CITY OF SPRING HILL, KS

TRAFFIC ENGINEERING ASSISTANCE PROGRAM: INTERSECTION REVIEW

199TH STREET & RIDGEVIEW ROAD IN SPRING HILL, KANSAS

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199TH STREET AND RIDGEVIEW ROAD IN SPRING HILL, KANSAS

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Kansas Department of Transportation

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1 INTRODUCTION AND SUMMARY

The Traffic Engineering Assistance Program (TEAP) provides a way for roadways not managed by the Kansas Department of Transportation (KDOT) to receive traffic analysis services at no cost to the local agency. Local jurisdictions apply for funds by describing their potential issues. If the application is selected, a consultant reviews the location, analyzes the data and develops feasible recommendations for the local jurisdiction to implement.

1.1 TEAP OVERVIEW

TEAP is administered by KDOT. The program provides federal funds to local municipalities and counties that have traffic engineering needs but do not typically have the staff or funds to investigate the issues. These funds are used on roadways and intersections that are generally not on state routes addressed by KDOT staff.

KDOT staff receive applications from across the state and select projects from the list of applicants. KDOT may select an entire application to be studied, or may decide to reduce the scope of the application so that only part of the initial application is analyzed based on available funding and resources at the time.

1.2 EXECUTIVE SUMMARY

This report provides analysis and recommendations for a TEAP Study requested by the Community Development Director of Spring Hill, KS. The study was initiated as a result of traffic delays during peak traffic conditions resulting in drivers making questionable judgements leading to numerous near-misses as well as a variety of crashes at the intersection of 199th Street & Ridgeview Road. The active development of many surrounding residential subdivisions has increased traffic at the intersection. The problem statement supplied by the City of Spring Hill, KS was addressed through a review of background data and field investigation followed by an analysis of operations and safety. Thus, issues were identified and specific recommendations were made to improve safety at the intersection.

EXISTING CONDITIONS REVIEW

Six (2005-2016) traffic impact studies from nearby developments were recently performed for residential development which were considered in the project analysis.

A review of the most recent five year (2012 – 2016) crash data within the study area shows that the intersection's crash rate was slightly higher than Kansas's average rural intersection, but was not above the statistically significant critical crash rate. The most frequent types of crashes at the intersection were side-angle impacts involving northbound drivers in the morning and southbound rear ends coinciding with the nearby school's release time.

A field review of typical traffic operations during a school day showed that conventional traffic rules were not always followed; drivers turning left from the eastbound direction would "wave on" the northbound through traffic, sometimes without knowing that it would be safe for the car to enter the intersection. This deviation from normal traffic rules caused many "close calls" that could easily have become crashes. Long queues were also observed for the eastbound left and northbound through movements during the AM peak hour, and for the northbound through movement during the school-related PM peak hour. In both cases, the queues dispersed within 15 minutes from the start of the vehicles stacking up.

PROPOSED TREATMENTS

This report identifies and provides analysis for several treatments to address the safety concerns for 199th Street & Ridgeview Road. The high-cost build and interim improvement alternatives were analyzed using Vissim microsimulation modeling to determine the amount of driver delay and level of service (LOS) expected by each option. The Highway Safety Manual (HSM) was used to determine the safety benefit from the reduction in crashes due to each of the build options.

<u>*Low-Cost Options*</u>

- Provide proper maintenance of the grassy area on all sides of the intersection, especially the southwest corner, since it was found to obstruct the sight of the northbound movements below the required minimum when the grass was unmowed.

- Staggering Spring Hill High School and Wolf Creek Elementary School's hours so that there is more than five minutes between the beginning and end of each school. This may increase the amount of time that the intersection needs to accommodate school traffic, but it will decrease the intensity of the traffic, which will increase the safety and operations of the intersection.

- Ticketing illegal movements through the intersection should minimize the number of drivers in the eastbound 199th Street left-turn lane who courteously "wave through" northbound traffic on Ridgeview. This could begin by first giving drivers a warning that it is illegal to do so.

- Encouraging drivers traveling to the elementary and high school to consider other routes or travel modes would also reduce the strain at the intersection. However, if too many all change their route in the same way, it may just displace the safety concerns at this intersection to another area in the city.

<u>*Medium-Cost Option*</u>

- Performing earthwork grading at the southwest corner of the intersection to lower the elevation of the ground to permanently increase the sight distance at the southwest corner.

High-Cost Option

- Currently, the traffic at the intersection does not warrant the installation of a traffic signal. The projection for 2037 traffic volumes based on the continual growth of the traffic and development of nearby subdivisions predicts that traffic signal warrants will be met in the future. However, just because signal warrants are met does not necessitate the installation of one. The Vissim microsimulation showed that the traffic signal alternative did not have an operational benefit over other options in 2037, and did not have a positive benefit-to-cost ratio based on the savings to the driving public from 20 years of reduced crashes. Therefore, the installation of a traffic signal at 199th Street & Ridgeview Road is not recommended at this or any time in the future.

- A single-lane modern roundabout layout was created that requires minimal acquisition of right-of-way and movement of utilities. The roundabout is expected to improve the operations during the AM peak hour, and throughout the day. The benefit-to-cost ratio based on the savings to the public over 20 years due to the decreased crash rate is 1.51. Therefore, this study recommends the installation of a single-lane modern roundabout as a permanent solution to the safety concerns for the intersection.

Since it may take many months or years to acquire adequate funding for the high-cost options, two interim options were investigated to determine their feasibility.

Interim Options

- The 2017 traffic for the intersection met the warrant for conversion to an all-way stop controlled intersection. The benefit-to-cost ratio for such a change is expected to be 151.43; however, it also quadrupled the average delay in 2017 which renders this options infeasible to be implemented.

- A layout for an accelerated low-cost roundabout was created that fits within the already paved area of the intersection. Accelerated low-cost roundabouts are a type of mini roundabout with a fully traversable center island and can be implemented quickly and relatively inexpensively compared to other options. Accelerated low-cost roundabouts tend to also have shorter design lives than other build options. If milling and overlay is performed prior to installation, it is expected that the roundabout will last eight years. If no mill or overlay is performed, the intersection will only last four years.

Cost estimates for each treatment are discussed in section 4 and itemized in the Appendix.

2 EXISTING CONDITIONS

The Community Development Director of Spring Hill, KS, Mr. Jim Hindershot, submitted a TEAP application requesting that a traffic study be performed at the intersection of 199th Street & Ridgeview Road. The problem statement reads:

"*This intersection is currently a two-way stop controlled intersection with east/west traffic on 199th Street having the right-of-way. Because of active subdivision development and the Spring Hill High School in the immediate vicinity, traffic experiences delays that are seen as unacceptable by the driving public. As a result, drivers tend to make questionable judgments leading to accidents or near crash results. Traffic counts are increasing with development and the High School will soon be constructing additional facilities including a sports complex.*"

Follow-up discussions with the City of Spring Hill staff, local law enforcement, and Spring Hill School District staff provided additional information regarding the following items:

- The jurisdiction for the intersection is split between Spring Hill (east half) and Johnson County (west half).
- KDOT plans to improve the US-169 & 199th Street intersection as a grade separated interchange facility when the traffic warrants improvement and funding is available.
- For the 2018 school year, the attendance boundaries for the Wolf Creek Elementary school will be changing; the attendance at the elementary school is expected to decrease substantially.
- The City of Spring Hill has been experiencing a relatively large growth rate, averaging 250 people per year (in 2014, its population was about 5,900).
- Based on observations of the intersections operations, student-aged drivers tend to make fewer unsafe driving maneuvers than their more experienced adult counterparts.
- Ridgeview Road is a popular bicycling route, especially from Garmin employees utilizing the road for mid-day cycling.
- While there may not be a large crash history at the intersection, there have been many close calls, and the driving public is cautious at the intersection—mainly during the school year.
- There are plans for Ridgeview Road to become a four-lane separated facility from 191st to 207th once both sides of Ridgeview Road are annexed by Spring Hill. This is part of the reason why there are few pedestrian facilities along Ridgeview Road.

The focus of this study will be to evaluate the most viable treatments to the intersection that will improve both safety and operations.

2.1 OVERVIEW OF STUDY AREA

The study area consists of the intersection at 199th Street & Ridgeview Road and surrounding developments. The intersection is currently a two-way stop controlled intersection, with STOP signs on the northbound and southbound approaches. All approaches at the intersection have 12-foot wide lanes, with one through/right-turn and one left-turn lane. The storage length is 185 feet for the southbound approach, 135 feet for the westbound approach, 175 feet for the northbound approach, and 320 feet for the eastbound approach. The posted speed limit of all approaches is 45 mph. Intersection warning signs exist east and west of the intersection on 199th Street with an advisory speed limit of 35 mph. The only sidewalk is on the east side of the southbound approach, which extends northward toward the schools.

North of the intersection, there are two schools: Spring Hill High School and Wolf Creek Elementary School. There is a 5-minute offset of the start and end times of these schools; the high school's hours are from 8:00 AM to 3:05 PM, while the elementary school's hours are from 8:05 AM to 3:10 PM. Thus, the morning and afternoon traffic peaks for both schools overlap. Spring Hill is a growing city, with new developments being added annually. The locations or the proposed developments around the intersection are shown in Figure 1.

Figure 1 – Map of Study Area

Source: Google Earth, 2017

2.2 REVIEW OF PREVIOUS TRAFFIC STUDIES

The City of Spring Hill, KS provided six recent studies to be considered in this TEAP study:

- Traffic Impact Study – Spring Hill High School, Spring Hill, Kansas (December, 2016)
- Traffic Impact Study – Rose Park (Boulder Springs) Residential Development (May, 2015)
- Traffic Impact Study – Ridgefield Residential Development (January, 2007)
- Revised Traffic Impact Study – Prairie Ridge Residential Development (September, 2006)
- Traffic Impact Study – Estates of Wolf Creek Residential Development (August, 2005)
- Traffic Impact Study – Biltmore Farms (Brookwood)Residential Development (August, 2005)

These studies focused on new developments or expansions at or near the 199th Street & Ridgeview Road intersection.

Traffic Impact Study Spring Hill High School – Olsson Associates

This study looked at the traffic impacts associated with the Spring Hill High School's proposed additional development. The expansion will accommodate 600 more students at the high school. This study gives the following recommendations, should the school continue with the proposed expansion:

- Traffic signal warrants for 199th Street & Ridgeview Road should be reviewed periodically as it is expected that the intersection will meet at least one warrant by 2037.
- If a traffic signal is installed, a right-turn lane on the southbound approach of 199th Street & Ridgeview Road should be installed.
- If traffic volumes increase, installation of a westbound right turn lane at 199th Street & Ridgeview Road should be considered.

It should be noted that the turning movement counts for this study were collected during Thanksgiving week on Tuesday, November 22, 2016; therefore, the traffic volumes used in the study may not have been representative of actual typical traffic at the intersection.

Rose Park (Boulder Springs) Traffic Impact Study – TranSystems

This study examined the traffic impacts on the traffic network produced by the Rose Park residential development, as proposed, located northwest of the 199th Street & Ridgeview Road intersection. This study generated trips onto 199th Street, however it had no recommendations for the study area. The land has been cleared to start construction; however, no buildings have been finished yet. The name of the subdivision was also changed from Rose Park to Boulder Springs.

Ridgefield Traffic Impact Study – Phelps Engineering Inc.

This study analyzed the potential traffic impacts resulting from the proposed Ridgefield residential subdivision, a subdivision to be developed south of 199th Street, east of the Ridgeview Road intersection. This study did not have any direct recommendations to the study area.

Revised Traffic Impact Study for Prairie Ridge Subdivision – Landplan Engineering

This study looked at the traffic impact of the Prairie Hill residential development, located slightly east of Spring Hill High School. The study determined the additional trips created by the development and suggested the following improvements:

- The installation of a traffic signal at 199th Street & Ridgeview Road, when warranted by the MUTCD.
- The addition of northbound and southbound left-turn lanes at the 199th Street & Ridgeview Road intersection, when warranted by guidelines determined by the National Cooperative Highway Research Program (NCHRP).

The northbound and southbound left-turn lanes have since been built, and construction of this subdivision has begun.

Estates of Wolf Creek Traffic Impact Study – Bucher, Willis & Ratliff Corporation

This study analyzed the potential traffic impacts resulting from the proposed Estates of Wolf Creek, which will be placed in between Ridgeview Road and Woodland Avenue, located northwest of the 199th Street & Ridgeview Road intersection. The study estimated additional trips to be added to Ridgeview Road, due to the development. The recommendations did not have any improvements for the intersection of 199th Street & Ridgeview Road.

Biltmore Farms (Brookwood) Traffic Assessment – Bucher, Willis & Ratliff Corporation

This traffic impact study provided trip generation estimates for the Biltmore Farms development plan, which has already been partially developed south of 199th Street, between Ridgeview Road and Woodland Avenue. This study had no recommended improvements for the intersection at 199th Street & Ridgeview Road. Recently, the subdivision's name changed from Biltmore Farms to Brookwood.

A summary of expected trips generated by each development at full build are shown later in the document, in Section 4.

2.3 CRASH REVIEW AND DATA ANALYSIS

The most recent five years (2012 – 2016) of crash data within the study area was requested and obtained from KDOT. The severity and types of crashes by year are shown in Table 1 and Table 2, respectively. There was a total of nine crashes with three resulting in injuries, while the other six were property damage only (PDO) crashes. One of the injury crashes was a disabling injury. The locations of the crashes are shown in a collision diagram in Figure 2 and mapped over an aerial image in Figure 3.

Table 1 – Crashes at 199th Street & Ridgeview Road by Year and Severity

Year	PDO	Injury	Fatal	Total
2012	2	1	-	**3**
2013	1	-	-	**1**
2014	-	1	-	**1**
2015	2	-	-	**2**
2016	1	1	-	**2**
Total	**6**	**3**	**-**	**9**

Source: Kansas Department of Transportation (KDOT)

Table 2 –Type of Crashes at 199th Street & Ridgeview Road by Year

Year	Angle-Side Impact	Rear End	Head On	Total
2012	2	1	-	**3**
2013	-	1	-	**1**
2014	-	-	1	**1**
2015	1	1	-	**2**
2016	1	1	-	**2**
Total	**4**	**4**	**1**	**9**

Source: Kansas Department of Transportation (KDOT)

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

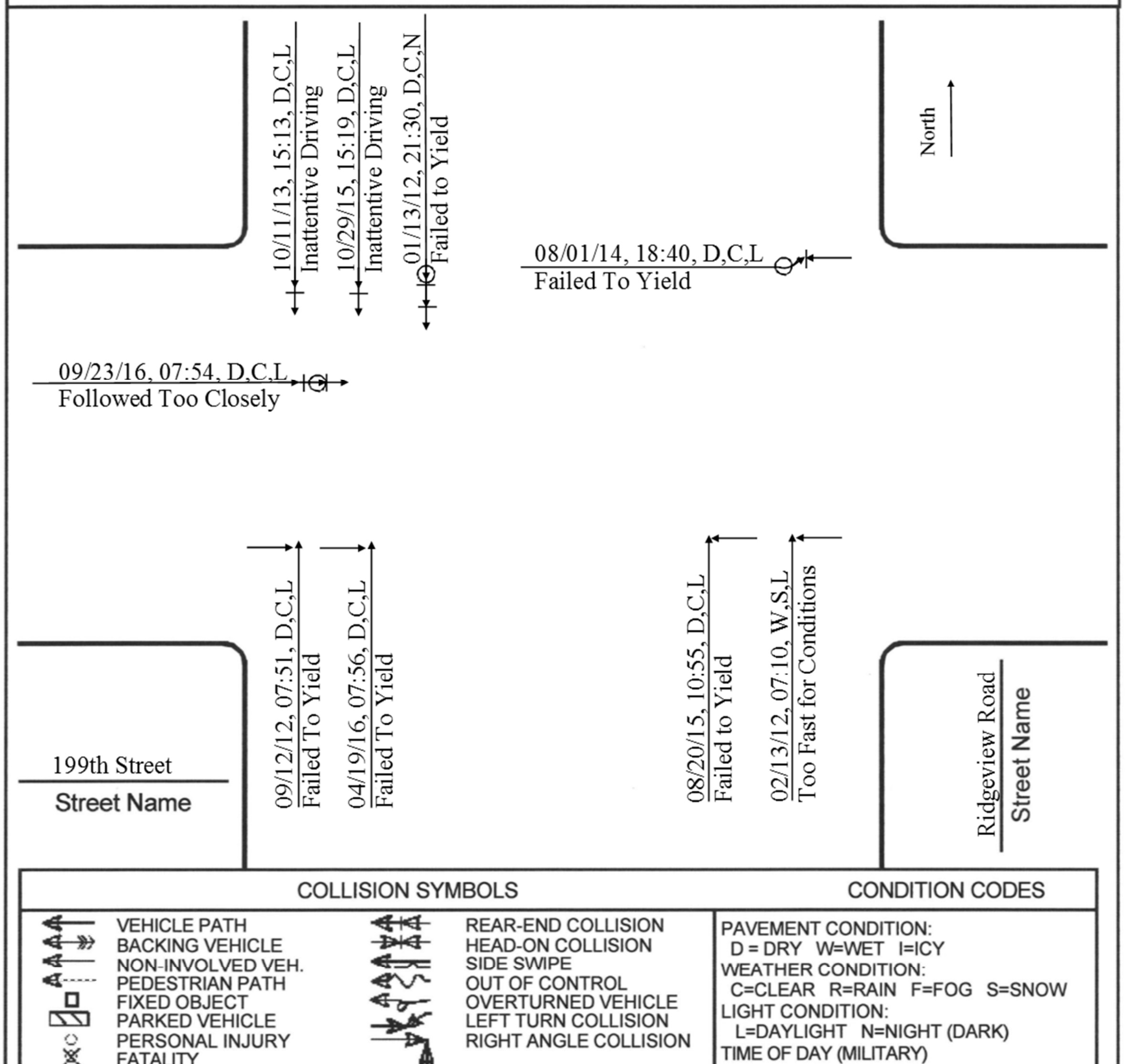
FORM 750-020-05
TRAFFIC ENGINEERING
10/99

COLLISION DIAGRAM

LOCATION ID: 199th Street and Ridgeview Road

COUNTY: Johnson CITY: Spring Hill

PERIOD 2012 TO 2016 PREPARED BY: WSP



CRASH SUMMARY

	PROP. DMG ONLY	INJURY	FATAL	TOTAL
DAYTIME	6	2	0	8
NIGHTTIME	0	1	0	1
TOTAL	6	3	0	9

Figure 2 – Collision Diagram for Crashes at 199th Street and Ridgeview Road

Source: Kansas Department of Transportation (KDOT)

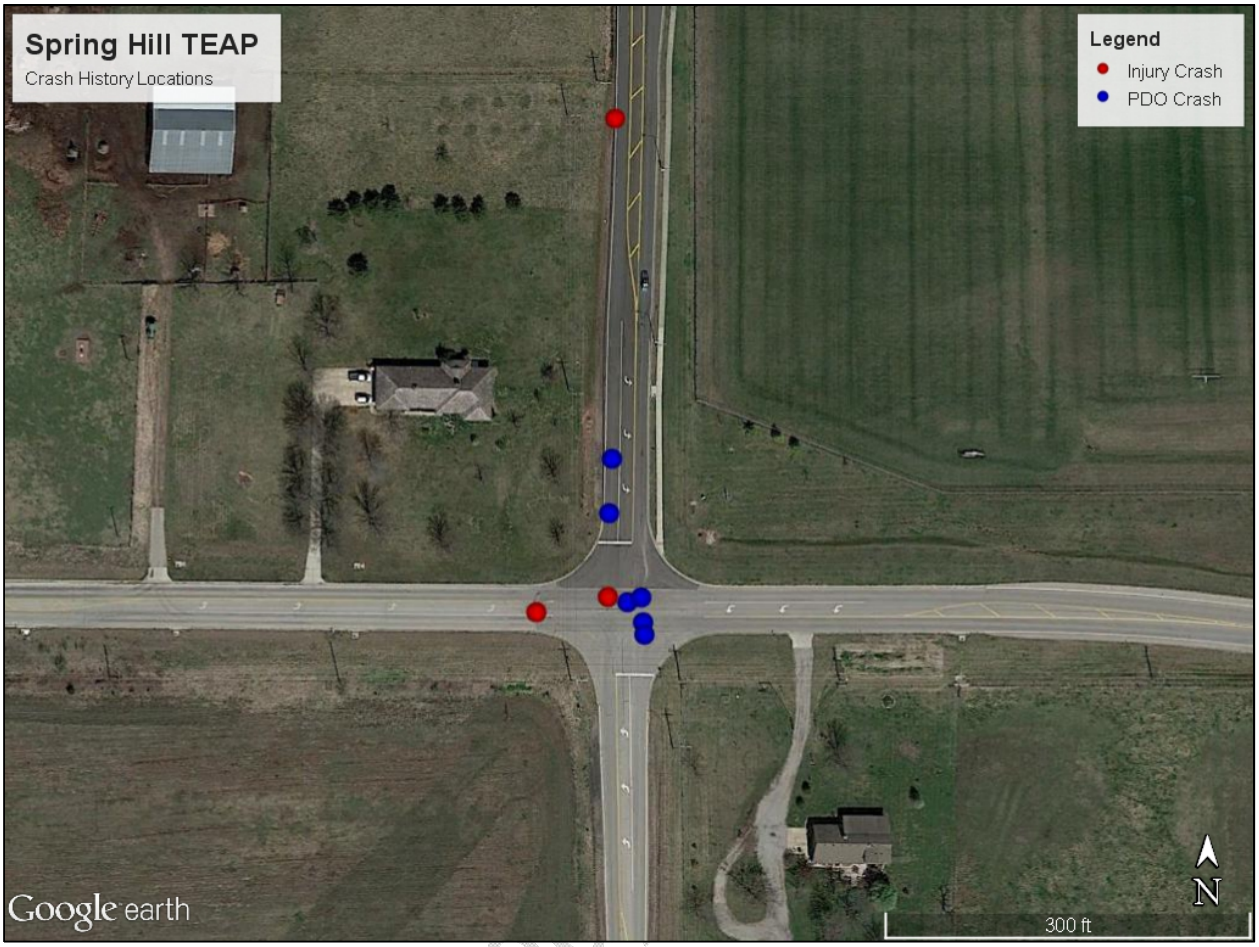


Figure 3 – Location of Crashes Impacted at the 199th Street & Ridgeview Road Intersection

Source: Google Earth, 2017

Crash rates are used to determine the relative safety compared to other similar intersections within the state by accounting for traffic volumes. The crash rate for the intersection at 199th Street & Ridgeview Road was calculated to be 7.98 crashes per ten million entering vehicles (TMEV). This rate is higher than Kansas's statewide average of 6 crashes per TMEV at rural intersections. However, the intersection crash rate is less than the calculated critical crash rate of 10.43 crashes per TMEV, which indicates that the higher than average crash rate is not statistically significant.

The most common collision types were side-angled impacts from the northbound through movement on Ridgeview in the morning, rear-end collisions in the southbound Ridgeview approach at the end of the school day and in the eastbound 199th Street left-turn lane in the morning. An interesting deviation from normal crash trends is that none of the side-angle impact crashes resulted in injuries, but two of the rear-end events did. The side-angle impacts were mostly caused by northbound drivers failing-to-yield at the stop control, while the rear-end crashes were mostly caused by inattentive driving.

2.4 TRAFFIC COUNTS

On May 10, 2017, Priority Engineers, Inc., a sub-consultant to WSP, collected a 24-hour approach volume count for all approaches at the intersection during the AM and PM peak periods controlled by the hours of the Spring Hill High School. A spot speed survey was also performed on 199th Street, near the intersection with Ridgeview Drive, during off-peak travel times. The 24-hour volume count was specifically requested to assist the necessary traffic signal warrant, capacity analyses, and to determine the average daily traffic during a normal school day to provide more accurate estimates of future volumes. The turning movements for the intersection are shown in Table 3, Table 4, and Table 5 for the AM peak, PM school related peak, and the PM non-school related peak. The AM peak hour contained the largest traffic count since it includes both school traffic and daily commuters. Thus, the analysis of future conditions will be based on the AM peak hour. Figure 4 shows the turning movements for the AM Peak hour.

Table 3 – AM Peak Hour Traffic at 199th Street & Ridgeview Road

Time	Ridgeview Road			199th Street			Ridgeview Road			199th Street			Intersection Total
	SB Left	SB Thru	SB Right	WB Left	WB Thru	WB Right	NB Left	NB Thru	NB Right	EB Left	EB Thru	EB Right	
7:15 - 7:30	5	4	13	4	27	13	0	9	5	71	36	0	187
7:30 - 7:45	1	1	32	2	20	26	0	4	1	129	27	1	244
7:45 - 8:00	4	4	84	0	25	37	0	17	6	196	33	1	407
8:00 - 8:15	7	11	28	2	15	4	2	8	3	27	27	0	134
7:15 - 8:15	**17**	**20**	**157**	**8**	**87**	**80**	**2**	**38**	**15**	**423**	**123**	**2**	**972**

Source: Priority Engineers, Inc.

Table 4 – PM Peak Hour Traffic at 199th Street & Ridgeview Road (School Related)

Time	Ridgeview Road			199th Street			Ridgeview Road			199th Street			Intersection Total
	SB Left	SB Thru	SB Right	WB Left	WB Thru	WB Right	NB Left	NB Thru	NB Right	EB Left	EB Thru	EB Right	
14:45 - 15:00	1	5	10	2	17	11	0	7	2	35	16	0	106
15:00 - 15:15	12	40	52	4	17	8	0	9	1	17	18	2	180
15:15 - 15:30	9	33	75	2	26	2	0	3	2	7	14	1	174
15:30 - 15:45	5	29	25	1	38	7	0	7	1	18	13	2	146
14:45-15:45	**27**	**107**	**162**	**9**	**98**	**28**	**0**	**26**	**6**	**77**	**61**	**5**	**606**

Source: Priority Engineers, Inc.

wsp

Table 5 – PM Peak Hour Traffic at 199th Street & Ridgeview Road (Non-School Related)

Time	Ridgeview Road			199th Street			Ridgeview Road			199th Street			Intersection Total
	SB Left	SB Thru	SB Right	WB Left	WB Thru	WB Right	NB Left	NB Thru	NB Right	EB Left	EB Thru	EB Right	
17:30 - 17:45	12	5	22	4	45	5	0	5	4	10	25	1	138
17:45 - 18:00	11	22	34	2	43	10	0	5	3	21	19	2	172
18:00 - 18:15	12	14	52	10	37	10	0	10	1	35	15	0	196
18:15 - 18:30	8	8	14	5	30	10	0	12	1	45	22	1	156
17:30 - 18:30	**43**	**49**	**122**	**21**	**155**	**35**	**0**	**32**	**9**	**111**	**81**	**4**	**662**

Source: Priority Engineers, Inc.

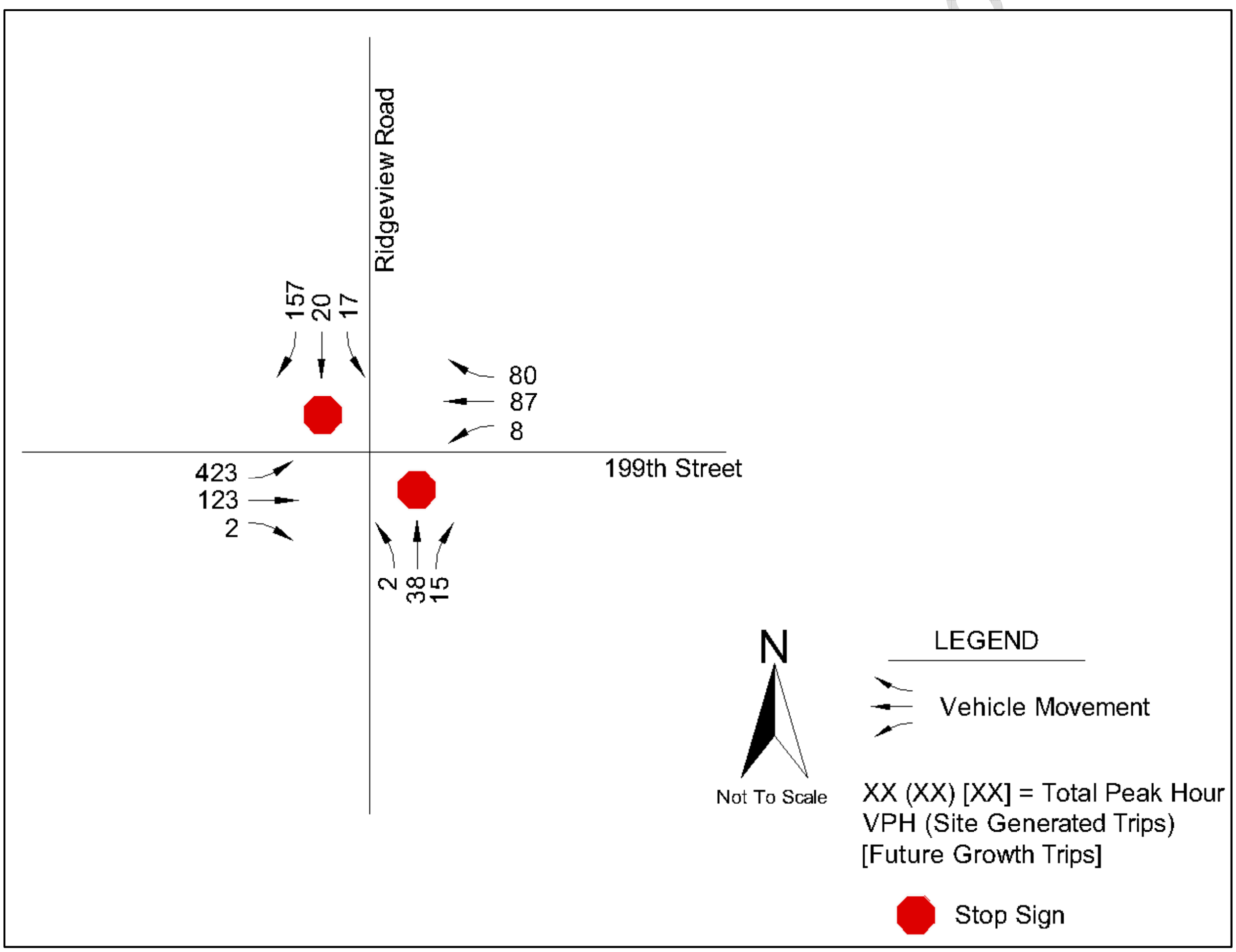


Figure 4 – Turning Movements for AM Peak Hour – 199th & Ridgeview Road

2.5 SPEED STUDY

A spot speed study was collected 0.4 miles west of 199th Street & Ridgeview Road to determine the free-flow (85th percentile) speed of vehicles on May 9, 2017 by Priority Engineers, Inc. The speed of vehicles was measured with a handheld radar gun device and recorded by speed frequencies. Vehicles which accelerated from a driveway, decelerated, or yielded to pedestrians were not recorded since they did not maintain a constant speed profile. For the combined spot speed data at each location, see the Appendix.

Based on the resulting data observations shown in Table 6, the 85th percentile speed for the intersection was determined to be 49.8 mph. This is within 5 mph of the actual posted speed limit of 45 mph, so the speed limit is appropriately set.

Table 6 – Result of Spot Speed test

Approach	Posted (mph)	Minimum (mph)	Maximum (mph)	Average (mph)	Median (mph)	Mode (mph)	85th Percentile (mph)	10 mph Pace	Percent in Pace
EB & WB	45	35	54	45.9	45.8	47	49.8	40-50	89.7%

2.6 FIELD OBSERVATIONS

A field visit was conducted in the morning and mid-afternoon of May 9, 2017. The purpose of the visit is to investigate existing conditions, take photographs of the signs/pavement markings, and observe typical driver behavior.

A meeting with the Spring Hill Community Development Director, law enforcement officers, and the Superintendent of the Spring Hill School District occurred on the morning of June 15, 2017 to discuss additional issues not originally included in the TEAP study application. Later that same day, data was collected to determine the sight distance at the intersection.

An examination of normal operations during the 30 minutes before the start of Spring Hill High School and Wolf Creek Elementary School and the 30 minutes after the end of the school day was performed during the field visit. Key observations from the visit were as follows:

- During the AM peak, the northbound approach experienced very long delays; however, there was a relatively short maximum queue of about ten cars.
- The eastbound left-turn lane experienced long delay and a had a very long queue of about one-quarter mile in length during the AM peak hour.
- Eastbound left-turn drivers sometimes yield to northbound through vehicles during the AM peak and would "wave" the northbound cars through the intersection. However, it

was not always possible for the left-turning vehicle to determine that there were no eastbound through vehicles conflicting with the northbound vehicles. The un-mowed grass on the southwest corner of the intersection obscured the sight of the northbound vehicle to see eastbound through vehicles. Several "near-misses" occurred during the AM peak hour observation period where northbound cars crossed the intersection within a second or two of a high-speed vehicle moving eastbound to cross the intersection.

- Some northbound vehicles drove through the intersection ahead of eastbound left-turn vehicles without being "waved" through. These vehicles typically quickly accelerated through the intersection just after an eastbound left-turn vehicle had crossed over the center of the intersection and before the following eastbound left-turn vehicle could see whether the oncoming westbound movement was clear. This is similar to drivers who exhibit a behavior called "sneaking" involving making a left-turn at an intersection after opposing vehicles have stopped for a red-light indication since they couldn't find a gap in traffic during the green or yellow light phase.

- The maximum southbound queue during the PM school peak extended approximately one-half mile north of the intersection.

- Both the AM and PM school peak periods had a very short duration. Within approximately 15 minutes from the beginning of the high traffic volume, the queues had fully dissipated and the volume of vehicles through the intersection had drastically decreased.

- The land in the southwest corner of the intersection was covered in long, un-mowed grass which drastically reduced the sight distance for the northbound approach.

2.7 INTERSECTION SIGHT DISTANCE ANALYSIS

This section provides information regarding how intersection sight distance is determined, as well as the lengths along the road that sight distance needs to be available. The required sight distance and existing available sight distance is also reported.

As noted in the previous section, the southwest corner of the intersection was covered in long, un-mowed grass which drastically reduced the sight distance for the northbound approach. However, when a second field visit was made to measure the sight distance, this grass had been mowed close to the ground. The data collected on this second visit was therefore collected under ideal conditions, and should be considered the maximum possible sight distance. With minimal maintenance of the vegetation, the sight distances measured would typically be shorter in practice.

2.7.1 SIGHT DISTANCE FOR INTERSECTION WITH STOP CONTROL ON MINOR ROAD

The design and construction of roadways in the U.S. is guided by AASHTO's *A Policy on Geometric Design of Highways and Streets*, often referred to as the "Green Book". The most recent update is from 2011. Henceforth, this set of AASHTO guidelines will be referenced extensively throughout this report, and will be referred to as "the Green Book".

This study follows the guidelines found in Chapter 9.5.3 of the Green Book, using option B, for stop controlled intersections at the crossing of a major and a minor road. Chapter 9 of the Green Book states: "*Departure sight triangles for intersections with stop control on the minor road should be considered for three situations:*

- *Case B1—Left turns from the minor road;*
- *Case B2—Right turns from the minor road; and*
- *Case B3—Crossing the major road from a minor-road approach.*

Intersection sight distance criteria for stop-controlled intersections are longer than stopping sight distance to allow the intersection to operate smoothly. Minor-road vehicle operators can wait until they can proceed safely without forcing a major-road vehicle to stop."

The Green Book provides guidelines for intersection sight distances and stopping sight distances for intersections with stop controls on the minor road. Table 7 shows the minimum stopping sight distance requirements for left-turning vehicles. Table 8 shows the sight distance requirements for right-turn and crossing maneuvers. "Intersection Ahead" (W2-1) signs are posted ahead of the intersection with Ridgeview Road on 199th Street. These signs have advisory speed plaques posted with 35 mph. Because these advisory speeds are not statutory speed limits, and do not legally need to be complied with by drivers, both the posted speed limit and advisory speed limits are shown in the sight distance.

The posted speed limit on 199th Street is 45 mph, therefore the minimum sight distance required at the intersection is 500 feet for left-turns, 430 for a right-turn or crossing maneuver, and 360 feet for stopping. This is highlighted by the red box in Table 7 and Table 8. For the 35 mph advisory speed limit, the minimum sight distance required at the intersection is 390 feet for left-turns, 335 feet for a right-turn or crossing maneuver, and 250 feet for stopping. This is highlighted by the blue box in Table 7 and Table 8.

Table 7 - Design Intersection Sight Distance – Case B1, Left Turn from Stop

Metric				U.S. Customary			
Design Speed (km/h)	Stopping Sight Distance (m)	Intersection Sight Distance for Passenger Cars Calculated (m)	Intersection Sight Distance for Passenger Cars Design (m)	Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars Calculated (ft)	Intersection Sight Distance for Passenger Cars Design (ft)
20	20	41.7	45	15	80	165.4	170
30	35	62.6	65	20	115	220.5	225
40	50	83.4	85	25	155	275.6	280
50	65	104.3	105	30	200	330.8	335
60	85	125.1	130	35	250	385.9	390
70	105	146.0	150	40	305	441.0	445
80	130	166.8	170	45	360	496.1	500
90	160	187.7	190	50	425	551.3	555
100	185	208.5	210	55	495	606.4	610
110	220	229.4	230	60	570	661.5	665
120	250	250.2	255	65	645	716.6	720
130	285	271.1	275	70	730	771.8	775
—	—	—	—	75	820	826.9	830
—	—	—	—	80	910	882.0	885

Source: A Policy on Geometric Design of Highways and Streets, 2011, Table 9-6

Table 8 - Design Intersection Sight Distance - Case B2, Right Turn from Stop, and Case B3, Crossing Maneuver

Metric				U.S. Customary			
Design Speed (km/h)	Stopping Sight Distance (m)	Intersection Sight Distance for Passenger Cars		Design Speed (mph)	Stopping Sight Distance (ft)	Intersection Sight Distance for Passenger Cars	
		Calculated (m)	Design (m)			Calculated (ft)	Design (ft)
20	20	36.1	40	15	80	143.3	145
30	35	54.2	55	20	115	191.1	195
40	50	72.3	75	25	155	238.9	240
50	65	90.4	95	30	200	286.7	290
60	85	108.4	110	35	250	334.4	335
70	105	126.5	130	40	305	382.2	385
80	130	144.6	145	45	360	430.0	430
90	160	162.6	165	50	425	477.8	480
100	185	180.7	185	55	495	525.5	530
110	220	198.8	200	60	570	573.3	575
120	250	216.8	220	65	645	621.1	625
130	285	234.9	235	70	730	668.9	670
—	—	—	—	75	820	716.6	720
—	—	—	—	80	910	764.4	765

Source: A Policy on Geometric Design of Highways and Streets, 2011, Table 9-8

2.7.2 DEPARTURE SIGHT TRIANGLES FOR YIELD OR STOP CONTROLLED APPROACHES

Once a driver is stopped at a stop sign, the driver needs to be able to see further down the cross road to enter the intersection safely. Figure 5 shows the departure sight triangles for stop or yield-controlled approaches. The Green Book states, "*Figure 9-15B [Figure 5] shows typical departure sight triangles to the left and to the right of the location of a stopped vehicle on the minor road. ... Distance a2 in Figure 9-15B is equal to distance a1 plus the width of the lane(s) departing from the intersection on the major road to the right*" (AASHTO, 2011, pp. 9-31).

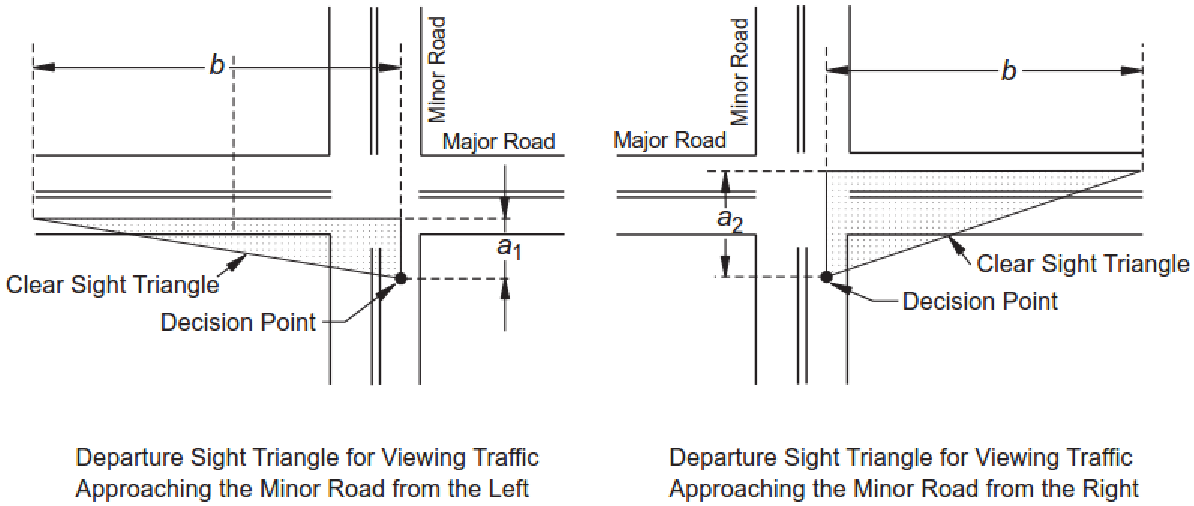


Figure 5 - Intersection Sight Triangles

Source: A Policy on Geometric Design of Highways and Streets, Figure 9-15B

2.7.3 DETERMINATION OF SIGHT OBSTRUCTIONS WITHIN CLEAR SIGHT TRIANGLES

According to the Green Book, "*Within a sight triangle, any object at a height above the elevation of the adjacent roadways that would obstruct the driver's view should be removed or lowered, if practical. Such objects may include buildings, parked vehicles, highway structures, roadside hardware, hedges, trees, bushes, unmowed grass, tall crops, walls, fences, and the terrain itself.*

The determination of whether an object constitutes a sight obstruction should consider both the horizontal and vertical alignment of both intersecting roadways, as well as the height and position of the object. In making this determination, it should be assumed that the driver's eye is 1.08 m [3.50 ft] above the roadway surface and that the object to be seen is 1.08 m [3.50 ft] above the surface of the intersecting road" (AASHTO, 2011, pp. 9-31).

Wooden rods 3.5 feet tall with bright orange painted tips were used to determine sight triangles at the intersection (Figure 6). The rods were supported by 2.5 feet tall orange cones which served to keep the rods vertical and to provide more warning to approaching drivers than the small orange surface area on the ends of the rods would.

Figure 6 - Sight Distance Rods and Measuring Wheel

Source: WSP

2.8 INTERSECTION ANALYSIS

Based on discussions with City staff, local law enforcement, and school representatives, there are several safety concerns for this intersection, including poor sight distance at the intersection. The sight distances and stopping sight distances at the intersection were checked in the field to determine if they meet the minimum requirements using the methodology described in the previous section.

Since the intersection of 199th Street & Ridgeview Road is stop control with stop signs on the northern and southern approaches of Ridgeview Road, the left-turn and right-turn stopping sight distance were determined for the northbound and southbound approaches, while the stopping sight distance was determined for the eastbound and westbound. Table 9 and Table 10 show the measured and required lengths for turning movement sight distance and stopping sight distance, respectively. Figure 7 shows the existing sight distances for the intersection at 199th Street & Ridgeview Road.

Table 9 – Intersection Sight Distance for 199th Street & Ridgeview Road Turning Movements (in feet)

	Northbound Measured	Southbound Measured	Minimum (45 mph)	Minimum (35 mph)
Left-Turn Sight Distance	930	480	500	390
Right-Turn/ Crossing Sight Distance	380	870	430	335

Source: WSP and A Policy on Geometric Design of Highways and Streets, 2011, Table 9-8

Table 10 – Stopping Sight Distance for 199th Street & Ridgeview Road (in feet)

	Eastbound Measured	Westbound Measured	Minimum (45 mph)	Minimum (35 mph)
Stopping Sight Distance	610	880	360	250

Source: WSP and A Policy on Geometric Design of Highways and Streets, 2011, Table 9-8

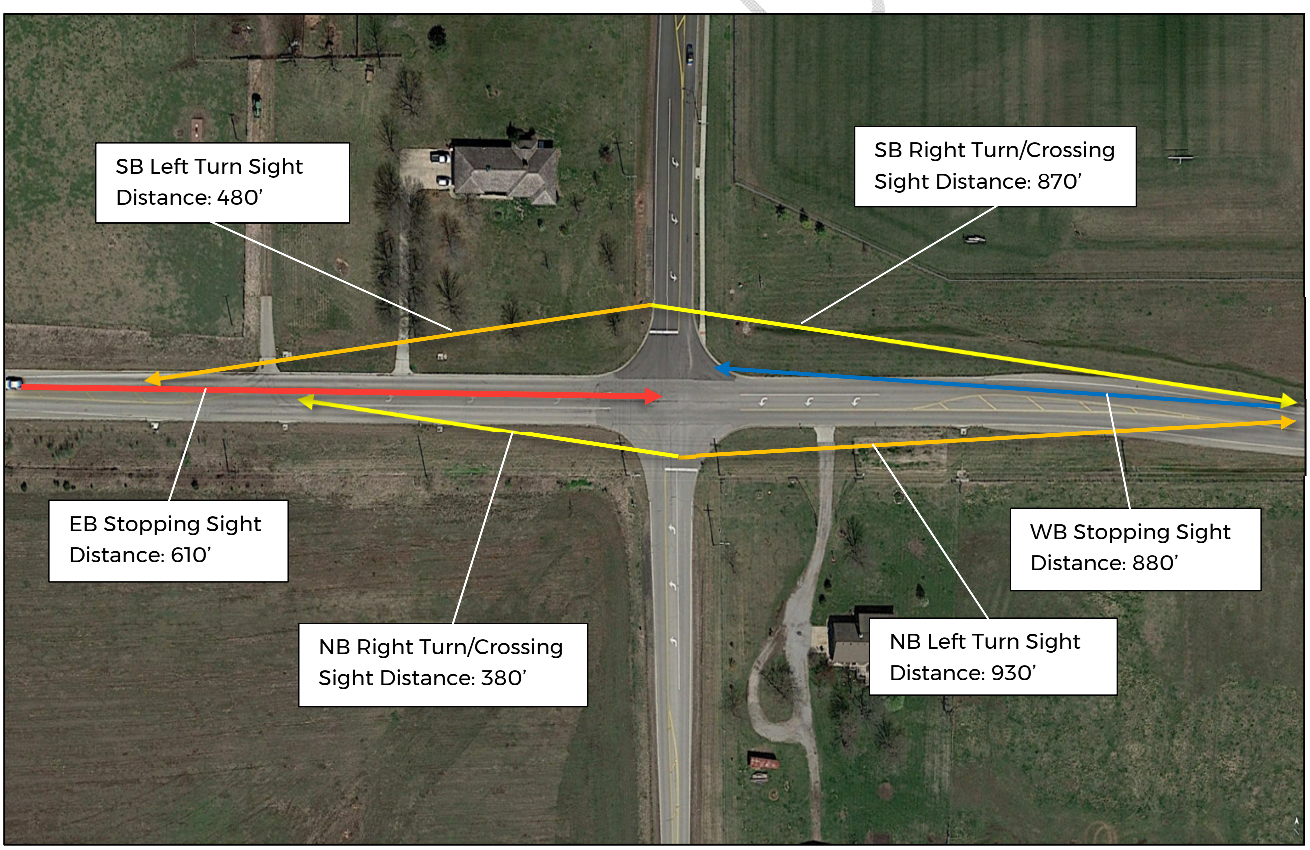


Figure 7 - Existing Sight Distance at 199th Street & Ridgeview Road

Source: Google Earth, 2017

Two intersection sight distance measurements did not meet the necessary minimum lengths from the Green Book for a 45 mph design speed on 199th Street. These are the two sight distances looking towards the west from the northbound and southbound approaches. These two approaches do meet the minimum sight distance for the advisory speed limit of 35 mph. Furthermore, under ideal conditions there exists adequate stopping sight distance for the vehicles traveling eastbound such that if a northbound or southbound vehicle pulled into the roadway, then an eastbound vehicle would have sufficient time to stop before colliding with the entering vehicle (stopping sight distance).

Because the southwest corner of the intersection appeared to have minimum maintenance of the vegetation, a sight distance issue is present when the area has not been recently mowed. This is true even accounting for the advisory speed limit. Before being mowed, this vegetation was approximately 12 to 18 inches tall, which would have restricted the northbound right-turn/crossing to around 200-250 feet. The stopping sight distance for 45 mph is calculated as 360 feet and for 35 mph is calculated as 250 feet. With a sight distance of around 200-250 feet, sufficient stopping sight distance would not exist for an eastbound vehicle to slow and stop before colliding with a northbound vehicle proceed into the intersection even if the eastbound vehicle were complying with the 35 mph advisory speed.

3 TRAFFIC ANALYSIS

3.1 TRIPS GENERATED

Transportation infrastructure must accommodate traffic for many years after it is built. Therefore, changes to the intersection of 199th Street & Ridgeview Road should be able to handle future traffic demands. This study projects existing 2017 traffic volumes into 2037 traffic volumes by accounting for the trips generated by the surrounding developments as well as expected annual growth. The number of trips generated for the AM peak hour by the surrounding subdivisions and the expansion of Spring Hill High School were obtained from the traffic impact studies provided by the City of Spring Hill.

The studies used the Institute of Transportation Engineers' *Trip Generation Manual* to estimate the trips generated by the developments for the peak travel periods (ITE 2012). Table 11 shows the distribution of trips generated by each subdivision that passed through the study intersection. The 2017 AM peak hour distribution was used to translate volumes on either Ridgeview Road or 199th Street to turning movements at the intersection. It should be noted that Prairie Ridge, Wolf Creek, and Biltmore Farms (Brookwood) are partially built, however the trips generated by those subdivisions were not reduced to account for their existing traffic impact to provide a conservative estimate of future traffic.

Table 11 – Trips Generated by Recent Developments (Estimated)

	Ridgeview Road			199th Street			Ridgeview Road			199th Street		
	SB Left	SB Thru	SB Right	WB Left	WB Thru	WB Right	NB Left	NB Thru	NB Right	EB Left	EB Thru	EB Right
Spring Hill High School Expansion	12	11	47	0	0	6	0	5	0	23	0	0
Rose Park (Boulder Springs)	0	0	0	1	13	13	0	0	0	12	4	0
Prairie Ridge	2	0	0	4	43	39	0	0	1	0	12	0
Wolf Creek	2	3	20	0	0	0	1	15	6	0	0	0
Biltmore Farms (Brookwood)	0	12	22	0	12	0	0	0	0	22	6	2
Ridgefield	4	0	0	8	86	78	0	0	2	0	24	0
Total Trips:	**20**	**26**	**89**	**13**	**154**	**136**	**1**	**20**	**9**	**57**	**46**	**2**

Source: Traffic Impact Studies provided by the city of Spring Hill, KS

Alongside the trips generated by the development of the subdivisions listed above, an annual growth rate of 2% was also used to estimate the background growth of traffic. Figure 8 shows the 2037 AM peak hour turning movements for the intersection as well as the trips added by the subdivision developments and continual annual growth. It should be noted that the 2037 volumes utilized in the model present a best-case scenario from a development standpoint, which coincides with the worst traffic situation.

wsp

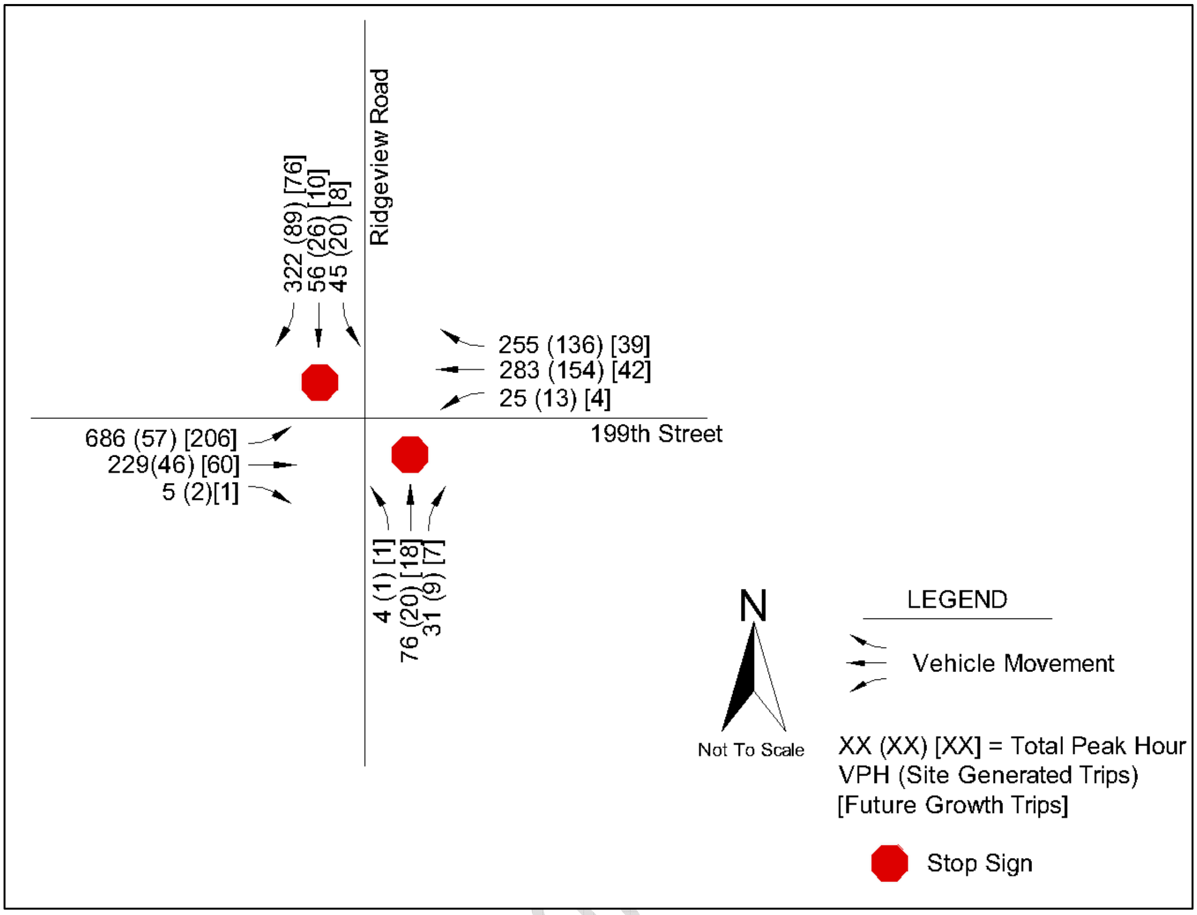


Figure 8 - 2037 Projected AM Peak Hour Traffic Volume and Turning Movement Counts by Origin, 199th Street & Ridgeview Road

3.2 BUILD OPTION WARRANTS

3.2.1 TRAFFIC SIGNAL

Review of Traffic Signal Warrants 1, 2, 3, and 7 were performed using the Highway Capacity Software 2010 (HCS) for both existing 2017 traffic volumes and projected 2037 traffic volumes. These warrants are four of nine warrants of which at least one must be met to consider the installation of a traffic signal. Warrants 1 and 2 (Eight-Hour and Four-Hour Vehicular Volumes) are intended for application at locations where large volumes of intersecting traffic are the principal reason for installing a traffic control signal. Warrant 3 (Peak Hour Vehicular Volume) is intended for use at locations where traffic conditions are such that for a minimum of one hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. Warrant 7 is intended for application where the severity and frequency of crashes are the principal reason to consider installing a traffic control signal. Warrants 4, 5, 6, 8, and 9 are not applicable to the intersection at 199th Street & Ridgeview Road.

Per the MUTCD, engineering judgment and rationale should be used in applying signal warrants to cases where approaches consist of auxiliary lanes (left or right-turn lanes). "*For a street approach with one through/left-turn lane plus a right turn lane, the degree of conflict of the minor-street right-turn traffic with traffic on the major street should be considered. Thus, right-turn traffic should not be included in the minor street volume if the movement enters the major street with minimal conflict. The approach should be evaluated as a one-lane approach with only the traffic volume in the through/left-turn lane considered.*" (Federal Highway Administration, 2009, p. 436)

WARRANT 1, EIGHT HOUR VEHICULAR VOLUME

For Warrant 1, the Eight Hour Vehicular Volume Warrant, the major street vehicles per hour and the higher-volume minor-street approaches for the maximum eight-hour time period would have to be larger than the volumes in both 100% columns of Condition A OR Condition B, as show as red boxes in Figure 9. The other condition for Warrant 1 to be met is for the vehicles per hour given in both 80 % columns of Condition A AND Condition B, as shown by blue boxes in Figure 9, must exist on the major-street and the higher volume minor-street approaches.

If the posted speed limit or the 85th percentile speed on the major street exceeds 40 mph, the 70 % and 56 % values for the corresponding conditions can be used instead of the 100 % and 80 % values described above. The posted speed limit and 85th percentile speed on W 199th are both over 40 mph, therefore the lower volumes for the warrant can be used for all Warrants.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Figure 9 –Table 4C-1 for Warrant 1, Eight-Hour Vehicular Volume

Source: MUTCD, 2009

The current traffic does not satisfy Warrant 1 with existing volumes or future 2037 volumes. The 2017 traffic volumes only exceed the warrant's threshold for one of the time periods. The 2037 traffic volumes exceed the thresholds set in the warrant for only four of the eight required periods to satisfy Condition A and one of the eight periods required to satisfy Condition B.

WARRANT 2, FOUR HOUR VEHICULAR VOLUME

Warrant 2, the Four-Hour Vehicular Volume, states that the need for a traffic signal shall be considered if an engineering study find that for each of any four hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 10 for the existing or combination of approach lanes.

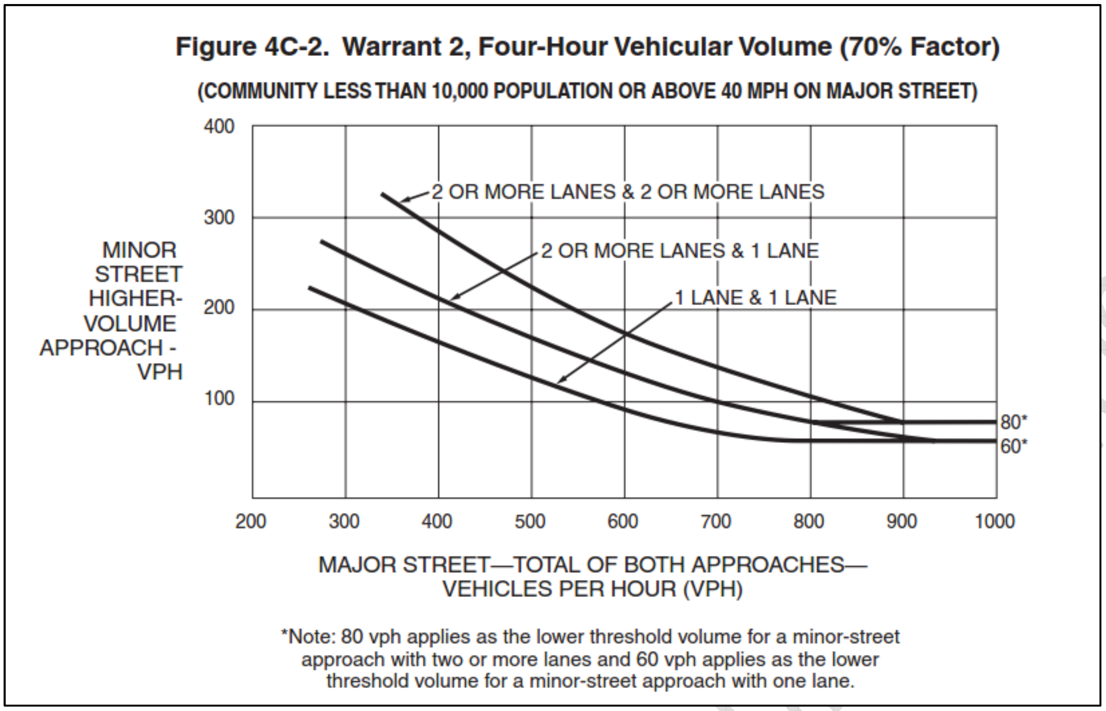


Figure 10 – Figure 4C-1 for Warrant 2, Four-Hour Vehicular Volume

Source: MUTCD, 2009

With the existing conditions Warrant 2 is not met. No set of major and minor street volumes meet the requirement to merit a traffic signal. However, for the projected 2037 traffic, four hours meet the requirements, so a traffic signal may be warranted in the future, should traffic volumes increase as projected.

WARRANT 3, PEAK HOUR VEHICULAR VOLUME

Warrant 3, the Peak Hour signal warrant, intended for use at locations where traffic conditions are such that for a minimum of one hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. This warrant should only be applied in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

This warrant is met if the plotted point representing the vehicles per hour on the major street. Warrant 3 is also met when the total stopped time delay experienced by the traffic on one minor-street approach controlled by a stop sign equals or exceeds four vehicle-hours, the volume on the same minor-street approach equals or exceeds 100 vehicles per hour AND the total entering volume serviced during the hour equals or exceeds 800 vehicles per hour for vehicles with four approaches.

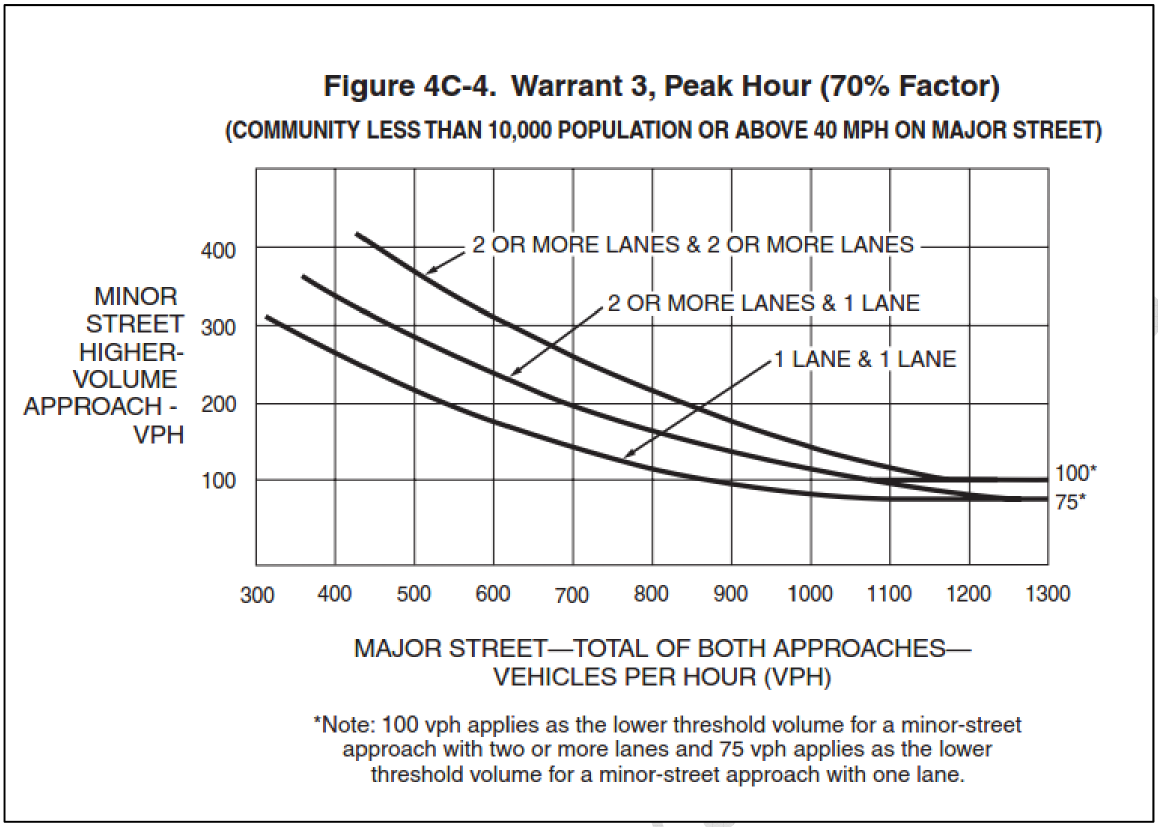


Figure 11 - Figure 4C-4 for Warrant 3, Peak Hour

Source: MUTCD, 2009

The current traffic volume does satisfy Warrant 3. The projected 2037 volume meets Warrant 3, so it is possible that in the future the intersection may warrant a traffic signal.

WARRANT 7, CRASH EXPERIENCE

Warrant 7 for traffic signals is the Crash Experience warrant. This warrant is met if there are five or more reported crashes within a 12-month period of types susceptible to correction by a traffic signal, an adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency, AND for each of any eight hours of an average day, the vehicles per hour given in both 80 % column of Condition A OR B exist on the major-street and the higher-volume minor-street approach.

Since the average crash frequency at the intersection was 1.8 crashes per year, Warrant 7 is not met with the current crash history. However, it is possible that sometime in the future the crash rate may increase, which could warrant a signal if the frequency increases above five crashes within a 12-month period, and other alternatives do not improve the intersections safety.

OVERVIEW OF TRAFFIC SIGNAL WARRANTS

Table 12 summarizes the traffic signal warrants used to analyze the intersection at 199th Street & Ridgeview Road. None of the warrants are met for 2017, so a traffic signal should not be considered until traffic increases. With the 2037 traffic projections, both the Four-Hour and Peak Hour Warrants are met, so it is feasible that sometime in the future that a traffic signal may be considered. A traffic signal should never be installed unless at least one warrant is met, however that does not necessitate the installation of a traffic signal.

Table 12 - Summary of Warrant Analysis

	2017	2037
Warrant 1	no	no
Warrant 2	no	**yes**
Warrant 3	no	**yes**
Warrant 4	n/a	n/a
Warrant 5	n/a	n/a
Warrant 6	n/a	n/a
Warrant 7	no	no
Warrant 8	n/a	n/a
Warrant 9	n/a	n/a

3.2.2 ALL-WAY STOP CONTROL

Since the installation of a traffic signal should not be considered by today's traffic, the applicability of converting the two-way stop controlled intersection into an all-way stop controlled intersection was investigated to improve the safety of the intersection. The MUTCD provides guidance to the minimum volumes required to merit an all-way stop controlled intersection. The minimum average eight-hour volume requirements to justify the installation of all-way stop control for intersections with major approach speeds more than 40 mph are compared to the existing volumes in Table 13.

Since the exiting average eight hour volumes are above the minimum, the intersection could be considered for the installation of all-way stop control based on today' traffic. Even though the change in intersection control could be considered, it does not mean that the conversion is recommended.

Table 13 – Requirements for All-Way Stop Control (MUTCD, 2009)

Condition	Required Minimum	Existing (11 AM to 6 PM)
Average Eight Hour Volume (vehicle/hour)	210	252
Minor Street Entering Volume (vehicle/hour)	140	143

3.2.3 ROUNDABOUT

Currently there are no formal warrants providing guidance for the installation of roundabouts in the United States. Usually such decisions are directed by engineering judgement. Examples of when engineering judgement can be used to warrant the installation of a roundabout include the intersection meeting at least one of the warrants for a traffic signal and safety concerns that could be improved with a roundabout (i.e. a large percentage of angled impacts). Given that four crashes (44.4%) were side-angle impact crashes and one crash (11.1%) was a head-on collision in the five years of crash history, the installation of a roundabout could be justified.

3.3 OPERATION ANALYSIS

Existing and future traffic operation analyses included determining the Level of Service (LOS) and delay per vehicle for the existing AM peak hour. The traffic analysis was performed using microsimulation modeling with Vissim software to determine the delay for each movement and determining the LOS using the Highway Capacity Manual 2010 (HCM) designated levels based on those delays. Since the AM peak hour contained the most traffic, and included both school-related and daily commuter traffic, the LOS analyses performed are based during this time period.

LOS is defined by the HCM as "*a quantitative stratification of a performance measure or measures that represent quality of service*" (Transportation Research Board, 2010, pp. 5-1). Vehicular LOS calculations are based on the driver's perception of the traffic conditions. LOS A is the best operating condition from the driver's perspective and LOS F has the longest delays, making it the worst operating condition. LOS D or better is considered acceptable in most urban settings during the peak hour conditions. None of the vehicular LOS indicators take into account the user's perspective from other modes such as pedestrians, cyclists, or transit users. The description of LOS (A through F) for stop-controlled intersections/roundabouts and signalized intersections are shown Table 14 and Table 15, respectively.

Table 14 - Two-Way and All-Way Stop Controlled and Roundabout Intersection Level of Service Criteria

Level of Service	Description	Average Control Delay per Vehicle (seconds/vehicle)
A	Little or no delay.	≤ 10
B	Short traffic delays.	> 10 - 15
C	Average Traffic delays.	> 15 – 25
D	Long traffic delays.	> 25 – 35
E	Very long traffic delays.	> 35 - 50
F	Demand exceeds capacity resulting in extreme delays and queuing.	> 50

Source: Highway Capacity Manual (HCM), 2010

Table 15 - Signalized Intersection Level of Service Criteria

Level of Service	Description	Average Control Delay per Vehicle (seconds/vehicle)
A	Little to no delay. Progression is either exceptionally favorable or the cycle length is very short.	≤ 10
B	Volume-to-capacity ratio is low and either progression is highly favorable or the cycle length is short.	> 10 - 20
C	Progression is favorable or the cycle length is moderate. Individual cycle failures may begin to appear at this level	> 20 – 35
D	Volume-to-capacity ratio is high, progression is unfavorable, and the cycle length is long. Individual cycle failures are noticeable.	> 35 – 55
E	Volume -to- capacity ratio is very high, progression is unfavorable and the cycle length is long. Individual cycle failures are frequent.	> 55 - 80
F	Volume-to-capacity ratio is very high, progression is very poor, and the cycle length is long. Most cycles fail to clear the queue.	> 80

Source: Highway Capacity Manual (HCM), 2010

3.3.1 TWO-WAY STOP CONTROL

The two-way stop-controlled Vissim microsimulation model was calibrated to model the traffic conditions observed during the field review as best as possible. This calibration included allowing "improper" movements like the eastbound left-turn "waving" the northbound through movement. Figure 12 shows the LOS and delay per movement. Currently, the intersection is operating with an average delay of 28.5 seconds per vehicle at a LOS of C. Specific traffic movements showing a poor LOS include eastbound left-turn (LOS D with a delay of 36.5 seconds per vehicle), northbound through (LOS F with a delay of 107 seconds per vehicle) and southbound left-turn (LOS F with a delay of 160.4 seconds per vehicle). This validates the delay experienced during the field review (AM peak).

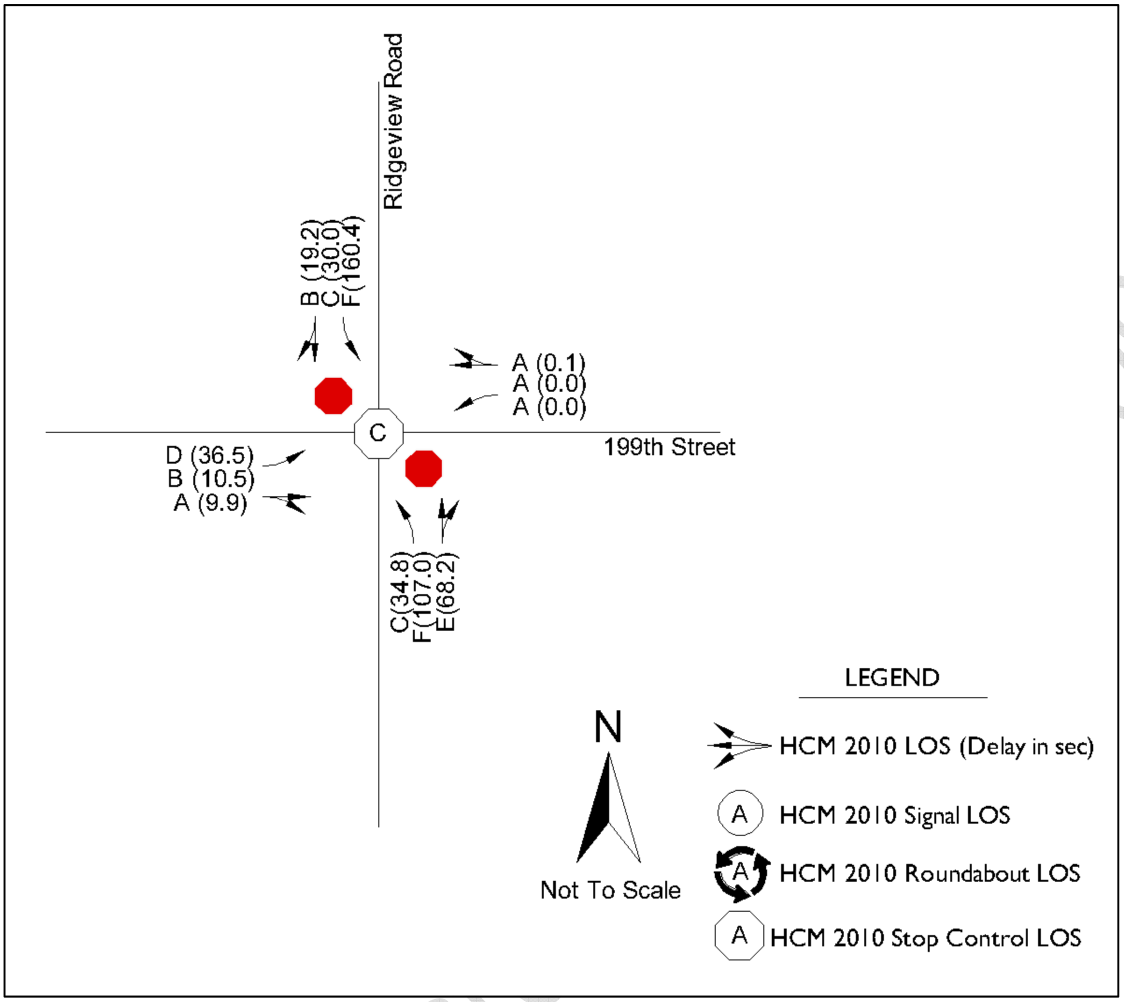


Figure 12 – LOS and Delay per Movement for Two-Way Stop Controlled with 2017 AM Peak Hour Traffic - 199th Street & Ridgeview Road

The LOS and delay for the no-build 2037 situation is show in Figure 13. There is an average delay of 156.9 seconds per vehicle, which means that the intersection is operating at a LOS of F.

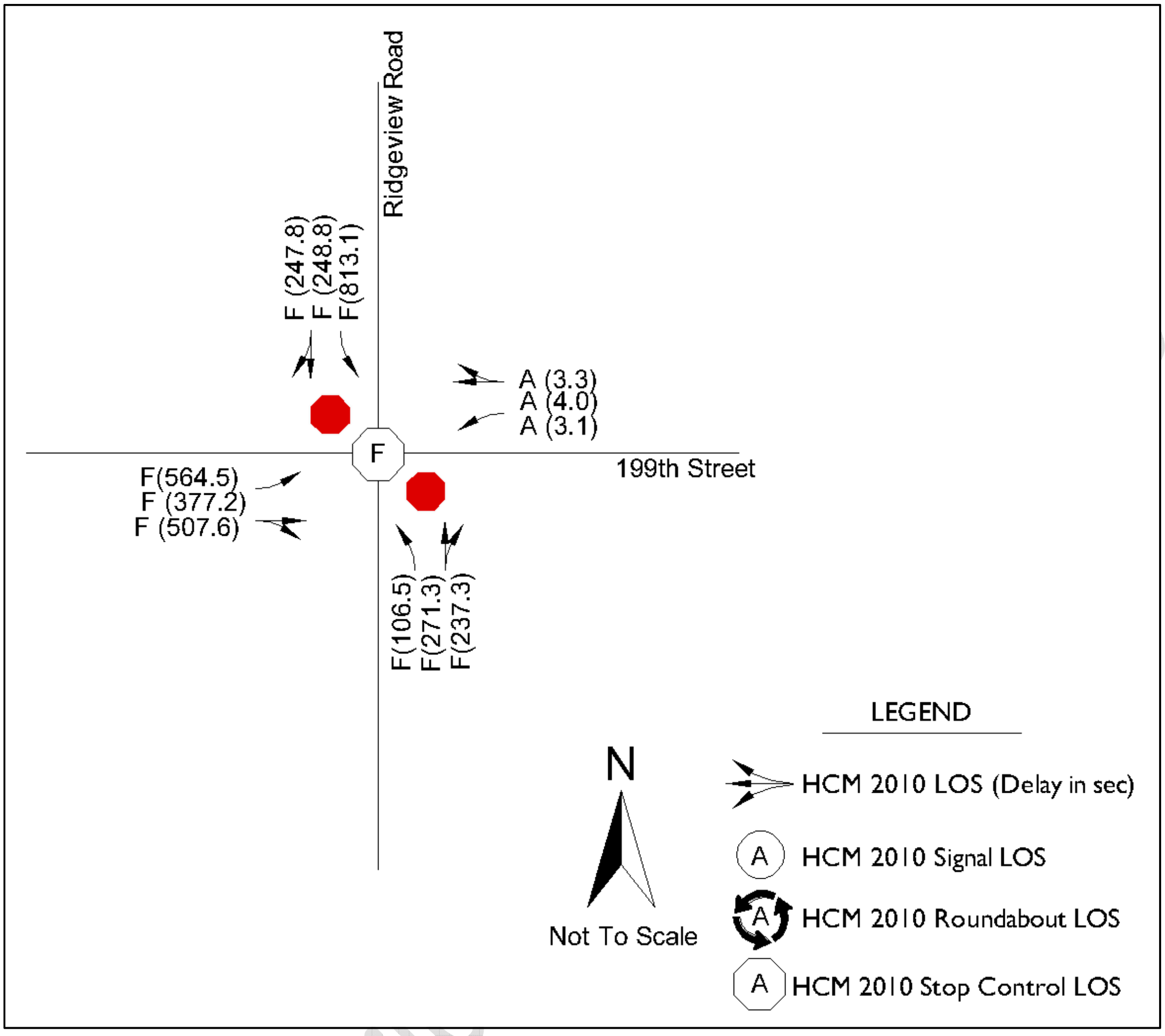


Figure 13 – LOS and Delay per Movement for Two-Way Stop Controlled with 2037 AM Peak Hour Traffic -199th Street & Ridgeview Road

3.3.2 ALL-WAY STOP CONTROL

Since today's traffic would allow the consideration of an all-way stop control at the intersection at 199th Street & Ridgeview Road, microsimulation modeling was performed to quantify the effect the change would have on the operation of the intersection. Figure 14 shows the delay per vehicle and LOS for the intersection as an all-way stop controlled intersection. The average delay for the intersection is 111.5 seconds (nearly four-times as much as the two-way stop control situation), which means the intersection would operate with a LOS of F.

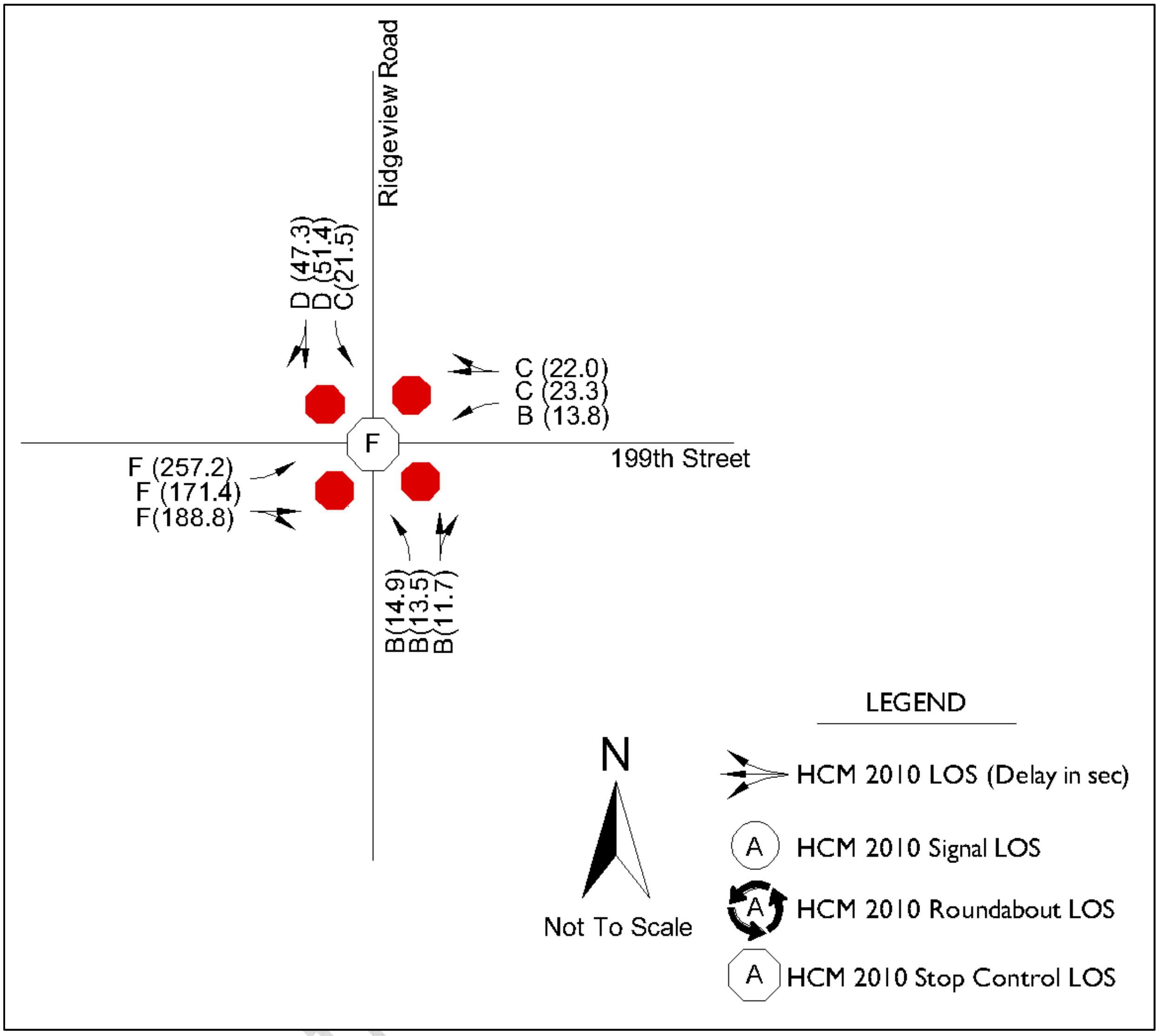


Figure 14 - LOS and Delay per Movement for All-Way Stop Controlled with 2017 AM Peak Hour Traffic - 199th Street & Ridgeview Road

The 2037 LOS and delay for the all-way stop controlled intersection is shown in Figure 15. The delay per vehicle was 390.0 seconds, meaning the intersection will operate with an LOS of F, assuming traffic grows as projected.

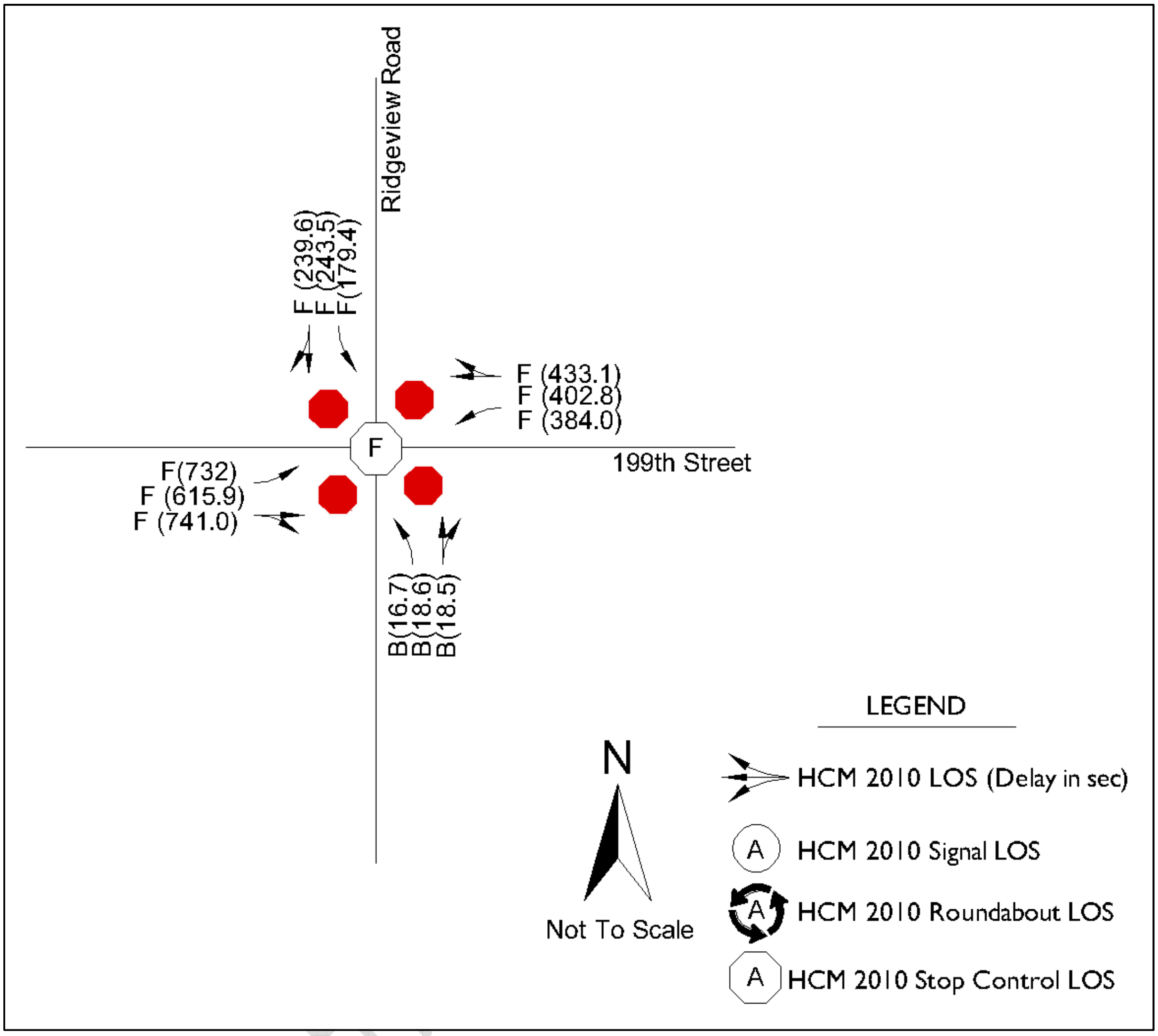


Figure 15 - LOS and Delay per Movement for All-Way Stop Controlled with 2037 AM Peak Hour Traffic - 199th Street & Ridgeview Road

3.3.3 ROUNDABOUT

Two roundabout designs were developed from this study. The first design is a typical single-lane modern roundabout, while the second roundabout design is an accelerated low-cost (ALC) roundabout. The modern roundabout is seen in Figure 16, and will require approximately 2,000 square feet of right-of-way acquisition. The accelerated low-cost roundabout is seen in Figure 17, and fits within the current intersection's pavement. The ALC roundabout has two construction options: performing mill and overlay before construction and not doing so. While milling and overlaying the intersection will cost time and money, doing so is expected to double the design life of the intersection from four to eight years.

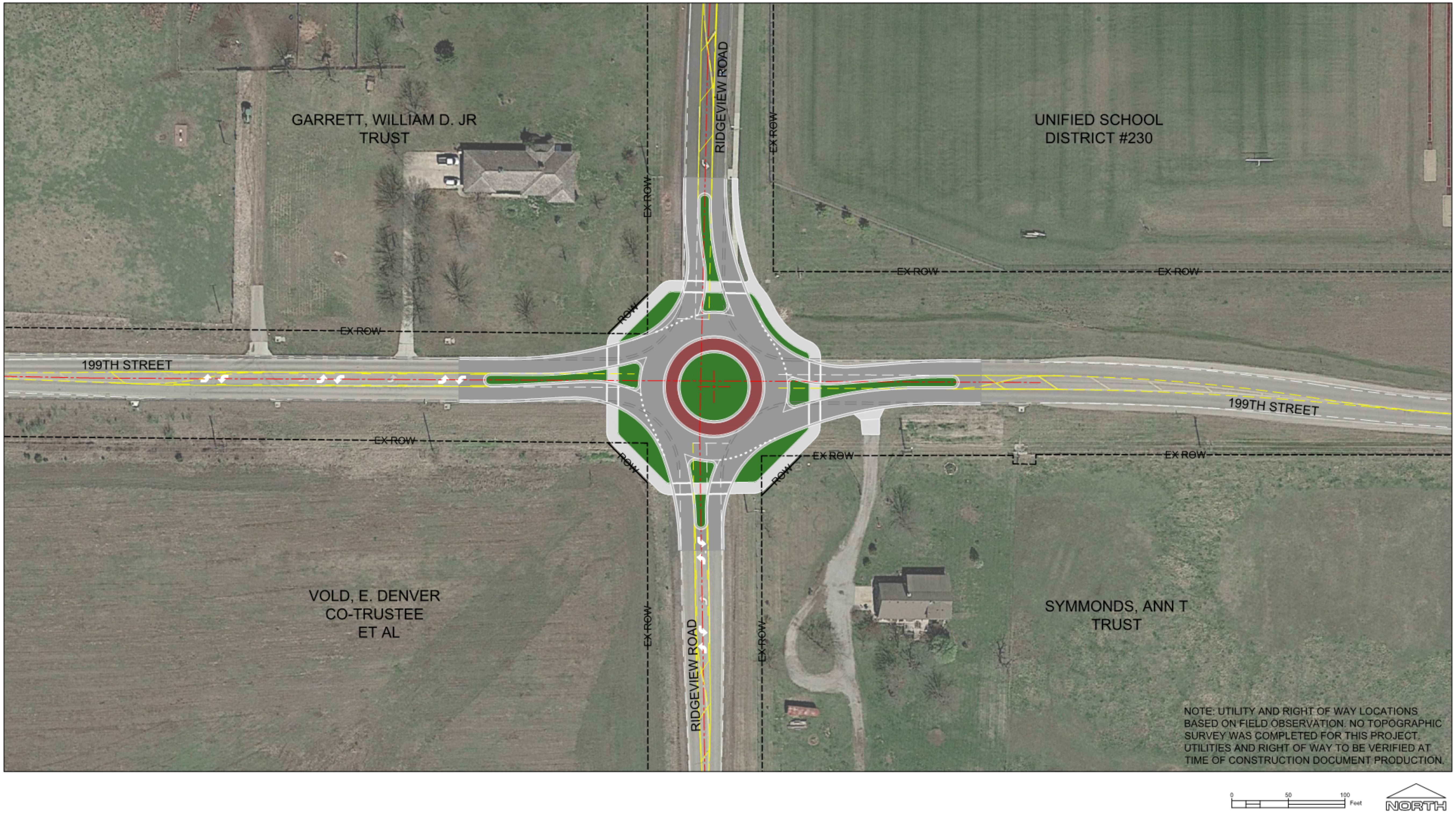


Figure 16 - Design Concept Sketch for Single Lane Roundabout – 199th Street & Ridgeview Road

Figure 17 – Design Concept Sketch for Accelerated Low-Cost Roundabout – 199th Street & Ridgeview Road

An accelerated low-cost roundabout differs from a modern single-lane roundabout in that the ALC is a type of mini-roundabout with a fully traversable center island, while the center of a single-lane roundabout is raised, with a mountable truck apron to facilitate the turning movement of the larger trucks.

The single-lane roundabout design was microsimulated in Vissim, while the accelerated low-cost roundabout was not microsimulated as it is expected to operate similar to the single-lane roundabout. The LOS and delay per movement for a roundabout using the AM peak hour traffic for 2017 has a delay of 23.5 seconds, and operates with a LOS of C. The roundabout reduced the delay per vehicle by 5 seconds compared to the two-way stop condition. It is noted that LOS for the westbound movement is between 58 and 60 seconds per vehicle due to the lack of adequate gaps within the roundabout from the heavy eastbound to northbound movement. However, as drivers become accustomed to driving roundabouts, gap acceptance increases over time, which reduces delay and improves LOS.

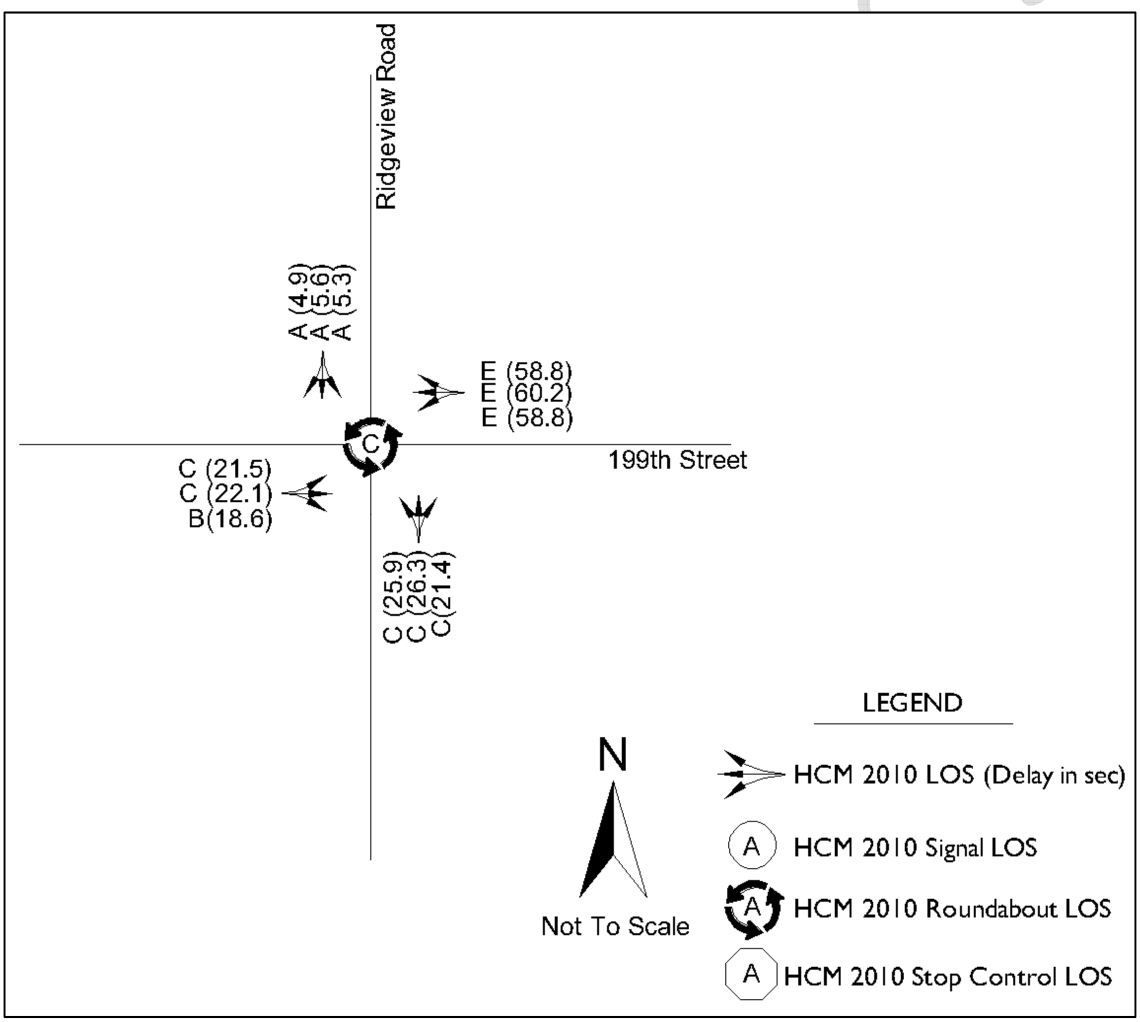


Figure 18 - LOS and Delay per Movement for a Roundabout with 2017 AM Peak Hour Traffic - 199th Street & Ridgeview Road

The delay and LOS for the 2037 AM peak hour are shown in Figure 19. The average delay per vehicle is 157.9 seconds, so the LOS is an F. This delay is minutely worse than the 2037 no-build condition. In the future, if traffic ever grew to require it, the single-lane roundabout could be built out to either a two-lane or hybrid roundabout; however, due to the proximity of utilities, this would be expensive.

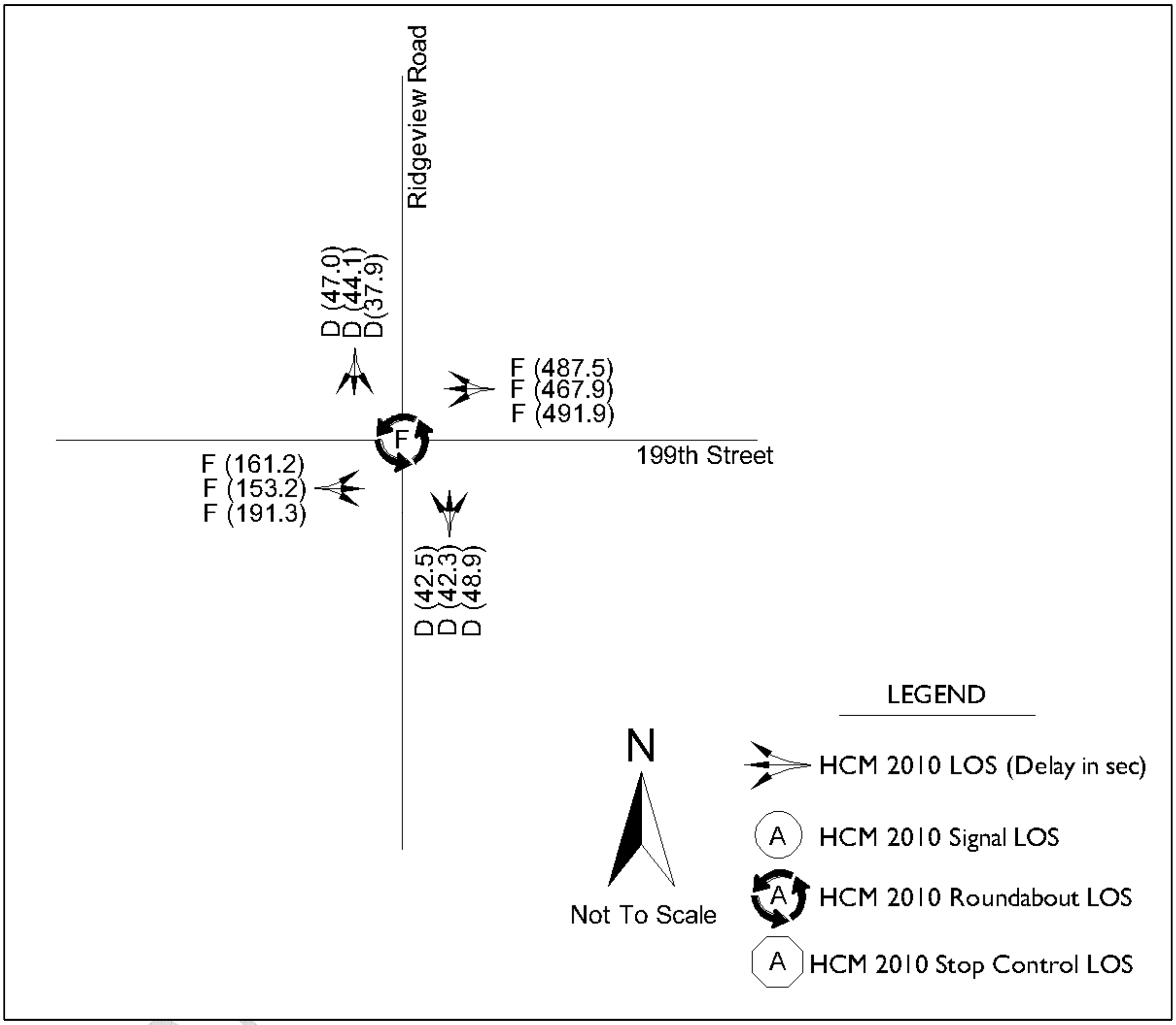


Figure 19 - LOS and Delay per Movement for a Roundabout with 2037 AM Peak Hour Traffic - 199th Street & Ridgeview Road

3.3.4 TRAFFIC SIGNAL

Since a traffic signal should not be considered with today's traffic, microsimulation for a traffic signal was only performed using the 2037 traffic projection, with a timing schedule optimized for the expected traffic. The delay and LOS were 150.6 seconds per vehicle and F, respectively.

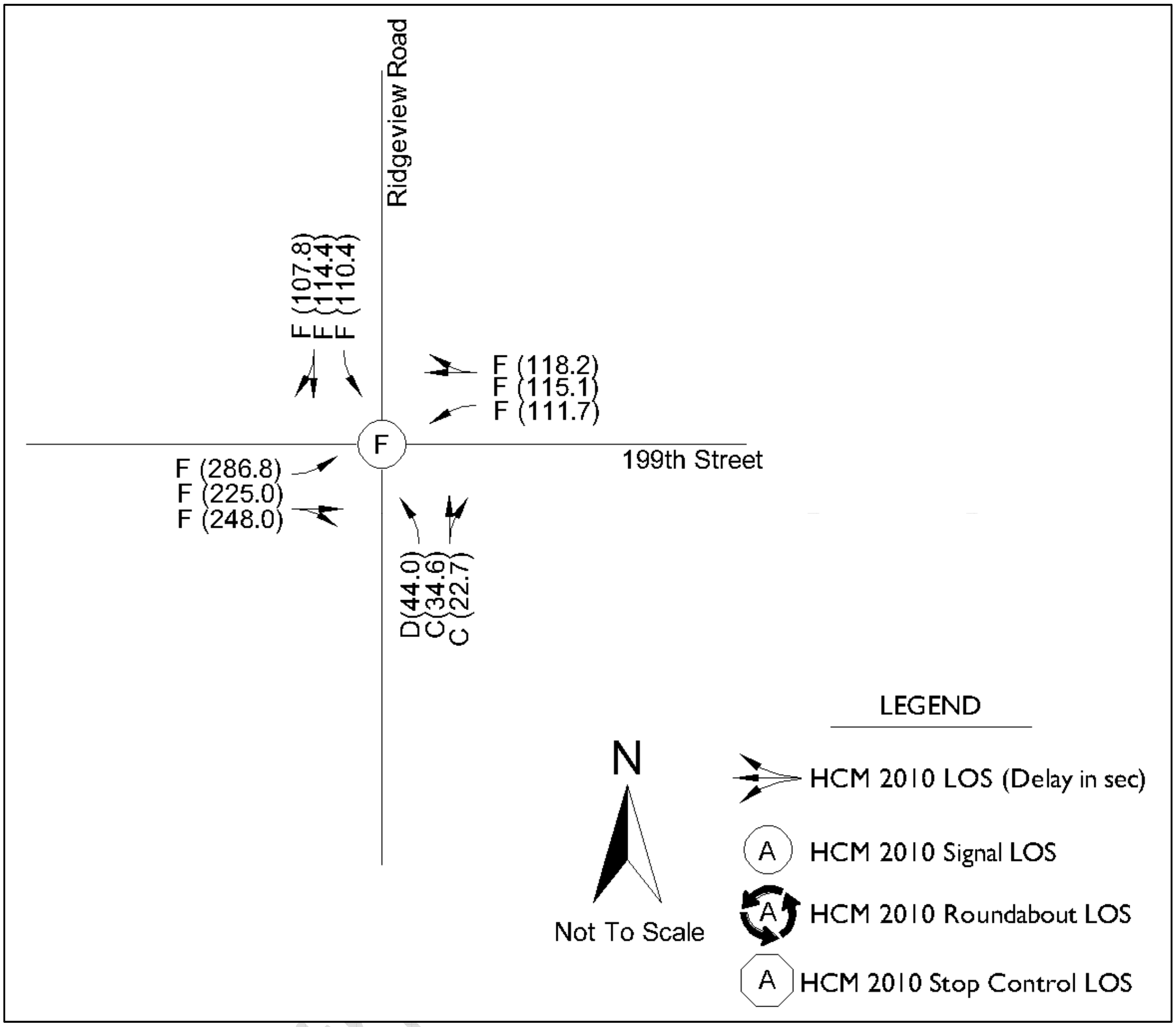


Figure 20 - LOS and Delay per Movement for a Traffic Signal with 2037 AM Peak Hour Traffic - 199th Street & Ridgeview Road

3.4 SAFETY ANALYSIS

To determine the effect each of the build options on the safety of the intersection, the potential safety benefit for each option was determined using HSM (2010 Edition) methodology. Crash modification factors (CMFs) obtained from the CMF Clearing house (Federal Highway Administration, 2016) were used to determine the percent change in crashes expected by altering the intersection. The change in crash percentage is calculated by subtracting the CMF from one and multiply by 100. (For example: 1-0.52=**48% crash reduction** OR 1-1.02= **2% crash increase**). The estimated annual benefit for each recommendation was calculated by multiplying the expected reduction in crashes by the comprehensive crash cost. The present value of the annual benefit over twenty years factoring in inflation and traffic growth was then determined to estimate the twenty year safety benefit for each option.

Table 16 shows the crash modification factors for the total number of crashes and the expected annual and 20-year benefit to the driving public based on the reduction of crashes for each build option. Full calculations for the reduction of crashes and safety benefits are shown in the Appendix. The roundabout options are expected to decrease the number of crashes the most (58% reduction in total crashes). The installation of a traffic signal is expected to reduce the intersection's crashes at a reduced rate (11% reduction in total crashes) and therefore provides the lowest annual benefit.

Table 16 – Safety Benefits for Build Options

Build Option	Source of CMF	CMF for Total Crashes	Annual Benefit	Design Life Benefit*
All-Way Stop Control	HSM Table 14-5	0.52	$53,000	$1,060,000
Accelerated Low-Cost Roundabout, no mill or overlay	Clearing House, 207 & 211	0.42	$89,000	$356,000
Accelerated Low-Cost Roundabout, with mill and overlay	Clearing House, 207 & 212	0.42	$89,000	$712,000
Single Lane Roundabout	Clearing House, 207 & 213	0.42	$89,000	$1,780,000
Traffic Signal	HSM Table 14-7	0.89	$13,000	$260,000

**The design life benefit was estimated using 20 years for the traffic signal, single-lane roundabout, and all-way stop control. The design life for the ALC was eight years for the mill and overlay option, and four years without.*

4 RECOMMENDATIONS AND IMPLEMENTATIONS

Based on the analysis described in this report, specific recommendations and interim improvements to mitigate the safety concerns at this intersection are discussed below. The recommendations are sub-divided into three sections based on cost: low-cost, medium-cost, and high-cost. Interim improvements are also provided for the high cost recommendations to improve the safety of the intersection between the construction of the modification.

The construction cost estimates are based on WSP USA's professional experience and judgment and shall be deemed to represent the company's opinion. WSP has no control over the cost of labor, material, equipment and other relevant factors that could influence the ultimate construction costs. Thus, our company does not guarantee that proposals, bids, or the actual facility cost will be the same as the estimate of probable construction cost or that construction costs will not vary from its opinions of probable cost. Costs for design, right-of-way, coordination, or construction oversight are not included in the following cost estimates

4.1 LOW-COST OPTIONS

The low-cost recommendations include regular maintenance of the southwest corner of the intersection, education, and enforcement activities. These recommendations include regularly mowing the study intersection area, staggering the start and end times of the Wolf Creek Elementary and Spring Hill High schools by at least 15 minutes, warning then ticketing improper/illegal movements through the intersection, and encouraging students and parents to consider the use of alternate modes of transportation and routes to arrive at the school in the morning. The low-cost options are detailed as follows:

- Regular mowing of the southwest corner of the intersection is essential to provide the proper stopping sight distance whether or not drivers on 199th Street comply with the 35 mph advisory speed. Without mowing, drivers do not have sufficient sight distance to make an abrupt stop to avoid colliding with northbound cars if they pull out into oncoming traffic.

- Staggering school hours for the elementary and high school will provide enough time between the start and end of the schools for the traffic from the earlier period to clear out before the second school's release time. This may increase the amount of time during which the intersection is influenced by the schools, but it should reduce the intensity of the traffic. The peak traffic period was observed to be only approximately 15 minutes in duration, so staggering the beginning and end times by 15-20 minutes should help to minimize the peak traffic demand.

- Ticketing the illegal movements through the intersection should reduce the number of eastbound-left turn vehicles that yield to the northbound through drivers. This activity of “waving” the northbound traffic through is both illegal and dangerous. Enforcing the legal movements at this intersection may encourage the northbound through drivers to find a different route as the delay for these vehicles will become extreme without being “waved” through or cutting in front of eastbound left vehicles.

- Directly educating the school users and encouraging alternate modes and routes could be an initiative run by the school district, Parent-Teacher Association, or during school assemblies. This could begin simply with a letter to the parents to consider the route to school in the morning, with an explanation of risky driving behaviors occurring at this intersection. A safer alternate route would be to divert so that the driver approached the 199th Street & Ridgeview Road intersection from the east (westbound approach) rather than from the south (northbound approach) so that a westbound right-turn could be made rather than a northbound through movement.

While these options would be expected to improve the safety, there are no means to quantify the expected benefit. No heavy construction work would be involved in these methods, so a cost estimate is not provided. There will be some ongoing costs incurred with these changes, but the costs are likely minimal compared to any construction options.

4.2 MEDIUM-COST OPTION

The medium-cost recommendation is to perform earthwork grading in the southwest corner of 199th Street & Ridgeview Road intersection. Lowering the elevation of the ground to the extent feasibly from a drainage perspective on this corner and planting sod turf grass would increase the sight distance for vehicles on the northbound approach looking westward.

Since only two crashes in the five-year crash history involved a northbound through vehicle failing to yield to an eastbound through vehicle, this option may only slightly improve the safety of the intersection, but has the potential to minimize the risk of a future serious injury or fatal crash resulting from a high speed right-angle crash. This improvement is estimated to cost approximately $12,000.

4.3 HIGH-COST OPTIONS

The high-cost recommendations will require engineering design and construction of improved infrastructure for the intersection. As it may take months or years to procure funding for these options, two interim options are also included. The high-cost build, interim, and no build options were simulated using Vissim software to obtain the LOS and delay using the 2017 AM peak hour volumes and the projected 2037 volumes, as seen in the previous chapter. A summary of the operations, cost, and safety benefit of these options is provided in the next section.

4.3.1 SECONDARY ENTRANCE TO SPRING HILL HIGH SCHOOL

The construction of a secondary entrance to the Spring Hill High School east of the intersection off 199th Street would reduce the strain on the intersection with Ridgeview Road caused by the start and end hours of the school day. A new entrance would create more gaps in the westbound traffic due to students turning right earlier, so the queue for the eastbound left-turn movement would decrease faster. However, before the entrance can be priced or built, a more detailed study should look into how it would tie into the school's internal system and whether any additional auxiliary lanes will be necessary.

4.3.2 TRAFFIC SIGNAL

While the intersection does not currently meet any traffic signal warrants, the projected 2037 traffic showed that if all the planned developments are finished and the traffic grows at a 2% annual growth rate, then a traffic signal might be considered in the future. The MUTCD notes that an intersection meeting one or more traffic signal warrants does not require the installation of a traffic signal. If future traffic at 199th Street & Ridgeview Road is found to meet one or more traffic signal warrants, engineering judgement should be applied to determine if the traffic control device will improve the intersection. The construction of the signal would require minimal roadway reconstruction and right of way acquisition. Based on the layout of the intersection, it is expected that 700 square feet of right of way acquisition and some amount of utility work would be required to install a traffic signal.

Vissim microsimulation was only performed for the 2037 condition for this option due to the intersection not currently being considered for a traffic signal. The expected LOS for 2037 was an F with a delay of 150.9 seconds per vehicle. The estimated cost to construct a traffic signal in 2037, accounting for inflated construction costs, is $602,000. If a traffic signal is installed, it is expected to save the public about $13,000 annually due to the reduction of crashes. Over 20 years, the total saving is expected to be $260,000. Therefore, the benefit to cost ratio for a traffic signal built when the traffic allows for consideration is 0.43.

4.3.3 ROUNDABOUT

The preferred high-cost option for the intersection is to construct single-lane modern roundabout at the intersection of 199th Street & Ridgeview Road. Modern roundabouts reduce the number of conflict points at intersections, which in turns improves the safety by minimizing the chances for vehicles to collide. They also reduce the speed of circulating traffic so when a collision occurs in a roundabout, the potential damage is minimized.

Vissim microsimulation analysis for both the 2017 AM peak hour and the projected 2037 AM peak hour was performed. Today's delay decreased to 23.5 seconds per vehicle, which is a LOS of C and an 18% reduction in delay over the existing conditions. The delay for the 2037 traffic remained essentially the same to the no-build scenario with a LOS of F and delay of 157.9 seconds per vehicle. However, as drivers become accustomed to driving roundabouts, gap acceptance increases over time, which reduces delay and improves LOS.

The design and construction of a single lane roundabout is estimated to cost $1,181,000. The reduction in crashes due to the single lane roundabout will save the public approximately $89,000 annually, for a total of $1,780,000 in present dollars over a 20-year period. The benefit to cost ratio for the roundabout is 1.51.

If a roundabout is constructed, it would be important that the daily users including the bus drivers and students were educated on the proper way to drive through a roundabout, which could be performed through public outreach. In the future, the single-lane roundabout could be built out to either a two-lane or hybrid roundabout; however, due to the proximity of utilities, this would be expensive.

4.3.4 INTERIM OPTIONS

ALL-WAY STOP CONTROL

One interim improvement option for the intersection is to change the intersection control method to an all-way stop. Since the traffic counts for 2017 at the intersection at 199th Street & Ridgeview Road meet the warrant for all-way stop control, this option could be implemented today. This modification would greatly increase the safety of the intersection at the expense of much higher delays for the vehicles. To implement this modification, two stop signs (R1-1) should be installed and the "ALL WAY" plaque (R1-3P) installed under each of the existing and new stop signs.

The Vissim microsimulation for the all-way stop control intersection for the 2017 AM peak was found to nearly quadruple the delay of the intersection, bringing the LOS of the intersection to an F with 111.5 seconds of delay per vehicle. With the 2037 traffic projections, the delay increased to 390.0 seconds per vehicle, more than double the other options modeled.

The cost for the installation of the all-way stop is estimated to be $7,000. Over the course of 20 years, it is expected converting the intersection to a four-way stop controlled intersection will save $53,000 annually on comprehensive crash costs, which in present day value is $1,060,000 over a 20-year period. The benefit-to-cost ratio for the all-way stop control is 151.43 when accounting for only safety benefits. However, due to the large amount of delay created by this option, converting the intersection to all-way stop control is not recommended.

ACCELERATED LOW-COST ROUNDABOUT

The preferred interim improvement is an "accelerated low-cost" roundabout. Accelerated low-cost roundabouts are a subcategory of a mini-roundabout. A mini-roundabout is a smaller diameter roundabout with a fully traversable center island that allows larger vehicles to traverse the intersection while minimizing the footprint of the roundabout. Accelerated low-cost roundabouts provide similar safety benefits to regular modern roundabouts but are constructed primarily with pavement marking, delineators, and minimal pavement reconstruction. These roundabouts can often be constructed using public agency maintenance staff and not require the typical construction bidding process. While accelerated low-cost roundabouts usually save time and money on the front end, they have shorter design lives and require more maintenance than conventional roundabouts.

The operation of this option was not analyzed in Vissim; however, it was estimated that its operations would be similar to the single lane roundabout, so it would perform well for today's traffic, but not perform significantly better than the two-way stop control (no-build) layout in the future.

To maximize the design life of an accelerated low-cost roundabout, it is recommended to mill and overlay the intersection before restriping as an accelerated low-cost roundabout. This will increase the estimated design life from approximately four years if no mill and overlay is performed to approximately eight years. If the intersection's pavement is milled and overlaid, it is expected to cost $220,000 to build, while saving the driving public an estimated $89,000 annually, which sums to $712,000 for its design life of eight years. If no mill and overlay is performed before the installation of an ACL roundabout will cost $118,000 and save the driving public $356,000 over its four-year design life. This means that the benefit cost ratios for the ACL are 3.24 for the mill and overlay option and 3.02 for no mill or overlay option.

4.4 COMPARISON OF HIGH COST OPTIONS AND INTERIM IMPROVEMENTS

The present and future LOS for the AM peak period, ROW acquisition, estimated costs, and crash savings to the public are shown for the different build options in Table 17. It is important to note that even though the LOS's for 2017 and 2037 seem low, they are only for the AM peak traffic period. The low-cost and medium-cost options were not included in the table due to the lack of any methodology to quantify the effect of the improvements.

Table 17 – Comparison of LOS, Delay, Right of Way Acquisition, Estimated Cost, and 20-year Expected Savings to the Public

Build Option	2017 LOS (AM)	2017 Delay (s/veh)	2037 LOS (AM)	2037 Delay (s/veh)	ROW Acquisition (ft^2)	Estimated Construction Cost	Design Life Benefit*	Benefit to Cost Ratio
No Build								
Two-Way Stop (No-Build)	C	28.5	F	156.9	0	n/a	n/a	n/a
High Cost Options								
Traffic Signal	n/a	n/a	F	150.6	700	$602,000	$260,000	0.43
Single-Lane Roundabout	C	23.5	F	157.9	2,000	$1,181,000	$1,780,000	1.51
Interim Improvements								
All-Way Stop Control	F	111.5	F	390.0	0	$7,000	$1,060,000	151.43
Accelerated Low-Cost Roundabout, no mill or overlay	C	23.5	F	157.9	0	$118,000	$356,000	3.02
Accelerated Low-Cost Roundabout, with mill and overlay	C	23.5	F	157.9	0	$220,000	$712,000	3.24

**The design life benefit was estimated using 20 years for the traffic signal, single-lane roundabout, and all-way stop control. The design life for the ALC was eight years for the mill and overlay option, and four years without.*

While the two-way stop control operates well during off-peak time periods, safety issues during the AM peak were observed during the field visit which will likely only worsen unless changes are made.

A traffic signal should not be installed until there is adequate traffic to consider it. However, the traffic signal option did operate with the least amount of delay under the projected 2037 traffic.

The traffic signal also had the lowest benefit-to-cost ratio of all the options. Therefore, it is not recommended with this study that a traffic signal be considered now or in the future for installation.

The single-lane roundabout has a net positive benefit-to-cost ratio for its 20-year design life, so it will greatly improve the safety of the intersection even though its expected cost to design and build is $1.2 million. The roundabout will also decrease the existing delay by 18%. Therefore, this study recommends that a single-lane roundabout be installed as a permanent solution to improve the safety and operations at 199th Street & Ridgeview Road.

Even though the all-way stop controlled intersection has the highest safety benefit-to-cost ratio, the extreme level of delay that this change would introduce to the intersection would be excessive, which renders the option highly infeasible. The public would likely not accept this change, and the all-way stop control would likely be quickly removed due to political pressure. Additional costs to society should be considered with this option including the increased fuel consumption and pollution emissions due to the requirement to come to a complete stop on 199th Street. It is recommended with this study that an all-way stop control not be considered now or in the future for this intersection.

The accelerated low-cost roundabout options both have relatively high positive benefit-to-cost ratio; however, they should not be installed in place of a traditional modern roundabout, as they are expected to have somewhat lower safety and operational benefits. These lowered safety and operation benefits are difficult to quantify with current methodology. However, the accelerated low-cost roundabouts do not provide as much deflection on the entries or through the circulating roadway, leading to slightly more severe crashes than a full modern roundabout would have. They will also require more frequent maintenance and have a shorter design life. This study recommends the installation of an accelerated low-cost roundabout, but it should be considered a “temporary interim improvement” prior to the installation of a full single-lane modern roundabout.

4.5 ADDITIONAL RECOMMENDATIONS

There are currently plans to convert the two-mile stretch of Ridgeview Road from 191st to 207th Street to a four-lane median divided roadway. However, the existing and projected future 2037 traffic volumes do not appear to need a four-lane facility. If a separated facility is desired, it is recommended that Ridgeview Road’s cross-section be designed like the layout shown in Figure 21.

This cross section includes five-foot bike lanes along with three-foot buffer areas to accommodate the large volume of cyclists who currently use the road, and may encourage students to bike to school. The combination of the 11-foot lanes, three-foot buffer area, five-foot bike lanes, and 1.5-foot wide gutter pans provide a total curb to curb width of 22 feet. This width is similar to the total width that would be provided by a four-lane divided facility and sufficient to provide access to emergency vehicles even if a stalled vehicle is present on the roadway.

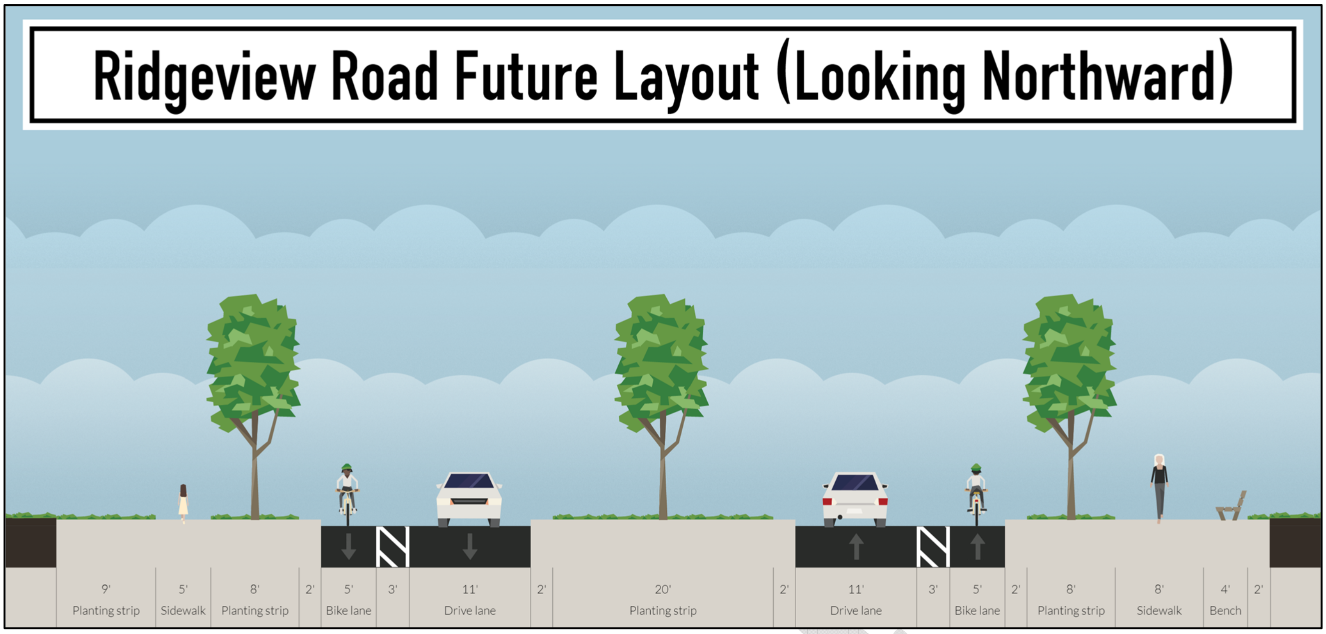


Figure 21 – Recommended Cross-Section for Ridgeview Road as a Separated Facility

WORKS CITED

— Federal Highway Administration. (2009). *Manual on Uniform Traffic Control Devices.* Washington, D.C.: U.S. Department of Transportation.

— Institute of Transportation Engineers. (2012). *Trip Generation Manual, 9th Edition.* Washington, D.C.: Institue of Transportation Engineers.

— Transportation Board. (2012). *Highway Capacity Manual 2010.* Washington, D.C.: Transportation Research Board.

APPENDIX

Date: 5/9/2017
Location: Spring Hill, KS
Time Interval: Midnight - Noon

Time	Ridgeview Road			199th Street			Ridgeview Road			199th Street		
	SB Left	SB Thru	SB Right	WB Left	WB Thru	WB Right	NB Left	NB Thru	NB Right	EB Left	EB Thru	EB Right
0:00 - 0:15	0	0	0	0	1	1	0	0	0	0	0	0
0:15 - 0:30	0	0	0	0	2	1	0	0	0	0	0	0
0:30 - 0:45	1	1	1	0	0	1	0	0	0	0	0	0
0:45 - 1:00	0	0	0	0	0	0	0	1	0	0	0	0
1:00 - 1:15	0	0	0	0	0	0	0	0	0	0	1	0
1:15 - 1:30	0	0	0	0	0	0	0	0	0	0	0	0
1:30 - 1:45	1	0	0	0	0	0	0	0	0	2	0	0
1:45 - 2:00	0	0	0	0	0	0	0	0	0	0	0	0
2:00 - 2:15	0	0	1	0	1	0	0	0	0	0	1	0
2:15 - 2:30	0	0	0	0	0	0	0	0	0	0	0	0
2:30 - 2:45	0	1	0	0	0	0	0	0	0	1	0	0
2:45 - 3:00	0	0	0	0	0	0	0	0	0	0	0	0
3:00 - 3:15	0	0	0	0	0	0	0	0	0	0	0	0
3:15 - 3:30	0	0	0	0	0	0	0	0	0	0	0	0
3:30 - 3:45	0	0	0	0	0	0	0	0	0	0	1	0
3:45 - 4:00	1	0	1	0	0	1	0	0	0	1	0	0
4:00 - 4:15	0	0	0	0	1	0	0	0	0	0	0	0
4:15 - 4:30	0	0	0	0	1	0	0	0	0	0	2	0
4:30 - 4:45	0	0	0	0	2	0	0	0	0	0	0	0
4:45 - 5:00	0	0	1	0	1	1	0	0	0	0	2	0
5:00 - 5:15	0	0	0	0	0	0	0	1	0	1	3	0
5:15 - 5:30	0	0	1	0	4	1	0	1	0	1	3	0
5:30 - 5:45	0	1	0	1	3	0	0	0	0	1	6	0
5:45 - 6:00	1	0	1	0	4	2	0	2	0	2	10	0
6:00 - 6:15	2	1	2	1	9	2	0	4	0	1	9	0
6:15 - 6:30	4	2	1	0	10	2	0	1	1	6	23	0
6:30 - 6:45	4	2	3	1	8	6	0	4	0	8	25	0
6:45 - 7:00	6	2	8	2	9	3	0	3	0	9	30	1
7:00 - 7:15	3	4	9	1	15	9	0	13	2	35	30	1
7:15 - 7:30	5	4	13	4	27	13	0	9	5	71	36	0
7:30 - 7:45	1	1	32	2	20	26	0	4	1	129	27	1
7:45 - 8:00	4	4	84	0	25	37	0	17	6	196	33	1
8:00 - 8:15	7	11	28	2	15	4	2	8	3	27	27	0
8:15 - 8:30	4	2	6	0	16	2	0	4	2	9	28	0
8:30 - 8:45	2	3	4	1	23	5	0	6	2	15	21	1
8:45 - 9:00	7	3	7	2	15	3	1	2	2	18	9	0
9:00 - 9:15	6	3	5	0	12	2	0	2	1	5	12	0
9:15 - 9:30	2	0	3	2	11	4	0	5	0	15	17	0
9:30 - 9:45	3	4	6	0	8	5	0	7	0	15	17	0
9:45 - 10:00	2	2	8	1	11	2	0	3	1	9	9	1
10:00 - 10:15	4	2	6	4	9	4	0	0	1	5	15	0
10:15 - 10:30	3	2	6	3	14	1	0	4	0	6	6	0
10:30 - 10:45	3	6	15	3	12	7	0	2	1	12	17	0
10:45 - 11:00	2	6	10	0	11	11	0	5	2	13	12	0
11:00 - 11:15	5	6	12	1	11	8	0	2	0	11	14	0
11:15 - 11:30	2	8	16	1	15	5	0	3	2	8	12	0
11:30 - 11:45	4	7	5	3	17	0	0	2	1	7	8	1
11:45 - 12:00	3	3	9	0	12	1	0	4	4	4	10	1

Date: 5/9/2017
Location: Spring Hill, KS
Time Interval: Noon - Midnight

Time	Ridgeview Road SB Left	Ridgeview Road SB Thru	Ridgeview Road SB Right	199th Street WB Left	199th Street WB Thru	199th Street WB Right	Ridgeview Road NB Left	Ridgeview Road NB Thru	Ridgeview Road NB Right	199th Street EB Left	199th Street EB Thru	199th Street EB Right
12:00 - 12:15	3	6	5	1	16	4	0	2	3	4	13	0
12:15 - 12:30	3	4	7	2	10	3	0	2	3	10	15	0
12:30 - 12:45	4	8	7	2	12	5	0	2	1	3	15	0
12:45 - 13:00	2	4	9	0	14	3	0	0	1	4	11	1
13:00 - 13:15	7	7	3	2	15	5	0	1	0	8	13	0
13:15 - 13:30	2	4	6	1	12	3	1	3	1	7	12	1
13:30 - 13:45	3	6	13	0	16	1	0	2	0	4	13	0
13:45 - 14:00	4	3	19	0	18	5	1	5	1	3	17	0
14:00 - 14:15	1	4	13	5	32	1	0	4	2	16	19	0
14:15 - 14:30	6	9	20	1	21	3	0	3	5	10	8	2
14:30 - 14:45	3	4	19	1	23	5	0	2	1	12	22	0
14:45 - 15:00	1	5	10	2	17	11	0	7	2	35	16	0
15:00 - 15:15	12	40	52	4	17	8	0	9	1	17	18	2
15:15 - 15:30	9	33	75	2	26	2	0	3	2	7	14	1
15:30 - 15:45	5	29	25	1	38	7	0	7	1	18	13	2
15:45 - 16:00	5	12	15	3	32	5	0	5	2	5	21	1
16:00 - 16:15	7	14	12	0	28	7	0	6	1	13	28	0
16:15 - 16:30	8	18	28	1	36	6	1	3	2	14	18	0
16:30 - 16:45	8	10	22	6	28	6	1	6	2	21	24	3
16:45 - 17:00	5	14	19	1	35	6	0	6	3	11	20	2
17:00 - 17:15	8	18	23	3	49	7	1	5	4	12	22	1
17:15 - 17:30	12	17	26	7	33	6	0	11	1	19	22	0
17:30 - 17:45	12	5	22	4	45	5	0	5	4	10	25	1
17:45 - 18:00	11	22	34	2	43	10	0	5	3	21	19	2
18:00 - 18:15	12	14	52	10	37	10	0	10	1	35	15	0
18:15 - 18:30	8	8	14	5	30	10	0	12	1	45	22	1
18:30 - 18:45	1	5	11	3	14	8	0	7	1	29	15	0
18:45 - 19:00	2	6	8	3	18	7	0	9	1	23	16	1
19:00 - 19:15	3	10	13	2	14	2	0	3	0	13	14	0
19:15 - 19:30	4	19	57	5	16	3	0	2	0	7	7	0
19:30 - 19:45	0	2	7	1	13	5	0	2	0	8	9	1
19:45 - 20:00	4	3	5	3	18	4	0	1	1	5	8	0
20:00 - 20:15	6	21	46	0	7	2	0	0	0	5	8	0
20:15 - 20:30	5	9	26	4	12	2	0	2	1	5	12	0
20:30 - 20:45	2	5	4	3	4	1	0	0	0	2	5	0
20:45 - 21:00	2	5	5	1	13	0	0	2	1	3	9	0
21:00 - 21:15	1	8	3	1	9	1	0	3	0	1	14	0
21:15 - 21:30	2	3	5	1	9	1	0	0	0	1	6	0
21:30 - 21:45	4	2	3	1	4	1	0	1	0	3	0	0
21:45 - 22:00	2	5	4	1	6	1	0	0	0	2	3	0
22:00 - 22:15	1	1	1	2	2	1	0	2	0	0	1	0
22:15 - 22:30	0	2	1	0	4	3	0	0	0	0	2	0
22:30 - 22:45	1	1	2	0	5	1	0	1	0	3	0	0
22:45 - 23:00	0	1	3	0	1	0	0	1	0	1	3	0
23:00 - 23:15	0	1	0	0	0	1	0	0	0	2	2	0
23:15 - 23:30	0	0	3	0	4	0	0	0	0	1	0	0
23:30 - 23:45	0	0	1	1	1	0	0	0	0	1	0	0
23:45 - 24:00	1	1	1	1	1	1	0	0	0	0	2	0

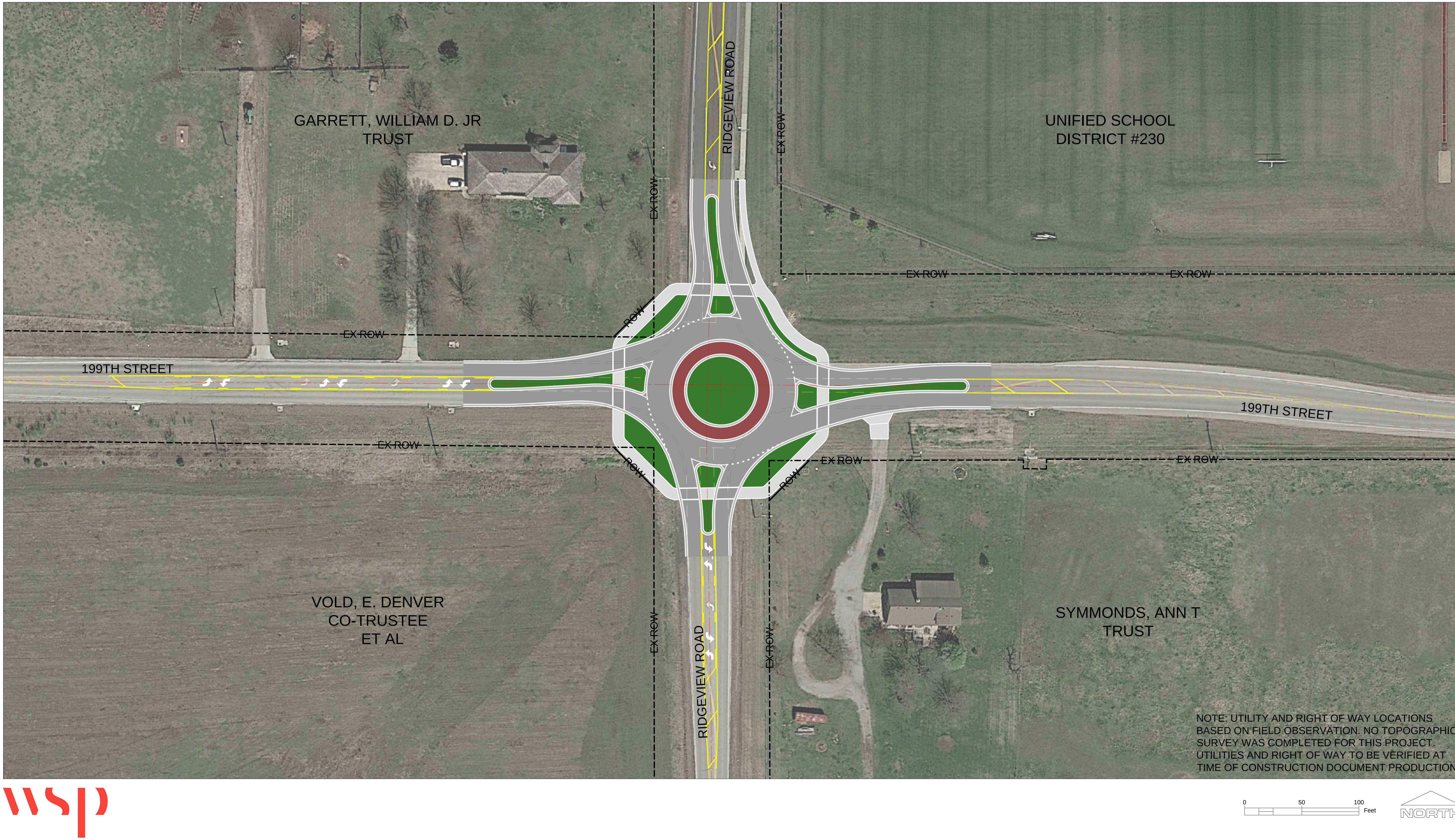
Speed (MPH)	Frequency	Relative Frequency	Cumulative Frequency
70			
69			
68			
67			
66			
65			
64			
63			
62			
61			
60			
59			
58			
57			
56			
55			
54	1	0.86%	100.00%
53	4	3.45%	99.14%
52	2	1.72%	95.69%
51	2	1.72%	93.97%
50	10	8.62%	92.24%
49	10	8.62%	83.62%
48	10	8.62%	75.00%
47	16	13.79%	66.38%
46	12	10.34%	52.59%
45	7	6.03%	42.24%
44	14	12.07%	36.21%
43	5	4.31%	24.14%
42	9	7.76%	19.83%
41	5	4.31%	12.07%
40	6	5.17%	7.76%
39	0	0.00%	2.59%
38	2	1.72%	2.59%
37	0	0.00%	0.86%
36	0	0.00%	0.86%
35	1	0.86%	0.86%
34			
33			
32			
31			
30			
29			
28			
27			
26			
25			
24			
23			
22			
21			
20			

Observer: J. Skinner
Date: 5-9-17
Weather: Sunny
Posted Speed Limit:45 MPH
Start Time: 10:16

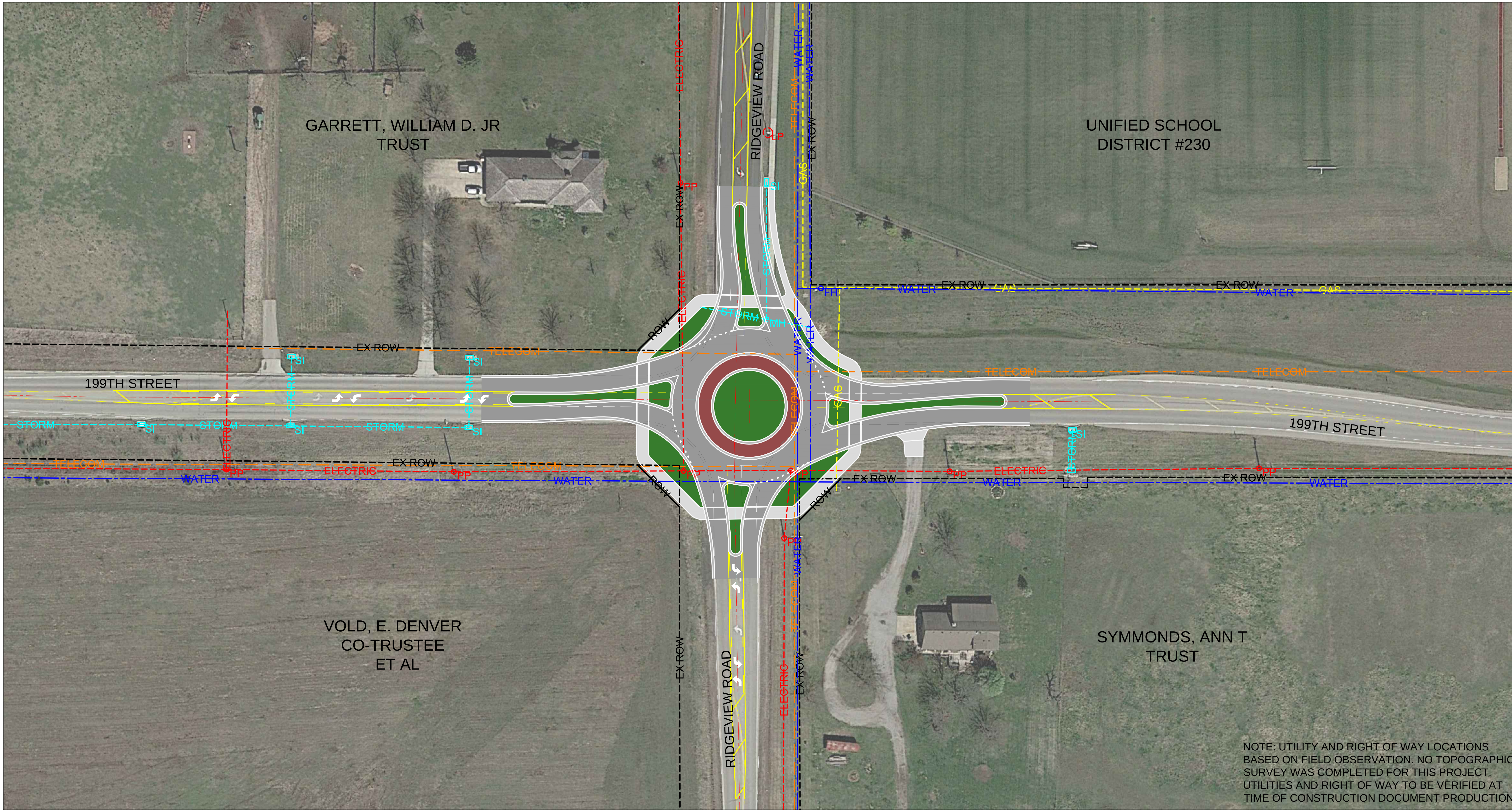
Location: .4 mi W of 199th St.
and Ridgeview Rd.
City of Spring Hill
Johnson Co. Ks.

Maximum Speed	54	MPH
Minimum Speed	35	MPH
Average Speed (grouped)	45.9	MPH
Mode	47	MPH
50th Percentile Speed (Median)	45.8	MPH
85th Percentile Speed	49.8	MPH
Pace	40-50	MPH
Percent within Pace	89.7%	
Distribution Westbound	55.2%	
Distribution Eastbound	44.8%	
% Trucks	4.4%	

199th Street & Ridgeview Road Roundabout Layout (DRAFT)



199th Street & Ridgeview Road Roundabout Layout (DRAFT)

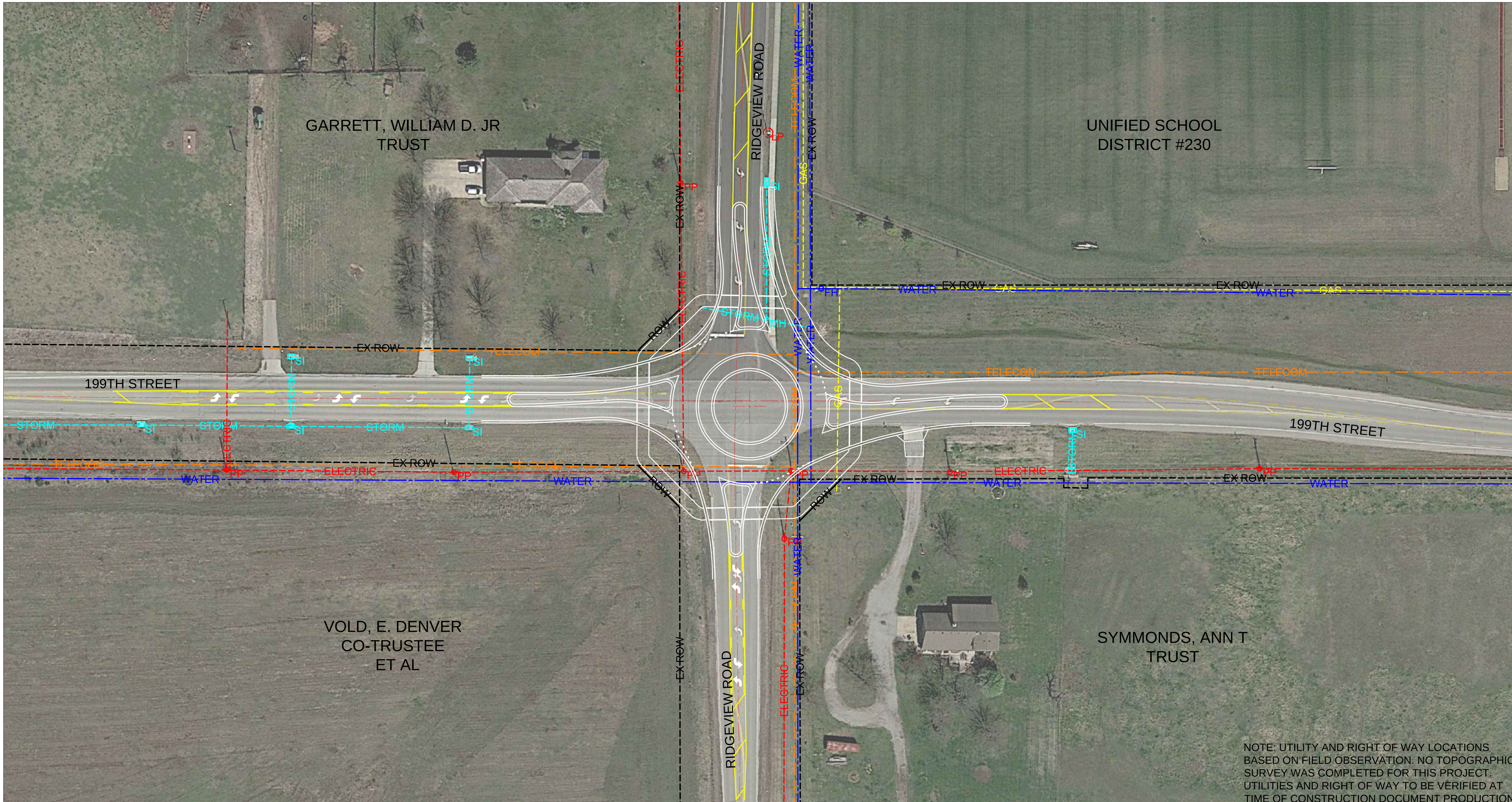


0 50 100 Feet

NORTH

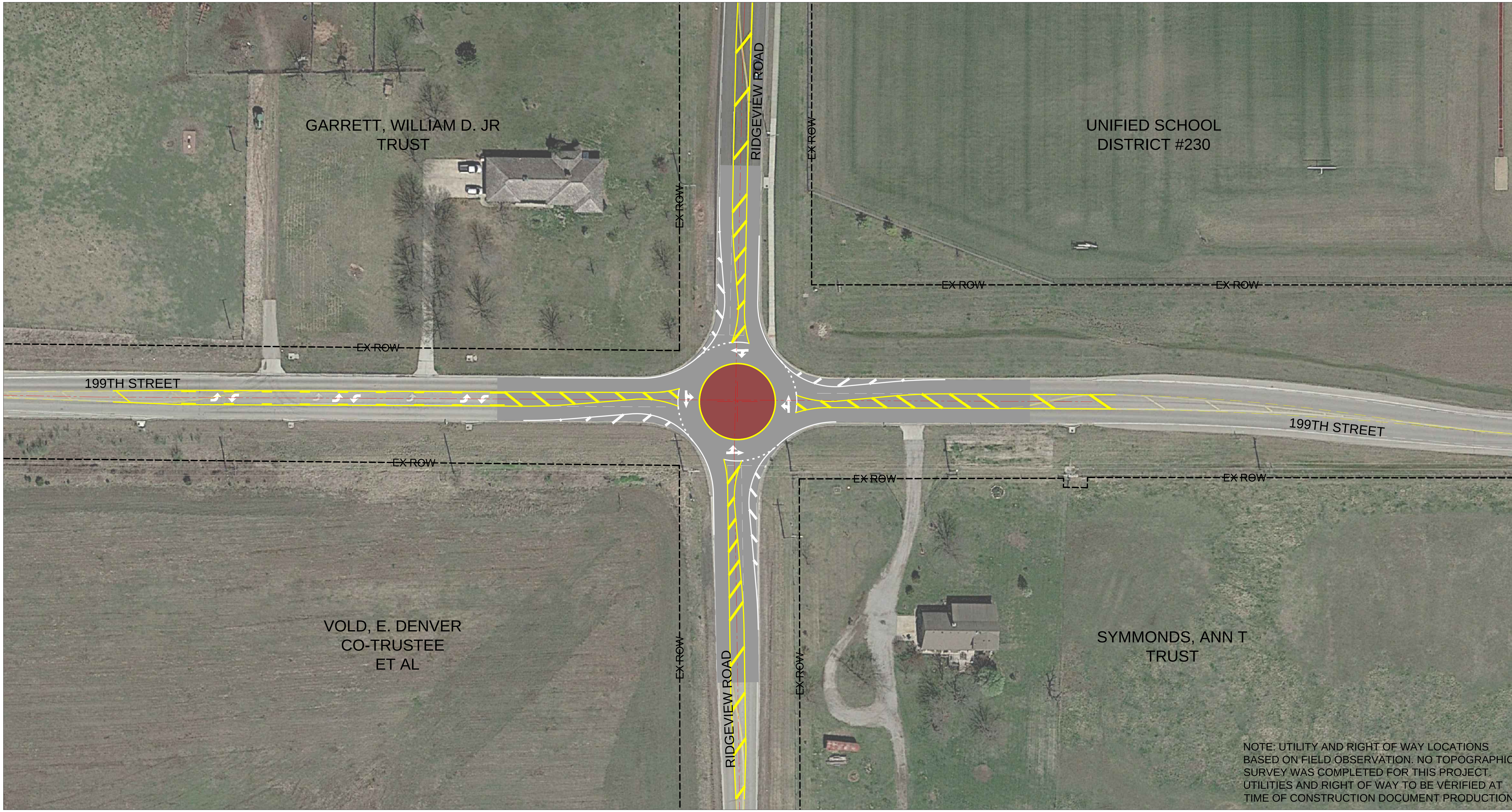
wsp

199th Street & Ridgeview Road Roundabout Layout (DRAFT)



wsp

199th Street & Ridgeview Road Accelerated Low Cost Roundabout Layout (DRAFT)

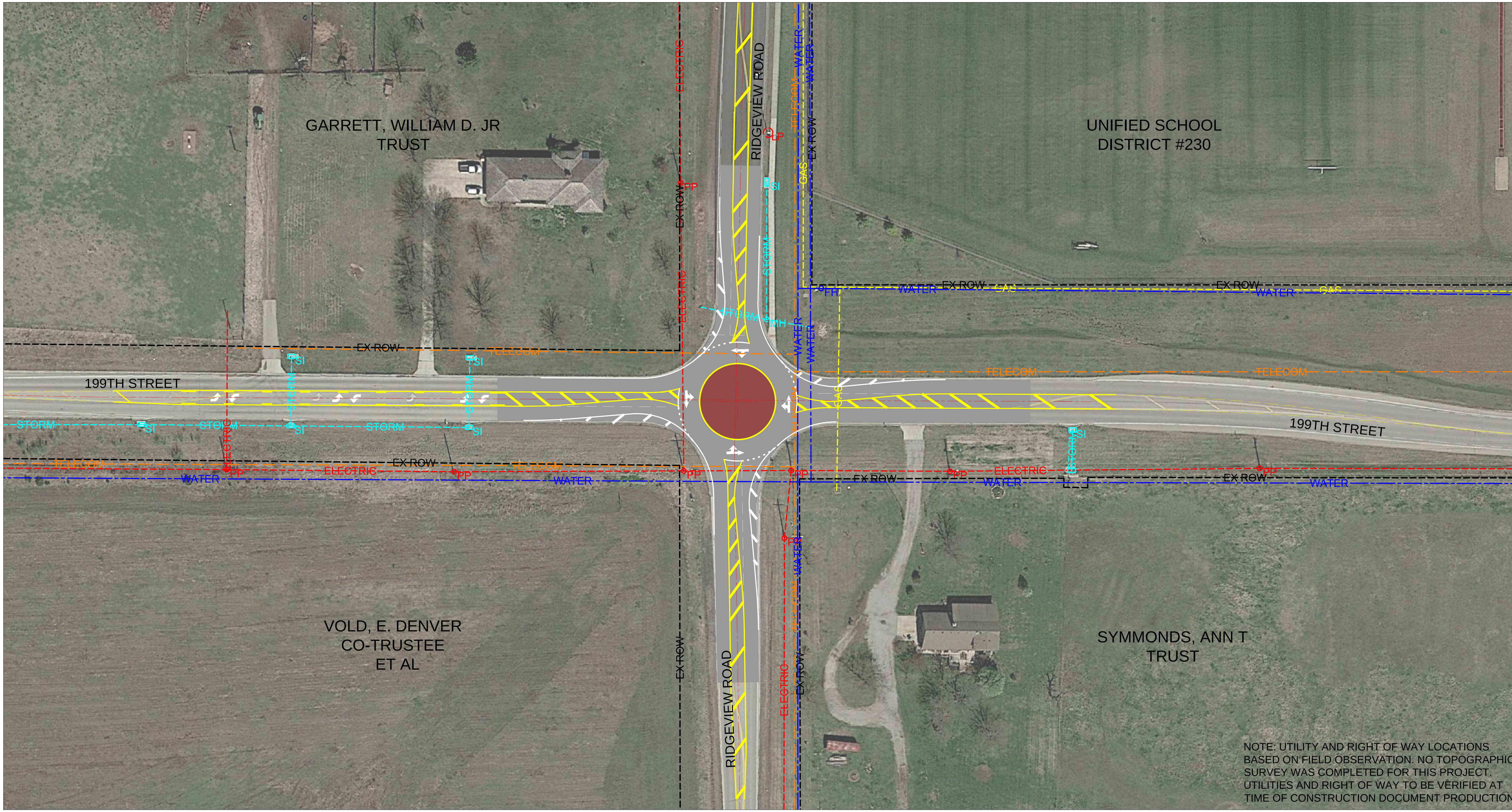


wsp

0 50 100 Feet

NORTH

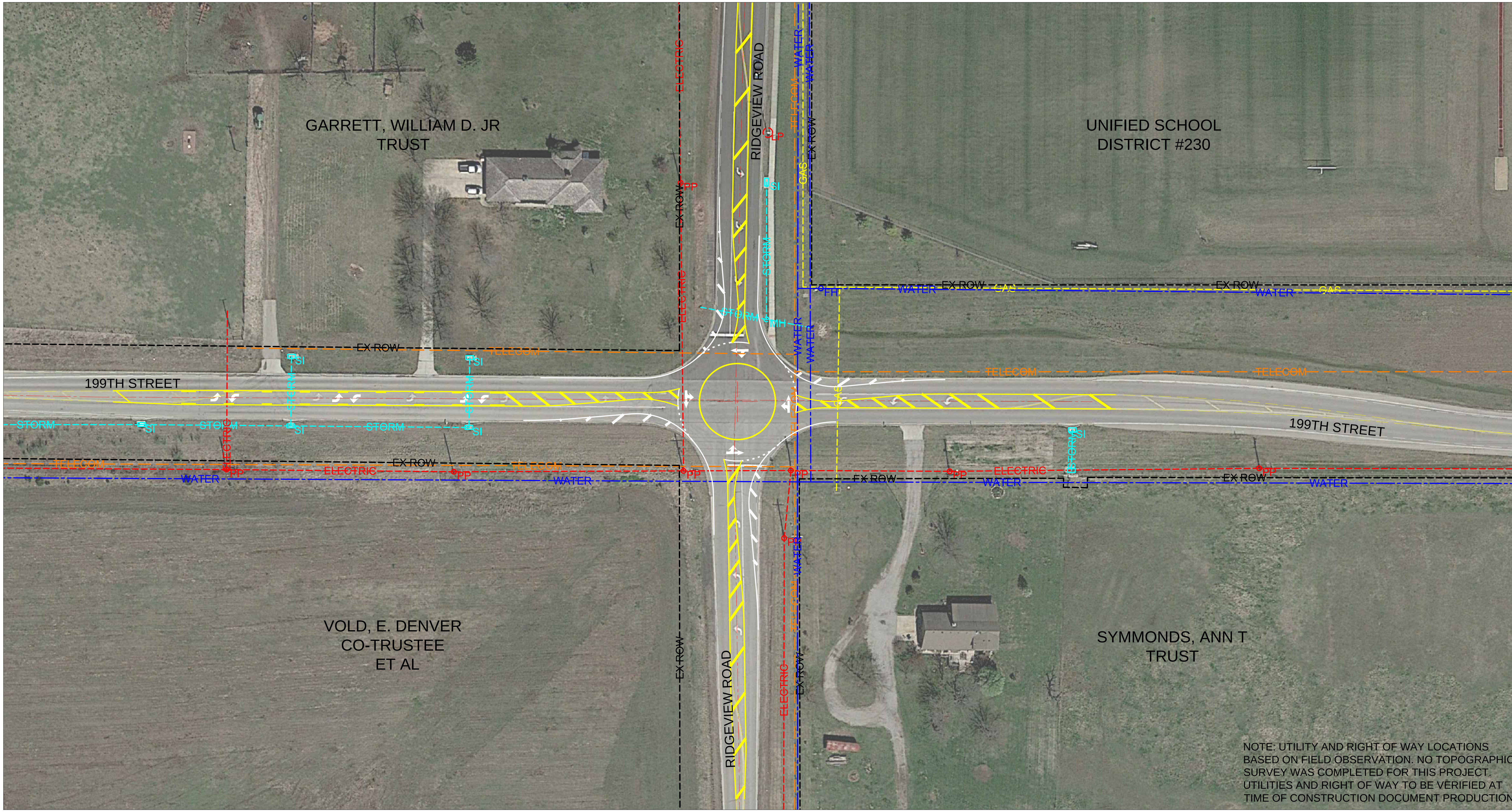
199th Street & Ridgeview Road Accelerated Low Cost Roundabout Layout (DRAFT)



0 50 100 Feet

NORTH

199th Street & Ridgeview Road Accelerated Low Cost Roundabout Layout (DRAFT)



0 50 100 Feet

NORTH

Two-Way Stop Control - 2017 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	177	36.5	7.9	829	245	D
1: 199th & Ridgeview	EB	Through	32	10.5	1.8	829	245	B
1: 199th & Ridgeview	EB	Right 2	1	9.9	1.8	829	245	A
1: 199th & Ridgeview	WB	Left 2	5	2.7	0.1	19	0	A
1: 199th & Ridgeview	WB	Through	26	1.0	0.0	0	0	A
1: 199th & Ridgeview	WB	Right 2	33	1.6	0.0	0	0	A
1: 199th & Ridgeview	NB	Left 2	3	34.8	23.0	121	39	C
1: 199th & Ridgeview	NB	Through	13	107.0	77.9	117	37	F
1: 199th & Ridgeview	NB	Right 2	5	68.2	47.3	136	44	E
1: 199th & Ridgeview	SB	Left 2	6	160.4	146.9	242	69	F
1: 199th & Ridgeview	SB	Through	11	30.0	5.7	238	65	C
1: 199th & Ridgeview	SB	Right 2	79	19.2	1.6	289	94	B
1: 199th & Ridgeview	Total	Total	391	28.5	9.1	832	59	C

Two-Way Stop Control - 2037 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	48	564.5	288.1	1,693	1,615	F
1: 199th & Ridgeview	EB	Through	14	377.2	167.2	1,693	1,615	F
1: 199th & Ridgeview	EB	Right 2	0	507.6	234.7	1,693	1,615	F
1: 199th & Ridgeview	NB	Through	19	271.3	192.9	496	275	F
1: 199th & Ridgeview	NB	Right 2	8	237.1	170.2	516	295	F
1: 199th & Ridgeview	NB	Left 2	3	106.5	69.7	499	279	F
1: 199th & Ridgeview	WB	Right 2	115	3.3	0.0	0	0	A
1: 199th & Ridgeview	WB	Through	83	4.0	0.0	0	0	A
1: 199th & Ridgeview	WB	Left 2	13	3.1	0.0	14	0	A
1: 199th & Ridgeview	SB	Left 2	5	813.1	779.5	1,033	832	F
1: 199th & Ridgeview	SB	Right 2	64	247.8	144.5	1,080	879	F
1: 199th & Ridgeview	SB	Through	13	248.8	143.5	1,030	828	F
1: 199th & Ridgeview	Total	Total	385	156.9	84.0	1,693	500	F

All-Way Stop Control - 2017 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	89	257.2	28.8	1,696	1,246	F
1: 199th & Ridgeview	EB	Through	18	171.4	17.5	1,696	1,246	F
1: 199th & Ridgeview	EB	Right 2	0	188.8	18.1	1,696	1,246	F
1: 199th & Ridgeview	WB	Left 2	5	13.8	1.4	150	28	B
1: 199th & Ridgeview	WB	Through	26	23.3	2.9	150	28	C
1: 199th & Ridgeview	WB	Right 2	33	22.0	3.0	150	28	C
1: 199th & Ridgeview	NB	Left 2	3	14.9	2.2	61	3	B
1: 199th & Ridgeview	NB	Through	14	13.5	1.3	61	3	B
1: 199th & Ridgeview	NB	Right 2	6	11.7	0.7	61	3	B
1: 199th & Ridgeview	SB	Left 2	8	21.5	3.1	359	129	C
1: 199th & Ridgeview	SB	Through	10	51.4	7.4	359	129	D
1: 199th & Ridgeview	SB	Right 2	75	47.3	6.5	359	129	D
1: 199th & Ridgeview	Total	Total	287	111.5	12.8	1,696	352	F

All-Way Stop Control - 2037 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	71	732.0	119.3	1,697	1,627	F
1: 199th & Ridgeview	EB	Through	19	615.9	97.3	1,697	1,627	F
1: 199th & Ridgeview	EB	Right 2	1	741.0	115.0	1,697	1,627	F
1: 199th & Ridgeview	NB	Through	29	18.6	3.0	115	12	B
1: 199th & Ridgeview	NB	Right 2	11	18.5	3.1	115	12	B
1: 199th & Ridgeview	NB	Left 2	5	16.7	2.7	115	12	B
1: 199th & Ridgeview	WB	Right 2	46	433.1	54.0	1,700	1,557	F
1: 199th & Ridgeview	WB	Through	42	402.8	51.6	1,700	1,557	F
1: 199th & Ridgeview	WB	Left 2	5	384.0	43.7	1,700	1,557	F
1: 199th & Ridgeview	SB	Left 2	9	179.4	21.2	1,047	879	F
1: 199th & Ridgeview	SB	Right 2	72	243.5	32.1	1,047	879	F
1: 199th & Ridgeview	SB	Through	15	239.6	31.2	1,047	879	F
1: 199th & Ridgeview	Total	Total	324	390.0	56.7	1,701	1,019	F

Single Lane Roundabout - 2017 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	185	21.5	3.0	749	138	C
1: 199th & Ridgeview	EB	Through	33	22.1	3.3	749	138	C
1: 199th & Ridgeview	EB	U-Turn	0			749	138	F
1: 199th & Ridgeview	EB	Right 2	1	18.6	2.4	749	138	B
1: 199th & Ridgeview	WB	Right 2	31	58.8	38.1	330	112	E
1: 199th & Ridgeview	WB	U-Turn	0			330	112	F
1: 199th & Ridgeview	WB	Through	25	60.2	37.5	330	112	E
1: 199th & Ridgeview	WB	Left 2	4	55.4	36.5	330	112	E
1: 199th & Ridgeview	NB	Through	14	26.3	19.3	95	14	C
1: 199th & Ridgeview	NB	Right 2	6	21.4	14.5	95	14	C
1: 199th & Ridgeview	NB	Left 2	3	25.9	19.6	95	14	C
1: 199th & Ridgeview	NB	U-Turn	0			95	14	F
1: 199th & Ridgeview	SB	U-Turn	0			155	7	F
1: 199th & Ridgeview	SB	Left 2	8	5.3	0.6	155	7	A
1: 199th & Ridgeview	SB	Right 2	80	4.9	0.5	155	7	A
1: 199th & Ridgeview	SB	Through	11	5.6	0.9	155	7	A
1: 199th & Ridgeview	Total	Total	400	23.5	8.6	768	68	C

Single Lane Roundabout - 2037 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	155	161.2	48.0	1,677	1,336	F
1: 199th & Ridgeview	EB	Through	34	153.2	45.1	1,677	1,336	F
1: 199th & Ridgeview	EB	U-Turn	0			1,677	1,336	F
1: 199th & Ridgeview	EB	Right 2	2	191.3	62.5	1,677	1,336	F
1: 199th & Ridgeview	WB	Right 2	41	487.5	215.2	1,696	1,584	F
1: 199th & Ridgeview	WB	U-Turn	0			1,696	1,584	F
1: 199th & Ridgeview	WB	Through	43	467.9	208.7	1,696	1,584	F
1: 199th & Ridgeview	WB	Left 2	5	491.9	223.9	1,696	1,584	F
1: 199th & Ridgeview	NB	Through	28	42.3	29.4	185	55	D
1: 199th & Ridgeview	NB	Right 2	10	48.9	35.0	185	55	D
1: 199th & Ridgeview	NB	Left 2	5	42.5	29.0	185	55	D
1: 199th & Ridgeview	NB	U-Turn	0			185	55	F
1: 199th & Ridgeview	SB	U-Turn	0			953	378	F
1: 199th & Ridgeview	SB	Left 2	17	37.9	6.3	953	378	D
1: 199th & Ridgeview	SB	Right 2	154	47.0	8.4	953	378	D
1: 199th & Ridgeview	SB	Through	30	44.1	8.0	953	378	D
1: 199th & Ridgeview	Total	Total	522	157.9	57.4	1,696	838	F

Signalized Intersection - 2037 AM Peak								
Intersection	Approach	Movement	Volume	Delay (sec)	Delay Stopped (sec)	Queue Length Max (feet)	Queue Length Average (feet)	LOS
1: 199th & Ridgeview	EB	Left 2	113	286.8	224.8	1,677	1,471	F
1: 199th & Ridgeview	EB	Through	27	225.0	171.8	1,677	1,471	F
1: 199th & Ridgeview	EB	Right 2	1	248.0	192.0	1,676	1,450	F
1: 199th & Ridgeview	NB	Through	28	34.6	27.0	162	29	C
1: 199th & Ridgeview	NB	Right 2	11	22.7	15.6	187	42	C
1: 199th & Ridgeview	NB	Left 2	5	44.0	34.2	162	29	D
1: 199th & Ridgeview	WB	Right 2	86	118.2	83.7	1,640	863	F
1: 199th & Ridgeview	WB	Through	63	115.1	82.9	1,624	850	F
1: 199th & Ridgeview	WB	Left 2	10	111.7	81.7	1,624	850	F
1: 199th & Ridgeview	SB	Left 2	14	110.4	74.5	1,012	644	F
1: 199th & Ridgeview	SB	Right 2	120	107.8	64.4	1,070	701	F
1: 199th & Ridgeview	SB	Through	24	114.4	71.9	1,012	644	F
1: 199th & Ridgeview	Total	Total	501	150.6	109.0	1,692	756	F

Cost Estimate
Installation of 4-Way Stop Control

Item	Total Cost		QTY	Cost per		Unit
Pavement Marking / Pavement Scoring	$	500.00	50	$	10.00	/L.F.
Pavement Marking Symbols	$	1,000.00	4	$	250.00	/Ea.
Sign Plaques (Type XI High Intensity Prismatic)	$	600.00	4	$	150.00	/Ea.
Signs (Type XI High Intensity Prismatic, Incl. Base and Pole)	$	3,000.00	4	$	750.00	/Ea.
Subtotal	$	5,100.00				
Miscellaneous Items (20%)	$	1,020.00				
Professional Design Services (N/A)	$	-				
Grand Total	$	6,120.00				
Rounded Grand Total	**$**	**7,000.00**				
ROW Acquisition Estimated		**0.00**	**S.F.**			

Cost Estimate
Single-Lane Roundabout Installation

Item	Total Cost	QTY	Cost per	Unit
Pavement Removal	$ 67,000.00	3350	$ 20.00	/S.Y.
Earthwork Cut	$ 5,000.00	1000	$ 5.00	/C.Y.
Earthwork Fill	$ 5,000.00	1000	$ 5.00	/C.Y.
Asphalt Paving (Incl. Subgrade)	$ 275,000.00	2750	$ 100.00	/S.Y.
Concrete Paving (Tinted, Incl. Subgrade)	$ 39,000.00	300	$ 130.00	/S.Y.
Concrete Paving (Driveway)	$ 15,000.00	200	$ 75.00	/S.Y.
Sidewalk / Trail	$ 27,500.00	550	$ 50.00	/S.Y.
ADA Ramps	$ 24,000.00	8	$ 3,000.00	/Ea.
Concrete Curb & Gutter	$ 102,000.00	2550	$ 40.00	/L.F.
Pavement Marking	$ 6,000.00	2400	$ 2.50	/L.F.
Pavement Marking Symbols	$ 2,000.00	8	$ 250.00	/Ea.
Signs (Type XI High Intensity Prismatic, Incl. Base and Pole)	$ 18,000.00	24	$ 750.00	/Ea.
Sod / Landscaping	$ 17,250.00	1150	$ 15.00	/S.Y.
Storm Sewer Structures	$ 70,000.00	14	$ 5,000.00	/Ea.
Storm Sewer Pipe	$ 65,000.00	1000	$ 65.00	/L.F.
Water Main Adjustment	$ 22,500.00	300	$ 75.00	/L.F.
Water Main Appurtenances	$ 15,000.00	10	$ 1,500.00	/Ea.
Telecommunications Adjustment	$ 25,000.00	250	$ 100.00	/L.F.
Gas Main Adjustment	$ 26,250.00	175	$ 150.00	/L.F.
Underground Electric Main	$ 37,500.00	150	$ 250.00	/L.F.
Erosion Control / Incidentals	$ 30,000.00	1	$ 30,000.00	/LS
Subtotal	$ 894,000.00			
Miscellaneous Items (20%)	$ 178,800.00			
Professional Design Services (10%)	$ 107,280.00			
Grand Total	$ 1,180,080.00			
Rounded Grand Total	**$ 1,181,000.00**			
ROW Acquisition Estimated	**2000**	**S.F.**		

Cost Estimate
Accelerated Low-Cost Roundabout Installation - 8 Year Design Life
(With Mill & Overlay, Paved Center Island)

Item	Total Cost	QTY	Cost per	Unit
Pavement Mill & 2" Asphalt Overlay	$ 105,000.00	3000	$ 35.00	/S.Y.
Pavement Mill & Center Island Construction (Tinted 4" Concrete on Existing Asphalt Base)	$ 18,000.00	360	$ 50.00	/S.Y.
Sidewalk / Trail	$ 1,800.00	40	$ 45.00	/S.Y.
ADA Ramps	$ 3,000.00	1	$ 3,000.00	/Ea.
Pavement Marking	$ 13,000.00	5200	$ 2.50	/L.F.
Pavement Marking Symbols	$ 2,500.00	10	$ 250.00	/Ea.
Signs (Type XI High Intensity Prismatic, Incl. Base and Pole)	$ 9,000.00	12	$ 750.00	/Ea.
Subtotal	$ 152,300.00			
Miscellaneous Items (20%)	$ 30,460.00			
Professional Design Services (20%)	$ 36,552.00			
Grand Total	$ 219,312.00			
Rounded Grand Total	**$ 220,000.00**			
ROW Acquisition Estimated	**0.00 S.F.**			

Cost Estimate
Accelerated Low-Cost Roundabout Installation - 4 Year Design Life
(No Mill & Overlay, Painted Center Island)

Item	Total Cost	QTY	Cost per	Unit
Pavement Marking Removal	$ 10,600.00	2650	$ 4.00	/L.F
Sidewalk / Trail	$ 1,800.00	40	$ 45.00	/S.Y.
ADA Ramps	$ 3,000.00	1	$ 3,000.00	/Ea.
Pavement Marking / Pavement Scoring	$ 54,500.00	5450	$ 10.00	/L.F.
Pavement Marking Symbols	$ 2,500.00	10	$ 250.00	/Ea.
Signs (Type XI High Intensity Prismatic, Incl. Base and Pole)	$ 9,000.00	12	$ 750.00	/Ea.
Subtotal	$ 81,400.00			
Miscellaneous Items (20%)	$ 16,280.00			
Professional Design Services (20%)	$ 19,536.00			
Grand Total	$ 117,216.00			
Rounded Grand Total	**$ 118,000.00**			
ROW Acquisition Estimated	**0.00**	**S.F.**		

Convert Intersection to All-Way Stop Control (HSM Table 14-5)			
	Total	**Injury**	**PDO**
Observed Crashes	9	3	6
Annual Crashes	1.80	0.60	1.20
CMF	0.52	0.52	0.52
Estimated Annual Crashes	0.94	0.312	0.62
Reduced Annual Crashes	0.86	0.288	0.58
Annual Benefit	n/a	$50,452.80	$1,872.00
	Total Annual Benefit:	$52,324.80	
	Rounded Annual Benefit:	**$53,000.00**	
	Total 20-Year Benefit:	$1,060,000.00	
	Total 20-Year Benefit:	**$1,060,000.00**	

Injury Severity Level	Comprehensive Crash Cost
Fatality (K)	$4,733,650
Disabling Injury (A)	$402,550
Evident Injury (B)	$80,500
Possible Injury (C)	$42,500
PDO (O)	$3,250

Cost Estimate
Traffic Signal Installation

Item	Total Cost	QTY	Cost per	Unit
Earthwork Cut	$ 2,500.00	500	$ 5.00	/C.Y.
Earthwork Fill	$ 2,500.00	500	$ 5.00	/C.Y.
Sidewalk / Trail	$ 7,200.00	160	$ 45.00	/S.Y.
ADA Ramps	$ 24,000.00	8	$ 3,000.00	/Ea.
Pavement Marking / Pavement Scoring	$ 500.00	50	$ 10.00	/L.F.
Signs (Type XI High Intensity Prismatic, Incl. Base and Pole)	$ 3,000.00	4	$ 750.00	/Ea.
Traffic Signal	$ 200,000.00	1	$ 200,000.00	/LS
Sod / Landscaping	$ 7,500.00	500	$ 15.00	/S.Y.
Erosion Control / Incidentals	$ 5,000.00	1	$ 5,000.00	/LS
Subtotal	$ 252,200.00			
Miscellaneous Items (20%)	$ 50,440.00			
Professional Design Services (10%)	$ 30,264.00			
Grand Total	$ 332,904.00			
Rounded Grand Total	$ 333,000.00			
Grand Total of Construction in 2037	$ 601,435.04	*		
Rounded Grand Total of Construction	**$ 602,000.00**			
ROW Acquisition		**700 S.F.**		

*2037 construction values determined using a 3% growth in costs per year over the next 20 years (assuming 2% inflation and 5% increase in construction costs per year).

Construct a Single Lane Roundabout (Clearing House: 211 & 207)			
	Total	**Injury**	**PDO***
Observed Crashes	9	3	6
Annual Crashes	1.80	0.60	1.20
CMF	0.42	0.18	0.46
Estimated Annual Crashes	0.76	0.108	0.552
Reduced Annual Crashes	1.04	0.492	0.65
Annual Benefit	n/a	$86,190.20	$2,106.00
Total Annual Benefit:	$88,296.20		
Rounded Annual Benefit:	**$89,000.00**		
Total 20-Year Benefit:	$1,780,000.00		
Total 20-Year Benefit:	**$1,780,000.00**		
*The CMF for the PDO crashes was calculated by reducing the total expected crashes by the injury crashes			

Injury Severity Level	Comprehensive Crash Cost
Fatality (K)	$4,733,650
Disabling Injury (A)	$402,550
Evident Injury (B)	$80,500
Possible Injury (C)	$42,500
PDO (O)	$3,250

Construct an ALC with Mill and Overlay Roundabout (Clearing House: 211 & 207)			
	Total	**Injury**	**PDO***
Observed Crashes	9	3	6
Annual Crashes	1.80	0.60	1.20
CMF	0.42	0.18	0.46
Estimated Annual Crashes	0.76	0.108	0.552
Reduced Annual Crashes	1.04	0.492	0.65
Annual Benefit	n/a	$86,190.20	$2,106.00
	Total Annual Benefit:	$88,296.20	
	Rounded Annual Benefit:	**$89,000.00**	
	Total 20-Year Benefit:	$712,000.00	
	Total 20-Year Benefit:	**$712,000.00**	
*The CMF for the PDO crashes was calculated by reducing the total expected crashes			

Injury Severity Level	**Comprehensive Crash Cost**
Fatality (K)	$4,733,650
Disabling Injury (A)	$402,550
Evident Injury (B)	$80,500
Possible Injury (C)	$42,500
PDO (O)	$3,250

Construct an ALC Roundabout, no Mill and Overlay (Clearing House: 211 & 207)			
	Total	**Injury**	**PDO***
Observed Crashes	9	3	6
Annual Crashes	1.80	0.60	1.20
CMF	0.42	0.18	0.46
Estimated Annual Crashes	0.76	0.108	0.552
Reduced Annual Crashes	1.04	0.492	0.65
Annual Benefit	n/a	$86,190.20	$2,106.00
	Total Annual Benefit:	$88,296.20	
	Rounded Annual Benefit:	**$89,000.00**	
	Total 20-Year Benefit:	$356,000.00	
	Total 20-Year Benefit:	**$356,000.00**	
*The CMF for the PDO crashes was calculated by reducing the total expected crashes by the			

Injury Severity Level	Comprehensive Crash Cost
Fatality (K)	$4,733,650
Disabling Injury (A)	$402,550
Evident Injury (B)	$80,500
Possible Injury (C)	$42,500
PDO (O)	$3,250

Install a Traffic Signal, (HSM Table 14-7)				
	Right-Angle	**Left-Turn**	**Rear End**	**Other**
Observed Crashes	3	1	4	1
Annual Crashes	0.60	0.20	0.80	0.20
CMF	0.23	0.4	1.58	0.56
Estimated Annual Crashes	0.138	0.08	1.264	0.11
Reduced Annual Crashes	0.462	0.12	-0.46	0.09
Annual Benefit	$27,979.23	$7,267.33	($28,100.36)	$5,329.38
Total Annual Benefit:	$12,475.59			
Rounded Annual Benefit:	**$13,000.00**			
Total 20-Year Benefit:	$260,000.00			
Total 20-Year Benefit:	**$260,000.00**			

Injury Severity Level	Comprehensive Crash Cost
Fatality (K)	$4,733,650
Disabling Injury (A)	$402,550
Evident Injury (B)	$80,500
Possible Injury (C)	$42,500
PDO (O)	$3,250