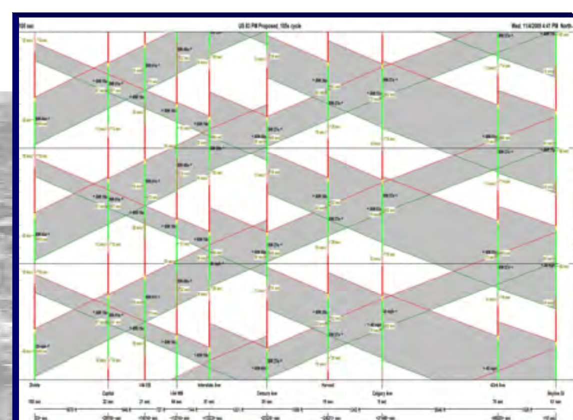
Final Report

January 14, 2010

Bismarck Signal Optimization Project

For
Bismarck Expressway
State Street



Bismarck-Mandan
Metropolitan Planning Organization

Bismarck

URS

Houston Engineering Inc.

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The following provides a brief overview of the Bismarck Signal Optimization Project and highlights some of the key results of the project. This project was completed for the City of Bismarck and the Bismarck-Mandan MPO.

Project Description

The Bismarck Signal Optimization Project includes the following roadway segments within the City of Bismarck.

- Bismarck Expressway: Washington Street through I-94 (including the Century Avenue / Centennial Road intersection)
- State Street (US 83): Divide Avenue through Skyline Boulevard

These two corridors include a total of 30 signalized intersections. These two corridors are critical to the everyday commuting traffic patterns within the City of Bismarck. Many of the busiest intersections within the city are located along these two corridors. At the same time these corridors serve as the front door to much of the retail developments within the community.

Project Purpose

Traffic signal optimization is a cost effective way to improve the flow of traffic along a corridor. In high-volume traffic corridors like Bismarck Expressway and State Street it is important for the signal timing plans to match existing traffic patterns at each intersection, but it also critical to coordinate signal timings for adjacent signalized intersections. The synchronizing and coordinating of the signals along a corridor allow platoons of traffic to move smoothly and quickly through a corridor. Benefits from signal coordination include:

- Reduction in travel time and delays
- Reduction in stops and traffic slow downs could reduce accident potential
- Reduction in fuel consumption (i.e., less idling time) and vehicle emissions
- Potential to delay / eliminate the need for roadway widening

In order to meet the project purpose an evaluation of existing conditions and new timing plans were developed and implemented. As part of the project an estimate of the project benefits was also developed.

The purpose of this document is to present the results of the Bismarck Signal Optimization Project, as discussed in the following chapters:

- Existing Conditions (Chapter 2)
- Signal Timing Optimization (Chapter 3)
- Benefit Cost Analysis (Chapter 4)
- Conclusions (Chapter 5)

Project Tasks

This primary project tasks completed for this project are outlined below:

Task 1 – Data Collection – “Before” Conditions

- Intersection Turn Movement Counts
- Corridor Travel Times
- Average Travel Speeds

Task 2 – Existing Condition Evaluation

- Analyze Existing Traffic Conditions and Identify Deficiencies
- Evaluate Corridor Safety

Task 3 – Develop Signal Timing Plans

- Develop Timing Plans for Each Intersection
- Develop Coordination Plans for Each Corridor
- Timing Plans for Each Peak and Non-Peak Period Throughout the Day

Task 4 – Deploy Signal Timing Plans in Field

- Upload Revised Signal Timing Plans at Each Intersection
- Field Check New Signal Timings and Fine Tune
- Conduct “After” Condition Data Collection
- Prepare Project Summary Report

Task 5 – Public Involvement

- Project Outreach Program
- Webpage
- Public Meeting
- Project Steering Committee
- Public Input

Before / After Travel Time Comparison

A comparison of “before” and “after” travel time studies were completed to document the improvements for mainline traffic flow in both corridors A comparison of the before / after travel time runs is provided in Tables ES-1 through ES-3.

As shown in these tables, the comparison of the “before” and “after” travel time runs reveals substantial time savings for mainline traffic. The time savings range from a few seconds to over 90 seconds. Considering the fact that the majority of these intersections were already coordinated prior to this project the time savings are encouraging.

Time periods with lower levels of travel time savings either indicate that the previous coordinated plan was an efficient one or more emphasis was placed on one direction over the opposite direction with the new signal timing plan.

TABLE ES-1. BISMARCK EXPRESSWAY WEST TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
Washington to Burlington	M	279.7	277.1	2.6	1%
	MM	287.6	242.1	45.5	16%
	MD	307.5	248.8	58.7	19%
	A	312.6	279.2	33.5	11%
	E	366.5	287.1	79.4	22%
	LE	317.1	249.9	67.2	21%
Burlington to Washington	M	359.2	293.5	65.7	18%
	MM	311.6	259.3	52.3	17%
	MD	334.3	286.4	47.9	14%
	A	355.9	273.5	82.4	23%
	E	405.2	314.2	91.0	22%
	LE	345.2	249.3	95.9	28%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

TABLE ES-2. BISMARCK EXPRESSWAY EAST TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
Main to Century	M	242.5	226.4	16.1	7%
	MM	209.2	192.9	16.3	8%
	MD	215.8	200.8	15.0	7%
	A	202.2	201.5	0.6	0%
	E	255.2	241.4	13.8	5%
	LE	204.5	177.2	27.3	13%
Century to Main	M	219.0	195.3	23.7	11%
	MM	201.8	190.9	10.9	5%
	MD	209.6	191.0	18.6	9%
	A	222.3	196.6	25.7	12%
	E	215.5	207.3	8.2	4%
	LE	193.7	197.0	-3.3	-2%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

TABLE ES-3. STATE STREET TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
Divide to Skyline	M	281.9	277.0	4.9	2%
	MM	257.5	243.7	13.8	5%
	MD	282.8	258.6	24.2	9%
	A	294.6	268.4	26.2	9%
	E	306.0	246.7	59.3	19%
	LE	297.0	260.8	36.2	12%
Skyline to Divide	M	294.5	263.6	30.9	11%
	MM	308.7	264.6	44.1	14%
	MD	344.2	272.3	71.9	21%
	A	351.1	281.3	69.8	20%
	E	371.7	275.0	96.7	26%
	LE	343.7	265.7	78.0	23%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

Benefit / Cost Analysis

A benefit / cost analysis was completed to determine the economic benefits associated with the Bismarck Signal Optimization Project. The project benefits are calculated by evaluating the "before" and "after" conditions for corridor travel time, number of vehicle stops, and fuel consumption.

The net annual economic benefit of this project is estimated to be **$795,750**. This number includes over 38,000 vehicle hours of travel and approximately 30,000 gallons of fuel.

The benefit / cost ratio is calculated based on the project benefits versus the project cost. The Bismarck Signal Optimization Project resulted in a one-year benefit / cost ratio of **3.5:1**. However, newly implemented signal timing plans have a lifetime of at least three years. That would increase the benefit / cost ratio to **10.5:1**.

Conclusions

The implementation of the new optimized signal timing plans in these two corridors has proven to be beneficial for Bismarck citizens based upon the project results discussed. The traffic signal retiming effort has been a cost-effective way to improve traffic flow along the project corridors by reducing travel times, delays, and vehicle stops. The project also resulted in reduced fuel consumption that saves money for Bismarck citizens. This project has also proven to be financially beneficial with a benefit / cost ratio of 3.5:1.

Traffic signals affect the lives of Bismarck citizens everyday. Signalized intersections provide for the organized control of conflicting traffic movements in a safe manner; however these intersections can be a source of frustration for motorists due to delays. The City of Bismarck has expanded and travel patterns have changed over the last several years, leading to outdated traffic signal timings plans.

The Bismarck Signal Optimization Project includes the following roadway segments within the City of Bismarck.

- Bismarck Expressway: Washington Street through I-94 (including the Century Avenue / Centennial Road intersection)
- State Street (US 83): Divide Avenue through Skyline Boulevard

The project corridors are shown in Figure 1. These two corridors are highlighted on the Project Map and include 16 and 10 signalized intersections in the Bismarck Expressway and State Street corridors, respectively. An additional 4 signalized intersections within close proximity to these two corridors are also included in the project.

These two corridors are critical to the everyday commuting traffic patterns within the City of Bismarck. Many of the busiest intersections within the city are located along these two corridors. At the same time these corridors serve as the front door to much of the retail developments within the community.

1.1 Project Purpose

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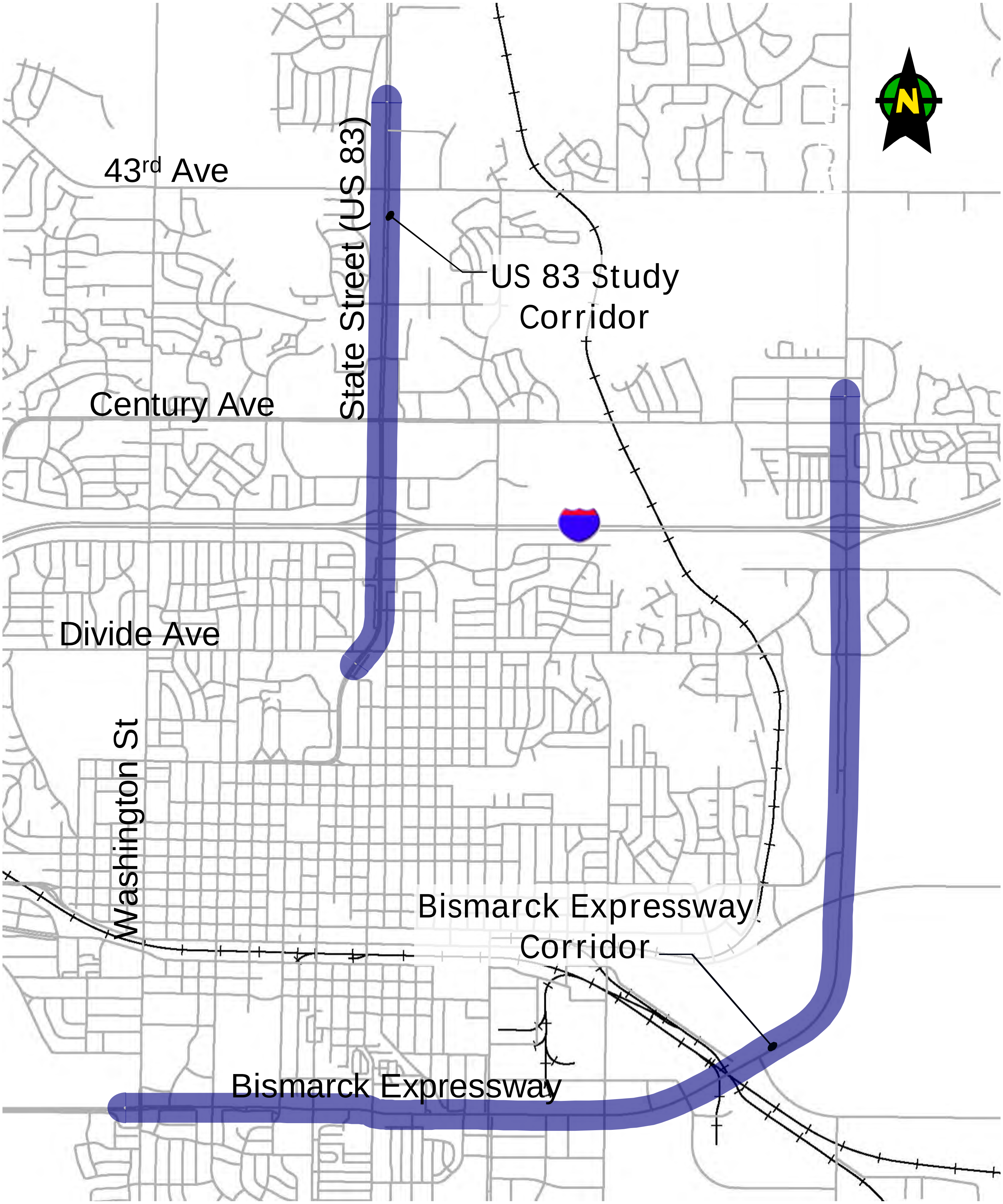

FIGURE 1: Project Corridors

1.2 Project Tasks

This project required the completion of numerous tasks as outlined below:

Task 1 – Data Collection – "Before" Conditions

- Intersection Turn Movement Counts
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- Project Steering Committee
- Public Input

1.3 Public Involvement

For this project a website has been maintained to provide updates on the project. That website can be accessed at www.bismarcksignal.com. Via the website the public can provide comments. A public meeting was held on November 20, 2009 between 6:30 to 8:00 pm in the Tom Baker Room at the City-County Building. The public meeting was advertised in the Bismarck Tribune; however, no members of the public attended the meeting.

Prior to developing new signal timing plans, it was important to understand the existing conditions in each corridor. Using the data collected in the field and knowledge gained through field observations a more refined set of signal timing plans could be developed. Topics that will be covered in this chapter include:

- Existing Roadway and Traffic Characteristics
- Before Condition – Field Data Collection
- Existing Condition Traffic Models
- Existing Condition Traffic Operations

2.1 Roadway / Traffic Characteristics

The following sections document the key characteristics of existing conditions in the Bismarck Expressway and State Street corridors.

2.1.1 Roadway and Intersection Geometry

The Bismarck Expressway and State Street corridors serve as key transportation corridors within the Bismarck community. In addition to serving an important transportation function, these corridors also serves significant commercial districts within the city. The Bismarck Expressway has four through lanes and a continuous left-turn lane for the majority of the corridor. In the State Street corridor a six-lane cross section with raised medians is currently provided for the majority of that corridor. A summary of the existing lane configurations at the major study area intersections along these two corridors is provided in Tables 1 and 2. Field reviews were conducted for each intersection to confirm lane configuration and storage bay lengths.

All other intersection approaches within the corridor consist of a single-lane and two-way stop sign control. Most of the turn-lanes appear to have adequate storage capacity to meet demand. Inadequate storage was noted during field observations for the eastbound left-turn movements at 9th Street and Bismarck Expressway for a short period of time during the AM peak hour.

The posted speed limits along Bismarck Expressway and State Street are listed below:

<u>Bismarck Expressway</u>

40 mph – Washington Street to just east of Burlington Drive

50 mph – Burlington Drive to just north of Revere Drive /Commerce Drive

40 mph – Divide Avenue to north of Century Avenue

Majority of side streets are 35 mph with a few signed for 25 mph

<u>State Street</u>

40 mph – Divide Avenue to Skyline Drive

Majority of side streets are 35 mph with a few signed for 25 mph

Additional information on travel speeds, based on field data collection, is provided later in this chapter.

TABLE 1: INTERSECTION LANE CONFIGURATION FOR BISMARCK EXPRESSWAY

Intersection	Intersection Approach (1)			
	Eastbound	Westbound	Northbound	Southbound
Washington St (2)	L, T, T,T, R	L, L, T, T, R	L, L, T, T, R	L, L, T, T, R
2nd St	L, T, T	T, T, R	- -	L, R
3rd St	L, T, T, R	L, T, T, R	L, T, TR	L, T, TR
Kirkwood Mall	L, T, TR	L, T, T, R	LTR	LT, R
7th St	T, TR	L, T, T	L, R	L, L, T, R
9th St	L, T, T, R	L, T, T, R	L, T, T, R	- -
12th St	L, T, TR	L, T, TR	L, TR	L, TR
19th St & Airport	L, T, TR	L, T, TR	L, T, TR	L, T, TR
26th St	L, T, T, R	L, T, T, R	L, TR	L, T, R
Burlington Dr	L, T, T, R	L, T, TR	L, L, TR	L, TR
Yegen	T, T, R	L, T, T-	L, R	- -
Main Ave	L, TR	L, TR	L, T, TR	L, T, TR
Rosser Ave	L, R	- -	L, T, T	T, T, R
Commerce & Revere	L, TR	L, TR	L, T, TR	L, T, TR
Divide Ave	L, TR	L, T, R	L, T, T, R	L, T, T, R
I-94 EB	LT, R	- -	T, T, R	L, T, T
I-94 WB	- -	LT, R	L, T, T	T, T, R
Century Ave	L, TR	L, TR	L, TR	L, TR

Notes:

(1) L= Left-turn lane; T = Through lane; R = Right-turn lane; LT, LR, TR, LTR = Shared lanes

(2) Third eastbound through lane drops approximately 150 east of intersection and is not utilized much by through traffic.

TABLE 2: INTERSECTION LANE CONFIGURATION FOR STATE STREET (US 83)

Intersection	Intersection Approach (1)			
	Eastbound	Westbound	Northbound	Southbound
Divide Ave (2)	L, T, TR	L, T, TR	L, T, T, TR	L, T, T, TR
Capitol Ave	L, TR	L, TR	L, T, T, TR	L, T, T, TR
I-94 EB	L, LTR, R	- -	T, T, T, R	L, T, T, T
I-94 WB	- -	L, LTR, R	L, T, T, T	T, T, T, R
Interstate Av	L, T, R	L, T, TR	L, L, T,T,T, R	L, L, T,T,T,R
Gateway Mall	R	R	L, T, T, TR	L, T, T, TR
Century Ave	L, T, T, R	L, T, T, R	L, L, T,T,T, R	L, L, T,T,T,R
Harvest Ln	L, T, R	L, T, R	L, T, T, TR	L, T, T, T, R
Calgary Ave	L, TR	L, TR	L, T, T, R	L, T, T, R
43rd Ave	L, TR	L, TR	L, T, T, R	L, T, T, R
Skyline Blvd	- -	L, L, R	T, T, R	L, T, T

Notes:

(1) L= Left-turn lane; T = Through lane; R = Right-turn lane; LT, LR, TR, LTR = Shared lanes
(2) Second eastbound/westbound through lanes drop approximately one block downstream

2.1.2 Signal Timings

Existing signal timings were obtained from the City of Bismarck. Key parameters obtained from these signal timing files include:

- Minimum/maximum green times
- Clearance intervals (yellow and all red)
- Pedestrian intervals
- Coordination data (i.e., cycle length, offsets, phase splits)
- Time of day (TOD) plans

A summary of the TOD plans is provided in Table 3.

TABLE 3: EXISTING CONDITION SIGNAL TIMING PLANS

Corridor / Segment	Operation	Time of Day	Plan	Cycle
Bismarck Expressway – Main to I-94	TOD	6:30 am to 6:30 pm 6:30 pm to 6:30 am	111 Free	90 - -
Bismarck Expressway - Century	FREE	12:00 am to 11:59 pm	- -	- -
Bismarck Expressway - Yegen	FREE	12:00 am to 11:59 pm	- -	- -
Bismarck Expressway – Washington to 12th	TOD	7:15 am to 8:15 am 8:15 am to 11:15 am 11:15 am to 1:30 pm 1:30 pm to 3:30 pm 3:30 pm to 6:30 pm 6:30 pm to 7:30 pm 7:30 pm to 7:15 am	311 211 322 222 333 233 Free	90 75 90 75 90 75 - -
Bismarck Expressway – Airport to Burlington	FREE	12:00 am to 11:59 pm	- -	- -
State Street	TOD	6:30 am to 9:00 am 9:00 am to 3:00 pm 3:00 pm to 7:00 pm 7:00 pm to 9:00 pm 9:00 pm to 6:30 am	111 112 113 112 Free	90 90 90 90 - -

In the Bismarck Expressway and State Street corridors a total of three different brands of traffic signal controllers (central control software) are used, as listed below:

- Econolite (Aries) – Bismarck Expressway from Yegen to I-94
- Peek (CLMATS) – Bismarck Expressway from Washington to Burlington
- Eagle (MARCNX) – State Street

All of the intersections in these three zones have communications to the central software and are interconnected with each other. The exception is the intersection of Bismarck Expressway/ Yegen Road. The traffic signal interconnects consist of fiber and twisted pair wiring.

2.1.3 Traffic Volumes

Intersection turning movement counts for this project were conducted by the City of Bismarck and URS. These traffic counts were conducted between 2006 and 2008. These counts were collected over a few years and at different times of the year, resulting in some differences in traffic volumes between adjacent intersections. These differences were adjusted during a "smoothing" process in order to develop more consistent turn movement volumes between up and downstream intersections. Intersection turn movement volumes for the morning, mid-day, and afternoon peak hours are provided in Appendix A.

As illustrated in Figures 2 and 3, traffic volumes experience several peak periods throughout the day and by direction of travel. Traffic volumes are shown in fifteen-minute intervals in these figures. The AM peak period is typically more pronounced (i.e., lower peak hour factors), while peak spreading (i.e., more balanced traffic volumes throughout a single hour) occurs during other peak periods throughout the day. The presence of commercial destinations along each of these corridors results in less of a dip in traffic volumes during time periods typically associated with the off-peaks.

2.1.4 Truck Traffic Volumes

The percentage of truck traffic was collected as part of turning movement counts. Vehicles that were counted as heavy vehicles include single unit (e.g., delivery van), three axle truck (e.g., dump truck) or truck/tractor trailer combination. A pickup truck with a trailer was not counted as a heavy vehicle. Higher than typical truck volume percentages were observed for two corridors. First, along Bismarck Expressway between Yegen Road and Century Avenue there are a number of businesses (origin-destination) for trucks. Second, along State Street between I-94 and Skyline Boulevard there are a number of trucks due to that roadways role as a state highway. Truck percentages from the turn movement counts were used to develop the traffic models for this project. The truck percentages on the mainline roadways ranged from 2 to 13%, with the majority of the roadway segments in the 2 to 3% range. For side streets and minor traffic movements (e.g., main street left-turns) the truck percentages ranged from 1 to 40%, again with the majority falling in the 1 to 3% range. A minimum truck percentage of 2% was used for the project traffic models.

2.1.5 Crash History

As part of the Bismarck Signal Optimization project a review of the crash history for the US 83 (State Street) and Bismarck Expressway corridors was conducted to determine whether high crash locations are present and to identify any crash patterns that can be attributed to traffic signal operations. Crash data for a three-year period from 2005 through 2007 was obtained from the North Dakota DOT. The crash data for these two corridors is presented in three sets of tables as outlined below.

- Tables 4 and 5: Crashes by Year and Crash Rates
- Tables 6 and 7: Crash Severity
- Tables 8 and 9: Crash Type

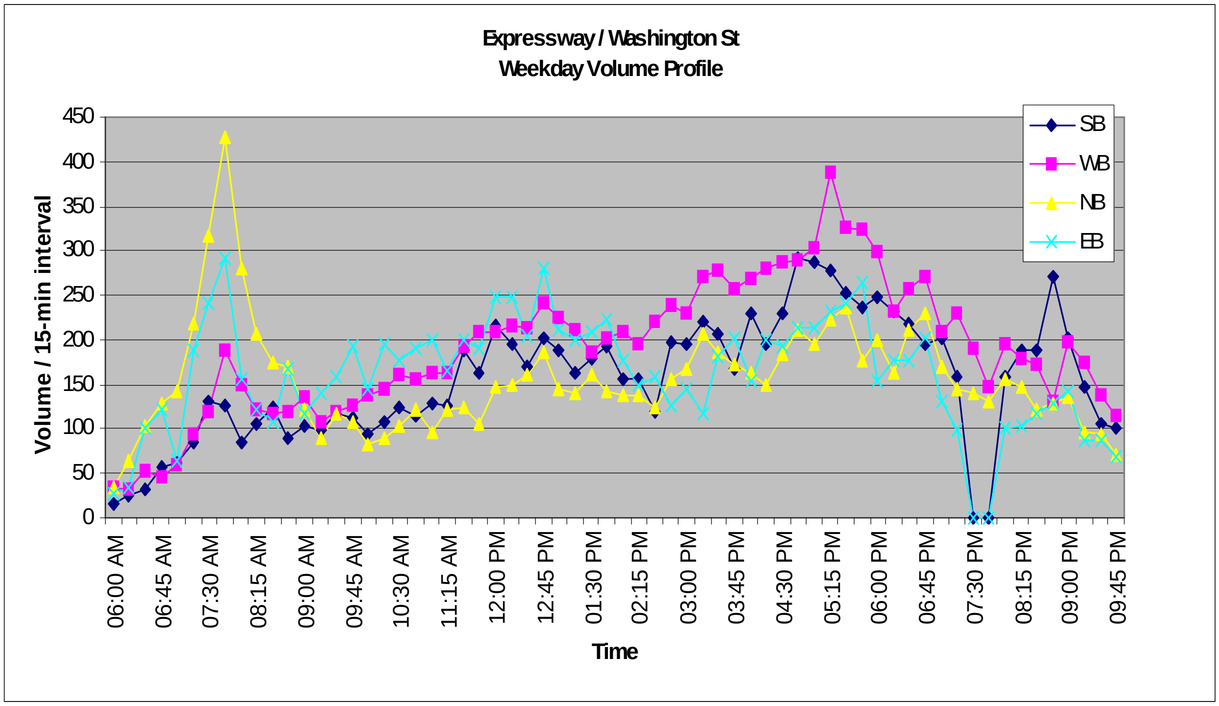

Figure 2 Bismarck Expressway / Washington Street Daily Traffic Volumes

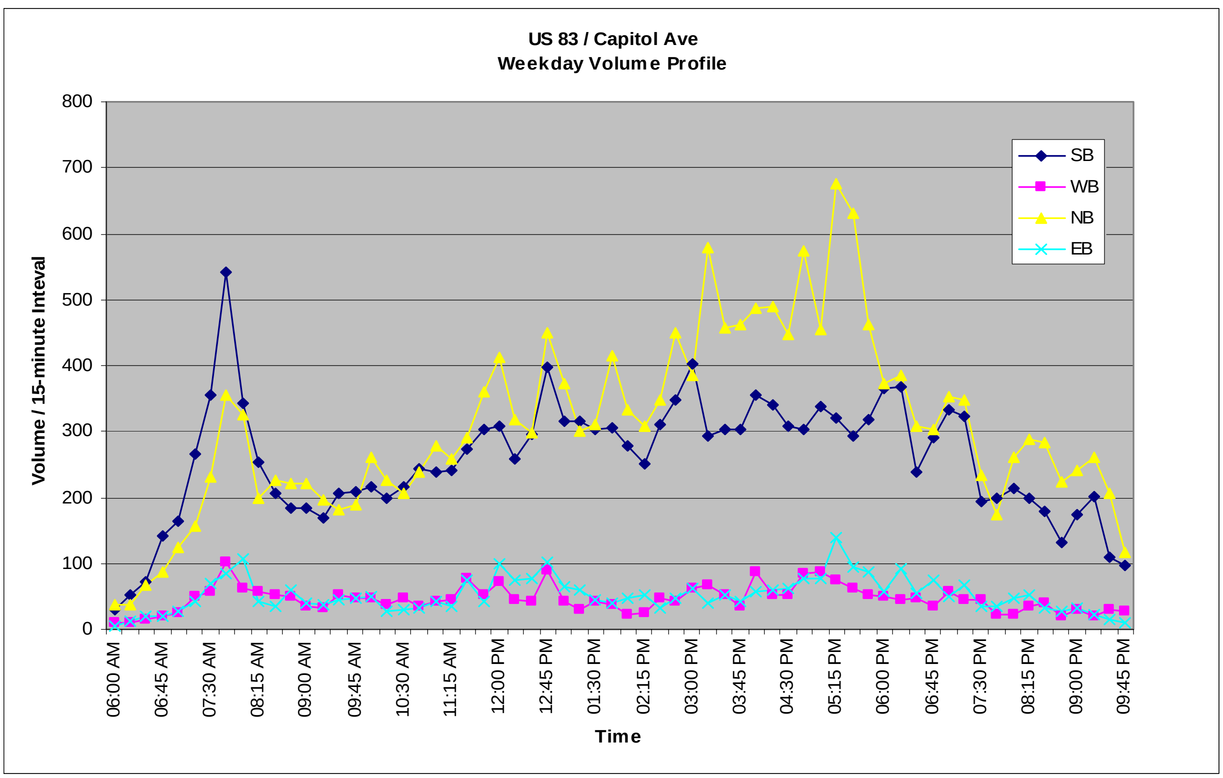

Figure 3 State Street / Capitol Avenue Daily Traffic Volumes

The crash data information is provided for signalized and unsignalized intersections, but do not include segment crashes along these two corridors. The key findings of the crash data review are summarized below:

- A total of 364 crashes occurred in the US 83 corridor during the three year period. The majority of the crashes occurred at signalized intersections (89%).
- In the Bismarck Expressway corridor a total of 419 crashes occurred over the three year period. Again, the majority of the crashes occurred at signalized intersections (80%). This corridor is longer than the US 83 corridor and also has a higher number of unsignalized intersections.
- Each crash was evaluated to determine if it is assigned to the correct intersection and/or segment. For example, at the intersection of US 83/Interchange Avenue there was a large number of northbound rear-end crashes that are related to northbound congestion / queuing and those crashes were re-assigned to the US 83 / I-94 South (EB) ramp intersection.
- The crash rates for signalized intersections ranged from 0.33 to 1.59 crashes per million entering vehicles (MEV). The average signalized intersection crash rates were 0.92 and 0.79 for the US 83 and Bismarck Expressway corridors, respectively. A typical crash rate for urban intersections falls in the range of 0.7 to 1.0 crashes/MEV.
- The signalized intersections with the highest number of crashes experience a crash once every 2 to 3 weeks on average. Considering all crashes in each corridor a crash occurs once every 3 days on average in each corridor.
- The proportion of injury crashes for signalized intersections in the US 83 and Bismarck Expressway corridors was 32% and 35%, respectively
- A total of two fatal crashes occurred in the two corridors over the three year period.
- The most common type of crash at signalized intersections in the US 83 and Bismarck Expressway corridors are rear end collisions, accounting for 61% and 53% of all crashes in the two corridors, respectively. These types of collisions typically result from traffic congestion and/or driver inattention
- The second most common crash type at signalized intersections are angle collisions, accounting for 21% and 18% of all crashes in the US 83 and Bismarck Expressway corridors, respectively. This type of collision typically results when a driver chooses a gap that is too short to complete their turn (failure to yield) and or driver inattention.
- The third most common crash type at signalized intersections is left-turn collisions, accounting for 11% and 17% of all crashes in the US 83 and Bismarck Expressway corridors, respectively. Similar to angle collisions, this type of collision typically results when a driver chooses a gap that is too short to complete their turn (failure to yield) and or driver inattention.
- A total of seven collisions between a motor vehicle and a pedestrian / bicyclist occurred at five signalized intersections in the two corridors over the three year period. The only intersection with more than one pedestrian / bicyclist crash was Bismarck Expressway / 12th Street with three crashes over the three year period. All three of the crashes at 12th Street involved in bicyclist riding in the crosswalk (with the WALK signal) that were struck by a vehicle attempting to make a right-turn on red.

TABLE 4. SUMMARY OF US 83 CRASHES BY YEAR AND CRASH RATES

Intersection	Crashes by Year			Total Crashes	Daily Traffic (MEV)	Crash Rate
	2005	2006	2007			
Divide Ave	14	6	22	*42*	39,150	0.98
Capitol Ave	22	13	29	*64*	36,700	1.59
I-94 South (EB)	15	16	23	*54*	40,050	1.23
I-94 North (WB)	7	7	14	*28*	37,800	0.68
Interstate Ave	21	16	16	*53*	43,550	1.11
Century Ave	20	2	15	*37*	39,400	0.86
Weiss Ave (Harvest Ln)	3	7	10	*20*	28,875	0.63
Calgary Ave	6	4	2	*12*	22,090	0.50
43rd Ave	1	5	3	*9*	19,875	0.41
Skyline Blvd [a]	0	2	4	*6*	16,650	0.33
Totals	109	78	138	325		0.92
Unsignalized Intersections						
12th St	1	0	0	*1*	31,550	0.03
Spaulding Ave	2	3	0	*5*	32,000	0.14
Interchange Ave	8	6	5	*19*	35,875	0.48
Totals	11	9	5	25		0.23

Notes:
a – Traffic signal was installed at this intersection in 2006 with opening of Wal-Mart retail site.

TABLE 5. SUMMARY OF BISMARCK EXPRESSWAY CRASHES BY YEAR AND CRASH RATES

Intersection	Crashes by Year			Total Crashes	Daily Traffic (MEV)	Crash Rate
	2005	2006	2007			
Washington St	17	20	13	*50*	36,350	1.26
3rd St	15	16	14	*45*	32,700	1.26
7th St	13	16	10	*39*	38,550	0.92
9th St	11	8	8	*27*	31,200	0.79
12th St	8	11	15	*34*	28,250	1.10
Airport Rd (19th St)	5	10	6	*21*	28,500	0.67
26th St	1	8	5	*14*	23,500	0.54
Burlington Dr [a]		1	1	*2*	17,550	0.31
Yegen Rd [a]				*0*	11,700	0.00
Main Ave	6	6	7	*19*	18,650	0.93
Rosser Ave	1	6	3	*10*	18,450	0.49
Revere Dr (Commerce)	3	1	1	*5*	16,900	0.27
Divide Ave	13	6	12	*31*	22,875	1.24
I-94 South (EB)	3	3	7	*13*	24,150	0.49
I-94 North (WB)	5	3	3	*11*	18,975	0.53
Centennial / Century	4	4	5	*13*	15,975	0.74
Totals	105	119	110	334		0.79
Unsignalized Intersections						
2nd St	5	3	1	*9*	24,775	0.33
Kirkwood Mall	6	2	4	*12*	29,100	0.38
11th St	1	3		*4*	24,250	0.15
18th St	3	1	7	*11*	19,800	0.51
22nd St			1	*1*	19,750	0.05
23rd St		1		*1*	19,750	0.05
Yegen Rd	3			*3*	11,700	0.35
Centennial / Trenton		2	2	*4*	17,575	0.21
Centennial / Catham	1	1		*2*	14,000	0.13
Totals	19	13	15	47		0.19

Notes:
a – Traffic signal was installed at this intersection in 2006 with opening of Wal-Mart retail site.
b – Traffic signal was installed at this intersection within the past year.

TABLE 6. SUMMARY OF US 83 CRASH SEVERITY

Intersection	Crash Severity			Total Crashes
	PDO	Injury	Fatal	
Divide Ave	27	15		*42*
Capitol Ave	42	22		*64*
I-94 South (EB)	39	15		*54*
I-94 North (WB)	17	11		*28*
Interstate Ave	36	17		*53*
Century Ave	25	12		*37*
Weiss Ave (Harvest Ln)	13	7		*20*
Calgary Ave	8	4		*12*
43rd Ave	8	1		*9*
Skyline Blvd	5	1		*6*
Totals	220	105	0	325
Unsignalized Intersections				
12th St	1			*1*
Spaulding Ave	1	4		*5*
Interchange Ave	14	5		*19*
Totals	16	9	0	25

TABLE 7. SUMMARY OF BISMARCK EXPRESSWAY CRASH SEVERITY

Intersection	Crash Severity			Total Crashes
	PDO	Injury	Fatal	
Washington St	35	15		*50*
3rd St	31	14		*45*
7th St	26	13		*39*
9th St	18	9		*27*
12th St	18	16		*34*
Airport Rd (19th St)	10	11		*21*
26th St	10	4		*14*
Burlington Dr	2			*2*
Yegen Rd [a]				*0*
Main Ave	9	9	1	*19*
Rosser Ave	5	5		*10*
Revere Dr (Commerce)	2	3		*5*
Divide Ave	23	8		*31*
I-94 South (EB)	10	3		*13*
I-94 North (WB)	9	2		*11*
Centennial / Century	9	4		*13*
Totals	217	116	1	334
Unsignalized Intersections				
2nd St	8	1		*9*
Kirkwood Mall	10	2		*12*
11th St	3	1		*4*
18th St	7	4		*11*
22nd St	1			*1*
23rd St	1			*1*
Yegen Rd	3			*3*
Centennial / Trenton	2	2		*4*
Centennial / Catham		2		*2*
Totals	35	12	0	47

TABLE 8. SUMMARY OF US 83 CRASH TYPES

Intersection	Manner / Type of Crash					
	Left-Turn	Angle	Rear End	Ped / Bike	Fixed Object	Other [a]
Divide Ave	10%	7%	79%	0%	2%	2%
Capitol Ave	6%	38%	52%	0%	0%	5%
I-94 South (EB)	6%	7%	83%	2%	0%	2%
I-94 North (WB)	14%	18%	54%	0%	4%	11%
Interstate Ave	23%	21%	47%	0%	0%	9%
Century Ave	16%	22%	57%	0%	0%	5%
Weiss Ave (Harvest Ln)	0%	30%	60%	5%	0%	5%
Calgary Ave	8%	8%	67%	0%	0%	17%
43rd Ave	11%	67%	11%	0%	0%	11%
Skyline Blvd	17%	17%	67%	0%	0%	0%
Totals	11%	21%	61%	0.5%	0.5%	6%
Unsignalized Intersections						
12th St	100%	0%	0%	0%	0%	0%
Spaulding Ave	20%	60%	20%	0%	0%	0%
Interchange Ave	21%	32%	16%	0%	5%	26%
Totals	24%	36%	16%	0%	4%	20%

Notes:
a – Most common type of "other" crashes are sideswipes along with a few head-on collisions.

TABLE 9. SUMMARY OF BISMARCK EXPRESSWAY CRASH TYPES

	Manner / Type of Crash					
Intersection	Left-Turn	Angle	Rear End	Ped / Bike	Fixed Object	Other [a]
Washington St	6%	8%	74%	2%	0%	10%
3rd St	18%	2%	73%	0%	0%	7%
7th St	5%	28%	54%	0%	0%	13%
9th St	4%	26%	59%	4%	0%	7%
12th St	26%	21%	26%	9%	12%	6%
Airport Rd (19th St)	10%	48%	38%	0%	0%	5%
26th St	21%	14%	50%	0%	7%	7%
Burlington Dr	0%	50%	0%	0%	0%	50%
Yegen Rd [a]						
Main Ave	42%	32%	21%	0%	0%	5%
Rosser Ave	20%	30%	40%	0%	0%	10%
Revere Dr (Commerce)	20%	20%	60%	0%	0%	0%
Divide Ave	26%	3%	52%	0%	0%	19%
I-94 South (EB)	0%	8%	92%	0%	0%	0%
I-94 North (WB)	45%	9%	36%	0%	9%	0%
Centennial / Century	31%	31%	31%	0%	8%	0%
Totals	17%	18%	53%	2%	2%	8%
Unsignalized Intersections						
2nd St	11%	78%	0%	0%	11%	0%
Kirkwood Mall	8%	67%	25%	0%	0%	0%
11th St	25%	25%	25%	0%	0%	25%
18th St	18%	27%	27%	0%	0%	27%
22nd St	0%	0%	100%	0%	0%	0%
23rd St	0%	100%	0%	0%	0%	0%
Yegen Rd	0%	0%	67%	0%	0%	33%
Centennial / Trenton	0%	75%	25%	0%	0%	0%
Centennial / Catham	0%	0%	100%	0%	0%	0%
Totals	11%	49%	28%	0%	2%	11%

Notes:
a – Most common type of "other" crashes are sideswipes along with a few head-on collisions.

2.2 BEFORE CONDITION – FIELD DATA COLLECTION

A number of field studies were undertaken to document the "before" travel conditions in the State Street and Bismarck Expressway roadway corridors. These studies were conducted by personnel from Houston Engineering and URS. The studies were done according to methods described in the *ITE Manual of Transportation Engineering Studies*. The data that was collected for this project included the following:

- Spot Speed Data
- Travel Time Data
- Maximum Queue Lengths

2.2.1 Spot Speed Studies

Spot speed studies were conducted at three locations in both the Bismarck Expressway and State Street corridors. The results of those speed studies are presented in Table 10. Speed data was collected for the AM, MD and PM peak periods during the weeks of May 19th and May 26, 2008. The spot speed for a minimum of 50 free flowing vehicles was recorded at each location using a radar gun. Where possible the field observers operated inside a vehicle to avoid influencing travel speeds significantly.

TABLE 10. PROJECT SPOT SPEED DATA

Roadway	Segment	Direction	Travel Speed by Time Period [1,2]		
			AM	MD	PM
Bismarck Expressway	Main to Rosser Ave	SB	36.8 / 41.2	40.2 / 45.2	34.9 / 39.5
		NB	41.4 / 45.3	41.0 / 46.7	36.3 / 44.7
	9th to 12th St	WB	37.4 / 42.7	33.8 / 38.2	33.6 / 37.8
	3rd to 7th St	WB	36.1 / 41.2	37.3 / 40.8	36.3 / 39.5
		EB	35.9 / 40.6	35.2 / 39.3	34.7 / 39.1
US 83	Capitol to I-94 EB ramp	SB	37.8 / 41.8	36.7 / 42.2	38.2 / 41.7
		NB	34.7 / 39.4	35.4 / 40.3	36.7 / 41.0
	Century to Interstate Ave	SB	36.5 / 39.8	37.2 / 41.6	35.6 / 39.5
		NB		35.3 / 39.3	33.8 / 38.6
	Calgary to 43rd Ave	SB	46.2 / 50.2	45.2 / 49.1	
		NB			43.9 / 47.5

Notes:
1 – Spot speed reported as miles per hour (mph).
2 – X / X = The two speeds reported are the "mean" and "85th–percentile" speeds, respectively.

Most of the recorded 85th percentile speeds are close to the posted speed limits for their respective roadway segments. The exception is the Bismarck Expressway segment between Main and Rosser Avenue. Contributing factors for the lower speeds at that location is a fairly high percentage of heavy truck traffic and a significant portion of vehicles traversing that segment had to stop for a red light at Rosser and/or Main Avenue.

The above speed information is supplemented by an earlier Bismarck Expressway speed study conducted by the NDDOT in May 2007. That study included speed data that was collected over a 24-hour period at three locations in the corridor. The results of that speed study are provided in Table 11.

TABLE 11. NDDOT SPEED DATA FOR BISMARCK EXPRESSWAY

Segment	Direction	Volume	Travel Speed (mph)	
			Mean	85th %-ile
Divide Ave to Commerce / Revere Dr	NB	8050	46.4	52.7
	SB	7954	45.7	51.3
Commerce / Revere Dr to Rosser Ave	NB	6069	52.4	57.8
	SB	6883	48.4	53.6
Main Ave to Yegen Rd	NB	5405	51.6	56.6
	SB	5110	51.6	57.3

2.2.2 Travel Time Run Data

Travel time run data was collected to document existing "before" conditions. The type of data collected during from the travel time runs include:

- Total corridor travel time
- Delay time by intersection and corridor wide
- Average travel speed
- Number of vehicle stops corridor wide

The floating car method was used to conduct the travel time runs. A minimum of ten runs per direction for the entire length of each corridor were completed during each of the six time periods throughout the day. Additional travel time runs were made for intermediate routes through each corridor in order to replicate typical daily travel paths. A minimum of five runs were completed for each intermediate route. The paths for the travel time runs during the morning and afternoon time periods are shown in Figures 4 and 5. These travel time runs were conducted on a Tuesday, Wednesday, or Thursday using a GPS-base data collection system.

A description of each of the travel time paths is provided below:

Travel Path	Roadway	Enter Intersection	Exit Intersection
EB 1	Bismarck Expressway	Washington St	Century Ave
EB 2	Bismarck Expressway	Washington St	9th St (right-turn)
EB 3	Bismarck Expressway	7th St	9th St (right-turn)
EB 4	Bismarck Expressway	Washington St	9th St (left-turn)
EB 5	Bismarck Expressway	Main Ave	Century Ave
EB 6	Bismarck Expressway	7th St	Yegen Rd
WB 1	Bismarck Expressway	Century Ave	Washington St
WB 2	Bismarck Expressway	26th St	Washington St
WB 3	Bismarck Expressway	7th St	Washington St
WB 4	Bismarck Expressway	Yegen Rd	9th St
WB 5	Bismarck Expressway	12th St	9th St
NB 1	US 83	Divide Ave	Skyline Blvd
NB 2	US 83	Divide Ave	Century Ave
NB 3	US 83	Divide Ave	I-94 WB (left-turn)
NB 4	US 83	I-94 EB	Skyline Blvd
NB 5	US 83	I-94 WB	43rd Ave
SB 1	US 83	Skyline Blvd	Divide Ave
SB 2	US 83	Century Ave	I-94 WB
SB 3	US 83	43rd Ave	Century Ave
SB 4	US 83	43rd Ave	I-94 EB

In order to ensure the experiences of different road users are accounted for the travel time paths would begin/end the run using different turn movements. For example, for the EB1 travel path the eastbound travel time runs would begin at Bismarck Expressway / Washington Street intersection with an eastbound through movement, a southbound left-turn or a northbound right-turn movement.

A summary of travel time results is provided in Tables 12 through 15. The travel times reported in these tables include some time before entering the first intersection and after exiting the last intersection. A segment by segment summary of the actual travel times compared to the travel time at the speed limit is provided in Figures 6 and 7 for the morning and afternoon peak periods.

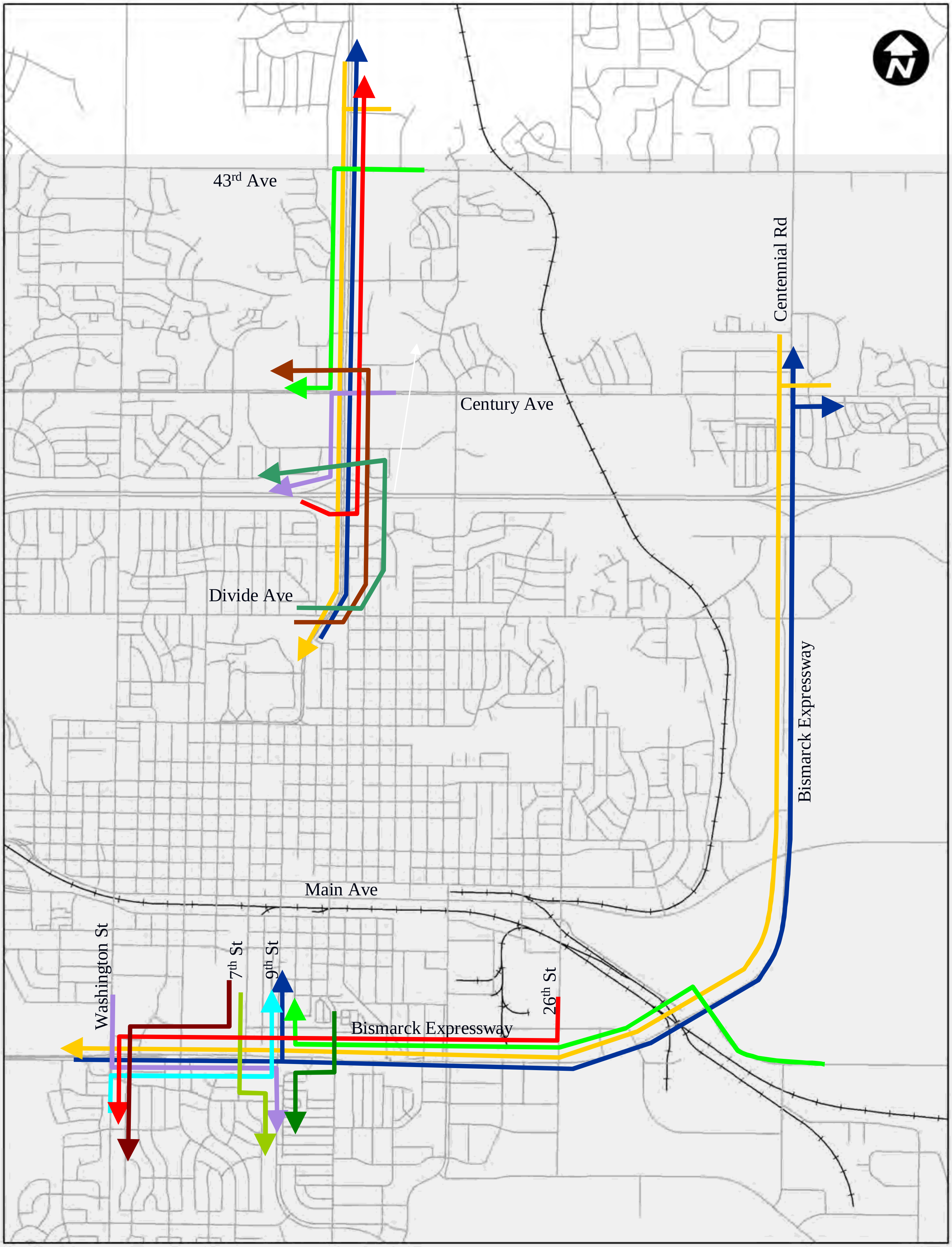

FIGURE 4: Travel Time Routes (AM Peak)

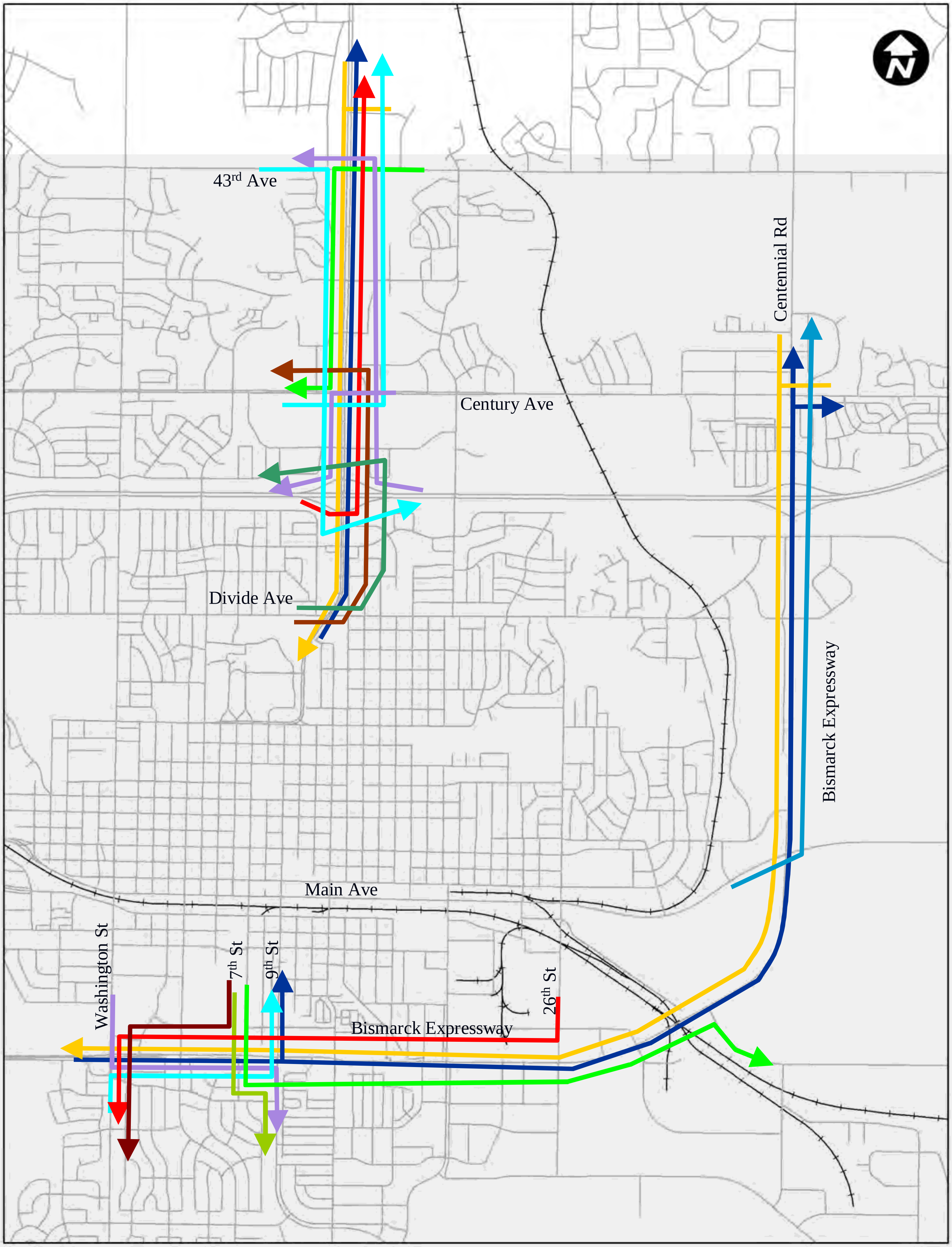

FIGURE 5: Travel Time Routes (PM Peak)

TABLE 12. EASTBOUND BISMARCK EXPRESSWAY TRAVEL TIME RUNS

Travel Path	Time Period [1]	Average Travel Time	Std. Deviation	Min. Travel Time	Max. Travel Time	Average Speed	Delay Time [2]
EB1	M	683.5	99.5	529.0	916.0	29.6	224.3
	MM	651.7	41.0	583.0	740.0	31.1	192.5
	MD	675.9	52.7	611.0	754.0	30.0	216.7
	A	647.7	60.2	580.0	760.0	31.3	188.5
	E	792.5	112.0	661.0	1044.0	25.6	333.3
	LE	672.6	61.9	591.0	761.0	30.1	213.4
	All Day	*685.9*	*86.6*	*529.0*	*1044.0*	*29.5*	*226.7*
EB2	M	156.6	28.4	124.0	199.0	17.2	89.3
	MM	154.2	19.0	136.0	182.0	17.5	86.9
	MD	174.0	16.7	154.0	193.0	15.5	106.7
	A	157.8	34.6	119.0	206.0	17.1	90.5
	E	189.8	16.3	174.0	215.0	14.2	122.5
	LE	185.2	17.8	165.0	202.0	14.5	117.9
	All Day	*169.6*	*25.6*	*119.0*	*215.0*	*15.9*	*102.3*
EB3	M	51.6	7.6	39.0	58.0	10.2	38.5
	MM	60.2	14.8	45.0	80.0	8.7	47.1
	MD	44.0	4.8	38.0	49.0	8.7	30.9
	A	70.8	33.2	37.0	114.0	7.4	57.7
	E	69.4	30.4	40.0	108.0	7.6	56.3
	LE	67.4	32.1	39.0	105.0	7.8	54.3
	All Day	*60.6*	*23.7*	*37.0*	*114.0*	*8.7*	*47.5*
EB4	M	176.4	46.5	142.0	238.0	15.3	109.1
	MM	136.2	14.5	118.0	152.0	19.8	68.9
	MD	175.2	22.7	155.0	207.0	15.4	107.9
	A	154.2	16.8	140.0	183.0	17.5	86.9
	E	197.2	27.9	182.0	247.0	13.7	129.9
	LE	177.6	41.9	113.0	221.0	15.2	110.3
	All Day	*169.5*	*34.3*	*113.0*	*247.0*	*15.9*	*102.1*
EB5	A	272.2	32.3	233.0	309.0	27.2	109.8
	E	281.6	16.5	259.0	302.0	26.3	119.2
EB6	A	353.2	43.3	296.0	417.0	21.7	170.9
	E	347.8	43.4	289.0	411.0	22.0	165.5

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)

2 - Delay time is the difference between actual travel time and ideal travel time, which is calculated based on the travel path length / posted speed limit.

TABLE 13. WESTBOUND BISMARCK EXPRESSWAY TRAVEL TIME RUNS

Travel Path	Time Period [1]	Average Travel Time	Std. Deviation	Min. Travel Time	Max. Travel Time	Average Speed	Delay Time [2]
WB1	M	709.5	96.0	611.0	876.0	28.5	250.3
	MM	638.4	48.2	577.0	721.0	31.7	179.2
	MD	686.8	52.1	622.0	780.0	29.5	227.6
	A	711.7	61.2	643.0	868.0	28.5	252.5
	E	757.5	69.5	663.0	865.0	26.7	298.3
	LE	669.1	61.5	532.0	755.0	30.3	209.9
	All Day	*694.6*	*74.0*	*532.0*	*876.0*	*29.2*	*235.4*
WB2	M	371.8	22.2	352.0	405.0	19.4	191.3
	MM	301.4	45.0	257.0	368.0	23.9	120.9
	MD	332.0	27.7	296.0	366.0	21.7	151.5
	A	367.2	23.7	340.0	397.0	19.7	186.7
	E	411.2	70.3	333.0	471.0	17.6	230.7
	LE	362.0	49.6	323.0	449.0	19.9	181.5
	All Day	*357.6*	*52.5*	*257.0*	*471.0*	*20.2*	*177.1*
WB3	M	147.8	7.2	135.0	152.0	14.7	93.6
	MM	154.6	30.9	100.0	175.0	14.0	100.4
	MD	162.8	3.4	158.0	167.0	13.3	108.6
	A	194.6	33.8	166.0	245.0	11.1	140.4
	E	174.4	40.7	140.0	243.0	12.4	120.2
	LE	166.0	4.5	161.0	172.0	13.1	111.8
	All Day	*166.7*	*27.6*	*100.0*	*245.0*	*13.0*	*112.5*
WB4	M	288.8	31.7	252.0	334.0	24.7	119.6
	MM	297.6	30.2	263.0	330.0	24.0	128.4
WB5	M	111.0	38.2	75.0	165.0	8.2	88.1
	MM	80.4	29.5	48.0	126.0	11.4	57.5

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 - Delay time is the difference between actual travel time and ideal travel time, which is calculated based on the travel path length / posted speed limit.

TABLE 14. NORTHBOUND US 83 TRAVEL TIME RUNS

Travel Path	Time Period [1]	Average Travel Time	Std. Deviation	Min. Travel Time	Max. Travel Time	Average Speed	Delay Time [2]
NB1	M	316.4	44.8	255.0	385.0	25.8	115.2
	MM	294.2	42.0	237.0	399.0	27.7	93.0
	MD	323.1	47.7	221.0	389.0	25.2	121.9
	A	337.0	47.8	289.0	440.0	24.2	135.8
	E	364.9	46.1	278.0	426.0	22.3	163.7
	LE	348.5	52.7	253.0	433.0	23.4	147.3
	All Day	*330.7*	*50.5*	*221.0*	*440.0*	*24.6*	*129.4*
NB2	M	263.2	35.7	227.0	321.0	13.9	172.1
	MM	270.8	18.8	255.0	299.0	13.5	179.7
	MD	272.6	10.4	256.0	282.0	13.4	181.5
	A	264.6	27.3	227.0	295.0	13.8	173.5
	E	298.8	46.2	246.0	363.0	12.2	207.7
	LE	262.0	30.5	230.0	312.0	13.9	170.9
	All Day	*272.0*	*30.5*	*227.0*	*363.0*	*13.4*	*180.9*
NB3	M	198.2	38.7	153.0	240.0	11.3	142.4
	MM	217.6	31.8	172.0	261.0	10.3	161.8
	MD	193.8	38.9	125.0	219.0	11.5	138.0
	A	219.6	58.0	153.0	291.0	10.2	163.8
	E	214.8	50.2	148.0	287.0	10.4	159.0
	LE	177.4	42.6	135.0	236.0	12.6	121.6
	All Day	*203.6*	*43.1*	*125.0*	*291.0*	*11.0*	*147.7*
NB4	M	256.0	33.5	219.0	304.0	25.1	98.2
	MM	226.4	13.8	216.0	250.0	28.3	68.6
	MD	268.0	15.2	248.0	284.0	23.9	110.2
	A	283.6	25.2	250.0	315.0	22.6	125.8
	E	257.8	34.3	219.0	313.0	24.9	100.0
	LE	255.0	25.0	226.0	284.0	25.2	97.2
	All Day	*257.8*	*29.2*	*216.0*	*315.0*	*24.9*	*100.0*
NB5	A	235.2	30.6	201.0	290.0	21.3	110.1
	E	267.0	44.7	235.0	345.0	18.7	141.9

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)

2 - Delay time is the difference between actual travel time and ideal travel time, which is calculated based on the travel path length / posted speed limit.

TABLE 15. SOUTHBOUND US 83 TRAVEL TIME RUNS

Travel Path	Time Period [1]	Average Travel Time	Std. Deviation	Min. Travel Time	Max. Travel Time	Average Speed	Delay Time [2]
SB1	M	311.7	57.5	209.0	391.0	26.2	110.5
	MM	333.9	43.8	282.0	434.0	24.4	132.7
	MD	371.4	28.3	322.0	434.0	21.9	170.2
	A	379.1	42.5	297.0	465.0	21.5	177.9
	E	398.9	41.0	356.0	461.0	20.4	197.7
	LE	369.2	27.7	315.0	407.0	22.1	168.0
	All Day	*360.7*	*49.3*	*209.0*	*465.0*	*22.6*	*159.5*
SB2	M	116.8	12.7	103.0	131.0	12.1	81.5
	MM	125.2	6.5	119.0	135.0	11.3	89.9
	MD	165.4	43.8	115.0	214.0	8.5	130.1
	A	170.2	54.4	104.0	244.0	8.3	134.9
	E	189.0	75.1	121.0	305.0	7.5	153.7
	LE	129.8	27.3	104.0	176.0	10.9	94.5
	All Day	*149.4*	*48.2*	*103.0*	*305.0*	*9.5*	*114.1*
SB3	M	178.2	29.9	156.0	229.0	20.2	88.4
	MM	174.0	14.0	159.0	195.0	20.6	84.2
	MD	191.6	9.1	176.0	199.0	18.8	101.8
	A	193.6	9.6	179.0	206.0	18.6	103.8
	E	182.2	23.4	149.0	213.0	19.7	92.4
	LE	165.8	21.0	129.0	182.0	21.7	76.0
	All Day	*180.9*	*20.2*	*129.0*	*229.0*	*19.9*	*91.1*
SB4	A	289.5	31.6	253.0	343.0	19.0	152.0
	E	338.2	49.1	276.0	382.0	16.3	200.7

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)

2 - Delay time is the difference between actual travel time and ideal travel time, which is calculated based on the travel path length / posted speed limit.

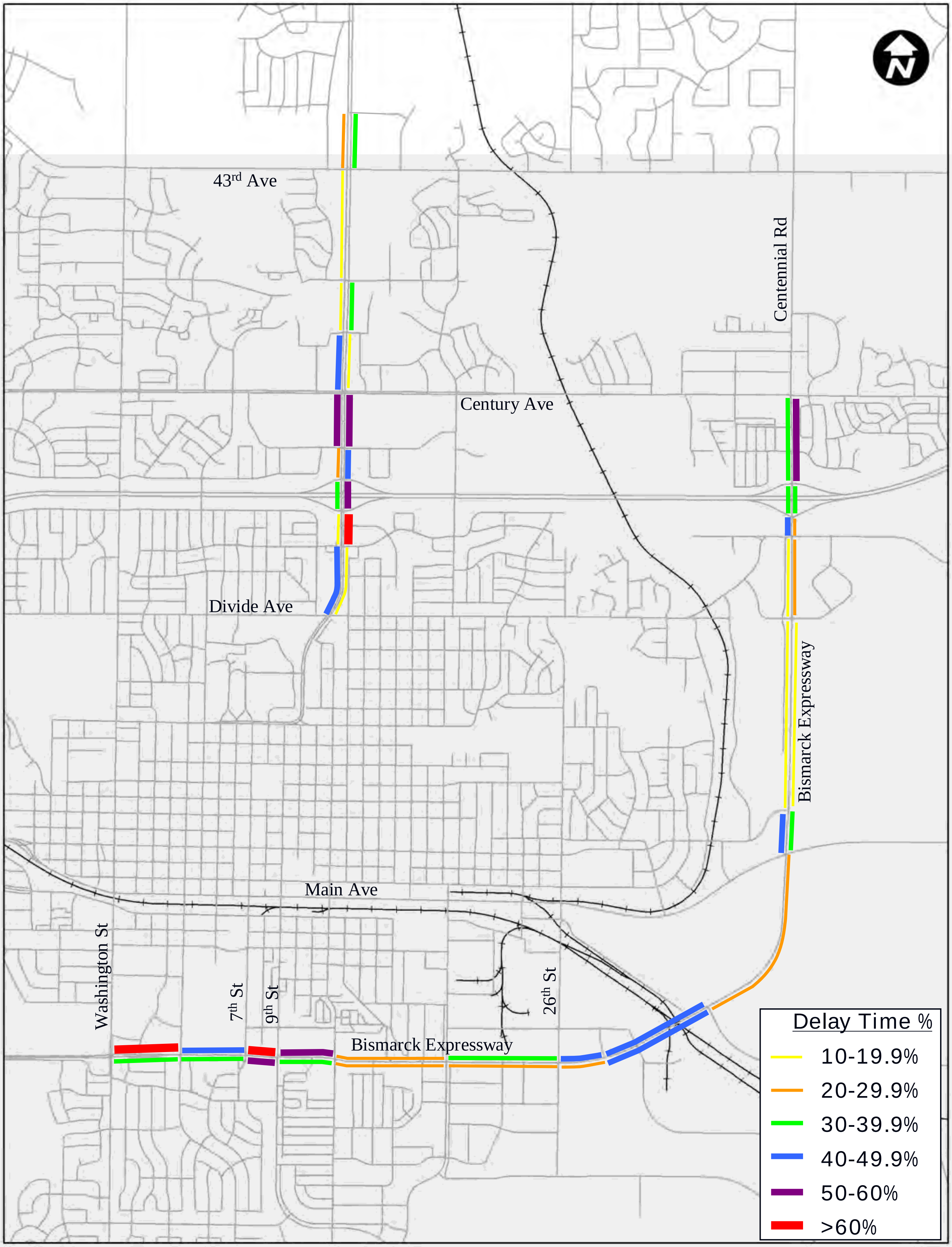

FIGURE 6: Existing Travel Time Delay
Morning (AM) Peak Hour

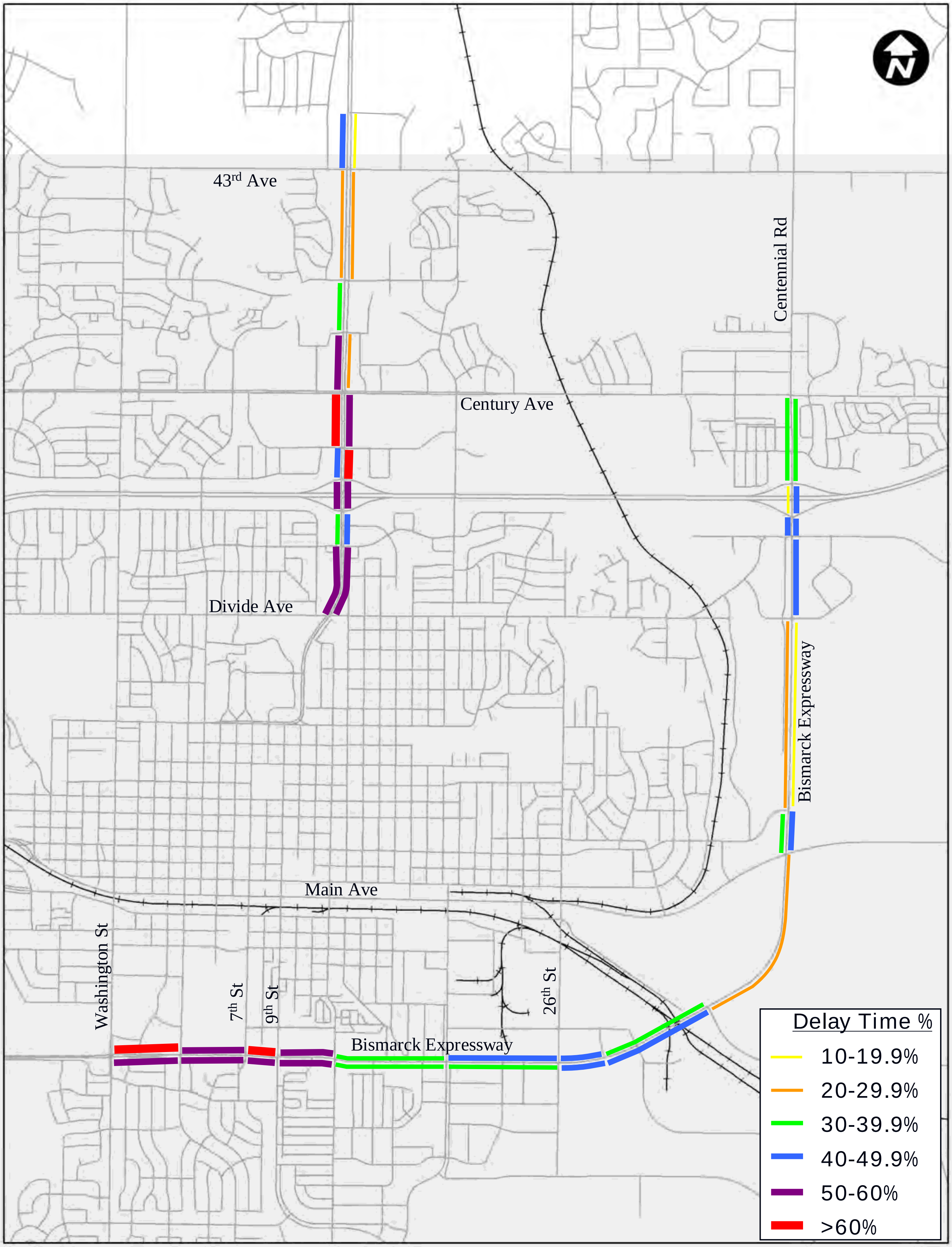

FIGURE 7: Existing Travel Time Delay
Evening (PM) Peak Hour

2.2.3 Queuing Studies

The maximum queue lengths were recorded for key intersection approaches / movements at eight intersections in the two corridors. The majority of this data was obtained from the same video recordings obtained for the turn movement counts. The video data was supplemented by manual queuing studies at the Bismarck Expressway intersections with 7th and 9th Street. This data was collected using the same parameters (i.e., day of week and while school was in session) as used for the turn movement counts. A water main break along Bismarck Expressway resulted in the two manual queuing studies being collected after the school year was completed. The results of the maximum queue length studies are documented in Table 16. The values reported in the table represent the longest queue observed during the course of each peak period, as described below:

- AM Peak Period = 7:00 to 8:30 a.m.
- Noon Peak Period = 11:00 a.m. to 1:00 p.m.
- PM Peak Period = 4:00 to 6:00 p.m.

Some of the key findings from the maximum queue length studies are provided below:

- In some cases the maximum queue length for adjacent lanes serving the same movement are quite different. A good example of this is the southbound dual left-turn at 7th Street and Bismarck Expressway where the outside lane has much longer queues. That is because motorists are positioning themselves for their next turn (i.e., eastbound right-turn) at the downstream intersection (i.e., 9th Street and Bismarck Expressway). A video clip from the PM peak at 7th Street and Bismarck Expressway showing the southbound left-turn imbalance if provided on the next page.
- At the intersection of 7th Street and Bismarck Expressway the northbound right-turn queue lengths in the AM peak would be longer if the queuing study had been completed during the school year.
- The maximum westbound queue length at 7th Street and Bismarck Expressway essentially represents the available space between 7th and 9th Street.
- The maximum eastbound left-turn queue length at 9th Street and Bismarck Expressway is greater than reported in the table. The value in the table represents the number of vehicles in the left-turn bay, but additional left-turn are intermixed with through vehicles in the through lane upstream from the left-turn bay. For a period of time that ranges from 10 to 20 minutes, particularly in the AM peak hour, it is common for the eastbound median through lane to back up through the 7th Street intersection.
- For the Bismarck Expressway intersection with 7th Street, 9th Street, and Main Avenue queuing data was collected on both May 22nd and May 28th. During the week of May 22nd Bismarck Expressway closed between 2nd and 3rd Street. It is interesting to note that the maximum queue lengths for southbound 7th Street and northbound 9th Street at Bismarck Expressway are about the same. It should be noted that during the week of the May 28th school was no longer in session.

Southbound Approach for 7th Street and Bismarck Expressway Showing Left-Turn Volume Imbalance

A couple of other more generalized observations of maximum queue lengths were developed through field work. These observations were either done because of a lack of video cameras at an intersection or because the queue lengths exceeded the field of view provided by the video cameras. A summary is provided below:

- At the 7th Street and Bismarck Expressway intersection the eastbound through queue was observed to reach just beyond the Kirkwood Mall entrance (approximately 800') during both the AM and PM peak hours.
- At the 3rd Street and Bismarck Expressway intersection the westbound queue was observed to reach about 1000' (i.e., about ¾ the distance between 3rd and 7th Street) during the PM peak period.
- The maximum northbound through queue at US 83 / I-94 EB (South) Ramp intersection was observed to almost reach the Capitol Avenue intersection (approximately 700') during the PM peak hour. That maximum queue length was only observed for the median through lane where many of those vehicles are destined to make a northbound left-turn at the US 83 / I-94 (North) Ramp intersection. The maximum queue length for the other two through lanes was approximately 300-350', the location of the US 83 / Interchange Avenue intersection.

TABLE 16. MAXIMUM QUEUE LENGTHS

Intersection	Approach	Movement	Maximum Queue Length		
			AM	MD	PM
Bismarck Expressway & 7th St. (Thursday 5/22/08)	SB	L	12 / 3[1]	17 / 12	18 / 9
		T	7	8	13
		R	3	12	18
Bismarck Expressway & 7th St. (Wednesday 5/28/08) [2]	SB	L	12 / 5	15 / 7	16 / 10
		T	3	8	12
		R	4	14	24
Bismarck Expressway & 7th St. (Tuesday 6/3/08)	NB	R	4	5	4
	WB	T	25	23	27
Bismarck Expressway & 9th St. (Thursday 5/22/08)	NB	L	4	6	8
		T	11 / 13	6 / 11	7 / 11
		R	4	3	5
Bismarck Expressway & 9th St. (Wednesday 5/28/08) [2]	NB	L	8	9	10
		T	9 / 12	7 / 8	6 / 10
		R	3	4	3
Bismarck Expressway & 9th St. (Tuesday 6/3/08)	WB	T	8	11	20
	EB	L	12	12	10
		R	6	6	9
Bismarck Expressway & Main Ave. (Thursday 5/22/08)	SB	T	5 / 9	4 / 3	5 / 5
	EB	T	5	6	7
		L	9	8	9
Bismarck Expressway & Main Ave. (Wednesday 5/28/08) [2]	SB	T	4 / 5	8 / 5	5 / 5
	EB	L	7	6	11
		T	4	6	9
Bismarck Expressway & Washington St. (Thursday 5/15/08)	EB	T	3 / 14 / 18		
	NB	T	9 / 14		
		R	10		
	WB	T			13 / 17
	SB	T			16 / 12
		R			4
Bismarck Expressway & Divide Ave. (Tuesday 5/20/08)	SB	T	11 / 6		
	NB	T			10 / 22
US 83 & Divide Ave. (Tuesday 5/20/08)	SB	T	29/ 31/28		
	NB	T			23/22/19
	EB	L			12
US 83 & Century Ave. (Tuesday 6/3/08)	SB	T	15/14/12		
		R	2		
	WB	L	12		
		T	7 / 6		
	EB	L			8
		T			6 / 9
	NB	L			6
		T			15 / 11 / 10
US 83 & 43rd Ave. (Thursday 5/8/08)	SB	T	7 / 8		
	WB	L	6		
	NB	T			11 / 10

Notes:
1 – X / X / X = Maximum queue lengths for multiple lanes serving the same movement.
2 – Due to a water main break on the Bismarck Expressway, data was collected during and after the incident.

- A combination of truck traffic and grade play a significant role in the maximum queue lengths for the southbound left-turn at the US 83 / I-94 EB (South) Ramp intersection. Due to slow acceleration rates for trucks on this grade it is common for only a few vehicles to be served during the left-turn phase for this movement.
- At the intersection of US 83 / I-94 (North) Ramp the northbound left-turn movement will have several cycles during the peak hour where the demand exceeds the available left-turn green time that result in significant queuing between the interchange ramps and beyond. This issue appears to be more prevalent in the PM peak hour, but a few instances were observed during the AM peak hour.

2.3 Existing Condition Traffic Models

Existing condition traffic models were developed for the Bismarck Expressway and State Street corridors using the Synchro 7 traffic software. Data inputted into each model included roadway / intersection geometrics, traffic volumes, signal timing information, and lane utilization factors. Models were developed for the morning (AM), midday, and evening (PM) peak periods.

2.3.1 Model Calibration

For each peak period a SimTraffic 7 simulation model was developed and calibrated based on the traffic performance data gathered for this project. The primary traffic performance data used to calibrate these simulation models were travel time and traffic volumes. The traffic simulation models were also checked against maximum queue length and movement delay data collected for this project.

Intersection volumes from each SimTraffic model were checked against the inputted values for each peak period and the through volumes were all found to be within five percent of the expected values. In a few cases, lower volume minor movements the differences in traffic volumes were greater than five percent. The model traffic volumes show reasonable correlation to the field data.

A comparison of field collected travel time data to the model output was performed to validate the simulation model calibration. The travel time data comparison is provided in Tables 17 through 22 for the two corridors and the three different time periods. The comparison shows reasonable correlation between the model data and the field collected travel time runs.

2.3.2 Existing Condition Traffic Operations

A summary of existing conditions traffic operations was completed using the Synchro 7 traffic models developed for the morning (AM), midday, and evening (PM) peak periods. This summary includes intersection capacity analysis and arterial capacity analysis. These analyses are expressed in terms of levels of service (LOS). LOS criteria are defined in the *2000 Highway Capacity Manual* (HCM) for both signalized intersections and urban arterials, as described in Tables 23 and 24. In Bismarck, the threshold for capacity deficiencies is typically the LOS C/D boundary.

The overall and approach intersection levels of service for each corridor during the three peak periods are documented in Tables 25 and 26. The arterial level of service is documented in Tables 27 and 28. The travel speeds documented in these tables is based on the field collected data. The Bismarck Expressway corridor between Washington Street and Burlington Drive and State Street corridor would be classified as Class II urban arterials based on 85th percentile speeds. The other segment of Bismarck Expressway would be classified as a Class I urban arterial.

The intersection capacity analysis found that the majority of the intersections are operating at an overall acceptable LOS during each peak hour. However, it should be noted that at several intersections there are periods of time (e.g, 15 to 30-minute durations) during the peak hours where traffic operations are unacceptable. Critical intersections identified through the traffic analysis and from field reviews include:

- Bismarck Expressway / Washington Street
- Bismarck Expressway / 7th Street
- Bismarck Expressway / 9th Street
- Centennial Road / Century Avenue
- State Street / Divide Avenue
- State Street / Interstate Avenue
- State Street / Century Avenue

These congested intersections correlate well with the arterial roadway segments with lower operating speeds.

TABLE 17. BISMARCK EXPRESSWAY TRAVEL TIME COMPARISON – AM PEAK

EASTBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Washington	0									
3rd	1,647	44.6	31	62	52.8	18.3%	11.9	23.2	8.2	Yes
7th	1,535	38.9	27	72	51.9	33.4%	12.7	24.8	13.0	Yes
9th	769	17.5	14	20	25.5	46.1%	1.8	3.4	8.0	No
12th	1,343	33.6	25	45	40.2	19.5%	5.9	11.5	6.6	Yes
19th	2,652	59.7	47	77	67.4	12.8%	9.9	19.4	7.7	Yes
26th	2,641	59.9	42	87	49.1	-18.0%	14.5	28.4	10.8	Yes
Burlington	1,096	25.5	17	43	22.0	-13.6%	9.6	18.8	3.5	Yes
Yegen	2,741	57.0	48	86	48.0	-15.8%	11.1	21.8	9.0	Yes
Main	4,420	69.0	49	93	70.0	1.4%	15.8	31.0	1.0	Yes
Rosser	1,043	21.8	15	55	19.1	-12.5%	11.3	22.1	2.7	Yes
Commerce	4,533	72.2	63	91	65.4	-9.4%	9.3	18.2	6.8	Yes
Divide	1,935	39.3	29	46	43.4	10.5%	6.0	11.7	4.1	Yes
I-94S	484	10.9	8	14	14.6	33.8%	2.0	4.0	3.7	Yes
I-94N	765	19.0	14	48	22.1	16.3%	9.8	19.1	3.1	Yes
Century	2,098	79.4	42	247	77.4	-2.5%	61.6	120.7	2.0	Yes
Total	**29,702**	**648.3**			**668.9**	**3.2%**			**20.6**	

WESTBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Century	0									
I-94N	2,098	54.8	37	91	55.0	0.4%	17.2	33.7	0.2	Yes
I-94S	765	19.3	13	38	18.6	-3.6%	9.0	17.7	0.7	Yes
Divide	484	13.7	8	37	15.9	16.1%	9.5	18.5	2.2	Yes
Commerce	1,935	33.3	28	60	36.6	9.9%	9.6	18.8	3.3	Yes
Rosser	4,533	74.2	62	96	69.5	-6.3%	10.1	19.7	4.7	Yes
Main	1,043	23.7	15	42	30.6	29.1%	8.8	17.2	6.9	Yes
Yegen	4,420	50.1	45	65	63.6	26.9%	5.9	11.5	13.5	No
Burlington	2,741	58.8	50	69	38.2	-35.0%	8.2	16.1	20.6	No
26th	1,096	27.3	17	47	30.4	11.4%	11.3	22.1	3.1	Yes
19th	2,641	74.1	47	105	62.6	-15.5%	21.3	41.8	11.5	Yes
12th	2,652	56.8	48	74	52.6	-7.4%	8.2	16.2	4.2	Yes
9th	1,343	50.1	27	80	51.9	3.6%	17.3	34.0	1.8	Yes
7th	769	35.4	18	72	54.6	54.2%	23.1	45.4	19.2	Yes
3rd	1,535	42.2	30	63	51.7	22.5%	12.2	23.9	9.5	Yes
Washington	1,647	73.3	29	105	59.9	-18.3%	29.9	58.7	13.4	Yes
Total	**29,702**	**687.1**			**691.7**	**0.7%**			**4.6**	

TABLE 18. BISMARCK EXPRESSWAY TRAVEL TIME COMPARISON – MD PEAK

EASTBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Washington	0									
3rd	1,647	46.9	28	69	48.0	2.3%	14.3	28.1	1.1	Yes
7th	1,535	47.9	30	70	49.2	2.7%	14.2	27.8	1.3	Yes
9th	769	28.7	14	58	36.3	26.4%	16.8	32.9	7.6	Yes
12th	1,343	37.3	25	57	33.5	-10.1%	10.1	19.8	3.8	Yes
19th	2,652	60.5	44	79	72.1	19.1%	13.4	26.2	11.6	Yes
26th	2,641	61.0	45	94	56.5	-7.4%	16.6	32.6	4.5	Yes
Burlington	1,096	25.1	20	39	26.9	7.2%	5.9	11.6	1.8	Yes
Yegen	2,741	54.5	50	63	44.6	-18.2%	4.0	7.9	9.9	No
Main	4,420	64.2	47	99	64.1	-0.1%	19.1	37.4	0.1	Yes
Rosser	1,043	23.6	14	50	18.2	-23.0%	12.9	25.3	5.4	Yes
Commerce	4,533	70.7	60	83	66.2	-6.4%	7.4	14.5	4.5	Yes
Divide	1,935	42.5	30	55	45.0	5.8%	8.9	17.4	2.5	Yes
I-94S	484	10.8	7	15	13.9	28.5%	2.2	4.3	3.1	Yes
I-94N	765	18.4	14	40	22.3	21.4%	7.4	14.6	3.9	Yes
Century	2,098	49.7	40	70	46.3	-6.9%	9.8	19.2	3.4	Yes
Total	**29,702**	**642.0**			**643.1**	**0.2%**			**1.1**	

WESTBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Century	0									
I-94N	2,098	43.4	36	78	50.3	15.9%	12.5	24.5	6.9	Yes
I-94S	765	17.3	12	40	17.0	-1.7%	9.3	18.3	0.3	Yes
Divide	484	15.5	8	35	13.3	-14.2%	10.4	20.5	2.2	Yes
Commerce	1,935	34.6	27	52	35.0	1.2%	9.4	18.3	0.4	Yes
Rosser	4,533	69.5	61	84	68.0	-2.2%	8.3	16.3	1.5	Yes
Main	1,043	29.3	16	56	25.2	-14.0%	15.3	30.1	4.1	Yes
Yegen	4,420	54	46	70	59.0	9.3%	8.1	15.8	5.0	Yes
Burlington	2,741	69	51	89	38.8	-43.8%	12.4	24.4	30.2	No
26th	1,096	44.3	20	77	33.1	-25.3%	22.1	43.4	11.2	Yes
19th	2,641	66.4	48	92	64.8	-2.4%	14.9	29.2	1.6	Yes
12th	2,652	63	47	87	61.4	-2.5%	14.7	28.8	1.6	Yes
9th	1,343	43.5	24	73	48.7	12.0%	19.0	37.2	5.2	Yes
7th	769	17.7	14	29	20.2	14.1%	4.6	9.1	2.5	Yes
3rd	1,535	43.2	29	75	38.7	-10.4%	14.2	27.8	4.5	Yes
Washington	1,647	56.2	30	81	59.0	5.0%	14.9	29.2	2.8	Yes
Total	**29,702**	**666.9**			**632.5**	**-5.2%**			**34.4**	

TABLE 19. BISMARCK EXPRESSWAY TRAVEL TIME COMPARISON – PM PEAK

EASTBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Washington	0									
3rd	1,647	67.3	34	88	60.4	-10.3%	16.2	31.7	6.9	Yes
7th	1,535	49.9	36	75	47.3	-5.2%	11.0	21.6	2.6	Yes
9th	769	20.8	16	48	22.7	9.1%	9.7	19.0	1.9	Yes
12th	1,343	56.4	26	81	47.7	-15.4%	17.5	34.2	8.7	Yes
19th	2,652	75.2	50	149	88.0	17.0%	30.2	59.2	12.8	Yes
26th	2,641	67.6	46	124	60.9	-9.9%	24.7	48.4	6.7	Yes
Burlington	1,096	29.3	19	48	28.3	-3.4%	11.4	22.3	1.0	Yes
Yegen	2,741	59.7	48	77	49.5	-17.1%	10.2	20.0	10.2	Yes
Main	4,420	70.0	51	91	70.0	0.0%	15.3	30.1	0.0	Yes
Rosser	1,043	23.9	15	43	21.4	-10.5%	8.5	16.6	2.5	Yes
Commerce	4,533	71.6	62	98	70.5	-1.5%	11.1	21.8	1.1	Yes
Divide	1,935	49.4	27	72	56.0	13.4%	13.5	26.5	6.6	Yes
I-94S	484	16.0	7	53	21.1	31.9%	13.2	25.9	5.1	Yes
I-94N	765	27.7	14	45	28.8	4.0%	12.2	24.0	1.1	Yes
Century	2,098	66.6	39	166	91.0	36.6%	39.0	76.5	24.4	Yes
Total	**29,702**	**751.4**			**763.6**	**1.6%**			**12.2**	

WESTBOUND

		Field Data			SimTraffic Model				Field vs.	
	Distance	Average	Min	Max	Average	Percent	Field	Allowable	Model	Within
Intersection	(ft)	(s)	(s)	(s)	(s)	Difference	Std. Dev.	Difference	Difference	Allowable
Century	0									
I-94N	2,098	54.6	38	82	52.2	-4.4%	15.0	29.5	2.4	Yes
I-94S	765	14.7	12	17	19.0	29.3%	1.7	3.3	4.3	No
Divide	484	14	8	36	15.3	9.3%	11.4	22.3	1.3	Yes
Commerce	1,935	31.4	29	36	35.2	12.1%	2.3	4.5	3.8	Yes
Rosser	4,533	78	61	93	75.0	-3.8%	9.4	18.4	3.0	Yes
Main	1,043	22.8	15	48	29.3	28.5%	9.4	18.3	6.5	Yes
Yegen	4,420	47.3	44	54	59.4	25.6%	2.8	5.5	12.1	No
Burlington	2,741	55	49	68	39.5	-28.2%	7.1	13.9	15.5	No
26th	1,096	32.8	19	73	40.0	22.0%	16.7	32.8	7.2	Yes
19th	2,641	69.3	46	108	71.5	3.2%	18.2	35.7	2.2	Yes
12th	2,652	75.6	54	103	66.8	-11.6%	12.4	24.3	8.8	Yes
9th	1,343	53	27	100	46.2	-12.8%	29.3	57.5	6.8	Yes
7th	769	53.4	14	72	57.3	7.3%	21.3	41.8	3.9	Yes
3rd	1,535	45.7	27	66	69.0	51.0%	13.5	26.4	23.3	Yes
Washington	1,647	75.4	33	92	69.0	-8.5%	17.7	34.7	6.4	Yes
Total	**29,702**	**723.0**			**744.7**	**3.0%**			**21.7**	

TABLE 20. STATE STREET TRAVEL TIME COMPARISON – AM PEAK

NORTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Divide	0									
Capitol	1,711	36.2	28	46	42.1	16.3%	5.6	11.0	5.9	Yes
I-94S	837	36.6	14	61	36.9	0.8%	21.4	42.0	0.3	Yes
I-94N	728	24.4	12	45	23.6	-3.3%	10.8	21.2	0.8	Yes
Interstate	754	21.6	15	34	20.1	-6.9%	7.0	13.6	1.5	Yes
Century	1,317	31.1	22	84	32.5	4.5%	18.7	36.7	1.4	Yes
Weiss	1,408	28.0	22	65	25.7	-8.2%	13.1	25.7	2.3	Yes
Calgary	1,244	31.8	19	49	29.5	-7.2%	11.5	22.6	2.3	Yes
43rd St	2,617	43.9	38	49	40.8	-7.1%	4.0	7.9	3.1	Yes
Skyline	1,339	28.3	17	51	20.1	-29.0%	10.4	20.5	8.2	Yes
Total	**11,955**	**281.9**			**271.3**	**-3.8%**			**10.6**	

SOUTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Skyline										
43rd St	1,339	24.1	19	38	27.1	12.4%	5.7	11.3	3.0	Yes
Calgary	2,617	41.6	37	48	43.8	5.3%	4.0	7.9	2.2	Yes
Weiss	1,244	24.4	20	33	24.7	1.2%	3.8	7.4	0.3	Yes
Century	1,408	45.5	29	58	52.1	14.5%	8.2	16.0	6.6	Yes
Interstate	1,317	58.2	26	86	56.1	-3.6%	27.6	54.0	2.1	Yes
I-94N	754	17.7	12	38	31.8	79.7%	7.5	14.8	14.1	Yes
I-94S	728	18.1	13	42	18.2	0.6%	9.0	17.6	0.1	Yes
Capitol	837	15.8	14	18	24.9	57.6%	1.6	3.2	9.1	No
Divide	1,711	49.1	28	114	53.7	9.4%	27.3	53.5	4.6	Yes
Total	**11,955**	**294.5**			**332.4**	**12.9%**			**37.9**	

TABLE 21. STATE STREET TRAVEL TIME COMPARISON – MD PEAK

NORTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Divide	0									
Capitol	1,711	49.1	31	76	36.3	-26.1%	17.3	33.9	12.8	Yes
I-94S	837	17.5	15	20	31.0	77.1%	2.1	4.1	13.5	No
I-94N	728	15.4	13	23	17.4	13.0%	2.9	5.7	2.0	Yes
Interstate	754	28.2	14	34	39.1	38.7%	6.8	13.3	10.9	Yes
Century	1,317	41.3	23	84	41.5	0.5%	25.1	49.2	0.2	Yes
Weiss	1,408	26.7	22	35	32.9	23.2%	3.9	7.7	6.2	Yes
Calgary	1,244	35.0	19	68	28.9	-17.4%	15.9	31.1	6.1	Yes
43rd St	2,617	45.2	36	56	43.4	-4.0%	7.5	14.6	1.8	Yes
Skyline	1,339	24.4	19	34	22.7	-7.0%	5.1	9.9	1.7	Yes
Total	**11,955**	**282.8**			**293.2**	**3.7%**			**10.4**	

SOUTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Skyline										
43rd St	1,339	30.9	19	56	24.0	-22.3%	13.7	26.9	6.9	Yes
Calgary	2,617	43.7	38	59	45.8	4.8%	7.0	13.8	2.1	Yes
Weiss	1,244	34.8	22	73	30.4	-12.6%	18.1	35.4	4.4	Yes
Century	1,408	46.2	28	60	60.8	31.6%	9.3	18.3	14.6	Yes
Interstate	1,317	76.0	26	86	59.1	-22.2%	18.0	35.3	16.9	Yes
I-94N	754	25.9	15	64	33.4	29.0%	19.3	37.9	7.5	Yes
I-94S	728	22.7	14	36	30.6	34.8%	8.7	17.1	7.9	Yes
Capitol	837	17.5	14	20	28.7	64.0%	2.0	3.8	11.2	No
Divide	1,711	46.5	32	114	55.7	19.8%	24.4	47.7	9.2	Yes
Total	**11,955**	**344.2**			**368.5**	**7.1%**			**24.3**	

TABLE 22. STATE STREET TRAVEL TIME COMPARISON – PM PEAK

NORTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Divide	0									
Capitol	1,711	51.7	30	81	44.9	-13.2%	21.2	41.5	6.8	Yes
I-94S	837	25.8	15	57	42.4	64.3%	13.2	25.9	16.6	Yes
I-94N	728	15.8	13	18	18.3	15.8%	1.9	3.7	2.5	Yes
Interstate	754	29.4	21	40	42.8	45.6%	5.7	11.2	13.4	No
Century	1,317	67.0	24	83	54.4	-18.8%	22.7	44.4	12.6	Yes
Weiss	1,408	29.0	23	33	30.5	5.2%	3.8	7.4	1.5	Yes
Calgary	1,244	25.5	18	62	26.4	3.5%	13.0	25.5	0.9	Yes
43rd St	2,617	38.9	36	43	44.0	13.1%	2.4	4.8	5.1	No
Skyline	1,339	22.9	19	30	22.9	0.0%	3.4	6.8	0.0	Yes
Total	**11,955**	**306.0**			**326.6**	**6.7%**			**20.6**	

SOUTHBOUND

Intersection	Distance (ft)	Field Data Average (s)	Field Data Min (s)	Field Data Max (s)	SimTraffic Model Average (s)	SimTraffic Model Percent Difference	Field Std. Dev.	Allowable Difference	Field vs. Model Difference	Within Allowable
Skyline										
43rd St	1,339	32.6	20	58	26.3	-19.3%	15.2	29.7	6.3	Yes
Calgary	2,617	41.7	38	49	42.6	2.2%	4.1	8.0	0.9	Yes
Weiss	1,244	40.0	20	71	42.7	6.8%	20.4	40.0	2.7	Yes
Century	1,408	61.0	45	102	56.0	-8.2%	16.5	32.4	5.0	Yes
Interstate	1,317	75.1	25	85	53.4	-28.9%	18.1	35.5	21.7	Yes
I-94N	754	21.5	15	65	36.3	68.8%	15.3	30.0	14.8	Yes
I-94S	728	19.5	13	34	32.3	65.6%	6.3	12.3	12.8	No
Capitol	837	22.3	15	61	27.1	21.5%	13.8	27.0	4.8	Yes
Divide	1,711	58.0	32	112	63.4	9.3%	29.0	56.8	5.4	Yes
Total	**11,955**	**371.7**			**380.1**	**2.3%**			**8.4**	

TABLE 23: INTERSECTION LEVEL OF SERVICE DESCRIPTIONS

Level of Service	Delay per Vehicle (Seconds)		Description
	Signalized	Unsignalized	
A	≤10	≤10	Free flow, minimal delays
B	>10 and ≤20	>10 and ≤15	Stable flow, occasional delays
C	>20 and ≤35	>15 and ≤25	Stable flow, periodic delays
D	>35 and ≤55	>25 and ≤35	Restricted flow, regular delays
E	>55 and ≤80	>35 and ≤50	Maximum capacity, extended delays
F	>80	>50	Forced flow, excessive delays

Source: 2000 Highway Capacity Manual, Chapter 16 and 17, Transportation Research Board

TABLE 24: ARTERIAL LEVEL OF SERVICE DESCRIPTIONS

Level of Service	Street Class / Free Flow Speed (mph)		
	55 to 45	45 to 35	35 to 25
	Class I	Class II	Class III
	Avg Speed	Avg Speed	Avg Speed
A	>42	>35	>25
B	>34	>28	>19
C	>27	>22	>13
D	>21	>17	>9
E	>16	>13	>7
F	<=16	<=13	<=7

Source: 2000 Highway Capacity Manual, Chapter 16 and 17, Transportation Research Board

TABLE 25: EXISTING INTERSECTION LEVEL OF SERVICE FOR STATE STREET (US 83)

Intersection	Morning(AM) Peak Hour					Midday Peak Hour					Evening(PM) Peak Hour				
	EB	WB	NB	SB	Int	EB	WB	NB	SB	Int	EB	WB	NB	SB	Int
Divide Ave	34.0 C	38.8 D	28.9 C	48.6 D	40.3 D	36.8 D	35.3 D	25.8 C	26.9 C	29.2 C	51.1 E	32.5 C	47.1 D	35.8 D	42.6 D
Capitol Ave	35.4 D	40.3 D	16.2 B	22.9 C	23.5 C	68.0 E	25.7 C	12.2 B	21.7 C	24.1 C	126 F	25.0 C	10.3 B	22.2 C	30.5 C
I-94 EB	49.5 D	- -	24.3 C	5.7 A	23.6 C	38.2 D	- -	11.4 B	15.5 B	17.0 B	40.3 D	- -	20.2 C	19.0 B	23.3 C
I-94 WB	- -	39.9 D	12.1 B	18.5 B	17.6 B	- -	40.1 D	5.0 A	13.6 B	11.5 B	- -	39.6 D	6.4 A	17.2 B	13.0 B
Interstate Av	19.5 B	21.1 C	14.2 B	29.9 C	21.2 C	26.5 C	22.3 C	25.3 C	66.0 E	37.2 D	26.8 C	28.0 C	31.8 C	15.9 B	26.4 C
Century Ave	25.0 C	46.2 D	14.2 B	32.2 C	28.7 C	25.6 C	36.5 D	19.4 B	30.0 C	26.9 C	29.9 C	39.4 D	25.9 C	26.2 C	29.7 C
Harvest Ln	21.5 C	25.5 C	12.0 B	8.4 A	10.6 B	19.2 B	24.3 C	17.5 B	11.0 B	16.1 B	66.9 E	22.4 C	17.0 B	21.7 C	29.0 C
Calgary Ave	14.1 B	50.2 D	13.8 B	11.1 B	13.7 B	17.2 B	36.4 D	12.5 B	11.2 B	14.2 B	15.8 B	37.5 D	11.7 B	12.6 B	14.6 B
43rd Ave	16.9 B	39.2 D	6.5 A	9.9 A	12.8 B	25.3 C	30.3 C	6.7 A	6.9 A	10.1 B	27.1 C	31.1 C	9.2 A	7.4 A	11.6 B
Skyline Blvd	- -	35.3 D	7.5 A	2.0 A	4.8 A	- -	36.5 D	3.6 A	3.5 A	12.7 B	- -	34.9 C	3.1 A	4.1 A	11.9 B

Notes:
Delay and LOS calculations computed using Synchro

TABLE 26: EXISTING INTERSECTION LEVEL OF SERVICE FOR BISMARCK EXPRESSWAY

Intersection	Morning(AM) Peak Hour					Midday Peak Hour					Evening(PM) Peak Hour				
	EB	WB	NB	SB	Int	EB	WB	NB	SB	Int	EB	WB	NB	SB	Int
Washington St	35.5 D	31.4 C	26.1 C	31.3 C	30.3 C	30.9 C	32.7 C	25.8 C	29.0 C	29.7 C	30.2 C	33.1 C	32.6 C	35.5 D	32.9 C
3rd St	31.0 C	29.0 C	26.2 C	21.2 C	28.5 C	23.2 C	14.5 B	25.9 C	33.0 C	21.2 C	32.8 C	27.4 C	24.1 C	30.9 C	29.3 C
7th St	29.4 C	43.5 D	85.5 F	94.7 F	59.3 E	25.0 C	5.8 A	43.0 D	83.7 F	44.0 D	22.7 C	38.6 D	52.1 D	30.4 C	31.7 C
9th St	28.2 C	35.0 D	98.3 F	- -	51.0 D	19.2 B	27.9 C	33.7 C	- -	24.5 C	18.3 B	25.5 C	32.5 C	- -	23.2 C
12th St	16.5 B	8.7 A	33.8 C	30.5 C	19.1 B	5.7 A	14.5 B	52.2 D	26.7 C	17.8 B	28.0 C	18.0 B	48.1 D	32.4 C	28.0 C
19th St & Airport Rd	35.0 D	34.9 C	29.8 C	33.4 C	33.7 C	36.6 D	34.2 C	29.5 C	31.7 C	33.8 C	56.8 E	47.8 D	44.0 D	34.1 C	47.4 D
26th St	9.8 A	15.0 B	16.3 B	22.1 C	14.4 B	11.5 B	19.5 B	17.5 B	23.2 C	16.5 B	14.3 B	22.8 C	19.2 B	27.3 C	19.6 B
Burlington Dr	5.4 A	3.2 A	15.5 B	9.6 A	4.4 A	9.3 A	6.7 A	15.5 B	19.9 B	9.8 A	12.2 B	6.6 A	15.0 B	23.5 C	11.0 B
Main Ave	179 F	43.1 D	14.6 B	5.5 A	31.7 C	32.2 C	17.8 B	10.2 B	3.7 A	12.9 B	37.6 D	14.5 B	16.0 B	19.7 B	23.0 C
Rosser Ave	29.2 C	- -	4.6 A	9.2 A	10.4 B	27.8 C	- -	7.0 A	10.9 B	13.0 B	33.3 C	- -	8.9 A	13.1 B	15.7 B
Commerce Dr	20.7 C	29.1 C	3.6 A	2.8 A	4.2 A	19.7 B	27.0 C	3.6 A	3.8 A	5.4 A	19.2 B	22.2 C	8.4 A	4.6 A	8.4 A
Divide Ave	36.4 D	20.5 C	9.2 A	5.2 A	10.5 B	36.2 D	18.0 B	11.0 B	3.9 A	12.6 B	38.3 D	17.5 B	12.1 B	8.2 A	14.7 B
I-94 EB	66.7 E	- -	8.9 A	2.8 A	22.3 C	26.0 C	- -	5.0 A	4.8 A	11.1 B	29.5 C	- -	10.3 B	4.6 A	14.4 B
I-94 WB	- -	42.1 D	16.0 B	25.2 C	22.9 C	- -	39.1 D	9.9 A	12.3 B	13.6 B	- -	37.2 D	10.4 B	14.0 B	13.0 B
Century Ave	8.0 A	* F	57.6 E	26.1 C	101 F	5.6 A	15.6 B	11.3 B	10.3 B	11.0 B	26.4 C	143 F	33.1 C	11.6 B	49.9 D

TABLE 27: EXISTING ARTERIAL LEVEL OF SERVICE FOR STATE STREET (US 83) - NORTHBOUND

Segment	Street Class	AM Peak Hour		PM Peak Hour	
		Avg. Speed	LOS	Avg. Speed	LOS
Divide to Capitol Ave	II	32	B	23	C
Capitol to I-94 EB	II	16	E	22	D
I-94 EB to I-94 WB	II	20	D	31	B
I-94 WB to Interstate Ave	II	24	C	17	E
Interstate to Century Ave	II	29	B	13	F
Century Ave to Harvest Ln	II	34	B	33	B
Harvest Ln to Calgary Ave	II	27	C	33	B
Calgary to 43rd Ave	II	41	A	46	A
43rd Ave to Skyline Blvd	II	32	B	40	A

Notes:
Field collected average speeds from travel time runs utilized for this table
Average speed in mph

SOUTHBOUND

Segment	Street Class	AM Peak Hour		PM Peak Hour	
		Avg. Speed	LOS	Avg. Speed	LOS
Divide to Capitol Ave	II	24	C	20	D
Capitol to I-94 EB	II	36	A	26	C
I-94 EB to I-94 WB	II	27	C	26	C
I-94 WB to Interstate Ave	II	29	B	24	C
Interstate to Century Ave	II	15	E	12	F
Century Ave to Harvest Ln	II	21	D	16	E
Harvest Ln to Calgary Ave	II	35	B	21	D
Calgary to 43rd Ave	II	43	A	43	A
43rd Ave to Skyline Blvd	II	38	A	28	C

Notes:
Field collected average speeds from travel time runs utilized for this table
Average speed in mph

TABLE 28: EXISTING ARTERIAL LEVEL OF SERVICE FOR BISMARCK EXPRESSWAY - EASTBOUND

Segment	Street Class	AM Peak Hour		PM Peak Hour	
		Avg. Speed	LOS	Avg. Speed	LOS
Washington to 3rd St	II	25	C	17	E
3rd to 7th St	II	27	C	21	D
7th to 9th St	II	30	B	25	C
9th to 12th St	II	27	C	16	E
12th St to Airport Rd	II	30	B	24	C
Airport Rd to 26th St	II	30	B	27	C
26th St to Burlington Dr	II	29	B	26	C
Burlington Dr to Yegen	I	33	C	31	C
Yegen to Main Ave	I	44	A	43	A
Main to Rosser Ave	I	33	C	30	C
Rosser Ave to Commerce Dr	I	43	A	43	A
Commerce Dr to Divide Ave	I	34	C	27	D
Divide Ave to I-94 EB	II	30	B	21	D
I-94 EB to I-94 WB	II	27	C	19	D
I-94 WB to Century Ave	II	18	D	21	D

Notes:
Field collected average speeds from travel time runs utilized for this table
Average speed in mph

WESTBOUND

Segment	Street Class	AM Peak Hour		PM Peak Hour	
		Avg. Speed	LOS	Avg. Speed	LOS
Washington to 3rd St	II	15	E	15	E
3rd to 7th St	II	25	C	23	C
7th to 9th St	II	15	E	10	F
9th to 12th St	II	18	D	17	E
12th St to Airport Rd	II	32	B	24	C
Airport Rd to 26th St	II	24	C	26	C
26th St to Burlington Dr	II	27	C	23	C
Burlington Dr to Yegen	I	32	C	34	C
Yegen to Main Ave	I	55	A	55	A
Main to Rosser Ave	I	30	C	31	C
Rosser Ave to Commerce Dr	I	42	B	40	B
Commerce Dr to Divide Ave	I	40	B	42	B
Divide Ave to I-94 EB	II	24	C	24	C
I-94 EB to I-94 WB	II	27	C	35	B
I-94 WB to Century Ave	II	26	C	26	C

Notes:
Field collected average speeds from travel time runs utilized for this table
Average speed in mph

A major focus of this project was to develop signal timing plans that promote efficient traffic flow along these two critical Bismarck transportation corridors. Development of optimized signal timing plans included an evaluation of the following:

- Signal System Zones
- Cycle Length
- Signal Phase Splits
- Signal Phasing Strategies
- Signal Coordination
- Time of Day

3.1 Signal System Zones

A feasibility review was conducted for Bismarck Expressway to determine whether additional signal coordination should be considered. This review was based on coordinability factor (CF) calculated by the Synchro traffic model and also based on field observations. The CF is a value ranging from 0 to 100 and higher values indicate a good fit for signal coordination. The CF is calculated based on travel time, traffic volumes, traffic in platoons, and storage space.

The results of this review determined the Bismarck Expressway intersections at Airport Road, 26th Street and Burlington Drive should be added to the signal coordination system in place between Washington Street and 12th Street. The intersection of Yegen Road at this time does not require coordination due to platoon dispersion and will remain operating in fully actuated mode. The intersection of Centennial Road / Century Avenue will be added to the signal coordination system to the south once the intersection is reconstructed.

A further review of coordinating the two current Bismarck Expressway signal systems found that the traffic patterns in the two segments exhibit different characteristics and they should not be combined into a single zone.

3.2 Cycle Length

The cycle length for each signal system zone were optimized using Synchro7 and by conducting a critical lane analysis. Table 29 highlights the cycle lengths selected for this project. For each corridor there are key intersections (e.g., Bismarck Expressway / Washington Street and State Street / Century Avenue) that establish the minimum cycle length. The cycle length selection process took into consideration the following:

- Minimum cycle length due to split requirements at key intersections
- Accommodates mainline traffic demand
- Minimize cross street impacts
- Maximize two-way progression

TABLE 29: PROPOSED CONDITION SIGNAL TIMING PLANS

Corridor / Segment	TOD	Time of Day	Plan / Pattern	Cycle
Bismarck Expressway – Main to I-94	AM	6:30 am to 8:30 am	3	90
	MM	8:30 am to 11:30 am	4	70
	MD	11:30 am to 4:00 pm	5	90
	PM	4:00 pm to 6:00 pm	6	90
	PPM	6:00 pm to 8:00 pm	7	90
	LE	8:00 pm to 6:30 am	8	70
Bismarck Expressway - Century	FREE	12:00 am to 11:59 pm	- -	- -
Bismarck Expressway - Yegen	FREE	12:00 am to 11:59 pm	- -	- -
Bismarck Expressway – Washington to Burlington	AM	7:00 am to 8:30 am	311	105
	MM	8:30 am to 11:15 am	111	75
	MD	11:15 am to 1:30 pm	211	90
	A	1:30 pm to 3:15 pm	112	75
	School	3:15 pm to 3:45 pm	313	105
	PM	3:45 pm to 6:00 pm	312	105
	PPM	6:00 pm to 8:00 pm	212	90
	LE	8:00 pm to 7:00 am	112	75
State Street	AM	6:30 am to 8:30 am	111	90
	MM	8:30 am to 11:15 am	211	70
	MD	11:15 am to 3:00 pm	311	105
	PM	3:00 pm to 6:00 pm	321	105
	PPM	6:00 pm to 8:00 pm	121	90
	LE	8:00 pm to 6:30 am	212	70

In some cases, the Synchro7 cycle optimization tool recommended longer cycle lengths than those implemented. The evaluation of longer cycle lengths found that the impacts to the side street delays were be significant and could potentially offset the mainline traffic flow benefits.

3.3 Signal Phase Splits

Intersection phase splits were optimized to minimize delay for mainline traffic flow, while maintaining appropriate split times for the minor traffic movements. The maximum green times were typically setup to accommodate 1.5 to 2 times the average demand per cycle. These splits were evaluated in Synchro7 to determine if projected levels of service would significantly degrade. These split times were also evaluated closely during field implementation, as discussed further later in this chapter.

3.4 Signal Timing Strategies

Before developing optimized signal timing plans a number of signal timing strategies were evaluated to determine the potential improvements that could result for these two roadway corridors. The potential strategies included the following:

- Protected / Permissive Left-Turn Phasing

- Lead / Lag Left-Turn Phasing
- Half Cycles

3.4.1 Protected / Permissive Left-Turn Phasing

Currently a high percentage of the mainline left-turn movements operate with protected only left-turn phasing. This mode of operation can lead to increased delays for those vehicles, particularly during the off-peak periods. A potential drawback of switching to protected/permissive left-turn phasing is an increase in left-turn crashes. For higher speed roadways this type of crash can be more severe. This signal timing strategy was dropped from consideration after discussion with the project steering committee and because both of these roadway corridors are included in the NDDOT system and their policy is protected only left-turn operations for roadways with operating speeds of 45 mph and above or on roadways with six lanes.

3.4.2 Lead / Lag Left-Turn Phasing

A signal timing strategy often used to improve two-way mainline corridor progression is lead / lag left-turn phasing. This strategy was evaluated and found to provide some benefits for two-way progression. This was particularly true for the intersections at I-94 in both roadway corridors. The primary concern with this mode of operation is that lead / lag scenario that would work during one peak period was normally the opposite in another peak period. This could lead to issues related to driver expectations (i.e., always expecting the left-turn arrow to appear in the same sequence) and the issue is compounded by the fact that these two roadway corridors host many out of town drivers. Another issue associated with a lagging left-turn phase is that it cannot be adjusted based on traffic volumes (i.e., maximum green or no time) and that could lead to increased delays for the opposing through movement vehicles. For those reasons the lead / lag left-turn strategy was not incorporated into the timing plans.

3.4.3 Half Cycles

Another signal timing strategy sometimes used to minimize side street (minor movement) delays is to use a cycle length that is half as long as the normal cycle length. This strategy was evaluated for the mainline and cross route intersections. On the mainline this strategy would hinder two-way corridor progression significantly. On the cross routes the only location that was evaluated was the Arbor Avenue intersections with 7th and 9th Street. At 9th Street / Arbor Avenue the half-cycle did not provide adequate window(s) of time to accommodate progression of the northbound through and the eastbound to northbound left-turn traffic movements from the 9th Street / Bismarck Expressway intersection. At 7th Street / Arbor Avenue the amount of time provided for the southbound through movement was considered too short. This signal timing strategy was dropped from further consideration.

3.5 Signal Coordination

Signal coordination is used along heavily traveled arterial streets with closely spaced traffic signals. Benefits from signal coordination include:

- Reduction in travel time and delays

- Reduction in stops and traffic slow downs could reduce accident potential
- Reduction in fuel consumption (i.e., less idling time) and vehicle emissions
- Potential to delay / eliminate the need for roadway widening

Traffic signal coordination, in its most basic form, is programming each traffic signal to turn green at set times that allow vehicles to progress through the corridor with minimal delays and stops. The key component of signal coordination is the offset times. For one-way progression the offset times are simply determined by the speed and the distance between traffic signals. For two-way progression, you must deal with groups of vehicles that might be arriving at a particular intersection at different times during the cycle. Setting up a corridor to primarily serve one direction of travel could lead to a frustrating experience for the opposite direction (i.e., hitting multiple red lights). Therefore, it is important to balance the needs of both travel directions on the main street along with the delay experienced by side street traffic.

Additional detail on the key factors that affect development of signal timing plans for two-way signal coordination is provided below:

- Desired travel speed – signal coordination plans are setup for the posted speed limit or the prevailing travel speeds, if significantly lower than the posted speed.
- Spacing between traffic signals – good signal coordination plans work best with uniformly spaced traffic signals and with traffic signals at least ¼ - mile apart.
- Traffic signal cycle length – traffic signals along a corridor must use the same cycle length in order to achieve signal coordination. Longer cycle lengths tend to produce better corridor progression, but that can result in more delay for side streets.
- Traffic demand on main street by direction – signal coordination plans are typically setup to favor the direction of travel with the higher volumes.
- Traffic demand for minor movements (i.e., main street left-turns and side street traffic) – higher side street and minor movement volumes results in less available time for the main street coordinated phases.
- Truck traffic – higher amounts of truck traffic can affect the corridor progression speeds.
- Congestion (i.e., traffic demand exceeds available capacity) – traffic coordination plans do not function well during those periods of time when traffic demand exceeds capacity.
- Traffic demand fluctuations throughout the day – a number of traffic coordination plans are developed to account for traffic pattern changes throughout a typical day.
- New traffic signal phases (e.g., left-turn arrow for the side street left-turn movements) – increased traffic volumes for minor intersection movement that require a new traffic signal phase results in a narrower window for the main street coordinated phase.
- Pedestrian volumes – typical pedestrian crossings of an intersection require more time than normally allocated for side street vehicle movements and that results in a reduced window for the main street coordinated phase or loss of signal coordination. Safety of pedestrians / bicyclists will be served first.

In the real world some of the above factors do not fit well with ideal conditions. For example, with a desired speed of 40 mph and a cycle length of 90 seconds the ideal spacing between signalized intersections would be ½ - mile when striving for good two-way coordination. A quick look at both the Bismarck Expressway or State Street corridor and you will see that most adjacent traffic signals are much closer than ½ - mile apart. In both of these corridors there are typically short bursts of heavy traffic during the morning and evening commute periods where congestion occurs at key locations. Consideration of the above factors requires a "balancing" act when developing coordinated signal timing plans.

Development of the coordinated signal timing plans was a two step process. In the first step, the Synchro7 model was be used to optimize the intersection offset times. These new coordinated signal timing plans were then imported into another program called Time Space Platoon Program (TSPP). In that program it was easier to make manual adjustments and to create multiple corridor progression bands for one direction of travel. One of the initial goals of providing two-way progression all the way through each corridor often resulted in progression bandwidths that were too small and were impacted by congestion issues. As a result several of the coordinated signal plans include a break point and multiple progression bands.

3.6 Time of Day Plans

Multiple signal timing plans were developed for each corridor and were based on existing traffic volume conditions throughout a typical weekday. The weekday timing plans were presented earlier in Table 29 and additional information on those plans and the weekend plans is provided in Appendix B.

3.7 Signal Timing Implementation

URS personnel worked with city staff to implement the signal timing plans for the following corridors:

- Bismarck Expressway East: Main Avenue to I-94 North Ramp (6 signals)
- Bismarck Expressway West: Washington Street to Burlington Drive (11 signals)
- State Street: Divide Avenue to Skyline Boulevard (11 signals)

These timing plans were implemented during two stages that occurred between August 12th to 21st, 2009 and between October 11th to 16th, 2009. After the signal timing plans were downloaded to the master and local signal controllers a number of evaluations were completed, as listed below:

- Time-space diagram review
- Signal split review
- Cycle failure review

Each corridor was driven multiple times during each timing plan to review the coordination parameters (e.g., offsets, travel speeds, progression bandwidths) shown on the time-space diagram for a particular timing plan. Based on these field reviews some adjustments were made to intersection offsets to improve corridor progression.

During these field reviews it was observed that the Bismarck Expressway at 3rd Street was often out of sync (i.e., not in coordination) and it was due to the high number of pedestrians crossing Bismarck Expressway at that location. The reason the traffic signal was out of coordination is because the required time for a pedestrian crossing is longer than allocated for the north/south through vehicular movement. In order to address this issue the maximum green time for the north/south through movement was increased to match the required pedestrian timing needs for several of the timing plans. This results in a smaller progression bandwidth for Bismarck Expressway, but the signal coordination is maintained.

As URS personnel drove the corridors they also observed traffic operations for minor traffic movements and made notes to further investigate. The evaluation of split times (i.e., maximum green time) for minor movements at several intersections in each corridor resulted in some adjustments. URS personnel also activated a signal controller feature called detector switching at several intersections in order to increase efficiency for cross street traffic operations.

URS personnel also watched for cycle failures in each corridor. A cycle failure is where all the vehicles waiting at a traffic light when it turns green do not make it through the intersection before the light turns red. Cycles failures were observed in each corridor at key intersections during the height of morning and evening rush hours. These cycle failures typically only impact a few cycles and are primarily the result of demand exceeding intersection capacity. An example of this issue occurs at Bismarck Expressway / Washington Street during the morning peak between approximately 7:45 to 7:55am. At that time all of the signal phases are using their maximum green times and there is no spare time to accommodate the capacity issues.

Based on the field reviews some adjustments to beginning/end times for some time of day plans were completed. For the Bismarck Expressway West corridor a new time of day plan was added to account for school departure traffic.

A final field review of the signal timing plans was completed during the week of November 16th, 2009. A few minor adjustments to intersection offsets were implemented in the Bismarck Expressway West corridor due to some travel pattern changes that occurred now that the roadway construction on Washington Street and the Bismarck Expressway bridge was completed.

The purpose of this chapter is to document the benefits of the Bismarck Signal Optimization Project. To determine the benefits a series of "after" condition travel time runs were completed and the results compared to the "before" condition. In addition, a benefit / cost analysis was completed to determine the cost effectiveness of the project.

4.1 Before / After Travel Time Comparison

Travel time studies were completed by Houston Engineering for State Street during the week of October 26th, 2009 and for Bismarck Expressway during the week of November 9th, 2009. These travel time runs were completed using the same equipment and techniques employed for the "before" travel time runs. For the "after" condition only travel time runs that covered the entire length of each corridor were completed. A comparison of the before / after travel time runs is provided in Tables 30 through 32. The "before" travel time runs reported in these tables differ slightly from those reported in Chapter 2 because these travel time runs only include the time it took to drive from the beginning to exiting intersections.

As shown in these tables, the comparison of the "before" and "after" travel time runs reveals substantial time savings for mainline traffic. The time savings range from a few seconds to over 90 seconds. Considering the fact that the majority of these intersections were already coordinated prior to this project the time savings are encouraging.

Time periods with lower levels of travel time savings either indicate that the previous coordinated plan was an efficient one or more emphasis was placed on one direction over the opposite direction with the new signal timing plan.

TABLE 30. BISMARCK EXPRESSWAY WEST TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
EB1	M	279.7	277.1	2.6	1%
	MM	287.6	242.1	45.5	16%
	MD	307.5	248.8	58.7	19%
	A	312.6	279.2	33.5	11%
	E	366.5	287.1	79.4	22%
	LE	317.1	249.9	67.2	21%
WB2	M	359.2	293.5	65.7	18%
	MM	311.6	259.3	52.3	17%
	MD	334.3	286.4	47.9	14%
	A	355.9	273.5	82.4	23%
	E	405.2	314.2	91.0	22%
	LE	345.2	249.3	95.9	28%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

TABLE 31. BISMARCK EXPRESSWAY EAST TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
NB1 (EB)	M	242.5	226.4	16.1	7%
	MM	209.2	192.9	16.3	8%
	MD	215.8	200.8	15.0	7%
	A	202.2	201.5	0.6	0%
	E	255.2	241.4	13.8	5%
	LE	204.5	177.2	27.3	13%
SB2 (WB)	M	219.0	195.3	23.7	11%
	MM	201.8	190.9	10.9	5%
	MD	209.6	191.0	18.6	9%
	A	222.3	196.6	25.7	12%
	E	215.5	207.3	8.2	4%
	LE	193.7	197.0	-3.3	-2%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

TABLE 32. STATE STREET TRAVEL TIME RUNS

Travel Path	Time Period [1]	Before Travel Time	After Travel Time	Travel Time Savings	Percent Savings
NB1	M	281.9	277.0	4.9	2%
	MM	257.5	243.7	13.8	5%
	MD	282.8	258.6	24.2	9%
	A	294.6	268.4	26.2	9%
	E	306.0	246.7	59.3	19%
	LE	297.0	260.8	36.2	12%
SB2	M	294.5	263.6	30.9	11%
	MM	308.7	264.6	44.1	14%
	MD	344.2	272.3	71.9	21%
	A	351.1	281.3	69.8	20%
	E	371.7	275.0	96.7	26%
	LE	343.7	265.7	78.0	23%

Notes:

1 - Time Periods: M= Morning Peak (7:00 - 9:00 am); MM = Mid-morning (9:00 - 11:00 am); MD = Mid-day Peak (11:00 am - 1:00 pm); A = Afternoon (1:00 - 4:00 pm); E = Evening Peak (4:00 - 6:00 pm); LE = Late evening (6:00 - 8:00 pm)
2 – Travel times reported in seconds.

In many cases the field "after" condition travel time runs resulted in more time savings than indicated by the SimTraffic7 traffic models.

4.2 Benefit / Cost Analysis

A benefit / cost analysis was completed to determine the economic benefits associated with the Bismarck Signal Optimization Project. The project benefits are calculated by evaluating the "before" and "after" conditions for corridor travel time, number of vehicle stops, and fuel consumption. These measures of effectiveness (MOE) were determined from SimTraffic7 model runs for the morning, mid-day, and evening peak hours.

4.2.1 Project Benefits

The project benefits are measured in terms of reductions for corridor travel time, vehicle stops and fuel consumption. The dollar values assumed for these project benefits are provided below:

- Time value = $10.00
- Vehicle stops = $0.06
- Fuel cost = $2.60

The time value assumed for this project is relatively low compared to other studies researched for this project, but provides a conservative estimate. Reducing the number of vehicle stops prolongs the lifespan of roadway pavements. The fuel cost is the approximate value in North Dakota over the last six months according to AAA.

4.2.2 Daily Economic Benefit

The net change in project MOEs for the three peak hours in the three project corridors are shown in Table 33. The net benefit on a daily basis for just these three peak periods is $1,273. Project benefits are also realized during the off-peak periods as documented earlier in this chapter. Making the assumption that these three peak hours represent 40% of the daily reduction in MOEs, then the daily benefits for the project would be $3,183.

TABLE 33. PEAK HOUR MOE

MOE	Before	After	Net Reduction	Percent Reduction
Travel Time (hours) [1]	1,009.6	886.7	61.5	6%
Stops (vehs)	130,152	121,249	8,903	7%
Fuel (gallons)	3,265	3,217	48	1.5%

Notes:

1 – Assumed that mainline reduction in travel time would be partially offset by increased "delay" for cross street and minor movement traffic. Assumed only 50% of travel time reduction when developing overall project benefits.

4.2.3 Annual Economic Benefit

The annual economic benefit for the project is based on 250 working days. Not including the weekends provides a more conservative approach. The net annual economic benefit of this project is estimated to be $795,750. This number includes over 38,000 vehicle hours of travel and approximately 30,000 gallons of fuel.

4.2.4 Benefit / Cost Ratio

The benefit / cost ratio is calculated based on the project benefits versus the project cost. The estimated project cost was $227,000 and includes consulting fees and agency staff time. This yields a one-year benefit / cost ratio of **3.5:1**. However, newly implemented signal timing plans have a lifetime of at least three years. That would increase the benefit / cost ratio to **10.5:1**.

The implementation of the new optimized signal timing plans in these two corridors has proven to be beneficial for Bismarck citizens based upon the project results discussed. The traffic signal retiming effort has been a cost-effective way to improve traffic flow along the project corridors by reducing travel times, delays, and vehicle stops. The project also resulted in reduced fuel consumption that saves money for Bismarck citizens. This project has also proven to be financially beneficial with a benefit / cost ratio of 3.5:1.

5.1 Recommendations

As part of the Bismarck Signal Optimization Project a comprehensive review of the signal system was completed. Based on that review the following recommendations are provided:

- Review vehicle detection for left-turn movements. During our field reviews it was noted some intersections (e.g., Airport Road - westbound, Washington Street southbound) where the left-turn phase was occasionally skipped with vehicles present.
- Work with signal hardware vendor to find solution for southbound left-turn arrow appearing at the intersection of State Street / Harvest Lane when vehicles are not present.
- Plan for providing a dual left-turn lane for the northbound approach at the intersection of State Street / Harvest Lane. That traffic volume has increased significantly and a disproportionate amount of the cycle length has been allocated to that phase.
- Monitor the eastbound / westbound traffic volumes at the intersection of State Street / Calgary Avenue. With the extension of Calgary Avenue and new developments, traffic volumes have increased within the last year.
- Encourage city staff not to provide significantly more time for the northbound approach at the intersection of Bismarck Expressway / 26th Street for a couple of reasons. First, it has the potential to harm corridor progression. Second, the Burlington Drive intersection is severely underutilized. Some of the burden of redirecting traffic to Burlington Drive should be placed on the retailers at that location.
- Work with the Bismarck School District to try and move up the start time for Wachter middle school to try and separate the Bismarck Expressway and school traffic peaks during the morning rush.
- Continue to work towards a geometric capacity improvement at the I-94 interchanges to accommodate the high number of northbound left-turn vehicles accessing the interstate.
- Continue to work towards a geometric solution for the eastbound / westbound left-turn movements at the intersection of State Street / Century Avenue.
- Continue to work towards a geometric solution for the eastbound left-turn movement at the intersection of Bismarck Expressway / 9th Street.
- Continue planning for expansion of a fiber optic communication network to serve these two corridors.

Bismarck Signal Optimization Project

Balanced Turn Movement Counts for Bismarck Expressway Corridor

AM Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Washington St	75	545	153	149	294	194	271	603	319	172	219	39
3rd St	108	877	51	29	514	103	107	320	139	114	77	36
7th St	X	1028	20	18	466	X	101	X	234	492	118	115
9th St	500	890	364	86	373	124	111	833	35	X	X	X
12th St	81	700	90	33	500	50	63	223	36	52	143	90
Airport Rd	118	500	159	164	434	68	48	252	138	38	264	76
26th St	181	301	104	35	480	107	38	36	14	34	98	180
Burlington Dr	3	286	60	28	599	22	19	2	13	4	0	4
Yegen Rd	X	230	65	104	395	X	266	X	120	X	X	X
Main Ave	90	43	9	59	343	190	22	310	24	71	431	214
Rosser Ave	155	2	44				79	507			672	302
Commerce Dr	23	4	42	15	3	6	72	556	34	12	924	32
Divide Ave	77	66	14	71	53	192	25	477	83	226	883	215
I-94 EB	109		428	X	X	X	X	646	100	15	896	X
I-94 WB	X	X	X	81		11	319	436	X	X	830	390
Century Ave	17	20	131	470	150	40	135	195	50	40	485	19

MD Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Washington St	74	435	143	241	388	219	124	310	227	166	315	69
3rd St	105	750	34	75	840	160	38	136	70	190	136	50
7th St	X	910	10	26	730	X	20	X	30	550	114	340
9th St	247	944	299	38	584	175	172	349	38	X	X	X
12th St	51	770	130	44	603	70	142	134	40	100	261	52
Airport Rd	124	630	110	110	490	66	98	228	87	46	207	114
26th St	124	342	213	28	317	51	180	129	23	64	119	148
Burlington Dr	10	284	135	60	300	9	86	15	70	6	16	10
Yegen Rd	X	261	99	70	275	X	110	X	60	X	X	X
Main Ave	184	104	8	37	92	63	10	275	36	82	300	160
Rosser Ave	181		60				50	466			482	150
Commerce Dr	18	7	45	20	7	15	57	563	34	8	581	9
Divide Ave	120	75	26	80	68	210	15	481	100	170	492	120
I-94 EB	183		285	X	X	X	X	701	110	13	497	X
I-94 WB	X	X	X	112		26	317	567	X	X	398	179
Century Ave	6	4	65	64	2	27	70	420	103	31	448	15

PM Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Washington St	104	530	283	386	757	288	209	423	250	261	596	111
3rd St	133	780	87	205	1250	220	69	147	54	183	338	135
7th St	X	944	19	26	1183	X	44	X	83	700	225	481
9th St	294	942	491	64	967	188	242	297	47	X	X	X
12th St	86	700	156	52	948	84	148	213	62	201	369	60
Airport Rd	109	750	102	144	677	57	223	329	127	96	248	173
26th St	162	532	279	22	454	67	258	153	32	126	124	142
Burlington Dr	9	581	100	83	437	15	92	12	146	22	6	14
Yegen Rd	X	514	235	124	401	X	134	X	103	X	X	X
Main Ave	285	176	31	67	77	58	16	510	91	188	427	135
Rosser Ave	300		90				75	778			660	143
Commerce Dr	40	4	72	19	7	23	68	940	27	5	712	9
Divide Ave	195	61	30	76	53	266	19	891	93	166	620	119
I-94 EB	326		353	X	X	X	X	1225	127	20	552	X
I-94 WB	X	X	X	98		32	423	1128	X	X	474	221
Century Ave	49	113	135	234	58	18	134	515	264	13	231	25

Bismarck Signal Optimization Project

Balanced Turn Movement Counts for State Street (US 83) Corridor

AM Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Divide Ave	66	196	108	145	245	179	108	745	33	143	1211	120
Capitol Ave	171	96	45	161	63	46	33	903	68	52	1318	97
I-94 EB	462		326	X	X	X	X	1026	98	93	1136	X
I-94 WB	X	X	X	171		124	234	1254	X	X	1058	272
Interstate Ave	27	110	148	90	81	34	173	889	316	31	1092	50
Century Ave	55	276	145	203	270	50	168	426	256	80	875	107
Harvest Ln	32	17	36	28	20	16	71	428	32	45	998	186
Calgary Ave	13	24	139	47	10	7	66	347	63	15	1043	23
43rd Ave	21	50	117	84	45	5	24	237	20	4	900	21
Skyline Blvd	X	X	X	34	X	11	X	195	68	28	891	X

MD Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Divide Ave	120	151	94	110	223	140	85	928	95	138	900	83
Capitol Ave	244	94	27	110	70	59	60	1036	82	77	1001	116
I-94 EB	306		108	X	X	X	X	1163	86	86	1096	X
I-94 WB	X	X	X	94		119	146	1323	X	X	1088	276
Interstate Ave	88	161	242	195	168	110	285	923	234	89	927	74
Century Ave	122	383	241	217	390	90	256	666	234	94	702	94
Harvest Ln	119	61	189	67	46	48	142	662	74	32	634	70
Calgary Ave	38	27	108	66	21	21	109	641	79	20	562	46
43rd Ave	42	31	43	37	32	16	53	514	50	18	509	55
Skyline Blvd	X	X	X	271	X	40	X	317	255	45	311	X

PM Peak Hour

Approach -->	Eastbound			Westbound			Northbound			Southbound		
Movement -->	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**
Divide Ave	187	303	85	88	239	176	143	1366	169	185	944	77
Capitol Ave	260	101	28	134	77	95	56	1520	105	95	1059	121
I-94 EB	365		240	X	X	X	X	1650	145	125	1070	X
I-94 WB	X	X	X	90		156	279	1736	X	X	1105	496
Interstate Ave	92	135	258	268	160	96	348	1355	189	55	1075	43
Century Ave	139	358	183	239	483	143	282	915	306	126	713	120
Harvest Ln	226	74	167	61	49	78	207	886	104	37	731	93
Calgary Ave	47	30	124	85	45	30	150	970	70	11	703	46
43rd Ave	76	55	54	51	59	13	78	922	77	13	604	63
Skyline Blvd	X	X	X	349	X	92	X	699	282	45	331	X

Intersection: US 83 / Divide

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle		
1/1	90	***AM***	
2/1	70	***MM***	
3/1	105	***MD***	
3/2	105	***PM***	
1/2	90	***PPM***	
1/3	90	***LE***	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	13	0 = Actuated	2	45	1 = Coordinate	3	15	0	4	17	0
5	16	0	6	42	1	7	11	0	8	21	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	11	0 = Actuated	2	25	1 = Coordinate	3	17	0	4	17	0
5	11	0	6	25	1	7	17	0	8	17	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	49	1 = Coordinate	3	20	0	4	20	0
5	16	0	6	49	1	7	20	0	8	20	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	18	0 = Actuated	2	46	1 = Coordinate	3	18	0	4	23	0
5	18	0	6	46	1	7	18	0	8	23	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	14	0 = Actuated	2	42	1 = Coordinate	3	14	0	4	20	0
5	16	0	6	40	1	7	14	0	8	20	0

Traffic Plan Data

	D/S/O			
Plan:	1/1/1	Offset Time:	73	
Plan:	2/1/1	Offset Time:	2	
Plan:	3/1/1	Offset Time:	29	
Plan:	3/2/1	Offset Time:	7	
Plan:	1/2/1	Offset Time:	28	
Plan:	2/1/2	Offset Time:	2	<< --- This plan has the same splits / offsets as the MM plan (2/1/1)

Traffic Data

Event	Program Day	Time	D/S/O	
1	1	11:00	1/2/1	
2	1	20:00	2/1/1	
3	2	6:30	1/1/1	
4	2	8:30	2/1/1	
5	2	11:15	3/1/1	
6	2	15:00	3/2/1	
7	2	18:00	1/2/1	
8	2	20:00	2/1/2	<< --- This plan has the same splits / offsets as the MM plan (2/1/1)
9				
10				

Intersection: US 83 / Capital

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	50	1 = Coordinate	3	0	0	4	28	0
5	14	0	6	48	1	7	0	0	8	28	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	11	0 = Actuated	2	39	1 = Coordinate	3	0	0	4	20	0
5	11	0	6	39	1	7	0	0	8	20	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	14	0 = Actuated	2	58	1 = Coordinate	3	0	0	4	33	0
5	14	0	6	58	1	7	0	0	8	33	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	57	1 = Coordinate	3	0	0	4	36	0
5	12	0	6	57	1	7	0	0	8	36	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	52	1 = Coordinate	3	0	0	4	26	0
5	14	0	6	50	1	7	0	0	8	26	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	31
Plan:	2/1/1	Offset Time:	30
Plan:	3/1/1	Offset Time:	46
Plan:	3/2/1	Offset Time:	22
Plan:	1/2/1	Offset Time:	57
Plan:	2/1/2	Offset Time:	30

Intersection: US 83 / I-94 EB (South)

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	0	0 = Actuated	2	61	1 = Coordinate	3	0	0	4	29	0
5	20	0	6	41	1	7	0	0	8	0	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	0	0 = Actuated	2	50	1 = Coordinate	3	0	0	4	20	0
5	16	0	6	34	1	7	0	0	8	0	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	0	0 = Actuated	2	74	1 = Coordinate	3	0	0	4	31	0
5	20	0	6	54	1	7	0	0	8	0	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	0	0 = Actuated	2	75	1 = Coordinate	3	0	0	4	30	0
5	20	0	6	55	1	7	0	0	8	0	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	0	0 = Actuated	2	64	1 = Coordinate	3	0	0	4	26	0
5	18	0	6	46	1	7	0	0	8	0	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	19
Plan:	2/1/1	Offset Time:	24
Plan:	3/1/1	Offset Time:	32
Plan:	3/2/1	Offset Time:	21
Plan:	1/2/1	Offset Time:	59
Plan:	2/1/2	Offset Time:	24

Intersection: US 83 / I-94 WB (North)

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0 = Actuated	2	44	1 = Coordinate	3	0	0	4	0	0
5	0	0	6	69	1	7	0	0	8	21	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	36	1 = Coordinate	3	0	0	4	0	0
5	0	0	6	52	1	7	0	0	8	18	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	62	1 = Coordinate	3	0	0	4	0	0
5	0	0	6	82	1	7	0	0	8	23	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	32	0 = Actuated	2	51	1 = Coordinate	3	0	0	4	0	0
5	0	0	6	83	1	7	0	0	8	22	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	22	0 = Actuated	2	50	1 = Coordinate	3	0	0	4	0	0
5	0	0	6	72	1	7	0	0	8	18	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	66
Plan:	2/1/1	Offset Time:	58
Plan:	3/1/1	Offset Time:	81
Plan:	3/2/1	Offset Time:	64
Plan:	1/2/1	Offset Time:	6
Plan:	2/1/2	Offset Time:	58

Intersection: US 83 / Interstate Ave

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	15	0 = Actuated	2	47	1 = Coordinate	3	12	0	4	16	0
5	12	0	6	50	1	7	10	0	8	18	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	31	1 = Coordinate	3	11	0	4	16	0
5	11	0	6	32	1	7	11	0	8	16	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	48	1 = Coordinate	3	20	0	4	21	0
5	12	0	6	52	1	7	20	0	8	21	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	45	1 = Coordinate	3	20	0	4	20	0
5	12	0	6	53	1	7	20	0	8	20	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	43	1 = Coordinate	3	16	0	4	15	0
5	11	0	6	48	1	7	16	0	8	15	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	71
Plan:	2/1/1	Offset Time:	0
Plan:	3/1/1	Offset Time:	95
Plan:	3/2/1	Offset Time:	81
Plan:	1/2/1	Offset Time:	19
Plan:	2/1/2	Offset Time:	0

Intersection: US 83 / Century Ave

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	13	0 = Actuated	2	41	1 = Coordinate	3	14	0	4	22	0
5	13	0	6	41	1	7	12	0	8	24	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	27	1 = Coordinate	3	12	0	4	19	0
5	11	0	6	28	1	7	12	0	8	19	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	18	0 = Actuated	2	45	1 = Coordinate	3	15	0	4	27	0
5	13	0	6	50	1	7	12	0	8	30	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	18	0 = Actuated	2	45	1 = Coordinate	3	16	0	4	26	0
5	13	0	6	50	1	7	13	0	8	29	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	15	0 = Actuated	2	39	1 = Coordinate	3	15	0	4	21	0
5	12	0	6	42	1	7	12	0	8	24	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	58
Plan:	2/1/1	Offset Time:	44
Plan:	3/1/1	Offset Time:	85
Plan:	3/2/1	Offset Time:	85
Plan:	1/2/1	Offset Time:	20
Plan:	2/1/2	Offset Time:	44

Intersection: US 83 / Harvest

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	53	1 = Coordinate	3	11	0	4	14	0
5	12	0	6	53	1	7	11	0	8	14	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	29	1 = Coordinate	3	11	0	4	14	0
5	12	0	6	33	1	7	11	0	8	14	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	25	0 = Actuated	2	51	1 = Coordinate	3	11	0	4	18	0
5	11	0	6	65	1	7	11	0	8	18	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	51	1 = Coordinate	3	11	0	4	23	0
5	12	0	6	59	1	7	15	0	8	19	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	44	1 = Coordinate	3	11	0	4	15	0
5	11	0	6	53	1	7	11	0	8	15	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	9	
Plan:	2/1/1	Offset Time:	59	
Plan:	3/1/1	Offset Time:	0	
Plan:	3/2/1	Offset Time:	18	
Plan:	1/2/1	Offset Time:	60	
Plan:	2/1/2	Offset Time:	54	????

Intersection: US 83 / Calgary

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	60	1 = Coordinate	3	0	0	4	18	0
5	12	0	6	60	1	7	0	0	8	18	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	44	1 = Coordinate	3	0	0	4	14	0
5	12	0	6	44	1	7	0	0	8	14	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	14	0 = Actuated	2	65	1 = Coordinate	3	0	0	4	26	0
5	12	0	6	67	1	7	0	0	8	26	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	18	0 = Actuated	2	62	1 = Coordinate	3	0	0	4	25	0
5	12	0	6	68	1	7	0	0	8	25	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	58	1 = Coordinate	3	0	0	4	20	0
5	12	0	6	58	1	7	0	0	8	20	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	0
Plan:	2/1/1	Offset Time:	19
Plan:	3/1/1	Offset Time:	2
Plan:	3/2/1	Offset Time:	8
Plan:	1/2/1	Offset Time:	59
Plan:	2/1/2	Offset Time:	19

Intersection: US 83 / 43rd Ave

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	52	1 = Coordinate	3	0	0	4	26	0
5	12	0	6	52	1	7	0	0	8	26	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	44	1 = Coordinate	3	0	0	4	14	0
5	12	0	6	44	1	7	0	0	8	14	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	71	1 = Coordinate	3	0	0	4	22	0
5	12	0	6	71	1	7	0	0	8	22	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	14	0 = Actuated	2	66	1 = Coordinate	3	0	0	4	25	0
5	12	0	6	68	1	7	0	0	8	25	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	56	1 = Coordinate	3	0	0	4	22	0
5	12	0	6	56	1	7	0	0	8	22	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	66
Plan:	2/1/1	Offset Time:	58
Plan:	3/1/1	Offset Time:	46
Plan:	3/2/1	Offset Time:	76
Plan:	1/2/1	Offset Time:	18
Plan:	2/1/2	Offset Time:	58

Intersection: US 83 / Skyline

Coordination Data
check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	62	1 = Coordinate	3	0	0	4	16	0
5	0	0	6	74	1	7	0	0	8	16	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	42	1 = Coordinate	3	0	0	4	16	0
5	0	0	6	54	1	7	0	0	8	16	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	16	0 = Actuated	2	63	1 = Coordinate	3	0	0	4	26	0
5	0	0	6	79	1	7	0	0	8	26	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	14	0 = Actuated	2	66	1 = Coordinate	3	0	0	4	25	0
5	0	0	6	80	1	7	0	0	8	25	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	12	0 = Actuated	2	56	1 = Coordinate	3	0	0	4	22	0
5	0	0	6	68	1	7	0	0	8	22	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	52
Plan:	2/1/1	Offset Time:	52
Plan:	3/1/1	Offset Time:	52
Plan:	3/2/1	Offset Time:	61
Plan:	1/2/1	Offset Time:	6
Plan:	2/1/2	Offset Time:	52

Intersection: Century / 11st

Coordination Data

check Maximum Mode: 0 = Inhibit

Dial / Split	Cycle	
1/1	90	
2/1	70	
3/1	105	
3/2	105	
1/2	90	
1/3	90	<< --- This plan is not used, replaced by plan 2/1/2, 70s cycle

Split Times and Phase Modes

Dial 1 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	17	0 = Actuated	2	40	1 = Coordinate	3	11	0	4	22	0
5	11	0	6	46	1	7	11	0	8	22	0

Dial 2 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	13	0 = Actuated	2	30	1 = Coordinate	3	11	0	4	16	0
5	11	0	6	32	1	7	11	0	8	16	0

Dial 3 / Split 1

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	46	1 = Coordinate	3	13	0	4	26	0
5	13	0	6	53	1	7	13	0	8	26	0

Dial 3 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	20	0 = Actuated	2	46	1 = Coordinate	3	13	0	4	26	0
5	13	0	6	53	1	7	13	0	8	26	0

Dial 1 / Split 2

Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode	Ph.	Splits	Ph. Mode
1	17	0 = Actuated	2	40	1 = Coordinate	3	11	0	4	22	0
5	11	0	6	46	1	7	11	0	8	22	0

Traffic Plan Data

Plan:	1/1/1	Offset Time:	27
Plan:	2/1/1	Offset Time:	22
Plan:	3/1/1	Offset Time:	40
Plan:	3/2/1	Offset Time:	43
Plan:	1/2/1	Offset Time:	85
Plan:	2/1/2	Offset Time:	22

Intersection: Bismarck Expressway / Main

Coordination Patterns

Pattern:	3				(AM)		
Cycle Length	90	COS	311				
Offset	57						
							Check
Splits	1 -	2 -	47	3 -	4 -	43	90
	5 -	6 -	47	7 -	8 -	43	90
	9 -	10 -		11 -	12 -		
Pattern:	4				(MM)		
Cycle Length	70	COS	411				
Offset	29						
Splits	1 -	2 -	45	3 -	4 -	25	70
	5 -	6 -	45	7 -	8 -	25	70
	9 -	10 -		11 -	12 -		
Pattern:	5				(MD)		
Cycle Length	90	COS	322				
Offset	60						
Splits	1 -	2 -	58	3 -	4 -	32	90
	5 -	6 -	58	7 -	8 -	32	90
	9 -	10 -		11 -	12 -		
Pattern:	6				(PM)		
Cycle Length	90	COS	333				
Offset	73						
Splits	1 -	2 -	47	3 -	4 -	43	90
	5 -	6 -	47	7 -	8 -	43	90
	9 -	10 -		11 -	12 -		
Pattern:	7				(PPM)		
Cycle Length	90	COS	344				
Offset	86						
Splits	1 -	2 -	60	3 -	4 -	30	90
	5 -	6 -	60	7 -	8 -	30	90
	9 -	10 -		11 -	12 -		
Pattern:	8				(LE)		
Cycle Length	70	COS	422				
Offset	68						
Splits	1 -	2 -	50	3 -	4 -	20	70
	5 -	6 -	50	7 -	8 -	20	70
	9 -	10 -		11 -	12 -		

NIC Program Steps

Step	Program	Step Begin	Pattern
1	1	6:30	3
2	1	8:30	4
3	1	11:30	5
4	1	16:00	6
5	1	18:00	7
6	1	20:00	8
7	2	6:30	4
8	2	11:00	5
9	2	20:00	8

Intersection: Bismarck Expressway / Rosser

Coordination Patterns

Pattern:	3				(AM)			
Cycle Length	90	COS	311					
Offset	53							
								Check
Splits	1 -	2 -	65	3 -	4 -	25		90
	5 -	6 -	65	7 -	8 -	25		90
	9 -	10 -		11 -	12 -			
Pattern:	4				(MM)			
Cycle Length	70	COS	411					
Offset	23							
Splits	1 -	2 -	50	3 -	4 -	20		70
	5 -	6 -	50	7 -	8 -	20		70
	9 -	10 -		11 -	12 -			
Pattern:	5				(MD)			
Cycle Length	90	COS	322					
Offset	69							
Splits	1 -	2 -	65	3 -	4 -	25		90
	5 -	6 -	65	7 -	8 -	25		90
	9 -	10 -		11 -	12 -			
Pattern:	6				(PM)			
Cycle Length	90	COS	333					
Offset	7							
Splits	1 -	2 -	56	3 -	4 -	34		90
	5 -	6 -	56	7 -	8 -	34		90
	9 -	10 -		11 -	12 -			
Pattern:	7				(PPM)			
Cycle Length	90	COS	344					
Offset	85							
Splits	1 -	2 -	70	3 -	4 -	20		90
	5 -	6 -	70	7 -	8 -	20		90
	9 -	10 -		11 -	12 -			
Pattern:	8				(LE)			
Cycle Length	70	COS	422					
Offset	5							
Splits	1 -	2 -	56	3 -	4 -	14		70
	5 -	6 -	56	7 -	8 -	14		70
	9 -	10 -		11 -	12 -			

NIC Program Steps

See Main

Intersection: Bismarck Expressway / Revere

Coordination Patterns

Pattern:	3				(AM)		
Cycle Length	90	COS	311				
Offset	43						
							Check
Splits	1 -	2 -	70	3 -	4 -	20	90
	5 -	6 -	70	7 -	8 -	20	90
	9 -	10 -		11 -	12 -		
Pattern:	4				(MM)		
Cycle Length	70	COS	411				
Offset	26						
Splits	1 -	2 -	52	3 -	4 -	18	70
	5 -	6 -	52	7 -	8 -	18	70
	9 -	10 -		11 -	12 -		
Pattern:	5				(MD)		
Cycle Length	90	COS	322				
Offset	15						
Splits	1 -	2 -	70	3 -	4 -	20	90
	5 -	6 -	70	7 -	8 -	20	90
	9 -	10 -		11 -	12 -		
Pattern:	6				(PM)		
Cycle Length	90	COS	333				
Offset	68						
Splits	1 -	2 -	70	3 -	4 -	20	90
	5 -	6 -	70	7 -	8 -	20	90
	9 -	10 -		11 -	12 -		
Pattern:	7				(PPM)		
Cycle Length	90	COS	344				
Offset	36						
Splits	1 -	2 -	70	3 -	4 -	20	90
	5 -	6 -	70	7 -	8 -	20	90
	9 -	10 -		11 -	12 -		
Pattern:	8				(LE)		
Cycle Length	70	COS	422				
Offset	4						
Splits	1 -	2 -	56	3 -	4 -	14	70
	5 -	6 -	56	7 -	8 -	14	70
	9 -	10 -		11 -	12 -		

NIC Program Steps

See Main

Intersection: Bismarck Expressway / Divide

Coordination Patterns

Pattern:	3					(AM)		
Cycle Length	90		COS	311				
Offset	43							
								Check
Splits	1 -		2 -	65	3 -	4 -	25	90
	5 -	14	6 -	51	7 -	8 -	25	90
	9 -		10 -		11 -	12 -		
Pattern:	4					(MM)		
Cycle Length	70		COS	411				
Offset	56							
Splits	1 -		2 -	50	3 -	4 -	20	70
	5 -	14	6 -	36	7 -	8 -	20	70
	9 -		10 -		11 -	12 -		
Pattern:	5					(MD)		
Cycle Length	90		COS	322				
Offset	61							
Splits	1 -		2 -	64	3 -	4 -	26	90
	5 -	14	6 -	50	7 -	8 -	26	90
	9 -		10 -		11 -	12 -		
Pattern:	6					(PM)		
Cycle Length	90		COS	333				
Offset	0							
Splits	1 -		2 -	60	3 -	4 -	30	90
	5 -	14	6 -	46	7 -	8 -	30	90
	9 -		10 -		11 -	12 -		
Pattern:	7					(PPM)		
Cycle Length	90		COS	344				
Offset	86							
Splits	1 -		2 -	68	3 -	4 -	22	90
	5 -	12	6 -	56	7 -	8 -	22	90
	9 -		10 -		11 -	12 -		
Pattern:	8					(LE)		
Cycle Length	70		COS	422				
Offset	40							
Splits	1 -		2 -	52	3 -	4 -	18	70
	5 -	12	6 -	40	7 -	8 -	18	70
	9 -		10 -		11 -	12 -		

NIC Program Steps

See Main

Intersection: Bismarck Expressway / I-94 Eastbound (South Ramp)

Coordination Patterns

Pattern:	3				(AM)		
Cycle Length	90	COS	311				
Offset	46						
							Check
Splits	1 -	2 -	55	3 -	4 -	35	90
	5 -	6 -	55	7 -	8 -		55
	9 -	10 -		11 -	12 -		
Pattern:	4				(MM)		
Cycle Length	70	COS	411				
Offset	50						
Splits	1 -	2 -	48	3 -	4 -	22	70
	5 -	6 -	48	7 -	8 -		48
	9 -	10 -		11 -	12 -		
Pattern:	5				(MD)		
Cycle Length	90	COS	322				
Offset	63						
Splits	1 -	2 -	60	3 -	4 -	30	90
	5 -	6 -	60	7 -	8 -		60
	9 -	10 -		11 -	12 -		
Pattern:	6				(PM)		
Cycle Length	90	COS	333				
Offset	12						
Splits	1 -	2 -	60	3 -	4 -	30	90
	5 -	6 -	60	7 -	8 -		60
	9 -	10 -		11 -	12 -		
Pattern:	7				(PPM)		
Cycle Length	90	COS	344				
Offset	81						
Splits	1 -	2 -	65	3 -	4 -	25	90
	5 -	6 -	65	7 -	8 -		65
	9 -	10 -		11 -	12 -		
Pattern:	8				(LE)		
Cycle Length	70	COS	422				
Offset	41						
Splits	1 -	2 -	52	3 -	4 -	18	70
	5 -	6 -	52	7 -	8 -		52
	9 -	10 -		11 -	12 -		

NIC Program Steps

See Main

Intersection: Bismarck Expressway / I-94 Westbound (North Ramp)

Coordination Patterns

Pattern:	3					(AM)			
Cycle Length	90		COS	311					
Offset	88								
									Check
Splits	1 -		2 -	70	3 -		4 -		70
	5 -	18	6 -	52	7 -		8 -	20	90
	9 -		10 -		11 -		12 -		
Pattern:	4					(MM)			
Cycle Length	70		COS	411					
Offset	21								
Splits	1 -	12	2 -	40	3 -		4 -		52
	5 -		6 -	52	7 -		8 -	18	70
	9 -		10 -		11 -		12 -		
Pattern:	5					(MD)			
Cycle Length	90		COS	322					
Offset	20								
Splits	1 -	20	2 -	48	3 -		4 -		68
	5 -		6 -	68	7 -		8 -	22	90
	9 -		10 -		11 -		12 -		
Pattern:	6					(PM)			
Cycle Length	90		COS	333					
Offset	0								
Splits	1 -	20	2 -	50	3 -		4 -		70
	5 -		6 -	70	7 -		8 -	20	90
	9 -		10 -		11 -		12 -		
Pattern:	7					(PPM)			
Cycle Length	90		COS	344					
Offset	36								
Splits	1 -	14	2 -	58	3 -		4 -		72
	5 -		6 -	72	7 -		8 -	18	90
	9 -		10 -		11 -		12 -		
Pattern:	8					(LE)			
Cycle Length	70		COS	422					
Offset	7								
Splits	1 -	12	2 -	44	3 -		4 -		56
	5 -		6 -	56	7 -		8 -	14	70
	9 -		10 -		11 -		12 -		

NIC Program Steps

See Main

Intersection: Bismarck Expressway / Washington

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2), except for
2/1	90	**MD**		for the intersection of 7th Street
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	14	32	14	40	14	32	23	31
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	20	32	17	31	14	38	15	33
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	20	32	17	31	14	38	15	33
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	17	39	17	27	13	43	17	27
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	17	41	17	25	13	45	13	29
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	16	39	17	28	20	35	13	32
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	20	33	20	27	13	40	15	32

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	49	14	14		68	33			73	66

Time of Day Plans

Plan	TOD	C/O/S	
1	0:00	1/1/2	LE
1	7:00	3/1/1	AM
1	8:30	1/1/1	MM
1	11:15	2/1/1	MD
1	13:30	1/1/2	LE
1	15:15	3/1/3	School
1	15:45	3/1/2	PM
1	18:00	2/1/2	PPM
1	20:00	1/1/2	LE
2	0:00	1/1/2	LE
2	10:30	2/1/1	MD
2	20:00	1/1/2	LE

Intersection: Bismarck Expressway / 3rd

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	11	43	17	29	11	43	17	29
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	14	43	14	29	14	43	14	29
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	14	43	14	29	14	43	14	29
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	11	44	11	34	11	44	11	34
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	40	11	36	13	40	11	36
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	11	37	11	41	11	37	11	41
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	52	13	22	13	52	11	24

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	70	44	44		9	70			27	25

Intersection: Bismarck Expressway / 7th

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		51	26	23		51		
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		43	40	17		43		
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3		43	32	25		43		
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1		57	29	14		57		
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		58	31	11		58		
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		55	29	16		55		
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2		55	32	13		55		

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	103	85	85		35	20			63	58

Intersection: Bismarck Expressway / 9th

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	19	48		33	36	31		33
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	11	60		29	29	42		29
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	11	60		29	29	42		29
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	17	54		29	27	44		29
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	57		30	22	48		30
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	16	51		33	27	40		33
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	18	49		33	27	40		33

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	17	82	82		46	19			73	65

Intersection: Bismarck Expressway / 12th

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		60		40		60		40
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		57		43		57		43
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3		57		43		57		43
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1		60		40		60		40
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		67		33		67		33
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		60		40		60		40
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2		60		40		60		40

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	38	63	63		68	60			27	11

Intersection: Bismarck Expressway / Airport (19th)

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	16	45	15	24	16	45	15	24
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	16	45	15	24	16	45	15	24
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	16	45	15	24	16	45	15	24
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	17	50	11	22	17	50	13	20
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	58	11	18	11	60	11	18
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	16	51	11	22	16	51	13	20
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	17	48	11	24	17	48	11	24

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	8	4	4		41	19			0	54

Intersection: Bismarck Expressway / 26th

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	10	57		33	14	53	11	22
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	9	51		40	17	43	17	23
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	9	51		40	17	43	17	23
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	11	49		40	17	43	17	23
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	54		33	11	56	16	17
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	13	54		33	16	51	13	20
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	51		36	13	51	16	20

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	59	52	52		81	69			24	21

Intersection: Bismarck Expressway / Burlington

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	11	61	14	14	0	72		28
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	14	56	14	16	0	70		30
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	14	56	14	16	0	70		30
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	13	54	16	17	0	67		33
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	55	14	18	0	68		32
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	16	52	16	16	0	68		32
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13	51	16	20	0	64		36

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	66	58	58		73	72			12	73

Intersection: Washington / Denver

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	10%	49%	26%	15%	10%	49%	0%	41%
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	11%	43%	28%	18%	11%	43%		46%
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3	11%	43%	28%	18%	11%	43%		46%
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1	10%	49%	26%	15%	10%	49%		41%
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13%	35%	30%	22%	13%	35%		52%
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1	13%	36%	30%	21%	10%	39%		51%
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2	13%	36%	30%	21%	10%	39%		51%

Cycle/Split	3/1	3/2	3/3	2/1	2/2	1/1	1/2
Cycle	9	10		5	6	1	2
Cycle Length	105	105	105	90	90	75	75
Max Dwell / Min Cycle	95	95	95	80	80	65	65
Offset 1	99	89	89	38	11	55	35

Intersection: 7th / Arbor

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		65%		35%				35%
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		55%		45%				45%
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3		55%		45%				45%
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1		60%		40%				40%
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2		60%		40%				40%
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1		60%		40%				40%
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2		60%		40%				40%

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	76	65	65		9	5			18	22

Intersection: 9th / Arbor

cycle/split				
3/1	105	**AM**		
3/2	105	**PM**		
3/3	105	**School**	<< ---	This plan is the same as PM plan (3/2)
2/1	90	**MD**		
2/2	90	**PPM**		
1/1	75	**MM**		
1/2	75	**LE**		

Cycle	3	(AM)							
	Phase	1	2	3	4	5	6	7	8
Split	1				35%		65%		35%
Cycle	3	(PM)							
	Phase	1	2	3	4	5	6	7	8
Split	2				45%		55%		45%
Cycle	3	(School)							
	Phase	1	2	3	4	5	6	7	8
Split	3				45%		55%		45%
Cycle	2	(MD)							
	Phase	1	2	3	4	5	6	7	8
Split	1				40%		60%		40%
Cycle	2	(PPM)							
	Phase	1	2	3	4	5	6	7	8
Split	2				40%		60%		40%
Cycle	1	(MM)							
	Phase	1	2	3	4	5	6	7	8
Split	1				35%		65%		35%
Cycle	1	(LE)							
	Phase	1	2	3	4	5	6	7	8
Split	2				40%		60%		40%

Cycle/Split	3/1	3/2	3/3		2/1	2/2			1/1	1/2
Cycle	9	10			5	6			1	2
Cycle Length	105	105	105		90	90			75	75
Max Dwell / Min Cycle	95	95	95		80	80			65	65
Offset 1	100	48	48		17	13			22	34