City of Hiawatha
Engineering Department
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To: **Mayor and City Council** **Date: September 25, 2019**

From: John C. Bender PE, City Engineer

Re: Tower Terrace Road Reconstruction Traffic Study

Report:

City Council approved a contract with Snyder and Associates as the design consultants for the environmental study/NEPA study /preliminary and final design of the City's approximately 2000 feet of Tower Terrace Road reconstruction. The contract was itemized into 5 sections. The first section is the base contract which included the completion of a traffic study utilizing the Interchange Justification Report (IJR) traffic count data. The study was to develop projected opening day traffic volumes for both AM and PM peak hour turning movements with the new Tower Terrace Interchange in operation. The second projected traffic forecast was to develop 2040, or design year traffic, projections for study as well.

Traffic simulation models were prepared for several scenarios to evaluate average delays, levels of service, and vehicle queuing. Models were prepared for 4 events:

- Opening year with traffic signal at Center Point Road
- Opening year with roundabout at Center Point Road
- Design year with traffic signal at Center Point Road
- Design year with roundabout at Center Point Road

Based on these results, the consultant was to prepare a recommendation as to which type of intersection would provide acceptable opening year and design year traffic operations. The attached final report is a summary of the consultant's findings. Although

the roundabout alternative is approximately 8% more cost in initial construction, the life-cycle costs for transportation users of the 20 year analysis period, combined with the safety benefits which provide reduction in vehicle crashes and personal injury, the roundabout option is the recommended alternative.

We had a presentation by the consultant at the work session September 23 and a public open house the evening of Tuesday September 24. Approximately 25 citizens attended the open house. There were no serious objections raised at either meeting when the findings of the report were presented by the consultant.

See attached final report as the Council agenda item will be to receive and file the report. If Council has any questions, please let me know.

DRAFT

RESOLUTION NO. 19-
City Council

RESOLUTION ACCEPTING AND PLACING ON FILE THE CITY OF HIAWATHA TOWER TERRACE ROAD TRAFFIC STUDY INTERSTATE 380 INTERCHANGE TO NORTH CENTER POINT ROAD

BE IT RESOLVED BY THE CITY COUNCIL OF HIAWATHA, IOWA, to accept and place on file the City of Hiawatha Tower Terrace Traffic Study Interstate 380 Interchange to North Center Point Road from August 2, 2019. The *I-380 Interchanges at Tower Terrace Road and Boyson Road Interchange Report* identified Tower Terrace Road as a new location for Interstate 380 access. The Tower Terrace Traffic Study determines the necessary traffic control and lane configurations at the intersection of Tower Terrace Road and North Center Point Road east of the new interchange and evaluates two primary alternatives for the traffic control at the intersection Tower Terrace Road and North Center Point Road: signal control and a roundabout.

AYES:
NAYS:
ABSENT:

PASSED AND APPROVED this 2nd day of October, 2019.

_____
Bill Bennett, Mayor

ATTEST:

_____
Kari Graber, City Clerk

TOWER TERRACE ROAD TRAFFIC STUDY

INTERSTATE 380 INTERCHANGE TO NORTH CENTER POINT ROAD

Hiawatha, Iowa | September 25, 2019

SNYDER & ASSOCIATES

TOWER TERRACE ROAD TRAFFIC STUDY

INTERSTATE 380 INTERCHANGE TO NORTH CENTER POINT ROAD

Hiawatha, Iowa | September 25, 2019

Prepared for:

City of Hiawatha

Snyder & Associates, Inc. Project No. 119.0219

Prepared by:

LICENSED PROFESSIONAL ENGINEER ANTHONY J. BOES 12387 IOWA	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa. Anthony J. Boes 9/25/19 Anthony J. Boes, P.E. Date License Number 12387 My License Renewal Date is December 31, 2019 Pages or sheets covered by this seal: All

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EXECUTIVE SUMMARY

Tower Terrace Road was identified as a new location for Interstate 380 access in the *I-380 Interchanges at Tower Terrace Road and Boyson Rd Interchange Justification Report* (IJR). The purpose of this report is to determine the necessary traffic control and lane configurations at the intersection of Tower Terrace Road and North Center Point Road east of the interchange.

The traffic patterns and volumes are projected to change and grow significantly with the new interchange. Forecasted daily traffic is projected to grow from about 11,600 vehicles per day in the opening year (2023) to 28,500 vehicles per day in the design year (2040). Due to projected rapid growth, the opening year alternatives were analyzed with 10 years of growth from the opening year.

Two primary alternatives were evaluated for the traffic control at the intersection Tower Terrace Rd and N Center Point Rd: signal control and a roundabout. The forecasted volumes make maintaining two-way stop control (TWSC) or switching to all-way stop control (AWSC) infeasible. The functional lane needs were determined for the opening year based on 2033 traffic and for the full build based on 2040 traffic. The functional lane needs were determined using *Synchro version 10* for the traffic signal and *Sidra version 7* for the roundabout. Those lane configurations were then analyzed with the microsimulation analysis in *VISSIM version 9*. VISSIM models for the IJR were provided by the Iowa DOT and modified for this study.

Based on analyses performed for this study, both Tower Terrace Rd and N Center Point Rd intersection alternatives (roundabout or traffic signal) provide acceptable opening year and design year traffic operations. The signal alternative has lower initial construction costs, however, future improvements needed for this alternative to accommodate projected 2040 traffic would be more expensive than for the roundabout alternative. Total initial plus future estimated project cost for the roundabout alternative is approximately $340,000 (8%) more than the signal alternative.

Considering life-cycle costs for transportation system users over the 20-year analysis period, the roundabout alternative is projected to provide more than $15 million in cost savings compared to the signal alternative, including more than $2 million in safety benefits (vehicle crash and injury reductions). Therefore, the roundabout alternative is recommended as the preferred alternative.

Due to opening year lane configurations needed for the interchange and the N Center Point Rd intersection, Tower Terrace Rd should be constructed as four-lane divided street west of N Center Point Rd. Providing four continuous through lanes with initial construction will avoid potential operational and safety issues associated with lane drops (merges) as well as future construction costs for this segment.

After the interchange and N Center Point Rd intersection are opened to traffic, traffic operations should be periodically evaluated to determine when additional intersection improvements may be needed. Based on projected traffic growth, the proposed design year improvements may be needed within 10-15 years after the opening year. This is consistent with recommended design practice for roundabouts, minimizing the number of lanes initially to optimize safety, but designing for future expandability.

1. INTRODUCTION

Tower Terrace Road was identified as a new location for Interstate 380 access in the *I-380 Interchanges at Tower Terrace Road and Boyson Rd Interchange Justification Report* (IJR). The preferred alternative in that report included a diverging diamond interchange (DDI) at Tower Terrace Road with two through lanes each direction eastbound and westbound. The purpose of this report is to determine the necessary traffic control and lane configurations at the intersection of Tower Terrace Road and North Center Point Road east of the interchange. The project location is shown in **Figure 1**.

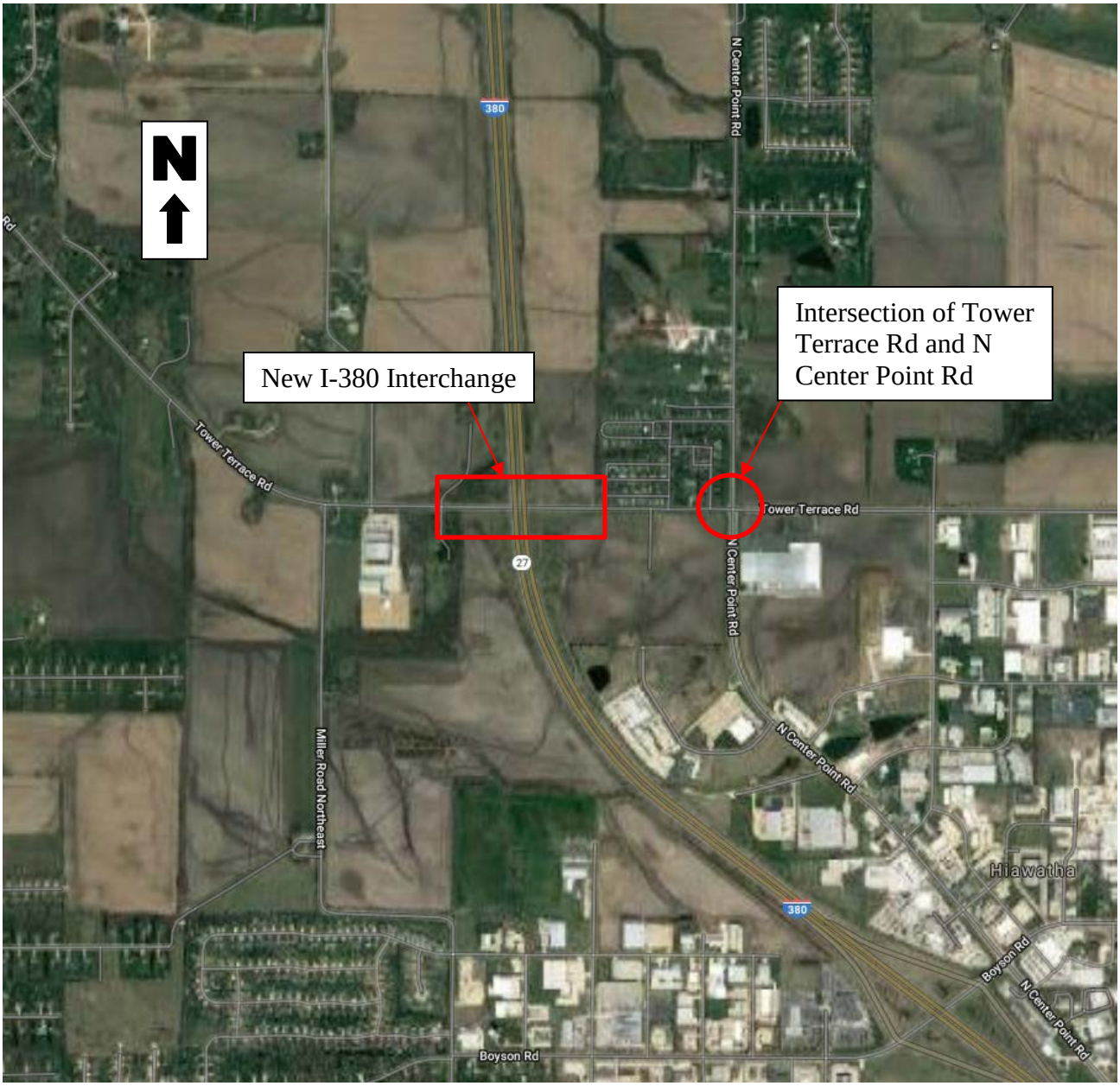


Figure 1. Project Location Map

2. EXISTING CONDITIONS

Tower Terrace Rd is a two-lane undivided road with a rural cross section and a speed limit of 35 mph west of N Center Point Rd and 45 mph to the east. N Center Point Rd is a two lane undivided road with a rural cross section north of Tower Terrace Rd and a three-lane road with an urban cross section to the south. The speed limit on N Center Point Rd 35 mph. The intersection has curbs on all the corner radii, and the only turn lanes are northbound and southbound left turn lanes. It is two way stop controlled (TWSC) with the stop signs on the eastbound and westbound approaches. The existing intersection layout is shown in **Figure 2**.

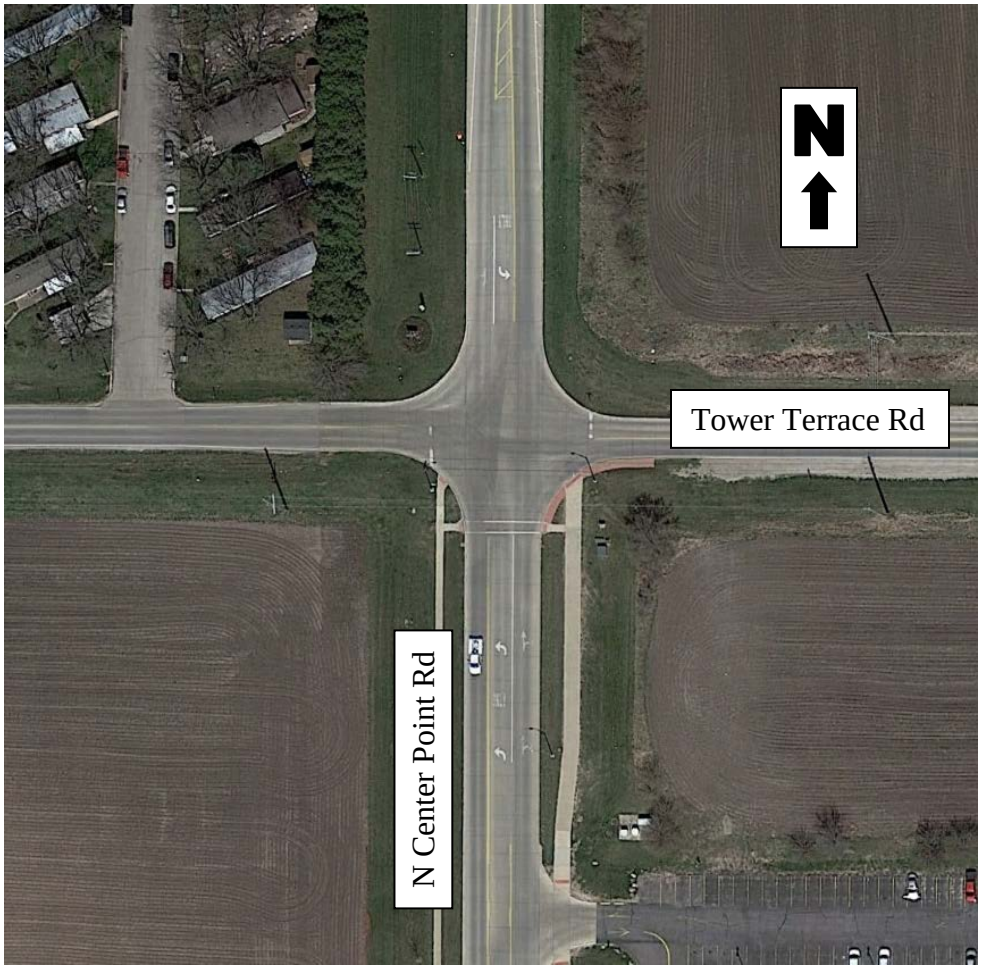


Figure 2. Intersection of Tower Terrace Rd and N Center Point Rd

3. CRASH HISTORY

Reported crashes from 2014 through 2018 at the intersection of Tower Terrace Rd and N Center Point Rd were reviewed using the Iowa DOT's crash database (https://icat.iowadot.gov/). There were 9 crashes within that time frame for a crash rate of 0.64 crashes per million entering vehicles. There was 1 major injury crash, 1 minor injury crash, 3 possible/unknown crashes, and 4 property damage only crashes. Of the 9 crashes, 6 of them were broadside/right angle crashes and 2 were oncoming left turn crashes.

It is important to note that limited conclusions can be gathered from this crash review due to the significant changes expected in the traffic patterns with the new interchange. The introduction of an access to I-380 is expected to spur significant growth in the area and change the routes drivers take to and from origins and destinations in the area.

4. EXISTING TRAFFIC

The 2017 annual average daily traffic (AADT) volumes in the area are shown in **Figure 3**. Again, the volumes in the area are expected to change significantly with the new interchange. However, the existing volumes shown and the existing volumes at the adjacent I-380 interchanges can provide a baseline for comparison with the overall forecasted growth east and west of I-380. This is discussed further in the Forecasted Traffic section.

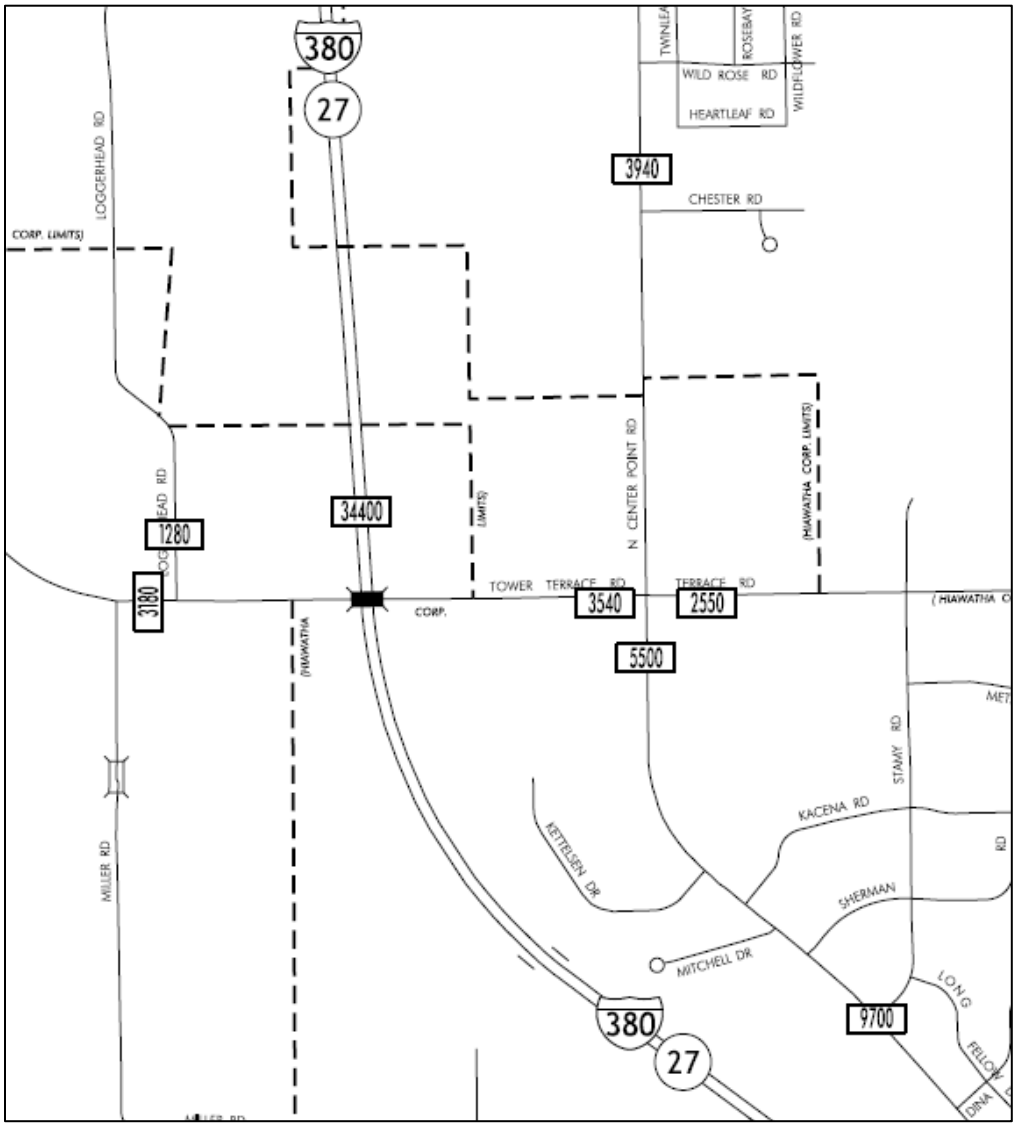


Figure 3. 2017 AADT (source: Iowa DOT)

5. FORECASTED TRAFFIC

The IJR included forecasted daily and peak hour volumes for the design year of 2040, but it did not include opening year forecasts. However, the Corridor Metropolitan Planning Organization provided daily traffic forecasts for a travel demand model scenario with the Tower Terrace Rd interchange open and other roads open to reflect the expected network in 2023. This model used socio-economic data from 2013, so a growth rate for the area was calculated between 2013 and 2040 using the MPO and IJR volumes, respectively. This resulted in a growth rate of 5.4 percent per year.

That growth rate was then used to estimate the opening year (2023) peak hour volumes by reversing the growth from the 2040 peak hour volumes, with minor adjustments for turning movements that decreased from the existing peak hour volumes to the forecasted 2040 peak hour volumes. Daily traffic on Tower Terrace Rd is projected to increase from approximately 11,600 vehicles per day to 28,500 vehicles per day from 2023 to 2040. The 2017, 2023, and 2040 peak hour volumes are shown in **Exhibits 1, 2, and 4**, respectively. Additionally, due to the high growth, interim peak hour volumes were estimated for 2033. The 2033 volumes were used for the opening year scenarios to ensure the initial build alternatives had sufficient capacity for 10 years of growth. **Exhibit 3** shows the estimated 2033 peak hour volumes.

6. ALTERNATIVES

Two primary alternatives were evaluated for the traffic control at the intersection Tower Terrace Rd and N Center Point Rd: signal control and a roundabout. The forecasted volumes make maintaining two-way stop control (TWSC) or switching to all-way stop control (AWSC) infeasible. The functional lane needs were determined for the opening year based on 2033 traffic and for the full build based on 2040 traffic. The functional lane needs were determined using *Synchro version 10* for the traffic signal and *Sidra version 7* for the roundabout. Those lane configurations were then analyzed with the microsimulation analysis in *VISSIM version 9*. VISSIM models for the IJR were provided by the Iowa DOT and modified for this study.

The opening year signal layout is shown in **Figure 4**, and the design year signal layout is shown in **Figure 5**. The opening year roundabout layout is shown in **Figure 6**, and the design year roundabout layout is shown in **Figure 7**. The functional lane needs for the opening year and design year are also summarized in **Table 1**.

Table 1. Summary of Functional Lane Needs

		Opening Year (2023)			Design Year (2040)		
Alternative	**Approach**	**Left**	**Thru**	**Right**	**Left**	**Thru**	**Right**
Signal	NB	1	1	shared	1	2	1
	SB	1	1	1	1	2	1
	EB	2	1	1	2	2	shared
	WB	1	2	shared	1	2	1
Roundabout	NB	1	1	1	shared	2	1
	SB	shared	1	1	shared	2	1
	EB	shared	2	shared	1	2	shared
	WB	shared	2	shared	shared	2	1

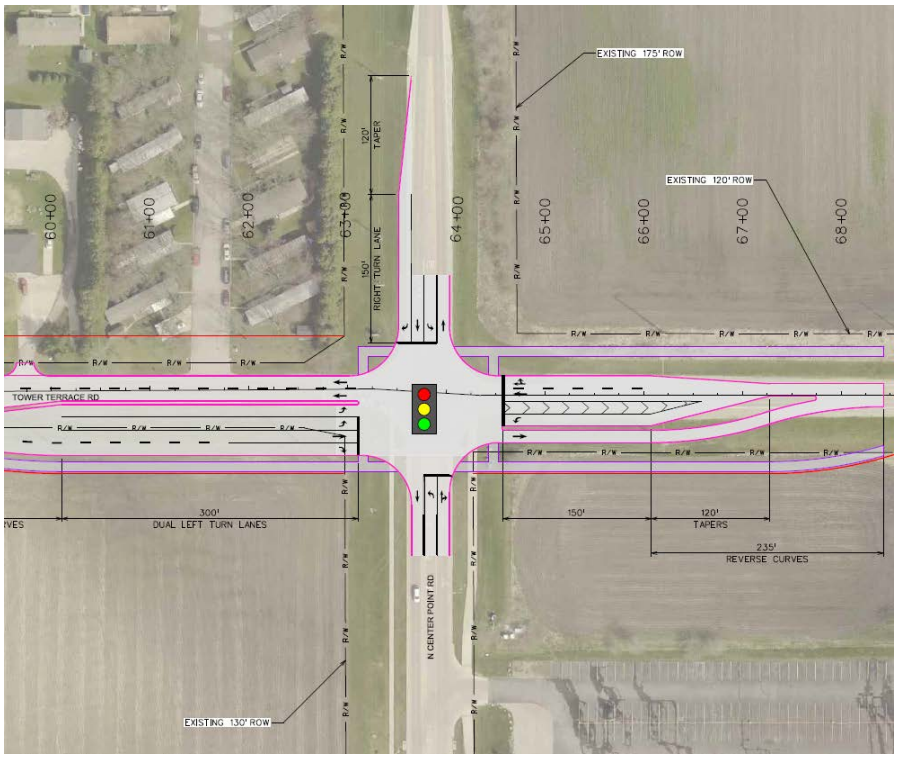


Figure 4. Opening Year (2023) Signal Function Lane Needs

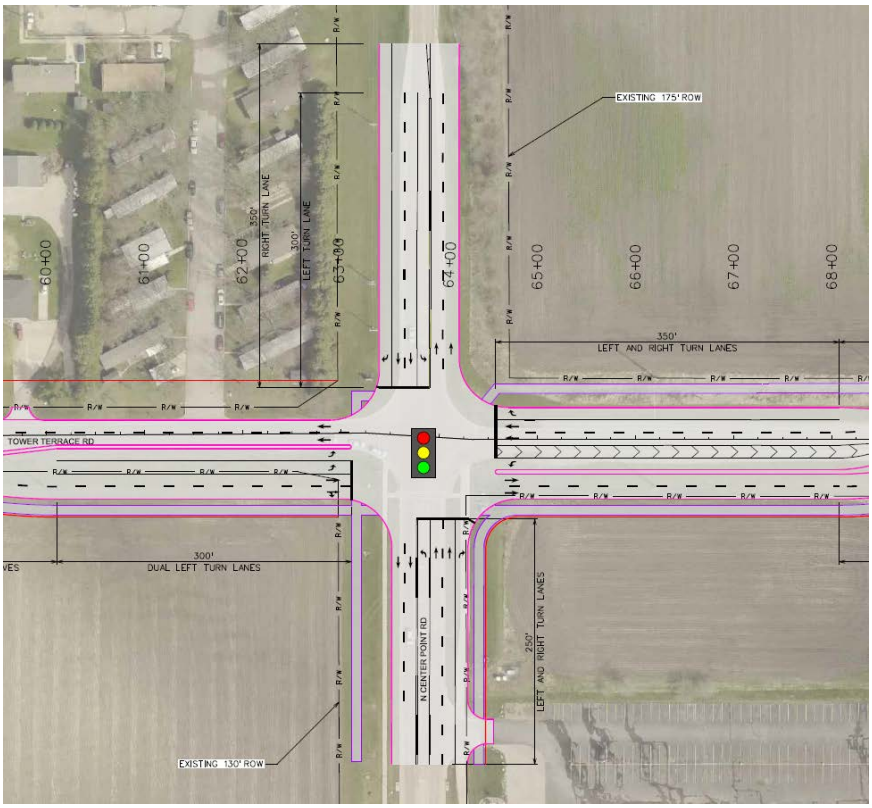


Figure 5. Design Year (2040) Signal Function Lane Needs

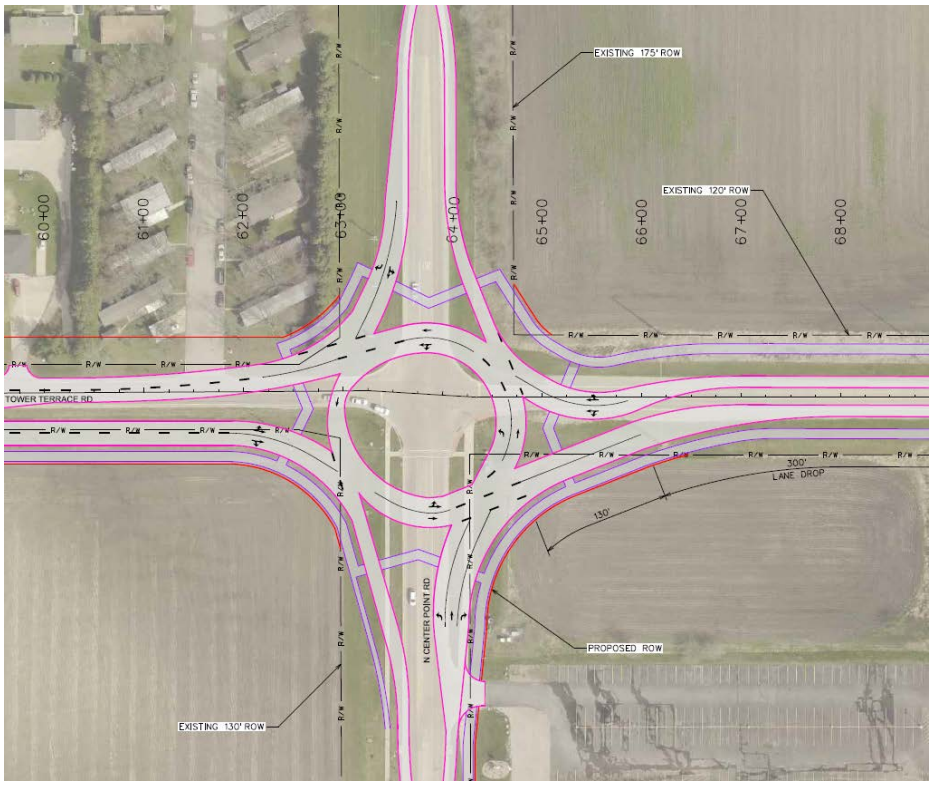


Figure 6. Opening Year (2023) Roundabout Function Lane Needs

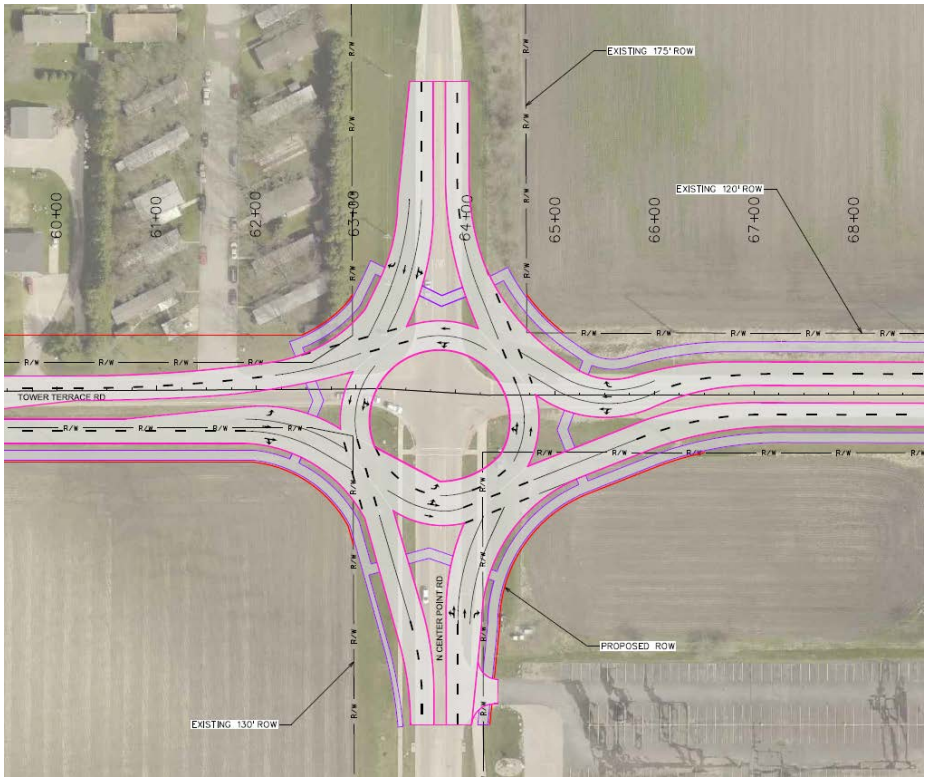


Figure 7. Design Year (2040) Roundabout Function Lane Needs

7. FORECASTED OPERATIONS – ALTERNATIVES

The layouts in **Figure 4** through **Figure 7** were further analyzed in the microsimulation software *VISSIM version 9*. These models included the proposed I-380 interchange in order to analyze the interaction between the interchange and the N Center Point Rd intersection. The opening year layouts were evaluated with the forecasted 2033 traffic to ensure an adequate level of service with 10 years of growth. The design year layouts were evaluated with the forecasted 2040 traffic. The AM and PM peak hours were modeled for all the alternative and year combinations.

The main measures of effectiveness used to evaluate the alternatives were delay per vehicle (and the corresponding level of service or LOS) and queue length. The LOS thresholds for delay according to the Highway Capacity Manual 6 (*HCM 6*) are given in **Table 2**. In the *HCM 6*, roundabouts use the unsignalized LOS thresholds, which are lower than the signalized LOS thresholds due to driver expectations for delay when a signal is not present. Typically, LOS D is considered the minimum acceptable level of service in urban areas.

Table 2. Level of Service Definition (*HCM 6*)

LOS	Average Delay per Vehicle (seconds)	
	Signalized Intersection	**Unsignalized Intersection**
A	< 10	< 10
B	10 to 20	10 to 15
C	20 to 35	15 to 25
D	35 to 55	25 to 35
E	55 to 80	35 to 50
F	> 80 or V/C > 1.0	> 50 or V/C > 1.0

V/C - Volume to Capacity Ratio

Table 3 and **Table 4** summarize the delay and LOS results for the opening year and design year alternatives, respectively. Both the roundabout and signal alternative provide acceptable levels of service at the intersection of Tower Terrace Rd and N Center Point Rd with the opening year layouts and forecasted 2033 traffic. The roundabout has less delay than the signal with LOS B or better overall and LOS C or better for all approaches. The signal provides LOS C or better overall and for the approaches. The signal alternative provides slightly less delay at the NB I-380 Ramps signal due to its ability to be coordinated with the interchange signals.

The design year analysis shows similar results to the opening year with 2033 traffic. Again, the roundabout alternative has less delay overall than the signal alternative, and the signal alternative provides slightly less delay at the NB I-380 Ramps due to the coordination. The main difference in the design year analysis is that the WB approach in the PM peak sees a increase in delay. This is due to the high volume of EB left turns and NB left and through vehicles limiting the gaps available for WB traffic. In reality, as delays increase, drivers are willing to accept smaller gaps, which would likely result in less delay than shown. Results by individual movement are provided in the appendix.

Table 3. Summary of Delay in sec per veh / LOS for Opening Year

		Roundabout		Signal	
Intersection	**Approach**	**AM Peak**	**PM Peak**	**AM Peak**	**PM Peak**
Tower Terrace Rd & N Center Point Rd	NB	4 / A	13 / B	21 / C	27 / C
	SB	9 / A	4 / A	17 / B	10 / B
	EB	13 / B	11 / B	27 / C	35 / C
	WB	7 / A	22 / C	26 / C	28 / C
	Total	**9 / A**	**12 / B**	**23 / C**	**26 / C**
Tower Terrace Rd & NB I-380 Ramps	NB	17 / B	22 / C	18 / B	20 / C
	EB	12 / B	6 / A	15 / B	6 / A
	WB	15 / B	12 / B	8 / A	9 / A
	Total	**14 / B**	**14 / B**	**12 / B**	**12 / B**
Tower Terrace Rd & SB I-380 Ramps	SB	5 / A	4 / A	5 / A	5 / A
	EB	21 / C	24 / C	20 / C	24 / C
	WB	7 / A	6 / A	9 / A	8 / A
	Total	**12 / B**	**13 / B**	**13 / B**	**14 / B**

Table 4. Summary of Delay in sec per veh / LOS for Design Year (2040)

		Roundabout		Signal	
Intersection	**Approach**	**AM Peak**	**PM Peak**	**AM Peak**	**PM Peak**
Tower Terrace Rd & N Center Point Rd	NB	4 / A	12 / B	19 / B	25 / C
	SB	9 / A	4 / A	21 / C	16 / B
	EB	11 / B	7 / A	23 / C	34 / C
	WB	10 / B	35 / E	22 / C	23 / C
	Total	**9 / A**	**14 / B**	**22 / C**	**26 / C**
Tower Terrace Rd & NB I-380 Ramps	NB	19 / B	20 / B	19 / B	19 / B
	EB	8 / A	7 / A	11 / B	6 / A
	WB	25 / C	18 / B	16 / B	15 / B
	Total	**18 / B**	**16 / B**	**15 / B**	**14 /B**
Tower Terrace Rd & SB I-380 Ramps	SB	8 / A	8 / A	8 / A	9 / A
	EB	22 / C	25 / C	23 / C	24 / C
	WB	13 / B	11 / B	14 / B	12 / B
	Total	**16 / B**	**16 / B**	**17 / B**	**16 / B**

Table 5 summarizes the maximum queues at the intersection of Tower Terrace Rd and N Center Point Rd. The queue lengths are provided in feet and the letters in the parentheses indicate the lane with the longest queue. In general, the maximum queues were 350 feet or less.

Table 5. Summary of Max Queue Length in feet per Approach (Lane with Max Queue)

		Roundabout		Signal	
Scenario	**Approach**	**AM Peak**	**PM Peak**	**AM Peak**	**PM Peak**
Opening Year Layout with 2033 Traffic	NB	85 (T)	256 (T)	238 (T/R)	538 (T)
	SB	288 (L/T)	71 (L/T)	303 (T)	87 (L)
	EB	336 (L/T)	335 (L/T)	258 (T)	237 (L)
	WB	150 (T/R)	226 (L/T)	266 (T)	265 (L)
Design Year (2040)	NB	60 (L/T)	144 (L/T)	121 (T)	217 (T)
	SB	253 (L/T)	80 (L/T)	309 (R)	322 (R)
	EB	332 (L)	330 (L)	207 (L)	297 (L)
	WB	279 (L/T)	501 (L/T)	328 (T)	236 (T)

8. IMPROVEMENT COST OPINIONS

Preliminary cost opinions were prepared for the opening year alternatives as well as future improvements necessary to accommodate design year traffic. **Table 6** summarizes the cost opinions for the roundabout and signal alternatives for the intersection of the Tower Terrace Rd and N Center Point Rd. These cost opinions included estimated quantities and costs for major bid items, engineering, and right-of-way acquisition.

The roundabout alternative has higher initial construction costs (by approximately $880,000) than the signal, but lower additional costs to achieve the design year layout (by approximately $540,000). This results in higher total costs for the design year roundabout (by approximately $340,000). Itemized cost breakdowns are included in the appendix.

Table 6. Summary of Preliminary Cost Opinions

Scenario	Cost Category	Roundabout	Signal
Opening Year Costs	Construction Total	$3,436,740	$2,710,140
	Engineering and ROW	$758,000	$602,000
	Total Project Cost	$4,194,740	$3,312,140
Additional Costs to Design Year	Construction Total	$399,300	$844,800
	Engineering and ROW	$80,000	$178,000
	Total Project Cost	$479,300	$1,022,800
Total Costs to Design Year	Construction Total	$3,836,040	$3,554,940
	Engineering and ROW	$838,000	$780,000
	Total Project Cost	**$4,674,040**	**$4,334,940**

9. LIFE-CYCLE COST ANALYSIS

In addition to the initial construction cost, the long-term operation costs and safety benefits of the roundabout and signal alternatives were compared. The additional factors considered were safety, value of time for users, fuel costs to users, emissions, and maintenance. The process of quantifying these considerations is described in this section.

- Safety
  - Based on existing crash rates at the intersection and established crash modification factors (CMFs) from the Iowa DOT's Traffic Safety Improvement Program (based on factors from the CMF Clearinghouse – http://www.cmfclearinghouse.org)
  - Societal costs of crashes from the Iowa DOT's Traffic Safety Improvement Program (Fatal – $4,500,00; Major – $325,000; Minor – $65,000; Possible – $35,000, Property Damage Only – $7,400)
  - Signal assumed to have same crash rate as historic crash rate at intersection.
  - Roundabout assumed to have a 65 percent reduction for injury crashes and 20 percent reduction for property damage only crashes, per Iowa DOT CMF information.
  - Note: existing crash history may not be representative of the crash frequency after the interchange opens due to the changes in traffic patterns and growth. It is likely the crash frequency will be higher than the history indicates, so the safety benefit of the roundabout alternative is likely greater than shown
- Value of Time
  - Based on delay at the interchange and intersection from *VISSIM 9* models.
  - Included off peak analysis. Off peak was defined as the 11 hours with the highest traffic other than the AM and PM peak. Based on Iowa DOT automated traffic recorder data, these off peak hours average 75 percent of the PM peak volumes. According to the same data, the AM peak, PM peak, and next highest volume 11 hours account for 80-85 percent of daily volume. The impact of the final 15-20 percent traffic on the analysis was assumed be negligible and was excluded.
  - Value of time – $15.21 per hour. Based on a weighted average of personal use and truck driver time from Benefit-Cost Analysis Guidance for Discretionary Grant Programs from the FHWA.
- Fuel Costs
  - Based on fuel consumption output at the interchange and intersection in *VISSIM 9* models.
  - Cost of fuel – $3.00 per hour. Based on current fuel prices in Iowa and expected cost increases.
- Emissions
  - Based on emissions output at the interchange and intersection for nitrogen oxides (NO_x), volatile organic compounds (VOCs), and carbon dioxide (CO_2) in *VISSIM 9* models.
  - Societal costs of emissions from Benefit-Cost Analysis Guidance for Discretionary Grant Programs from the FHWA and its underlying research. (NO_x – $7,508 per ton, VOCs – $1,905 per ton, and CO_2 – $39 per ton)
- Maintenance Costs
  - Roundabout: power for lighting, signing, markings. Assumed $2,500 annual cost.
  - Traffic signal: power, lighting, signing, markings, signal maintenance, regular retiming. Assumed $5,000 annual cost.

The life span of both alternatives was assumed to be 20 years. The total life cycle costs for each of the categories are compared between the roundabout and signal alternatives in Table 7 and Figure 8. It should be noted that the travel time, fuel, and emissions costs include data from the interchange ramps to capture any interaction between the intersection alternatives and the interchange. While the roundabout alternative is slightly more expensive to construct, it offers a benefit over the signal alternative in all the other categories. The largest differences are in travel time, fuel, and crash costs. The roundabout showed benefits of over $8 million in travel time savings, over $4 million in fuel cost savings, and over $2 million in value of crashes prevented.

Table 7. Life Cycle Cost Summary (20 Year Totals)

Cost Category	Roundabout	Signal
Construction	$4,674,040	$4,334,940
Crashes	$1,359,000	$3,620,000
Travel Time	$21,059,000	$29,575,000
Fuel	$19,958,000	$24,304,000
Emissions	$1,059,000	$1,306,000
Maintenance	$50,000	$100,000
Total	**$48,159,040**	**$63,239,940**

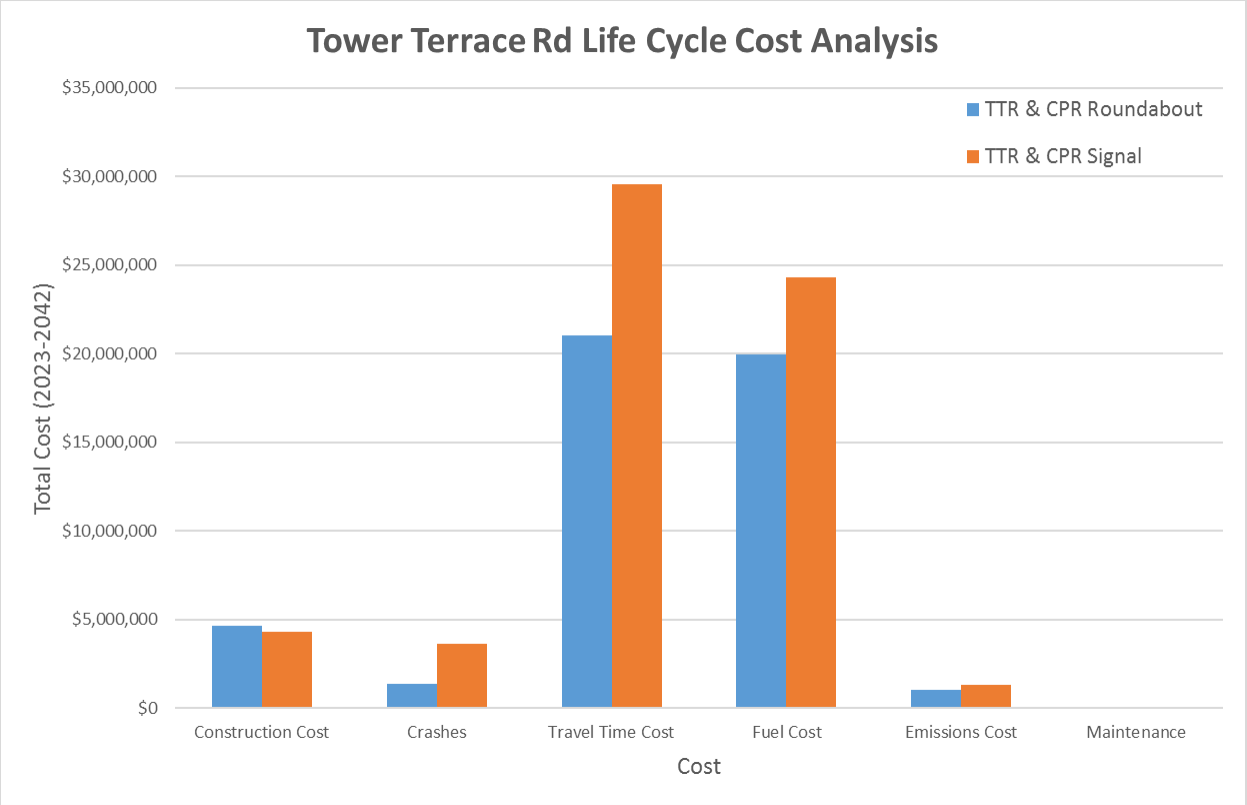


Figure 8. Summary of Life Cycle Cost Comparison

10.ALTERNATIVES DISCUSSION

This section summarizes the differences between the two alternatives for traffic control at the intersection of Tower Terrace Rd and N Center Point Rd.

Roundabout Alternative

The various characteristics of the roundabout alternative are outlined below. It is expected to operate well with low delays in general. The preliminary cost opinion indicates a higher initial construction cost, and a slightly higher total construction cost than the signal alternative. However, the life cycle cost analysis indicates a significant benefit for the roundabout alternative compared to the signal.

- Operations
  - Opening Year (with 2033 traffic): LOS B or better overall, LOS C or better on approaches
  - Design Year: LOS B or better overall, LOS B or better on all approaches except WB in the PM peak (border of LOS D and LOS E)
- Construction Costs
  - Opening Year: $4,194,740
  - Additional cost to Design Year: $479,300
  - Total Cost to Design Year: $4,674,040
- Life Cycle Costs
  - Significant benefit over the signal alternative in several categories: travel time (over $8 million), fuel (over $4 million), and crashes (over $2 million)

Signal Alternative

The various characteristics of the signal alternative are outlined below. It is expected to operate with acceptable delays, though the delays are higher than the roundabout alternative. However, it is worth noting that with the significant growth expected, the signals offer adaptability to changing traffic patterns by way of signal retiming. The preliminary cost estimate indicates a lower initial construction cost, and a slightly lower total construction cost. However, the life cycle cost analysis indicates a significant benefit for the roundabout alternative compared to the signal.

- Operations
  - Opening Year (with 2033 traffic): LOS C or better overall, LOS C or better on approaches
  - Design Year: LOS C or better overall, LOS C or better on all approaches
- Construction Costs
  - Opening Year: $3,312,140
  - Additional cost to Design Year: $1,022,800
  - Total Cost to Design Year: $4,334,940
- Life Cycle Costs
  - Expected to incur significantly more societal costs than the roundabout (about $15 million over the 20 year analysis period)

11.CONCLUSIONS/RECOMMENDATIONS

Based on analyses performed for this study, both Tower Terrace Rd and N Center Point Rd intersection alternatives (roundabout or traffic signal) provide acceptable opening year and design year traffic operations. Although the signal alternative has lower initial construction costs, future improvements needed for this alternative to accommodate projected 2040 traffic would be more expensive than for the roundabout alternative. Total initial plus future estimated project cost for the roundabout alternative is approximately $340,000 (8%) more than the signal alternative.

Considering life-cycle costs for transportation system users over the 20-year analysis period, the roundabout alternative is projected to provide more than $15 million in cost savings compared to the signal alternative, including more than $2 million in safety benefits (vehicle crash and injury reductions). Therefore, the roundabout alternative is recommended as the preferred alternative.

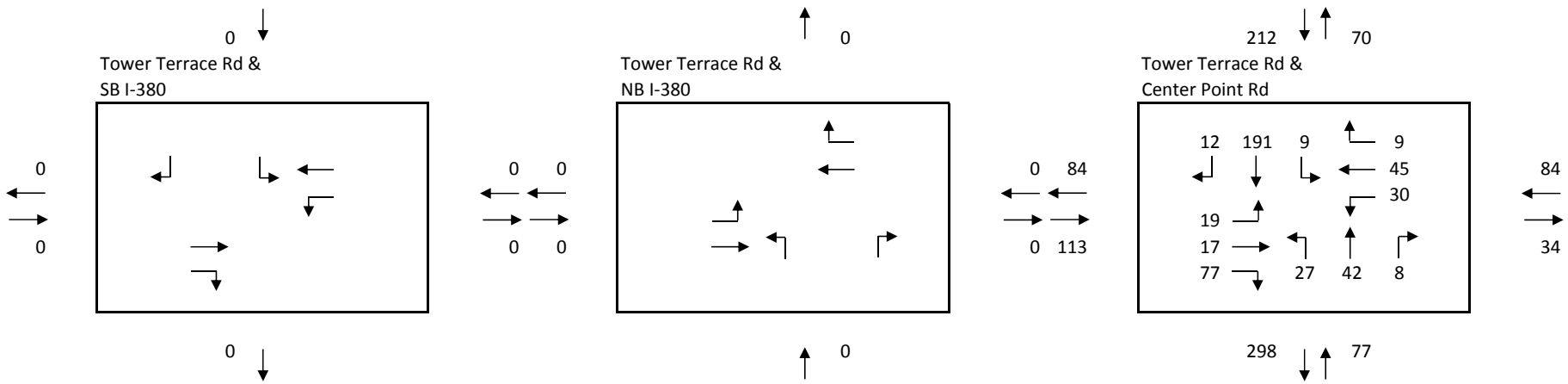
Due to opening year lane configurations needed for the interchange and the N Center Point Rd intersection, Tower Terrace Rd should be constructed as four-lane divided street west of N Center Point Rd. Providing four continuous through lanes with initial construction will avoid potential operational and safety issues associated with lane drops (merges) as well as future construction costs for this segment.

After the interchange and N Center Point Rd intersection are opened to traffic, traffic operations should be periodically evaluated to determine when additional intersection improvements may be needed. Based on projected traffic growth, the proposed design year improvements may be needed within 10-15 years after the opening year. This is consistent with recommended design practice for roundabouts, minimizing the number of lanes initially to optimize safety, but designing for future expandability.

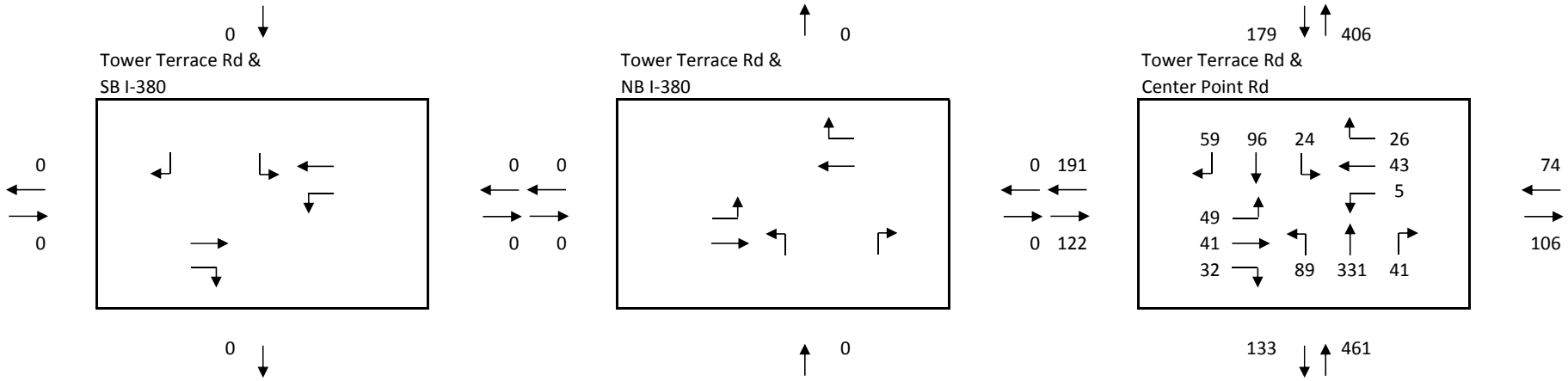
APPENDIX A

Peak Hour Traffic Volume Exhibits

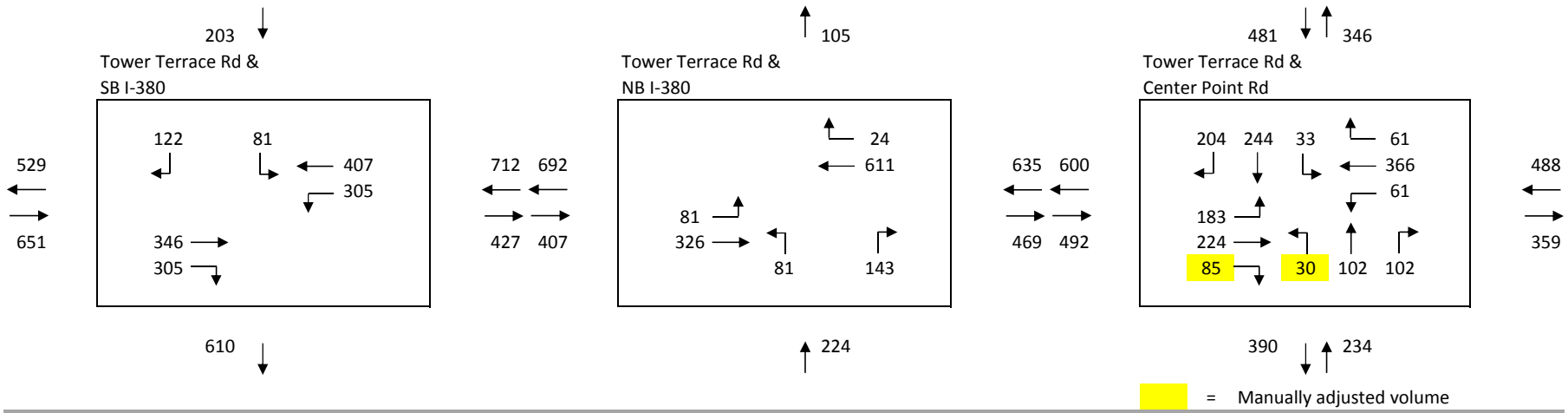
2017 - AM PEAK



2017 - PM PEAK

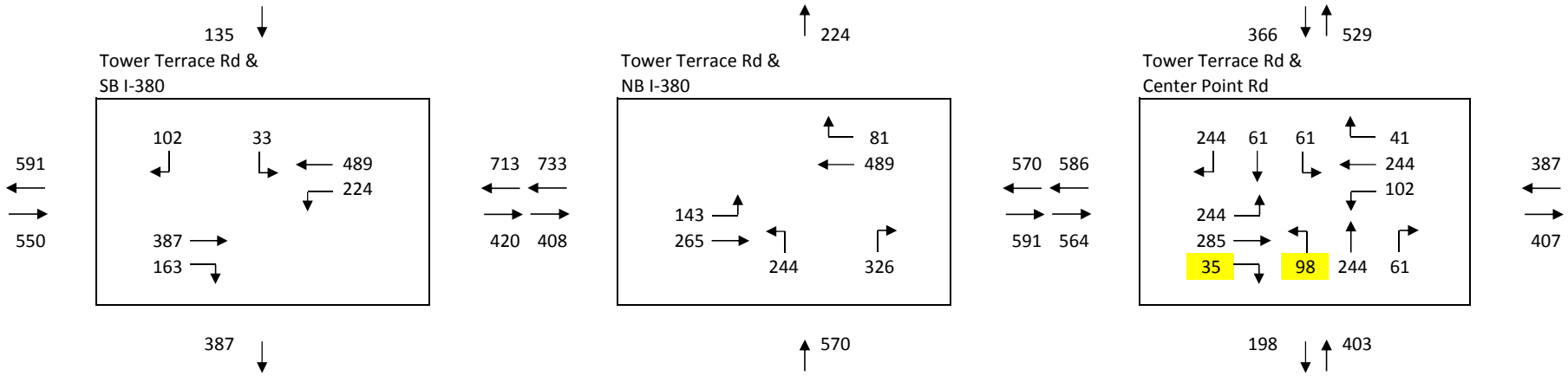


2023 - AM PEAK

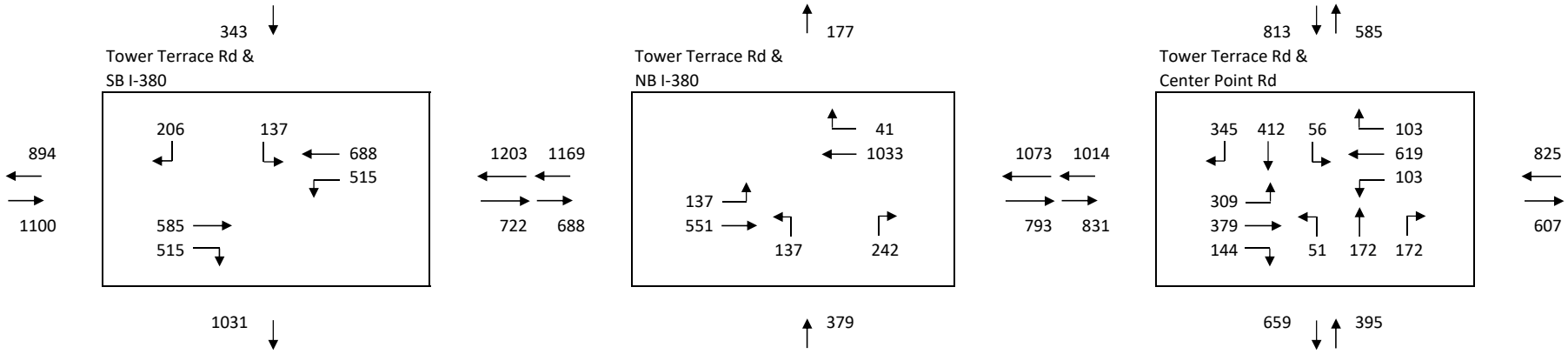


= Manually adjusted volume

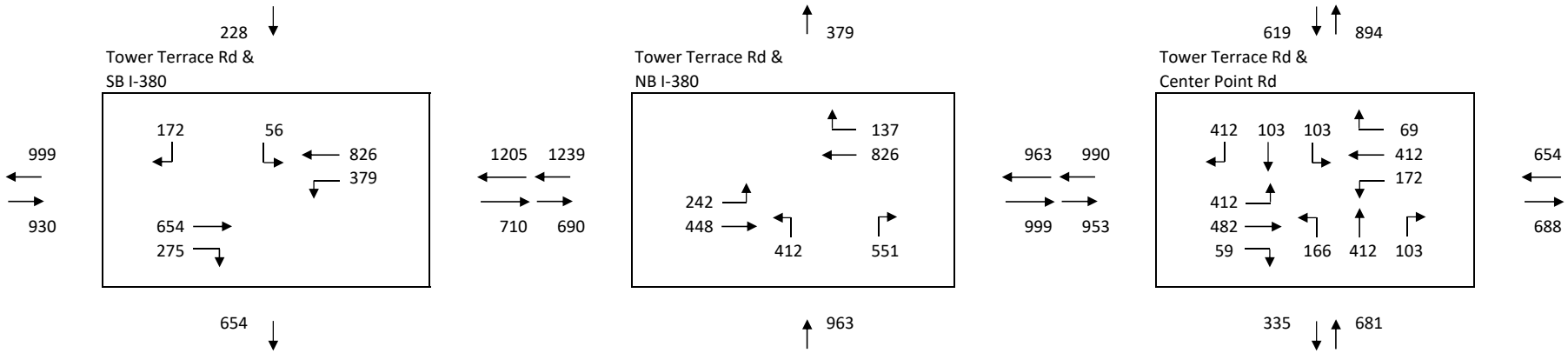
2023 - PM PEAK



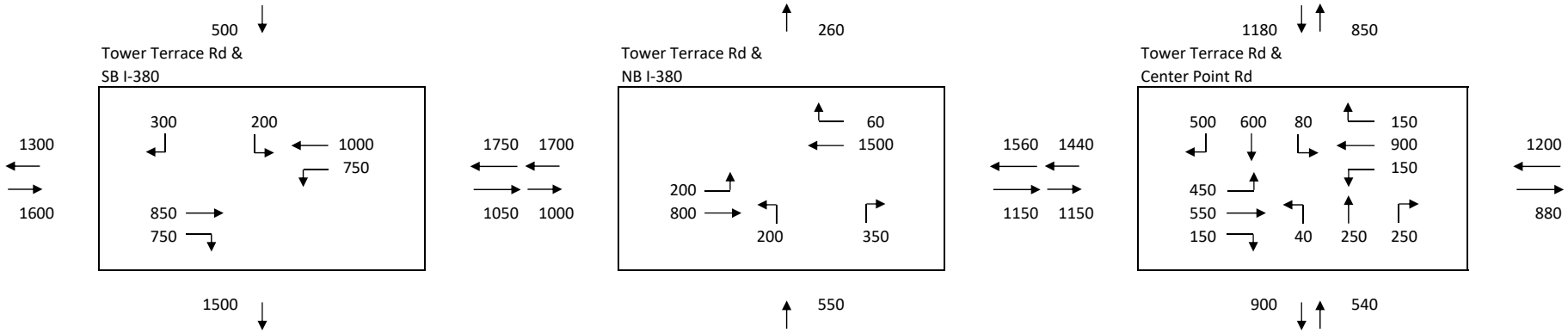
2033 - AM PEAK



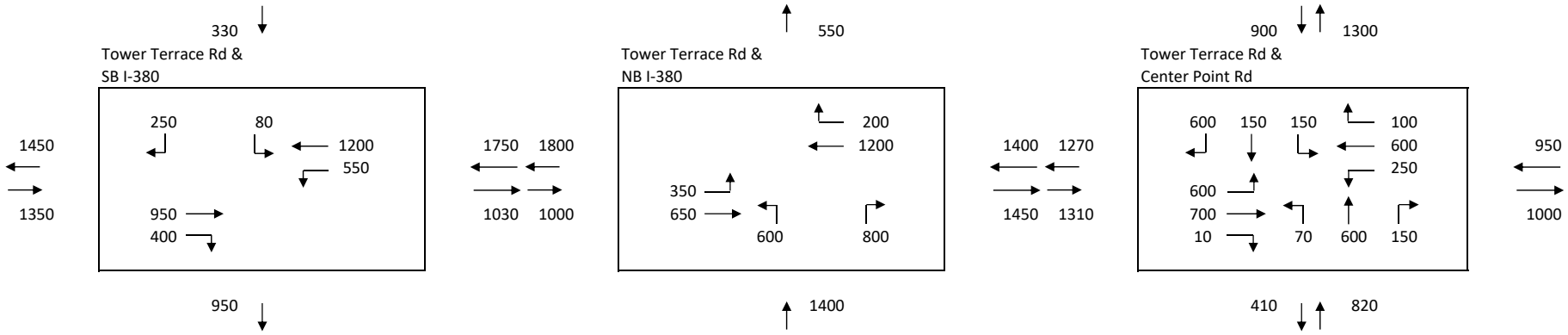
2033 - PM PEAK



2040 - AM PEAK

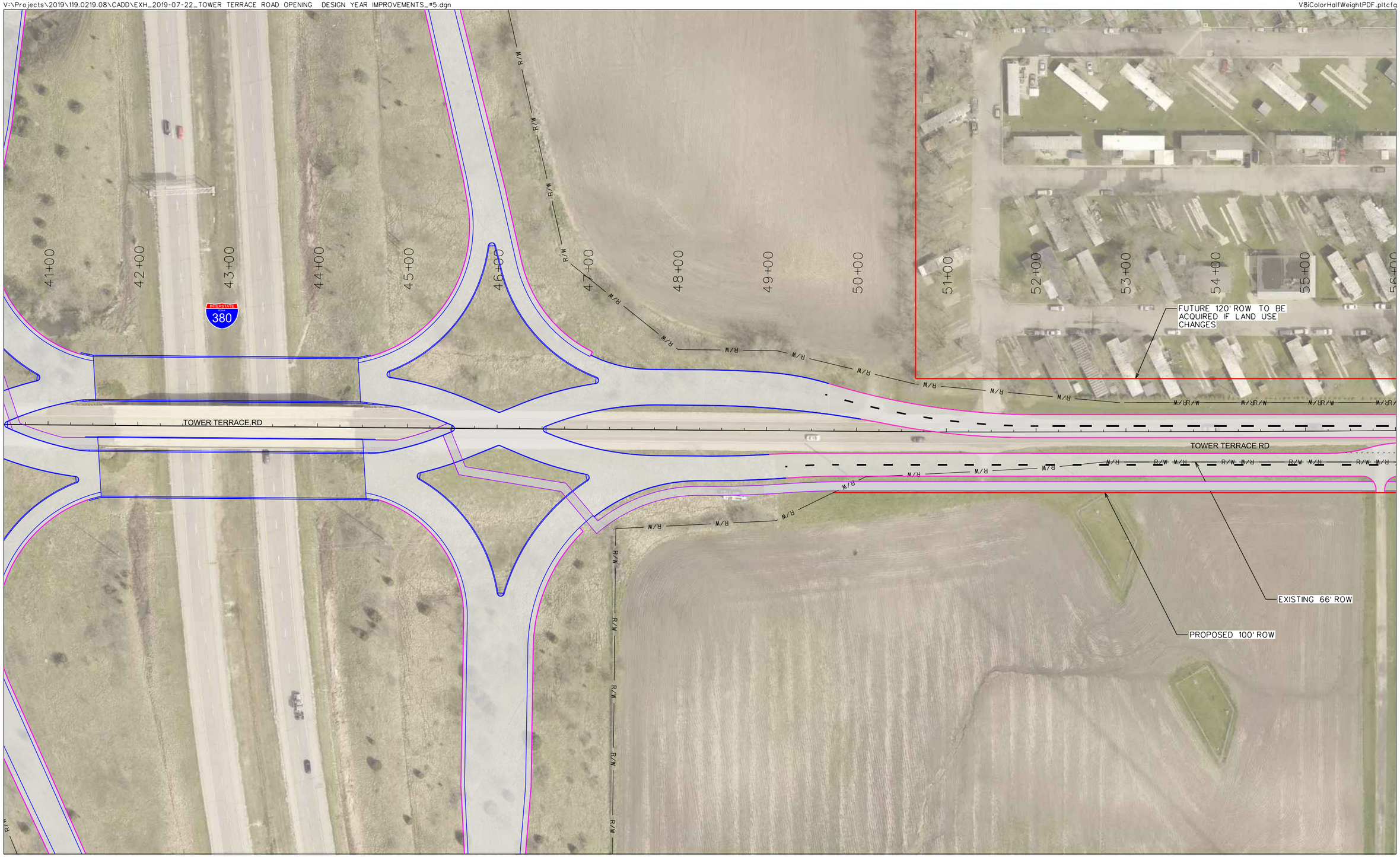


2040 - PM PEAK



APPENDIX B

Improvement Alternative Exhibits



SNYDER & ASSOCIATES

0 50 100
FEET

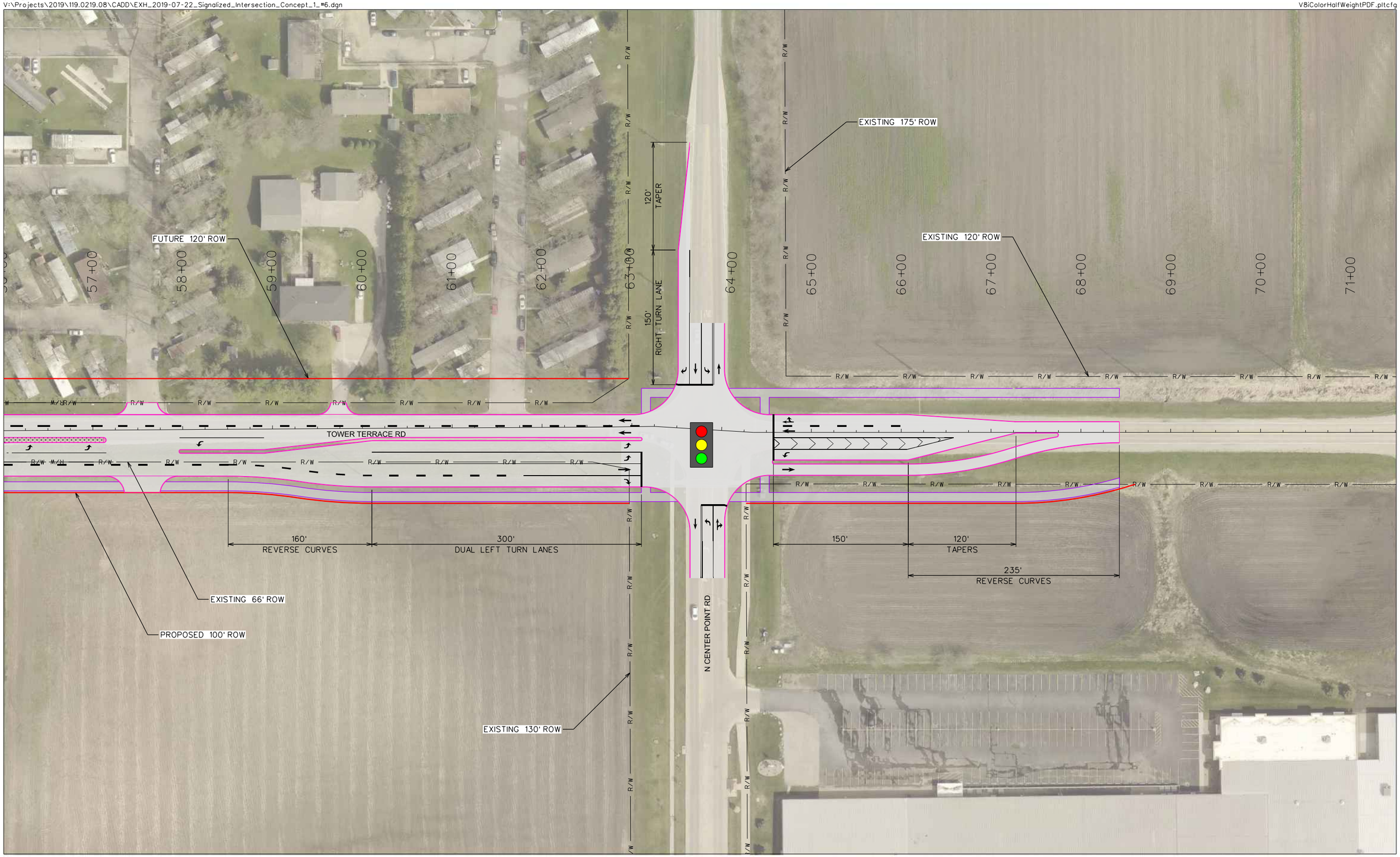
N

TOWER TERRACE RD RECONSTRUCTION
I-380 TO N CENTER POINT RD

Hiawatha, Iowa

EXHIBIT - 5: TOWER TERRACE ROAD IMPROVEMENTS

08/02/2019



SNYDER & ASSOCIATES

0 50 100
FEET

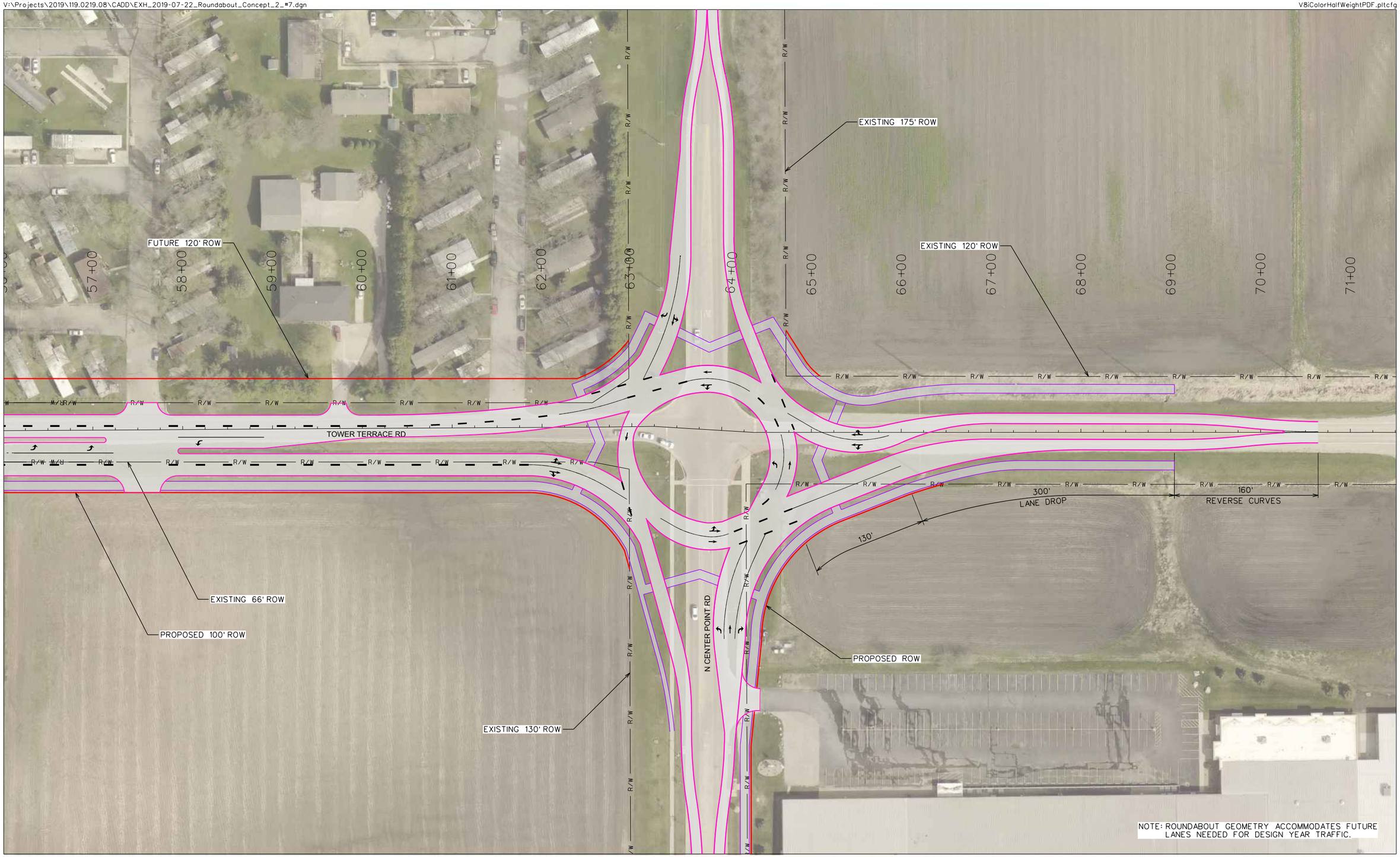
N

TOWER TERRACE RD RECONSTRUCTION
I-380 TO N CENTER POINT RD

Hiawatha, Iowa

EXHIBIT - 6: SIGNALIZED INTERSECTION CONCEPT - OPENING YEAR

08/02/2019



SNYDER & ASSOCIATES

0 50 100
FEET

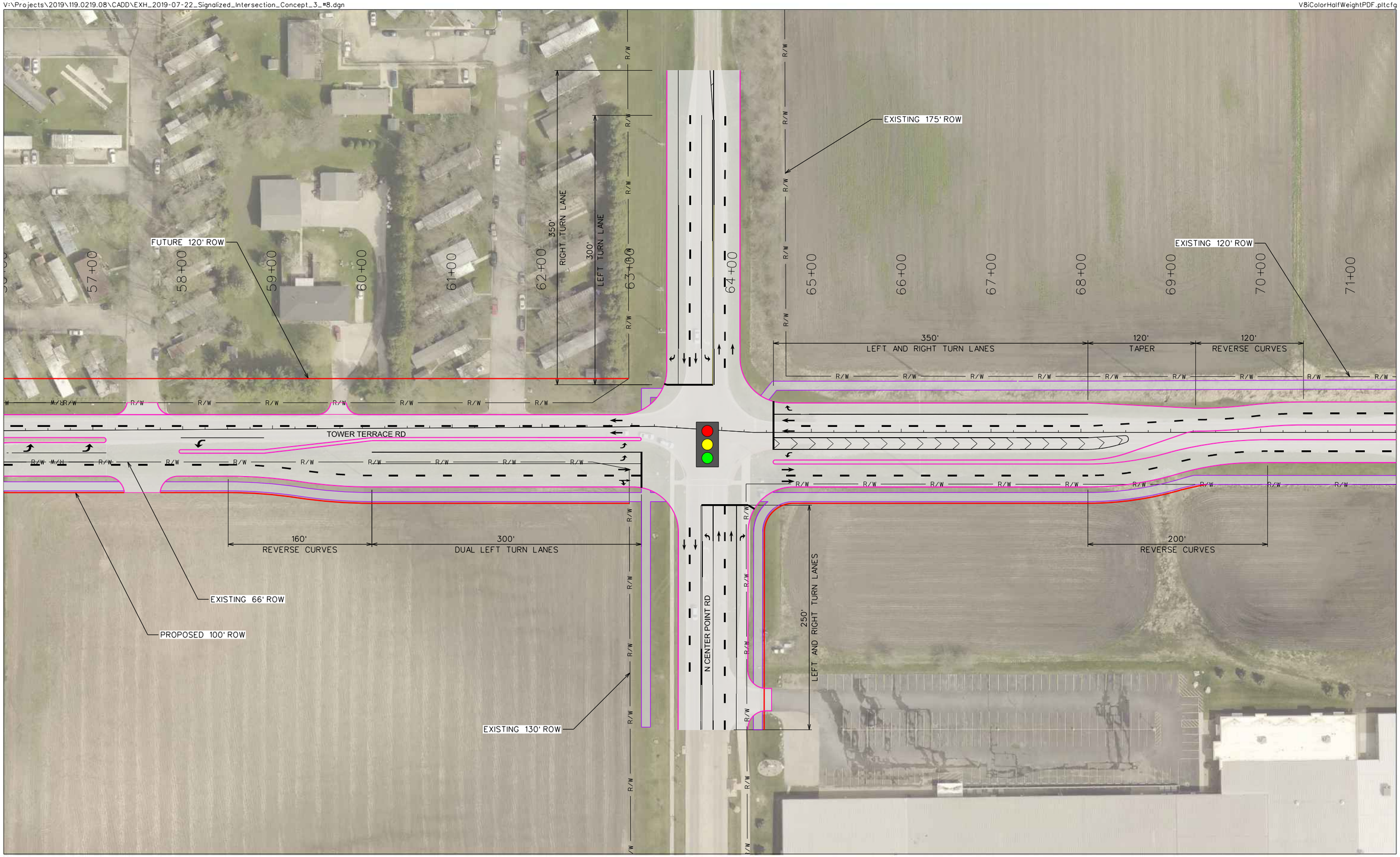
N

TOWER TERRACE RD RECONSTRUCTION
I-380 TO N CENTER POINT RD

Hiawatha, Iowa

EXHIBIT - 7: ROUNDABOUT CONCEPT - OPENING YEAR

08/02/2019



SNYDER & ASSOCIATES

0 50 100
FEET

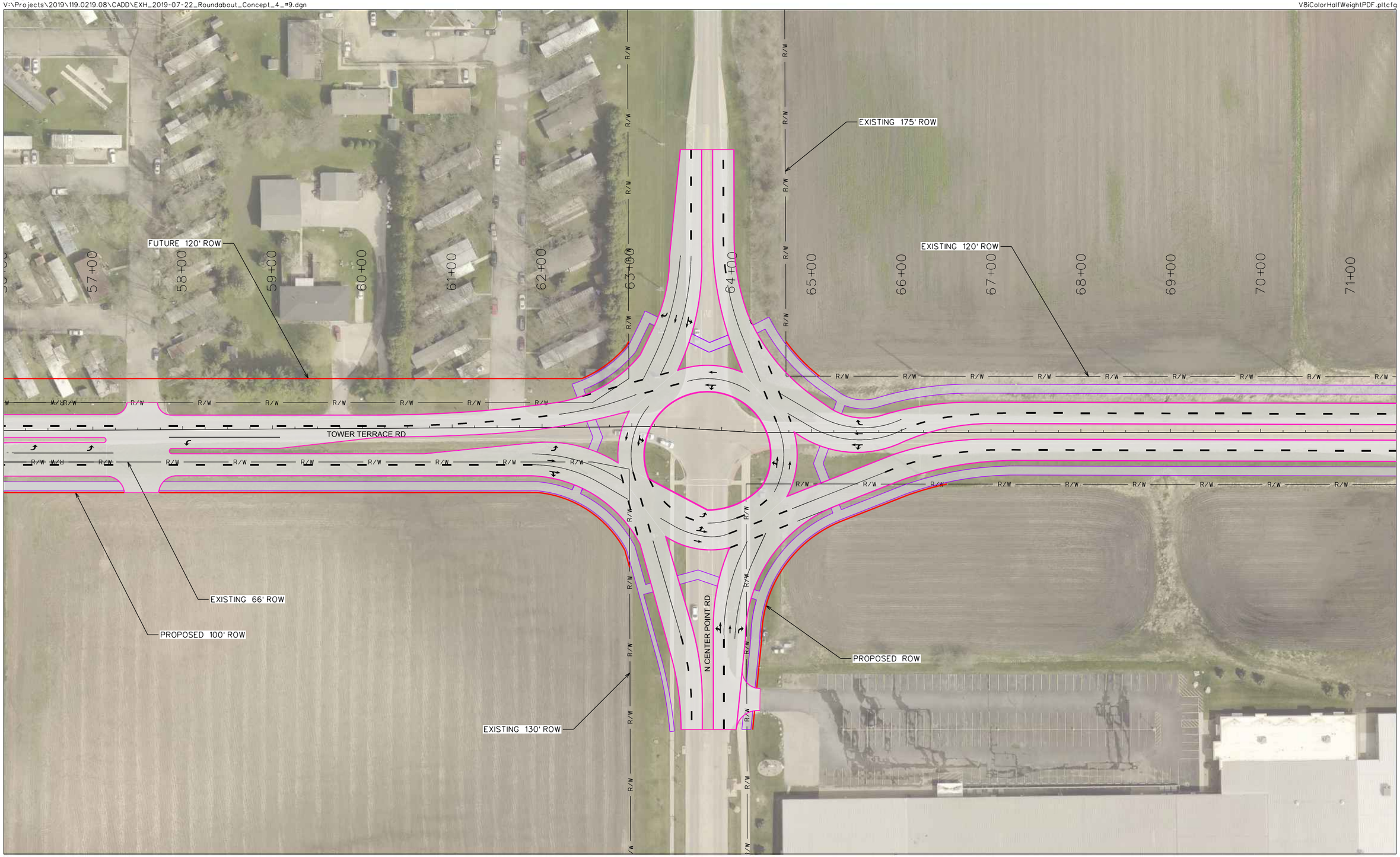
N

TOWER TERRACE RD RECONSTRUCTION
I-380 TO N CENTER POINT RD

Hiawatha, Iowa

EXHIBIT - 8: SIGNALIZED INTERSECTION CONCEPT - DESIGN YEAR

08/02/2019



SNYDER & ASSOCIATES

0 50 100
FEET

N

TOWER TERRACE RD RECONSTRUCTION
I-380 TO N CENTER POINT RD

Hiawatha, Iowa

EXHIBIT - 9: ROUNDABOUT CONCEPT - DESIGN YEAR

08/02/2019

APPENDIX C

Improvement Alternative Cost Opinions

7/26/2019

Engineer's Preliminary Opinion of Probable Project Costs

Tower Terrace Rd, I-380 to N Center Point Rd

Roundabout Alternative - Opening Year

City of Hiawatha, Iowa

Snyder & Associates Project No. 119.0219

Item Number	Item Description	Estimated Quantity	Unit	Unit Price	Total Amount
1	Clearing & Grubbing	1	LS	$12,000	$12,000
2	Excavation	13,600	CY	$15	$204,000
3	Storm Sewer	3,670	LF	$100	$367,000
4	Intakes and Manholes	21	EA	$5,500	$115,500
5	Subdrain	5,970	LF	$15	$89,550
6	PCC Pavement	18,030	SY	$80	$1,442,400
7	Sidewalk/ Trail Pavement	2,820	SY	$55	$155,100
8	Pavement Removal	13,540	SY	$10	$135,400
9	Roundabout Lighting	1	LS	$68,000	$68,000
10	Traffic Control	1	LS	$60,000	$60,000
11	Seeding & Mulching	1	LS	$15,000	$15,000
12	Erosion Control	1	LS	$25,000	$25,000
13	Mobilization	1	LS	$150,000	$150,000
14	Pavement Markings	1	LS	$25,000	$25,000

Subtotal	**$**	**2,863,950**
Misc. & Contingency (20% +/-)	**$**	**572,790**
Construction Total	**$**	**3,436,740**
Design and Construction Engineering (20%+/-)	**$**	**687,000**
Right-of-Way Acquistion	**$**	**71,000**
Total Project Cost	**$**	**4,194,740**

7/26/2019

Engineer's Preliminary Opinion of Probable Project Costs

Tower Terrace Rd, I-380 to N Center Point Rd

Signalized Intersection Alternative - Opening Year

City of Hiawatha, Iowa

Snyder & Associates Project No. 119.0219

Item Number	Item Description	Estimated Quantity	Unit	Unit Price	Total Amount
1	Clearing & Grubbing	1	LS	$10,000	$10,000
2	Excavation	9,000	CY	$15	$135,000
3	Storm Sewer	2,470	LF	$100	$247,000
4	Intakes and Manholes	15	EA	$5,500	$82,500
5	Subdrain	3,970	LF	$15	$59,550
6	PCC Pavement	13,000	SY	$80	$1,040,000
7	Sidewalk/ Trail Pavement	2,820	SY	$55	$155,100
8	Pavement Removal	6,930	SY	$10	$69,300
9	Traffic Signal	1	LS	$250,000	$250,000
10	Traffic Control	1	LS	$50,000	$50,000
11	Seeding & Mulching	1	LS	$10,000	$10,000
12	Erosion Control	1	LS	$20,000	$20,000
13	Mobilization	1	LS	$110,000	$110,000
14	Pavement Markings	1	LS	$20,000	$20,000

Subtotal	**$**	**2,258,450**
Misc. & Contingency (20% +/-)	**$**	**451,690**
Construction Total	**$**	**2,710,140**
Design and Construction Engineering (20%+/-)	**$**	**542,000**
Right-of-Way Acquistion	**$**	**60,000**
Total Project Cost	**$**	**3,312,140**

8/1/2019

Engineer's Preliminary Opinion of Probable Project Costs

Tower Terrace Rd, I-380 to N Center Point Rd

Roundabout Alternative - Design Year

City of Hiawatha, Iowa

Snyder & Associates Project No. 119.0219

Item Number	Item Description	Estimated Quantity	Unit	Unit Price	Total Amount
1	Clearing & Grubbing	1	LS	$1,000	$1,000
2	Excavation	800	CY	$15	$12,000
3	Storm Sewer	48	LF	$100	$4,800
4	Intakes and Manholes	4	EA	$5,500	$22,000
5	Subdrain	550	LF	$15	$8,250
6	PCC Pavement	2,270	SY	$80	$181,600
7	Sidewalk/ Trail Pavement	20	SY	$55	$1,100
8	Pavement Removal	2,800	SY	$10	$28,000
9	Roundabout Lighting	1	LS	$2,000	$2,000
10	Traffic Control	1	LS	$25,000	$25,000
11	Seeding & Mulching	1	LS	$2,000	$2,000
12	Erosion Control	1	LS	$5,000	$5,000
13	Mobilization	1	LS	$35,000	$35,000
14	Pavement Markings	1	LS	$5,000	$5,000

Subtotal	**$**	**332,750**
Misc. & Contingency (20% +/-)	**$**	**66,550**
Construction Total	**$**	**399,300**
Design and Construction Engineering (20%+/-)	**$**	**80,000**
Right-of-Way Acquistion	**$**	**-**
Total Project Cost	**$**	**479,300**

8/1/2019

Engineer's Preliminary Opinion of Probable Project Costs

Tower Terrace Rd, I-380 to N Center Point Rd

Signalized Intersection Alternative - Design Year

City of Hiawatha, Iowa

Snyder & Associates Project No. 119.0219

Item Number	Item Description	Estimated Quantity	Unit	Unit Price	Total Amount
1	Clearing & Grubbing	1	LS	$2,000	$2,000
2	Excavation	1,640	CY	$15	$24,600
3	Storm Sewer	72	LF	$100	$7,200
4	Intakes and Manholes	6	EA	$5,500	$33,000
5	Subdrain	1,110	LF	$15	$16,650
6	PCC Pavement	5,480	SY	$80	$438,400
7	Sidewalk/ Trail Pavement	350	SY	$55	$19,250
8	Pavement Removal	1,790	SY	$10	$17,900
9	Traffic Signal	1	LS	$50,000	$50,000
10	Traffic Control	1	LS	$25,000	$25,000
11	Seeding & Mulching	1	LS	$3,000	$3,000
12	Erosion Control	1	LS	$7,000	$7,000
13	Mobilization	1	LS	$50,000	$50,000
14	Pavement Markings	1	LS	$10,000	$10,000

Subtotal	**$**	**704,000**
Misc. & Contingency (20% +/-)	**$**	**140,800**
Construction Total	**$**	**844,800**
Design and Construction Engineering (20%+/-)	**$**	**169,000**
Right-of-Way Acquistion	**$**	**9,000**
Total Project Cost	**$**	**1,022,800**

APPENDIX D

VISSIM Analysis Results

TTR Roundabout Concept 1 - 2033 AM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	51	58	0.95	7	A	0	37
		Thru	172	170	0.15	6	A	1	85
		Right	172	169	0.23	1	A	0	0
		Total	**395**	**397**	**0.10**	**4**	**A**	**-**	**-**
	SB	Left	56	56	0.00	20	C	20	288
		Thru	412	407	0.25	14	B	19	286
		Right	345	335	0.54	2	A	0	0
		Total	**813**	**798**	**0.53**	**9**	**A**	**-**	**-**
	EB	Left	309	301	0.46	23	C	40	336
		Thru	379	366	0.67	8	A	40	334
		Right	144	134	0.85	5	A	2	204
		Total	**832**	**801**	**1.08**	**13**	**B**	**-**	**-**
	WB	Left	103	102	0.10	11	B	4	110
		Thru	619	625	0.24	6	A	8	150
		Right	103	95	0.80	8	A	5	150
		Total	**825**	**822**	**0.10**	**7**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2865**	**2818**	**0.88**	**9**	**A**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	137	156	1.57	25	C	21	163
		Right	242	247	0.32	12	B	11	107
		Total	**379**	**403**	**1.21**	**17**	**B**	**-**	**-**
	EB	Left	137	151	1.17	3	A	-	-
		Thru	551	532	0.82	14	B	22	193
		Total	**688**	**683**	**0.19**	**12**	**B**	-	-
	WB	Thru	1033	1105	2.20	15	B	40	352
		Right	41	55	2.02	2	A	-	-
		Total	**1074**	**1160**	**2.57**	**15**	**B**	**-**	**-**
	INTERSECTION TOTAL		**2141**	**2246**	**2.24**	**14**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	137	124	1.14	7	A	3	49
		Right	206	204	0.14	4	A	0	94
		Total	**343**	**328**	**0.82**	**5**	**A**	**-**	**-**
	EB	Thru	585	563	0.92	36	D	59	259
		Right	515	513	0.09	4	A	-	-
		Total	**1100**	**1076**	**0.73**	**21**	**C**	**-**	**-**
	WB	Left	515	550	1.52	4	A	-	-
		Thru	688	706	0.68	9	A	14	219
		Total	**1203**	**1256**	**1.51**	**7**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2646**	**2660**	**0.27**	**12**	**B**	**0**	**0**

TTR Roundabout Concept 1 - 2033 PM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	166	166	0.00	17	C	6	149
		Thru	412	426	0.68	14	B	13	256
		Right	103	102	0.10	5	A	0	0
		Total	**681**	**694**	**0.50**	**13**	**B**	**-**	**-**
	SB	Left	103	99	0.40	12	B	3	71
		Thru	103	93	1.01	5	A	3	70
		Right	412	411	0.05	2	A	0	55
		Total	**618**	**603**	**0.61**	**4**	**A**	**-**	**-**
	EB	Left	412	421	0.44	19	C	38	335
		Thru	482	489	0.32	4	A	37	334
		Right	59	57	0.26	3	A	0	64
		Total	**953**	**967**	**0.45**	**11**	**B**	**-**	**-**
	WB	Left	172	178	0.45	34	D	35	226
		Thru	412	420	0.39	18	C	36	224
		Right	69	62	0.86	13	B	10	138
		Total	**653**	**660**	**0.27**	**22**	**C**	**-**	**-**
	INTERSECTION TOTAL		**2905**	**2924**	**0.35**	**12**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	412	443	1.50	31	C	52	219
		Right	551	566	0.63	14	B	25	212
		Total	**963**	**1009**	**1.46**	**22**	**C**	**-**	**-**
	EB	Left	242	227	0.98	3	A	-	-
		Thru	448	447	0.05	8	A	11	68
		Total	**690**	**674**	**0.61**	**6**	**A**	**-**	**-**
	WB	Thru	826	833	0.24	14	B	28	177
		Right	137	135	0.17	2	A	-	-
		Total	**963**	**968**	**0.16**	**12**	**B**	**-**	**-**
	INTERSECTION TOTAL		**2616**	**2651**	**0.68**	**14**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	56	52	0.54	6	A	1	47
		Right	172	171	0.08	4	A	0	46
		Total	**228**	**223**	**0.33**	**4**	**A**	**-**	**-**
	EB	Thru	654	621	1.31	33	C	59	212
		Right	275	277	0.12	4	A	-	-
		Total	**929**	**898**	**1.03**	**24**	**C**	**-**	**-**
	WB	Left	379	395	0.81	3	A	-	-
		Thru	826	881	1.88	8	A	12	195
		Total	**1205**	**1276**	**2.02**	**6**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2362**	**2397**	**0.72**	**13**	**B**	**0**	**0**

TTR Signal - 2033 AM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	51	58	0.95	19	B	7	110
		Thru	172	171	0.08	25	C	33	234
		Right	172	169	0.23	17	B	35	238
		Total	**395**	**398**	**0.15**	**21**	**C**	**-**	**-**
	SB	Left	56	56	0.00	16	B	4	88
		Thru	412	409	0.15	25	C	54	303
		Right	345	334	0.60	6	A	3	101
		Total	**813**	**799**	**0.49**	**17**	**B**	**-**	**-**
	EB	Left	309	306	0.17	41	D	44	173
		Thru	379	367	0.62	20	C	37	258
		Right	144	129	1.28	12	B	9	191
		Total	**832**	**802**	**1.05**	**27**	**C**	**-**	**-**
	WB	Left	103	101	0.20	17	B	7	89
		Thru	619	622	0.12	28	C	55	266
		Right	103	95	0.80	18	B	45	237
		Total	**825**	**818**	**0.24**	**26**	**C**	**-**	**-**
	INTERSECTION TOTAL		**2865**	**2817**	**0.90**	**23**	**C**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	137	156	1.57	27	C	23	118
		Right	242	247	0.32	12	B	11	105
		Total	**379**	**403**	**1.21**	**18**	**B**	**-**	**-**
	EB	Left	137	153	1.33	3	A	-	-
		Thru	551	537	0.60	18	B	29	254
		Total	**688**	**690**	**0.08**	**15**	**B**	-	-
	WB	Thru	1033	1103	2.14	8	A	17	157
		Right	41	55	2.02	1	A	-	-
		Total	**1074**	**1158**	**2.51**	**8**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2141**	**2251**	**2.35**	**12**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	137	124	1.14	8	A	3	63
		Right	206	204	0.14	3	A	0	0
		Total	**343**	**328**	**0.82**	**5**	**A**	**-**	**-**
	EB	Thru	585	567	0.75	33	C	54	253
		Right	515	512	0.13	4	A	-	-
		Total	**1100**	**1079**	**0.64**	**20**	**C**	**-**	**-**
	WB	Left	515	549	1.47	3	A	-	-
		Thru	688	708	0.76	13	B	23	257
		Total	**1203**	**1257**	**1.54**	**9**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2646**	**2664**	**0.35**	**13**	**B**	**0**	**0**

TTR Signal - 2033 PM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	166	165	0.08	20	C	4	74
		Thru	412	425	0.64	30	C	19	538
		Right	103	102	0.10	27	C	0	0
		Total	**681**	**692**	**0.42**	**27**	**C**	**-**	**-**
	SB	Left	103	99	0.40	15	B	2	87
		Thru	103	93	1.01	21	C	2	85
		Right	412	412	0.00	6	A	0	30
		Total	**618**	**604**	**0.57**	**10**	**B**	**-**	**-**
	EB	Left	412	423	0.54	39	D	23	237
		Thru	482	486	0.18	34	C	23	236
		Right	59	57	0.26	6	A	0	80
		Total	**953**	**966**	**0.42**	**35**	**D**	**-**	**-**
	WB	Left	172	178	0.45	20	C	58	265
		Thru	412	418	0.29	32	C	58	264
		Right	69	62	0.86	18	B	18	237
		Total	**653**	**658**	**0.20**	**28**	**C**	**-**	**-**
	INTERSECTION TOTAL		**2905**	**2920**	**0.28**	**26**	**C**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	412	441	1.40	28	C	46	212
		Right	551	566	0.63	14	B	24	187
		Total	**963**	**1007**	**1.40**	**20**	**C**	**-**	**-**
	EB	Left	242	229	0.85	3	A	-	-
		Thru	448	446	0.09	8	A	12	87
		Total	**690**	**675**	**0.57**	**6**	**A**	-	-
	WB	Thru	826	836	0.35	10	B	29	232
		Right	137	136	0.09	2	A	-	-
		Total	**963**	**972**	**0.29**	**9**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2616**	**2654**	**0.74**	**12**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	56	52	0.54	6	A	2	48
		Right	172	171	0.08	5	A	0	23
		Total	**228**	**223**	**0.33**	**5**	**A**	**-**	**-**
	EB	Thru	654	624	1.19	33	C	61	220
		Right	275	277	0.12	4	A	-	-
		Total	**929**	**901**	**0.93**	**24**	**C**	**-**	**-**
	WB	Left	379	398	0.96	2	A	-	-
		Thru	826	878	1.78	11	B	14	216
		Total	**1205**	**1276**	**2.02**	**8**	**A**	**-**	**-**
	INTERSECTION TOTAL		**2362**	**2400**	**0.78**	**14**	**B**	**0**	**0**

TTR Roundabout Concept 1 - 2040 AM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	40	36	0.65	15	C	2	60
		Thru	250	250	0.00	4	A	1	59
		Right	250	249	0.06	2	A	0	0
		Total	**540**	**535**	**0.22**	**4**	**A**	**-**	**-**
	SB	Left	80	69	1.27	13	B	11	253
		Thru	600	601	0.04	11	B	12	250
		Right	500	486	0.63	6	A	1	92
		Total	**1180**	**1156**	**0.70**	**9**	**A**	**-**	**-**
	EB	Left	450	438	0.57	18	C	29	332
		Thru	550	546	0.17	6	A	1	111
		Right	150	137	1.09	6	A	1	111
		Total	**1150**	**1121**	**0.86**	**11**	**B**	**-**	**-**
	WB	Left	150	126	2.04	20	C	27	279
		Thru	900	897	0.10	10	B	28	278
		Right	150	130	1.69	1	A	0	0
		Total	**1200**	**1153**	**1.37**	**10**	**B**	**-**	**-**
	INTERSECTION TOTAL		**4070**	**3965**	**1.66**	**9**	**A**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	200	220	1.38	23	C	20	143
		Right	350	344	0.32	16	B	20	153
		Total	**550**	**564**	**0.59**	**19**	**B**	**-**	**-**
	EB	Left	200	221	1.45	3	A	-	-
		Thru	800	808	0.28	10	B	19	341
		Total	**1000**	**1029**	**0.91**	**8**	**A**	-	-
	WB	Thru	1500	1546	1.18	25	C	95	565
		Right	60	69	1.12	5	A	-	-
		Total	**1560**	**1615**	**1.38**	**25**	**C**	**-**	**-**
	INTERSECTION TOTAL		**3110**	**3208**	**1.74**	**18**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	200	193	0.50	10	B	6	70
		Right	300	297	0.17	6	A	1	96
		Total	**500**	**490**	**0.45**	**8**	**A**	**-**	**-**
	EB	Thru	850	828	0.76	34	C	75	271
		Right	750	742	0.29	7	A	-	-
		Total	**1600**	**1570**	**0.75**	**22**	**C**	**-**	**-**
	WB	Left	750	758	0.29	6	A	-	-
		Thru	1000	1003	0.09	17	B	45	329
		Total	**1750**	**1761**	**0.26**	**13**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3850**	**3821**	**0.47**	**16**	**B**	**0**	**0**

TTR Roundabout Concept 1 - 2040 PM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	70	66	0.49	36	E	14	144
		Thru	600	585	0.62	12	B	17	143
		Right	150	132	1.52	1	A	0	0
		Total	**820**	**783**	**1.31**	**12**	**B**	**-**	**-**
	SB	Left	150	166	1.27	9	A	3	80
		Thru	150	155	0.40	5	A	3	79
		Right	600	617	0.69	3	A	0	45
		Total	**900**	**938**	**1.25**	**4**	**A**	**-**	**-**
	EB	Left	600	619	0.77	12	B	22	330
		Thru	700	724	0.90	3	A	1	65
		Right	10	10	0.00	1	A	0	65
		Total	**1310**	**1353**	**1.18**	**7**	**A**	**-**	**-**
	WB	Left	250	232	1.16	69	F	122	501
		Thru	600	602	0.08	27	D	122	500
		Right	100	109	0.88	2	A	0	0
		Total	**950**	**943**	**0.23**	**35**	**E**	**-**	**-**
	INTERSECTION TOTAL		**3980**	**4017**	**0.59**	**14**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	600	619	0.77	27	C	44	308
		Right	800	831	1.09	14	B	13	146
		Total	**1400**	**1450**	**1.32**	**19**	**B**	**-**	**-**
	EB	Left	350	337	0.70	3	A	-	-
		Thru	650	657	0.27	7	A	10	109
		Total	**1000**	**994**	**0.19**	**6**	**A**	**-**	**-**
	WB	Thru	1200	1210	0.29	20	C	58	348
		Right	200	195	0.36	6	A	-	-
		Total	**1400**	**1405**	**0.13**	**18**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3800**	**3849**	**0.79**	**15**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	80	83	0.33	9	A	3	70
		Right	250	233	1.09	8	A	2	89
		Total	**330**	**316**	**0.78**	**8**	**A**	**-**	**-**
	EB	Thru	950	909	1.34	34	C	82	284
		Right	400	419	0.94	7	A	-	-
		Total	**1350**	**1328**	**0.60**	**25**	**C**	**-**	**-**
	WB	Left	550	562	0.51	4	A	-	-
		Thru	1200	1267	1.91	14	B	44	390
		Total	**1750**	**1829**	**1.87**	**11**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3430**	**3473**	**0.73**	**16**	**B**	**0**	**0**

TTR Signal - 2040 AM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	40	36	0.65	21	C	3	47
		Thru	250	252	0.13	30	C	24	121
		Right	250	244	0.38	7	A	1	41
		Total	**540**	**532**	**0.35**	**19**	**B**	**-**	**-**
	SB	Left	80	69	1.27	26	C	9	87
		Thru	600	602	0.08	29	C	51	237
		Right	500	486	0.63	12	B	16	309
		Total	**1180**	**1157**	**0.67**	**21**	**C**	**-**	**-**
	EB	Left	450	437	0.62	32	C	44	207
		Thru	550	540	0.43	18	B	36	176
		Right	150	135	1.26	18	B	34	177
		Total	**1150**	**1112**	**1.13**	**23**	**C**	**-**	**-**
	WB	Left	150	127	1.95	10	B	5	67
		Thru	900	897	0.10	26	C	62	328
		Right	150	130	1.69	6	A	0	35
		Total	**1200**	**1154**	**1.34**	**22**	**C**	**-**	**-**
	INTERSECTION TOTAL		**4070**	**3955**	**1.82**	**22**	**C**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	200	220	1.38	25	C	21	143
		Right	350	344	0.32	15	B	19	128
		Total	**550**	**564**	**0.59**	**19**	**B**	**-**	**-**
	EB	Left	200	219	1.31	3	A	-	-
		Thru	800	809	0.32	14	B	27	237
		Total	**1000**	**1028**	**0.88**	**11**	**B**	**-**	**-**
	WB	Thru	1500	1545	1.15	17	B	48	239
		Right	60	69	1.12	3	A	-	-
		Total	**1560**	**1614**	**1.36**	**16**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3110**	**3206**	**1.71**	**15**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	200	193	0.50	10	B	6	70
		Right	300	297	0.17	6	A	1	88
		Total	**500**	**490**	**0.45**	**8**	**A**	**-**	**-**
	EB	Thru	850	828	0.76	36	D	79	294
		Right	750	745	0.18	8	A	-	-
		Total	**1600**	**1573**	**0.68**	**23**	**C**	**-**	**-**
	WB	Left	750	759	0.33	6	A	-	-
		Thru	1000	1006	0.19	19	B	49	332
		Total	**1750**	**1765**	**0.36**	**14**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3850**	**3828**	**0.36**	**17**	**B**	**0**	**0**

TTR Signal - 2040 PM Peak

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & N Center Point Rd	NB	Left	70	66	0.49	15	B	5	103
		Thru	600	585	0.62	30	C	53	217
		Right	150	132	1.52	7	A	0	36
		Total	**820**	**783**	**1.31**	**25**	**C**	**-**	**-**
	SB	Left	150	165	1.20	25	C	20	146
		Thru	150	154	0.32	23	C	12	84
		Right	600	617	0.69	12	B	20	322
		Total	**900**	**936**	**1.19**	**16**	**B**	**-**	**-**
	EB	Left	600	619	0.77	36	D	67	297
		Thru	700	727	1.01	33	C	67	278
		Right	10	11	0.31	41	D	63	272
		Total	**1310**	**1357**	**1.29**	**34**	**C**	**-**	**-**
	WB	Left	250	236	0.90	15	B	14	150
		Thru	600	602	0.08	30	C	51	236
		Right	100	109	0.88	7	A	0	49
		Total	**950**	**947**	**0.10**	**23**	**C**	**-**	**-**
	INTERSECTION TOTAL		**3980**	**4023**	**0.68**	**26**	**C**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & NB I-380 Ramps	NB	Left	600	617	0.69	27	C	43	225
		Right	800	830	1.05	14	B	14	146
		Total	**1400**	**1447**	**1.25**	**19**	**B**	**-**	**-**
	EB	Left	350	337	0.70	3	A	-	-
		Thru	650	658	0.31	8	A	12	108
		Total	**1000**	**995**	**0.16**	**6**	**A**	**-**	**-**
	WB	Thru	1200	1212	0.35	16	B	43	324
		Right	200	193	0.50	5	A	-	-
		Total	**1400**	**1405**	**0.13**	**15**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3800**	**3847**	**0.76**	**14**	**B**	**-**	**-**

Intersection	Approach	Movement	Input Volume (vph)	Modeled Volume (vph)	GEH	Avg Delay (s)	LOS	Avg Queue	Max Queue
Tower Terrace Rd & SB I-380 Ramps	SB	Left	80	83	0.33	10	B	3	70
		Right	250	233	1.09	8	A	2	89
		Total	**330**	**316**	**0.78**	**9**	**A**	**-**	**-**
	EB	Thru	950	911	1.28	32	C	77	276
		Right	400	419	0.94	7	A	-	-
		Total	**1350**	**1330**	**0.55**	**24**	**C**	**-**	**-**
	WB	Left	550	565	0.64	4	A	-	-
		Thru	1200	1270	1.99	15	B	47	469
		Total	**1750**	**1835**	**2.01**	**12**	**B**	**-**	**-**
	INTERSECTION TOTAL		**3430**	**3481**	**0.87**	**16**	**B**	**0**	**0**