

Capacity Analysis

TH 41 Expansion, Carver County, Minnesota



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TH 41 through Chaska is one of the most congested corridors in Carver County carrying traffic to medical destinations, commercial centers, an industrial park, and residential neighborhoods. Carver County applied for and secured federal funding to lead an expansion of TH 41 from Hundertmark Road to north of CSAH 14/Pioneer Trail. Expanding the highway from two lanes to four-lane divided required a significant engineering effort as the current alignment was woven between homes and Lake Grace on the west and a ravine/drainage area on the east.

Using technical expertise and knowledge in design flexibility, multiple right-sized alternatives were developed. Roadway alignments and profiles were developed to best tie into natural terrain barriers and other utility and private property constraints. A comprehensive traffic analysis was completed to understand exact turn lane needs along mainline and the cross streets to best fit the expansion into the surrounding area while maintaining performance. Synchro/SimTraffic was used for the bulk of the analysis, which included construction at two signalized intersections as well as the impacts of numerous nearby intersections. Analysis was also used to determine benefit-cost of certain geometric decisions including where the required lane drops would be placed.

We led the county, city, MnDOT, other project partners, and the public through the preliminary design process to arrive at a consensus-based solution. Using design flexibility, impacts were minimized while still providing full roadway functionality. This process successfully developed a cost-conscious approach for which the county hired Bolton & Menk to design and administer the construction.

Existing and Future Traffic Conditions Memorandum document is included on the following pages.



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MEMORANDUM

Date: May 9, 2016

To: Lyndon Robjent, P.E., Carver County Engineer

From: Ross B. Tillman, P.E.

Kelsey E. Retherford, E.I.T.

Subject: Existing and Future Traffic Conditions

TH 41 Reconstruction, Carver County, MN

Introduction

The intersections along Trunk Highway (TH) 41 between Hundertmark Road and Pioneer Trail are located in the City of Chaska on the east side of Carver County. Carver County received funding to expand TH 41 from a two lane to a four lane roadway from south of Hundertmark Road to north of Pioneer Trail. Carver County, in cooperation with the City and MnDOT, has requested a traffic operations study of the intersections be completed to analyze the existing as well as future traffic operations based on anticipated growth for the expansion project on TH 41.

Recommendation

Add final recommendation with supporting results once determined.

Existing Conditions

Currently, the intersections of TH 41 at both Hundertmark Road and Pioneer Trail are signalized. This study also included the analysis of the intersections of Hundertmark Road with the Two Twelve Medical Center and Bender Road as well as the intersections of Pioneer Trail with the Jonathan Square access and Kwik Trip/Lakeview Clinics accesses. The intersection of Hundertmark Road with Two Twelve Medical Center is signalized. All other intersections are side-street stop controlled with Hundertmark Road and Pioneer Trail having the right of way. TH 41 is currently a two lane undivided roadway with channelized left and right turn lanes at the intersections of Hundertmark Road and Pioneer Trail. The speed limit along TH 41 is 50 MPH. The speed limiting along Hundertmark Road west of TH 41 is 40 MPH and east of TH 41 is 35 MPH. The speed limit along Pioneer Trail west of TH 41 is 40 MPH and east of TH 41 is 45 MPH. TH 41 and Pioneer Trail are classified as A Minor Expanders and Hundertmark Road is classified as a Major Collector.

Data Collection

13-hour turning movement counts were completed at the intersections of TH 41 with Hundertmark Road and Pioneer Trail in March of 2016. Peak hour counts were completed at all other intersections. The existing traffic volumes are shown in **Figure 1 of Appendix A**.



Existing Operational Analysis

A level of service (LOS) analysis of the peak hours was completed using the existing turning movement counts in SimTraffic. The LOS results are based on average delay per vehicle as calculated by the 2010 Highway Capacity Manual (HCM), which defines the level of service, based on control delay. Control delay is the delay experienced by vehicles slowing down as they are approaching the intersection, the wait time at the intersection, and the time for the vehicle to speed up through the intersection and enter into the traffic stream. The average intersection control delay is a volume weighted average of delay experienced by all motorists entering the intersection on all intersection approaches. Intersections and each movement are given a ranking from LOS A through LOS F. LOS A indicates the best traffic operation, with vehicles experiencing minimal delays. LOS A through D is generally perceived to be acceptable to drivers. LOS E indicates that an intersection is operating at, or very near, its capacity and that drivers experience considerable delays. LOS F indicates an intersection where demand exceeds capacity and drivers experience substantial delays. **Table 1** includes the results of the existing traffic analysis.

Table 1 - Existing (2016) Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Maximum Delay- LOS**		Limiting Movement ***	Max v/c Ratio ****	Max Queue		
								Direction	Average Queue (ft)	Max Queue (ft) *****
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	39	D	70	E	NBL	0.77	NBT	437	777
	PM	43	D	65	E	NBL	0.76	SBT	330	526
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	2	A	15	C	SBL	0.30	SBL	17	69
	PM	3	A	22	C	SBL	0.40	SBL	43	80
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	2	A	14	B	SBL/NBR	0.22	EBL/T	21	91
	PM	2	A	24	C	NBT	0.33	EBL/T	21	68
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	7	A	51	F	NBT	0.40	EBT	50	217
	PM	3	A	18	C	NBL	0.36	EBT	5	53
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	40	D	70	E	SBL	0.83	NBT	333	603
	PM	90	F	238	F	SBL	1.04	SBT	1499	2557
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	14	B	30	C	SBL	0.45	EBT	121	216
	PM	19	B	34	C	EBL	0.45	EBT	116	208
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	A	73	E	NBL	0.72	WBR	74	138
	PM	59	E	234	F	WBL	1.34	WBR	738	1048
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	28	C	40	D	SBL	0.84	EBL	210	330
	PM	14	B	66	E	EBL	0.79	NBT	123	211

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

****Max v/c Ratio is the highest individual movement or lane group volume to capacity ratio

*****Max Queue refers to the 95% Queue

AM Peak Hour

- Intersection delay is acceptable with LOS D or better at all of the intersections.
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - TH 41 at Pioneer Trail
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- The limiting movement is anticipated to operate with LOS F at the intersection of Hundertmark Road at Bender Road.



- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lane.

PM Peak Hour

- Intersection delay is acceptable with LOS D or better at all of the intersections with the exception of TH 41 at Hundertmark Road and TH 41 at TH 212 North Ramp.
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - TH 41 at Pioneer Trail
 - TH 41 at TH 212 South Ramp
- The limiting movement is anticipated to operate with LOS F at the following intersections:
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- Maximum v/c ratio is greater than one at the intersections of TH 41 at Hundertmark Road and TH 41 at TH 212 North Ramp.
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through maximum queue extends beyond channelized turn lanes.
 - Southbound through average queue extends beyond channelized turn lanes.
 - Eastbound left maximum queue extends beyond channelized turn lane.
 - Westbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through maximum queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Westbound through maximum queue extends beyond channelized turn lanes.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at TH 212 North Ramp
 - Westbound average queues extend beyond channelized turn lanes.

Tables B1 and B2 in Appendix B show the existing delay and queue lengths for each movement at all of the intersections.

Traffic Forecasting

Future traffic volumes for 2018 and 2038 were developed from the both the City of Chaska Comprehensive Plan and the Carver County Comprehensive Plan. The City Comprehensive Plan provides 2006 and projected 2030 traffic volumes along TH 41, Pioneer Trail and Hundertmark Road. The 2016 intersection turning movement counts were projected to 2018 and 2038 using the growth rates determined from the City Comprehensive Plan. Volumes along Pioneer trail were included in the Carver County

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Comprehensive Plan. The projected 2030 volumes along Pioneer Trail in the Carver County Comprehensive Plan were recently updated and are higher than what is listed in the City Comprehensive Plan, so the higher AADT's were used to determine the growth rates along Pioneer Trail.

A 2% growth rate per year was assumed for future development growth at the Lakeview Clinic building. At the intersection of Pioneer Trail with the Jonathan Square access traffic growth was determined using the Trip Generational Manual. An apartment building and retail area are planned for the available land north of the Dairy Queen within Jonathan Square near the existing right in right out access to TH 41. The total number of trips added due to the proposed development were distributed between the Jonathan Square access off of Pioneer Trail and the access off of TH 41 based on current traffic patterns along TH 41 and Pioneer Trail.

The Trip Generation Manual was used to determine the increase in trips due to the future expansion of Two Twelve Medical Center. The Transportation Economic Development application estimated 100 employees would be added with proposed future growth. This increase in employees was used to determine the increase in traffic growth at the Two Twelve Medical Center access. No growth was assumed along Bender Road, the Kwik Trip access, or the SuperAmerica access as these locations are assumed to be fully built-out. The 2018 and 2038 forecasted turning movement counts are shown in **Figures 2 and 3** respectively in **Appendix A**.

Future Operations Analysis

The forecasted 2018 and 2038 turning movement counts were analyzed with the existing roadway geometry. **Tables 2 and 3** below show the SimTraffic results. **Tables C1-C4 in Appendix C** show the delay and queue lengths for each movement at all of the intersections with the forecasted traffic volumes.



Table 2 - 2018 No Build Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Maximum Delay- LOS**		Limiting Movement ***	Max v/c Ratio ****	Max Queue		
								Direction	Average Queue (ft)	Max Queue (ft) *****
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	44	D	68	E	NBL	0.81	NBT	520	841
	PM	46	D	65	E	NBL	0.78	SBT	386	742
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	3	A	23	C	SBL	0.32	EBL/T	25	88
	PM	4	A	30	D	SBL	0.48	SBL	58	120
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	7	A	75	F	SBL	0.24	EBL/T	52	240
	PM	2	A	25	D	NBT	0.35	EBL/T	25	73
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	7	A	223	F	SBL	0.41	EBT	43	230
	PM	5	A	46	E	NBR	0.37	EBT	25	133
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	42	D	70	E	SBL/T	0.83	SBT	399	630
	PM	130	F	352	F	SBL	1.04	SBT	2460	3448
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	15	B	30	C	SBL	0.47	EBT	125	237
	PM	24	C	54	D	NBL	0.50	EBT	115	200
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	A	67	E	NBL	0.82	WBR	73	139
	PM	59	E	215	F	WBL	1.41	WBR	799	1098
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	31	C	47	D	SBL	0.85	EBL	236	372
	PM	14	B	63	E	EBL	0.81	NBT	157	268

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

****Max v/c Ratio is the highest individual movement or lane group volume to capacity ratio

*****Max Queue refers to the 95% Queue

AM Peak Hour

- Intersection delay is acceptable with LOS D or better at all of the intersections.
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - TH 41 at Pioneer Trail
 - TH 41 at Hundertmark Road
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - Pioneer Trail at Kwik Trip
 - Hundertmark Road at Bender Road
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes.



PM Peak Hour

- Intersection delay is acceptable with LOS D or better at all of the intersections with the exception of TH 41 at Hundertmark Road and TH 41 at TH 212 North Ramp.
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - TH 41 at Pioneer Trail
 - Hundertmark Road at Bender Road
 - TH 41 at TH 212 South Ramp
- The limiting movement is anticipated to operate with LOS F at the following intersections:
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- Maximum v/c ratio is greater than one at the intersection of TH 41 at Hundertmark Road and at TH 41 at TH 212 North Ramp
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through maximum queue extends beyond channelized turn lanes.
 - Southbound through average queue extends beyond channelized turn lanes.
 - Westbound through maximum queue extends beyond channelized turn lanes.
 - Eastbound left maximum queue extends beyond channelized turn lane.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Westbound through maximum queue extends beyond channelized right turn lane.
 - TH 41 at TH 212 North Ramp
 - Westbound average queues extend beyond channelized turn lanes.



Table 3 - 2038 No Build Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Maximum Delay- LOS**		Limiting Movement ***	Max v/c Ratio ****	Max Queue		
								Direction	Average Queue (ft)	Max Queue (ft) *****
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	53	D	80	F	NBL/NBT	0.98	NBT	679	992
	PM	124	F	356	F	WBL	1.17	SBT	1296	2147
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	10	A	111	F	SBL	0.43	SBL	83	203
	PM	18	C	300	F	SBL	0.85	SBL	182	377
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	45	E	457	F	SBL	0.33	EBL/T	284	694
	PM	24	C	275	F	SBL	0.53	EBL/T	190	503
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	87	F	2088	F	NBT	0.47	EBT	365	622
	PM	90	F	1569	F	NBL	0.47	EBT	364	635
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	78	E	124	F	NBL	0.97	EBR	773	1534
	PM	177	F	459	F	SBL	1.34	SBT	3053	3665
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	19	B	35	D	NBL	0.65	EBT	198	358
	PM	104	F	349	F	NBL	0.70	WBT	524	721
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	17	B	70	E	NBL	0.82	NBT	144	378
	PM	64	E	224	F	WBL	1.97	WBL	873	889
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	47	D	81	F	NBT	0.91	NBT	413	675
	PM	19	B	118	F	EBL	0.90	EBL/T	201	428

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

****Max v/c Ratio is the highest individual movement or lane group volume to capacity ratio

*****Max Queue refers to the 95% Queue

AM Peak Hour

- Intersection delay is acceptable with LOS D or better at the intersections of Pioneer Trail at Jonathan Square, Hundertmark Road at 212 Medical Center, and the TH 41 at TH 212 Ramps.
- The limiting movement is anticipated to operate with LOS D at the following intersections:
 - Hundertmark Road at 212 Medical Center
- The limiting movement is anticipated to operate with LOS E at the following intersections:
 - TH 41 at TH 212 North Ramp
- The limiting movement is anticipated to operate with LOS F at all intersections analyzed.
- The limiting movement is anticipated to have excessive delay at all of the intersections analyzed except for Hundertmark Road at 212 Medical Center.
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - Hundertmark Road at Bender Road
 - Eastbound through average queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Westbound left maximum queue extends beyond channelized left turn lane.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes.



- TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized right turn lane.

PM Peak Hour

- Intersection delay is acceptable with LOS D or better at the intersections of Pioneer Trail at Jonathan Square, Pioneer Trail at Kwik Trip, and TH 41 at TH 212 South Ramp. All other intersections have excessive delay.
- The limiting movement is anticipated to have excessive delay at all of the intersections analyzed.
- Maximum v/c ratio is greater than one at the following intersections
 - TH 41 at Pioneer Trail
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - Westbound through average queue extends beyond channelized left turn lane.
 - Southbound through average queue extends beyond channelized turn lanes.
 - Hundertmark Road at Bender Road
 - Eastbound through average queue extends beyond channelized turn lanes.
 - TH 41 at Hundertmark Road
 - Southbound through average queue extends beyond channelized turn lanes.
 - Northbound through average queue extends beyond channelized turn lanes.
 - Eastbound through average queue extends beyond channelized turn lanes.
 - Westbound through average queue extends beyond channelized right turn lane.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes.
 - Westbound through average queue extends beyond channelized turn lanes.
 - TH 41 at TH 212 North Ramp
 - Westbound average queues extend beyond channelized turn lanes.
 - TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes.

Mitigation

Alternatives were evaluated throughout the project area to reduce delay and improve service levels. The alternatives were analyzed with both forecasted 2018 and 2038 turning movement counts. The following options were evaluated:

- **Option 1:** Convert TH 41 from a two lane to a four lane roadway. Increase storage of turn lanes. Convert Pioneer Trail at Jonathan Square to a right in right out intersection. Add channelized left turn lanes along Pioneer Trail at Kwik Trip/Lakeview Clinics. Install westbound dual left turn lanes at the intersection of TH 41 at Hundertmark Road.
- **Option 2:** Convert TH 41 from a two lane to a four lane roadway. Increase storage of turn lanes. Convert Pioneer Trail at Jonathan Square and Pioneer Trail at Lakeview Clinics to $\frac{3}{4}$ access intersections. Convert Pioneer Trail at Kwik Trip to a right in right out intersection. Install dual left turn lanes and a channelized right turn lane on all approaches at the intersection of TH 41 at Pioneer Trail. Install northbound, southbound and westbound dual left turn lanes at the intersection of TH 41 at Hundertmark Road.



TH 41 Lane Drop Analysis

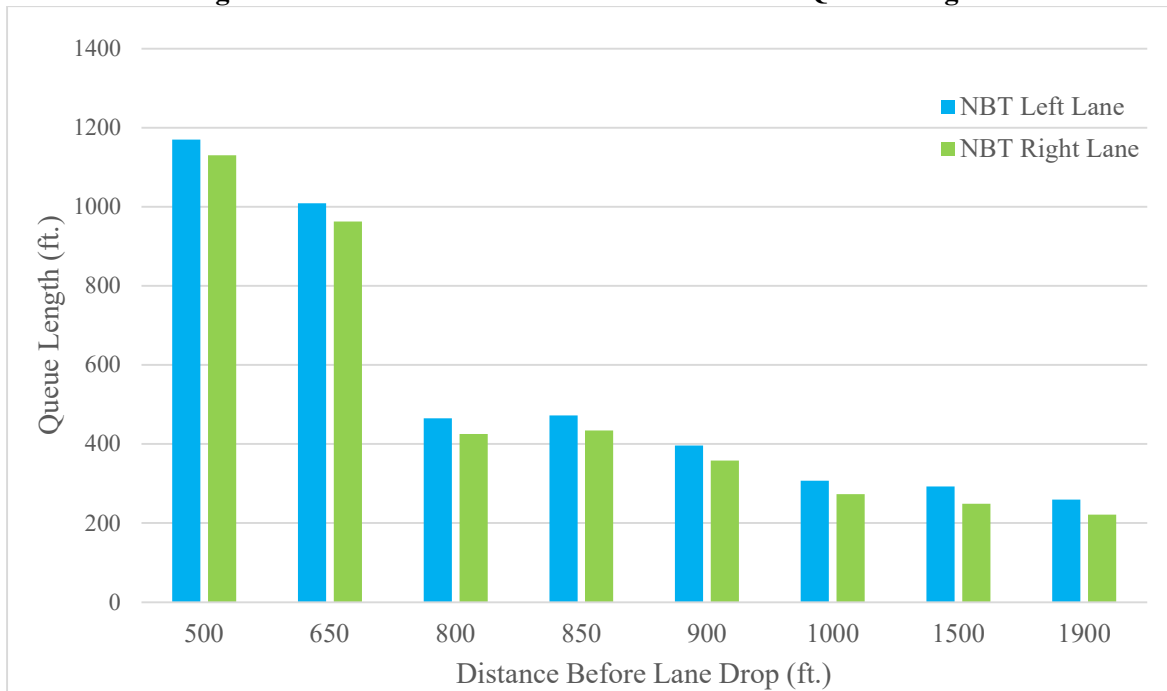
Analysis was completed to determine how far north of Pioneer Trail the four lane roadway should extend for TH 41. Various distances were analyzed in order to determine the length needed to keep LOS acceptable for both northbound through lanes. **Table 4** below shows the delay experienced at the intersection of TH 41 at Pioneer Trail overall and each northbound through lane.

Table 4. TH 41 Lane Drop Distance LOS Comparison

Distance Before Lane Drop	Intersection Delay*- LOS		NBT Delay* (left lane)		NBT Delay* (right lane)	
500	59	E	109	F	225	F
650	53	D	94	F	132	F
800	39	D	59	E	48	D
850	39	D	56	E	50	D
900	37	D	49	D	47	D
1000	34	C	40	D	42	D
1500	33	C	36	D	39	D
1900	27	C	34	C	35	D

Table 4 shows that at 900 feet the LOS for the both through lanes is acceptable with LOS D. Additionally the maximum northbound through queue lengths were analyzed for each of the options. The results are shown in **Figure 1** below, which shows that queues are excessive if the lane drop is 650 feet or less north of Pioneer Trail.

Figure 1. TH 41 at Pioneer Trail NBT Maximum Queue Lengths





Hundertmark Road Lane Drop Analysis

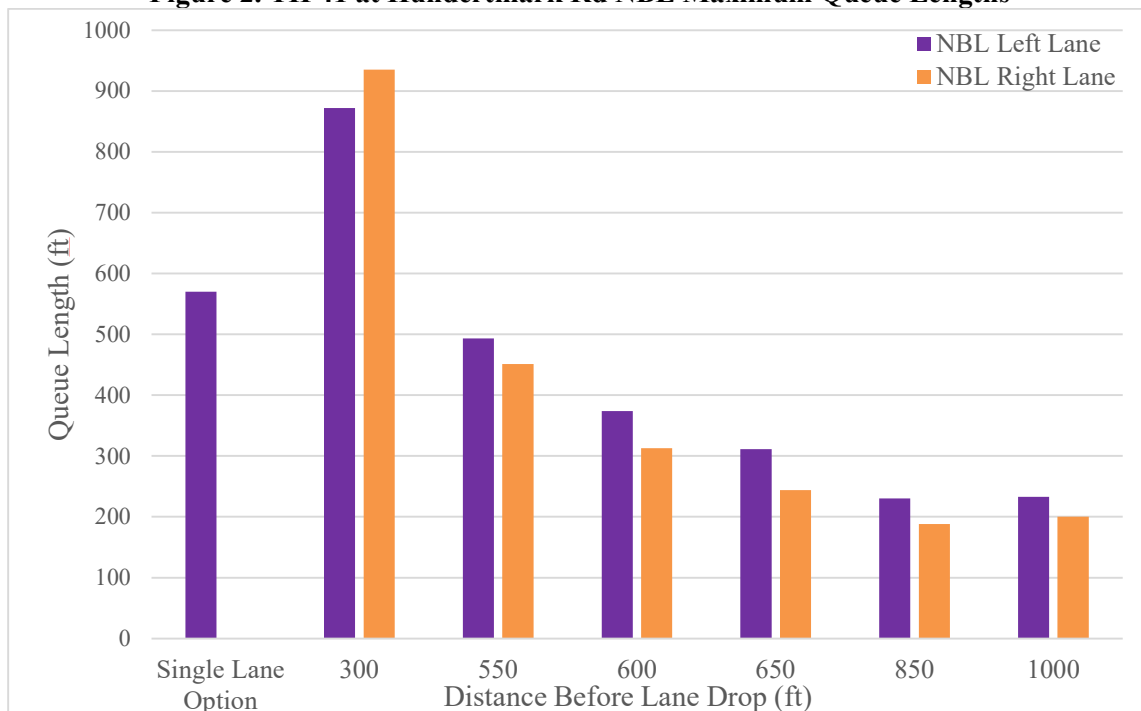
Additionally since Hundertmark Road is a two lane undivided roadway, in order for the dual northbound left at the intersection of TH 41 at Hundertmark Road in Option 2 to work there must be two westbound through lanes along Hundertmark Road west of TH 41. The distance of the additional through lane was analyzed similarly to the TH 41 lane drop. The LOS of each northbound left turn lane was analyzed in comparison to the single northbound left turn lane analyzed in Option 1. The results are found in **Table 5** below.

Table 5. Hundertmark Road Lane Drop Distance LOS Comparison

Distance Before Lane Drop	NBL Delay* (left lane)		NBL Delay* (right lane)	
Single Lane Option	67	E	-	
300	135	F	400	F
550	77	E	86	F
600	59	E	54	D
650	63	E	48	D
850	45	D	36	D
1000	45	D	38	D

The lane drop distance along Hundertmark Road is constrained to a distance of 600 feet due to a box culvert located between Village Road and Bender Road. **Table 5** shows that at a distance of 600 feet both northbound left turn lanes operate with less delay than the single lane option. The maximum northbound left queue lengths were analyzed for each of the options. The results are shown in **Figure 2** below, which shows that at 600 feet the maximum queue length with the dual left is 34% less than with the single left in Option 1.

Figure 2. TH 41 at Hundertmark Rd NBL Maximum Queue Lengths





Once the necessary lane drop distances were determined, Options 1 and 2 were analyzed with the forecasted 2018 and 2038 traffic volumes. **Table 6** below shows the results of the alternatives evaluated with 2018 forecasted traffic volumes and **Table 7** shows the results with 2038 forecasted traffic volumes. **Tables D1-D8 in Appendix D** show the delay and queue lengths for each movement at all of the intersections with the forecasted traffic volumes.

Table 6 – 2018 Alternative Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS	Maximum Delay- LOS**		Limiting Movement ***	Max v/c Ratio ****	Max Queue			
							Direction	Average Queue (ft)	Max Queue (ft) *****	
Option 1										
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	32	C	75	E	NBL	0.75	NBT	160	328
	PM	33	C	72	E	NBL	0.71	WBR	169	288
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	1	A	4	A	SBR	0.17	SBR	13	38
	PM	2	A	8	A	SBR	0.24	SBR	35	64
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	2	A	20	C	NBT	0.40	SBL/T/R	41	75
	PM	7	A	54	F	SBL	1.03	SBL/T/R	106	252
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	3	A	17	C	SBL/NBT	0.41	EBT	19	133
	PM	3	A	20	C	NBL	0.37	NBT	18	44
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	26	C	65	E	SBL	0.70	NBT	173	290
	PM	34	C	70	E	SBL	0.88	WBT	228	424
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	15	B	30	C	NBL	0.47	EBT	129	231
	PM	20	C	38	D	NBL	0.50	EBT	127	228
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	B	73	E	NBL	0.76	SBT	56	160
	PM	27	C	60	E	NBL	0.85	WBR	239	378
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	31	C	50	D	SBL	0.85	EBL	238	373
	PM	20	B	57	E	SBL	0.67	SBT	158	348
Option 2										
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	30	C	69	E	NBL	0.61	NBT	140	287
	PM	33	C	73	E	NBL	0.68	WBT	174	292
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	1	A	5	A	SBR	0.25	SBR	35	57
	PM	3	A	10	B	SBR	0.25	SBR	60	108
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	1	A	7	A	WBL	0.35	WBU/L	32	56
	PM	1	A	8	A	SBR	0.26	WBU/L	28	53
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	3	A	34	D	SBT	0.41	EBT	10	75
	PM	3	A	20	C	NBT	0.23	EBT	5	62
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	28	C	58	E	SBL	0.76	NBT	201	299
	PM	34	C	65	E	SBL	0.75	SBT	246	417
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	15	B	31	C	SBL	0.47	EBT	135	237
	PM	21	C	45	D	NBL	0.50	EBT	136	234
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	A	73	E	NBL	0.76	WBL/R	69	132
	PM	23	C	46	D	WBR	0.94	WBL/R	262	434
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	30	C	48	D	SBL	0.85	EBL	222	339
	PM	20	C	55	E	SBL	0.68	SBT	175	319

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

****Max v/c Ratio is the highest individual movement or lane group volume to capacity ratio

*****Max Queue refers to the 95% Queue



Option 1 (2018 Volumes):

- Traffic operations are acceptable with LOS C or better for all intersections overall during both peak hours.
- The limiting movement is operating with failing LOS during the PM peak hour at the intersection of Pioneer Trail at Kwik Trip. All other intersections are operating with LOS E or better during peak hours.
- Maximum v/c ratio is greater than one during the PM peak hour at the intersection of Pioneer Trail with Kwik Trip.
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Eastbound through maximum queue extends beyond channelized turn lanes during the AM peak hour.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes during the AM peak hour.
 - TH 41 at Hundertmark Road
 - Eastbound through average queue extends beyond channelized turn lanes during both peak hour.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - TH 41 at TH 212 North Ramp
 - Westbound maximum queues extends beyond channelized turn lanes during the PM peak hour.
 - TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes during the AM peak hour.

Option 2 (2018 Volumes):

- Traffic operations are acceptable with LOS C or better for both intersections overall during peak hours.
- The limiting movement is operating with LOS E during the AM peak hours at the following intersections
 - TH 41 at Pioneer Trail
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- The limiting movement is operating with LOS E during the PM peak hours at the following intersections
 - TH 41 at Pioneer Trail
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 South Ramp
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Eastbound through maximum queue extends beyond channelized right turn lane during the AM peak hour.
 - Westbound through maximum queue extends beyond channelized turn lanes during the PM peak hour.
 - TH 41 at Hundertmark Road
 - Eastbound through average queue extends beyond channelized turn lanes during both peak hours.



- Southbound through maximum queue extends beyond channelized turn lanes during the PM peak hour.
- Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
- TH 41 at TH 212 North Ramp
 - Westbound maximum queues extends beyond channelized turn lanes during the PM peak hour.
- TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes during the AM peak hour.



Table 7 – 2038 Alternative Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Maximum Delay- LOS**		Limiting Movement ***	Max v/c Ratio ****	Max Queue		
								Direction	Average Queue (ft)	Max Queue (ft) *****
Option 1										
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	38	D	78	E	NBL	0.82	NBT	238	458
	PM	43	D	67	E	NBT	0.79	NBT	263	428
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	2	A	5	A	SBR	0.34	EBT	32	119
	PM	2	A	9	A	SBR	0.33	SBR	38	67
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	12	B	140	F	SBL	0.75	SBL/T/R	131	317
	PM	15	C	158	F	SBL	2.30	SBL/T/R	235	521
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	7	A	74	F	NBT	0.47	EBT	48	214
	PM	3	A	34	D	NBT	0.47	EBT	18	113
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	34	C	74	E	SBL	0.76	NBR	206	345
	PM	48	D	84	F	SBT	0.91	SBT	404	648
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	17	B	32	C	EBL	0.65	EBT	202	373
	PM	26	C	72	E	NBL	0.71	EBT	193	349
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	11	B	76	E	NBL	0.83	WBR	128	210
	PM	50	D	95	F	SBT	0.94	SBT	620	1233
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	35	D	55	E	EBL	0.91	EBL	271	393
	PM	17	B	46	D	EBL	0.71	NBT	242	363
Option 2										
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	36	D	68	E	NBL	0.71	NBT	226	395
	PM	40	D	62	E	NBL	0.72	WBT	218	383
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	4	A	26	D	SBR	0.34	SBR	56	156
	PM	5	A	24	C	SBR	0.33	SBR	83	188
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	4	A	30	D	WBU	0.46	EBT	18	149
	PM	2	A	13	B	NBR	0.36	NBR	32	66
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	5	A	64	F	SBT	0.47	EBT	53	226
	PM	4	A	39	E	NBT	0.26	WBT	14	121
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	32	C	56	E	SBL	0.84	NBR	201	372
	PM	44	D	74	E	SBT	0.84	SBT	347	558
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	17	B	32	C	WBL	0.65	EBT	206	333
	PM	27	C	73	E	NBL	0.71	EBT	216	376
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	11	B	69	E	NBL	0.82	WBR	125	210
	PM	37	D	61	E	WBR	1.09	WBR	550	887
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	41	D	102	F	EBL	0.98	EBL	356	580
	PM	17	B	59	E	SBL	0.71	NBT	206	326

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

****Max v/c Ratio is the highest individual movement or lane group volume to capacity ratio

*****Max Queue refers to the 95% Queue

Option 1 (2038 Volumes):

- Traffic operations are acceptable with LOS D or better for both intersections overall during peak hours.



- The limiting movement is operating with LOS F during the AM peak hours at the following intersections
 - Pioneer Trail at Kwik Trip
 - Hundertmark Road at Bender Road
- The limiting movement is operating with LOS F during the PM peak hours at the following intersections
 - Pioneer Trail at Kwik Trip
 - TH 41 at Hundertmark Road
 - TH 41 at TH 212 North Ramp
- All other intersections are operating with LOS E or better during peak hours.
- Maximum v/c ratio is greater than one during the PM peak hour at the intersection of Pioneer Trail with Kwik Trip.
- Queue Lengths
 - TH 41 at Pioneer Trail
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - Westbound through maximum queue extends beyond channelized left turn lane during both the PM peak hour.
 - Northbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - TH 41 at Hundertmark Road
 - Eastbound through average queue extends beyond channelized turn lanes during both peak hours.
 - Southbound through average queue extends beyond the channelized turn lanes during the PM peak hour.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - Westbound through maximum queue extends beyond channelized turn lanes during the PM peak hour.
 - TH 41 at TH 212 North Ramp
 - Southbound through maximum queue extends beyond the intersection of TH 41 at Hundertmark Road during the PM peak hour.
 - TH 41 at TH 212 South Ramp
 - Eastbound left maximum queue extends beyond channelized turn lanes during the AM peak hour.

Option 2 (2038 Volumes):

- Traffic operations are acceptable with LOS D or better for both intersections overall during peak hours.
- The limiting movement is operating with failing LOS during the AM peak hour at the intersections of Hundertmark Road at Bender Road and TH 41 at the TH 212 South Ramp. All other intersections are operating with LOS E or better during peak hours.
- Maximum v/c ratio is greater than one during the PM peak hour at the intersection of TH 41 at the TH 212 North Ramp



- Queue Lengths
 - TH 41 at Pioneer Trail
 - Eastbound through maximum queue extends beyond channelized turn lanes during both peak hours.
 - Northbound through maximum queue extends beyond channelized left turn lane during the AM peak hour.
 - Hundertmark Road at Bender Road
 - Eastbound through maximum queue extends beyond channelized turn lanes during the AM peak hour.
 - Westbound through maximum queue extends beyond channelized turn lanes during the PM peak hour.
 - TH 41 at Hundertmark Road
 - Eastbound through average queue extends beyond channelized turn lanes during both peak hours.
 - Southbound through maximum queue extends beyond the channelized turn lanes during the PM peak hour.
 - Hundertmark Road at 212 Medical Center
 - Eastbound through average queue extends beyond channelized turn lanes during both peak hours.
 - TH 41 at TH 212 North Ramp
 - Westbound maximum queue extends beyond channelized turn lanes during the PM peak hour.
 - TH 41 at TH 212 South Ramp
 - Eastbound left average queue extends beyond channelized turn lanes during the AM peak hour.

TH 41 Corridor Average Speed

The average speed along TH 41 between the TH 212 North Ramp and Hazeltine Boulevard was analyzed to determine how the existing travel speeds compare to the 2038 no build, 2038 Option 1 and 2038 Option 2 alternatives. **Figure 3** shows the average speed during both peak hours for vehicles traveling northbound and southbound.



Figure 3. TH 41 Average Speed (mph)

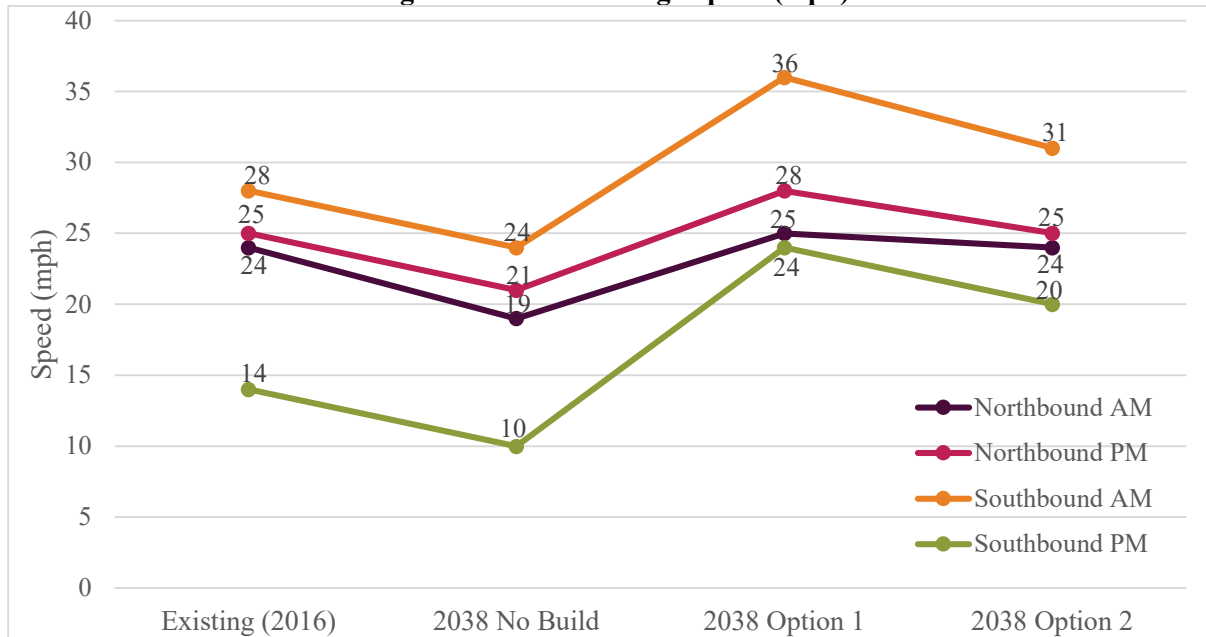


Figure 3 shows that the average speed is the lowest for southbound traveling vehicles during the PM peak hour. For southbound traveling vehicles in the PM peak hour Option 1 is able to improve the average speed from 14 MPH to 24 MPH and Option 2 is able to improve the average speed to 20 MPH. Overall Option 1 is able to best improve the average speeds in both directions during peak hours. This is because Option 1 gives more time to TH 41 at the intersection of TH 41 at Hundertmark Road. Option 2 keeps the average speed the same as it is in 2016 under existing conditions for northbound traveling vehicles in both peak hours, but speeds are improved for southbound traveling vehicles.

Network Delay

The total network delay throughout the project area was compared between 2038 No Build and 2038 Options 1 and 2. The results are shown below in **Figure 4**.

Figure 4. Total Network Delay (hours) Comparison

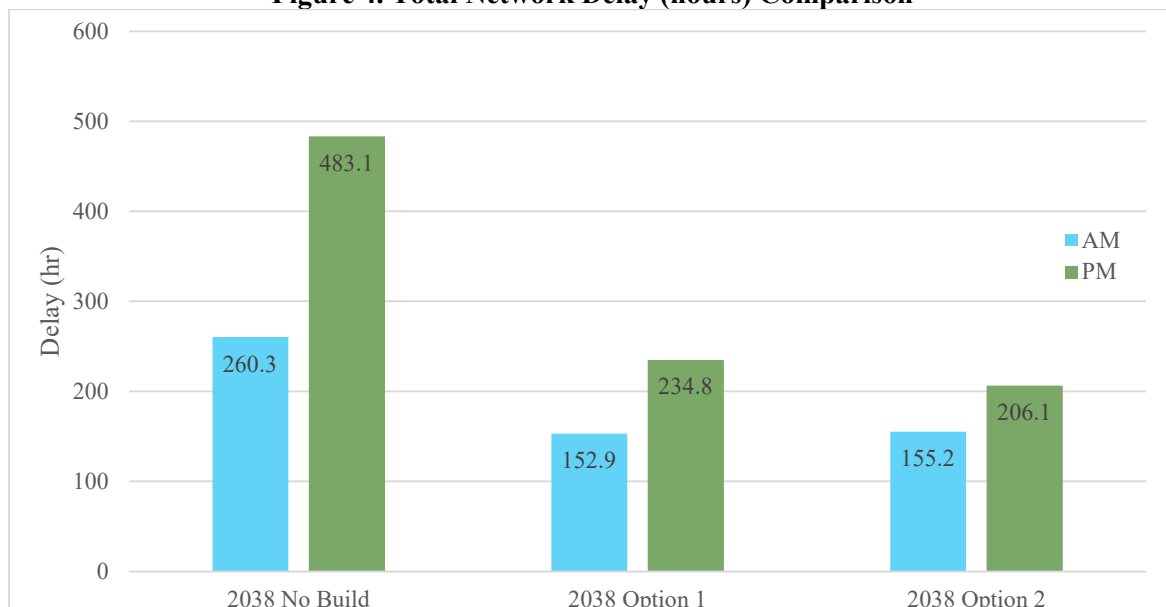




Figure 4 shows that if no changes are made the total network delay is anticipated to be over 260 hours in the AM peak hour and over 483 hours in the PM peak hour. With either Option 1 or 2 the overall network delay is over 100 hours less than the No Build alternative during the AM peak hour. During the PM peak hour the total network delay is over 50% less for Option 1 or Option 2 than the No Build alternative. Comparing Option 1 and 2, during the AM peak hour Option 1 operates better as it has 2.3 hours less day than Option 2. However, during the PM peak hour Option 2 operates better than Option 1 with 28.7 hours less total network delay.

Safety Analysis

A crash review was using the Minnesota Crash Mapping Analysis Tool (MnCMAT) for the previous five years (2010-2014). MnDOT uses a comparison of the crash rate and the critical rate when determining whether or not there is a safety issue at an intersection. The crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside of the expected, normal range. The critical index reports the magnitude of this difference and a critical index of less than one shows that the intersection is operating within the normal range. The critical index for the intersection of TH 41 at Pioneer Trail was found to be 1.32 and for the intersection of TH 41 at Hundertmark Road the critical index was found to be 1.38. Since the critical rate is greater than one for both intersection this shows that the intersections are experiencing a higher than usual number of crashes compared to similar intersections statewide. **Table 8** below summarizes the crashes reported at the intersection of TH 41 at Pioneer Trail from 2010 to 2014.

Table 8. Crash Type and Severity at TH 41 and Pioneer Trail

Crash Type	Crash Severity
Rear End	19-Property Damage, 6-Possible Injury, 1-Non-Incapacitating Injury
Right Angle	5-Property Damage, 3-Possible Injury, 1-Non-Incapacitating Injury
Ran Off Road	3-Property Damage
Left Turn	1-Property Damage, 2-Possible Injury, 1-Non-Incapacitating Injury
Sideswipe	1-Property Damage
Pedestrian	2-Possible Injury

Table 8 shows that rear end crashes are the most common type of crash at this intersection. Over the five year period analyzed there were a total of 45 crashes. More than half of the crashes were rear end crashes with most resulting in property damage only and some injury crashes. The rear end crashes were mostly from northbound, southbound and westbound traveling vehicles. The large number of rear end crashes for northbound and southbound traveling vehicles may be caused from the excessive queuing experienced during peak hours along TH 41.

Right angle crashes were the next most common type of crash experienced at TH 41 and Pioneer Trail with nine of the crashes being right angle crashes. There were two possible injury crashes involving pedestrians on bicycles.



Table 9 summarizes the crashes reported at the intersection of TH 41 at Hundertmark Road from 2010 to 2014.

Table 9. Crash Type and Severity at TH 41 and Hundertmark Road

Crash Type	Crash Severity
Rear End	27-Property Damage, 13-Possible Injury, 1-Non-Incapacitating Injury
Right Angle	2-Possible Injury, 1-Property Damage
Ran Off Road	1-Possible Injury
Left Turn	1-Property Damage, 2-Possible Injury, 1-Non-Incapacitating Injury
Sideswipe	3-Property Damage

Table 9 shows that rear end crashes are the most common type of crash at this intersection. Over the five year period analyzed there were a total of 52 crashes. 41 of the 52 total crashes were rear end crashes with 27 resulting in property damage only and 14 were injury crashes. Over half of the rear end crashes were from southbound traveling vehicles which could be due to the excessive queuing experienced during peak hours along TH 41. Three of the possible injury crashes involved pedestrians. One of the rear end crashes involved a pedestrian crossing against the traffic signal and two of the left turning crashes involved a pedestrians crossing against the traffic signal.

At the intersection of Hundertmark Road and Bender Road there were four crashes reported in the previous five years. All four crashes were property damage only crashes with two being eastbound rear end crashes. The critical crash rate was found to be 0.41 showing that this intersection is operating within the normal range.

There were no crashes reported using MnCMAT in the previous five years at the intersections of Pioneer Trail with the Kwik Trip access, Jonathan Square access or the intersection of Hundertmark Road with Two Twelve Medical Center. The intersection crash rate worksheets are included in **Appendix E**.

MnCMAT has crash data for 2015 from January 1st to June 1st. In 2015 there were four crashes reported at the intersection of TH 41 and Hundertmark. All of the crashes were property damage only rear end crashes along TH 41. At the intersection of TH 41 and Pioneer Trail there was one property damage rear end crash from a northbound traveling vehicle.

Roundabout Analysis

Multi-lane roundabouts were also analyzed at the intersections of TH 41 at Hundertmark Road and Pioneer Trail as the crash analysis indicates safety concerns at both intersections. 2038 peak hour volumes were analyzed with two approach lanes from each direction. The forecasted turning movement volumes were used to determine the lane configuration for each approach that optimizes operations. At the intersection of TH 41 at Hundertmark Road shared thru-left and thru-right turning lanes were analyzed on the northbound and southbound approaches. Due to the high number of anticipated westbound left turning vehicles, a designated left turn lane and shared thru-right turn lane was analyzed for the westbound approach. On the eastbound approach a shared thru-left and designated right turning lanes were analyzed due to the large amount of eastbound right turning vehicles. At the intersection of TH 41 at Pioneer Trail



shared thru-left and thru-right turning lanes were analyzed on each approach. **Table 10** below shows the operational analysis of multi-lane roundabouts at each intersection.

Table 10. 2038 Roundabout Traffic Operations Analysis

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Maximum Delay- LOS**		Limiting Movement ***
TH 41 at Pioneer Trail Roundabout	AM	34	D	72	F	NBT/R
	PM	33	D	46	E	SBT/R
TH 41 at Hundertmark Rd Roundabout	AM	67	F	148	F	NBT/R
	PM	97	F	141	F	NBT/R

*Delay in seconds per vehicle

**Maximum delay and LOS on any approach and/or movement

***Limiting Movement is the highest delay movement.

As can be seen with the anticipated 2038 traffic volumes the intersection of TH 41 at Pioneer Trail operations are acceptable with LOS D during both peak hours. The limiting movement operates with LOS F in the AM peak hour and LOS E during the PM peak hour. Delay was compared along TH 41 at Pioneer Trail with a roundabout or signalized intersection. During the AM peak hour with a roundabout the northbound through movement has 28 seconds more delay than with a signal. The northbound right turning movement has 55 seconds more delay with a roundabout. During the PM peak hour the southbound through movement has six seconds less delay with a roundabout than with a signal. The southbound right turning movement has 31 seconds more delay with a roundabout than with a signal. This shows that although operations are acceptable at the intersection overall with a roundabout at TH 41 and Pioneer Trail, the delay is greater for most key peak hour movements along TH 41.

A roundabout is not anticipated to function acceptably at the intersection of TH 41 at Hundertmark Road with 2038 traffic volumes. The intersection overall and limiting movement has failing LOS during both peak hours. **Tables D9 and D10 in Appendix D** show the delay and queue lengths for each movement at both intersections with the 2038 forecasted traffic volumes.



Appendix A – Turning Movement Counts



Appendix B – Existing Traffic Operations

Table B1. 2016 Traffic Operational Analysis - Existing Conditions

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	39	D	50	D	37	D	8	A	52	D	44	D	37	D	70	E	52	D	20	B	48	D	15	B	2	A
	PM	43	D	57	E	42	D	16	B	47	D	44	D	41	D	65	E	51	D	15	B	48	D	41	D	12	B
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	2	A	5	A	1	A	-	-	-	-	2	A	2	A	-	-	-	-	15	C	-	-	4	A		
	PM	3	A	7	A	1	A	-	-	-	-	2	A	2	A	-	-	-	-	22	C	-	-	7	A		
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	2	A	3	A	2	A	0	A	5	A	0	A	0	A	12	B	7	A	14	B	14	B	5	A	2	A
	PM	2	A	7	A	2	A	0	A	2	A	0	A	0	A	12	B	24	C	5	A	16	C	14	B	8	A
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	7	A	1	A	6	A	3	A	7	A	2	A	1	A	44	E	51	F	36	E	36	E	21	C	23	C
	PM	3	A	4	A	2	A	1	A	5	A	3	A	2	A	18	C	15	C	7	A	15	C	14	B	10	A
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	40	D	44	D	46	D	24	C	59	E	40	D	2	A	53	D	38	D	11	B	70	E	65	E	14	B
	PM	90	F	62	E	70	E	16	B	88	F	107	F	4	A	82	F	25	C	5	A	238	F	205	F	170	F
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	14	B	27	C	14	B	5	A	26	C	17	B	7	A	28	C	23	C	5	A	30	C	13	B	4	A
	PM	19	B	34	C	15	B	5	A	33	C	20	C	14	B	31	C	21	C	7	A	33	C	22	C	7	A
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	A	-	-	-	-	-	-	52	D	-	-	15	B	73	E	5	A	-	-	-	-	7	A	6	A
	PM	59	E	-	-	-	-	-	-	234	F	-	-	98	F	82	F	6	A	-	-	-	-	10	A	7	A
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	28	C	38	D	-	-	5	A	-	-	-	-	-	-	-	-	39	D	14	B	40	D	10	A	-	-
	PM	14	B	66	E	-	-	8	A	-	-	-	-	-	-	-	-	11	B	4	A	41	D	7	A	-	-

*Delay in seconds per vehicle

Table B2. 2016 Peak Hour Queues by Movement - Existing Conditions

Traffic Control Scenario	Peak Hour	Queue Lengths																									
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR			
		Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	149	249	145	232	50	113	38	95	74	157	74	157	129	393	437	777	69	315	29	65	79	158	8	29	-	-
	PM	113	202	102	174	44	88	174	297	174	297	174	297	140	314	264	499	51	223	64	232	330	526	53	109	-	-
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	17	69	17	69	-	-	-	-	0	0	0	3	-	-	-	-	-	-	33	63	-	-	13	37	-	-
	PM	22	69	22	69	-	-	-	-	0	3	2	13	-	-	-	-	-	-	43	80	-	-	31	58	-	-
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	21	91	21	91	2	25	10	38	10	38	0	3	-	-	2	13	-	-	-	-	20	44	-	-	-	-
	PM	21	68	21	68	0	0	4	25	4	25	0	0	-	-	22	48	-	-	-	-	29	57	-	-	-	-
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	0	4	50	217	0	0	7	29	0	0	0	0	-	-	32	89	-	-	-	-	26	64	-	-	-	-
	PM	1	7	5	53	0	0	12	41	0	0	0	0	-	-	19	45	-	-	-	-	14	37	-	-	-	-
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	86	174	205	349	161	272	120	204	53	115	1	13	123	308	333	603	101	310	53	190	346	576	51	230	-	-
	PM	61	130	130	239	97	195	246	425	248	453	30	194	311	477	310	647	63	245	71	265	1499	2557	230	579	-	-
Hundertmark Rd at 212 Medical Center <i>Side-Street Stop Controlled</i>	AM	50	96	121	216	48	106	14	44	50	97	34	82	11	34	3	14	3	14	21	52	4	21	25	53	-	-
	PM	62	113	116	208	23	52	12	39	83	153	83	153	47	90	17	44	17	44	24	56	10	42	30	61	-	-
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	-	-	-	-	-	-	66	122	66	122	74	138	10	30	42	88	-	-	-	-	43	86	5	17	-	-
	PM	-	-	-	-	-	-	774	1011	774	1011	738	1048	84	153	27	66	-	-	-	-	72	128	45	92	-	-
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	210	330	-	-	30	96	-	-	-	-	-	-	-	-	217	311	94	184	178	259	60	116	-	-	-	-
	PM	115	204	-	-	24	51	-	-	-	-	-	-	-	-	123	211	24	62	53	98	90	129	-	-	-	-

*Max Queue refers to the 95% Queue



Appendix C – Forecasted 2018 and 2038 Traffic Operations with Existing Geometry

Table C1. 2018 Traffic Operational Analysis - Existing Geometry

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	44	D	50	D	38	D	9	A	53	D	45	D	32	C	68	E	62	E	26	C	49	D	23	C	4	A
	PM	46	D	57	E	43	D	17	B	56	E	44	D	39	D	65	E	52	D	17	B	54	D	55	E	14	B
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	3	A	5	A	2	A	-	-	-	-	2	A	2	A	-	-	-	-	23	C	-	-	4	A		
	PM	4	A	7	A	1	A	-	-	-	-	2	A	2	A	-	-	-	-	30	D	-	-	9	A		
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	7	A	8	A	5	A	0	A	5	A	0	A	0	A	24	C	8	A	0	A	75	F	32	D	33	D
	PM	2	A	7	A	2	A	0	A	2	A	0	A	0	A	11	B	25	D	6	A	19	C	9	A	9	A
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	7	A	2	A	6	A	2	A	8	A	2	A	2	A	24	C	24	C	31	D	32	D	223	F	10	B
	PM	5	A	8	A	5	A	0	A	6	A	3	A	2	A	36	E	24	C	46	E	35	E	22	C	10	A
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	42	D	44	D	46	D	19	B	53	D	38	D	2	A	57	E	43	D	14	B	70	E	70	E	16	B
	PM	130	F	68	E	87	F	20	B	103	F	105	F	6	A	97	F	36	D	6	A	352	F	341	F	314	F
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	15	B	29	C	15	B	5	A	29	C	17	B	7	A	27	C	19	B	7	A	30	C	18	B	4	A
	PM	24	C	35	D	14	B	4	A	33	C	26	C	15	B	54	D	24	C	12	B	34	C	23	C	9	A
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	10	A	-	-	-	-	-	-	51	D	-	-	15	B	67	E	5	A	-	-	-	-	6	A	3	A
	PM	59	E	-	-	-	-	-	-	215	F	-	-	121	F	81	F	7	A	-	-	-	-	10	B	7	A
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	31	C	40	D	-	-	6	A	-	-	-	-	-	-	-	-	38	D	16	B	47	D	15	B	-	-
	PM	14	B	63	E	-	-	8	A	-	-	-	-	-	-	-	-	13	B	4	A	43	D	6	A	-	-

*Delay in seconds per vehicle

Table C2. 2018 Peak Hour Queues by Movement - Existing Geometry

Traffic Control Scenario	Peak Hour	Queue Lengths																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	173	271	148	231	56	113	46	107	72	157	72	157	178	484	520	841	123	440	31	70	135	250	14	37
	PM	127	220	103	179	53	106	122	232	184	303	184	303	140	304	282	483	45	183	91	326	386	742	89	318
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	25	88	25	88	-	-	-	-	0	0	1	8	-	-	-	-	-	-	36	71	-	-	13	37
	PM	29	83	29	83	-	-	-	-	0	3	0	5	-	-	-	-	-	-	58	120	-	-	36	77
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	52	240	52	240	21	175	9	35	9	35	0	5	-	-	2	14	-	-	-	39	152	-	-	
	PM	25	73	25	73	0	0	4	20	4	20	0	5	-	-	24	52	-	-	-	31	61	-	-	
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	0	1	43	230	0	3	7	29	0	0	0	0	-	-	29	67	-	-	-	27	69	-	-	
	PM	2	16	25	133	0	0	11	36	0	0	0	0	-	-	27	73	-	-	-	16	40	-	-	
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	101	202	180	320	148	262	107	190	50	96	1	10	175	421	426	627	124	272	58	218	399	630	68	284
	PM	80	175	149	294	109	223	290	508	270	506	56	281	324	531	422	925	142	604	70	255	2460	3448	234	586
Hundertmark Rd at 212 Medical Center <i>Side-Street Stop Controlled</i>	AM	50	104	125	237	39	89	18	46	46	90	36	70	10	32	4	17	4	17	19	46	4	20	24	50
	PM	58	101	115	200	24	52	14	44	98	186	92	175	75	183	22	81	22	81	23	55	12	48	33	63
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	-	-	-	-	-	-	73	139	73	139	71	131	8	26	3	48	-	-	-	39	86	5	16	
	PM	-	-	-	-	-	-	801	1090	801	1090	799	1098	93	167	43	91	-	-	-	90	139	46	95	
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	236	372	-	-	29	53	-	-	-	-	-	-	-	-	216	314	114	213	197	275	102	170	-	-
	PM	122	199	-	-	24	50	-	-	-	-	-	-	-	-	157	268	32	80	51	92	61	93	-	-

*Max Queue refers to the 95% Queue

Table C3. 2038 Traffic Operational Analysis - Existing Geometry

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	53	D	71	E	40	D	12	B	57	E	49	D	48	D	80	F	80	F	35	D	54	D	24	C	5	A
	PM	124	F	132	F	57	E	33	C	356	F	78	E	77	E	158	F	85	F	32	C	155	F	208	F	104	F
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	10	A	14	B	7	A	-		-		2	A	2	A	-		-		-		111	F	-		15	C
	PM	18	C	24	C	9	A	-		-		3	A	2	A	-		-		-		300	F	-		73	F
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	45	E	56	F	28	D	3	A	12	B	1	A	0	A	30	D	39	E	51	F	457	F	244	F	358	F
	PM	24	C	64	F	32	D	2	A	5	A	1	A	0	A	77	F	230	F	111	F	275	F	28	D	172	F
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	87	F	41	E	47	E	24	C	8	A	2	A	2	A	845	F	2088	F	952	F	1057	F	1972	F	873	F
	PM	90	F	69	F	122	F	77	F	5	A	3	A	2	A	1569	F	0	A	1225	F	1388	F	908	F	980	F
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	78	E	67	E	77	E	43	D	121	F	43	D	3	A	124	F	102	F	34	C	90	F	88	F	25	C
	PM	177	F	112	F	203	F	52	D	194	F	153	F	14	B	145	F	53	D	14	B	459	F	427	F	395	F
Hundertmark Rd at 212 Medical Center <i>Signalized Intersection</i>	AM	19	B	33	C	20	C	7	A	32	C	20	C	5	A	35	D	14	B	6	A	31	C	18	B	5	A
	PM	104	F	45	D	22	C	6	A	82	F	168	F	156	F	349	F	66	E	63	E	36	D	30	C	45	D
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	17	B	-		-		-		43	D	-		31	C	70	E	18	B	-		-		7	A	3	A
	PM	64	E	-		-		-		224	F	-		178	F	72	E	12	B	-		-		7	A	6	A
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	47	D	54	D	-		7	A	-		-		-		-		81	F	38	D	48	D	11	B	-	
	PM	19	B	118	F	-		9	A	-		-		-		-		14	B	5	A	52	D	8	A	-	

*Delay in seconds per vehicle

Table C4. 2038 Peak Hour Queues by Movement - Existing Geometry

Traffic Control Scenario	Peak Hour	Queue Lengths																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	237	274	148	249	95	203	57	133	100	195	100	195	317	629	679	992	180	535	36	75	149	257	20	47
	PM	217	294	123	217	77	140	270	396	469	786	378	659	304	535	480	995	120	403	334	700	1296	2147	517	958
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	83	137	83	137	-	-	-	-	2	25	0	3	-	-	-	-	-	-	83	203	-	-	32	99
	PM	74	136	74	136	-	-	-	-	1	17	3	17	-	-	-	-	-	-	182	377	-	-	48	138
Pioneer Trail at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	284	694	284	694	219	651	20	63	20	63	5	34	-	-	5	23	-	-	-	-	256	505	-	-
	PM	190	503	190	503	111	414	7	36	7	36	0	3	-	-	66	162	-	-	-	-	124	360	-	-
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	3	41	365	622	10	84	5	24	0	0	0	0	-	-	213	380	-	-	-	-	248	486	-	-
	PM	3	42	364	635	26	143	5	26	0	0	0	0	-	-	160	342	-	-	-	-	186	428	-	-
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	140	264	298	347	218	256	261	460	90	199	1	11	374	662	1003	1467	773	1534	94	291	556	774	134	450
	PM	134	272	291	359	196	296	469	547	429	598	121	432	425	593	704	1325	376	1100	108	322	3053	3665	217	565
Hundertmark Rd at 212 Medical Center <i>Side-Street Stop Controlled</i>	AM	54	133	198	358	76	217	20	53	75	144	47	102	16	48	3	14	3	14	23	54	5	25	29	51
	PM	70	155	190	330	39	139	41	179	524	721	282	362	246	365	52	173	52	173	23	58	33	115	57	105
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	-	-	-	-	-	-	43	143	-	-	-	132	243	14	43	144	378	-	-	-	49	99	5	18
	PM	-	-	-	-	-	-	873	889	-	-	-	873	888	120	223	81	223	-	-	-	53	106	24	54
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	283	468	-	-	31	62	-	-	-	-	-	-	-	-	413	675	354	674	214	321	73	136	-	-
	PM	201	428	-	-	31	65	-	-	-	-	-	-	-	-	220	347	57	117	51	92	113	182	-	-

*Max Queue refers to the 95% Queue



Appendix D – Forecasted 2018 and 2038 Traffic Operations with Alternative Options

Table D1. 2018 Traffic Operational Analysis - Option 1

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																								
				EBL		EBT		EBR		WBU		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR
TH 41 at Pioneer Trail Signalized Intersection	AM	32	C	43	D	35	D	6	A	-	52	D	43	D	31	C	75	E	32	C	12	B	47	D	17	B	3	A
	PM	33	C	50	D	41	D	8	A	-	43	D	42	D	42	D	72	E	25	C	9	A	45	D	24	C	9	A
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	1	A	-	-	1	A	-	-	-	-	2	A	2	A	-	-	-	-	-	-	-	-	-	-	-	4	A
	PM	2	A	-	-	1	A	-	-	-	-	2	A	2	A	-	-	-	-	-	-	-	-	-	-	-	8	A
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	2	A	2	A	1	A	1	A	-	5	A	0	A	0	A	16	C	20	C	5	A	18	C	12	B	9	A
	PM	7	A	8	A	1	A	0	A	-	2	A	0	A	0	A	14	B	11	B	5	A	54	F	46	E	32	D
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	3	A	1	A	3	A	1	A	-	10	B	2	A	1	A	14	B	17	C	14	B	17	C	7	A	7	A
	PM	3	A	8	A	1	A	0	A	-	5	A	2	A	2	A	20	C	19	C	6	A	17	C	9	A	9	A
TH 41 at Hundertmark Rd Signalized Intersection	AM	26	C	39	D	34	C	13	B	-	54	D	43	D	8	A	53	D	24	C	12	B	65	E	21	C	6	A
	PM	34	C	59	E	52	D	17	B	-	55	E	62	E	41	D	52	D	20	C	9	A	70	E	30	C	18	B
Hundertmark Rd at 212 Medical Center Signalized Intersection	AM	15	B	28	C	15	B	6	A	-	29	C	17	B	6	A	30	C	12	B	7	A	26	C	19	B	4	A
	PM	20	C	36	D	15	B	5	A	-	35	D	20	B	14	B	38	D	20	C	8	A	32	C	23	C	6	A
TH 41 at TH 212 North Ramp Signalized Intersection	AM	10	B	-	-	-	-	-	-	-	50	D	-	-	19	B	73	E	4	A	-	-	-	-	7	A	3	A
	PM	27	C	-	-	-	-	-	-	-	33	C	-	-	24	C	60	E	24	C	-	-	-	-	31	C	12	B
TH 41 at TH 212 South Ramp Signalized Intersection	AM	31	C	41	D	-	-	5	A	-	-	-	-	-	-	-	-	-	35	D	14	B	50	D	17	B	-	-
	PM	20	B	41	D	-	-	11	B	-	-	-	-	-	-	-	-	-	22	C	5	A	57	E	14	B	-	-

*Delay in seconds per vehicle

Table D2. 2018 Peak Hour Queues by Movement - Option 1

Traffic Control Scenario	Peak Hour	Queue Lengths																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*
TH 41 at Pioneer Trail Signalized Intersection	AM	167	275	147	240	51	115	38	88	78	172	78	172	61	111	160	328	8	25	35	73	67	126	11	33
	PM	114	185	96	159	38	67	116	224	139	256	169	288	122	211	93	183	16	46	45	87	125	207	50	101
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	-	-	4	28	-	-	-	-	0	0	0	0	-	-	-	-	-	-	-	-	-	-	13	38
	PM	-	-	0	0	-	-	-	-	0	0	0	0	-	-	-	-	-	-	-	-	-	-	35	64
Pioneer Rd at Kwik Trip Side-Street Stop Controlled	AM	11	33	0	3	0	3	9	34	0	6	0	0	-	3	19	-	-	-	-	41	75	-	-	-
	PM	23	53	1	14	0	0	3	16	0	6	0	4	-	25	52	-	-	-	-	106	252	-	-	-
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	0	0	19	133	2	32	8	33	1	16	0	0	-	27	61	-	-	-	-	19	44	-	-	-
	PM	2	16	4	43	0	0	9	31	0	0	0	0	-	18	44	-	-	-	-	14	37	-	-	-
TH 41 at Hundertmark Rd Signalized Intersection	AM	87	177	139	253	115	230	70	137	58	127	10	53	129	212	173	290	83	178	31	72	93	176	11	34
	PM	66	128	109	217	78	168	117	216	228	424	38	101	257	406	152	138	67	126	32	72	161	262	24	61
Hundertmark Rd at 212 Medical Center Side-Street Stop Controlled	AM	52	117	129	231	46	114	18	45	43	88	41	83	13	39	3	15	3	15	15	40	5	23	23	49
	PM	56	117	127	228	30	91	13	41	62	119	94	162	84	158	21	72	21	72	18	47	11	43	27	58
TH 41 at TH 212 North Ramp Signalized Intersection	AM	-	-	-	-	-	-	70	138	-	-	83	160	9	30	0	0	-	-	-	-	56	106	6	21
	PM	-	-	-	-	-	-	207	334	-	-	239	378	88	159	166	248	-	-	-	-	197	357	71	194
TH 41 at TH 212 South Ramp Signalized Intersection	AM	238	373	-	-	28	58	-	-	-	-	-	-	-	213	301	118	226	188	271	120	189	-	-	-
	PM	95	171	-	-	29	64	-	-	-	-	-	-	-	201	319	36	83	75	125	158	348	-	-	-

*Max Queue refers to the 95% Queue

Table D3. 2018 Traffic Operational Analysis - Option 2

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																											
				EBU		EBL		EBT		EBR		WBU		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail Signalized Intersection	AM	30	C	-		48	D	35	D	6	A	-		52	D	42	D	9	A	69	E	27	C	12	B	53	D	17	B	4	A
	PM	33	C	-		55	E	42	D	9	A	-		46	D	44	D	10	B	73	E	27	C	11	B	45	D	20	B	8	A
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	1	A	2	A	3	A	1	A	-		-		-		2	A	1	A	-		-		-		-		-		5	A
	PM	3	A	5	A	8	A	1	A	-		-		-		3	A	2	A	-		-		-		-		-		10	B
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	1	A	-		-		1	A	0	A	6	A	7	A	0	A	0	A	-		-		6	A	-		-		4	A
	PM	1	A	-		-		1	A	0	A	3	A	4	A	1	A	0	A	-		-		6	A	-		-		8	A
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	3	A	-		6	A	2	A	0	A	-		8	A	2	A	1	A	18	C	23	C	12	B	18	C	34	D	5	A
	PM	3	A	-		10	B	1	A	0	A	-		6	A	4	A	1	A	13	B	20	C	6	A	17	C	7	A	5	A
TH 41 at Hundertmark Rd Signalized Intersection	AM	28	C	-		41	D	35	D	13	B	-		51	D	42	D	9	A	53	D	28	C	16	B	58	E	28	C	6	A
	PM	34	C	-		51	D	49	D	16	B	-		53	D	47	D	25	C	51	D	21	C	9	A	65	E	42	D	13	B
Hundertmark Rd at 212 Medical Center Signalized Intersection	AM	15	B	-		28	C	15	B	6	A	-		31	C	16	B	8	A	26	C	20	B	7	A	31	C	21	C	4	A
	PM	21	C	-		36	D	16	B	5	A	-		36	D	20	B	14	B	45	D	23	C	7	A	34	C	22	C	5	A
TH 41 at TH 212 North Ramp Signalized Intersection	AM	10	A	-		-		-		-		-		49	D	-		18	B	73	E	4	A	-		-		6	A	3	A
	PM	23	C	-		-		-		-		-		37	D	-		27	C	46	D	14	B	-		-		23	C	12	B
TH 41 at TH 212 South Ramp Signalized Intersection	AM	30	C	-		38	D	-		5	A	-		-		-		-		-		36	D	16	B	48	D	16	B	-	
	PM	20	C	-		41	D	-		9	A	-		-		-		-		-		22	C	5	A	55	E	15	B	-	

*Delay in seconds per vehicle

Table D4. 2018 Peak Hour Queues by Movement - Option 2

Traffic Control Scenario	Peak Hour	Queue Lengths																											
		EBU		EBL		EBT		EBR		WBU		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *
TH 41 at Pioneer Trail Signalized Intersection	AM	-		99	164	142	231	52	112	-		27	62	63	134	15	37	65	113	140	287	17	48	27	65	53	104	8	23
	PM	-		63	113	96	167	38	74	-		72	126	174	292	16	84	135	210	105	215	29	70	39	82	107	186	36	79
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	4	19	4	19	1	12	-		-		-	0	0	0	0	-		-		-		-		-		-	35	57
	PM	28	58	28	58	5	40	-		-		-	0	0	3	8	-		-		-		-		-		-	60	108
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	-		-		0	0	0	0	32	56	32	56	1	21	0	0	-		-		3	17	-		-		13	33
	PM	-		-		0	4	0	0	28	53	28	53	2	19	0	0	-		-		25	53	-		-		22	43
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	-		1	8	10	75	0	0	-		8	30	2	44	0	0	-		23	53	-		-		23	48	-	
	PM	-		1	9	5	62	0	0	-		11	39	0	0	0	0	-		19	45	-		-		13	35	-	
TH 41 at Hundertmark Rd Signalized Intersection	AM	-		93	188	156	273	127	239	-		70	127	56	126	7	45	86	147	201	299	130	226	28	71	125	230	16	42
	PM	-		68	149	106	209	80	169	-		106	189	182	342	26	85	171	260	153	237	74	136	31	83	246	417	46	187
Hundertmark Rd at 212 Medical Center Signalized Intersection	AM	-		46	88	135	237	44	102	-		18	49	43	87	43	87	14	40	3	14	3	14	16	42	6	25	25	52
	PM	-		56	102	136	234	28	88	-		14	44	91	164	91	161	92	174	24	83	24	83	18	49	10	41	30	57
TH 41 at TH 212 North Ramp Signalized Intersection	AM	-		-		-		-		-		69	132	-		69	132	11	36	0	2	-		-		42	86	4	16
	PM	-		-		-		-		-		210	346	-		262	434	73	139	84	154	-		-		136	250	63	150
TH 41 at TH 212 South Ramp Signalized Intersection	AM	-		222	339	222	339	28	55	-		-		-		-		-		209	302	133	245	182	263	106	167	-	
	PM	-		93	159	93	159	28	59	-		-		-		-		-		202	312	33	72	73	125	175	319	-	

*Max Queue refers to the 95% Queue

Table D5. 2038 Traffic Operational Analysis - Option 1

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail Signalized Intersection	AM	38	D	43	D	29	C	7	A	53	D	53	D	38	D	78	E	51	D	15	B	50	D	22	C	5	A
	PM	43	D	56	E	41	D	10	A	46	D	45	D	43	D	58	E	67	E	14	B	39	D	38	D	17	B
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	2	A	-		2	A	-		-		2	A	2	A	-		-		-		-		-		5	A
	PM	2	A	-		1	A	-		-		2	A	2	A	-		-		-		-		-		9	A
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	12	B	4	A	3	A	0	A	14	B	0	A	0	A	22	C	55	F	0	A	140	F	46	E	87	F
	PM	15	C	14	B	1	A	0	A	4	A	1	A	0	A	33	D	29	D	12	B	158	F	155	F	141	F
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	7	A	6	A	6	A	1	A	11	B	2	A	1	A	58	F	74	F	45	E	47	E	23	C	17	C
	PM	3	A	12	B	2	A	0	A	5	A	3	A	2	A	22	C	34	D	8	A	28	D	22	C	19	C
TH 41 at Hundertmark Rd Signalized Intersection	AM	34	C	42	D	38	D	20	B	56	E	39	D	9	A	58	E	34	C	26	C	74	E	28	C	8	A
	PM	48	D	67	E	53	D	20	C	69	E	57	E	46	D	67	E	18	B	13	B	68	E	84	F	36	D
Hundertmark Rd at 212 Medical Center Signalized Intersection	AM	17	B	32	C	19	B	7	A	32	C	16	B	8	A	32	C	22	C	8	A	30	C	14	B	4	A
	PM	26	C	38	D	18	B	5	A	37	D	23	C	21	C	72	E	27	C	18	B	34	C	25	C	7	A
TH 41 at TH 212 North Ramp Signalized Intersection	AM	11	B	-		-		-		47	D	-		25	C	76	E	6	A	-		-		7	A	3	A
	PM	50	D	-		-		-		24	C	-		37	D	88	F	22	C	-		-		95	F	48	D
TH 41 at TH 212 South Ramp Signalized Intersection	AM	35	D	55	E	-		7	A	-		-		-		-		40	D	24	C	51	D	12	B	-	
	PM	17	B	46	D	-		13	B	-		-		-		-		24	C	6	A	39	D	8	A	-	

*Delay in seconds per vehicle

Table D6. 2038 Peak Hour Queues by Movement - Option 1

Traffic Control Scenario	Peak Hour	Queue Lengths																							
		EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*	Avg	Max*
TH 41 at Pioneer Trail <i>Signalized Intersection</i>	AM	194	259	210	323	72	158	47	114	104	217	104	217	118	285	238	458	10	33	35	68	79	138	22	51
	PM	136	213	141	242	49	100	142	267	224	365	224	365	188	317	263	428	42	83	44	95	166	257	96	182
Pioneer Trail at Jonathan Square <i>Side-Street Stop Controlled</i>	AM	-	-	32	119	-	-	-	-	0	0	0	3	-	-	-	-	-	-	-	-	-	-	20	44
	PM	-	-	5	44	-	-	-	-	0	0	0	0	-	-	-	-	-	-	-	-	-	-	38	67
Pioneer Rd at Kwik Trip <i>Side-Street Stop Controlled</i>	AM	18	69	23	166	10	99	15	41	0	3	0	0	-	2	13	-	-	-	-	-	131	317	-	-
	PM	38	89	5	48	0	0	0	6	0	4	1	7	-	33	69	-	-	-	-	-	235	521	-	-
Hundertmark Rd at Bender Rd <i>Side-Street Stop Controlled</i>	AM	1	7	48	214	0	0	8	30	0	0	0	0	-	31	74	-	-	-	-	-	34	98	-	-
	PM	3	16	18	113	0	0	14	42	0	0	0	3	-	21	56	-	-	-	-	-	18	48	-	-
TH 41 at Hundertmark Rd <i>Signalized Intersection</i>	AM	92	186	194	318	159	270	109	182	84	169	9	50	140	225	216	307	206	345	35	79	116	198	15	42
	PM	84	173	149	272	93	199	168	296	289	489	38	101	302	570	161	352	89	187	57	201	404	648	135	389
Hundertmark Rd at 212 Medical Center <i>Side-Street Stop Controlled</i>	AM	58	157	202	373	85	236	21	51	61	107	49	96	18	44	4	16	4	16	18	48	4	21	23	48
	PM	59	141	193	349	33	129	14	62	124	277	146	255	146	275	37	140	37	140	18	51	12	40	33	60
TH 41 at TH 212 North Ramp <i>Signalized Intersection</i>	AM	-	-	-	-	-	-	76	140	-	-	128	210	14	38	-	-	-	-	-	-	54	106	6	21
	PM	-	-	-	-	-	-	208	373	-	-	382	604	120	214	135	223	-	-	-	-	620	1233	248	463
TH 41 at TH 212 South Ramp <i>Signalized Intersection</i>	AM	271	393	-	-	28	51	-	-	-	-	-	-	-	-	268	345	217	340	222	309	59	121	-	-
	PM	111	188	-	-	28	60	-	-	-	-	-	-	-	-	242	363	61	114	87	143	68	159	-	-

*Max Queue refers to the 95% Queue

Table D7. 2038 Traffic Operational Analysis - Option 2

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																											
				EBU		EBL		EBT		EBR		WBU		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail Signalized Intersection	AM	36	D	-		49	D	32	C	7	A	-		53	D	40	D	13	B	68	E	44	D	17	B	50	D	23	C	4	A
	PM	40	D	-		62	E	39	D	10	B	-		51	D	44	D	14	B	56	E	51	D	15	B	38	D	34	C	18	B
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	4	A	1	A	5	A	2	A	-		-		3		A	2	A	-		-		-		-		-		26	D	
	PM	5	A	19	C	16	C	2	A	-		-		3		A	2	A	-		-		-		-		-		24	C	
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	4	A	-		-		3	A	0	A	30	D	27	D	1	A	0	A	-		-		17	C	-		-	4	A	
	PM	2	A	-		-		2	A	0	A	6	A	6	A	1	A	0	A	-		-		13	B	-		-	11	B	
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	5	A	-		8	A	3	A	1	A	-		9	A	2	A	1	A	22	C	32	D	26	D	36	E	64	F	16	C
	PM	4	A	-		11	B	2	A	1	A	-		8	A	5	A	1	A	26	D	39	E	9	A	31	D	36	E	6	A
TH 41 at Hundertmark Rd Signalized Intersection	AM	32	C	-		36	D	37	D	18	B	-		52	D	39	D	6	A	49	D	30	C	22	C	56	E	33	C	7	A
	PM	44	D	-		61	E	50	D	22	C	-		60	E	51	D	37	D	59	E	19	B	13	B	69	E	74	E	22	C
Hundertmark Rd at 212 Medical Center Signalized Intersection	AM	17	B	-		31	C	18	B	6	A	-		32	C	16	B	7	A	28	C	10	A	7	A	31	C	16	B	4	A
	PM	27	C	-		37	D	23	C	6	A	-		38	D	20	C	16	B	73	E	29	C	14	B	37	D	27	C	7	A
TH 41 at TH 212 North Ramp Signalized Intersection	AM	11	B	-		-		-		-		-		46	D	-		26	C	69	E	4	A	-		-		9	A	4	A
	PM	37	D	-		-		-		-		-		31	C	-		61	E	60	E	17	B	-		-		45	D	22	C
TH 41 at TH 212 South Ramp Signalized Intersection	AM	41	D	-		102	F	-		8	A	-		-		-		-		30	C	19	B	68	E	14	B	-			
	PM	17	B	-		56	E	-		12	B	-		-		-		-		16	B	6	A	59	E	8	A	-			

*Delay in seconds per vehicle

Table D8. 2038 Peak Hour Queues by Movement - Option 2

Traffic Control Scenario	Peak Hour	Queue Lengths																											
		EBU		EBL		EBT		EBR		WBU		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
		Avg	Max*	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *	Avg	Max *
TH 41 at Pioneer Trail Signalized Intersection	AM	-		135	228	175	281	76	169	-		35	76	77	161	23	82	99	193	226	395	21	57	28	66	68	129	11	29
	PM	-		74	147	125	219	57	110	-		89	168	218	383	37	154	175	286	207	313	44	89	32	69	143	240	20	168
Pioneer Trail at Jonathan Square Side-Street Stop Controlled	AM	23	54	23	54	20	98	-		-		-		6	43	2	11	-		-		-		-		-		56	156
	PM	39	70	39	70	27	110	-		-		-		1	8	4	20	-		-		-		-		-		83	188
Pioneer Trail at Kwik Trip Side-Street Stop Controlled	AM	-		-		18	149	10	91	43	67	43	67	26	104	0	0	-		-		4	21	-		-		12	29
	PM	-		-		9	58	0	5	34	57	34	57	4	36	1	14	-		-		32	66	-		-		21	48
Hundertmark Rd at Bender Rd Side-Street Stop Controlled	AM	-		2	31	53	226	0	0	-		9	34	0	0	0	0	-		40	108	-		-		32	80	-	
	PM	-		2	14	11	81	0	3	-		17	52	14	121	0	4	-		24	54	-		-		16	41	-	
TH 41 at Hundertmark Rd Signalized Intersection	AM	-		97	195	179	316	158	266	-		104	177	76	170	9	51	107	178	207	319	201	372	32	83	163	264	20	46
	PM	-		75	165	156	282	118	226	-		154	266	284	474	48	93	249	447	163	289	99	183	41	137	347	558	92	312
TH 41 at 212 Medical Center Signalized Intersection	AM	-		64	164	206	333	59	165	-		22	52	63	125	51	107	20	48	4	17	4	17	16	42	4	21	28	53
	PM	-		82	210	216	376	45	141	-		13	44	91	171	123	195	158	289	57	175	57	175	19	48	9	42	32	61
TH 41 at TH 212 North Ramp Signalized Intersection	AM	-		-		-		-		-		78	141	-		125	210	12	35	0	6	-		-		69	128	7	21
	PM	-		-		-		-		-		303	688	-		550	887	220	361	120	194	-		-		247	392	135	297
TH 41 at TH 212 South Ramp Signalized Intersection	AM	-		356	580	-		33	57	-		-		-		-		-		230	332	169	275	278	278	90	164	-	
	PM	-		127	202	-		29	60	-		-		-		-		-		206	326	53	110	95	156	60	173	-	

*Max Queue refers to the 95% Queue

Table D9. 2038 Traffic Operational Analysis - Roundabouts

Traffic Control Scenario	Peak Hour	Intersection Delay*- LOS		Movement Delay (sec/veh)																							
				EBL		EBT		EBR		WBL		WBT		WBR		NBL		NBT		NBR		SBL		SBT		SBR	
TH 41 at Pioneer Trail Roundabout	AM	34	D	18	C	21	C	21	C	16	C	16	C	16	C	56	F	72	F	72	F	7	A	7	A	6	A
	PM	33	D	20	C	21	C	21	C	37	E	42	E	42	E	24	C	29	D	29	D	41	E	46	E	37	E
TH 41 at Hundertmark Rd Roundabout	AM	67	F	22	C	22	C	23	C	20	C	13	B	13	B	93	F	148	F	148	F	10	B	11	B	11	B
	PM	97	F	27	D	27	D	19	C	111	F	97	F	97	F	87	F	141	F	141	F	84	F	101	F	101	F

*Delay in seconds per vehicle

Table D10. 2038 Peak Hour Queues by Movement - Roundabouts

Traffic Control Scenario	Peak Hour	Queue Lengths											
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
		Max*	Max*	Max*	Max*	Max*	Max*	Max*	Max*	Max*	Max*	Max*	Max*
TH 41 at Pioneer Trail Roundabout	AM	150	175	175	50	50	50	300	400	400	25	25	25
	PM	100	125	125	200	225	225	175	225	225	200	225	150
TH 41 at Hundertmark Rd Roundabout	AM	125	150	150	75	25	25	575	575	575	50	50	50
	PM	125	125	75	375	350	350	600	900	900	350	425	425

*Max Queue refers to the 95% Queue



Appendix E – Intersection Crash Rates

Intersection Safety Screening

Intersection: TH 41 at Pioneer Trail



Crash Data, 2010-2014

Crashes by Crash Severity	
Fatal	0
Incapacitating Injury	0
Non-incapacitating Injury	3
Possible Injury	13
Property Damage	29
Total Crashes	45

Intersection Characteristics	
Entering Volume	28,700
Traffic Control	Signals
Environment	Suburban
Speed Limit	50 mph

Annual crash cost = \$349,520

Statewide Comparison

Signals: high volume, high speed

Total Crash Rate	
Observed	0.86
Critical Rate	0.65
Critical Index	1.32

Fatal & Serious Injury Crash Rate	
Observed	0.00
Critical Rate	2.73
Critical Index	0.00

The observed crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside the expected, normal range. The critical index reports the magnitude of this difference.

The observed total crash rate for this period is 0.86 per MEV; this is 1.3 times the critical rate. If crashes were reduced by 10 over five years, this intersection would perform within normal range.

The observed fatal and serious injury crash rate for this period is 0.00 per 100 MEV; this is 100% below the critical rate. The intersection operates within the normal range.

Intersection Safety Screening

Intersection: TH 41 at Hundertmark Road



Crash Data, 2010-2014

Crashes by Crash Severity	
Fatal	0
Incapacitating Injury	0
Non-incapacitating Injury	2
Possible Injury	18
Property Damage	32
Total Crashes	52

Intersection Characteristics	
Entering Volume	32,400
Traffic Control	Signals
Environment	Suburban
Speed Limit	50 mph

Annual crash cost = \$402,960

Statewide Comparison

Signals: high volume, high speed

Total Crash Rate	
Observed	0.88
Critical Rate	0.64
Critical Index	1.38

Fatal & Serious Injury Crash Rate	
Observed	0.00
Critical Rate	2.54
Critical Index	0.00

The observed crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside the expected, normal range. The critical index reports the magnitude of this difference.

The observed total crash rate for this period is 0.88 per MEV; this is 1.4 times the critical rate. If crashes were reduced by 14 over five years, this intersection would perform within normal range.

The observed fatal and serious injury crash rate for this period is 0.00 per 100 MEV; this is 100% below the critical rate. The intersection operates within the normal range.

Intersection Safety Screening

Intersection: Hundertmark Road at Bender Road



Crash Data, 2010-2014

Crashes by Crash Severity	
Fatal	0
Incapacitating Injury	0
Non-incapacitating Injury	0
Possible Injury	0
Property Damage	4
Total Crashes	4

Intersection Characteristics	
Entering Volume	12,200
Traffic Control	Thru / stop
Environment	Suburban
Speed Limit	40 mph

Annual crash cost = \$5,920

Statewide Comparison

Urban Thru / Stop

Total Crash Rate	
Observed	0.18
Critical Rate	0.44
Critical Index	0.41

Fatal & Serious Injury Crash Rate	
Observed	0.00
Critical Rate	4.06
Critical Index	0.00

The observed crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside the expected, normal range. The critical index reports the magnitude of this difference.

The observed total crash rate for this period is 0.18 per MEV; this is 59% below the critical rate. Based on similar statewide intersections, an additional 6 crashes over the five years would indicate this intersection operates outside the normal range.

The observed fatal and serious injury crash rate for this period is 0.00 per 100 MEV; this is 100% below the critical rate. The intersection operates within the normal range.