SR 162 & 128th Street East

SR Milepost 6.11

Intersection Control Analysis

July 31, 2018

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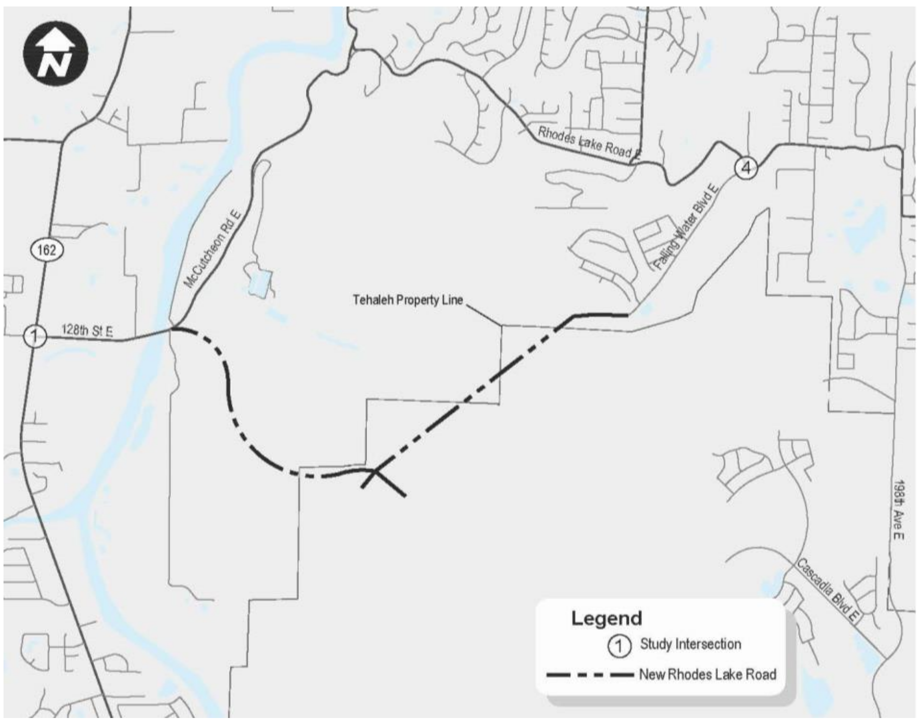
Introduction

This report summarizes the Intersection Control Analysis (ICA) for the intersection of State Route (SR) 162 and 128th Street East in Pierce County, Washington based on the guidelines set in Chapter 1300.05(1) Intersection Control Analysis Section of the Washington State Department of Transportation (WSDOT) Design Manual. This analysis evaluates potential intersection control alternatives and identifies a recommended alternative. The alternatives evaluated include construction of a multi-lane roundabout or the retention of the existing traffic signal with additional lane capacity.

Pierce County is proposing construction of New Rhodes Lake Road East shown on Figure 1. With the existing traffic control and channelization, the SR 162/128th Street East intersection operations are projected to fall below WSDOT LOS D or better standard with the new roadway and forecasted 2030 land use growth as documented in the *New Rhodes Lake Road East ROW Acquisition, Design & Construction SDEIS Draft Transportation Discipline Report (TDR),* September 27, 2017 (herein referred to as New Rhodes Lake Road TDR).

Figure 1 – SR 162/128th Street East Intersection & Project Vicinity



The analysis summarized in the following sections is intended to support build-out of the New Rhodes Lake Road East corridor to a four- to five-lane cross section and forecasted growth in the study area by 2030. Consistent with the SEIS, improvements are needed at the intersection with completion of the new roadway connection. The evaluation focuses on the 2030 improvement needs based on coordination with WSDOT and Pierce County staff. The 2030 horizon year captures completion of the New Rhodes Lake Road East corridor and anticipated land use development in the area.

The following documents the 5-step ICA screening process evaluating the alternatives and determining the best possible intersection type and design. The steps include:

1. Background and Project Needs
2. Feasibility
3. Analysis
4. Benefit/Cost Analysis
5. Selection

Step 1: Background and Project Needs

The following section summarizes the SR 162/128th Street East intersection existing conditions as well as the project needs and the performance measures used for analysis and comparison of project alternatives.

Existing Conditions

The SR 162/128th Street East intersection is signalized. The eastbound and westbound approaches (128th Street East) each provide a single-lane each while the northbound and southbound approaches each provide a left-turn lane and through/right-turn lane. There are signalized pedestrian crossings on the 128th Street East approaches of the intersection and on the northbound SR 162 approach. Designated bicycle facilities are not provided on SR 162 or 128th Street East within the study area; the multimodal Foothills Trail runs along the west side of SR 162.

128th Street East runs east-west and provides access to mobile homes on the west side of SR 162 and access to mostly single-family homes on the east side of SR 162. This road is classified as an urban-minor arterial with a posted speed limit of 35 miles per hour (mph).

SR 162 is a state highway classified as an urban minor arterial. It is a major north-south corridor in the study area connecting between the Cities of Orting and Sumner. This road has a posted speed limit of 50 mph and an average daily traffic (2016 ADT) volume of approximately 20,300 vehicles per day (vpd).[1] Approximately 8.5 percent of all vehicles on this arterial are classified as trucks.

A railroad track, which currently has approximately one train daily, is located approximately 25 feet west of the 128th Street East stop bar on the eastbound approach. The railroad track would remain when the intersection is improved.

Project Needs

Pierce County Council passed Ordinance No. 2008-28s establishing a new arterial corridor from the east limit of 128th Street East to Falling Water Boulevard East in June 2008. The proposed New Rhodes Lake Road East roadway improvement includes ROW acquisition, design and construction of a new major arterial corridor that would create a new link between SR 162 in the Orting Valley and Falling Water Boulevard East on the Bonney Lake Plateau. The new approximately 2.5-mile east-west corridor would add capacity to accommodate both existing traffic demands and anticipated growth within unincorporated Pierce County and City of Bonney Lake. The improvements would include widening 128th Street East to 4-travel lanes and a TWLTL, construction of the 4/5-lane new arterial from the Bonney Lake Plateau to the Orting Valley, and improvements at key intersections. The corridor would be fully constructed by 2030.

[1] Traffic volumes were provided by WSDOT and are for April 2016 along SR 162 just south of 128th Street East.

Development of the corridor would result in the need to add capacity to the SR 162/128th Street East intersection to accommodate future traffic demands.

Intersection Control Alternatives

Two alternatives are identified to mitigate for the increase in traffic volumes due to future development and the New Rhodes Lake Road East corridor: (1) modifications to the existing traffic signal to accommodate additional lane capacity and (2) construction of a multi-lane roundabout. The conceptual channelization for each intersection control alternative are provided in Appendix A.

The signalized intersection alternative channelization was developed based on the future 2030 forecasts and the analysis presented in the September 2017 New Rhodes Lake Road TDR.

For the signalized alternative, the following signal timing parameters were assumed for analysis:

- Signal cycle length and splits were optimized for future traffic conditions
- Actuated-uncoordinated control with a 170-second cycle length during the future AM peak hour and 150-second cycle length during the future 2030 weekday PM peak hour
- Eastbound and Westbound phases would be run as split phasing
- Protected northbound and southbound left turn phases
- Right-turn overlap phases for the northbound right and the westbound right turns
- Pedestrian walk phases allowed during the northbound, southbound and eastbound phases.

Detailed intersection channelization for the traffic signal alternative is provided in Appendix A and signal timing sheets are provided in Appendix C.

For the roundabout alternative, key features of the roundabout include:

- Three-lanes on the westbound and southbound approaches:
  - Westbound right-turn slip lane, left/through lane, and dedicated left-turn lane
  - Southbound dedicated left-turn lane, left/through lane, and through/right lane
- Three-lanes in the northwest quadrant to accommodate the dedicated westbound and southbound left-turns
- One-lane shared eastbound left/through/right lane

The roundabout design and ultimate footprint will include 3-lanes in two quadrants. The main driver of the 3rd lane is the high southbound left-turn, westbound left-turn and westbound right-turn traffic volumes with anticipated growth on the Bonney Lake Plateau. At opening, however, the roundabout will operate with a two-lane entry with the ability to expand to 3-lanes.

The inscribed diameter for the roundabout is 180-feet in the east-west direction and 150-feet in the north-south direction. The roundabout channelization was developed in coordination with WSDOT staff (Joseph Perez and Brian Walsh). Detailed intersection channelization for the roundabout alternative is provided in Appendix A.

Performance Measures

Level of service (LOS) and volume to capacity ratio (V/C) are used as performance measures to compare each alternative. For the signal alternative, operations are evaluated using

Synchro 9.1 software and for the roundabout alternative, operations are evaluated using *Sidra 6.1*. Sidra model settings used for the roundabout alternative were based on the guidelines in the *WSDOT Sidra Policy Settings*. November 2015.

In addition, a safety analysis was conducted to compare the alternatives. More details regarding performance measures is provided in Step 3.

Step 2: Feasibility

The two intersection alternatives were analyzed for feasibility in terms of the factors included in Chapter 1300 of the WSDOT *Design Manual*. Table 1 summarizes the feasibility comparison of each alternative. Appendix B illustrates the right-of-way impacts of the signal and roundabout alternatives.

Table 1. Intersection Feasibility Comparison

Factor	Signal	Roundabout
Right-of-Way Requirements	The widening of SR 162 and 128th St E would result in the displacement of three (3) residences or three (3) residential properties. Widening of the roadway would also result in reduced setbacks for existing properties along SR 162 and to the north and south of 128th St E. Access to remaining properties would be generally unchanged. The total property requirements would be: Full Property = 4 Partial Property = 26 *With the partial property required, 2 would have access compromised.*	In addition to right-of-way impacts noted for the signal, the roundabout would displace two (2) additional residences or three (3) additional properties for a total of six (6) properties. The additional impacts are because the roundabout requires the intersection to be shifted to the southeast to avoid impacts to the railroad to the west and the historic church to the northeast. This results in additional full property takes for properties along the southeast side of SR 162 with the roundabout. The roundabout slip lanes would also restrict access to some properties in proximity to the intersection including the historic McMillin Grange building and McMillin Upper Room Church. The total property requirements would be: Full Property = 7 Partial Property = 23 *With the partial property required, 4 would have access compromised.*
Environmental Concerns	There are no wetlands or sensitive areas located within the intersection footprint. The total impervious surface area for the traffic signal alternative would be 283,000 square feet.	There are no wetlands or sensitive areas located within the roundabout footprint. The total impervious surface area for the roundabout alternative would be 264,500 square feet. Given the additional ROW and access impacts to the McMillin community including the historical buildings and properties, there would likely be more SEPA impacts.

Table 1. Intersection Feasibility Comparison (Continued)

Factor	Signal	Roundabout
	Access. Public comments have indicated that there are properties that access directly onto SR 162 that use the traffic signal to provide gaps and allow vehicles to enter the traffic stream.	**Access.** The roundabout would result in continuous flow and reduce the number of gaps for properties that access directly onto SR 162 to enter the traffic stream. Left-turns may be more difficult from driveways so drivers may need to turn right and travel out of direction using the roundabout to turnaround. This could be more difficult for property on the eastside of SR 162 when there is no roundabout at SR 162/Military Road East to facilitate U-turns.
	Rail. North-south traffic along SR 162 would continue to be served even with a train passing on the west approach of the intersection. With increases in rail activity and additional conflicts, gates may be needed on the west approach if safety issues arise.	**Rail.** The roundabout could experience blockages when trains are passing on the eastbound approach of the intersection.[1] It is noted that the volumes to and from the west are currently low and there is approximately one train per day along the rail line; therefore, blockages would be infrequent. However, there is no restriction on the volume of rail traffic; therefore, if there were future increases in rail use would impact the roundabout operations and add to conflicts between trains and vehicles.
Context Sensitive/ Sustainable Design	**Pedestrian.** Pedestrian crossing distances for the roundabout and signal would be similar; however, the signal would provide a designated phase for crossing between the regionally significant Foothills trail and the regional trail to the plateau proposed by the County Road Project (New Rhodes Lake Road East). The signal would also accommodate visually impaired pedestrians through audible pedestrian signals (APS).	**Pedestrian.** Pedestrian crossing distances for the roundabout and signal would be similar; however, the roundabout would provide a pedestrian refuge and allow for shorter crossings in two stages. Pedestrian beacon or a HAWK signal would need to be installed to accommodate pedestrians including the visually impaired. The two-stage crossing of the roundabout helps the operational flows at the intersections because traffic is accommodated after the pedestrian crosses halfway rather than at a signal where vehicles need to wait for pedestrians to cross the full distance before vehicles can flow in the opposing direction.
	Land Use. The Pierce County Comprehensive Plan designates the parcels adjacent to this intersection within the Alderton-McMillin area as rural neighborhood center. The traffic signal would minimize the impacts to these parcels and allow for future redevelopment consistent with the County's Comprehensive Plan.	**Land Use.** As noted with the traffic signal, the County Comprehensive Plan designates the parcels adjacent to this intersection as rural neighborhood center. Because of additional ROW take and additional access restrictions imposed by the roundabout, the roundabout would impact the redevelopment potential of the McMillin neighborhood as envisioned in the County's Comprehensive Plan.

1. The southbound through/right-turn lane would be obstructed when 3- to 4-vehicles are stopped for a train crossing and the southbound through/left-turn lane would be obstructed with 4- to 5-vehicles stopped for the train crossing.

Both alternatives provide sidewalk and pedestrian crossings; however, vehicle traffic flows at the roundabout are improved compared to the signal with the two-stage crossing allowing for vehicles in the opposing direction to flow after pedestrians cross halfway instead of waiting for the pedestrian to cross the entire leg. The alternatives also accommodate the railroad on the eastbound approach; however, there is no restriction on the use of this rail line and the roundabout option has greater risk of future rail and vehicle conflicts should use of the rail increase (there is currently one train per day on average). With the current traffic volume to and from the west and the one train per day, there is a very low risk of blockages in the roundabout. The current design assumes that there would be no gate for the rail line with the signal alternative given the limited service and slow-moving train at about 5 to 10 mph and the ability to control the traffic with the proposed signal. The roundabout alternative includes gates for the railroad on the west approach given that drivers would have limited expectations for a train and there would be no signal to control the movements as the train approaches. Future increases in rail traffic (including possible commuter rail) may require gates for the west leg of the signalized intersection, and may require gates on all approaches of the roundabout intersection.

Sound Transit 3 (ST3) includes a High Capacity Transit (HCT) Corridor Study for a potential future commuter rail connection from Orting to the existing Sounder South line service in Puyallup. This could result in commuter rail service at the SR 162/128th Street East intersection. The study will help to identify the range of alternatives, evaluate routes and station locations and terminals, prepare for formal environmental review and engineering, and position the Sound Transit Board to evaluate options and establish priorities for implementation in future phases of HCT investments. If the study is approved, there is a possibility that the HCT line from Orting would connect to the existing railroad track just west of the intersection before connecting to the South Sounder line around year 2040. The current ST3 funding is for the HCT study and there is no current funding for implementing HCT Orting to Puyallup. If HCT was provided along the existing rail line then railroad crossing gates would be needed.

Traffic volumes to and from the eastbound approach are currently low, which minimizes the conflicts that occur with rail activity. If the sites accessing the eastbound approach of the SR 162/128th Street East intersection were to redevelop, traffic volumes to and from this approach would likely increase resulting in additional vehicle and rail crossing conflicts.

Step 3: Analysis

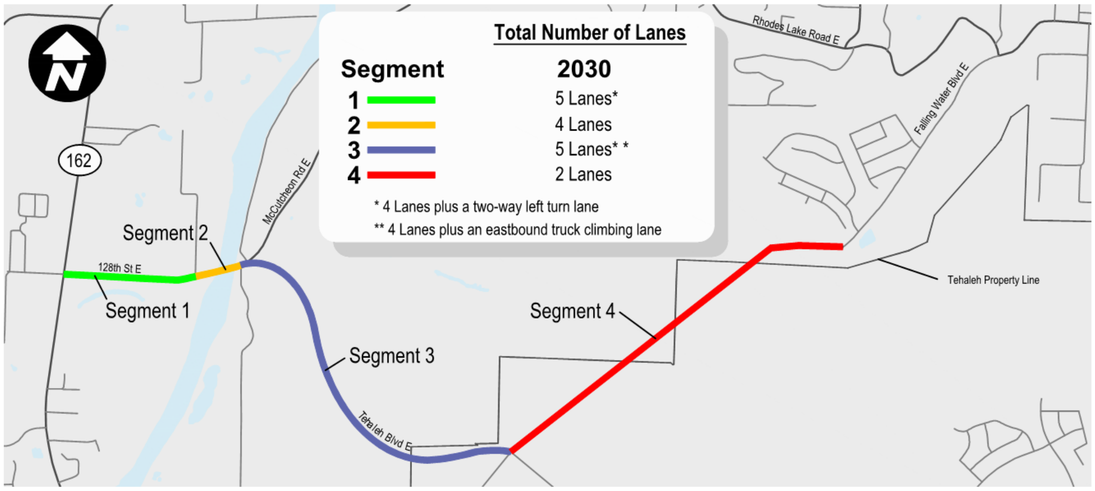
This section summarizes the anticipated future (2030) traffic volumes at the study intersection, intersection operations analysis, traffic safety analysis, and multimodal safety and operations for each intersection alternative.

Traffic Volumes

Existing traffic volumes and future 2030 forecasts were based on the New Rhodes Lake Road TDR. Existing weekday peak period traffic counts were collected from 6:00 to 9:00 a.m. and from 4:00 to 6:00 p.m. in October 2014. These periods represent the highest cumulative total traffic for the adjacent street system providing a conservative timeframe for LOS analysis. The periods were selected based on 24-hour traffic counts of SR 162. Existing weekday AM and PM peak hour traffic volumes at the SR 162/128th Street East intersection are summarized in Table 2.

The 2030 future traffic volumes assume construction of the New Rhodes Lake Road East corridor. Figure 2 illustrates the corridor improvements assumed for the 2030 conditions. Traffic forecasts are based on application of a revised version of the Pierce County travel demand model that was developed for the County's *2015 Transportation Element* of the Comprehensive Plan. Travel forecasts were prepared for the 2030 horizon year as part of the New Rhodes Lake Road TDR and are shown in Table 2.

Figure 2 – Project Segment Lane Assumptions for 2030 Conditions



Note: Number of lanes reflects the roadway segment; there may be additional turn lanes provided at the intersections.

Table 2. SR 162/128th St E Weekday Peak Hour Turning Movement Movements

Traffic Movement	Existing (2014)	2030
Weekday AM Peak Hour		
Southbound Left-Turn	65	940
Southbound Through	285	244
Southbound Right-Turn	5	7
Northbound Left-Turn	1	1
Northbound Through	815	639
Northbound Right-Turn	120	395
Westbound Left-Turn	245	198
Westbound Through	0[1]	0[1]
Westbound Right-Turn	85	1,550
Eastbound Left-Turn	10	7
Eastbound Through	4	13
Eastbound Right-Turn	2	2
Weekday PM Peak Hour		
Southbound Left-Turn	70	1,441
Southbound Through	1,050	823
Southbound Right-Turn	15	11
Northbound Left-Turn	3	5
Northbound Through	455	390
Northbound Right-Turn	60	474
Westbound Left-Turn	245	806
Westbound Through	4	16
Westbound Right-Turn	105	1,518
Eastbound Left-Turn	15	14
Eastbound Through	2	10
Eastbound Right-Turn	3	5

1. The roundabout analysis assumes 1 vehicle for this movement due to Sidra software analysis constraints.

As shown in Table 2, for some movements traffic volumes for the future 2030 conditions are projected to be less than the existing conditions. This decrease in traffic volumes is related to changes in travel patterns that are anticipated to occur with development on the Bonney Lake Plateau such as the Tehaleh Phase 2 Employment-Based Planned Community as well as the construction of the New Rhodes Lake Road East corridor. Overall, the total SR 162/128th Street East intersection volume would more than double between 2014 and 2030.

The most recent ADT volumes available from WSDOT are from April 2016 and represent SR 162 at milepost 6.11 (just south of 128th Street East). As previously documented, the ADT along SR 162 is currently a total of 20,300 vpd. Future 2030 ADT forecasts were based on the Pierce County travel demand model consistent with the weekday peak hour conditions. Future daily traffic volumes are reported for the segment of SR 162 just north of 128th Street East to capture anticipated growth in traffic volumes due to development on the Bonney Lake Plateau. The ADT volumes are anticipated to be approximately 51,500 vpd under 2030 conditions.

Traffic Operations

Level of service, delay and queues are evaluated for the 2030 traffic conditions at the intersection of SR 162/128th Street East for each of the control alternatives. This analysis is based on the weekday AM and PM peak hour traffic volumes described above.

Intersection Operations

For signalized and roundabout controlled intersections, LOS is measured in average delay per vehicle and is reported for the intersection as a whole. Traffic operations for an intersection can be described alphabetically with a range of levels of service (LOS A through F), with LOS A indicating free-flowing traffic and LOS F indicating extreme congestion and long vehicle delays.

Per the *WSDOT Sidra Policy Settings* (November 2015), the measure of effectiveness (MOE) for roundabouts is not primarily LOS but rather a consideration of a mix of MOEs. The first MOE is to “ensure that each lane group generates no more than about 0.85-0.90 V/C with reasonable queues given local conditions.”

Intersection operations were evaluated using the *Synchro 9.1* software for the signal alternative and *Sidra Intersection 6.1* for the roundabout alternative.

WSDOT’s standard at the SR 162/128th Street East intersection is:

- LOS D based on delay for the signal
- V/C ratio of 0.90 or less for the roundabout

Table 3 shows the overall intersection operations at the SR 162/128th Street East intersection during weekday AM and PM peak hours under 2030 conditions. Detailed LOS worksheets are provided in Appendix D.

Table 3. SR 162/128th St E: 2030 Intersection Level of Service Summary

	V/C[1]	LOS[2]	Delay[3]
Weekday AM Peak Hour			
Traffic Signal Alternative	0.80	D	42
Roundabout Alternative[4]	0.96	A	9
Weekday PM Peak Hour			
Traffic Signal Alternative	1.00	E	63
Roundabout Alternative[4]	0.98	B	14

1. Highest V/C Ratio reported for roundabout alternative. Overall V/C Ratio reported for signal alternative based on HCM 2000.
2. Level of Service (A – F) as defined by the 2010 *Highway Capacity Manual* (HCM), Transportation Research Board.
3. Average delay per vehicle in seconds.
4. Delay calculations based on Sidra 6.1 roundabout methodology with LOS value based on 2010 *HCM* signalized delay thresholds.

As shown in Table 3, the signal would meet the WSDOT LOS D standard in 2030 during the weekday AM peak hour conditions. This WSDOT LOS standard is not met during the weekday PM peak hour for the signal alternative. For the roundabout alternative, as described above, WSDOT assesses operations based on the V/C ratio[2]. The analysis shows the V/C ratio would be 0.96 during the weekday AM peak hour and 0.98 during the weekday PM peak hour. These V/C ratios are higher than WSDOT's V/C ratio threshold of 0.90. The highest V/C ratios occur for the westbound right-turn lane during the weekday AM peak hour and on the northbound approach and westbound right-turn lane during the weekday PM peak hour. Although the V/C ratio is over 0.90 for the roundabout alternative the overall seconds of delay per vehicle is much less compared to the signal alternative.

Travel Time

In addition to LOS, delay, and V/C ratio, WSDOT often considers intersections within a system and the travel time savings relative to traffic control. As shown in Table 3, the roundabout alternative would experience less overall average delay per vehicle as compared to the traffic signal, which would have approximately 33 seconds more average delay per vehicle during the weekday AM peak hour and 49 seconds more average delay per vehicle during the PM peak hour. During the off-peak hours, when delay for both the roundabout and traffic signal would be considerably less, the roundabout alternative would be anticipated to experience less delay per vehicle compared to a traffic signal. Overall, the roundabout alternative is expected to show cumulative vehicular delay savings over the life cycle of the intersection when compared to the signal alternative. More discussion of the travel time savings is provided in Step 4: Cost/Benefit Analysis section.

Vehicle Queues

The 95th-percentile queues for the traffic signal and roundabout alternatives are also reviewed for the weekday AM and PM peak hour 2030 conditions. Table 4 provides a comparison of the vehicle queues for each alternative. The 95th-percentile queues represent the vehicle queue lengths that would only be exceeded 5 percent of the time. *Simtraffic* was used to analyze the queues.

[2] WSDOT Sidra Policy Settings, November 2015

Table 4. SR 162/128th St E: 2030 Intersection 95th-Percentile Queue Summary

	Traffic Signal Alternative		Roundabout Alternative	
Movement	**Storage[1]**	**Queue (feet)[2]**	**Storage[1]**	**Queue (feet)[2]**
Weekday AM Peak Hour				
Eastbound	500	45	500	5
Westbound Left-Turn	750	90	2,000	15
Westbound Through (Through/Left-Turn)[3]	2,000	110	2,000	15
Westbound Right-Turn	425	235	425	0[4]
Northbound Left-Turn	100	20	NA	NA
Northbound Through (Through/Left-Turn)[3]	1,250	325	1,250	100
Northbound Right-Turn (Through/Right-Turn)[3]	350	270	400	110
Southbound Left-Turn	1,260	365	200	50
Southbound Through (Through/Left-Turn)[3]	~3,900	60	1,750	50
Southbound Through-Right-Turn	1,750	20	300	25
Weekday PM Peak Hour				
Eastbound	500	65	500	20
Westbound Left-Turn	750	400	2,000	55
Westbound Through (Through/Left-Turn)[3]	2,000	410	2,000	60
Westbound Right-Turn	425	165	425	0[4]
Northbound Left-Turn	100	45	NA	NA
Northbound Through (Through/Left-Turn)[3]	1,250	255	1,250	245
Northbound Right-Turn (Through/Right-Turn)[3]	350	335	700	290
Southbound Left-Turn	1,260	1,160	300	235
Southbound Through (Through/Left-Turn)[3]	~3,900	2,445	1,750	235
Southbound Through-Right-Turn	2,000	2,150	300	165

NA = Not applicable, this lane is not provided for the roundabout configuration.
1. The storage length represents proposed improvements with New Rhodes Lake Road East for each alternative. Turn pocket lengths are shown for left and right-turn lanes and for through lanes the distance of continuous lane between intersections is shown.
2. The 95th-percentile queues are based on Simtraffic for the signal alternative and Sidra for the roundabout alternative at the SR 162/128th Street East intersection. All queues are rounded to nearest 5 feet.
3. Roundabout configuration shown in parentheses.
4. The roundabout configuration features a westbound-right slip/bypass lane, which provides a free movement and result in no vehicle queues.

As shown in the table, all the vehicle queues would be accommodated within the anticipated storage for both alternatives except for the southbound through/right-turn queue during the weekday PM peak hour for the signal alternative. It is noted that roundabout queues are moving queues, which are not perceived by drivers to be as negative as signal queues and is therefore better for drivers. Pedestrian beacons would need to be installed on the multilane roundabout approaches to facilitate crossings for visually impaired.

Rail Operation Impacts

The traffic operations analysis does not account for rail crossings along the west leg of the intersection. It is anticipated when there is a rail crossing that there would be additional delays and blockage within the roundabout as vehicles queue into the intersection. With the signalized intersection, during the rail crossing it is anticipated that the north-south traffic along SR 162 would continue to be served even when there is a rail crossing; however, there would be additional delays to traffic coming to and from the west leg.

WSDOT reviews provision of a signal or roundabout near an active rail line on a case-by-case basis. A review of the *National Cooperative Highway Research Program (NCHRP) Report 672 – Roundabout: An Informational Guide* Chapter 7 (Application of Traffic Control

Devices) states that locating an intersection near an at-grade rail crossing is generally discouraged. This guide also notes that where roundabouts include an at-grade rail crossing, a key consideration is the accommodation of vehicle queues to avoid queuing across the tracks. Vehicle queues also need to be considered at signalized intersections; the signal alternative provides the stop sign and bar behind the railroad tracks to minimize vehicles stopping on the railroad tracks.

Traffic to and from the eastbound approach is limited with approximately 30 to 45 vehicles during the weekday peak hours. Vehicle delays for the eastbound approach (west leg) would be approximately 25 or less seconds per vehicle during the weekday peak hours and vehicle queues would be approximately 25-feet or less (i.e., less than one vehicle). The roundabout design would accommodate approximately one vehicle between the rail line and roundabout intersection. The southbound through/right-turn lane would be obstructed when 2- to 3-vehicles are stopped for a train crossing and the southbound through/left-turn lane would be obstructed with 3- to 4-vehicles stopped for the train crossing. Given the limited traffic to and from the eastbound approach and minimal train activity (i.e., one train per day), it is not anticipated that vehicles would block the rail line or impact roundabout operations significantly based on the 2030 forecasts and the current activity. If the area west of SR 162 redeveloped and traffic volumes to and from the eastbound approach increased and/or rail activity increased, roundabout and rail operations could be impacted. Vehicle queue impacts on the rail line would not be an issue with the traffic signal alternative because the stop bar would be placed to the west behind the rail line.

Traffic Safety

Typically, an ICA requires reporting expected crash frequency for each intersection alternative. This is conducted using the Predicted Safety Performance spreadsheet[3] that predicts the number of collisions based on future conditions and intersection parameters. However, this approach cannot be used for intersections with a major approach AADT over 45,700 vehicles and a minor approach AADT over 9,300 vehicles.

The SR 162/128th Street East intersection major and minor AADT are forecasted to be above the thresholds designated in the Predicted Safety Performance spreadsheet; therefore, it is not possible to quantitatively predict expected crash frequency for the study intersection during the analysis year of 2030. Based on discussion and coordination with WSDOT Safety staff, the appropriate method to estimate the differences in traffic safety between the two intersection alternatives is to analyze the existing collisions at the intersection and apply crash modification factors (CMFs).

Analysis of Existing Signalized Intersection Collisions

Collision records over the most recent complete five-year period were reviewed for the study intersection. Historical collision data was provided by WSDOT for the period of January 1, 2012 to December 31, 2016 as part of the New Rhodes Lake Road TDR. The SR 162/128th Street East intersection had 17 reported collisions over the 5 years with an average of about 3.4 collisions per year. Most collisions were rear end collisions (14), which is typical of signalized intersections with congestion and stop-and-go traffic. Of the 17 total collisions, 9 were categorized as property damage only (PDO) and the remaining 8 were categorized as possible injury. None of these reported collisions involved a fatality or serious injury. The collision rate per Million Entering Vehicles (MEV) for the existing signalized intersection was calculated to be 0.46, which is below the 1.0 collisions per MEV threshold typically used to identify intersections for further investigation of an adverse safety condition. Based on this review of historical collisions, no specific adverse safety condition for vehicles, pedestrians, or bicyclists were identified at the signalized intersection.

[3] HSM Part C Training Tool: HSM1 Extended Spreadsheet for Part C Chapter 12 (v.9, 2016)

Analysis of Roundabout Collisions

The existing SR 162/128th Street East signalized intersection collision rate per MEV is compared to the calculated roundabout collision rate per MEV to understand the difference in traffic safety for the two control types. Roundabouts have the potential to reduce the total amount of collisions and the severity compared to signalized intersections because roundabouts slow drivers down with the splitter island channelized approaches and a raised central island that results in lower speeds and fewer conflict points. The Insurance Institute of Highway Safety reports converting four-way stop or signalized intersections to roundabouts shows:

- 90 percent reduction in fatal and serious injury collisions
- 75 percent in all injury collisions

Using the percent reduction in collisions noted above, the existing annual average number of collisions per year were factored to demonstrate how the observed collisions per year may be reduced by converting the signal to a roundabout. Table 5 summarizes how the CMF was applied to the existing collisions.

Table 5. Application of Roundabout Collision Modification Factor (CMF)

	Collision Type			
	Property Damage Only	**Possible Injury**	**Fatal & Serious Injury**	**Total Collisions**
Number of Collisions in 5-Year (2012 to 2016)[1,2]	9	8	0	17
Existing Annual Average	**1.8**	**1.6**	**0**	**3.4**
CMF Applied to Annual Average[3]	1.00	0.25[4]	0.10[4]	-
Projected Roundabout Collisions per Year	***1.8***	***0.4***	***0***	***2.2***

1. Collision data provided by WSDOT for the period of January 1, 2012 to December 31, 2016.
2. Under 23 U.S. Code § 409 and 23 U.S. Code § 148, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.
3. CMF = Collision modification factor. This factor is applied to possible injury and fatal and serious injury collisions only. The factor used for this analysis converts existing average annual collisions at the signalized intersection to predicted collisions for changing the intersection control to a roundabout.
4. Roundabouts have 75 percent less possible injury collisions or 25 percent of this type of collision observed at a signal and 90 percent less fatality and serious injury collision or 10 percent of the fatal and serious injury collisions are observed at a signal.

As seen in Table 5, it is projected that the number of possible injury collisions per year would be reduced from 1.6 with a traffic signal to approximately 0.4 per year with a roundabout. The analysis of existing data shows that conversion from the existing signal control to a roundabout would reduce the annual collisions from 3.4 with the traffic signal to 2.2 with the roundabout. As traffic volumes increase, the number of conflicts at the intersection will increase and collisions could also potentially increase. As noted above, roundabouts have a significant impact on reducing the severity of collisions.

Multimodal Safety and Operations

The Foothills Trail runs along the west side of SR 162 near the SR 162/128th Street East intersection. The New Rhodes Lake Road East corridor improvements would improve east-west non-motorized connectivity along 128th Street East with a multimodal trail (i.e., shared path with pedestrians and cyclists) along the corridor. The trail would be on the south side of the corridor along 128th Street East. The SR 162/128th Street East intersection provides the trail crossing between the Foothill Trails and the Bonney Lake Plateau area.

There were no bicyclists counted during the existing weekday peak hours; however, it is anticipated that with planned growth the presence of bicyclists and pedestrians would increase in the future. Based on conversations with property owners and the County, the Foothills trail is primarily a recreational trail at this time but with future planned development it could become a commuter trail. In addition, there were no pedestrian or bicyclist related collisions within the studied 5-year span at this intersection. Both the roundabout and the signalized alternatives would connect bicyclists to the existing and future non-motorized facilities. Pedestrian beacons would need to be installed at the approaches to the roundabout.

The existing traffic counts showed 1 pedestrian during the weekday PM peak hour and no pedestrians during the weekday AM peak hour. The presence of pedestrians during weekday AM and PM peak hours would increase in the future with planned development in the area and the location of the trail crossing. Pedestrian crossings would be accommodated on the south and west legs with both alternatives. The roundabout would provide a center pedestrian refuge for a two-stage crossing but would have less gaps in traffic while the signal alternative will provide a longer signaled pedestrian crossing with a designated pedestrian phase.

Step 4: Benefit/Cost Analysis

This section summarizes the benefits and costs associated with each intersection alternative in terms of the following factors:

- Project costs related to design, ROW, and construction
- Societal cost savings

A comparison of the two intersection control alternatives cost/benefits are provided in Table 6.

Table 6. Cost/Benefit Analysis

	Signal Alternative	Roundabout Alternative
Fixed Costs		
Project Cost (Design, Right-of-Way, Construction)	$8,393,170	$10,632,653
Annual Costs		
Societal Cost Savings (Collisions)[1]	$72,000[2]	$0
20-Year Annual Cost	$1,440,000	$0
20-Year Total Cost (Annual + Fixed)	$9,833,170	$10,632,653

1. Based on societal cost of $60,000 per possible injury crash found in Chapter 1300 Step 4 of WSDOT Design Manual and the reduction in possible injury collisions as discussed in Step 3.
2. This means the signal has no cost savings in terms of safety compared to the roundabout.
3. This could be an over estimate given the unique configuration of the roundabout, which is not consistent with the roundabouts that were used to determine this value.
4. This assumes a flat rate benefit over the 20-year period with any interest rate.

As shown in Table 6, the total cost (fixed plus annual) for the roundabout alternative would be more than the signal alternative. Appendix E provides the fixed cost estimates.

In addition to the cost/benefit shown in Table 6, the roundabout configuration would require less annual maintenance and is projected to experience cumulative vehicular delay savings over the life cycle of the intersection. Per coordination with WSDOT staff, the total travel times saving in dollars that is described in Chapter 1300 of the Design Manual is typically reserved for a corridor/network analysis. However, based on a qualitative analysis, the roundabout alternative would experience less overall average delay per vehicle as compared to the traffic signal. The signal would have approximately 33 seconds more average delay per vehicle during the weekday AM peak hour and 49 seconds more average delay per vehicle during the PM peak hour. During the off-peak hours, when delay for both the roundabout and traffic signal would be considerably less, the roundabout alternative would be anticipated to experience less delay per vehicle compared to a traffic signal. Overall, the roundabout alternative is expected to show cumulative vehicular delay savings over the life cycle of the intersection when compared to the signal alternative.

Relevant Studies

The legislature appropriated $465,000 of “Connecting Washington” funds in the 2016-2017 biennium towards the SR 162 corridor study. The *Draft SR 162 Sumner to Orting Congestion Study Report SR 162 MP 0.00 to MP 8.11* was issued in May 2017. Growth has resulted in travelers along SR 162 experiencing congestion and delay during the weekday morning and evening peak periods. The study identified 5 corridor strategies to improve travel-time, predictability, and the safe operation of the SR 162 corridor. Strategies will be considered for implementation in the short-, mid-, and long-term conditions. These strategies include:

- Transportation Demand Management – work hour changes, rideshare, worksite parking policies, and telecommuting
- Operations/Intelligent Transportation Systems/Incident Management – signal improvement, traveler information, shoulder pullouts, and incident response resources
- Public Transportation Services
- Park & Ride Lots, Bicycle and Pedestrian Facility Improvements, Minor Access Management Measures – public park and ride facilities, shoulder widening, improved accessibility and mobility, delineation of highway access
- Intersection Control/Corridor Improvements – turn lanes, roundabouts, segment widening

Specific to the SR 162/128th Street East intersection, WSDOT explored a roundabout as a short-term strategy with the 2020 horizon year. This May 2017 SR 162 corridor study is WSDOT’s planning study for the corridor. As a next step, WSDOT will work with the stakeholders to implement low-cost solutions along the corridor. In addition, strategies for the short-, mid-, and long-term will be incorporated in the Corridor Sketch Phase 2 for the SR 162 corridor. Phase 2 will provide more detail on cost and implementation so that the SR 162 strategies can be prioritized on a statewide basis for future implementation. The SR 162 corridor improvements are currently unfunded.

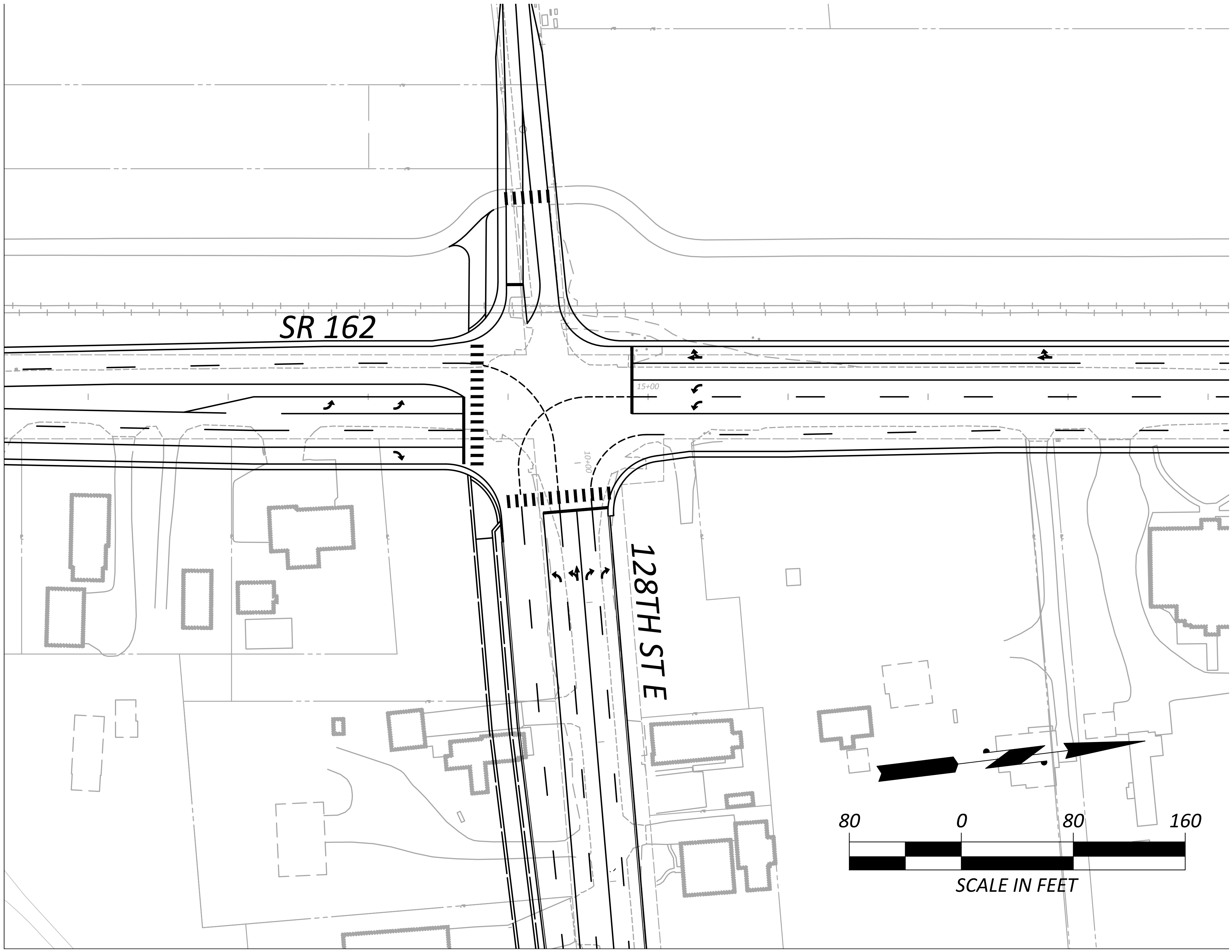
Step 5: Selection

Based on the evaluation presented in steps 2 through 4, the roundabout alternative is recommended. Selection of the recommended alternative was based on key factors including:

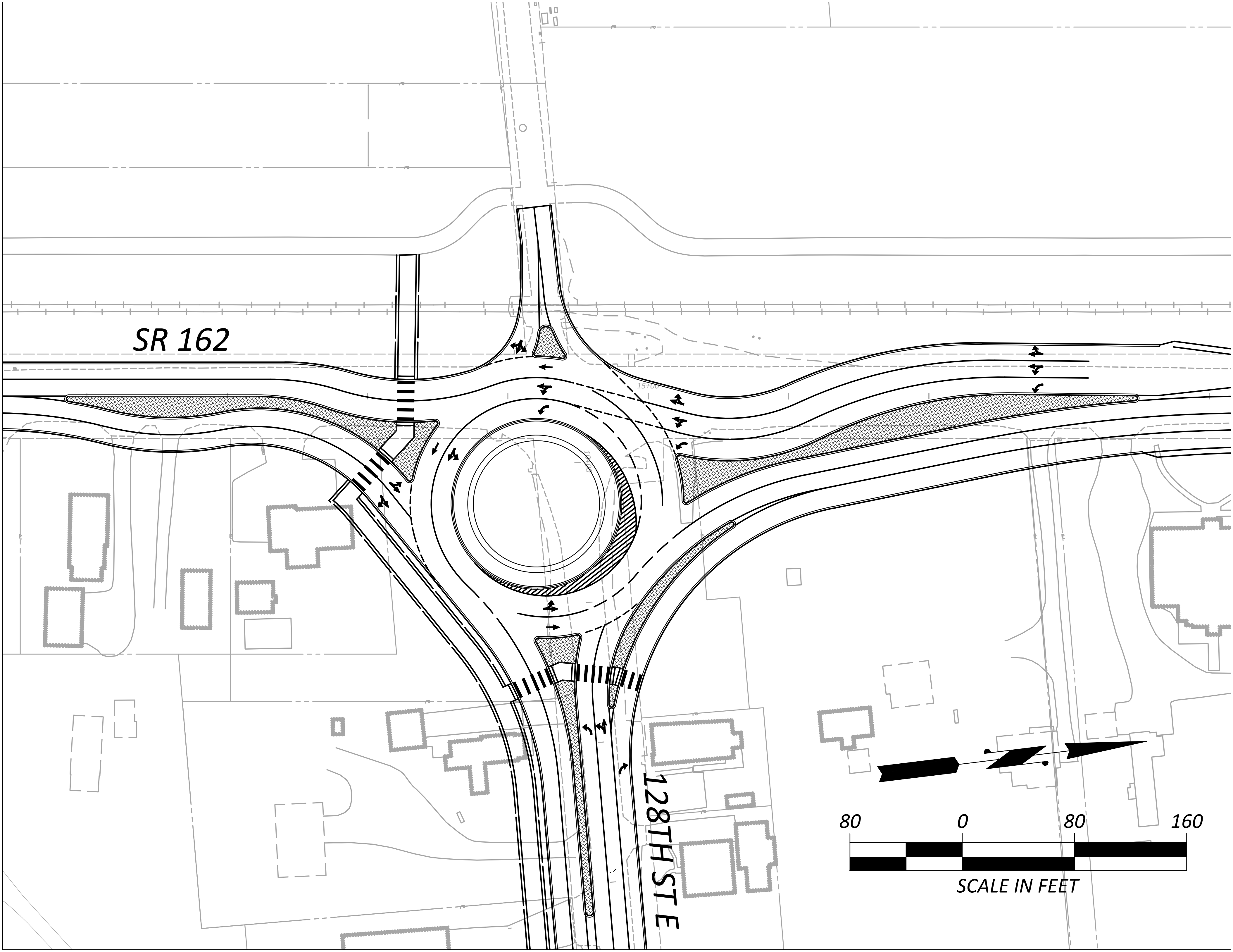
- **Context Sensitive/Sustainable Design:** Pedestrians, bicyclists, and vehicles would be accommodated with both alternatives. The roundabout would provide a pedestrian refuge and allow for shorter crossings in two stages. Traffic flows at the roundabout are also improved compared to the signal with the two-stage crossing allowing for vehicles in the opposing direction to flow after pedestrians cross halfway instead of waiting for pedestrians to cross the entire leg. Pedestrian beacons or a HAWK signal would need to be installed to accommodate pedestrians including the visually impaired.

- **Traffic Operations:** The roundabout alternative would have less overall average delay per vehicle and shorter vehicle queues as compared to the traffic signal. In addition, during the off-peak hours, when delay for both the roundabout and traffic signal would be considerably less, the roundabout alternative is anticipated to continue to result in less delay per vehicle compared to a traffic signal. Roundabout queues are moving queues, which are not perceived by drivers to be as negative as signal queues. Overall, the roundabout alternative is expected to show cumulative vehicular delay savings over the life cycle of the intersection when compared to the signal alternative.
- **Traffic Safety:** The analysis of existing data shows that conversion from the existing signal control to a roundabout would reduce the annual collisions. Insurance Institute of Highway Safety reports roundabouts have a significant impact on reducing the severity of collisions when compared to traffic signals.
- **Benefit/Cost Analysis:** When including fixed costs and 20 years of annual costs, the signal alternative would cost approximately $9.8M versus $10.6M for the roundabout alternative. However, this does not include travel time cost savings with the roundabout given reduced delays. In addition, with increases in traffic volumes at the future intersection the overall safety benefits are likely to be higher with the roundabout reducing severity of collisions.

Appendix A: Intersection Alternative Designs



SR 162
128TH ST E
15+00
10+00
80
0
80
160
SCALE IN FEET


SR 162
128TH ST E
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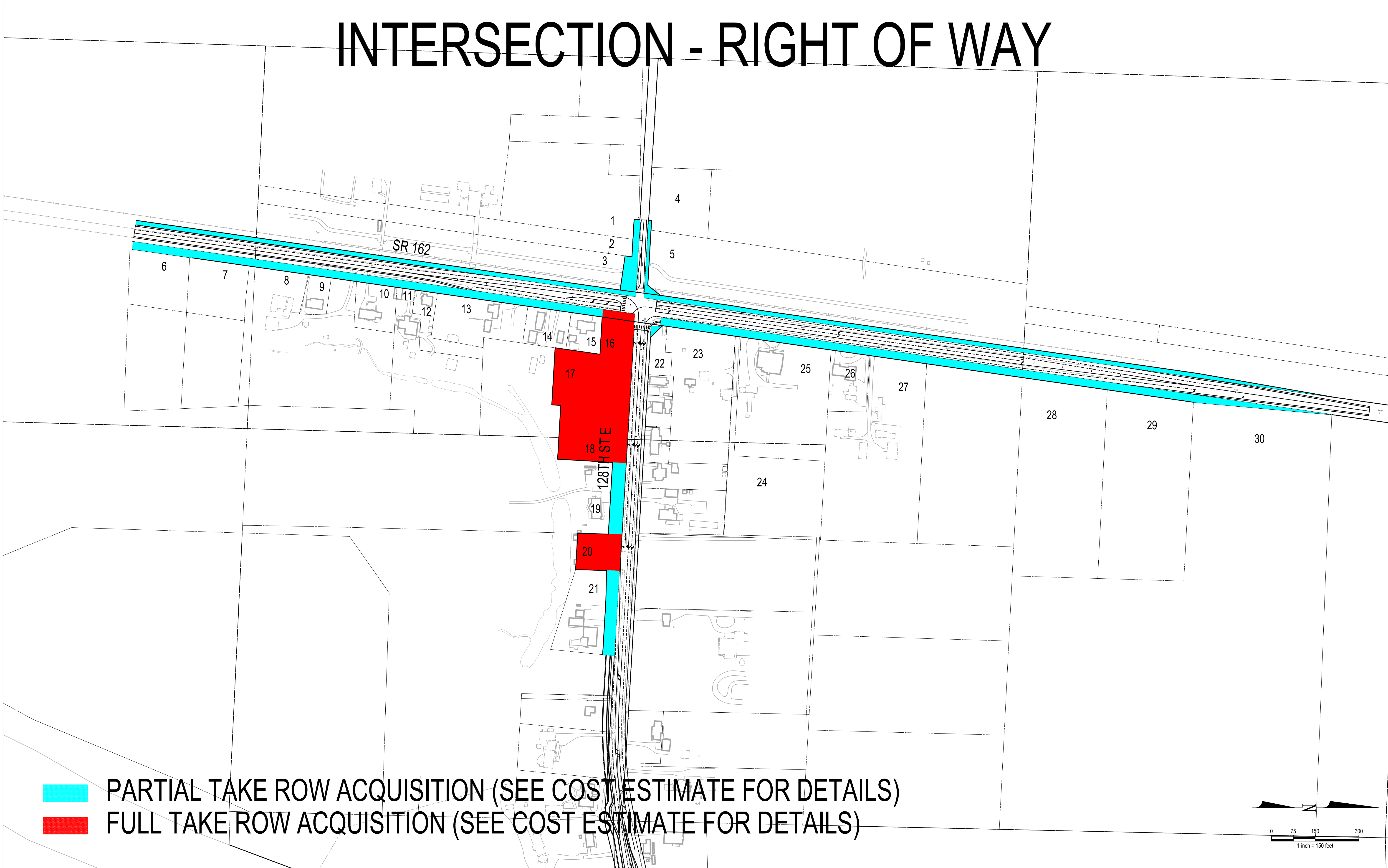
160
SCALE IN FEET

Appendix B: Right-of-Way Impacts

INTERSECTION - RIGHT OF WAY



PARTIAL TAKE ROW ACQUISITION (SEE COST ESTIMATE FOR DETAILS)

FULL TAKE ROW ACQUISITION (SEE COST ESTIMATE FOR DETAILS)

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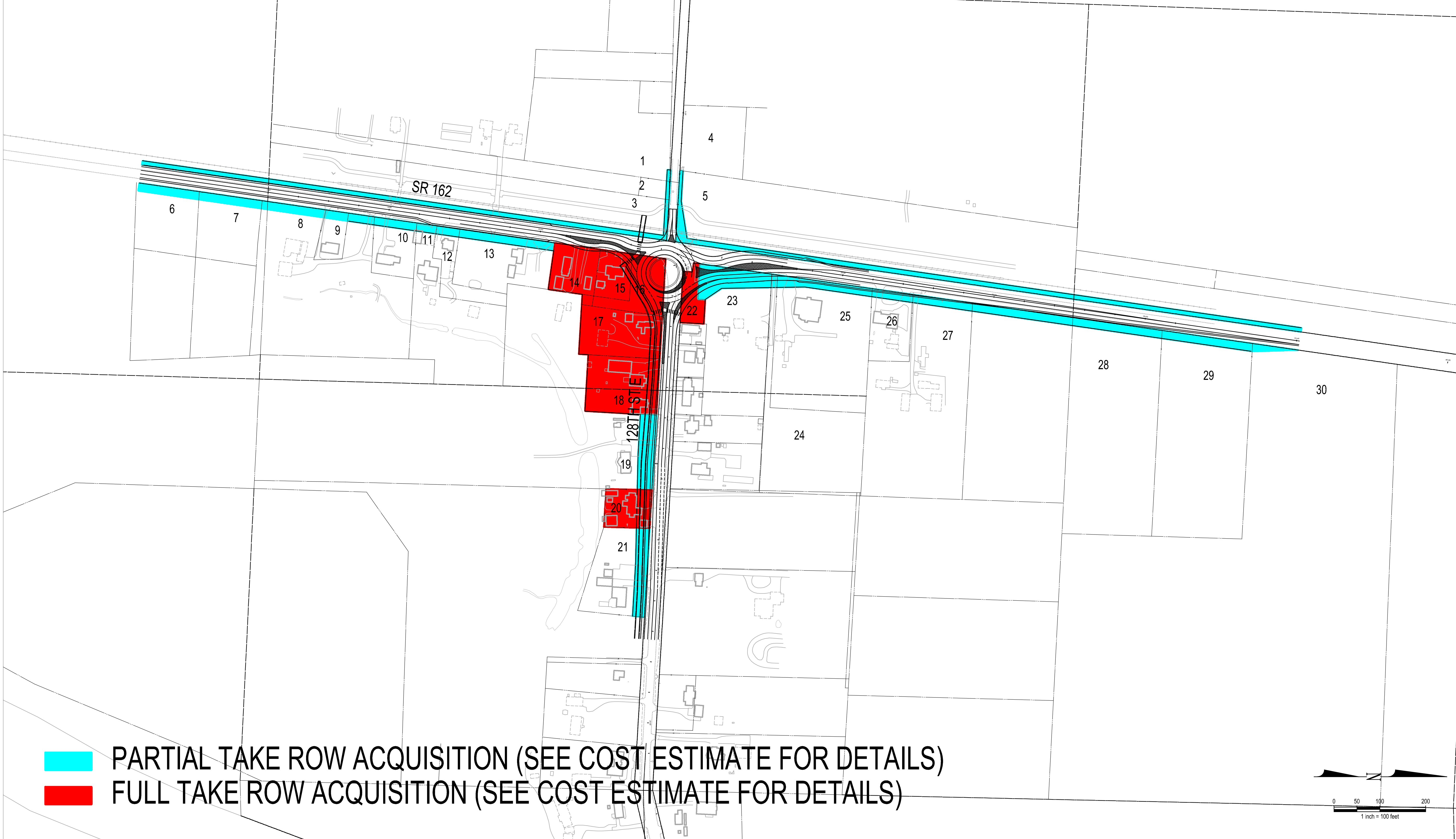
ROUNDABOUT - RIGHT OF WAY



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Appendix C: Signal Timing

Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations										
Traffic Volume (vph)	7	13	198	0	1550	1	639	395	940	244
Future Volume (vph)	7	13	198	0	1550	1	639	395	940	244
Turn Type	Perm	NA	Split	NA	pm+ov	Perm	NA	pm+ov	Prot	NA
Protected Phases		4	8	8	1		2	8	1	6
Permitted Phases	4				8	2		2		
Detector Phase	4	4	8	8	1	2	2	8	1	6
Switch Phase										
Minimum Initial (s)	4.0	4.0	6.0	6.0	6.0	10.0	10.0	6.0	6.0	10.0
Minimum Split (s)	36.0	36.0	10.6	10.6	10.6	34.7	34.7	10.6	10.6	24.7
Total Split (s)	36.0	36.0	20.7	20.7	67.5	45.8	45.8	20.7	67.5	113.3
Total Split (%)	21.2%	21.2%	12.2%	12.2%	39.7%	26.9%	26.9%	12.2%	39.7%	66.6%
Yellow Time (s)	3.5	3.5	3.6	3.6	3.6	4.7	4.7	3.6	3.6	4.7
All-Red Time (s)	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		4.0	4.6	4.6	4.6	5.7	5.7	4.6	4.6	5.7
Lead/Lag					Lag	Lead	Lead		Lag	
Lead-Lag Optimize?										
Recall Mode	None	None	None	None	None	Min	Min	None	None	Min
Act Effct Green (s)		11.5	13.2	13.2	60.4	31.0	31.0	50.7	44.3	80.4
Actuated g/C Ratio		0.10	0.11	0.11	0.53	0.27	0.27	0.44	0.39	0.70
v/c Ratio		0.36	0.55	0.55	0.89	0.00	0.73	0.47	0.77	0.11
Control Delay		70.9	70.4	70.4	16.5	45.0	47.9	6.8	38.2	7.3
Queue Delay		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		70.9	70.4	70.4	16.5	45.0	47.9	6.8	38.2	7.3
LOS		E	E	E	B	D	D	A	D	A
Approach Delay		70.9		22.6			32.2			31.7
Approach LOS		E		C			C			C

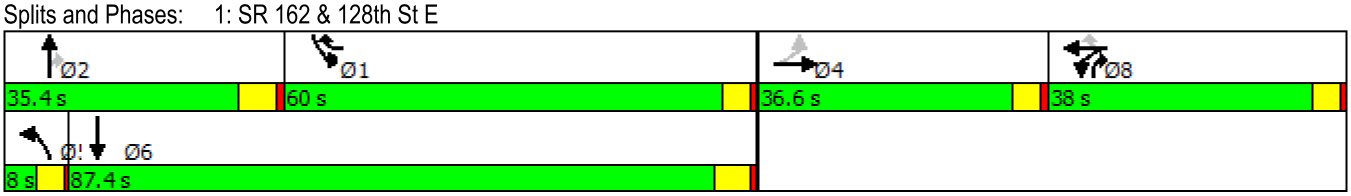
Intersection Summary	
Cycle Length: 170	
Actuated Cycle Length: 115	
Natural Cycle: 125	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.89	
Intersection Signal Delay: 28.1	Intersection LOS: C
Intersection Capacity Utilization 91.1%	ICU Level of Service F
Analysis Period (min) 15	
Description: EBT Ped phase reduced 3.6 seconds as FDW extends through ped phase	

Splits and Phases: 1: SR 162 & 128th St E

Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations										
Traffic Volume (vph)	14	10	806	16	1518	5	390	474	1441	823
Future Volume (vph)	14	10	806	16	1518	5	390	474	1441	823
Turn Type	Perm	NA	Split	NA	pm+ov	Prot	NA	pm+ov	Prot	NA
Protected Phases		4	8	8	1	5	2	8	1	6
Permitted Phases	4				8			2		
Detector Phase	4	4	8	8	1	5	2	8	1	6
Switch Phase										
Minimum Initial (s)	6.0	6.0	6.0	6.0	6.0	4.0	10.0	6.0	6.0	10.0
Minimum Split (s)	36.6	36.6	10.6	10.6	10.6	8.0	34.7	10.6	10.6	34.7
Total Split (s)	36.6	36.6	38.0	38.0	60.0	8.0	35.4	38.0	60.0	87.4
Total Split (%)	21.5%	21.5%	22.4%	22.4%	35.3%	4.7%	20.8%	22.4%	35.3%	51.4%
Yellow Time (s)	3.6	3.6	3.6	3.6	3.6	3.5	4.7	3.6	3.6	4.7
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	1.0
Lost Time Adjust (s)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)		4.6	4.6	4.6	4.6	4.0	5.7	4.6	4.6	5.7
Lead/Lag					Lag	Lead	Lead		Lag	Lag
Lead-Lag Optimize?						Yes				
Recall Mode	None	None	None	None	None	None	Min	None	None	Min
Act Effct Green (s)		12.9	34.0	34.0	92.4	4.1	21.9	61.7	56.3	81.6
Actuated g/C Ratio		0.09	0.24	0.24	0.66	0.03	0.16	0.44	0.40	0.58
v/c Ratio		0.56	1.06	1.06	0.73	0.10	0.76	0.56	1.10	0.43
Control Delay		92.2	113.2	112.0	5.8	80.2	67.6	9.7	96.0	19.1
Queue Delay		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay		92.2	113.2	112.0	5.8	80.2	67.6	9.7	96.0	19.1
LOS		F	F	F	A	F	E	A	F	B
Approach Delay		92.2		43.3			36.1			67.8
Approach LOS		F		D			D			E

Intersection Summary	
Cycle Length: 170	
Actuated Cycle Length: 139.8	
Natural Cycle: 145	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.10	
Intersection Signal Delay: 52.5	Intersection LOS: D
Intersection Capacity Utilization 97.9%	ICU Level of Service F
Analysis Period (min) 15	
Description: EBT Ped phase reduced 3.6 seconds as FDW extends through ped phase	

Splits and Phases: 1: SR 162 & 128th St E



Appendix D: LOS Worksheets

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	7	13	2	198	0	1550	1	639	395	940	244	7
Future Volume (vph)	7	13	2	198	0	1550	1	639	395	940	244	7
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)		4.0		4.6	4.6	4.6	5.7	5.7	4.6	4.6	5.7	
Lane Util. Factor		1.00		0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	
Frt		0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	
Flt Protected		0.98		0.95	0.95	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1716		1593	1593	2640	1676	3320	1485	3221	3308	
Flt Permitted		0.34		0.95	0.95	1.00	0.59	1.00	1.00	0.95	1.00	
Satd. Flow (perm)		597		1593	1593	2640	1047	3320	1485	3221	3308	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	7	13	2	202	0	1582	1	652	403	959	249	7
RTOR Reduction (vph)	0	2	0	0	0	418	0	0	224	0	1	0
Lane Group Flow (vph)	0	20	0	101	101	1164	1	652	179	959	255	0
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%	3%	2%
Turn Type	Perm	NA		Split	NA	pm+ov	Perm	NA	pm+ov	Prot	NA	
Protected Phases		4		8	8	1		2	8	1	6	
Permitted Phases	4					8	2		2			
Actuated Green, G (s)		7.7		13.2	13.2	58.0	31.0	31.0	44.2	44.8	80.4	
Effective Green, g (s)		7.7		13.2	13.2	58.0	31.0	31.0	44.2	44.8	80.4	
Actuated g/C Ratio		0.07		0.11	0.11	0.50	0.27	0.27	0.38	0.39	0.70	
Clearance Time (s)		4.0		4.6	4.6	4.6	5.7	5.7	4.6	4.6	5.7	
Vehicle Extension (s)		3.0		2.5	2.5	3.0	3.5	3.5	2.5	3.0	3.5	
Lane Grp Cap (vph)		39		181	181	1324	280	890	626	1248	2300	
v/s Ratio Prot				0.06	0.06	c0.34		c0.20	0.03	0.30	0.08	
v/s Ratio Perm		c0.03				0.10	0.00		0.09			
v/c Ratio		0.52		0.56	0.56	0.88	0.00	0.73	0.29	0.77	0.11	
Uniform Delay, d1		52.1		48.4	48.4	25.7	31.0	38.5	24.8	30.9	5.8	
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		11.1		3.0	3.0	7.0	0.0	3.2	0.2	2.9	0.0	
Delay (s)		63.2		51.4	51.4	32.6	31.0	41.8	24.9	33.8	5.8	
Level of Service		E		D	D	C	C	D	C	C	A	
Approach Delay (s)		63.2			34.8			35.3			27.9	
Approach LOS		E			C			D			C	

Intersection Summary			
HCM 2000 Control Delay	33.0	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	115.6	Sum of lost time (s)	18.9
Intersection Capacity Utilization	91.1%	ICU Level of Service	F
Analysis Period (min)	15		

Description: EBT Ped phase reduced 3.6 seconds as FDW extends through ped phase

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	7	13	2	198	0	1550	1	639	395	940	244	7
Future Volume (veh/h)	7	13	2	198	0	1550	1	639	395	940	244	7
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1800	1765	1800	1765	1765	1765	1765	1748	1748	1748	1748	1800
Adj Flow Rate, veh/h	7	13	2	202	0	1582	1	652	403	959	249	7
Adj No. of Lanes	0	1	0	2	0	2	1	2	1	2	2	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	2	2	2	2	3	3	3	3	3
Cap, veh/h	10	18	3	521	0	1513	345	947	654	1129	2275	64
Arrive On Green	0.02	0.02	0.02	0.15	0.00	0.15	0.29	0.29	0.29	0.35	0.69	0.69
Sat Flow, veh/h	544	1010	155	3361	0	3000	1060	3320	1485	3229	3300	93
Grp Volume(v), veh/h	22	0	0	202	0	1582	1	652	403	959	125	131
Grp Sat Flow(s),veh/h/ln	1710	0	0	1681	0	1500	1060	1660	1485	1614	1661	1732
Q Serve(g_s), s	1.3	0.0	0.0	5.6	0.0	16.1	0.1	18.2	21.7	28.6	2.6	2.6
Cycle Q Clear(g_c), s	1.3	0.0	0.0	5.6	0.0	16.1	2.7	18.2	21.7	28.6	2.6	2.6
Prop In Lane	0.32		0.09	1.00		1.00	1.00		1.00	1.00		0.05
Lane Grp Cap(c), veh/h	31	0	0	521	0	1513	345	947	654	1129	1145	1194
V/C Ratio(X)	0.71	0.00	0.00	0.39	0.00	1.05	0.00	0.69	0.62	0.85	0.11	0.11
Avail Cap(c_a), veh/h	526	0	0	521	0	1513	451	1281	803	1954	1719	1792
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	50.8	0.0	0.0	39.5	0.0	25.8	28.5	33.1	22.4	31.3	5.4	5.4
Incr Delay (d2), s/veh	25.8	0.0	0.0	0.4	0.0	36.0	0.0	1.1	1.2	1.9	0.1	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.9	0.0	0.0	2.6	0.0	14.0	0.0	8.5	11.5	13.0	1.2	1.3
LnGrp Delay(d),s/veh	76.6	0.0	0.0	39.8	0.0	61.7	28.5	34.2	23.5	33.2	5.5	5.5
LnGrp LOS	E			D		F	C	C	C	C	A	A
Approach Vol, veh/h		22			1784			1056			1215	
Approach Delay, s/veh		76.6			59.3			30.1			27.3	
Approach LOS		E			E			C			C	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4		6		8
Phs Duration (G+Y+Rc), s	42.0	35.3		5.9		77.4		20.7
Change Period (Y+Rc), s	5.7	* 5.7		4.0		5.7		4.6
Max Green Setting (Gmax), s	62.9	* 40		32.0		107.6		16.1
Max Q Clear Time (g_c+I1), s	30.6	23.7		3.3		4.6		18.1
Green Ext Time (p_c), s	5.8	6.0		0.1		6.0		0.0

Intersection Summary	
HCM 2010 Ctrl Delay	42.3
HCM 2010 LOS	D

Notes

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	14	10	5	806	16	1518	5	390	474	1441	823	11
Future Volume (vph)	14	10	5	806	16	1518	5	390	474	1441	823	11
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)		4.6		4.6	4.6	4.6	4.0	5.7	4.6	4.6	5.7	
Lane Util. Factor		1.00		0.95	0.95	0.88	1.00	0.95	1.00	0.97	0.95	
Frpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Flpb, ped/bikes		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt		0.98		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	
Flt Protected		0.98		0.95	0.95	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)		1679		1624	1630	2693	1676	3353	1500	3317	3412	
Flt Permitted		0.30		0.95	0.95	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)		515		1624	1630	2693	1676	3353	1500	3317	3412	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	14	10	5	822	16	1549	5	398	484	1470	840	11
RTOR Reduction (vph)	0	5	0	0	0	357	0	0	231	0	0	0
Lane Group Flow (vph)	0	24	0	419	419	1192	5	398	253	1470	851	0
Confl. Peds. (#/hr)			1	1								
Heavy Vehicles (%)	2%	2%	2%	0%	2%	0%	2%	2%	2%	0%	0%	2%
Turn Type	Perm	NA		Split	NA	pm+ov	Prot	NA	pm+ov	Prot	NA	
Protected Phases		4		8	8	1	5	2	8	1	6	
Permitted Phases	4					8			2			
Actuated Green, G (s)		9.9		34.0	34.0	93.8	0.7	21.9	55.9	59.8	81.6	
Effective Green, g (s)		9.9		34.0	34.0	93.8	0.7	21.9	55.9	59.8	81.6	
Actuated g/C Ratio		0.07		0.23	0.23	0.65	0.00	0.15	0.39	0.41	0.56	
Clearance Time (s)		4.6		4.6	4.6	4.6	4.0	5.7	4.6	4.6	5.7	
Vehicle Extension (s)		2.5		2.5	2.5	3.0	3.0	3.5	2.5	3.0	3.5	
Lane Grp Cap (vph)		35		380	381	1740	8	506	625	1367	1918	
v/s Ratio Prot				c0.26	0.26	0.28	0.00	c0.12	c0.09	c0.44	0.25	
v/s Ratio Perm		c0.05				0.16			0.07			
v/c Ratio		0.70		1.10	1.10	0.69	0.62	0.79	0.41	1.08	0.44	
Uniform Delay, d1		66.1		55.5	55.5	16.3	72.1	59.3	32.5	42.6	18.5	
Progression Factor		1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2		43.1		76.8	75.7	1.1	97.8	8.1	0.3	47.4	0.2	
Delay (s)		109.2		132.3	131.3	17.4	169.9	67.5	32.8	90.0	18.7	
Level of Service		F		F	F	B	F	E	C	F	B	
Approach Delay (s)		109.2			57.6			49.1			63.9	
Approach LOS		F			E			D			E	

Intersection Summary			
HCM 2000 Control Delay	59.1	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.00		
Actuated Cycle Length (s)	145.1	Sum of lost time (s)	19.5
Intersection Capacity Utilization	97.9%	ICU Level of Service	F
Analysis Period (min)	15		
Description: EBT Ped phase reduced 3.6 seconds as FDW extends through ped phase			
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	14	10	5	806	16	1518	5	390	474	1441	823	11
Future Volume (veh/h)	14	10	5	806	16	1518	5	390	474	1441	823	11
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.99	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1800	1765	1800	1800	1799	1800	1765	1765	1765	1800	1800	1800
Adj Flow Rate, veh/h	14	10	5	833	0	1549	5	398	484	1470	840	11
Adj No. of Lanes	0	1	0	2	0	2	1	2	1	2	2	0
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Percent Heavy Veh, %	2	2	2	0	2	0	2	2	2	0	0	0
Cap, veh/h	26	19	9	796	0	1889	8	693	658	1281	2069	27
Arrive On Green	0.03	0.03	0.03	0.23	0.00	0.23	0.01	0.21	0.21	0.39	0.60	0.60
Sat Flow, veh/h	807	576	288	3429	0	3056	1681	3353	1500	3326	3456	45
Grp Volume(v), veh/h	29	0	0	833	0	1549	5	398	484	1470	416	435
Grp Sat Flow(s),veh/h/ln	1671	0	0	1714	0	1528	1681	1676	1500	1663	1710	1792
Q Serve(g_s), s	2.5	0.0	0.0	33.4	0.0	1.0	0.4	15.4	29.7	55.4	18.5	18.5
Cycle Q Clear(g_c), s	2.5	0.0	0.0	33.4	0.0	1.0	0.4	15.4	29.7	55.4	18.5	18.5
Prop In Lane	0.48		0.17	1.00		1.00	1.00		1.00	1.00		0.03
Lane Grp Cap(c), veh/h	54	0	0	796	0	1889	8	693	658	1281	1023	1073
V/C Ratio(X)	0.53	0.00	0.00	1.05	0.00	0.82	0.59	0.57	0.74	1.15	0.41	0.41
Avail Cap(c_a), veh/h	372	0	0	796	0	1889	47	693	658	1281	1023	1073
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	68.5	0.0	0.0	55.2	0.0	21.3	71.4	51.4	31.0	44.2	15.3	15.3
Incr Delay (d2), s/veh	5.9	0.0	0.0	44.5	0.0	2.9	51.8	1.3	4.5	75.8	0.3	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.2	0.0	0.0	20.6	0.0	24.0	0.3	7.3	19.9	38.8	8.9	9.3
LnGrp Delay(d),s/veh	74.4	0.0	0.0	99.7	0.0	24.2	123.2	52.6	35.4	120.0	15.6	15.6
LnGrp LOS	E			F		C	F	D	D	F	B	B
Approach Vol, veh/h		29			2382			887			2321	
Approach Delay, s/veh		74.4			50.6			43.6			81.7	
Approach LOS		E			D			D			F	

Timer	1	2	3	4	5	6	7	8
Assigned Phs	1	2		4	5	6		8
Phs Duration (G+Y+Rc), s	61.1	35.4		9.3	4.7	91.8		38.0
Change Period (Y+Rc), s	5.7	* 5.7		4.6	4.0	5.7		4.6
Max Green Setting (Gmax), s	55.4	* 30		32.0	4.0	81.7		33.4
Max Q Clear Time (g_c+I1), s	57.4	31.7		4.5	2.4	20.5		35.4
Green Ext Time (p_c), s	0.0	0.0		0.1	0.0	20.0		0.0

Intersection Summary	
HCM 2010 Ctrl Delay	62.5
HCM 2010 LOS	E

Notes

Intersection: 1: SR 162 & 128th St E

Movement	EB	WB	WB	WB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	LTR	L	LT	R	R	L	T	T	R	L	L	T
Maximum Queue (ft)	50	99	113	938	260	24	362	338	308	396	361	82
Average Queue (ft)	17	42	70	190	165	1	229	186	149	238	190	18
95th Queue (ft)	44	90	109	607	237	21	324	293	269	365	321	57
Link Distance (ft)	227		1386	1386			506	506				543
Upstream Blk Time (%)										0		
Queuing Penalty (veh)										0		
Storage Bay Dist (ft)		750			425	100			350	1000	1000	
Storage Blk Time (%)							54	0	0	0		
Queuing Penalty (veh)							1	1	0	0		

Intersection: 1: SR 162 & 128th St E

Movement	SB
Directions Served	TR
Maximum Queue (ft)	37
Average Queue (ft)	2
95th Queue (ft)	21
Link Distance (ft)	543
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 1: SR 162 & 128th St E

Movement	EB	WB	WB	WB	WB	NB	NB	NB	NB	SB	SB	SB
Directions Served	LTR	L	LT	R	R	L	T	T	R	L	L	T
Maximum Queue (ft)	75	399	405	142	180	61	255	326	353	1000	1003	1935
Average Queue (ft)	27	268	282	84	114	8	167	145	218	856	862	1109
95th Queue (ft)	65	400	408	132	166	45	237	255	335	1156	1162	2447
Link Distance (ft)	226		1380	1380			1725	1725				1920
Upstream Blk Time (%)												11
Queuing Penalty (veh)												0
Storage Bay Dist (ft)		750			425	100			350	1000	1000	
Storage Blk Time (%)						0	40		1	3	10	0
Queuing Penalty (veh)						0	2		3	13	40	7

Intersection: 1: SR 162 & 128th St E

Movement	SB
Directions Served	TR
Maximum Queue (ft)	1931
Average Queue (ft)	836
95th Queue (ft)	2148
Link Distance (ft)	1920
Upstream Blk Time (%)	2
Queuing Penalty (veh)	0
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

LANE SUMMARY

Site: 1 [SR 162 - 128th Street E]

SR 162 - 128th Street E
(2030 AM Peak Hour)
Roundabout

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: SR 162													
Lane 1	473	3.0	761	0.621	100	11.9	LOS B	3.9	99.9	Full	1600	0.0	0.0
Lane 2[d]	583	3.0	938	0.621	100	10.8	LOS B	4.1	106.2	Full	1600	0.0	0.0
Approach	1056	3.0		0.621		11.3	LOS B	4.1	106.2				
East: 128th Street E													
Lane 1	87	2.0	968	0.090	100	10.1	LOS B	0.4	10.4	Full	2000	0.0	0.0
Lane 2[d]	116	2.0	1285	0.090	100	9.6	LOS A	0.5	11.5	Full	2000	0.0	0.0
Lane 3	1582	2.0	1642	0.963	100	5.2	LOS A	0.0	0.0	Full	725	0.0	0.0
Approach	1785	2.0		0.963		5.7	LOS A	0.5	11.5				
North: SR 162													
Lane 1	437	3.0	1275	0.342	100	11.9	LOS B	1.8	45.2	Short	1000	0.0	NA
Lane 2[d]	522	3.0	1526	0.342	100	11.7	LOS B	1.8	46.7	Full	2000	0.0	0.0
Lane 3	256	3.0	1205	0.213	62[5]	7.1	LOS A	1.0	24.5	Full	2000	0.0	0.0
Approach	1215	3.0		0.342		10.8	LOS B	1.8	46.7				
West: 128th Street E													
Lane 1[d]	22	2.0	618	0.036	100	8.4	LOS A	0.1	2.9	Full	500	0.0	0.0
Approach	22	2.0		0.036		8.4	LOS A	0.1	2.9				
Intersection	4079	2.6		0.963		8.7	LOS A	4.1	106.2				

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Lane LOS values are based on average delay per lane.
Intersection and Approach LOS values are based on average delay for all lanes.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

5 Lane under-utilisation found by the program
d Dominant lane on roundabout approach

Organisation: THE TRANSPO GROUP | Processed: Thursday, May 17, 2018 3:08:20 PM
Project: \\srv-dfs-wa\MM_Projects\Projects\15\15035.00 - Rhodes Lake Road East Corridor\Traffic Analysis\Traffic Operations\Sidra\AM Peak Hour \2030 AM Peak Hour (WSDOT)_v2.sip7

LANE SUMMARY

Site: 1 [SR 162 - 128th Street E]

SR 162 - 128th Street E
(2030 PM Peak Hour)
Roundabout

Lane Use and Performance	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: SR 162													
Lane 1	397	2.0	424	0.936	100	30.9	LOS C	9.5	241.1	Full	1600	0.0	0.0
Lane 2[d]	538	2.0	575	0.936	100	27.0	LOS C	11.2	285.7	Full	1600	0.0	0.0
Approach	934	2.0		0.936		28.6	LOS C	11.2	285.7				
East: 128th Street E													
Lane 1	390	0.0	1102	0.354	100	10.0	LOS A	2.1	52.9	Full	2000	0.0	0.0
Lane 2[d]	494	0.1	1397	0.354	100	9.4	LOS A	2.3	57.9	Full	2000	0.0	0.0
Lane 3	1632	0.0	1675	0.975	100	5.7	LOS A	0.0	0.0	Full	725	0.0	0.0
Approach	2516	0.0		0.975		7.1	LOS A	2.3	57.9				
North: SR 162													
Lane 1	775	0.0	912	0.849	100	19.3	LOS B	9.3	233.2	Short	1000	0.0	NA
Lane 2	775	0.0	912	0.849	100	19.3	LOS B	9.3	233.2	Full	2000	0.0	0.0
Lane 3[d]	897	0.0	1233	0.727	86[5]	10.3	LOS B	6.6	164.5	Full	2000	0.0	0.0
Approach	2446	0.0		0.849		16.0	LOS B	9.3	233.2				
West: 128th Street E													
Lane 1[d]	31	2.0	186	0.168	100	23.0	LOS C	0.7	18.6	Full	500	0.0	0.0
Approach	31	2.0		0.168		23.0	LOS C	0.7	18.6				
Intersection	5928	0.3		0.975		14.2	LOS B	11.2	285.7				

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Lane LOS values are based on average delay per lane.
Intersection and Approach LOS values are based on average delay for all lanes.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

5 Lane under-utilisation found by the program
d Dominant lane on roundabout approach

Organisation: THE TRANSPO GROUP | Processed: Thursday, May 17, 2018 2:37:18 PM
Project: \\srv-dfs-wa\MM_Projects\Projects\15\15035.00 - Rhodes Lake Road East Corridor\Traffic Analysis\Traffic Operations\Sidra\PM Peak Hour \2030 PM Peak Hour (WSDOT)_v2.sip7

Appendix E: Cost Estimates

May 2018

	SR 162/128TH ST Compare		SIGNALIZED INTERSECTION			ROUNDABOUT		
		Unit	Quantity	Unit Cost	Cost	Quantity	Unit Cost	Cost
STD Item	**Division 1 - General**							
	Mobilization (10%)	LS	1	$ 200,000	$ 200,000	1	$ 240,000	$ 240,000
	Traffic Control	LS	1	$ 50,000	$ 50,000	1	$ 200,000	$ 200,000
	Construction Staking (1.5%)	LS	1	$ 48,557	$ 48,557	1	$ 63,329	$ 63,329
	Division 2 - Earthwork							
	Clearing & Grubbing	ACRE	6.3	$ 8,000	$ 50,400	5.2	$ 8,000	$ 41,600
	Gravel Borrow	TON	5500	$ 50	$ 275,000	16500	$ 50	$ 825,000
	Division 4 - Surfacing							
	CSBC	TON	10850	$ 20	$ 217,000	8640	$ 20	$ 172,800
	Division 5 - Pavement							
	HMA for Roadway	TON	21000	$ 90	$ 1,890,000	16100	$ 90	$ 1,449,000
	HMA for Shared Pathway	TON	470	$ 100	$ 47,000	510	$ 100	$ 51,000
	Truck Apron Concrete	SY		$ 800	$ -	380	$ 800	$ 304,000
	Division 7 - Drainage							
	Drainage Pipe and Catch Basins	LS	1	$ 50,000	$ 50,000	1	$ 150,000	$ 150,000
	Division 8 - Miscellaneous							
7055	Cement Conc. Sidewalk	SY		$ 100	$ -	1,240	$ 100	$ 124,000
6700	Cement Conc. Traffic Curb and Gutter	LF	2220	$ 35	$ 77,700	1000	$ 35	$ 35,000
6698	Roundabout Splitter Island Nosing Curb	EA			$ -	5	$ 2,800	$ 14,000
6699	Roundabout Cement Concrete Curb and Gutter	LF			$ -	4820	$ 50	$ 241,000
6708	Roundabout Central Island Cement Concrete Curb	LF			$ -	310	$ 50	$ 15,500
6709	Roundabout Truck Apron Cem. Conc. Curb and Gutter	LF			$ -	380	$ 50	$ 19,000
	Light Poles	EA	4	$ 20,000	$ 80,000	12	$ 20,000	$ 240,000
	Traffic Signal	LS	1	$ 300,000	$ 300,000	1	$ 100,000	$ 100,000
	Overhead Signage	EA				3	$ 50,000	$ 150,000
				Sub-Total	**$ 3,285,657**		**Sub-Total**	**$ 4,435,229**
	Escalation (15%)		15%		$ 492,848			$ 665,284
	Design Contingency (15%)		15%		$ 492,848			$ 665,284
				Sub-Total	**$ 4,271,353**			**$ 5,765,797**
	Design Costs (30% Design to Final Design)		7%		$ 298,995			$ 403,606
	Public Agency Fees		2%		$ 85,427			$ 115,316
	Construction Management/Engineering Services		8%		$ 341,708			$ 461,264
				Sub-Total	**$ 4,997,484**			**$ 6,745,983**
	R/W Acquisition & Relocation Costs		LS		$ 3,395,687			$ 3,886,670
				Segment Total:	**$ 8,393,170**			**$ 10,632,653**