ware

Existing Conditions

The westbound left movement is at LOS F during the AM peak hour. The southbound thru movement is at LOS E in the AM peak and LOS D in the PM peak. Heavy northbound thru movement experiences LOS F in the PM peak.

Proposed Improvements

- Add an additional northbound thru and a receiving lane north of the intersection.
- Provide more time to the westbound left in AM peak.
- Add an additional 100-ft southbound thru lane with a 50-ft taper.
- Adjust splits to provide more time to the westbound left movement. See **Figure E-1.**

Costs

- Relocate culverts on southeast and southwest corners.
- Relocate one signal pull box on the northwest corner.
- Construct new pavement for northbound and southbound thru/right and receiving lanes.

Benefits

LOS for the northbound thru movement improves from F to C during the PM peak (74% decrease). See **Table 5-2**.

Table 5-2: Delay (sec/veh) and LOS - Auburn and Ware

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	22.1	C	17.9	B	23.2	C	20.4	C
EBT	37.1	D	34.6	C	39.5	D	34.4	C
EBR								
EB	35.9	D	33.3	C	36.5	D	31.8	C
WBL	88.2	F	31.1	C	28.9	C	23.9	C
WBT	33.5	C	23.9	C	34.4	C	31.0	C
WBR	34.0	C	24.2	C	35.6	D	32.0	C
WB	72.6	E	29.1	C	32.4	C	28.3	C
NBL	19.1	B	16.3	B	17.3	B	14.8	B
NBT	25.1	C	22.9	C	147.8	F	26.3	C
NBR								
NB	24.6	C	22.3	C	134.8	F	25.1	C
SBL	13.4	B	15.5	B	19.4	B	16.2	B
SBT	74.2	E	26.1	C	35.0	D	22.9	C
SBR								
SB	67.1	E	24.9	C	33.6	C	22.3	C
Overall	**54.2**	**D**	**26.8**	**D**	**72.1**	**E**	**26.3**	**C**

5.2.2. Trenton & 10th Street

Existing Conditions

Northbound and westbound left-turn movements are at LOS F during the AM and PM peaks. HCS+ indicates the eastbound through and shared right movements are operating at LOS D in the AM peak and LOS F in the PM peak. Field observation also indicates heavy eastbound right volumes forcing thru vehicles into one lane.

Proposed Improvements

- Add an eastbound right-turn lane and install overlap signal display to run this movement with northbound left.
- Adjust splits to provide additional time to northbound and westbound lefts. See **Figure E-2.**

Costs

- Add new pavement to accommodate an eastbound right-turn lane.
- Relocate three traffic signal pull boxes and a hydrant.
- Upgrade signal cabinet to provide an additional load switch for overlap phasing.
- Re-stripe eastbound approach.

Benefits

Eastbound thru and right movements improve to LOS C in the morning and LOS D in the evening peak. Both the westbound left and northbound left LOS improve from F to D during both peaks, experiencing a 40% to 60% improvement in delay. See **Table 5-3**.

Table 5-3: Delay (sec/veh) and LOS - Trenton and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	21.5	C	21.5	C	22.6	C	51.4	D
EBT	37.7	D	32.0	C	101.5	F	53.4	D
EBR			32.4	C			48.2	D
EB	35.4	D	30.6	C	93.9	F	51.9	D
WBL	124.4	F	51.1	D	89.4	F	54.8	D
WBT	36.9	D	36.9	D	47.2	D	31.4	C
WBR								
WB	65.1	E	41.5	D	57.9	E	37.3	D
NBL	106.3	F	35.8	D	204.9	F	47.3	D
NBT	30.6	C	27.7	C	34.9	C	29.1	C
NBR	30.9	C	27.7	C	28.7	C	25.0	C
NB	51.7	D	29.9	C	77.7	E	33.1	C
SBL	18.0	B	28.4	C	37.6	D	50.1	D
SBT	30.0	C	47.7	D	34.0	C	54.6	D
SBR	26.7	C	35.3	D	31.9	C	44.6	D
SB	28.0	C	43.4	D	34.1	C	51.6	D
Overall	**46.5**	**D**	**35.9**	**D**	**65.2**	**E**	**43.2**	**D**

5.2.3. Lark & Ware

Existing Conditions

The westbound and eastbound approaches are at LOS F during the AM peak and the westbound and northbound approaches are at LOS E during the PM peak. The east and west movements each have one approach lane. They are currently split phased and are already equipped with five-section heads.

Proposed Improvements

- Add pavement to form a 100-ft eastbound left turn lane with a 50-ft taper and a 200-ft westbound left-turn lane with 50-ft taper.
- Run east-west movement protected-permitted. See **Figure E-3.**

Costs

- Construct new pavement on both eastbound and westbound approaches.
- Relocate an electric service pole.
- Re-stripe eastbound and westbound approaches.

Benefits

The westbound approach improves to LOS C or D, and the eastbound approach improves to LOS D. Overall, the intersection experiences a delay reduction of nearly 60% and a LOS change from F to D in the AM peak. The benefits in the PM peak include a 30% reduction in delay for the entire intersection delay and a final LOS of B. See **Table 5-4.**

Table 5-4: Delay (sec/veh) and LOS - Lark and Ware

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL			20.3	C			24.7	C
EBT	191.8	F	53.3	D	48.0	D	45.1	D
EBR								
EB	191.8	F	50.3	D	48.0	D	43.3	D
WBL			27.9	C			26.1	C
WBT	224.8	F	34.8	C	69.4	E	42.7	D
WBR								
WB	224.8	F	31.2	C	69.4	E	36.8	D
NBL	19.3	B	20.5	C	14.6	B	12.3	B
NBT	39.1	D	36.5	D	61.2	E	39.7	D
NBR								
NB	37.1	D	34.9	C	55.4	E	36.3	D
SBL	17.6	B	18.6	B	19.0	B	16.5	B
SBT	51.4	D	46.6	D	27.7	C	23.4	C
SBR								
SB	48.0	D	43.8	D	26.8	C	22.7	C
Overall	**97.9**	**F**	**40.0**	**D**	**47.6**	**D**	**32.9**	**C**

5.2.4. Dove Avenue & 23rd Street

Existing Conditions

Southbound left and thru movements operates at LOS F during the AM peak. The westbound left is at LOS D for the AM peak period. The northbound thru movement is at LOS F during both peaks, likely caused by a heavy northbound right movement. Overall, the intersection operates at LOS F during both peaks.

Proposed Improvements

- Add a 100-ft northbound right-turn lane and 50-ft taper by adding pavement on the southeast corner. See **Figure E-4.**

Costs

- Relocate a signal pole, a water valve, an underground cable, and two electric poles on the southeast corner of intersection.
- Relocate a signal pole and an electric pole from the northwest corner of the intersection.
- Relocate a signal pole, controller cabinet, and three electric poles from the southwest corner of the intersection.

Benefits

The northbound thru improves to LOS D in both peaks. The southbound approach improves from LOS F to D in the AM peak and from LOS D to C in the PM. On the whole, the intersection improves to LOS D, and the delay is reduced by over 60%. See **Table 5-5.**

Table 5-5: Delay (sec/veh) and LOS - Dove and 23rd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	14.1	B	15.9	B	15.9	B	19.0	B
EBT	29.1	C	34.8	C	24.4	C	28.3	C
EBR								
EB	27.7	C	33.1	C	23.6	C	27.5	C
WBL	41.7	D	53.0	D	27.7	C	39.7	D
WBT	24.7	C	28.3	C	30.9	C	40.5	D
WBR								
WB	31.6	C	38.3	D	30.0	C	40.3	D
NBL	22.6	C	26.0	C	25.0	C	19.7	B
NBT	119.5	F	39.4	D	287.5	F	43.6	D
NBR			50.9	D			39.4	D
NB	114.9	F	42.4	D	261.5	F	40.2	D
SBL	146.5	F	61.0	E	32.5	C	30.0	C
SBT	177.7	F	31.0	C	53.5	D	31.0	C
SBR								
SB	170.7	F	38.1	D	49.4	D	30.8	C
Overall	**101.3**	**F**	**38.1**	**D**	**111.2**	**F**	**36.4**	**D**

5.2.5. Dove & 10th Street

Existing Conditions

The eastbound thru lanes are at LOS E and the southbound thru lane is at LOS F during the AM peak. The westbound thru lanes operate at LOS E during the PM peak. The intersection operates at LOS E during the AM peak period. Field observation confirms heavy east and west thrus and a heavy northbound left volume.

Proposed Improvements

- Widen the eastbound and westbound approaches to three thru lanes with shared right turns by adding pavement and re-striping narrower 11-ft lanes. The eastbound approach will require 15 feet of pavement on the north and 5 feet on the south side. The westbound approach requires a maximum of 7 feet on the north side and up to 12 feet on the south side.
- Convert the westbound right-turn lane to a shared thru-right lane.
- Re-stripe the shoulders to add an additional southbound thru and receiving lane.
- Add 10 feet of additional pavement to maintain a 100-ft southbound right turn lane with 50-ft taper. See **Figure E-5.**

Costs

- Add pavement to east, west, and south approaches.
- Relocate pedestrian sidewalks on northeast, northwest, and southwest legs.
- Re-stripe shoulder for southbound thru and receiving lanes.
- Re-stripe the eastbound and westbound approaches.
- Relocate a controller cabinet, a signal pole, a hydrant, two water valves, an inlet, and an overhead electric pole on the northwest corner.

Benefits

During the AM peak, the eastbound thru movement improves to LOS C. During the PM peak, the eastbound and northbound thru movements are at LOS C. See **Table 5-6.**

Table 5-6: Delay (sec/veh) and LOS - Dove and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	20.7	C	19.1	B	40.5	D	37.9	D
EBT	59.8	E	30.5	C	35.2	D	30.5	C
EBR								
EB	52.1	D	28.3	C	36.4	D	32.2	C
WBL	22.2	C	18.4	B	38.7	D	27.2	C
WBT	26.2	C	24.9	C	55.1	E	37.8	D
WBR	24.4	C	24.4	C	30.1	C		
WB	25.3	C	23.8	C	48.9	D	36.0	D
NBL	23.3	C	22.3	C	40.3	D	34.6	C
NBT	39.3	D	39.3	D	34.1	C	34.1	C
NBR	31.0	C	31.0	C	25.9	C	25.9	C
NB	36.8	D	36.7	D	34.7	C	33.4	C
SBL	33.6	C	33.6	C	45.0	D	45.0	D
SBT	125.6	F	40.2	D	47.7	D	33.8	C
SBR	32.2	C	32.2	C	38.2	D	36.5	D
SB	102.2	F	38.4	D	45.3	D	36.1	D
Overall	**60.4**	**E**	**32.3**	**C**	**41.8**	**D**	**34.6**	**C**

5.2.6. Nolana & 23rd Street

Existing Conditions

During the AM peak the westbound left, northbound thru, and southbound thru movements are at LOS F. During the PM peak, the westbound left and northbound thru are at LOS F and the eastbound thru lanes are at LOS E. The northbound right-turn movement is heavy during both peaks.

Proposed Improvements

- Add pavement to provide a 100-ft northbound and a 125-ft southbound right-turn lanes, each with a 50-ft taper.
- Run the northbound right overlapped with the westbound left.
- Add 6 feet of pavement to provide a shared thru-right lane for eastbound traffic. The eastbound approach can be re-striped with narrower 11-ft lanes to limit the additional pavement required. The receiving lane can be fit into an existing shoulder.
- Convert the westbound right lane to a shared through-right lane and add a 360-ft receiving lane with a 180-ft taper on 11 feet of new pavement. See **Figure E-6.**

Costs

- Relocate the east-west sidewalk on the southwest leg and the north-south sidewalk on the southeast leg.
- Relocate two signal poles, a pull box, six overhead electric poles, an underground cable, a water valve, and a hydrant.
- Upgrade the signal cabinet to provide an additional load switch for overlap phasing and upgrade to a five-section head.

Benefits

As a whole, the intersection delay decreases by over 50% in both peaks. During the morning, the westbound left and southbound thrus improve to LOS D, while the eastbound and northbound thrus improve to LOS C. In the evening peak, the westbound left and eastbound thru improve to LOS D and the northbound thru improves to LOS C. See **Table 5-7.**

Table 5-7: Delay (sec/veh) and LOS - Nolana and 23rd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	18.3	B	15.2	B	32.8	C	25.9	C
EBT	39.9	D	36.2	D	59.7	E	36.5	D
EBR								
EB	37.8	D	34.1	C	54.3	D	34.4	C
WBL	260.3	F	52.4	D	114.7	F	38.7	D
WBT	30.9	C	21.2	C	40.4	D	28.3	C
WBR	22.1	C			31.5	C		
WB	94.3	F	29.8	C	61.0	E	31.3	C
NBL	26.2	C	48.3	D	18.0	B	20.1	C
NBT	132.9	F	32.6	C	99.9	F	33.2	C
NBR			16.3	B			19.1	B
NB	118.2	F	28.3	C	88.8	F	26.5	C
SBL	27.3	C	31.8	C	22.1	C	20.1	C
SBT	122.6	F	42.2	D	26.8	C	29.1	C
SBR			30.2	C			25.7	C
SB	109.0	F	41.7	D	26.0	C	27.2	C
Overall	**88.2**	**F**	**33.3**	**C**	**62.9**	**E**	**29.5**	**C**

5.2.7. Nolana & 10th Street

Existing Conditions

In the PM peak, the westbound thru movement is at LOS E and the remaining thrus operate at LOS D.

Proposed Improvements

- Add pavement to form eastbound and westbound thrus. The receiving lanes for these movements can be accommodated in existing shoulders. Additional pavement (17 feet on the eastbound side and 11 feet on the westbound approach) is required to maintain the eastbound and westbound right-turn lanes.
- Adjust splits to provide additional green time to northbound and southbound thrus. See **Figure E-7.**

Costs

- Relocate the signal cabinet and signal poles on the northeast and southwest corners.
- Relocate three electric poles, a water valve, two storm sewer inlets, a gas valve, an underground cable, and two manholes.
- Acquire ROW on the southwest corner.
- Re-stripe and eastbound and westbound approaches.

Benefits

The delay savings across the intersection are 18% for the PM peak period for a LOS change from D to C. During the PM peak, all east and west movements run at LOS C. See **Table 5-8**.

Table 5-8: Delay (sec/veh) and LOS - Nolana and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	16.5	B	15.3	B	33.2	C	33.1	C
EBT	30.2	C	26.8	C	52.6	D	34.2	C
EBR	26.0	C	26.0	C	32.6	C	32.6	C
EB	28.3	C	25.7	C	46.0	D	33.8	C
WBL	20.8	C	17.6	B	29.4	C	28.1	C
WBT	29.0	C	26.3	C	56.3	E	34.5	C
WBR	24.2	C	24.2	C	33.3	C	33.3	C
WB	27.1	C	24.5	C	48.1	D	33.3	C
NBL	20.5	C	20.5	C	35.7	D	34.1	C
NBT	32.6	C	32.6	C	37.9	D	36.9	D
NBR	31.6	C	31.6	C	32.2	C	31.6	C
NB	30.5	C	30.5	C	36.4	D	35.4	C
SBL	20.3	C	20.3	C	26.5	C	26.3	C
SBT	32.7	C	32.7	C	35.5	D	34.8	C
SBR	30.5	C	30.5	C	29.9	C	29.5	C
SB	30.5	C	30.5	C	33.0	C	32.4	C
Overall	**28.8**	**C**	**27.3**	**C**	**41.2**	**D**	**33.7**	**C**

5.2.8. Nolana & 2nd Street

Existing Conditions

All thru movements operate at LOS D or worse during both peaks. During the AM peak, southbound and westbound thrus operate at LOS E. In the PM peak, the northbound thru is at LOS F while the eastbound thru is at LOS E. The overall LOS for the intersection during the peaks is D in the morning and LOS E in the evening.

Proposed Improvements

- Add 11 feet of pavement to create a 100-ft northbound right-turn lane.
- Add 7 to 11 feet of pavement to form one additional eastbound and one additional westbound thru lane with receiving lanes.
- Re-stripe narrower 11-ft lanes on eastbound and westbound approaches. See **Figure E-8.**

Costs

- Relocate three storm sewer inlets, three overhead power poles, two luminaries, an underground cable, and a traffic signal control box.
- Re-stripe eastbound and westbound approaches.

Benefits

The LOS for the entire intersection improves to LOS C for both peak periods. In both the morning and the evening peaks, all the thrus now operate at LOS C. Overall delay decreased around 40%. See **Table 5-9**.

Table 5-9: Delay (sec/veh) and LOS - Nolana and 2nd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	22.5	C	33.9	C	38.1	D	30.1	C
EBT	35.1	D	28.3	C	73.9	E	34.9	C
EBR	24.3	C	24.5	C	25.5	C	26.8	C
EB	32.7	C	28.6	C	64.9	E	33.5	C
WBL	18.4	B	18.9	B	26.9	C	20.9	C
WBT	75.3	E	31.7	C	52.5	D	32.9	C
WBR	23.6	C	23.8	C	25.5	C	26.8	C
WB	69.9	E	30.7	C	47.3	D	31.1	C
NBL	30.7	C	35.0	C	33.0	C	24.6	C
NBT	36.6	D	28.0	C	96.9	F	34.8	C
NBR			25.3	C			28.8	C
NB	35.0	D	29.3	C	85.3	F	32.1	C
SBL	25.4	C	19.4	B	29.6	C	23.3	C
SBT	64.1	E	34.9	C	41.2	D	31.7	C
SBR	30.6	C	25.5	C	34.1	C	28.0	C
SB	55.2	E	31.7	C	38.4	D	29.8	C
Overall	**50.3**	**D**	**30.1**	**C**	**59.6**	**E**	**31.9**	**C**

5.2.9. Daffodil & Ware

Existing Conditions

Due to lane configurations, the east-west movements are currently run split phased, though each is already equipped with five-section heads. Each of these approaches operates at LOS E or D in both peak periods. The northbound and southbound thrus operate at LOS F in the AM peak. The critical east-west movements are the westbound left turns and eastbound thrus and right turns.

Proposed Improvements

Add 12 feet of pavement to form a 100-ft eastbound left-turn lane and change the east-west movements to protected-permitted. See **Figure E-9.**

Costs

- Relocate three overhead electric service poles and an underground cable.
- Construct new pavement to widen the eastbound approach.

Benefits

All approaches improve to LOS C in both peaks. Without split-phased east-west movements, additional green time is available for the northbound and southbound movements. The overall intersection LOS improves from F to C in the AM peak. See **Table 5-10.**

Table 5-10: Delay (sec/veh) and LOS - Daffodil and Ware

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL			16.5	B			18.9	B
EBT	63.4	E	32.4	C	62.1	E	33.8	C
EBR								
EB	63.4	E	30.6	C	62.1	E	32.3	C
WBL	36.6	D	32.6	C	38.4	D	20.8	C
WBT	33.3	C	27.3	C	39.9	D	31.7	C
WBR								
WB	35.2	D	30.4	C	39.2	D	26.9	C
NBL	25.1	C	21.8	C	18.2	B	18.4	B
NBT	147.4	F	31.0	C	35.5	D	32.0	C
NBR								
NB	139.9	F	30.5	C	34.2	C	31.0	C
SBL	25.7	C	21.8	C	19.1	B	19.3	B
SBT	233.6	F	34.8	C	29.9	C	27.8	C
SBR								
SB	219.7	F	34.0	C	29.1	C	27.2	C
Overall	**152.5**	**F**	**31.9**	**C**	**34.9**	**C**	**29.4**	**C**

5.2.10. Harvey Avenue & 10th Street

Existing Conditions

Heavy eastbound thru movements operate at LOS D during the AM peak and LOS F in the PM peak. Currently, this movement is served with a single shared left-thru-right lane. The eastbound and westbound movements are currently running permitted-only.

Proposed Improvements

- Add a 100-ft eastbound left-turn lane with 50-ft taper by adding 10 feet of pavement on the northwest corner.
- Upgrade the eastbound and westbound signals to five-section heads and run these movements permitted-protected. See **Figure E-10.**

Costs

- Relocate one storm sewer inlet, a signal pole, and a water valve on northwest corner.
- Install five-section heads for eastbound and westbound left-turn movements.

Benefits

The eastbound thru lanes operate at LOS C in both peaks with a 60% delay decrease in the PM peak. See **Table 5-11.**

Table 5-11: Delay (sec/veh) and LOS - Harvey and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL			23.3	C			25.3	C
EBT	35.7	D	33.8	C	89.5	F	33.2	C
EBR								
EB	35.7	D	30.8	C	89.5	F	30.5	C
WBL	27.3	C	29.4	C	27.8	C	24.1	C
WBT	24.5	C	33.1	C	29.8	C	34.6	C
WBR								
WB	25.7	C	31.5	C	29.3	C	32.3	C
NBL	13.7	B	13.4	B	11.8	B	13.8	B
NBT	23.4	C	19.4	B	22.0	C	21.1	C
NBR								
NB	22.9	C	19.1	B	21.4	C	20.6	C
SBL	19.0	B	15.8	B	21.8	C	25.0	C
SBT	26.3	C	21.2	B	21.9	C	20.0	C
SBR								
SB	26.1	C	21.0	B	21.9	C	20.5	C
Overall	**26.5**	**C**	**23.4**	**C**	**29.8**	**C**	**22.9**	**C**

5.2.11. Tamarack & 23rd Street

Existing Conditions

The eastbound and westbound approaches operate at LOS D during both peak periods. They currently run split phased with minimal green time (15 seconds each). The westbound right movement operates at LOS E in the AM peak.

Proposed Improvements

- Realign the intersection to line up the eastbound and westbound thru movements, widening each approach (7 feet on the west and 18 feet on the east) to accommodate 100-ft left-turn lanes. Run the eastbound and westbound phases protected-permitted.
- Provide an overlap with the southbound left phase for the westbound right. See **Figure E-11.**

Costs

- Remove existing pavement on westbound approach.
- Relocate signal pole, traffic signal pull box, a pedestrian pole, four overhead electric service poles, and a gas valve on the northwest corner of the intersection.
- Upgrade signal cabinet to provide an additional load switch for overlap phasing and install five-section signal heads for the eastbound and westbound approaches.
- Acquire ROW on southeast corner.

Benefits

The eastbound and westbound approaches improve to LOS C. The westbound right improves from LOS E to LOS C. See **Table 5-12**.

Table 5-12: Delay (sec/veh) and LOS – Tamarack and 23rd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL			24.9	C			25.8	C
EBT	43.8	D	34.6	C	43.4	D	34.7	C
EBR								
EB	43.8	D	34.2	C	43.4	D	31.5	C
WBL			25.8	C			27.0	C
WBT	44.4	D	33.6	C	40.4	D	34.7	C
WBR	59.2	E	28.8	C	42.0	D	29.4	C
WB	53.6	D	28.1	C	41.2	D	29.2	C
NBL	13.7	B	16.3	B	15.8	B	15.6	B
NBT	16.3	B	16.3	B	19.9	B	19.5	B
NBR								
NB	16.3	B	16.7	B	19.8	B	19.4	B
SBL	8.8	A	11.6	B	10.2	B	9.9	A
SBT	23.5	C	21.8	C	19.7	B	19.3	B
SBR								
SB	21.1	C	20.1	C	18.8	B	18.4	B
Overall	**22.7**	**C**	**20.0**	**B**	**22.6**	**C**	**20.5**	**C**

5.2.12. Pecan & 10th Street

Existing Conditions

During the AM peak, the westbound and northbound approaches operate at LOS D and the eastbound approach operates at LOS E. All approaches are at LOS D during the PM peak.

Proposed Improvements

- Add 11ft of pavement to form a100-ft eastbound right-turn lane.
- Extend the westbound left-turn lane 75 feet and shift green time to this movement. See **Figure E-12**.

Costs

- Relocate sidewalk on the south side of the east approach.
- Relocate one signal pole and a traffic signal pull box on the southwest corner.
- Re-stripe lanes to extend the westbound left-turn lane.
- Acquire ROW and construct pavement for an eastbound right-turn lane.

Benefits

The westbound left improves to LOS C in the PM peak. The eastbound thrus now operate at LOS D while the right turn improves to LOS C in the AM peak. See **Table 5-13.**

Table 5-13: Delay (sec/veh) and LOS - Pecan and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	22.9	C	22.9	C	23.3	C	23.3	C
EBT	64.5	E	40.2	D	47.8	D	36.6	D
EBR			33.9	C			32.0	C
EB	60.1	E	37.3	D	44.9	D	34.2	C
WBL	24.3	C	23.2	C	44.8	D	34.9	C
WBT	41.1	D	41.1	D	54.7	D	54.7	D
WBR								
WB	38.7	D	38.6	D	52.6	D	50.5	D
NBL	16.8	B	16.8	B	32.6	C	32.6	C
NBT	38.4	D	38.4	D	45.5	D	45.5	D
NBR								
NB	36.8	D	36.8	D	43.5	D	43.5	D
SBL	22.4	C	22.4	C	22.8	C	22.8	C
SBT	30.9	C	30.9	C	47.5	D	47.5	D
SBR								
SB	29.2	C	29.2	C	44.6	D	44.6	D
Overall	**40.2**	**D**	**34.9**	**C**	**46.2**	**D**	**43.6**	**D**

5.2.13. Pecan & 6th Street

Existing Conditions

The eastbound and westbound movements are split phased, which limits progression through the intersection. Permitted-only northbound and southbound lefts, combined with a single shared lane for all movements, prevent the full queue from being served during some cycles. The northbound and southbound approaches currently operate at LOS D.

Proposed Improvements

- Add 6 feet of pavement to form 100-ft eastbound and westbound left turns and run the movements protected-permitted.
- Re-stripe the northbound and southbound approaches to include 75-ft left-turn bays. See **Figure E-13.**

Costs

- Acquire ROW and construct new pavement to widen the eastbound and westbound approaches.
- Re-stripe all approaches.
- Relocate two signal poles, two overhead power poles, and an underground cable.
- Upgrade the intersection with five-section heads in all directions

Benefits

The eastbound and westbound lefts now operate at LOS B and the thrus for these movements continue to operate at LOS C. The northbound and southbound lefts improve LOS C. See **Table 5-14**.

Table 5-14: Delay (sec/veh) and LOS - Pecan and 6th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL			15.9	B			12.3	B
EBT	34.3	C	30.4	C	29.2	C	23.7	C
EBR								
EB	34.3	C	30.2	C	29.2	C	22.9	C
WBL			24.5	B			18.3	B
WBT	31.6	C	30.6	C	31.1	C	22.6	C
WBR								
WB	31.6	C	30.3	C	31.1	C	22.4	C
NBL			17.0	B			21.5	C
NBT	34.2	C	28.2	C	38.5	D	33.8	C
NBR								
NB	34.2	C	26.6	C	38.5	D	30.3	C
SBL			17.6	B			21.2	C
SBT	38.7	D	27.7	C	37.3	D	33.8	C
SBR								
SB	38.7	D	23.9	C	37.3	D	31.7	C
Overall	**33.5**	**C**	**29.3**	**C**	**31.2**	**C**	**23.8**	**C**

5.2.14. Pecan & 2nd Street

Existing Conditions

The eastbound and westbound thrus and westbound right movements in both peaks operate at LOS D. The northbound thru operates at LOS D in the AM peak period. Field observation indicates the northbound and southbound right turns are heavy enough to result in a lane utilization imbalance, causing all thru vehicles to use the one thru-only lane.

Proposed Improvements

- Add a 560-ft acceleration pocket with 200-ft taper to permit the westbound right to run "free."
- Add 11 feet of pavement to form 150-ft northbound and southbound right-turn lanes with 100-ft tapers. See **Figure E-14.**

Costs

- Acquire ROW on east side and west side of the northbound and southbound approaches.
- Relocate sidewalks on west side of northbound and southbound approaches.
- Relocate signal poles on the southwest and northwest corners.
- Relocate three overhead power poles, a luminary, two hydrants, a gas valve, and an underground cable.

Benefits

The LOS for the eastbound and westbound movements improves to LOS C during both peaks. See **Table 5-15.**

Table 5-15: Delay (sec/veh) and LOS - Pecan and 2nd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	22.7	C	20.9	C	23.2	C	21.5	C
EBT	39.2	D	33.7	C	39.7	D	33.7	C
EBR	33.2	C	19.8	B	34.2	C	30.4	C
EB	36.9	D	30.5	C	36.9	D	31.7	C
WBL	26.1	C	23.6	C	23.7	C	21.9	C
WBT	41.4	D	34.7	C	38.8	D	33.3	C
WBR	51.3	D	0.1	A	47.1	D	0.0	A
WB	41.8	D	23.5	C	39.6	D	22.1	C
NBL	24.4	C	23.4	C	14.3	B	15.4	B
NBT	46.4	D	33.9	C	34.7	C	28.4	C
NBR			29.4	C			22.5	C
NB	43.0	D	31.7	C	32.5	C	26.4	C
SBL	31.9	C	34.0	C	21.7	C	25.4	C
SBT	28.9	C	28.2	C	27.4	C	25.1	C
SBR			22.9	C			21.5	C
SB	29.8	C	29.5	C	26.1	C	25.0	C
Overall	**37.4**	**D**	**28.5**	**C**	**33.6**	**C**	**26.1**	**C**

5.2.15. Pecan & McColl

Existing Conditions

The eastbound right movement operates at LOS D in the PM peak. The eastbound and westbound thrus and the northbound left movements operate at LOS E in the PM peak.

Proposed Improvements

Provide 150-ft northbound and southbound right-turn lanes with 100-ft tapers. See **Figure E-15.**

Costs

- Construct new pavement for northbound and southbound right-turn lanes.
- Relocate overhead power electric pole, an underground cable, and an inlet.

Benefits

In the PM peak, the eastbound thru improves to LOS D and the westbound thru and northbound left improve to LOS C. See **Table 5-16.**

Table 5-16: Delay (sec/veh) and LOS - Pecan and McColl

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	22.9	C	20.6	C	26.9	C	27.1	C
EBT	35.0	C	31.8	C	75.6	E	35.8	D
EBR	32.8	C	30.2	C	36.9	D	29.9	C
EB	32.8	C	29.8	C	64.5	E	33.9	C
WBL	26.8	C	22.8	C	29.5	C	32.6	C
WBT	39.1	D	34.5	C	61.9	E	34.8	C
WBR	31.8	C	29.3	C	37.9	D	30.5	C
WB	35.6	D	31.3	C	53.5	D	33.8	C
NBL	24.6	C	24.7	C	67.8	E	33.2	C
NBT	30.4	C	31.6	C	29.4	C	21.5	C
NBR			25.9	C			17.2	B
NB	29.4	C	29.8	C	38.5	D	23.9	C
SBL	17.5	B	18.5	B	18.5	B	30.8	C
SBT	32.4	C	33.4	C	29.7	C	34.8	C
SBR			26.0	C			27.4	C
SB	30.8	C	31.0	C	27.9	C	33.2	C
Overall	**32.0**	**C**	**30.5**	**C**	**43.9**	**D**	**30.5**	**C**

5.2.16. Hackberry & Bicentennial

Existing Conditions

The eastbound left operates at LOS F and the westbound thrus and lefts operate at LOS D during the PM peak. Eastbound and westbound lefts have dedicated lanes but run permitted-only.

Proposed Improvements

Upgrade to five-section heads in the eastbound and westbound directions and run these movements protected-permitted. See **Figure E-16.**

Costs

Upgrade east and west signals to five-section heads.

Benefits

The eastbound and westbound approaches improve to LOS C in the PM peak. See **Table 5-17.**

Table 5-17: Delay (sec/veh) and LOS - Hackberry and Bicentennial

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	25.4	C	21.6	C	138.1	F	20.3	C
EBT	27.9	C	31.5	C	32.8	C	29.7	C
EBR								
EB	27.5	C	30.1	C	65.6	E	26.8	C
WBL	26.4	C	21.7	C	45.5	D	27.2	C
WBT	29.7	C	34.8	C	35.7	D	33.5	C
WBR								
WB	29.1	C	32.2	C	38.1	D	32.0	C
NBL	12.4	B	15.0	B	11.0	B	19.8	B
NBT	26.4	C	21.9	C	21.1	C	29.9	C
NBR								
NB	25.6	C	21.5	C	20.2	C	29.0	C
SBL	13.2	B	19.2	B	11.8	B	30.6	C
SBT	27.9	C	22.9	C	22.2	C	32.4	C
SBR								
SB	25.9	C	22.4	C	20.3	C	32.1	C
Overall	**26.4**	**C**	**24.3**	**C**	**31.5**	**C**	**30.2**	**C**

5.2.17. Hackberry & 10th Street

Existing Conditions

The eastbound and westbound movements are split phased, which limits the ability to progress traffic through the intersection. The east and west approaches and the northbound thru operate at LOS D in both peaks.

Proposed Improvements

- Form a 100-ft westbound left-turn bay with 50-ft taper by adding 6 feet of pavement to the southeast corner.
- Run eastbound and westbound movements protected-permitted. See **Figure E-17.**

Costs

- Relocate signal head, overhead electric pole, and storm sewer inlet on southeast corner.
- Construct new pavement on the southeast corner.
- Upgrade the eastbound and westbound signals to five-section heads.

Benefits

The eastbound and westbound thrus improve to LOS C. The eastbound and westbound left improve to LOS B in the AM peak. Overall, the intersection LOS improves from D to C in both peaks. See **Table 5-18.**

Table 5-18: Delay (sec/veh) and LOS - Hackberry and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	33.9	C	19.4	B	35.0	C	22.3	C
EBT	41.6	D	32.5	C	50.9	D	32.2	C
EBR								
EB	40.0	D	29.8	C	46.6	D	29.5	C
WBL			18.8	B			20.8	C
WBT	45.1	D	34.4	C	46.8	D	32.6	C
WBR								
WB	45.1	D	32.2	C	46.8	D	31.4	C
NBL	18.3	B	14.5	B	19.5	B	13.5	B
NBT	31.6	C	26.3	C	37.7	D	22.0	C
NBR								
NB	30.1	C	24.9	C	36.3	D	21.3	C
SBL	28.4	C	22.5	C	29.4	C	19.6	B
SBT	31.4	C	24.8	C	35.2	D	21.2	C
SBR								
SB	31.1	C	24.5	C	34.8	C	21.1	C
Overall	**34.9**	**D**	**27.0**	**C**	**39.1**	**D**	**24.1**	**C**

5.2.18. Business 83 & 29th Street

Existing Conditions

The southbound approach operates at LOS F due to significant delays to the thru lanes during the both peaks. The approach consists of a left only lane, through lane, and a right only lane. The westbound thru is also at LOS F in the PM peak.

Proposed Improvements

- Re-stripe the southbound right only lane as a shared through-right lane. Add a 180-ft receiving lane with 50-ft taper on the south leg of the intersection by removing the two-way left-turn lane and narrowing the existing lanes to 12 feet. No additional pavement is required.
- Shift green time to the westbound thru phase. See **Figure E-18.**

Costs

Re-stripe the northbound approach.

Benefits

The southbound approach improves to LOS C during the AM and PM peaks. The westbound thru improves to LOS D during the PM peak. Overall, the intersection improves from E in the AM and F in the PM to LOS C. See **Table 5-19.**

Table 5-19: Delay (sec/veh) and LOS - Business 83 and 29th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	23.2	C	19.1	B	23.7	C	25.9	C
EBT	51.3	D	34.4	C	40.0	D	29.1	C
EBR								
EB	48.3	D	32.7	C	37.9	D	31.0	C
WBL	23.7	C	19.6	B	22.5	C	20.3	C
WBT	47.4	D	33.6	C	124.6	F	39.5	D
WBR								
WB	44.4	D	31.8	C	115.0	F	37.7	D
NBL	20.5	C	20.0	B	21.0	C	21.4	C
NBT	27.7	C	29.8	C	30.3	C	28.2	C
NBR								
NB	27.0	C	28.8	C	29.3	C	27.4	C
SBL	15.2	B	19.0	B	17.0	B	19.2	B
SBT	93.5	F	30.6	C	155.1	F	29.9	C
SBR	22.3	C			23.7	C		
SB	80.9	F	39.6	C	127.3	F	28.9	C
Overall	**50.4**	**D**	**30.7**	**C**	**81.8**	**F**	**30.0**	**C**

5.2.19. Business 83 & 23rd Street

Existing Conditions

The northbound and southbound movements are run split phased. All approaches are at LOS E or F in both peak periods. Overall, the intersection is at LOS E in the morning and LOS F in the evening.

Proposed Improvements

To avoid the railroad utilities, these improvements will require 10-ft lanes on the north and south approaches. By adding four feet of additional pavement on the east side of the north and south legs and narrowing all lanes to 10 feet wide, 150-ft northbound and southbound left-turn lanes can be formed. Run the north-south left-turn movements protected-permitted. See **Figure E-19.**

Costs

- Construct new pavement on the west side of the northbound and southbound approaches.
- Relocate a signal pole, an electric pole, and a storm inlet on the southwest corner.

Benefits

All approaches and movements operate at LOS C or better. See **Table 5-20.**

Table 5-20: Delay (sec/veh) and LOS - Business 83 and 23rd Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	28.4	C	20.0	C	28.8	C	20.7	C
EBT	74.7	E	34.4	C	78.9	E	34.6	C
EBR	37.4	D	29.3	C	36.7	D	28.9	C
EB	65.1	E	32.2	C	67.9	E	32.2	C
WBL	29.9	C	21.1	C	28.0	C	20.0	B
WBT	74.3	E	34.3	C	80.5	F	34.7	C
WBR	38.3	D	29.9	C	39.8	D	30.4	C
WB	62.4	E	31.7	C	68.7	E	32.6	C
NBL			21.4	C			21.8	C
NBT	84.4	F	27.3	C	135.9	F	34.2	C
NBR								
NB	84.4	F	26.2	C	135.9	F	32.7	C
SBL			18.2	B			21.2	C
SBT	62.1	E	33.4	C	149.0	F	31.8	C
SBR								
SB	62.1	E	31.1	C	149.0	F	30.8	C
Overall	**67.3**	**E**	**30.6**	**C**	**108.6**	**F**	**32.1**	**C**

5.2.20. Business 83 & 10th Street

Existing Conditions

This intersection currently operates at LOS D in the PM peak. The northbound and southbound thru and shared right movements are at LOS D in the AM peak and at LOS E in the PM peak.

Proposed Improvements

- Add an 80-ft northbound right-turn lane with a 50-ft taper. See **Figure E-20**.
- This intersection would also benefit from a southbound right-turn lane. Due to constraints of the railroad signals on the southbound approach, adding a southbound right-turn lane is very costly; therefore, it is not recommended.

Costs

Relocate signal pole, storm sewer inlet, and luminary on southeast corner.

Benefits

In the PM peak, the northbound thru lane improves to LOS D, the right-turn lane improves to LOS C, and the overall intersection improves to LOS C. The southbound thru movement remains at LOS E. See **Table 5-21**.

Table 5-21: Delay (sec/veh) and LOS – Business 83 and 10th Street

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL	14.9	B	14.9	B	16.5	B	16.5	B
EBT	27.2	C	27.2	C	26.7	C	26.7	C
EBR	21.7	C	21.7	C	23.2	C	23.2	C
EB	25.7	C	25.7	C	25.0	C	25.0	C
WBL	15.8	C	15.8	B	16.8	B	16.8	B
WBT	27.0	B	27.0	C	28.7	C	28.7	C
WBR								
WB	25.6	C	25.6	C	26.6	C	26.6	C
NBL	23.9	C	23.9	C	28.1	C	28.1	C
NBT	37.9	D	36.8	D	71.6	E	40.3	D
NBR			31.1	C			34.0	C
NB	35.7	D	34.4	C	64.3	E	37.1	D
SBL	24.4	C	23.9	C	26.3	C	23.5	C
SBT	47.1	D	47.1	D	56.1	E	56.1	E
SBR								
SB	43.0	D	42.9	D	52.1	D	51.7	D
Overall	**31.8**	**C**	**31.5**	**C**	**41.7**	**D**	**34.7**	**C**

5.2.21. Houston & Bicentennial

Existing Conditions

HCS+ analysis suggests the eastbound thru movement is operating at LOS D during the AM peak. Field observations showed that vehicles attempting to make permissive eastbound and westbound left turns are often unable to do so. This resulted in long queues of thru and left-turning vehicles. The intersection is also split phased in the northbound and southbound directions because these left-turn movements are not able to run concurrently.

Proposed Improvements

- Add 150-ft northbound and southbound left-turn bays with 100-ft tapers in the median and run these phases protected only.
- Provide 150-ft eastbound and westbound right-turn lanes with 50-ft tapers by re-striping narrower lanes and by adding 4-ft of extra pavement. Run the eastbound and westbound movements split phased. See **Figure E-21**.

Costs

- Upgrade eastbound and westbound signals to signal heads with left-turn arrows.
- Install signal heads on existing poles for northbound and southbound left turns.
- Remove and rebuild sidewalks in median.
- Relocate the controller cabinet, one pull box, one luminary, and one electric service pole.
- Construct new pavement in median for northbound and southbound left turns. Widen the westbound approach to accommodate a westbound right lane.
- Re-stripe the eastbound and westbound approaches.

Benefits

The intersection shows a 5.6% overall reduction in the delay in both peaks. The split phasing in the eastbound and westbound movements ensures left turns are served. See **Table 5-22**.

Table 5-22: Delay (sec/veh) and LOS - Houston and Bicentennial

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL								
EBT	37.4	D	42.3	D	34.9	C	42.3	D
EBR			36.0	D			36.0	C
EB	37.4	D	41.8	D	34.9	C	37.4	D
WBL								
WBT	35.1	D	39.0	D	39.9	D	39.0	D
WBR			38.6	D			38.6	C
WB	35.1	D	38.9	D	39.9	D	35.1	D
NBL			38.8	D			38.8	D
NBT	30.3	C	30.2	C	30.7	C	30.2	C
NBR								
NB	30.3	C	30.5	C	30.7	C	32.4	C
SBL			53.7	D			53.7	D
SBT	36.1	D	25.4	C	34.8	C	25.4	C
SBR								
SB	36.1	D	30.2	C	34.8	C	30.1	C
Overall	**33.8**	**C**	**31.9**	**C**	**33.8**	**C**	**31.9**	**C**

5.2.22. Jackson & Bicentennial

Existing Conditions

Split phase operation in the northbound and southbound directions reduces intersection efficiency. In both peaks, all approaches are at LOS D or E. The westbound thru is at LOS F in the AM peak and the westbound right is at LOS E in the PM peak.

Proposed Improvements

- Add 150-ft northbound and southbound left-turn bays with 100-ft tapers in the median and run the lefts protected only.
- Adjust the splits to provide more time to the eastbound and westbound movements. See **Figure E-22.**

Costs

- Remove and relocate sidewalk in north median.
- Install signal head for north and south left movements.
- Relocate one traffic signal pull box.
- Construct new pavement for northbound and southbound left turns.
- Move the northbound U-turn lane further south.

Benefits

The northbound and southbound thru movements improve from LOS D to C. The intersection overall improves from LOS D to LOS C during both peaks See **Table 5-23.**

Table 5-23: Delay (sec/veh) and LOS - Jackson and Bicentennial

Movement	AM Delay/LOS				PM Delay/LOS			
	Before		After		Before		After	
EBL								
EBT	43.4	D	40.5	D	42.5	D	40.6	D
EBR	37.5	D	36.1	D	38.4	D	37.5	D
EB	42.3	D	39.7	D	41.3	D	39.7	D
WBL								
WBT	42.1	F	38.1	D	53.0	D	40.4	D
WBR	44.2	D	38.8	D	61.0	E	42.2	D
WB	43.1	D	38.4	D	56.8	E	41.3	D
NBL			42.5	D			41.2	D
NBT	41.4	D	34.2	C	36.4	D	26.3	C
NBR								
NB	41.4	D	34.5	C	36.4	D	27.1	C
SBL			39.8	D			47.1	D
SBT	36.2	D	22.7	C	40.4	D	25.1	C
SBR								
SB	36.2	D	25.6	C	40.4	E	27.6	C
Overall	**47.5**	**D**	**31.9**	**C**	**41.6**	**D**	**30.6**	**C**

5.3. *Benefit-Cost Analysis*

5.3.1. Benefit Calculation

The calculation of the 5-year life-cycle benefit begins by determining the combined peak hour benefit to each intersection. Approach volumes are used to derive a time benefit from the approach delay savings. The approach volumes are multiplied by the approach delay savings and then added together for the total peak intersection time benefit. The time benefits for each intersection are shown in hours in **Table 5-24**.

Table 5-24: Intersection Peak Hour Benefit Calculations

Benefit Rank	Intersection	AM		PM		Combined Peak
		Delay Savings (sec)	Time Benefit (hr)	Delay Savings (sec)	Time Benefit (hr)	Time Benefit (hr)
1	Dove & 23rd Street	63.2	63.8	74.8	80.1	143.9
2	Daffodil & Ware	120.6	131.5	5.5	4.8	136.3
3	Nolana & 23rd Street	54.9	61.4	33.4	38.7	100.0
4	Business 83 & 23rd Street	36.7	1.5	76.5	75.8	77.3
5	Business 83 & 29th Street	19.7	15.5	51.8	50.0	65.5
6	Nolana & 2nd Street	20.2	21.3	27.7	32.6	53.9
7	Trenton & 10th Street	10.6	9.9	22.0	28.9	38.9
8	Dove & 10th Street	28.1	27.9	7.2	8.5	36.4
9	Lark & Ware	57.9	29.2	14.7	6.3	35.5
10	Auburn & Ware	27.4	10.3	45.8	21.6	32.0
11	Pecan & McColl	1.5	1.5	13.4	13.7	15.2
12	Pecan & 2nd Street	8.9	8.2	7.5	6.8	15.0
13	Hackberry & 10th Street	7.9	3.4	15.0	8.9	12.3
14	Nolana & 10th Street	1.5	1.4	7.5	10.2	11.6
15	Jackson & Bicentennial	15.6	3.8	11.0	6.2	10.0
16	Business 83 & 10th Street	0.3	0.2	7.0	6.8	7.0
17	Pecan & 10th Street	5.3	3.9	2.6	2.9	6.8
18	Harvey & 10th Street	3.0	1.6	6.9	5.1	6.8
19	Pecan & 6th Street	4.2	2.0	7.4	3.6	5.6
20	Tamarack & 23rd Street	2.7	1.4	2.1	1.0	2.4
21	Hackberry & Bicentennial	2.1	1.4	1.3	1.0	2.4
22	Houston & Bicentennial	1.9	1.0	1.9	1.1	2.1
Total Time Benefit (hrs)			402.1		414.5	816.7

To calculate a daily benefit in dollars, the two peaks hour benefits are added and multiplied by 1.5 to account for off-peak benefits, as shown in **Table 5-25**. This number is then multiplied by an assumed value of time ($18.81/hour, derived from the Texas Transportation Institute and adjusted using the Consumer Price Index). Assuming there are 250 weekdays in a year, the annual benefit is calculated from the daily benefit. A 5-year project life is used to obtain the life-cycle benefit.

Table 5-25: Life-Cycle Benefit Calculations

Benefit Rank	Intersection	Annual Benefit (250 days)	Life-Cycle Benefit (5 years)
1	Nolana & 2nd Street	$1,014,800	$5,074,000
2	Business 83 & 23rd St.	$961,200	$4,805,900
3	Nolana & 23rd Street	$705,500	$3,527,600
4	Lark & Ware	$545,000	$2,724,900
5	Dove & 10th Street	$461,800	$2,308,800
6	Business 83 & 29th St.	$380,100	$1,900,400
7	Pecan & 2nd Street	$274,100	$1,370,400
8	Nolana & 10th Street	$256,900	$1,284,300
9	Daffodil & Ware	$250,100	$1,250,700
10	Dove & 23rd Street	$225,500	$1,127,500
11	Auburn & Ware	$106,900	$534,500
12	Trenton & 10th Street	$105,700	$528,600
13	Hackberry & 10th Street	$86,900	$434,400
14	Houston & Bicentennial	$81,700	$408,300
15	Business 83 & 10th S.	$70,600	$353,100
16	Pecan & 6th Street	$49,500	$247,400
17	Pecan & McColl	$48,100	$240,400
18	Hackberry & Bicentennial	$47,900	$239,300
19	Tamarack & 23rd Street	$39,300	$196,400
20	Pecan & 10th Street	$17,000	$84,900
21	Jackson & Bicentennial	$16,700	$83,300
22	Harvey & 10th Street	$14,500	$72,300
Total Benefit		$5,759,500	$28,797,300

Note: Assumed value of travel time = $18.81 per hour.
Source: http://www.bls.gov/cpi/home.htm

5.3.2. Cost Calculation

The probable cost for completing each recommended intersection improvement was determined by itemizing all new pavement construction, required utility relocations, and necessary signal upgrades. A 20% contingency is also included for design costs. A list of generalized costs was acquired from City of McAllen staff (**Table 5-26**). Using notes and sketches from site visits to each intersection, the intersection drawings (originally drawn from aerial photographs) were updated with approximate locations of utilities. Schematics of the proposed improvements were developed, and a list of costs was formed. These estimates of probable cost are at the planning level only, and do not consider specific field conditions (road grades, soil conditions, drainage, environmental concerns, etc.) at the recommended locations. **Appendix E** contains the probable cost sheet for each intersection. **Table 5-27** displays the results of this exercise.

In general, the largest cost was due to new pavement. Certain intersections, such at Business 83 and 29th Street or Hackberry Avenue and Bicentennial Boulevard have very low costs relative to other intersections as their improvements require only re-striping or signal upgrades.

Table 5-26: Construction Units Costs

Item	Cost	Unit
Traffic Signal		
Controller Cabinet	$8,500	EA
Traffic Signal Pull Box	$800	EA
Signal Pole		
Steel Strain	$5,000	EA
Mast Arm	$7,500	EA
5-section head	$1,000	EA
Pedestrian Pole	$2,500	EA
Utilities		
Electrical Pole	$8,000	EA
Light Pole	$2,000	EA
5' Sidewalk	$28	LF
Water valve	$500	EA
Hydrant	$2,500	EA
Manhole	$2,500	EA
Inlet	$4,000	EA
Culvert	$2,500	EA
Gas valve	$500	EA
Telephone	$500	EA
New Pavement		
ROW	variable	SF
Subgrade	$4	SF
Base	$12	SF
Asphalt	$14	SF
Curb & Gutter	$9.50	LF
Clearing & Grubbing	$5	SF
Driveway Repair	$450	LF
Construction Traffic Control	$5,000	LS
Re-striping		
Reflective marking 4" white	$0.32	LF
Reflective marking 4" yellow	$0.29	LF
Reflective marking arrow	$112	EA
Reflective marking word	$140	EA
Remove Existing marking 4"	$0.22	LF
Remove Existing marking arrow	$27	EA
Remove Existing marking word	$38	EA

Note: EA = Each, LF = Linear Feet, SF = Square Feet

Table 5-27: Cost Analysis

Cost Rank	Intersection	Cost
1	Dove & 10th Street	$669,000
2	Nolana & 23rd Street	$583,100
3	Pecan & 2nd Street	$514,300
4	Tamarack & 23rd Street	$491,100
5	Nolana & 2nd Street	$470,600
6	Dove & 23rd Street	$460,300
7	Auburn & Ware	$452,200
8	Nolana & 10th Street	$425,700
9	Pecan & 6th Street	$376,400
10	Pecan & McColl	$272,700
11	Jackson & Bicentennial	$233,400
12	Business 83 & 23rd Street	$229,500
13	Lark & Ware	$218,100
14	Pecan & 10th Street	$130,500
15	Daffodil & Ware	$116,700
16	Houston & Bicentennial	$84,900
17	Trenton & 10th Street	$93,800
18	Harvey & 10th Street	$78,400
19	Hackberry & 10th Street	$70,700
20	Business 83 & 10th Street	$50,800
21	Hackberry & Bicentennial	$2,400
22	Business 83 & 29th Street	$1,400
Total Cost		$6,005,600

*Note: Worksheets for these calculations are located in **Appendix E**.*

5.3.3. Benefit-Cost Ratio

The benefit-cost ratio is a useful tool to prioritize projects of varying benefit and cost. It can aid in the selection of cost-effective solutions. Intersections with the greatest benefit should be considered for construction, though projects with larger benefit-cost ratios should be considered for construction first.

Most intersection improvements have a benefit-cost ratio greater than one, which indicates the project is cost-effective. Intersections with benefit-cost ratios less than one may have improvement costs that outweigh the estimated operational benefits. It is possible a more precise cost assessment could be performed for those intersections with benefit-cost ratios less than one and the costs may not be so high. Also, the project life span could be reevaluated and the benefits increase.

According to **Table 5-28**, Business 83 and 29th Street is the most favorable improvement due to its low cost. Many other intersections also have a large benefit-cost ratio and should be considered for implementation.

Table 5-28: Benefit-Cost Ratio

B/C Rank	Intersection	Life-cycle Benefit	Cost	B/C
1	Business 83 & 29th Street	$2,308,800	$1,400	1649.1
2	Daffodil & Ware	$4,805,900	$116,700	41.2
3	Hackberry & Bicentennial	$83,300	$2,400	34.7
4	Trenton & 10th Street	$1,370,400	$93,800	14.6
5	Business 83 & 23rd Street	$2,724,900	$229,500	11.9
6	Dove & 23rd Street	$5,074,000	$460,300	11.0
7	Hackberry & 10th Street	$434,400	$70,700	6.1
8	Nolana & 23rd Street	$3,527,600	$583,100	6.0
9	Lark & Ware	$1,250,700	$218,100	5.7
10	Business 83 & 10th Street	$247,400	$50,800	4.9
11	Nolana & 2nd Street	$1,900,400	$470,600	4.0
12	Harvey & 10th Street	$239,300	$78,400	3.1
13	Auburn & Ware	$1,127,500	$452,200	2.5
14	Pecan & McColl	$534,500	$272,700	2.0
15	Dove & 10th Street	$1,284,300	$669,000	1.9
16	Pecan & 10th Street	$240,400	$130,500	1.8
17	Jackson & Bicentennial	$353,100	$233,400	1.5
18	Pecan & 2nd Street	$528,600	$514,300	1.0
19	Nolana & 10th Street	$408,300	$425,700	1.0
20	Houston & Bicentennial	$72,300	$84,900	0.9
21	Pecan & 6th Street	$196,400	$376,400	0.5
22	Tamarack & 23rd Street	$84,900	$491,100	0.2
Total		$28,797,400	$6,005,600	4.8

6. Conclusion

Signal operations in McAllen have been greatly improved coordinated signal timing plans. For the project, the entire network was coordinated by splitting it into different corridors. The corridors that carry heavier traffic volumes were given priority over others to get better progression along the major arterials. Lead-lagging left turn movements yielded better progression and wider green bands on the major arterials. Lead-lagging more left turns could have improved the progression on some corridors.

These new timing plans have been implemented and are in operation. Based on the traffic operations models, it is expected that the new timing plans will reduce stops, delays, and travel times in the morning and afternoon peak-periods. Estimated delay savings from the new timing plans is $9,268,627 per year.

In order to maintain the benefit of the new traffic signal timings, it is important that each location routinely receive a time clock update. This can be done either by manually resetting each controller clock or remotely through a communication link and a closed loop signal system. The cost of installing closed loop systems is relatively low compared to the labor costs of manual resets. It is recommended that interconnected closed loop signal systems be installed for all of the signalized intersections in the McAllen network.

Several intersections in the study area suffered from over congestion, where the number of lanes was not able to handle all of the peak traffic, regardless of the signal timing. For these locations, alternative configurations were studied which included modifying lane assignments or adding additional lanes. The cost of these improvements was compared to the benefits of implementing them and all projects were ranked by their benefit to cost ratio. It is recommended that the City of McAllen utilize this list to develop a Capital Improvements program for all projects with a bc ratio of 1.5 or higher.