W Lilac Rd Roundabouts
San Diego County
Accretive Investments, Inc.

Roundabout Peer Review
Exhibit of Findings
October 2013

ReidMiddleton
1953 – 2013

Roundabout Exhibit of Findings

W Lilac Rd Roundabouts
San Diego County

The engineering material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a registered professional engineer is affixed below.

10-25-13

RACHEL S. PRICE
P.E. C-77191

ReidMiddleton
1953 – 2013

728 134th Street SW, Suite 200
Everett, WA 98204
425-741-3800
www.reidmiddleton.com

TABLE OF CONTENTS

Review Comments/Design Notes

Project Title:	W Lilac Rd Roundabouts	Design Phase (%):	Conceptual
Owner:	Accretive Investments, Inc.	Date:	October 25, 2013

Topic/ Reference	Comment
Introduction/ Initial Design Assumptions	Reid Middleton (RM) was contracted by Accretive Investments, Inc. to provide a peer review of two single lane roundabouts on W Lilac Rd. The conceptual roundabouts had been prepared by Landmark Consulting. RM was given the following assumptions for the design: - The design vehicle for these roundabouts is a WB-50. - Roundabout 1 (RB 1): The approach speeds from the existing west leg (W Lilac Rd) and from the proposed east leg (IOD) are 40mph. The speeds from the existing north leg (W Lilac Rd), proposed south leg (Residential Rd), and proposed southeast leg (Main St) are 30mph. - Roundabout 2 (RB 2): The approach speeds from the existing north leg (W Lilac Rd) and existing east leg (W Lilac Rd) are 40mph. The speeds from the proposed west leg (Main St) and proposed south leg (Residential Rd) are 30 mph. RM reviewed the roundabout traffic analysis, horizontal geometrics, and preliminary grading of the proposed roundabouts. To achieve a safe and efficient design, a roundabout needs proper deflection, good speed control and natural drive paths. In reviewing the layout of these roundabout designs, it was determined that the horizontal geometrics would not adequately achieve these goals (Figures 1-2). RM provided several alternative new layouts that address the concerns of the initial layouts and will provide the desired user behavior at these intersections (Figures 3-6). A comparison of the initial and RM proposed layouts can be seen in Figure 7-8. In addition, Appendix B contains all the corresponding back-up calculations for the horizontal geometrics of the RM conceptual roundabouts. To calculate the fastest paths in the initial and RM designed roundabouts, the method developed by the Ada County Highway District was used. The method was created to be objective, repeatable, conform to the current FHWA Roundabout Guide and to reflect anticipated driver behavior and vehicle performance. A copy of this method can be seen in Appendix D. The design vehicle (WB-50) movements were calculated with a tire clearance of 18in to the outside curb, 6in to mountable curbs, and 0in to truck aprons. Due to the conservative nature of Autoturn™, this distance will ensure trucks can negotiate the roundabout comfortably. RM will be available to answer any questions that might arise from the specifics of these layouts.

Topic/ Reference	Comment
Intersection 1 Traffic Analysis (Appendix A)	The all-way-stop-control does not accommodate the volumes at this intersection. The traffic signal and roundabout both provide good intersection performance; however, the roundabout provides greater reserve capacity for future growth (lower v/c ratios). The roundabout also provides a safer intersection where a diverse mix of users can successfully share the public right-of-way in a calm and aesthetic environment. The roundabout allows greater flexibility to accommodate a revised road configuration such as the addition of the IOD (or replacing W Lilac Rd with the IOD. Traffic analysis for a five leg roundabout (that incorporates both W Lilac Rd and IOD) show this configuration would work well with the traffic volumes. For full intersection analysis see Appendix A.
Intersection 2 Traffic Analysis (Appendix A)	The all-way-stop-control, the traffic signal and the roundabout all accommodate the traffic volumes at Intersection 2. Like Intersection 1, the roundabout provides greater reserve capacity for future growth (lower v/c ratios), and provides the other benefits listed above. For full intersection analysis see Appendix A.
Intersection Safety	Roundabouts offers safety features that traffic signals do not. The strength of a roundabout is entry speed reduction and speed consistency through the intersection. A well-designed roundabout minimizes differential speeds to reduce collision rates and severity of collisions between conflicting vehicles. According to NCHRP Report 572, a roundabout has a 76% reduction in severe injury collisions compared to traffic signals. The roundabout geometry removes the most severe collisions. Head on, right angle, and T-bone collisions do not occur at a roundabout; the geometry does not facilitate these types of collisions. The slow motor vehicle speeds through the intersection establishes a safer condition for pedestrians and bicycles users as well. At Intersection 1, a roundabout alternative will provide additional safety benefits due to the roadway configuration. The existing curvature of W Lilac Rd does not lend itself to the construction of a safe traffic signal. However, a roundabout uses this existing curvature to its advantage by slowing and directing vehicles to properly enter the intersection. Traffic signals do not always operate safely and efficiently under skewed roadway conditions. The intersect angle of proposed and existing alignments at Intersection 1 create this skewed condition, especially if the IOD alignment is constructed. Roundabouts on the other hand, can create order from alignments that intersect at skewed angles which results in added safety benefits. The roundabout will also offer added safety benefits at Intersection 2 where the roadway alignments also intersect at skewed angles. At this intersection, the higher approach speeds of W Lilac Rd (40mph) and roadway alignments make the roundabout a much safer alternative over the all-way-stop-control and traffic signal control.
Peer Review RB 1	A four-leg conceptual roundabout with the existing W Lilac Rd configuration was reviewed. The following item nos. 1-13 correspond to the triangular callouts on Figure 1.

Topic/ Reference	Comment
Item 1 (Figure 1)	The geometry for the approach from Main St does not slow vehicles as they enter the roundabout. Vehicles can enter the roundabout at a speed greater than 40mph while the conflicting traffic would be traveling approximately 15mph. Speeds this fast negate the innate safety benefits associated with single lane roundabouts. There will be an increase in failure to yield, increasing the potential for collisions. In addition, these potential collisions will result in severe damage due to the high speed differentials. A speed differential 6-7mph in conflicting paths is recommended at this location. In addition, entering speeds should be approximately 20-22mph.
Item 2 (Figure 1)	The geometry for the approach from Main St does nothing to slow vehicles down prior to the crosswalk location. The safety of pedestrian, bicycles, and equestrian users are dependent on slow vehicle speeds, controlled by the geometry of the roundabout. In addition, the commuter bicyclists will want to merge with vehicle traffic to negotiate the roundabout which is easier and safer when speeds are kept around 20-22mph.
Item 3 (Figure 1)	The geometry for the approaches from W Lilac Rd (both the west and north leg) do not slow vehicles sufficiently. Vehicles can enter the roundabout at 25mph while an entering speed of 20-22mph is more appropriate for a roundabout. See Item 2.
Item 4 (Figure 1)	The exit onto Main St, Residential St and W Lilac Rd (west leg) is not a natural path. Vehicles will need to brake to negotiate the exit safely, contrary to driver expectation. In addition, the splitter island does not guide circulating vehicles out of the roundabout in a path that is natural (see cyan line). The radius of this splitter island stripe should be tangent with the central truck apron curb. The potential for curb strikes on these exits is high and the capacity will be decreased with this type of design.
Item 5 (Figure 1)	Pavement marking arrows in circulating lane for a single lane roundabout are not recommended.
Item 6 (Figure 1)	The splitter island is too short on the Residential St. A minimum splitter island length of 50ft is recommended for this location. In addition, the pedestrian refuge is compromised on this leg. The pedestrian refuge island is an important safety feature at this location due to the trail connection and pedestrian connectivity.
Item 7 (Figure 1)	The bicycle crossing on W Lilac Rd (west leg) is located too far from the roundabout to get any safety benefits associated with vehicles slowing to negotiate the intersection. Ideally these crossings should be located one car length from the circulating roadway of the roundabout.
Item 8 (Figure 1)	The design vehicle (WB-50) does not seem to be accommodated on the exit to the Residential St and to Main St (see green lines depicting the tire tracks). A design vehicle should be able to negotiate the roundabout without having to put the tractor tires onto the truck apron (which is reserved for the trailer part of the truck). It is recommended that a WB-50 be able to negotiate this roundabout to ensure construction vehicles for the development will have adequate access.

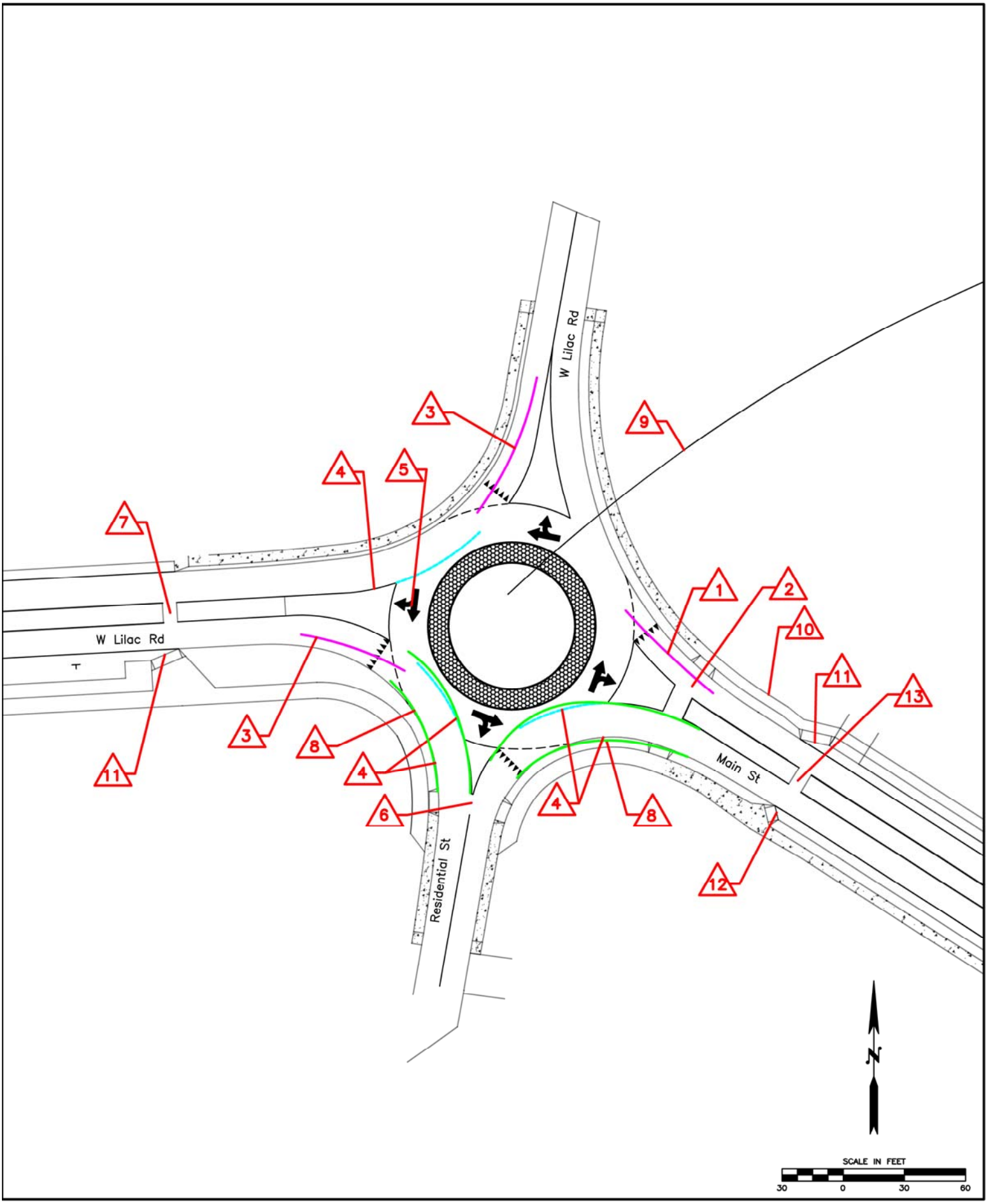
Topic/ Reference	Comment
Item 9 (Figure 1)	It is not clear how this roundabout would accommodate the proposed IOD without major shifts in central island location or other approach alignments.
Item 10 (Figure 1)	The minimum recommended multiuse trail is 8ft. On Main St from the bike ramp to the pedestrian crosswalk, a minimum width of 8ft should be maintained.
Item 11 (Figure 1)	The bike ramp to the multiuse trail from W Lilac Rd and Main St is too wide. This may be mistaken as a driveway and entice vehicle traffic. In addition, RM does not recommend bicycle ramps oriented this way as less experienced bicyclists will swerve into travel lane to line themselves up with the ramp. See Appendix E for more explanation on Bicycle Treatment Facilities.
Item 12 (Figure 1)	The bicycle ramp exiting onto Main St is angled in a way that inexperienced bicyclists will be guided into the vehicle traffic. See Appendix E for more explanation on Bicycle Facilities.
Item 13 (Figure 1)	This location is not recommended as a bicycle crossing (see Item 7).
Peer Review RB 2	The conceptual layout of RB 2 was in the development stages of design. Therefore, the roundabout details were not reviewed, including the design of bicycle and pedestrian facilities. The following item nos. 14-21 correspond to the triangular callouts on Figure 2.
Item 14 (Figure 2)	The taper rate for the splitter island on the Residential St is abrupt for an approach speed of 30mph.
Item 15 (Figure 2)	The geometry for the approach from W Lilac Rd (north leg) does not slow vehicles sufficiently as they enter the roundabout. Vehicles can enter the roundabout at 25mph while an entering speed of 20-22mph is more appropriate for a roundabout. This will ensure the safety benefits and capacity predicted for this single lane roundabout are achieved.
Item 16 (Figure 2)	The geometry for the approach from Main St and the Residential St does nothing to slow vehicles down prior to the crosswalk location, which causes safety concerns.

Topic/ Reference	Comment
Item 17 (Figure 2)	The pedestrian refuge island on the Residential St may not meet current standards for a minimum distance of 6.0ft. This refuge does not provide adequate protection.
Item 18 (Figure 2)	The splitter islands are too short on W Lilac Rd (both the north and east legs). A minimum splitter island length is 50ft, however due to the higher speeds on this approach a longer splitter island is desirable (100-150ft).
Item 19 (Figure 2)	The right turn from westbound W Lilac Rd is an unnatural path. Drivers will straighten this path out (see difference between outside curb lines and the blue line). The straightened path creates a faster right turn that is appropriate at this location. In addition, the unused space is inefficient and will collect debris.
Item 20 (Figure 2)	All of the exits from this roundabout are designed with an unnatural path, however, it is more pronounced on the W Lilac Rd (north and east legs). Vehicles will need to brake to negotiate these exits safely, contrary to driver expectation. In addition, the splitter island does not guide circulating vehicles out of the roundabout in a path that is natural (see cyan line). The radius of this splitter island stripe should be tangent with the central truck apron curb. The potential for curb strikes on these exits is high and the capacity will be decreased with this type of design.
Item 21 (Figure 2)	The design vehicle (WB-50) does not seem to be accommodated on the exit to the Residential St and to Main St (see green lines depicting the tire tracks). A design vehicle should be able to negotiate the roundabout without having to put the tractor tires onto the truck apron (which is reserved for the trailer part of the truck). It is recommended that a WB-50 be able to negotiate this roundabout to ensure construction vehicles for the development will have adequate access.
RM Design RB 1 RB 1 (Alt A) RB 1 (Alt B)	RM designed a conceptual roundabout that addresses the above concerns of the first intersection. This layout, RB 1, is designed to accommodate the existing W Lilac Rd (north leg). The following item nos. 22-25 correspond to the circular callouts on Figure 3. The roundabout is versatile so that with minor modifications, it will accommodate the proposed IOD alignment rather than the existing W Lilac Rd (north leg). The location of the central island and three legs are the same in this roundabout, RB 1 (Alt A) as in RB 1. An accurate representation of the roundabout impacts, regardless of which alignment is built for that fourth leg, can be determined and quantified for the majority of the intersection. Item no. 26 corresponds to the circular callouts on Figure 4. Finally, in an effort to provide for both the W Lilac Rd (north leg) and proposed IOD alignment, a five-leg roundabout, RB 1 (Alt B) was designed. The following item nos. 27-29 correspond to the circular callouts on Figure 5. Appendix B contains all the corresponding back-up calculations for the horizontal geometrics of these RM conceptual roundabouts such as fastest paths, truck turning movements and sight distance requirements.

Topic/ Reference	Comment
Item 22 (Figure 3)	Bike ramps are detailed based on RM recommended design. The reasoning behind this type of design can be found in Appendix E.
Item 23 (Figure 3)	Pedestrian refuge islands were designed with equestrian users in mind – the width is a minimum of 10ft.
Item 24 (Figure 3)	Multiuse trail and landscaping buffer widths can be adjusted. (Multiuse trail minimum width is 8ft with 10ft being desirable).
Item 25 (Figure 3)	This type of ramp was used to indicate that all multiuse path users except bicyclists should use this pedestrian crossing and subsequent multiuse paths. The bike path continues around the north side of the roundabout and "bike only" pavement markings could be used. For bicycle users, the path around the north of the roundabout was designed to limit crosswalk exposure for those traveling from Main St to westbound W Lilac Rd (only one crossing versus three if they traverse using the southern multiuse path).
Item 26 (Figure 4)	Entry curvature on Main St and exit curvature on W Lilac Rd changed slightly to accommodate the proposed IOD alignment. All other curb locations remain the same as RB 1.
Item 27 (Figure 5)	The splitter island length is influenced by the approach speed. When the approach speed is 30mph a minimum splitter island length of 50ft is acceptable. At higher speeds, the splitter island length increases.
Item 28 (Figure 5)	This type of ramp was used to indicate that all multiuse path users should use this pedestrian crossing and subsequent multiuse paths. Bicyclists are encouraged to use the southern multiuse path system as this route does not substantially increase their crosswalk exposure.

Topic/ Reference	Comment
Item 29 (Figure 5)	This roundabout provides an excellent way of designing for the existing W Lilac Rd, but leaving options open for future IOD alignment development. Residents that live along W Lilac Rd will not have to be inconvenienced with a road closure, and they will not have a negative impact on the roundabout safety or operations. The IOD leg can be built at a later time with no impact to existing roundabout operations.
RM Design RB 2	RM designed a conceptual roundabout, RB 2 that addresses the above concerns of the second intersection. The following item nos. 30-31 correspond to the circular callouts on Figure 6. Appendix B contains all the corresponding back-up calculations for the horizontal geometrics of these RM conceptual roundabouts such as fastest paths, truck turning movements and sight distance requirements.
Item 30 (Figure 6)	Pedestrian facilities and corresponding crosswalk locations can be adjusted as needed based on proposed routes.
Item 31 (Figure 6)	Taking out the reverse curves on the W Lilac Rd exit (north leg) allows for a more natural vehicle path as cars exit the roundabout.

Topic/ Reference	Comment
Grading (Appendix C)	Because design speeds (and fastest paths speeds) are controlled at roundabouts, there is flexibility in constructing roundabouts at topographically challenging sites. It appears the following grading guidelines are achievable in both RB 2 and RB 2 (See Appendix C): • Design the central island profile with vertical curve values equal to circulating speeds (15mph) • Design the central island profile with a maximum grade of 4% • Use an approximate 2% cross slope (1.5% to 2.5%) for circulating lane, approach lanes and exit lanes • Design outside curb profiles based on elevations of central island profile with appropriate cross slopes. Vertical curve values will be based on the design speed of the roundabout (20mph) • Tie into existing/proposed curb alignments at the leading edge of the splitter islands using vertical curve values consistent with approach speeds • Detail spot elevations based on vertical curve grading and check that all of the above guidelines are incorporated (*not included in Appendix C – detailed in final design*) • Check that positive drainage is achieved (*not included in Appendix C – detailed in final design*) • Check that all ADA grading requirements are met at pedestrian refuge islands (*not included in Appendix C – detailed in final design*) The initial finished grade at the location of RB 1 will need to be modified to incorporate roundabout grading principles. The initial finished grade at the location of RB 2 will only need slight adjustments to accommodate roundabout grading principles. These profiles can be finessed as final design continues to optimize grading. Based on preliminary roundabout grading, it appears that roundabouts can be constructed at these two locations without compromising the operations or safety of the intersections.
Conclusion	Through the use of curbs, truck aprons, sidewalks, and landscaping, the roundabout is a great way to balance the varying needs of heavy vehicles, commuter vehicles, local traffic, bicyclists, pedestrians and equestrian users. These roundabouts will create an environment where this diverse mix of users can successfully share the public right-of-way. The roundabouts will accommodate the predicted traffic with slightly less overall intersection delay than the traffic signal and with added safety benefits. The geometric flexibility of roundabouts can incorporate either the existing W Lilac Rd, the proposed IOD alignment, or both with improved safety and capacity over a traffic signal. Well-designed, single-lane roundabouts will operate more safely and efficiently at the two intersection locations on W Lilac Rd than the other options and are the recommended alternative.



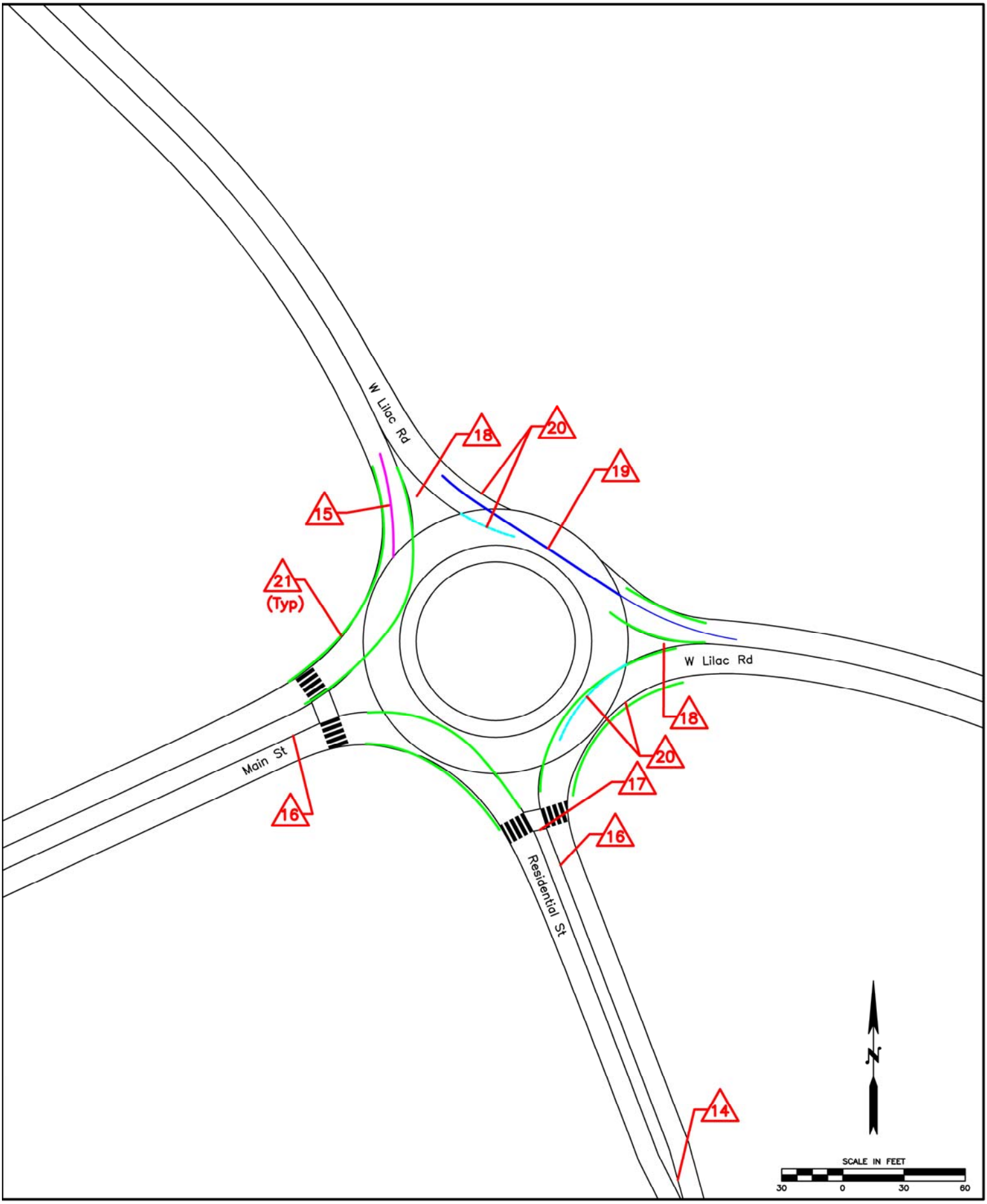
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Phone 425 741-3800

Peer Review of Roundabout 1

W Lilac Rd Roundabouts

Figure 1

October 2013



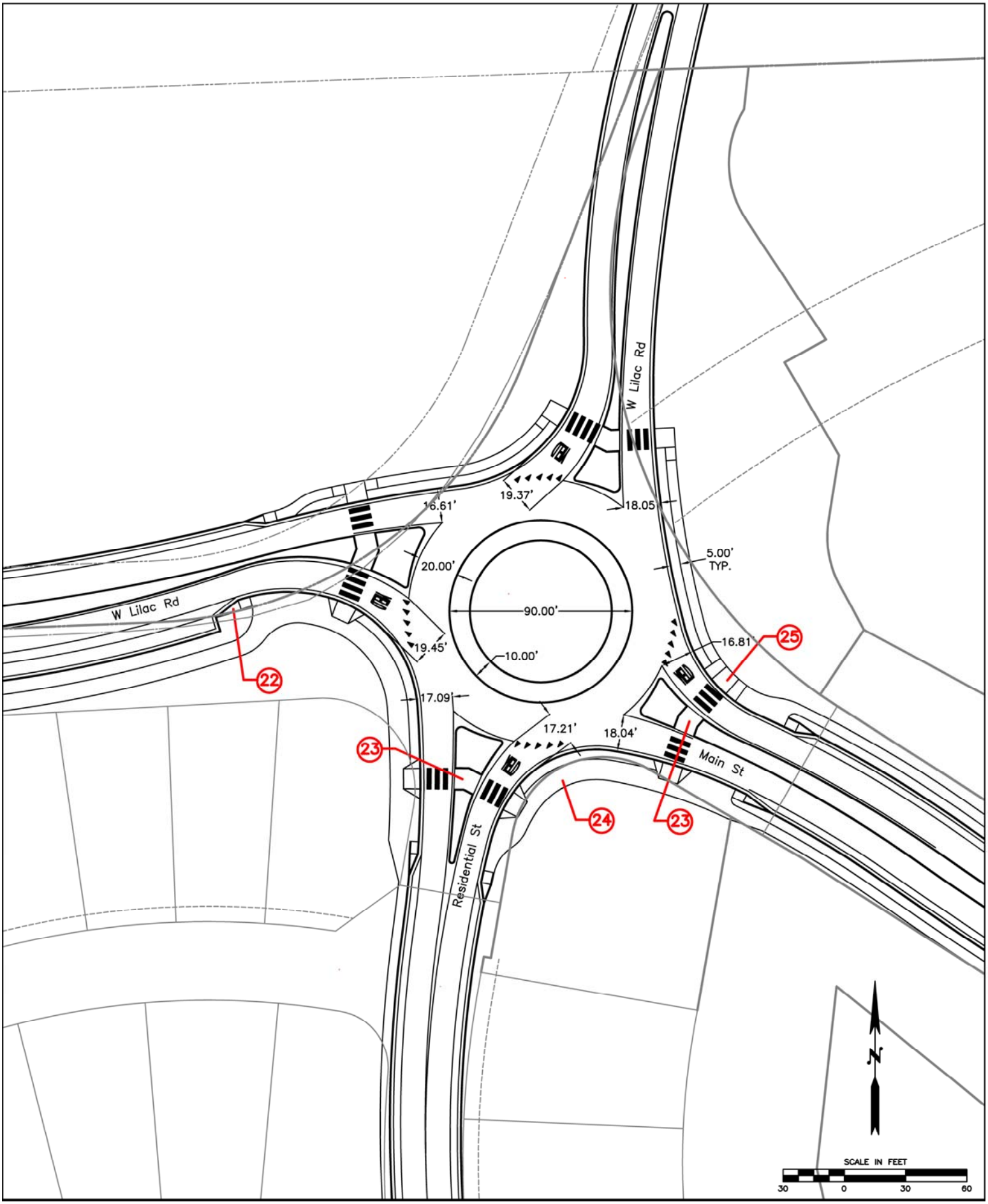
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Peer Review of Roundabout 2

W Lilac Rd Roundabouts

Figure 2

October 2013



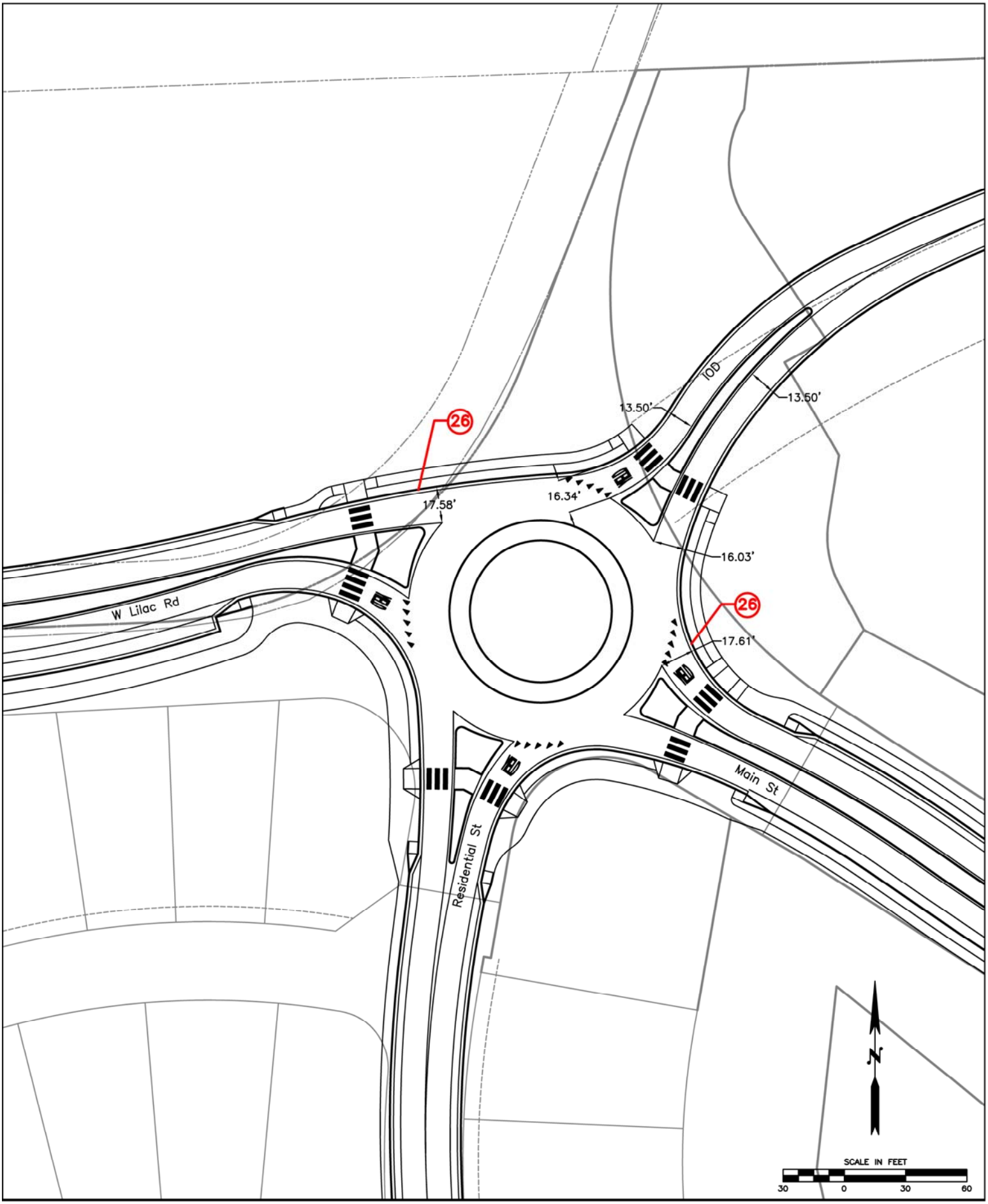
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - LAYOUT

Figure 3

W Lilac Rd Roundabouts

October 2013



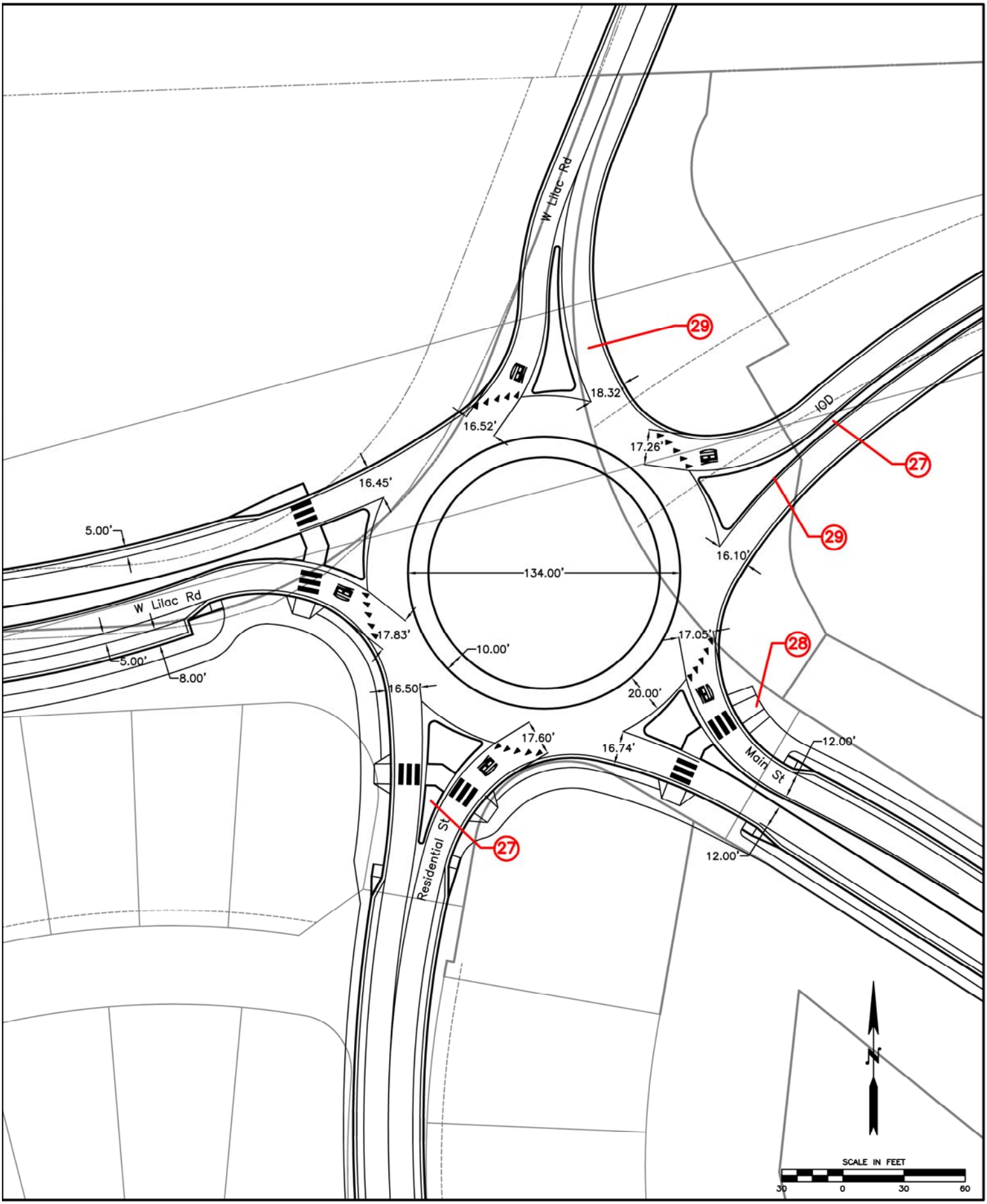
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - LAYOUT

Figure 4

W Lilac Rd Roundabouts

October 2013



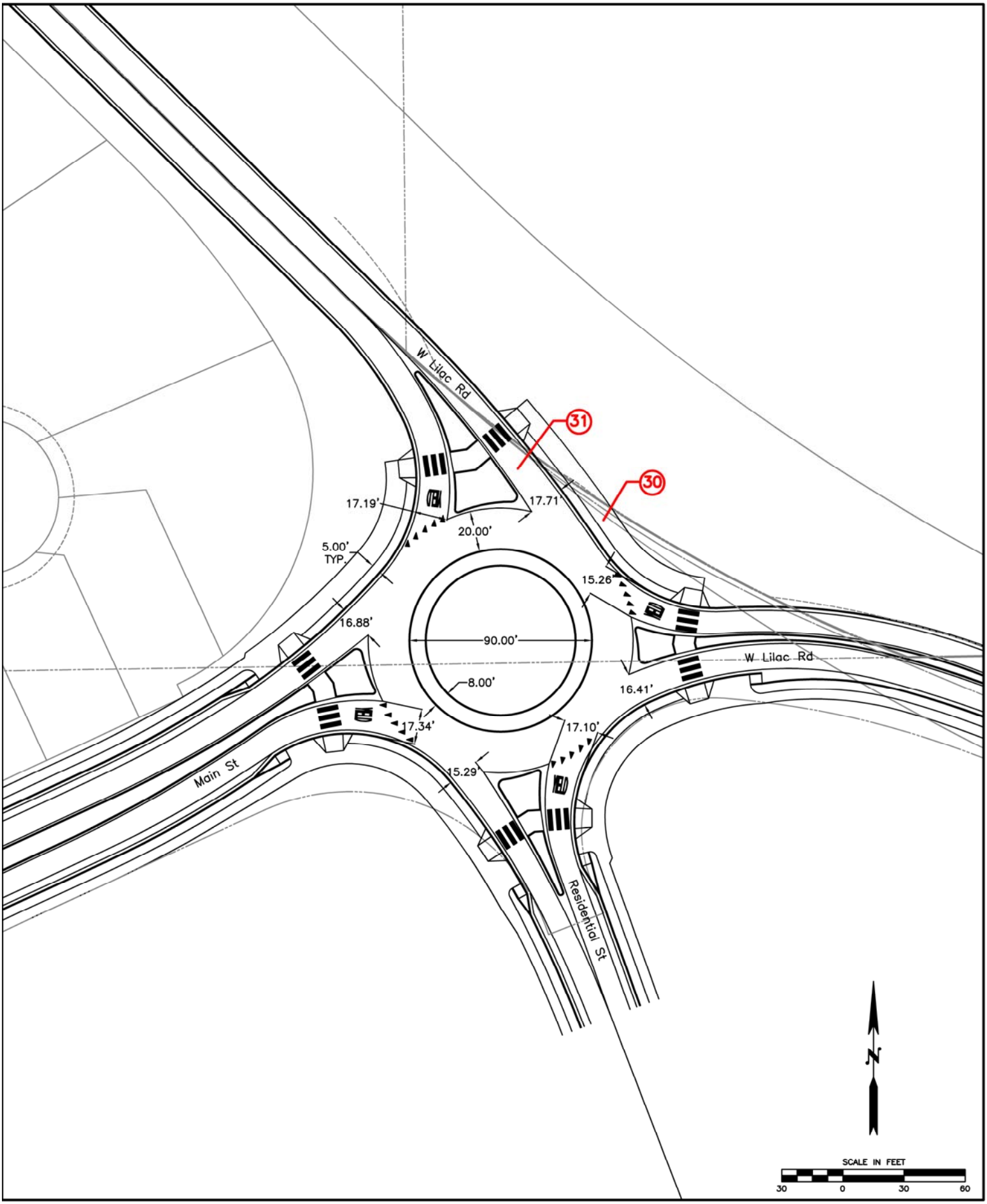
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Phone 425 741-3800

Reid Middleton RB 1 (Alt B) - LAYOUT

Figure 5

W Lilac Rd Roundabouts

October 2013



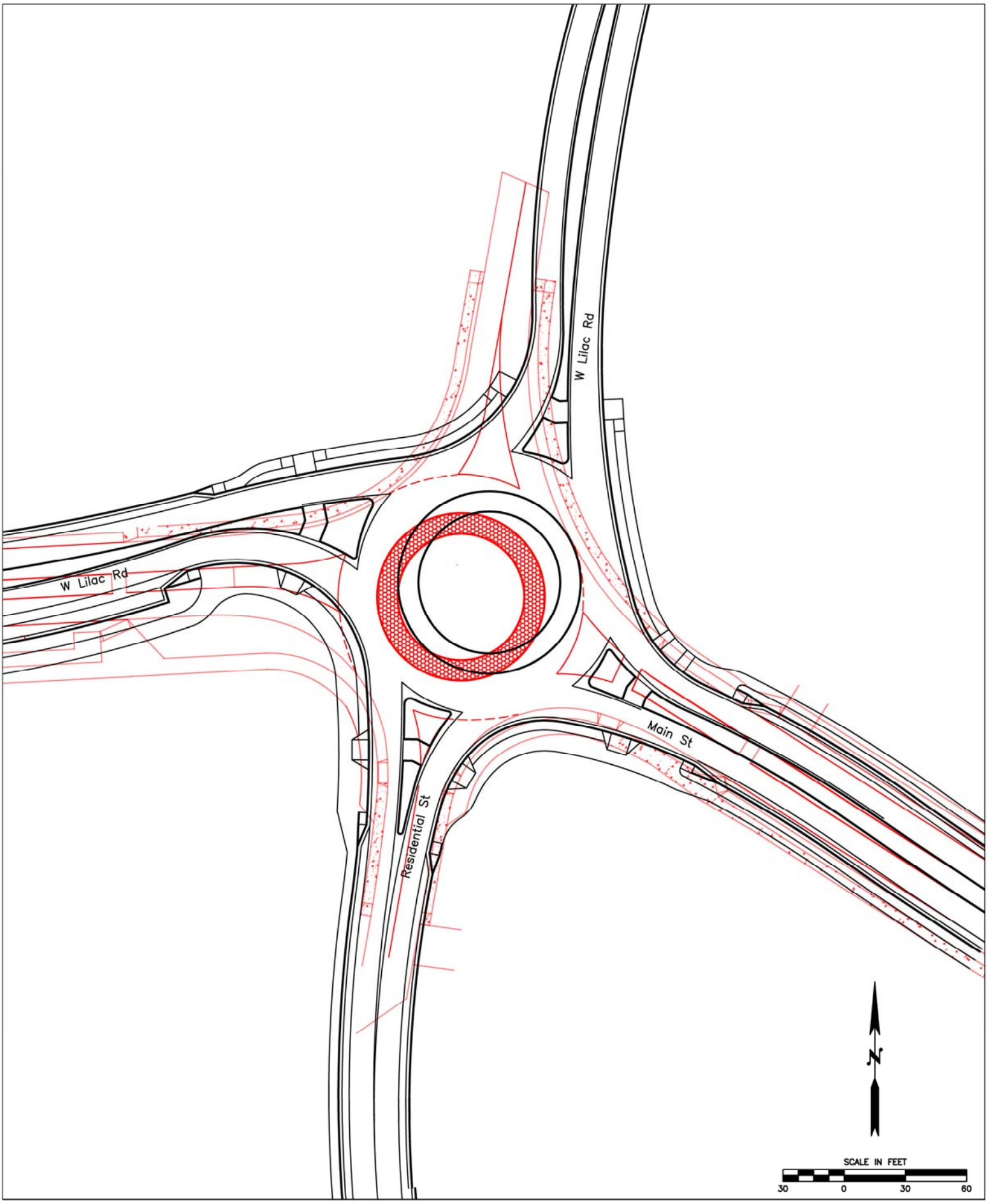
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 2 - LAYOUT

Figure 6

W Lilac Rd Roundabouts

October 2013



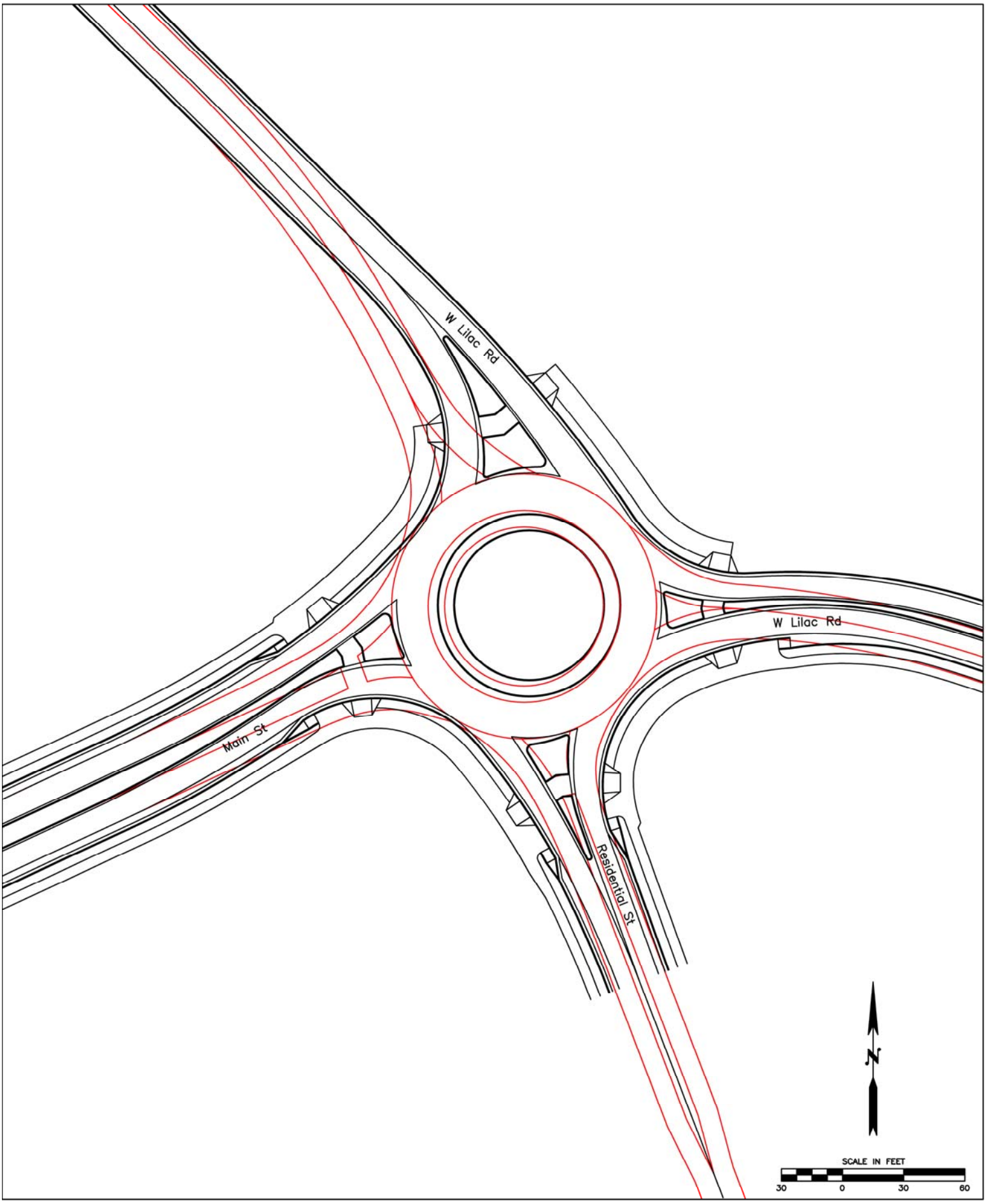
ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Roundabout 1 Proposed Designs - COMPARISON

Figure 7

W Lilac Rd Roundabouts

October 2013



Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Roundabout 2 Proposed Designs - COMPARISON

Figure 8

W Lilac Rd Roundabouts

October 2013

APPENDIX A
(TRAFFIC ANALYSIS)

Lilac Hills Intersection Analysis
October 22, 2013

This report summarizes the operational analysis of two intersections located at the west (Intersection 1) and east end (Intersection 2) of the Lilac Hills Ranch. Each intersection is analyzed for three types of intersection control.

1. All-Way Stop-Control (AWSC)
2. Traffic Signal
3. Roundabout

Analysis is conducted for the AM and PM peak hours at each intersection for two conditions: with and without Road 3. AWSC and traffic signal analysis is conducted with Synchro, Version 8.0; roundabout analysis is conducted using SIDRA, Version 5.1 with an Environmental Factor of 1.1. Roundabout analysis is conducted with Reid Middleton conceptual layout geometry. Tables 1 and 2 summarize 2030 AM and PM peak hour volumes provided by Landmark Consulting.

Table 1. Intersection 1 - 2030 Peak Hour Traffic Volumes

Time & Approach	Left	Through	Right
AM Peak Hour Without Road 3			
NB Approach	52	0	2
SB Approach	0	0	70
EB Approach	60	296	18
WB Approach	1	506	0
Intersection Total		1,005	
PM Peak Hour Without Road 3			
NB Approach	24	0	1
SB Approach	0	0	70
EB Approach	80	529	41
WB Approach	1	342	0
Intersection Total		1,088	
AM Peak Hour With Road 3			
NB Approach	52	0	2
SB Approach	0	0	140
EB Approach	90	341	18
WB Approach	1	626	0
Intersection Total		1,270	
PM Peak Hour With Road 3			
NB Approach	24	0	1
SB Approach	0	0	90
EB Approach	180	664	41
WB Approach	1	427	0
Intersection Total		1,428	

Table 2. Intersection 2 - 2030 Peak Hour Traffic Volumes

Time & Approach	Left	Through	Right
AM Peak Hour Without Road 3			
NB Approach	59	0	9
SB Approach	60	0	0
EB Approach	0	140	32
WB Approach	5	121	70
Intersection Total		496	
PM Peak Hour Without Road 3			
NB Approach	34	0	5
SB Approach	80	0	0
EB Approach	0	167	47
WB Approach	7	142	70
Intersection Total		552	
AM Peak Hour With Road 3			
NB Approach	59	0	9
SB Approach	90	0	0
EB Approach	0	185	0
WB Approach	5	241	140
Intersection Total		761	
PM Peak Hour With Road 3			
NB Approach	34	0	5
SB Approach	180	0	0
EB Approach	0	302	47
WB Approach	7	227	90
Intersection Total		892	

Table 3 summarize the Level of Service thresholds for AWSC, roundabout, and traffic signal control.

Table 3. AWSC and Roundabout LOS Criteria

Level of Service	AWSC & Roundabout Intersection Average Delay Per Vehicle (sec/veh)	Traffic Signal Intersection Average Delay Per Vehicle (sec/veh)
A	≤ 10	≤ 10
B	> 10 and ≤ 15	> 10 and ≤ 20
C	> 15 and ≤ 25	> 20 and ≤ 35
D	> 25 and ≤ 35	> 35 and ≤ 55
E	> 35 and ≤ 50	> 55 and ≤ 80
F	> 50	> 80

Intersection 1

Analysis showed the need for left-turn lanes on the eastbound and westbound approaches to Intersection 1 for the traffic signal control. Traffic signal analysis is conducted with a 60 second cycle and permitted left turns.

Intersection 1 AWSC fails with Road 3. The traffic signal and roundabout provide good intersection performance but the roundabout provides greater reserve capacity for future growth (lower v/c ratios), traffic calming, and a safer intersection.

Table 4. Intersection 1, 2030 AM Peak Hour Operational Analysis, Without Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach		Westbound Approach		Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.11	0.13	0.11	0.52	0.00	0.83	
Mvmt Delay, sec/veh	--	--	8.6 – A	13.2 – B	7.7 – A	28.2 – D	
App Delay, sec/veh	10.4 – B	9.7 – A	12.4 – B		28.2 – D		20.1 – C
95% Queue, feet [1]	--	--	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.20	0.18	0.19	0.38	0.00	0.61	
Mvmt Delay, sec/veh	--	--	5.8 – A	6.0 – A	4.0 - A	8.9 - A	
App Delay, sec/veh	12.7 – B	5.4 – A	6.0 – A		8.9 - A		7.8 – A
95% Queue, feet	32	22	18	64	1	119	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right		Left/Thru/Right		
v/c Ratio	0.06	0.09	0.31		0.43		
Mvmt Delay, sec/veh	--	--	--		--		
App Delay, sec/veh	11.4 – B	6.8 - A	5.3 – A		4.0 – A		5.1 - A
95% Queue, feet	6	9	31		60		

Int = Intersection; Mvmt = Movement; App = Approach
[1] HCM does not provide 95% queue lengths for AWSC Intersections

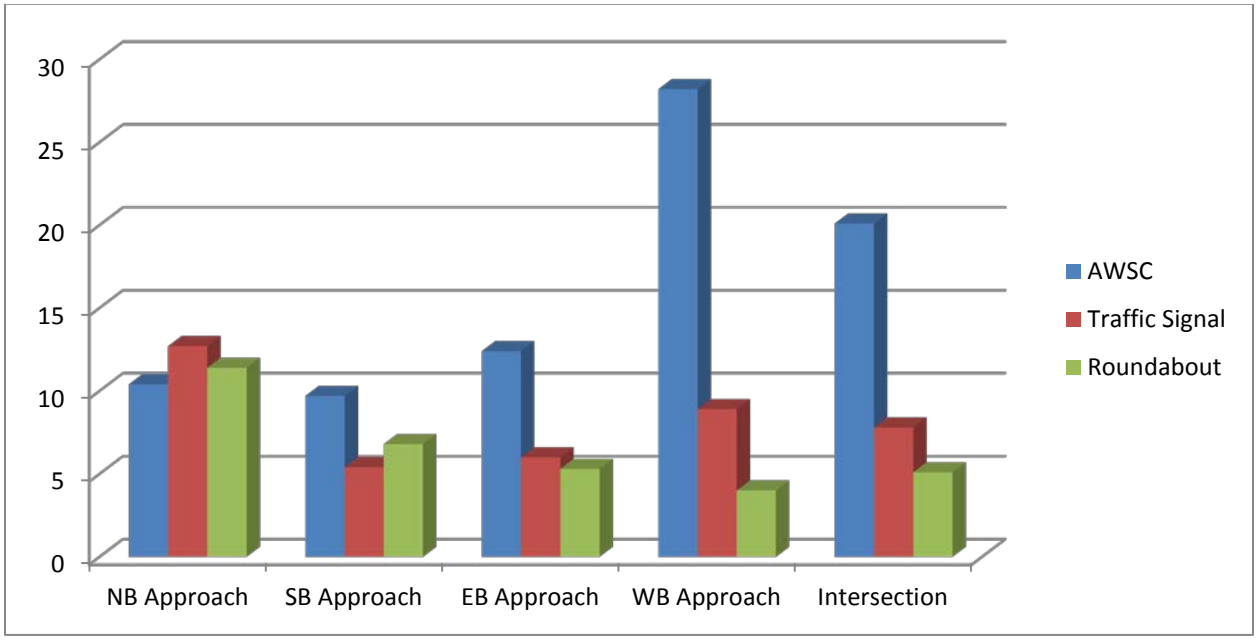


Figure 1. Intersection 1, 2030 AM Peak Hour Average Delay (sec/veh), Without Road 3

Table 5. Intersection 1, 2030 PM Peak Hour Operational Analysis, Without Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach		Westbound Approach		Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.05	0.13	0.14	0.89	0.00	0.58	
Mvmt Delay, sec/veh	--	--	8.5 – A	34.8 - D	7.9 – A	14.7 – B	
App Delay, sec/veh	10.1 – B	9.7 – A	31.6 – D		14.7 – B		24.3 – C
95% Queue, feet [1]	--	--	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.10	0.20	0.16	0.63	0.00	0.38	
Mvmt Delay, sec/veh	--	--	3.4 – A	8.2 – A	3.0 - A	5.3 - A	
App Delay, sec/veh	13.9 – B	6.4 – A	7.7 – A		5.3 - A		7.0 – A
95% Queue, feet	21	25	18	120	1	62	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right		Left/Thru/Right		
v/c Ratio	0.03	0.07	0.55		0.29		
Mvmt Delay, sec/veh	--	--	--		--		
App Delay, sec/veh	12.6 – B	5.9 - A	5.1 – A		3.9 - A		5.0 - A
95% Queue, feet	4	7	76		34		

Int = Intersection; Mvmt = Movement; App = Approach

[1] HCM does not provide 95% queue lengths for AWSC Intersections

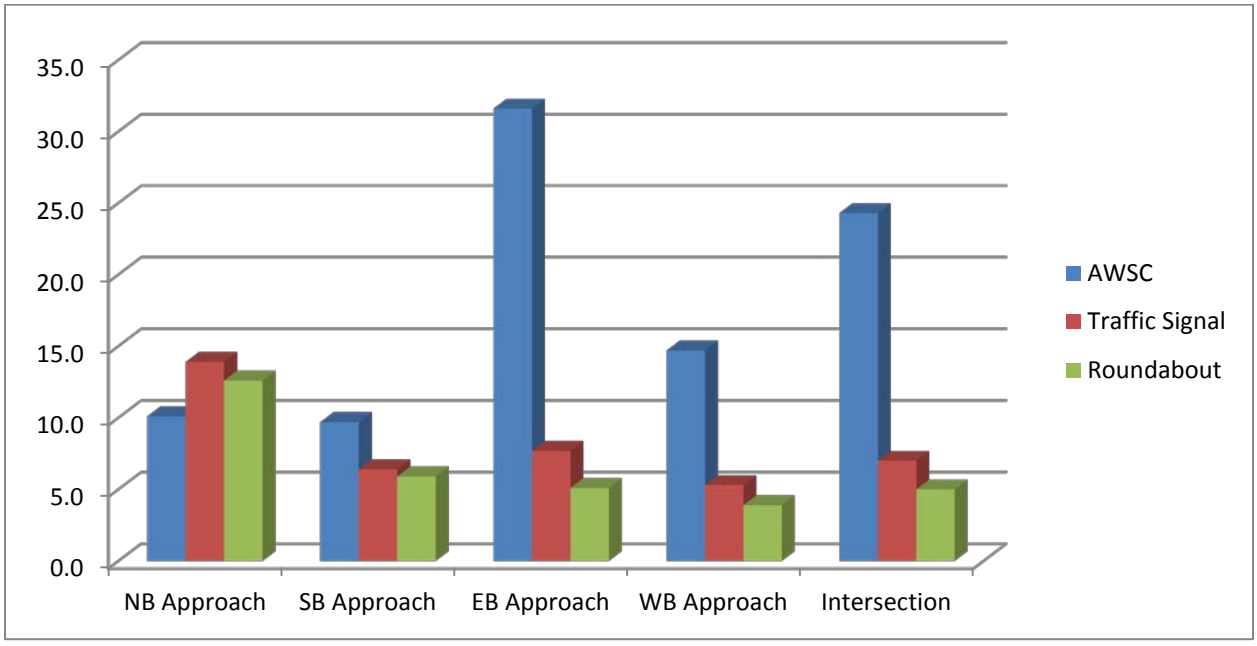


Figure 2. Intersection 1, 2030 PM Peak Hour Average Delay (sec/veh), Without Road 3

Table 6. Intersection 1, 2030 AM Peak Hour Operational Analysis, With Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach		Westbound Approach		Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.12	0.27	0.18	0.65	0.0	1.12	
Mvmt Delay, sec/veh	--	--	9.7 – A	18.1 – C	8.3 - A	97.5 – F	
App Delay, sec/veh	11.3 – B	11.6 – B	16.4 – C		97.4 – F		55.6 – F
95% Queue, feet [1]	--	--	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.18	0.33	0.35	0.39	0.00	0.68	
Mvmt Delay, sec/veh	--	--	8.3 – A	5.7 – A	4.0 – A	9.8 – A	
App Delay, sec/veh	14.8 – B	6.0 – A	6.2 – A		9.8 – A		8.3 – A
95% Queue, feet	38	36	31	77	1	168	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right		Left/Thru/Right		
v/c Ratio	0.06	0.19	0.37		0.54		
Mvmt Delay, sec/veh	--	--	--		--		
App Delay, sec/veh	11.8 - B	7.9 – A	5.5 – A		4.3 – A		5.5 – A
95% Queue, feet	6	24	43		88		

Int = Intersection; Mvmt = Movement; App = Approach
[1] HCM does not provide 95% queue lengths for AWSC Intersections

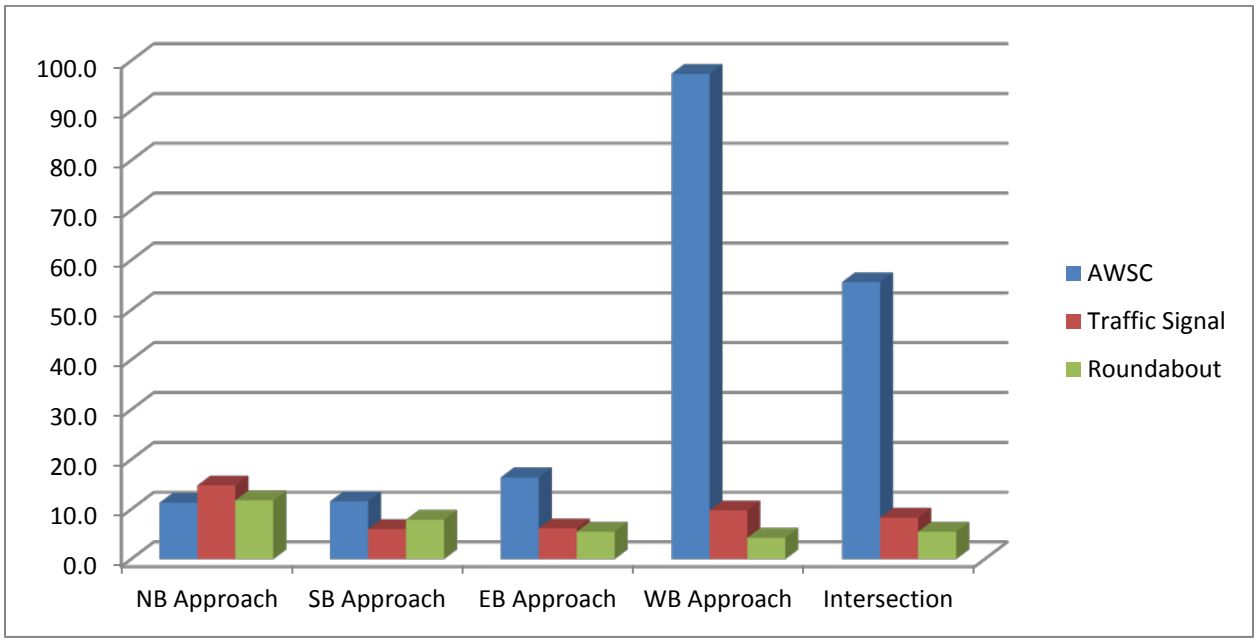


Figure 3. Intersection 1, 2030 AM Peak Hour Average Delay (sec/veh), With Road 3

Table 7. Intersection 1, 2030 PM Peak Hour Operational Analysis, With Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach		Westbound Approach		Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.05	0.17	0.33	1.16	0.00	0.76	
Mvmt Delay, sec/veh	--	--	10.7 - B	107.1 – F	8.2 – A	24.2 – C	
App Delay, sec/veh	10.6 – B	10.5 – B	87.5 – F		24.2 – C		62.2 – F
95% Queue, feet [1]	--	--	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left	Thru/Rt	Left	Thru/Rt	
v/c Ratio	0.12	0.27	0.38	0.70	0.00	0.42	
Mvmt Delay, sec/veh	--	--	6.0 – A	8.8 – A	3.0 – A	5.1 – A	
App Delay, sec/veh	17.6 – B	7.6 – A	8.2 – A		5.1 – A		7.4 – A
95% Queue, feet	24	32	43	172	1	81	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right		Left/Thru/Right		
v/c Ratio	0.04	0.10	0.74		0.40		
Mvmt Delay, sec/veh	--	--	--		--		
App Delay, sec/veh	14.9 – C	6.3 – A	5.6 – A		4.5 – A		5.5 – A
95% Queue, feet	5	10	177		53		

Int = Intersection; Mvmt = Movement; App = Approach
[1] HCM does not provide 95% queue lengths for AWSC Intersections

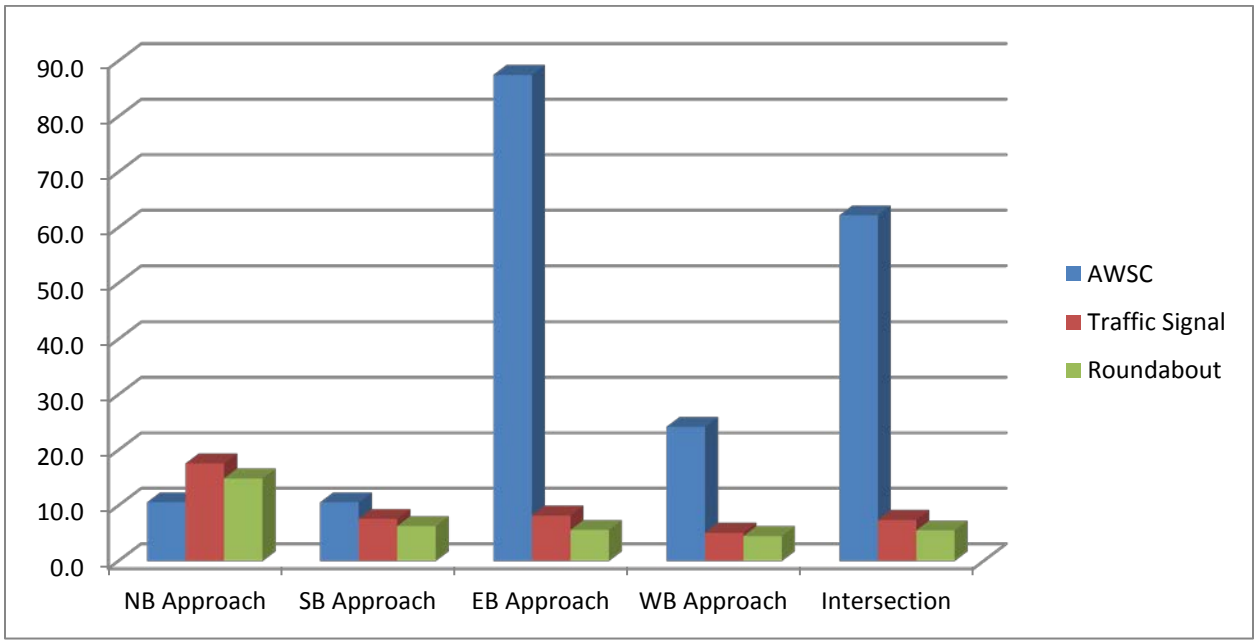


Figure 4. Intersection 1, 2030 PM Peak Hour Average Delay (sec/veh), With Road 3

Intersection 2

Analysis for Intersection 2 is conducted with single-lane approaches on all legs. Traffic signal analysis is conducted with a 60 second cycle and permitted left turns.

Intersections 2 accommodates AM and PM peak hour traffic for all the intersection controls with and without Road 3. The roundabout provides greater reserve capacity for future growth (lower v/c ratios), traffic calming, and a safer intersection.

Table 8. Intersection 2, 2030 AM Peak Hour Operational Analysis, Without Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach	Westbound Approach	Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.10	0.10	0.23	0.26	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.6 – A	8.7 – A	8.8 – A	8.8 – A	8.7 – A
95% Queue, feet [1]	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.12	0.11	0.31	0.35	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	6.1 - A	6.6 - A	6.2 – A	5.7 - A	6.1 – A
95% Queue, feet	17	16	29	29	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.07	0.06	0.15	0.11	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.6 – A	12.6 – B	3.7 – A	4.8 – A	6.1 – A
95% Queue, feet	6	5	15	12	

Int = Intersection; Mvmt = Movement; App = Approach
[1] HCM does not provide 95% queue lengths for AWSC Intersections

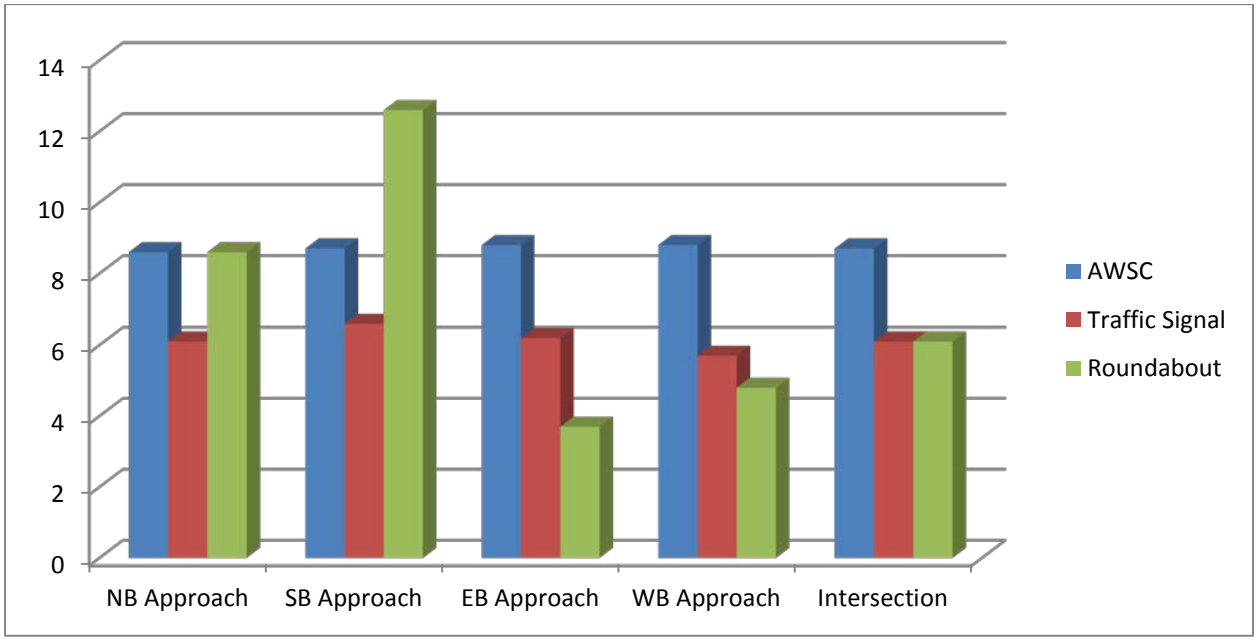


Figure 5. Intersection 2, 2030 AM Peak Hour Average Delay (sec/veh), Without Road 3

Table 9. Intersection 2, 2030 PM Peak Hour Operational Analysis, Without Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach	Westbound Approach	Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.06	0.13	0.29	0.29	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.6 – A	9.0 – A	9.2 – A	9.1 – A	9.1 – A
95% Queue, feet [1]	--	--	-- --	-- --	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.07	0.15	0.36	0.37	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	6.1 – A	7.2 – A	6.7 – A	6.3 – A	6.5 – A
95% Queue, feet	12	22	39	37	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.04	0.09	0.19	0.17	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.8 – A	12.8 – B	3.8 – A	5.4 – A	6.1 – A
95% Queue, feet	4	8	20	21	

Int = Intersection; Mvmt = Movement; App = Approach

[1] HCM does not provide 95% queue lengths for AWSC Intersections

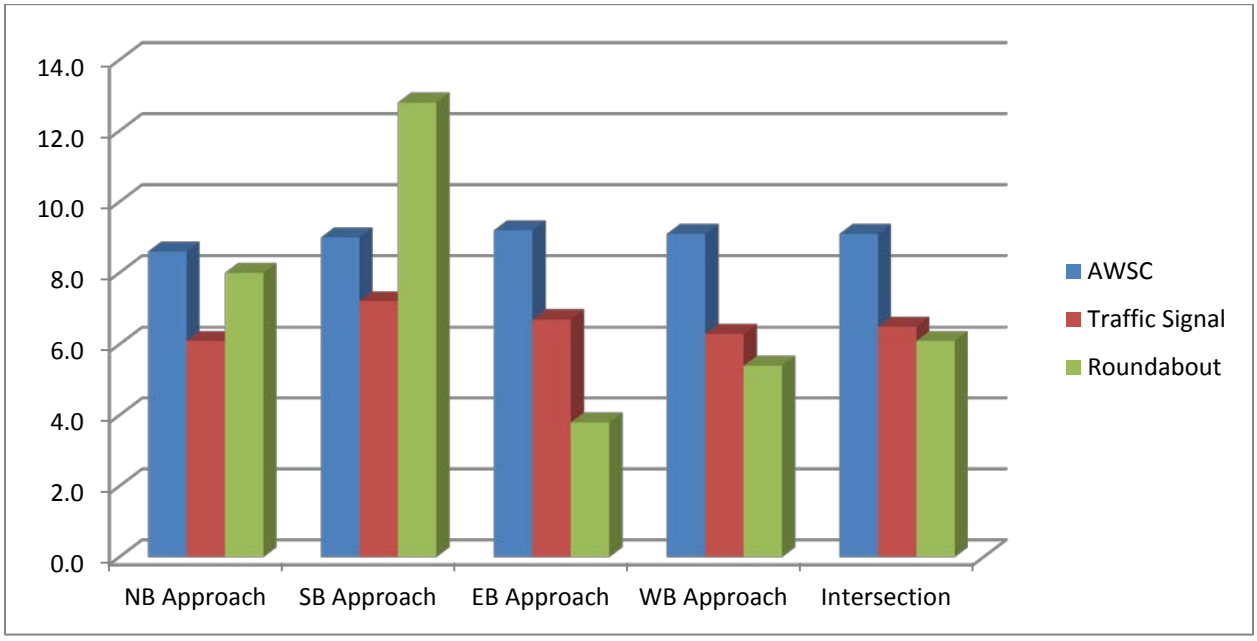


Figure 6. Intersection 2, 2030 PM Peak Hour Average Delay (sec/veh), Without Road 3

Table 10. Intersection 2, 2030 AM Peak Hour Operational Analysis, With Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach	Westbound Approach	Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.12	0.16	0.32	0.53	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	9.6 – A	9.9 – A	10.2 – B	12.6 – B	11.3 – B
95% Queue, feet [1]	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.20	0.28	0.31	0.55	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	9.1 – A	10.9 – B	6.3 – A	8.3 – A	8.1 – A
95% Queue, feet	28	38	48	84	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.07	0.10	0.17	0.31	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.9 – A	13.2 – B	3.8 – A	5.5 – A	6.4 – A
95% Queue, feet	7	10	18	44	

Int = Intersection; Mvmt = Movement; App = Approach

[1] HCM does not provide 95% queue lengths for AWSC Intersections

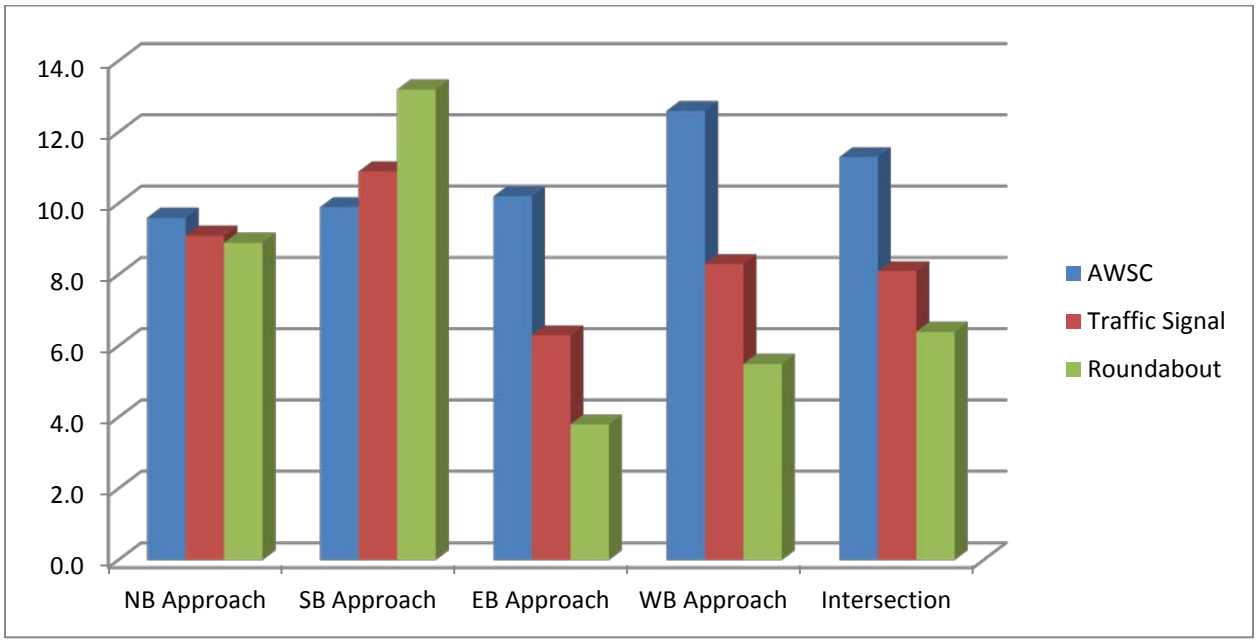


Figure 7. Intersection 2, 2030 AM Peak Hour Average Delay (sec/veh), With Road 3

Table 11. Intersection 2, 2030 PM Peak Hour Operational Analysis, With Road 3

Performance Measure	Northbound Approach	Southbound Approach	Eastbound Approach	Westbound Approach	Int Delay
All-Way Stop-Control	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.08	0.33	0.54	0.50	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	9.9 – A	12.1 – B	14.1 – B	13.1 - B	13.1 - B
95% Queue, feet [1]	--	--	--	--	
Traffic Signal	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.09	0.45	0.53	0.49	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	8.0 – A	12.7 – B	10.4 – B	9.3 – A	10.3 – B
95% Queue, feet	20	76	113	98	
Roundabout	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	Left/Thru/Right	
v/c Ratio	0.05	0.21	0.34	0.25	
Mvmt Delay, sec/veh	--	--	--	--	
App Delay, sec/veh	9.9 – A	13.4 – B	4.4 - A	5.2 – A	6.8 – A
95% Queue, feet	5	21	43	35	

Int = Intersection; Mvmt = Movement; App = Approach
[1] HCM does not provide 95% queue lengths for AWSC Intersections

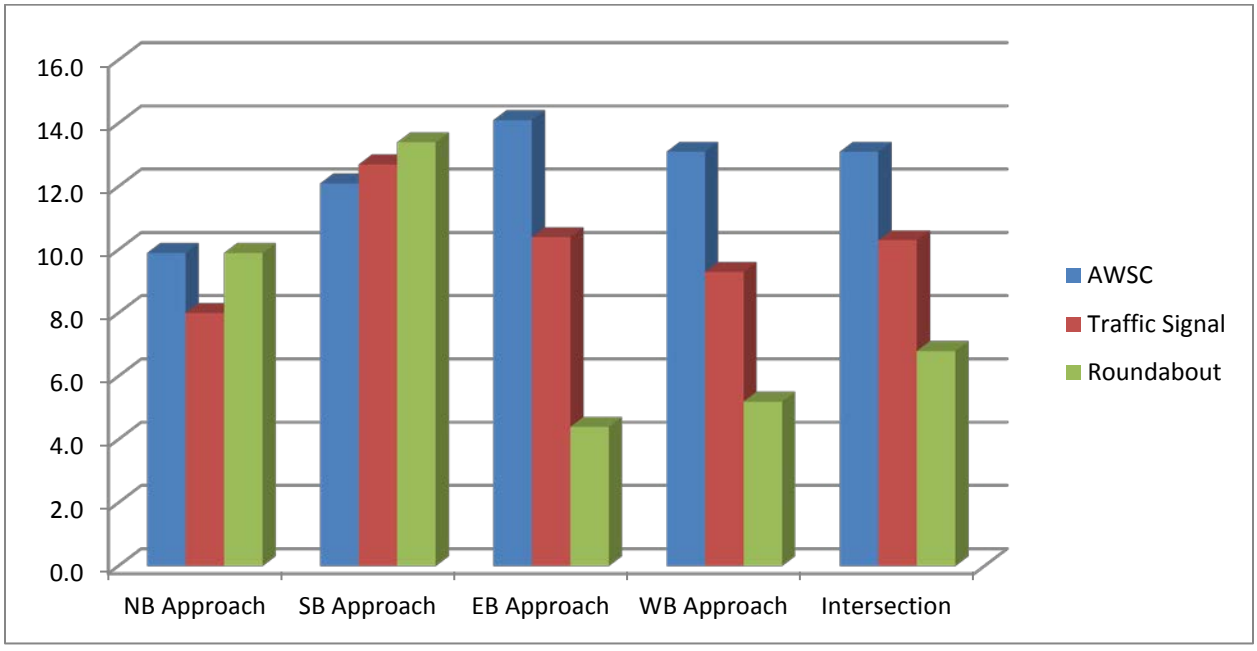


Figure 8. Intersection 2, 2030 PM Peak Hour Average Delay (sec/veh), With Road 3

Intersection 1 a with Five Leg Roundabout

Intersection 1 was also analyzed with a five-leg roundabout that would provide access to approximately 12 single-unit homes on the north leg. The five-leg roundabout accommodates the 2030 peak hour volumes with low delays, short 95th percentile queues, and reserve capacity for future growth. The five-leg roundabout provides access to the single-unit homes on the north leg, traffic calming, and a safer intersection. See Table 12 and Figure 9.

Table 12. Intersection 1, 2030 with a Five Leg Roundabout

Performance Measure	NB Approach	SB Approach	EB Approach	NWB Approach	SWB Approach	Int Delay
AM PH without Road 3	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	
v/c Ratio	0.06	0.01	0.30	0.44	0.09	
Mvmt Delay, sec/veh	--	--	--	--	--	
App Delay, sec/veh	11.2 – B	8.3 – A	5.2 – A	11.6 – B	6.6 – A	8.8 – A
95% Queue, feet [1]	5	1	34	61	10	
PM PH without Road 3	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	
v/c Ratio	0.03	0.01	0.52	0.30	0.08	
Mvmt Delay, sec/veh	--	--	--	--	--	
App Delay, sec/veh	12.2 – B	7.2 – A	4.9 – A	11.5 – B	5.6 – A	7.2 – A
95% Queue, feet	4	1	80	34	8	
AM PH with Road 3	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	
v/c Ratio	0.06	0.02	0.36	0.56	0.20	
Mvmt Delay, sec/veh	--	--	--	--	--	
App Delay, sec/veh	11.6 – B	9.5 – A	5.4 – A	11.9 – B	7.6 – A	9.2 – A
95% Queue, feet	6	2	45	89	27	
PM PH with Road 3	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	Lt/Thru/Rt	
v/c Ratio	0.04	0.01	0.70	0.40	0.10	
Mvmt Delay, sec/veh	--	--	--	--	--	
App Delay, sec/veh	14.4 – B	7.6 – A	5.5 – A	12.1 – B	6.0 – A	7.7 – A
95% Queue, feet	5	1	189	51	12	

NB = Northbound; SB = Southbound; EB = Eastbound; NWB = Northwest bound; SWB = Southwest bound
PH = Peak Hour; Int = Intersection; Mvmt = Movement; App = Approach

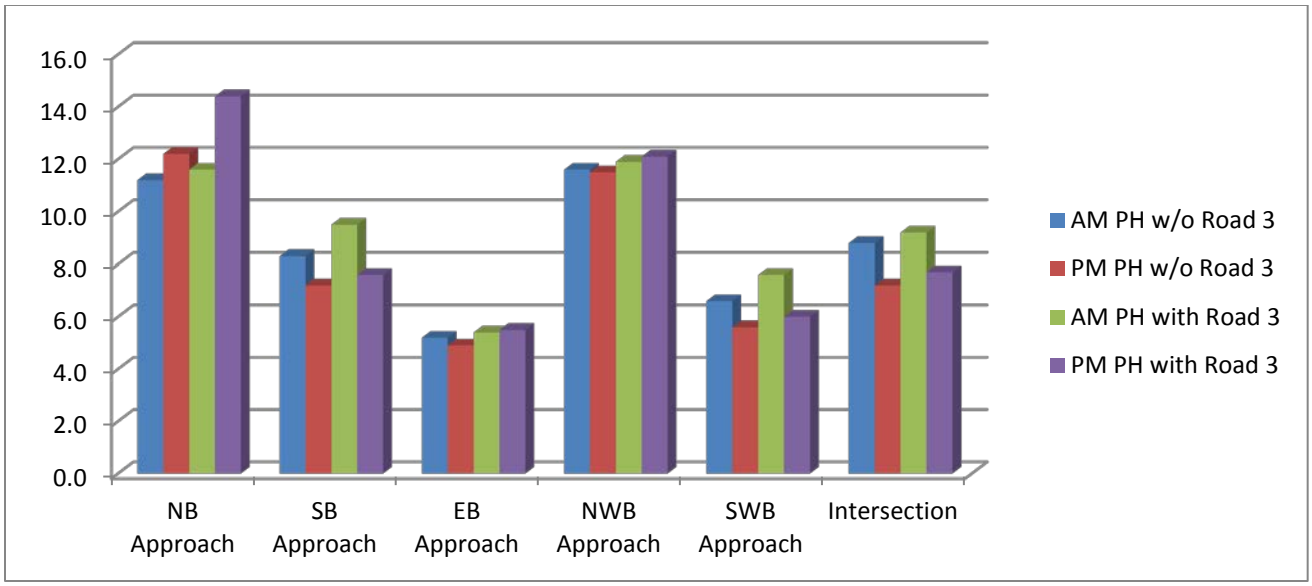
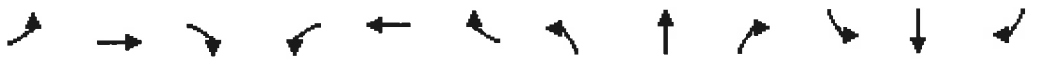


Figure 9. Intersection 1, 2030 with a Five-Leg Roundabout

H:\DOC\25St\13\012 Lilac Hills RB Peer Review (Accretive)\2013-10-22 Traffic\Intersection Operations Summary.docx

Intersection 1

All-Way Stop Control Analysis



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	60	296	18	1	506	1	52	1	2	1	1	70
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	65	322	20	1	550	1	57	1	2	1	1	76

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	65	341	1	551	60	78
Volume Left (vph)	65	0	1	0	57	1
Volume Right (vph)	0	20	0	1	2	76
Hadj (s)	0.53	-0.01	0.53	0.03	0.20	-0.55
Departure Headway (s)	6.1	5.5	5.9	5.4	6.6	5.8
Degree Utilization, x	0.11	0.52	0.00	0.83	0.11	0.13
Capacity (veh/h)	566	637	585	651	493	550
Control Delay (s)	8.6	13.2	7.7	28.2	10.4	9.7
Approach Delay (s)	12.4		28.2		10.4	9.7
Approach LOS	B		D		B	A

Intersection Summary			
Delay	20.1		
HCM Level of Service	C		
Intersection Capacity Utilization	49.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	80	529	41	1	342	1	24	1	1	1	1	70
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	87	575	45	1	372	1	26	1	1	1	1	76

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	87	620	1	373	28	78
Volume Left (vph)	**87**	**0**	**1**	**0**	**26**	**1**
Volume Right (vph)	0	45	0	1	1	76
Hadj (s)	**0.53**	**-0.02**	**0.53**	**0.03**	**0.20**	**-0.55**
Departure Headway (s)	5.8	5.2	6.1	5.6	6.8	5.9
Degree Utilization, x	**0.14**	**0.89**	**0.00**	**0.58**	**0.05**	**0.13**
Capacity (veh/h)	614	685	574	631	489	562
Control Delay (s)	**8.5**	**34.8**	**7.9**	**14.7**	**10.1**	**9.7**
Approach Delay (s)	31.6		14.7		10.1	9.7
Approach LOS	D		B		B	A

Intersection Summary				
Delay	24.3			
HCM Level of Service	C			
Intersection Capacity Utilization	51.8%	ICU Level of Service		A
Analysis Period (min)	15			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	90	341	18	1	626	1	52	1	2	1	1	140
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	371	20	1	680	1	57	1	2	1	1	152

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	98	390	1	682	60	154
Volume Left (vph)	98	0	1	0	57	1
Volume Right (vph)	0	20	0	1	2	152
Hadj (s)	0.53	0.00	0.53	0.03	0.20	-0.56
Departure Headway (s)	6.5	6.0	6.4	5.9	7.3	6.3
Degree Utilization, x	0.18	0.65	0.00	1.12	0.12	0.27
Capacity (veh/h)	536	585	541	617	453	539
Control Delay (s)	9.7	18.1	8.3	97.5	11.3	11.6
Approach Delay (s)	16.4		97.4		11.3	11.6
Approach LOS	C		F		B	B

Intersection Summary				
Delay	55.6			
HCM Level of Service	F			
Intersection Capacity Utilization	63.4%	ICU Level of Service	B	
Analysis Period (min)	15			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	180	664	41	1	427	1	24	0	1	1	1	90
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	196	722	45	1	464	1	26	0	1	1	1	98

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1
Volume Total (vph)	196	766	1	465	27	100
Volume Left (vph)	196	0	1	0	26	1
Volume Right (vph)	0	45	0	1	1	98
Hadj (s)	0.53	-0.01	0.53	0.03	0.20	-0.55
Departure Headway (s)	6.0	5.4	6.4	5.9	7.2	6.2
Degree Utilization, x	0.33	1.16	0.00	0.76	0.05	0.17
Capacity (veh/h)	582	666	548	597	459	541
Control Delay (s)	10.7	107.1	8.2	24.2	10.6	10.5
Approach Delay (s)	87.5		24.2		10.6	10.5
Approach LOS	F		C		B	B

Intersection Summary				
Delay	62.2			
HCM Level of Service	F			
Intersection Capacity Utilization	58.8%	ICU Level of Service	B	
Analysis Period (min)	15			

Intersection 1

Traffic Signal Analysis

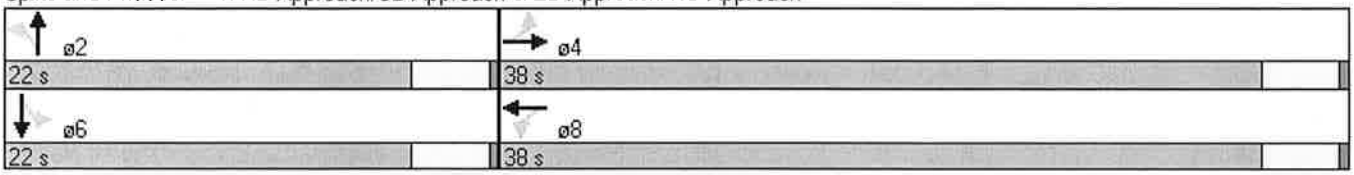
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	60	296	18	1	506	1	52	1	2	1	1	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	100		0	0		0	0		0
Storage Lanes	1		0	1		0	0		0	0		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1770	1846	0	1770	1863	0	0	1770	0	0	1615	0
Flt Permitted	0.374			0.555				0.688			0.996	
Satd. Flow (perm)	697	1846	0	1034	1863	0	0	1275	0	0	1610	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		9						2			76	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	65	342	0	1	551	0	0	60	0	0	78	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	38.0	38.0		38.0	38.0		22.0	22.0		22.0	22.0	
Total Lost Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Act Effct Green (s)	14.5	14.5		14.5	14.5			7.2			7.2	
Actuated g/C Ratio	0.48	0.48		0.48	0.48			0.24			0.24	
v/c Ratio	0.19	0.38		0.00	0.61			0.20			0.18	
Control Delay	5.8	6.0		4.0	8.9			12.7			5.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	5.8	6.0		4.0	8.9			12.7			5.4	
LOS	A	A		A	A			B			A	
Approach Delay		6.0			8.9			12.7			5.4	
Approach LOS		A			A			B			A	
Queue Length 50th (ft)	4	25		0	47			7			0	
Queue Length 95th (ft)	18	64		1	119			32			22	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)	100			100								
Base Capacity (vph)	672	1781		997	1797			801			1039	
Starvation Cap Reductn	0	0		0	0			0			0	
Spillback Cap Reductn	0	0		0	0			0			0	
Storage Cap Reductn	0	0		0	0			0			0	
Reduced v/c Ratio	0.10	0.19		0.00	0.31			0.07			0.08	

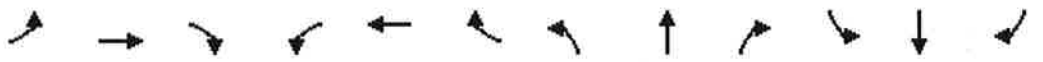
Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 30.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.61
Intersection Signal Delay: 7.8 Intersection LOS: A
Intersection Capacity Utilization 49.7% ICU Level of Service A

Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach





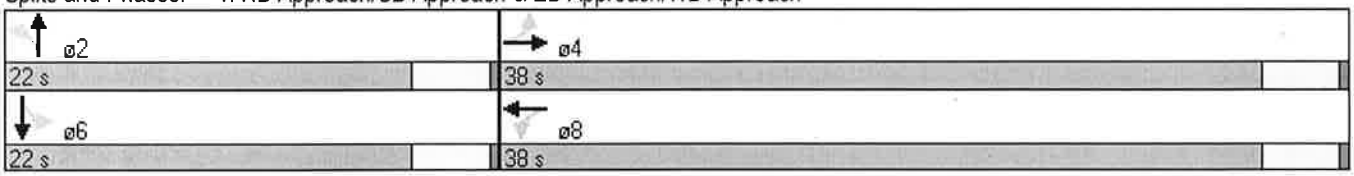
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	80	529	41	1	342	1	24	1	1	1	1	70
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	100		0	0		0	0		0
Storage Lanes	1		0	1		0	0		0	0		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1770	1842	0	1770	1863	0	0	1772	0	0	1615	0
Flt Permitted	0.540			0.337				0.716			0.997	
Satd. Flow (perm)	1006	1842	0	628	1863	0	0	1327	0	0	1612	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		11						1			76	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	87	620	0	1	373	0	0	28	0	0	78	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	38.0	38.0		38.0	38.0		22.0	22.0		22.0	22.0	
Total Lost Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Act Effct Green (s)	16.7	16.7		16.7	16.7			6.5			6.5	
Actuated g/C Ratio	0.53	0.53		0.53	0.53			0.21			0.21	
v/c Ratio	0.16	0.63		0.00	0.38			0.10			0.20	
Control Delay	4.3	8.2		3.0	5.3			13.9			6.4	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	4.3	8.2		3.0	5.3			13.9			6.4	
LOS	A	A		A	A			B			A	
Approach Delay		7.7			5.3			13.9			6.4	
Approach LOS		A			A			B			A	
Queue Length 50th (ft)	5	51		0	26			3			0	
Queue Length 95th (ft)	18	120		1	62			21			25	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)	100			100								
Base Capacity (vph)	953	1746		595	1765			796			997	
Starvation Cap Reductn	0	0		0	0			0			0	
Spillback Cap Reductn	0	0		0	0			0			0	
Storage Cap Reductn	0	0		0	0			0			0	
Reduced v/c Ratio	0.09	0.36		0.00	0.21			0.04			0.08	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 31.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.63
Intersection Signal Delay: 7.0 Intersection LOS: A
Intersection Capacity Utilization 51.8% ICU Level of Service A

Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach



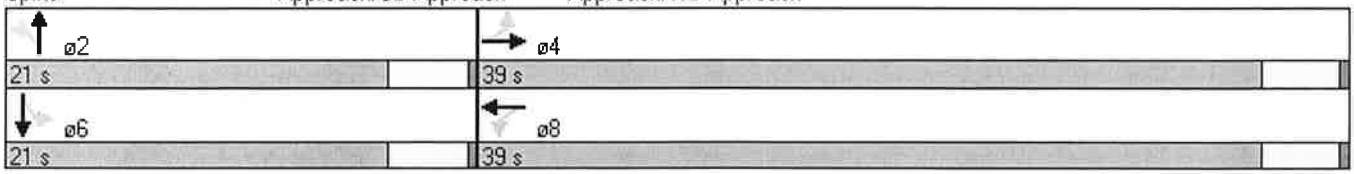
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	341	18	1	626	1	52	1	2	1	1	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	100		0	0		0	0		0
Storage Lanes	1		0	1		0	0		0	0		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1770	1848	0	1770	1863	0	0	1770	0	0	1615	0
Flt Permitted	0.285			0.521				0.819			0.998	
Satd. Flow (perm)	531	1848	0	970	1863	0	0	1518	0	0	1612	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		8						2			152	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	98	391	0	1	681	0	0	60	0	0	154	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	39.0	39.0		39.0	39.0		21.0	21.0		21.0	21.0	
Total Lost Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Act Effct Green (s)	18.5	18.5		18.5	18.5			7.6			7.6	
Actuated g/C Ratio	0.53	0.53		0.53	0.53			0.22			0.22	
v/c Ratio	0.35	0.39		0.00	0.68			0.18			0.33	
Control Delay	8.3	5.7		4.0	9.8			14.8			6.0	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	8.3	5.7		4.0	9.8			14.8			6.0	
LOS	A	A		A	A			B			A	
Approach Delay		6.2			9.8			14.8			6.0	
Approach LOS		A			A			B			A	
Queue Length 50th (ft)	8	30		0	67			8			0	
Queue Length 95th (ft)	31	77		1	168			38			36	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)	100			100								
Base Capacity (vph)	489	1702		893	1715			797			917	
Starvation Cap Reductn	0	0		0	0			0			0	
Spillback Cap Reductn	0	0		0	0			0			0	
Storage Cap Reductn	0	0		0	0			0			0	
Reduced v/c Ratio	0.20	0.23		0.00	0.40			0.08			0.17	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 34.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.68
Intersection Signal Delay: 8.3 Intersection LOS: A
Intersection Capacity Utilization 63.4% ICU Level of Service B

Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach



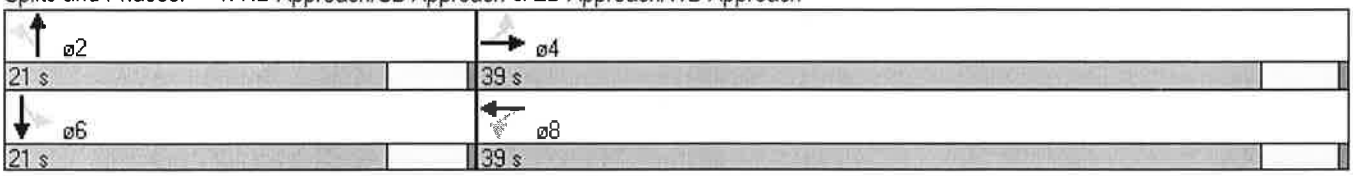
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	180	664	41	1	427	1	24	0	1	1	1	90
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	100		0	100		0	0		0	0		0
Storage Lanes	1		0	1		0	0		0	0		0
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1770	1846	0	1770	1863	0	0	1768	0	0	1617	0
Flt Permitted	0.471			0.259				0.693			0.997	
Satd. Flow (perm)	877	1846	0	482	1863	0	0	1284	0	0	1612	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		9						1			98	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	196	767	0	1	465	0	0	27	0	0	100	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	39.0	39.0		39.0	39.0		21.0	21.0		21.0	21.0	
Total Lost Time (s)	4.0	4.0		4.0	4.0			4.0			4.0	
Act Effct Green (s)	22.4	22.4		22.4	22.4			6.7			6.7	
Actuated g/C Ratio	0.60	0.60		0.60	0.60			0.18			0.18	
v/c Ratio	0.38	0.70		0.00	0.42			0.12			0.27	
Control Delay	6.0	8.8		3.0	5.1			17.6			7.6	
Queue Delay	0.0	0.0		0.0	0.0			0.0			0.0	
Total Delay	6.0	8.8		3.0	5.1			17.6			7.6	
LOS	A	A		A	A			B			A	
Approach Delay		8.2			5.1			17.6			7.6	
Approach LOS		A			A			B			A	
Queue Length 50th (ft)	14	73		0	35			5			0	
Queue Length 95th (ft)	43	172		1	81			24			32	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)	100			100								
Base Capacity (vph)	780	1643		429	1656			617			825	
Starvation Cap Reductn	0	0		0	0			0			0	
Spillback Cap Reductn	0	0		0	0			0			0	
Storage Cap Reductn	0	0		0	0			0			0	
Reduced v/c Ratio	0.25	0.47		0.00	0.28			0.04			0.12	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 37.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.70
Intersection Signal Delay: 7.4 Intersection LOS: A
Intersection Capacity Utilization 58.8% ICU Level of Service B

Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach



Intersection 1

Roundabout Analysis

MOVEMENT SUMMARY

Site: 2030 AM PH 4-Leg w/o Road 3 RMG

Intersection #1, 4-Leg, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
Without Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	57	2.0	0.060	11.8	LOS B	0.2	5.7	0.39	0.70	25.1
8	T	1	2.0	0.060	3.6	LOS A	0.2	5.7	0.39	0.38	26.4
18	R	2	2.0	0.060	4.9	LOS A	0.2	5.7	0.39	0.47	26.1
Approach		60	2.0	0.060	11.4	LOS B	0.2	5.7	0.39	0.68	25.1
East: WB Approach											
1L	L	1	2.0	0.429	9.0	LOS A	2.4	60.1	0.31	0.91	25.4
6T	T	550	2.0	0.429	4.0	LOS A	2.4	60.1	0.31	0.40	27.8
6R	R	1	2.0	0.429	4.1	LOS A	2.4	60.1	0.31	0.47	26.9
Approach		552	2.0	0.429	4.0	LOS A	2.4	60.1	0.31	0.40	27.8
North: SB Approach											
7	L	1	2.0	0.085	10.4	LOS B	0.3	8.9	0.49	0.80	24.6
4	T	1	2.0	0.085	4.2	LOS A	0.3	8.9	0.49	0.48	26.3
14	R	76	2.0	0.085	6.8	LOS A	0.3	8.9	0.49	0.62	26.7
Approach		78	2.0	0.085	6.8	LOS A	0.3	8.9	0.49	0.62	26.6
West: EB Approach											
5	L	65	2.0	0.314	10.3	LOS B	1.2	31.4	0.03	0.94	29.6
2	T	322	2.0	0.314	4.3	LOS A	1.2	31.4	0.03	0.37	34.3
12	R	20	2.0	0.314	5.6	LOS A	1.2	31.4	0.03	0.53	33.2
Approach		407	2.0	0.314	5.3	LOS A	1.2	31.4	0.03	0.47	33.4
All Vehicles		1097	2.0	0.429	5.1	LOS A	2.4	60.1	0.22	0.46	29.3

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 PM PH 4-Leg w/o Road 3 RMG

Intersection #1, 4-Leg, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
Without Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	26	2.0	0.033	13.2	LOS B	0.1	3.6	0.52	0.72	24.7
8	T	1	2.0	0.033	5.0	LOS A	0.1	3.6	0.52	0.48	25.8
18	R	1	2.0	0.033	6.3	LOS A	0.1	3.6	0.52	0.55	25.6
Approach		28	2.0	0.033	12.6	LOS B	0.1	3.6	0.52	0.71	24.7
East: WB Approach											
1L	L	1	2.0	0.294	8.9	LOS A	1.4	34.4	0.25	0.93	25.3
6T	T	372	2.0	0.294	3.9	LOS A	1.4	34.4	0.25	0.39	28.1
6R	R	1	2.0	0.294	4.0	LOS A	1.4	34.4	0.25	0.46	27.0
Approach		374	2.0	0.294	3.9	LOS A	1.4	34.4	0.25	0.39	28.0
North: SB Approach											
7	L	1	2.0	0.074	9.5	LOS A	0.3	6.6	0.36	0.78	25.0
4	T	1	2.0	0.074	3.3	LOS A	0.3	6.6	0.36	0.37	26.8
14	R	76	2.0	0.074	5.9	LOS A	0.3	6.6	0.36	0.55	27.0
Approach		78	2.0	0.074	5.9	LOS A	0.3	6.6	0.36	0.55	27.0
West: EB Approach											
5	L	87	2.0	0.546	10.3	LOS B	3.0	75.9	0.04	0.94	29.6
2	T	575	2.0	0.546	4.3	LOS A	3.0	75.9	0.04	0.37	34.2
12	R	45	2.0	0.546	5.6	LOS A	3.0	75.9	0.04	0.53	33.1
Approach		707	2.0	0.546	5.1	LOS A	3.0	75.9	0.04	0.45	33.5
All Vehicles		1187	2.0	0.546	5.0	LOS A	3.0	75.9	0.14	0.44	30.7

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 AM PH 4-Leg w Road 3 RMG

Intersection #1, 4-Leg, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
With Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	57	2.0	0.063	12.2	LOS B	0.2	6.2	0.43	0.71	25.0
8	T	1	2.0	0.063	3.9	LOS A	0.2	6.2	0.43	0.42	26.2
18	R	2	2.0	0.063	5.3	LOS A	0.2	6.2	0.43	0.50	26.0
Approach		60	2.0	0.063	11.8	LOS B	0.2	6.2	0.43	0.70	25.1
East: WB Approach											
1L	L	1	2.0	0.542	9.3	LOS A	3.5	87.9	0.40	0.89	25.4
6T	T	680	2.0	0.542	4.3	LOS A	3.5	87.9	0.40	0.44	27.5
6R	R	1	2.0	0.542	4.4	LOS A	3.5	87.9	0.40	0.49	26.6
Approach		683	2.0	0.542	4.3	LOS A	3.5	87.9	0.40	0.44	27.5
North: SB Approach											
7	L	1	2.0	0.191	11.5	LOS B	0.9	23.9	0.62	0.86	24.2
4	T	1	2.0	0.191	5.3	LOS A	0.9	23.9	0.62	0.61	25.7
14	R	152	2.0	0.191	7.9	LOS A	0.9	23.9	0.62	0.73	26.3
Approach		154	2.0	0.191	7.9	LOS A	0.9	23.9	0.62	0.73	26.3
West: EB Approach											
5	L	98	2.0	0.377	10.3	LOS B	1.7	42.6	0.03	0.92	29.6
2	T	371	2.0	0.377	4.3	LOS A	1.7	42.6	0.03	0.36	34.3
12	R	20	2.0	0.377	5.6	LOS A	1.7	42.6	0.03	0.52	33.1
Approach		488	2.0	0.377	5.5	LOS A	1.7	42.6	0.03	0.48	33.1
All Vehicles		1385	2.0	0.542	5.5	LOS A	3.5	87.9	0.30	0.50	28.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 PM PH 4-Leg w Road 3 RMG

Intersection #1, 4-Leg, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
With Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	26	2.0	0.041	15.5	LOS B	0.2	5.1	0.66	0.77	23.7
8	T	1	2.0	0.041	7.3	LOS A	0.2	5.1	0.66	0.59	24.7
18	R	1	2.0	0.041	8.7	LOS A	0.2	5.1	0.66	0.64	24.4
Approach		28	2.0	0.041	14.9	LOS B	0.2	5.1	0.66	0.76	23.8
East: WB Approach											
1L	L	1	2.0	0.403	9.5	LOS A	2.1	52.8	0.40	0.91	25.3
6T	T	464	2.0	0.403	4.5	LOS A	2.1	52.8	0.40	0.46	27.5
6R	R	1	2.0	0.403	4.6	LOS A	2.1	52.8	0.40	0.52	26.7
Approach		466	2.0	0.403	4.5	LOS A	2.1	52.8	0.40	0.46	27.5
North: SB Approach											
7	L	1	2.0	0.102	9.9	LOS A	0.4	10.3	0.44	0.79	24.9
4	T	1	2.0	0.102	3.6	LOS A	0.4	10.3	0.44	0.43	26.5
14	R	98	2.0	0.102	6.3	LOS A	0.4	10.3	0.44	0.59	26.8
Approach		100	2.0	0.102	6.3	LOS A	0.4	10.3	0.44	0.59	26.8
West: EB Approach											
5	L	196	2.0	0.744	10.4	LOS B	7.0	177.1	0.07	0.89	29.6
2	T	722	2.0	0.744	4.3	LOS A	7.0	177.1	0.07	0.36	34.1
12	R	45	2.0	0.744	5.7	LOS A	7.0	177.1	0.07	0.51	33.0
Approach		962	2.0	0.744	5.6	LOS A	7.0	177.1	0.07	0.47	32.9
All Vehicles		1557	2.0	0.744	5.5	LOS A	7.0	177.1	0.20	0.48	30.4

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

Intersection 2

All-Way Stop Control Analysis

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	1	140	32	5	121	70	59	1	9	60	1	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1	152	35	5	132	76	64	1	10	65	1	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	188	213	75	67
Volume Left (vph)	1	5	64	65
Volume Right (vph)	35	76	10	1
Hadj (s)	-0.08	-0.18	0.13	0.22
Departure Headway (s)	4.4	4.3	5.0	5.1
Degree Utilization, x	0.23	0.26	0.10	0.10
Capacity (veh/h)	778	794	655	638
Control Delay (s)	8.8	8.8	8.6	8.7
Approach Delay (s)	8.8	8.8	8.6	8.7
Approach LOS	A	A	A	A

Intersection Summary			
Delay	8.7		
HCM Level of Service	A		
Intersection Capacity Utilization	24.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	1	167	47	7	142	70	34	1	5	80	1	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1	182	51	8	154	76	37	1	5	87	1	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	234	238	43	89
Volume Left (vph)	1	8	37	87
Volume Right (vph)	51	76	5	1
Hadj (s)	-0.10	-0.15	0.13	0.22
Departure Headway (s)	4.4	4.4	5.2	5.3
Degree Utilization, x	0.29	0.29	0.06	0.13
Capacity (veh/h)	782	785	618	621
Control Delay (s)	9.2	9.1	8.6	9.0
Approach Delay (s)	9.2	9.1	8.6	9.0
Approach LOS	A	A	A	A

Intersection Summary				
Delay	9.1			
HCM Level of Service	A			
Intersection Capacity Utilization	28.5%	ICU Level of Service	A	
Analysis Period (min)	15			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	1	185	32	5	241	140	59	1	9	90	1	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1	201	35	5	262	152	64	1	10	98	1	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	237	420	75	100
Volume Left (vph)	1	5	64	98
Volume Right (vph)	35	152	10	1
Hadj (s)	-0.05	-0.18	0.13	0.22
Departure Headway (s)	4.9	4.6	5.8	5.8
Degree Utilization, x	0.32	0.53	0.12	0.16
Capacity (veh/h)	693	762	538	546
Control Delay (s)	10.2	12.6	9.6	9.9
Approach Delay (s)	10.2	12.6	9.6	9.9
Approach LOS	B	B	A	A

Intersection Summary			
Delay	11.3		
HCM Level of Service	B		
Intersection Capacity Utilization	37.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	1	302	47	7	227	90	34	1	5	180	1	1
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1	328	51	8	247	98	37	1	5	196	1	1

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	380	352	43	198
Volume Left (vph)	1	8	37	196
Volume Right (vph)	51	98	5	1
Hadj (s)	-0.05	-0.13	0.13	0.23
Departure Headway (s)	5.1	5.1	6.4	6.1
Degree Utilization, x	0.54	0.50	0.08	0.33
Capacity (veh/h)	668	672	463	534
Control Delay (s)	14.1	13.1	9.9	12.1
Approach Delay (s)	14.1	13.1	9.9	12.1
Approach LOS	B	B	A	B

Intersection Summary			
Delay	13.1		
HCM Level of Service	B		
Intersection Capacity Utilization	40.5%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection 2

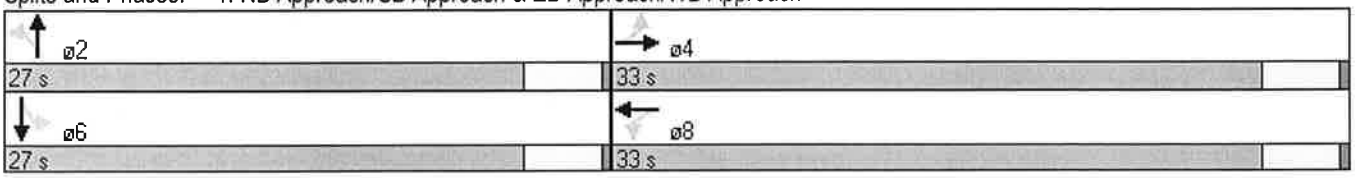
Traffic Signal Analysis

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (vph)	1	140	32	5	121	70	59	1	9	60	1	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	1816	0	0	1772	0	0	1754	0	0	1774	0
Flt Permitted		0.997			0.989			0.762			0.734	
Satd. Flow (perm)	0	1811	0	0	1754	0	0	1394	0	0	1365	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		27			64			10			1	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	188	0	0	213	0	0	75	0	0	67	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	33.0	33.0		33.0	33.0		27.0	27.0		27.0	27.0	
Total Lost Time (s)		4.0			4.0			4.0			4.0	
Act Effct Green (s)		7.5			7.4			10.1			10.1	
Actuated g/C Ratio		0.33			0.32			0.44			0.44	
v/c Ratio		0.31			0.35			0.12			0.11	
Control Delay		6.2			5.7			6.1			6.6	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.2			5.7			6.1			6.6	
LOS		A			A			A			A	
Approach Delay		6.2			5.7			6.1			6.6	
Approach LOS		A			A			A			A	
Queue Length 50th (ft)		10			10			4			4	
Queue Length 95th (ft)		29			29			17			16	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)												
Base Capacity (vph)		1811			1754			1353			1324	
Starvation Cap Reductn		0			0			0			0	
Spillback Cap Reductn		0			0			0			0	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.10			0.12			0.06			0.05	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 23
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.35
Intersection Signal Delay: 6.1 Intersection LOS: A
Intersection Capacity Utilization 24.6% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach

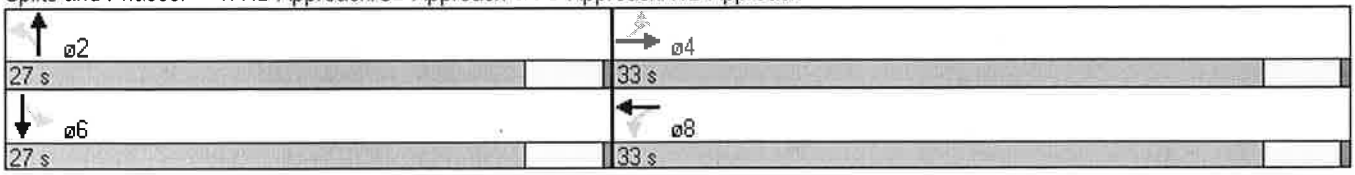


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (vph)	1	167	47	7	142	70	34	1	5	80	1	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	1809	0	0	1779	0	0	1758	0	0	1772	0
Flt Permitted		0.998			0.982			0.775			0.731	
Satd. Flow (perm)	0	1805	0	0	1751	0	0	1421	0	0	1359	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		32			54			5			1	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	234	0	0	238	0	0	43	0	0	89	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	33.0	33.0		33.0	33.0		27.0	27.0		27.0	27.0	
Total Lost Time (s)		4.0			4.0			4.0			4.0	
Act Effct Green (s)		8.0			8.0			10.2			10.2	
Actuated g/C Ratio		0.35			0.35			0.45			0.45	
v/c Ratio		0.36			0.37			0.07			0.15	
Control Delay		6.7			6.3			6.1			7.2	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.7			6.3			6.1			7.2	
LOS		A			A			A			A	
Approach Delay		6.7			6.3			6.1			7.2	
Approach LOS		A			A			A			A	
Queue Length 50th (ft)		14			13			3			6	
Queue Length 95th (ft)		39			37			12			22	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)												
Base Capacity (vph)		1805			1751			1353			1294	
Starvation Cap Reductn		0			0			0			0	
Spillback Cap Reductn		0			0			0			0	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.13			0.14			0.03			0.07	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 22.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.37
Intersection Signal Delay: 6.5 Intersection LOS: A
Intersection Capacity Utilization 28.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach

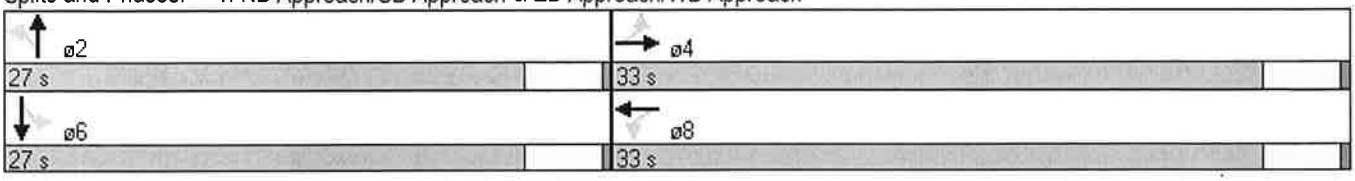


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (vph)	1	185	32	5	241	140	59	1	9	90	1	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	1825	0	0	1770	0	0	1754	0	0	1773	0
Flt Permitted		0.998			0.996			0.710			0.676	
Satd. Flow (perm)	0	1822	0	0	1764	0	0	1299	0	0	1258	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		20			66			10			1	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	237	0	0	419	0	0	75	0	0	100	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	33.0	33.0		33.0	33.0		27.0	27.0		27.0	27.0	
Total Lost Time (s)		4.0			4.0			4.0			4.0	
Act Effct Green (s)		11.2			11.2			7.8			7.8	
Actuated g/C Ratio		0.41			0.41			0.28			0.28	
v/c Ratio		0.31			0.55			0.20			0.28	
Control Delay		6.3			8.3			9.1			10.9	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		6.3			8.3			9.1			10.9	
LOS		A			A			A			B	
Approach Delay		6.3			8.3			9.1			10.9	
Approach LOS		A			A			A			B	
Queue Length 50th (ft)		16			29			6			9	
Queue Length 95th (ft)		48			84			28			38	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)												
Base Capacity (vph)		1730			1677			1108			1072	
Starvation Cap Reductn		0			0			0			0	
Spillback Cap Reductn		0			0			0			0	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.14			0.25			0.07			0.09	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 27.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.55
Intersection Signal Delay: 8.1 Intersection LOS: A
Intersection Capacity Utilization 37.1% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach

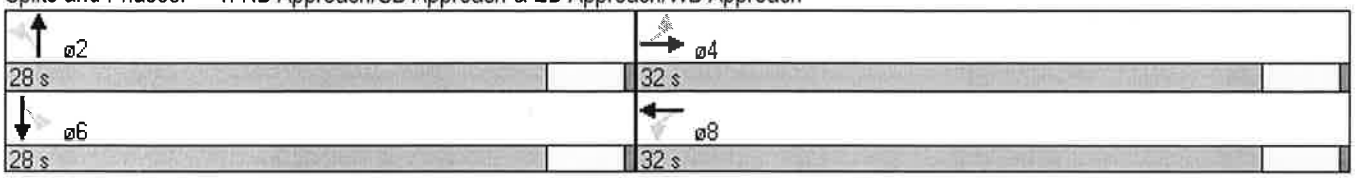


Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↕			↕			↕	
Volume (vph)	1	302	47	7	227	90	34	1	5	180	1	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	1829	0	0	1792	0	0	1758	0	0	1773	0
Flt Permitted		0.999			0.989			0.730			0.697	
Satd. Flow (perm)	0	1827	0	0	1774	0	0	1338	0	0	1297	0
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		17			43			5			1	
Link Speed (mph)		25			30			30			30	
Link Distance (ft)		378			388			430			422	
Travel Time (s)		10.3			8.8			9.8			9.6	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	380	0	0	353	0	0	43	0	0	198	0
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Total Split (s)	32.0	32.0		32.0	32.0		28.0	28.0		28.0	28.0	
Total Lost Time (s)		4.0			4.0			4.0			4.0	
Act Effct Green (s)		12.1			12.1			10.5			10.5	
Actuated g/C Ratio		0.39			0.39			0.34			0.34	
v/c Ratio		0.53			0.49			0.09			0.45	
Control Delay		10.4			9.3			8.0			12.7	
Queue Delay		0.0			0.0			0.0			0.0	
Total Delay		10.4			9.3			8.0			12.7	
LOS		B			A			A			B	
Approach Delay		10.4			9.3			8.0			12.7	
Approach LOS		B			A			A			B	
Queue Length 50th (ft)		37			31			4			21	
Queue Length 95th (ft)		113			98			20			76	
Internal Link Dist (ft)		298			308			350			342	
Turn Bay Length (ft)												
Base Capacity (vph)		1608			1565			1070			1036	
Starvation Cap Reductn		0			0			0			0	
Spillback Cap Reductn		0			0			0			0	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.24			0.23			0.04			0.19	

Intersection Summary

Area Type: Other
Cycle Length: 60
Actuated Cycle Length: 31.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.53
Intersection Signal Delay: 10.3 Intersection LOS: B
Intersection Capacity Utilization 40.5% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 1: NB Approach/SB Approach & EB Approach/WB Approach



Intersection 2

Roundabout Analysis

MOVEMENT SUMMARY

Site: 2030 AM PH w/o Road 3 RMG

Intersection #2, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
Without Road 3

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	64	2.0	0.067	9.1	LOS A	0.2	6.3	0.29	0.64	24.7
8	T	1	3.0	0.067	6.1	LOS A	0.2	6.3	0.29	0.44	32.5
18	R	10	2.0	0.067	5.5	LOS A	0.2	6.3	0.29	0.46	27.1
Approach		75	2.0	0.067	8.6	LOS A	0.2	6.3	0.29	0.62	25.1
East: WB Approach											
1L	L	5	2.0	0.109	10.6	LOS B	0.5	12.3	0.18	0.90	29.6
6T	T	132	2.0	0.109	4.6	LOS A	0.5	12.3	0.18	0.39	33.4
6R	R	1	3.0	0.109	6.8	LOS A	0.5	12.3	0.18	0.55	32.8
Approach		138	2.0	0.109	4.8	LOS A	0.5	12.3	0.18	0.42	33.2
North: SB Approach											
7	L	65	3.0	0.059	12.8	LOS B	0.2	5.3	0.27	0.68	29.3
4	T	1	3.0	0.059	6.0	LOS A	0.2	5.3	0.27	0.43	32.7
14	R	1	3.0	0.059	7.1	LOS A	0.2	5.3	0.27	0.50	32.2
Approach		67	3.0	0.059	12.6	LOS B	0.2	5.3	0.27	0.68	29.4
West: EB Approach											
5	L	1	3.0	0.153	12.4	LOS B	0.6	15.2	0.17	0.88	30.0
2	T	152	2.0	0.153	3.7	LOS A	0.6	15.2	0.17	0.35	28.3
12	R	35	2.0	0.153	3.8	LOS A	0.6	15.2	0.17	0.43	27.2
Approach		188	2.0	0.153	3.7	LOS A	0.6	15.2	0.17	0.37	28.1
All Vehicles		468	2.2	0.153	6.1	LOS A	0.6	15.2	0.21	0.47	29.0

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: 2030 PM PH w/o Road 3 RMG

Intersection #2, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
Without Road 3

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	37	2.0	0.040	9.3	LOS A	0.1	3.8	0.32	0.65	24.7
8	T	1	2.0	0.040	6.2	LOS A	0.1	3.8	0.32	0.45	32.3
18	R	5	2.0	0.040	5.6	LOS A	0.1	3.8	0.32	0.47	27.0
Approach		43	2.0	0.040	8.8	LOS A	0.1	3.8	0.32	0.62	25.1
East: WB Approach											
1L	L	8	2.0	0.172	10.5	LOS B	0.8	21.0	0.14	0.88	29.6
6T	T	154	2.0	0.172	4.4	LOS A	0.8	21.0	0.14	0.37	33.6
6R	R	76	2.0	0.172	6.8	LOS A	0.8	21.0	0.14	0.53	33.0
Approach		238	2.0	0.172	5.4	LOS A	0.8	21.0	0.14	0.44	33.2
North: SB Approach											
7	L	87	2.0	0.088	13.0	LOS B	0.3	7.9	0.28	0.69	29.2
4	T	1	2.0	0.088	6.1	LOS A	0.3	7.9	0.28	0.44	32.6
14	R	1	2.0	0.088	7.4	LOS A	0.3	7.9	0.28	0.52	32.0
Approach		89	2.0	0.088	12.8	LOS B	0.3	7.9	0.28	0.69	29.3
West: EB Approach											
5	L	1	2.0	0.193	12.5	LOS B	0.8	20.1	0.21	0.87	30.0
2	T	182	2.0	0.193	3.8	LOS A	0.8	20.1	0.21	0.37	28.2
12	R	51	2.0	0.193	3.9	LOS A	0.8	20.1	0.21	0.44	27.1
Approach		234	2.0	0.193	3.8	LOS A	0.8	20.1	0.21	0.39	28.0
All Vehicles		604	2.0	0.193	6.1	LOS A	0.8	21.0	0.20	0.47	29.7

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: 2030 AM PH w Road 3 RMG

Intersection #2, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
With Road 3

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	64	2.0	0.070	9.5	LOS A	0.3	6.9	0.35	0.66	24.6
8	T	1	2.0	0.070	6.4	LOS A	0.3	6.9	0.35	0.48	32.2
18	R	10	2.0	0.070	5.8	LOS A	0.3	6.9	0.35	0.50	26.9
Approach		75	2.0	0.070	8.9	LOS A	0.3	6.9	0.35	0.64	25.0
East: WB Approach											
1L	L	5	2.0	0.310	10.6	LOS B	1.7	44.1	0.22	0.85	29.5
6T	T	262	2.0	0.310	4.6	LOS A	1.7	44.1	0.22	0.39	33.1
6R	R	152	2.0	0.310	6.9	LOS A	1.7	44.1	0.22	0.54	32.7
Approach		420	2.0	0.310	5.5	LOS A	1.7	44.1	0.22	0.45	32.9
North: SB Approach											
7	L	98	2.0	0.097	13.4	LOS B	0.4	9.5	0.37	0.71	29.0
4	T	1	2.0	0.097	6.5	LOS A	0.4	9.5	0.37	0.49	32.0
14	R	1	2.0	0.097	7.8	LOS A	0.4	9.5	0.37	0.57	31.6
Approach		100	2.0	0.097	13.2	LOS B	0.4	9.5	0.37	0.71	29.1
West: EB Approach											
5	L	1	2.0	0.169	12.5	LOS B	0.7	17.7	0.22	0.89	30.0
2	T	201	2.0	0.169	3.8	LOS A	0.7	17.7	0.22	0.38	28.2
12	R	1	2.0	0.169	3.9	LOS A	0.7	17.7	0.22	0.46	27.1
Approach		203	2.0	0.169	3.8	LOS A	0.7	17.7	0.22	0.38	28.2
All Vehicles		798	2.0	0.310	6.4	LOS A	1.7	44.1	0.25	0.48	30.1

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 PM PH w Road 3 RMG

Intersection #2, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
With Road 3

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	37	2.0	0.047	10.4	LOS B	0.2	5.2	0.48	0.70	24.4
8	T	1	2.0	0.047	7.4	LOS A	0.2	5.2	0.48	0.55	31.3
18	R	5	2.0	0.047	6.7	LOS A	0.2	5.2	0.48	0.56	26.4
Approach		43	2.0	0.047	9.9	LOS A	0.2	5.2	0.48	0.68	24.8
East: WB Approach											
1L	L	8	2.0	0.249	10.5	LOS B	1.4	34.6	0.16	0.88	29.6
6T	T	247	2.0	0.249	4.4	LOS A	1.4	34.6	0.16	0.37	33.5
6R	R	98	2.0	0.249	6.8	LOS A	1.4	34.6	0.16	0.53	32.9
Approach		352	2.0	0.249	5.2	LOS A	1.4	34.6	0.16	0.43	33.2
North: SB Approach											
7	L	196	2.0	0.208	13.5	LOS B	0.8	21.2	0.38	0.73	29.0
4	T	1	2.0	0.208	6.7	LOS A	0.8	21.2	0.38	0.52	31.9
14	R	1	2.0	0.208	7.9	LOS A	0.8	21.2	0.38	0.59	31.5
Approach		198	2.0	0.208	13.4	LOS B	0.8	21.2	0.38	0.73	29.0
West: EB Approach											
5	L	1	2.0	0.339	13.0	LOS B	1.7	42.7	0.38	0.87	29.9
2	T	328	2.0	0.339	4.3	LOS A	1.7	42.7	0.38	0.44	27.6
12	R	51	2.0	0.339	4.5	LOS A	1.7	42.7	0.38	0.50	26.7
Approach		380	2.0	0.339	4.4	LOS A	1.7	42.7	0.38	0.45	27.5
All Vehicles		974	2.0	0.339	6.8	LOS A	1.7	42.7	0.30	0.51	29.4

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

Intersection 1

Five-Leg Roundabout Analysis

MOVEMENT SUMMARY

Site: 2030 AM PH 5-Leg w/o Road 3 RMG

Intersection #1, 5-Leg, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
Without Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	57	2.0	0.055	11.7	LOS B	0.2	5.3	0.37	0.68	25.4
8	T	1	2.0	0.055	1.9	LOS A	0.2	5.3	0.37	0.28	27.0
18	R	3	2.0	0.055	6.9	LOS A	0.2	5.3	0.37	0.51	32.0
Approach		61	2.0	0.055	11.2	LOS B	0.2	5.3	0.37	0.66	25.6
South East: NWB Approach											
3X	L	551	2.0	0.441	11.6	LOS B	2.4	61.0	0.31	0.65	29.8
18X	R	2	2.0	0.441	5.4	LOS A	2.4	61.0	0.31	0.42	32.7
Approach		553	2.0	0.441	11.6	LOS B	2.4	61.0	0.31	0.65	29.8
North East: SWB Approach											
1X	L	2	2.0	0.086	14.0	LOS B	0.4	10.3	0.54	0.91	30.0
16X	R	77	2.0	0.086	6.4	LOS A	0.4	10.3	0.54	0.57	32.5
Approach		79	2.0	0.086	6.6	LOS A	0.4	10.3	0.54	0.58	32.4
North: SB Approach											
7	L	2	2.0	0.009	14.9	LOS B	0.0	1.1	0.58	0.73	29.1
4	T	1	2.0	0.009	3.3	LOS A	0.0	1.1	0.58	0.39	26.2
14	R	4	2.0	0.009	6.3	LOS A	0.0	1.1	0.58	0.51	26.7
Approach		8	2.0	0.009	8.3	LOS A	0.0	1.1	0.58	0.55	27.3
West: EB Approach											
5	L	67	2.0	0.296	11.0	LOS B	1.3	33.7	0.05	0.92	30.8
12	R	341	2.0	0.296	4.0	LOS A	1.3	33.7	0.05	0.33	35.4
Approach		409	2.0	0.296	5.2	LOS A	1.3	33.7	0.05	0.43	34.5
All Vehicles		1110	2.0	0.441	8.8	LOS A	2.4	61.0	0.24	0.56	31.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 PM PH 5-Leg w/o Road 3 RMG

Intersection #1, 5-Leg, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
Without Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	26	2.0	0.032	13.0	LOS B	0.1	3.5	0.52	0.71	25.1
8	T	1	2.0	0.032	3.2	LOS A	0.1	3.5	0.52	0.40	26.1
18	R	2	2.0	0.032	7.8	LOS A	0.1	3.5	0.52	0.56	31.3
Approach		29	2.0	0.032	12.2	LOS B	0.1	3.5	0.52	0.69	25.5
South East: NWB Approach											
3X	L	373	2.0	0.298	11.5	LOS B	1.3	34.1	0.26	0.65	30.0
18X	R	2	2.0	0.298	5.3	LOS A	1.3	34.1	0.26	0.40	33.1
Approach		375	2.0	0.298	11.5	LOS B	1.3	34.1	0.26	0.65	30.0
North East: SWB Approach											
1X	L	2	2.0	0.075	13.0	LOS B	0.3	7.9	0.42	0.91	30.4
16X	R	77	2.0	0.075	5.4	LOS A	0.3	7.9	0.42	0.48	33.2
Approach		79	2.0	0.075	5.6	LOS A	0.3	7.9	0.42	0.49	33.1
North: SB Approach											
7	L	2	2.0	0.007	13.8	LOS B	0.0	0.8	0.45	0.73	29.6
4	T	1	2.0	0.007	2.2	LOS A	0.0	0.8	0.45	0.29	26.8
14	R	4	2.0	0.007	5.2	LOS A	0.0	0.8	0.45	0.45	27.2
Approach		8	2.0	0.007	7.2	LOS A	0.0	0.8	0.45	0.51	27.8
West: EB Approach											
5	L	96	2.0	0.518	10.9	LOS B	3.2	80.0	0.06	0.92	30.7
12	R	620	2.0	0.518	4.0	LOS A	3.2	80.0	0.06	0.33	35.3
Approach		715	2.0	0.518	4.9	LOS A	3.2	80.0	0.06	0.41	34.6
All Vehicles		1207	2.0	0.518	7.2	LOS A	3.2	80.0	0.16	0.50	32.5

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

SIDRA INTERSECTION

MOVEMENT SUMMARY

Site: 2030 AM PH 5-Leg w Road 3 RMG

Intersection #1, 5-Leg, Reid Middleton Geometry (RMG)
2030 AM Peak Hour
With Road 3 - Base + Project

Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	57	2.0	0.058	12.0	LOS B	0.2	5.8	0.42	0.69	25.3
8	T	1	2.0	0.058	2.2	LOS A	0.2	5.8	0.42	0.32	26.7
18	R	3	2.0	0.058	7.2	LOS A	0.2	5.8	0.42	0.54	31.8
Approach		61	2.0	0.058	11.6	LOS B	0.2	5.8	0.42	0.68	25.5
South East: NWB Approach											
3X	L	682	2.0	0.556	12.0	LOS B	3.5	89.4	0.41	0.67	29.5
18X	R	2	2.0	0.556	5.7	LOS A	3.5	89.4	0.41	0.47	32.1
Approach		684	2.0	0.556	11.9	LOS B	3.5	89.4	0.41	0.66	29.5
North East: SWB Approach											
1X	L	2	2.0	0.193	15.1	LOS B	1.1	26.9	0.67	0.94	29.6
16X	R	153	2.0	0.193	7.5	LOS A	1.1	26.9	0.67	0.67	31.8
Approach		155	2.0	0.193	7.6	LOS A	1.1	26.9	0.67	0.67	31.8
North: SB Approach											
7	L	2	2.0	0.015	16.7	LOS B	0.1	2.2	0.71	0.75	28.2
4	T	1	2.0	0.015	5.1	LOS A	0.1	2.2	0.71	0.51	25.5
14	R	8	2.0	0.015	8.1	LOS A	0.1	2.2	0.71	0.60	26.3
Approach		11	2.0	0.015	9.5	LOS A	0.1	2.2	0.71	0.62	26.6
West: EB Approach											
5	L	100	2.0	0.355	11.0	LOS B	1.8	44.7	0.05	0.90	30.8
12	R	390	2.0	0.355	4.0	LOS A	1.8	44.7	0.05	0.33	35.4
Approach		490	2.0	0.355	5.4	LOS A	1.8	44.7	0.05	0.44	34.3
All Vehicles		1401	2.0	0.556	9.2	LOS A	3.5	89.4	0.32	0.59	31.0

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2030 PM PH 5-Leg w Road 3 RMG

Intersection #1, 5-Leg, Reid Middleton Geometry (RMG)
2030 PM Peak Hour
With Road 3 - Base + Project

Roundabout

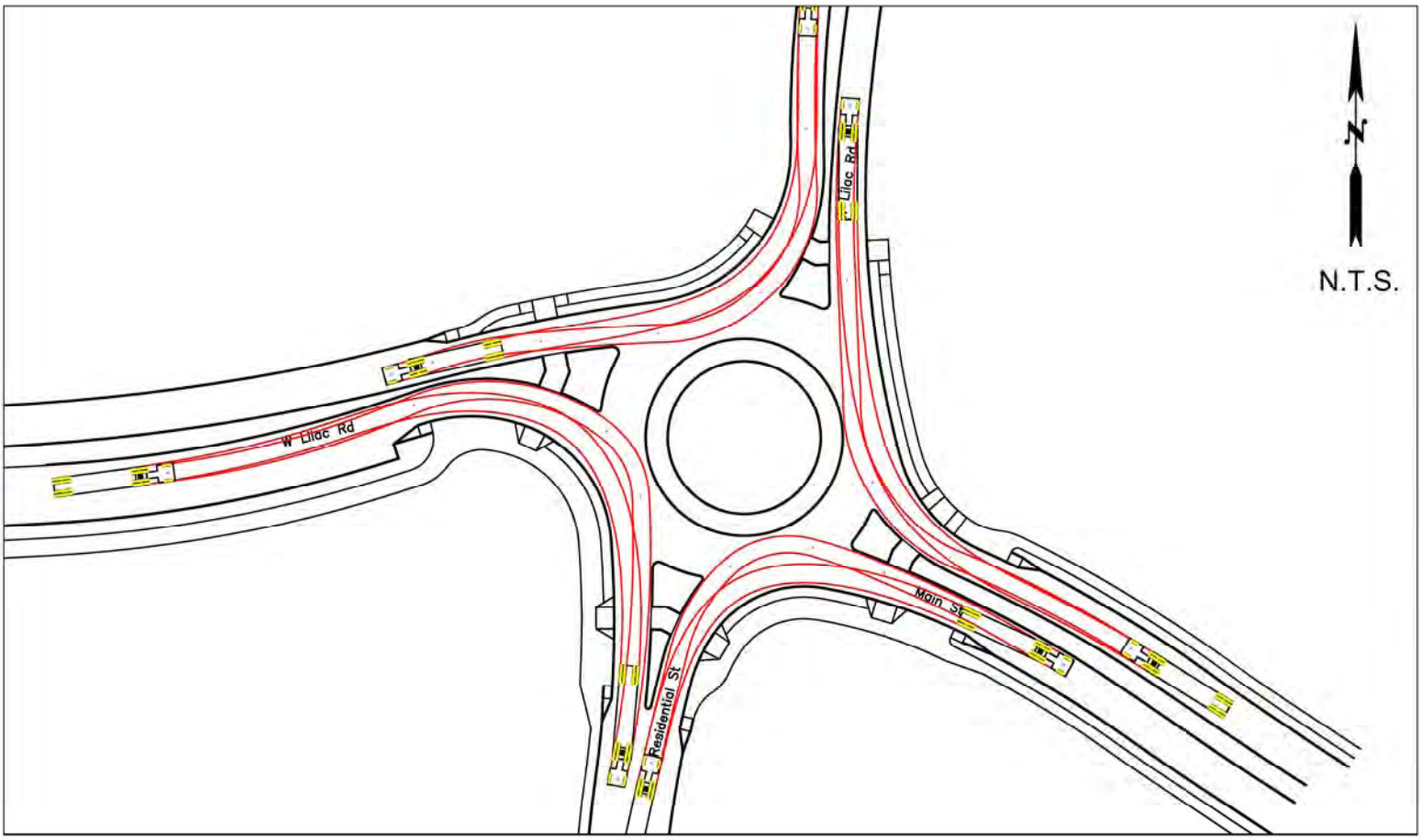
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Approach											
3	L	26	2.0	0.039	15.2	LOS B	0.2	5.1	0.67	0.75	24.2
8	T	1	2.0	0.039	5.4	LOS A	0.2	5.1	0.67	0.53	25.3
18	R	2	2.0	0.039	10.0	LOS A	0.2	5.1	0.67	0.65	30.2
Approach		29	2.0	0.039	14.4	LOS B	0.2	5.1	0.67	0.74	24.6
South East: NWB Approach											
3X	L	465	2.0	0.395	12.1	LOS B	2.0	50.7	0.39	0.69	29.6
18X	R	2	2.0	0.395	5.9	LOS A	2.0	50.7	0.39	0.49	32.2
Approach		467	2.0	0.395	12.1	LOS B	2.0	50.7	0.39	0.69	29.6
North East: SWB Approach											
1X	L	2	2.0	0.103	13.4	LOS B	0.5	12.0	0.50	0.91	30.3
16X	R	99	2.0	0.103	5.8	LOS A	0.5	12.0	0.50	0.52	32.8
Approach		101	2.0	0.103	6.0	LOS A	0.5	12.0	0.50	0.53	32.7
North: SB Approach											
7	L	2	2.0	0.008	14.2	LOS B	0.0	0.9	0.51	0.73	29.4
4	T	1	2.0	0.008	2.6	LOS A	0.0	0.9	0.51	0.34	26.5
14	R	4	2.0	0.008	5.6	LOS A	0.0	0.9	0.51	0.48	26.9
Approach		8	2.0	0.008	7.6	LOS A	0.0	0.9	0.51	0.53	27.6
West: EB Approach											
5	L	204	2.0	0.704	11.0	LOS B	7.4	189.0	0.11	0.86	30.7
12	R	766	2.0	0.704	4.1	LOS A	7.4	189.0	0.11	0.32	35.0
Approach		971	2.0	0.704	5.5	LOS A	7.4	189.0	0.11	0.43	33.9
All Vehicles		1576	2.0	0.704	7.7	LOS A	7.4	189.0	0.23	0.52	32.1

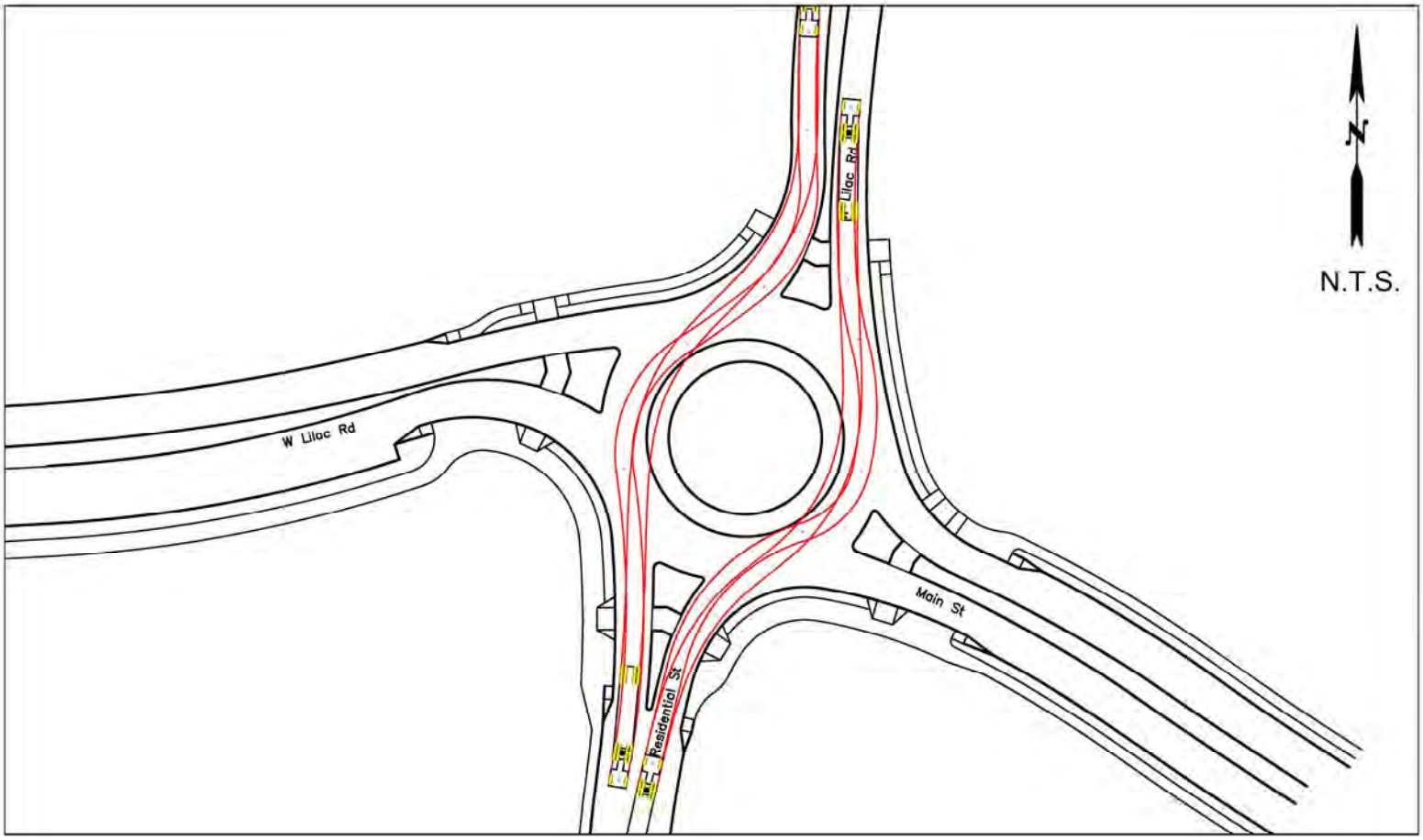
Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model used.

APPENDIX B
(ROUNDABOUT CALCULATIONS)

TABLE OF CONTENTS



WB-50 Turning Movements



WB-50 Turning Movements

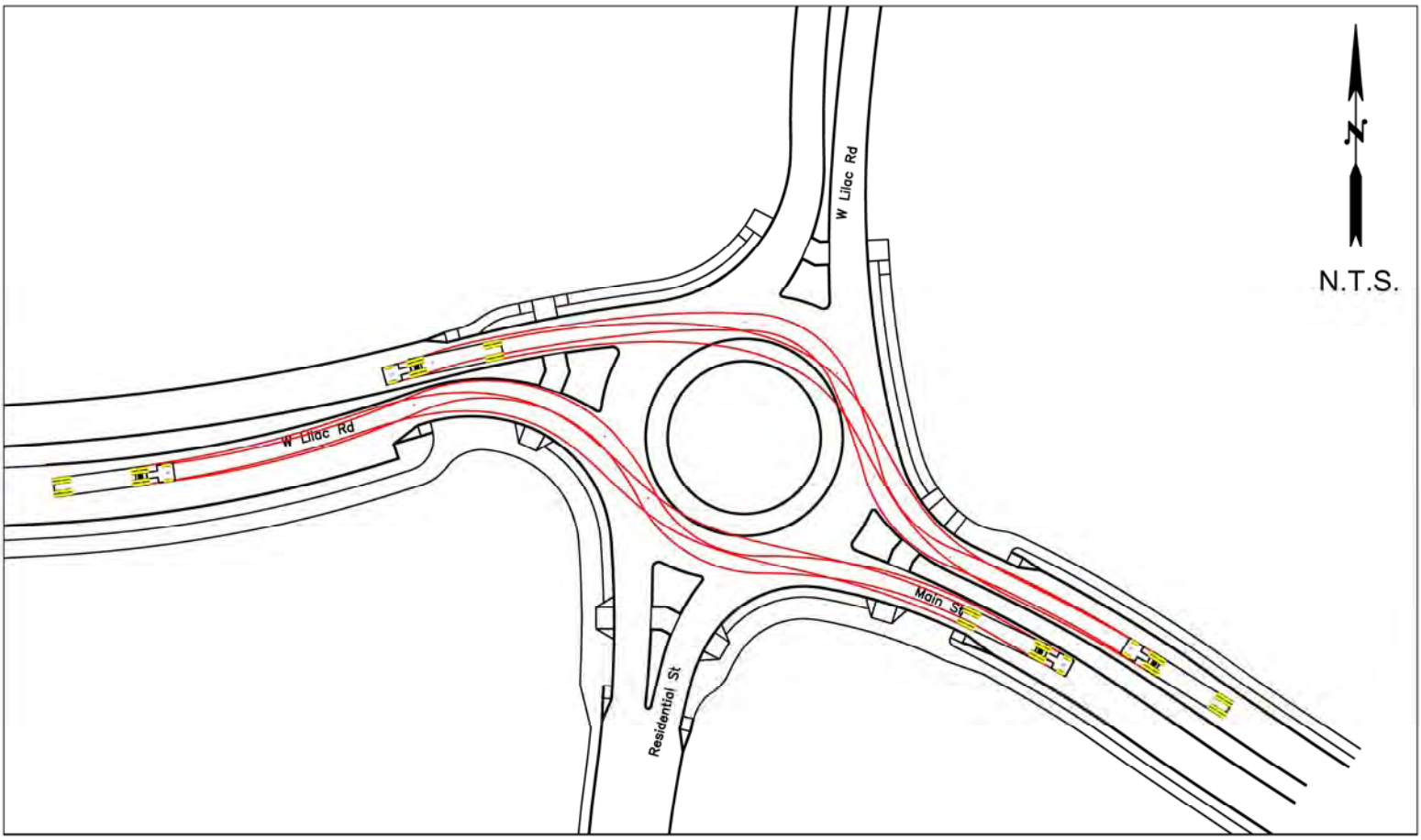
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - TRUCK TURNING

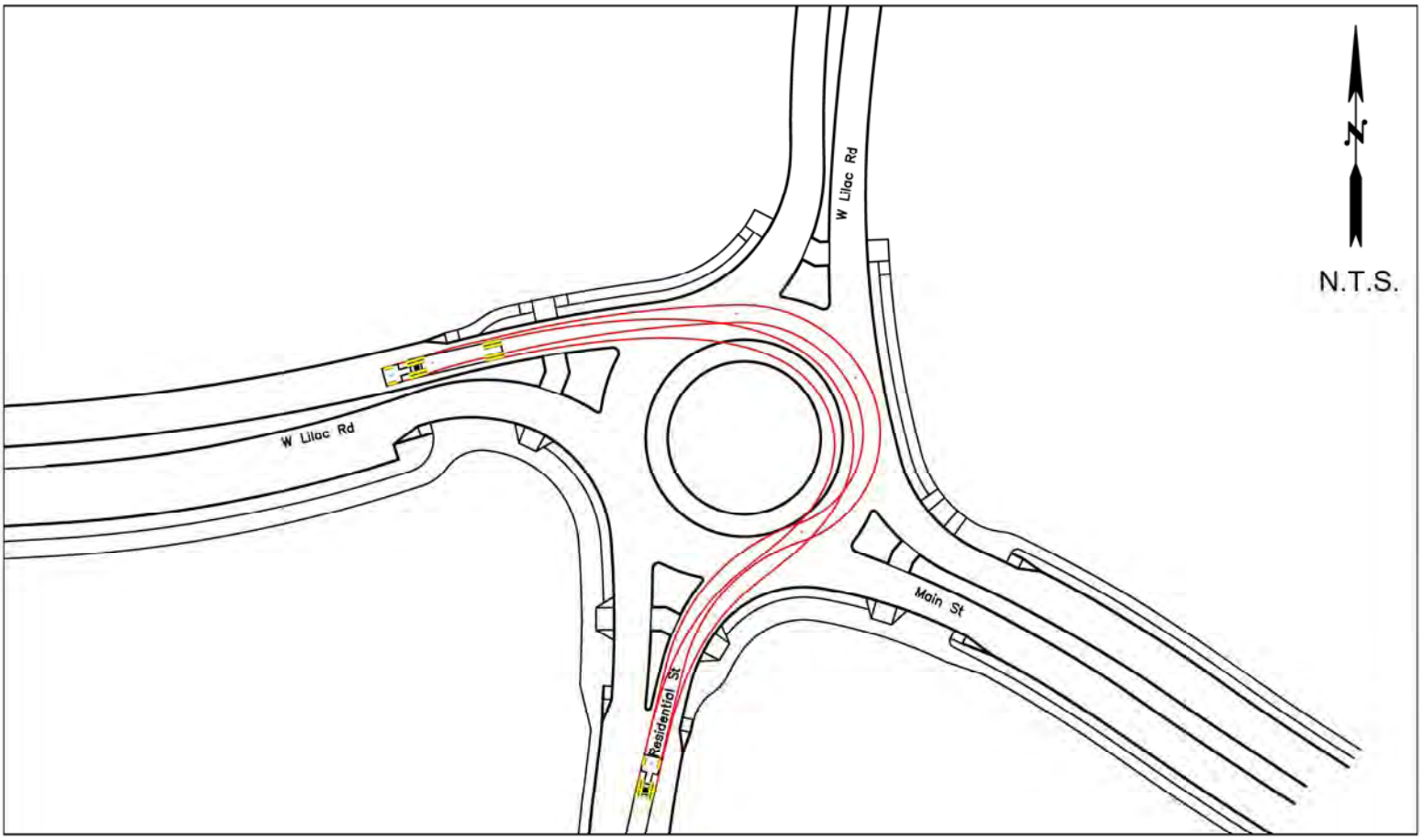
Figure B-1

W Lilac Rd Roundabouts

October 2013



WB-50 Turning Movements



WB-50 Turning Movements

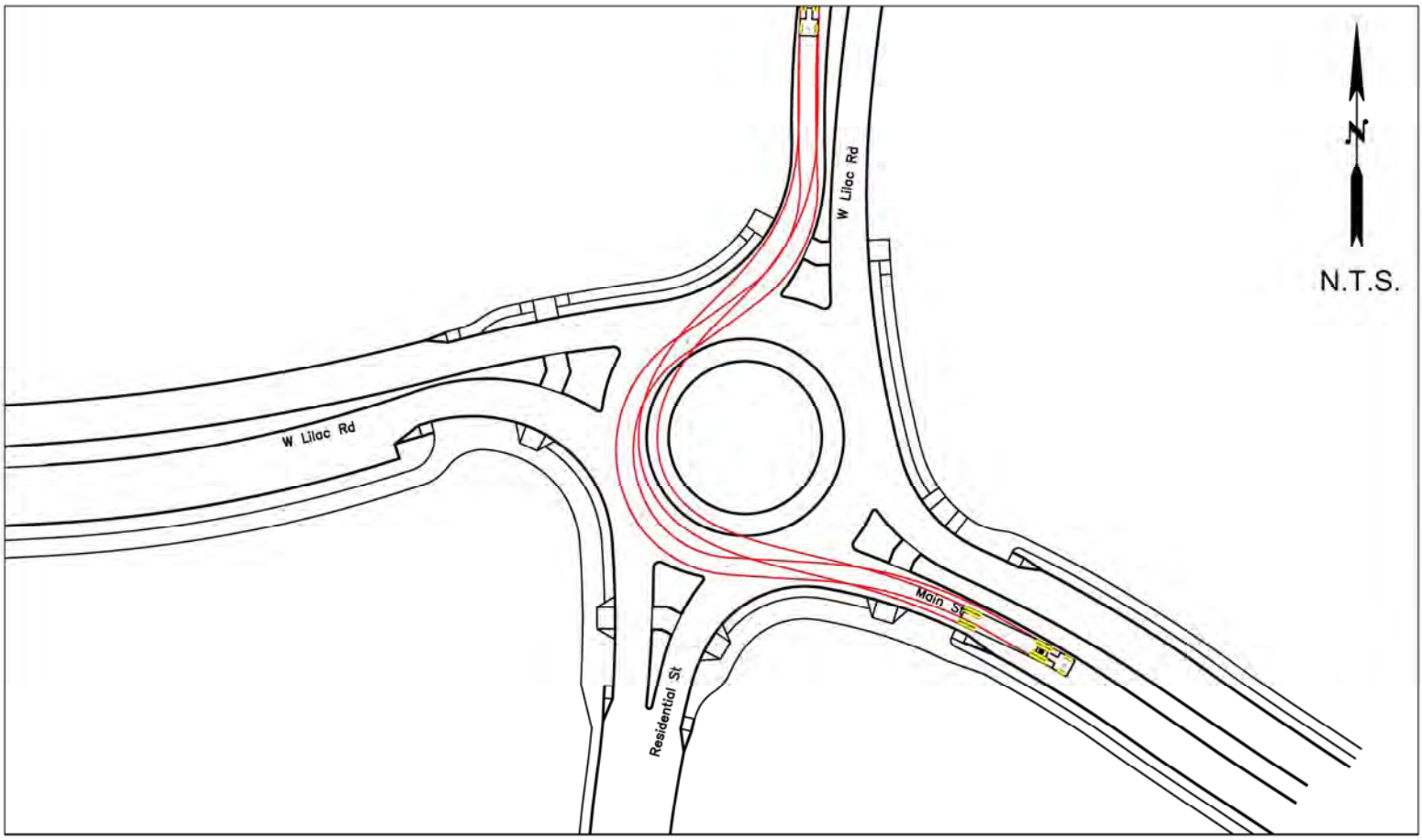
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - TRUCK TURNING

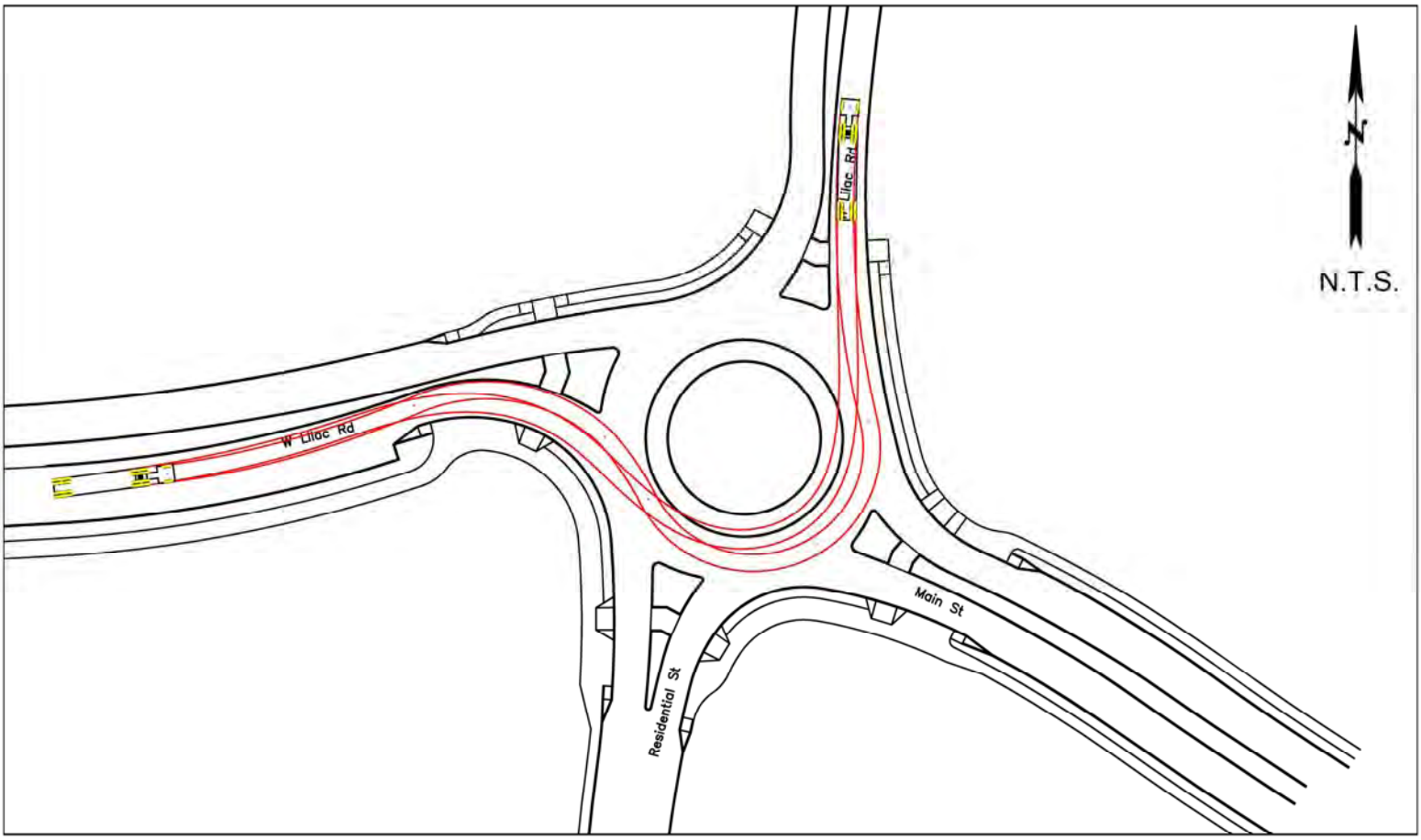
W Lilac Rd Roundabouts

Figure B-2

October 2013



WB-50 Turning Movements



WB-50 Turning Movements

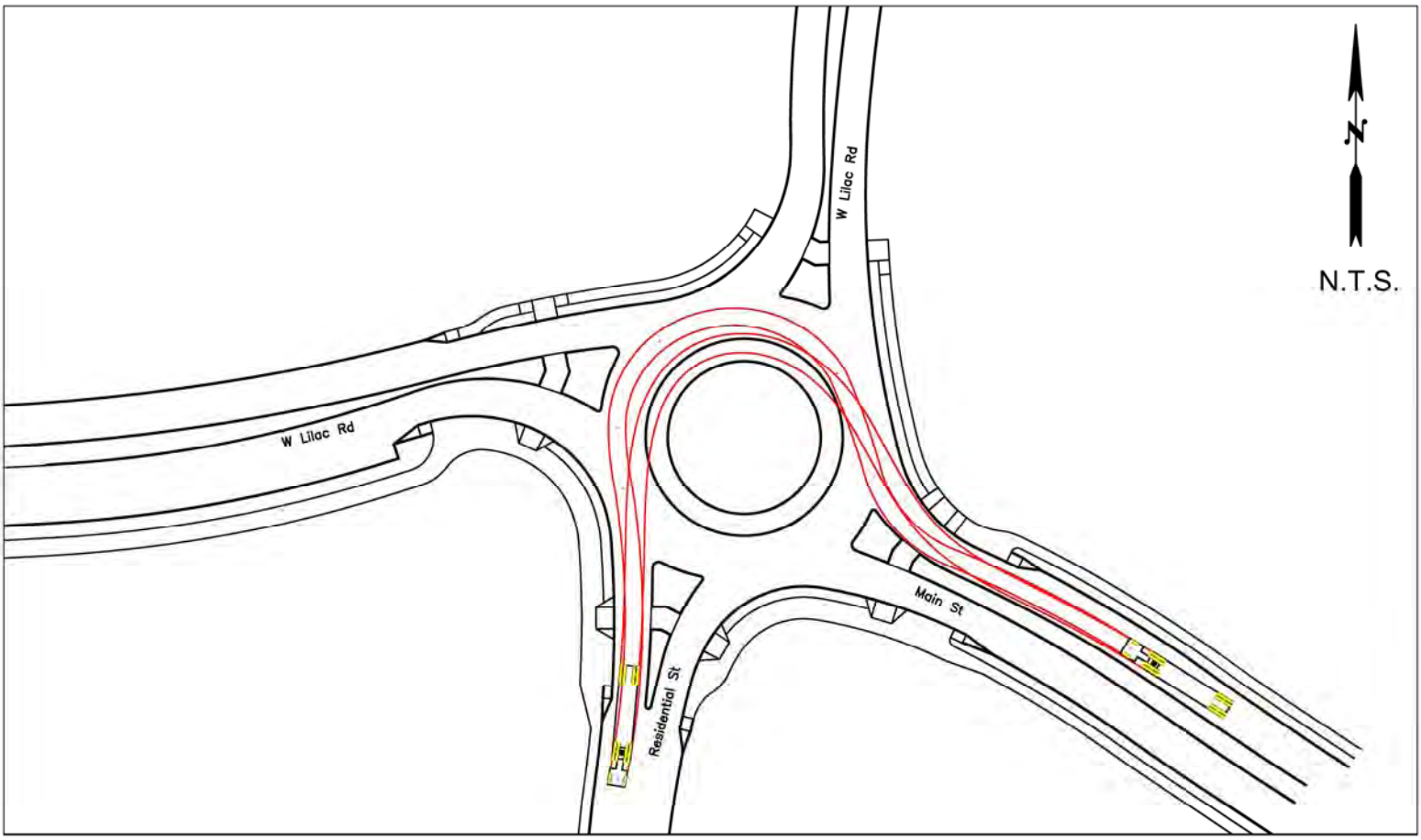
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - TRUCK TURNING

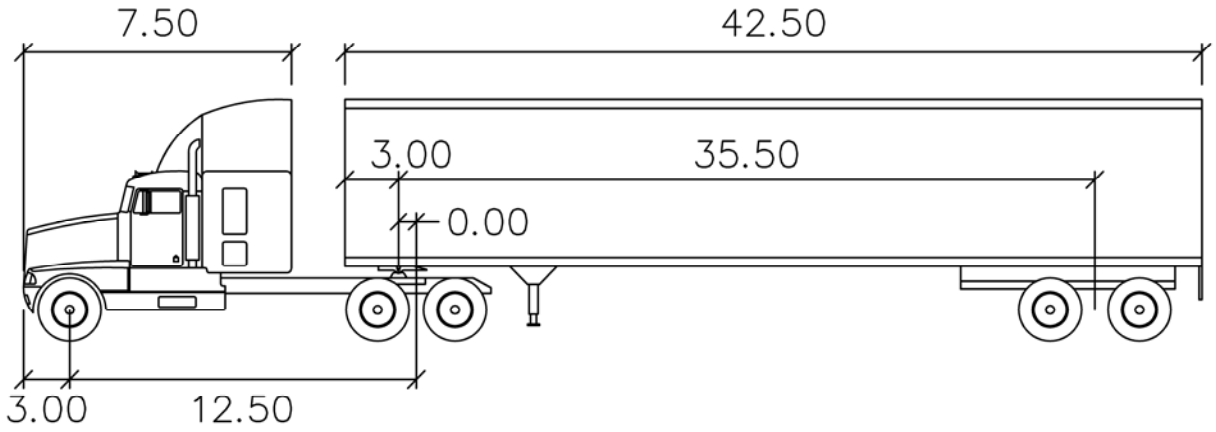
W Lilac Rd Roundabouts

Figure B-3

October 2013



WB-50 Turning Movements

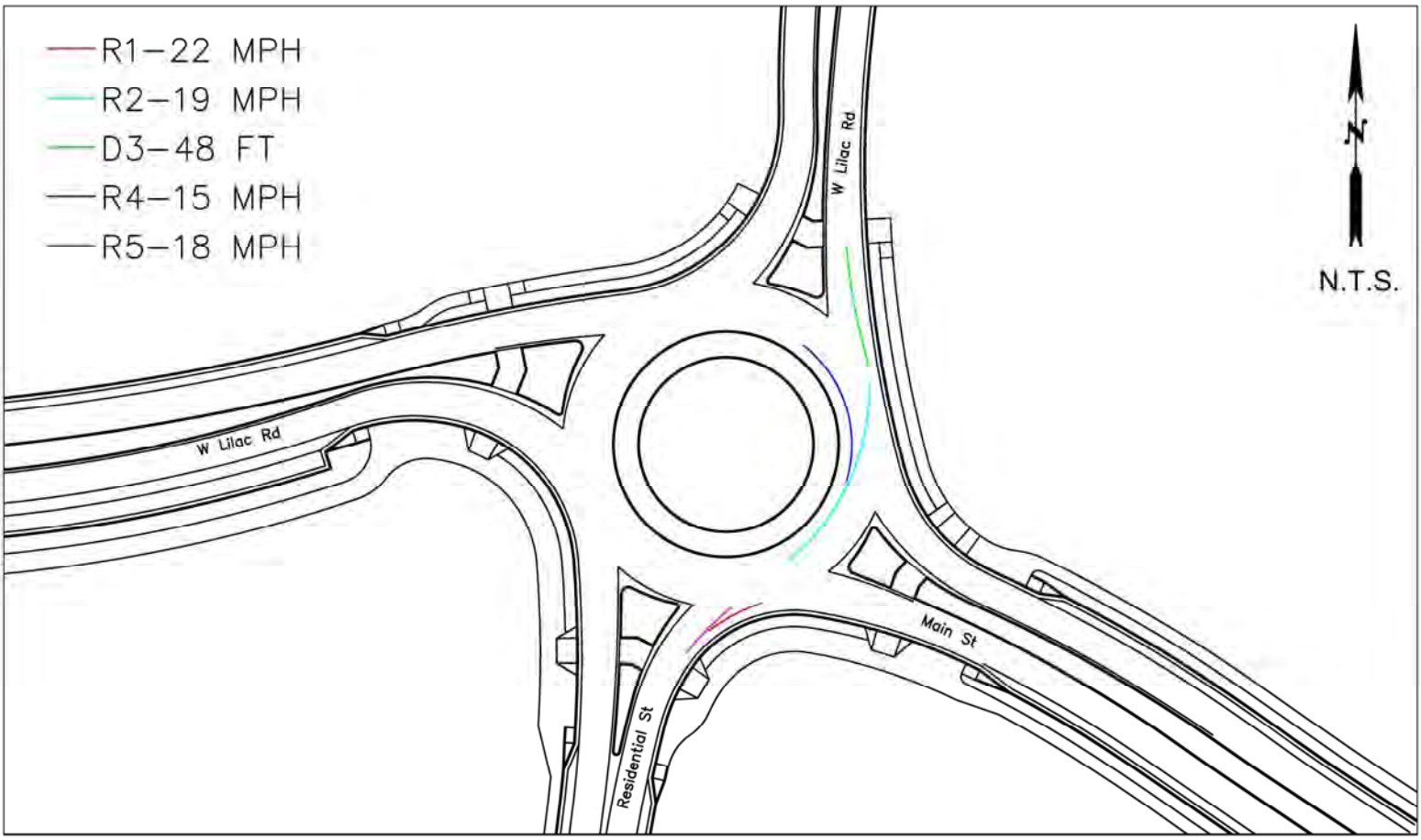


WB−50 feet

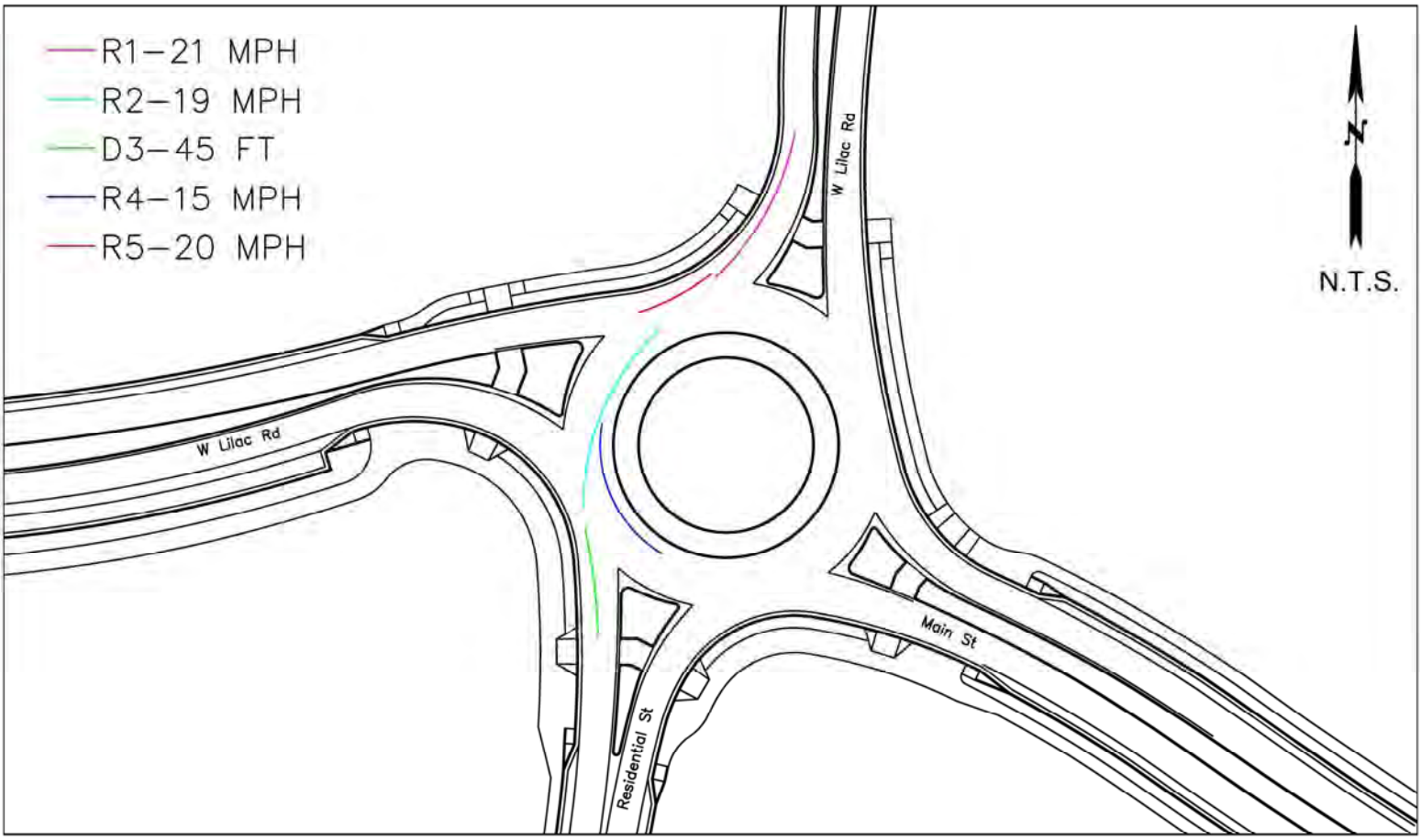
Tractor Width	: 8.00	Lock to Lock Time	: 6.0
Trailer Width	: 8.50	Steering Angle	: 17.7
Tractor Track	: 8.00	Articulating Angle	: 70.0
Trailer Track	: 8.50		

WB-50 Truck Profile

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



Northbound



Southbound

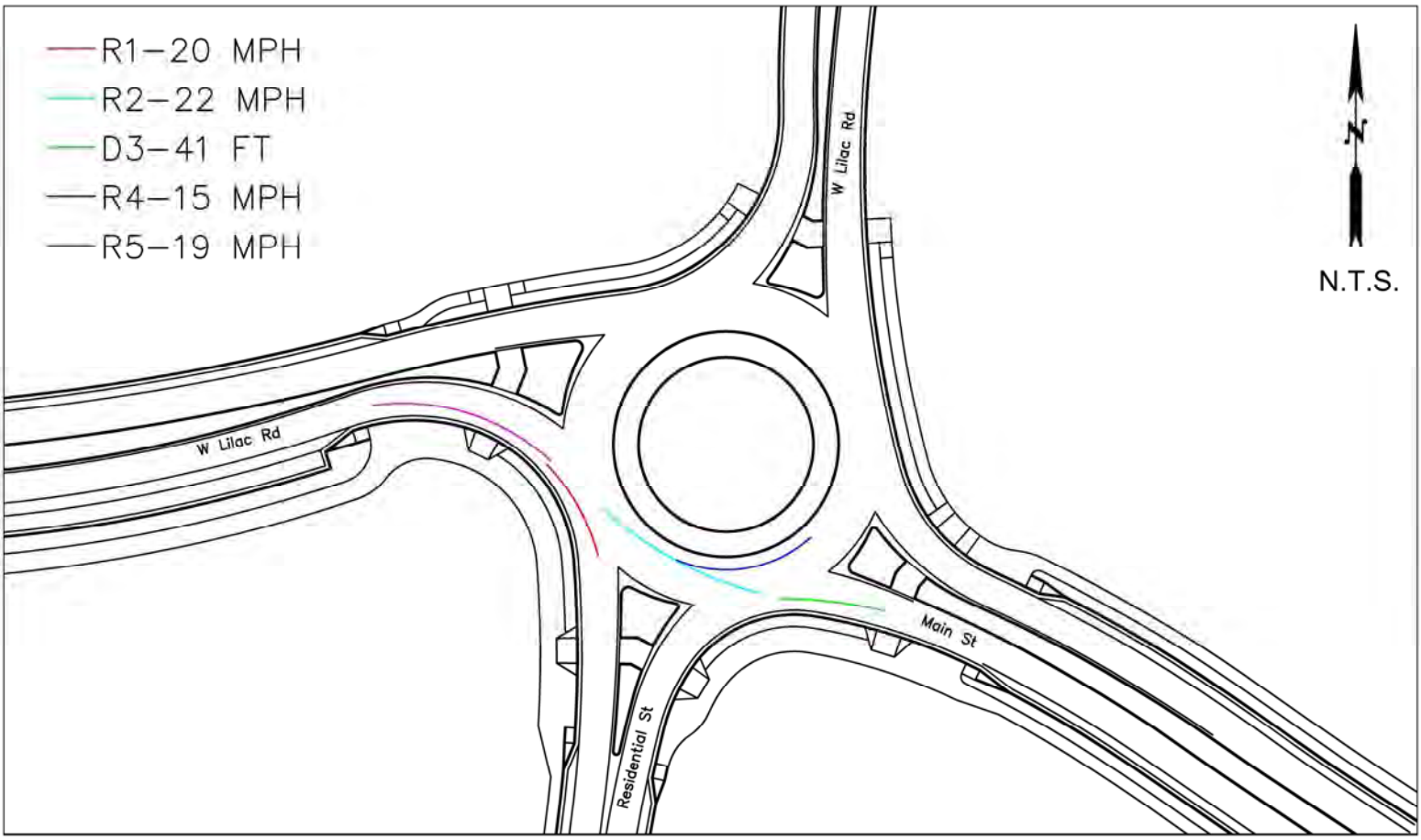
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - SPEED CURVES

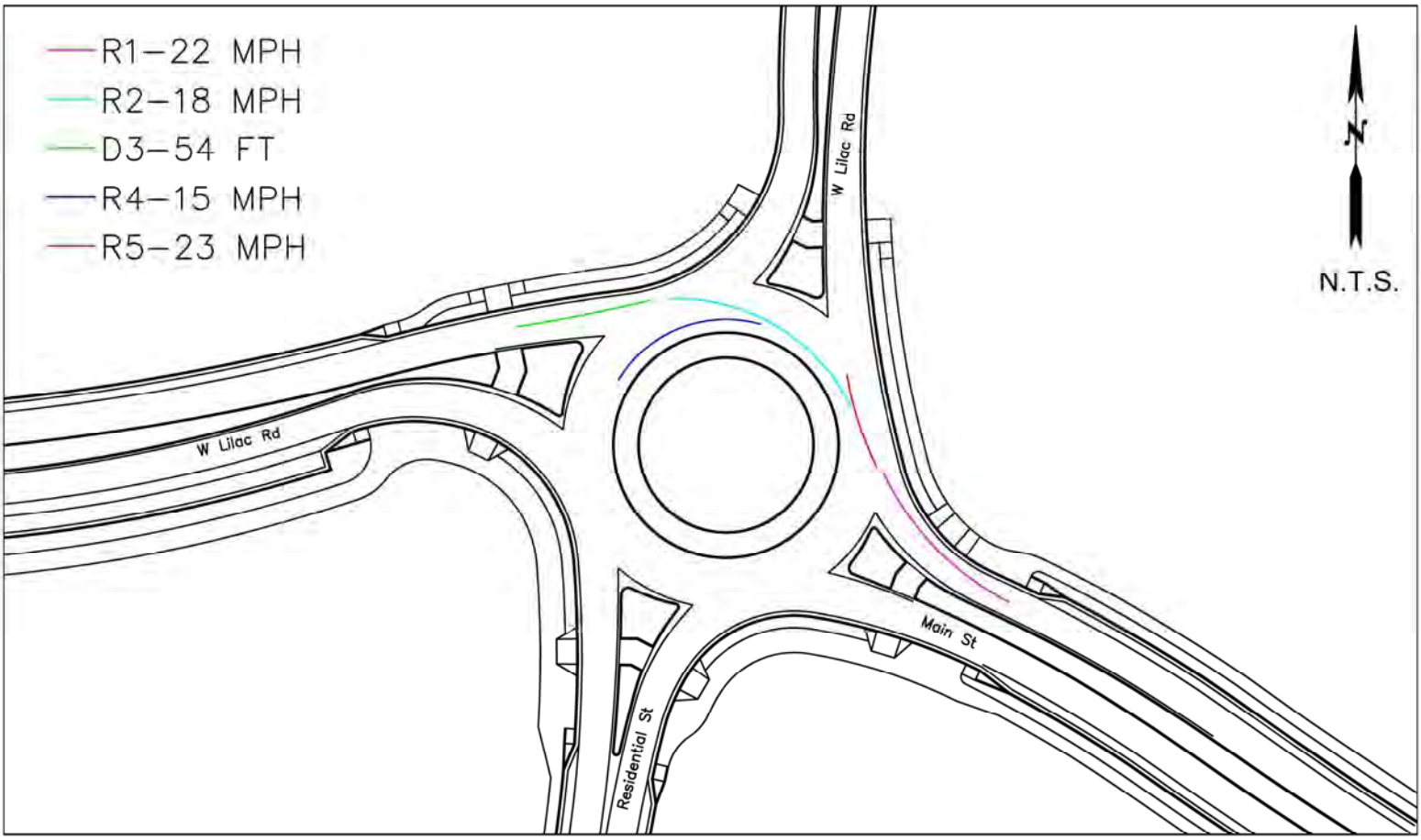
W Lilac Rd Roundabouts

Figure B-5

October 2013



Eastbound



Westbound

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - SPEED CURVES

Figure B-6

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 1 - Speed Calculations

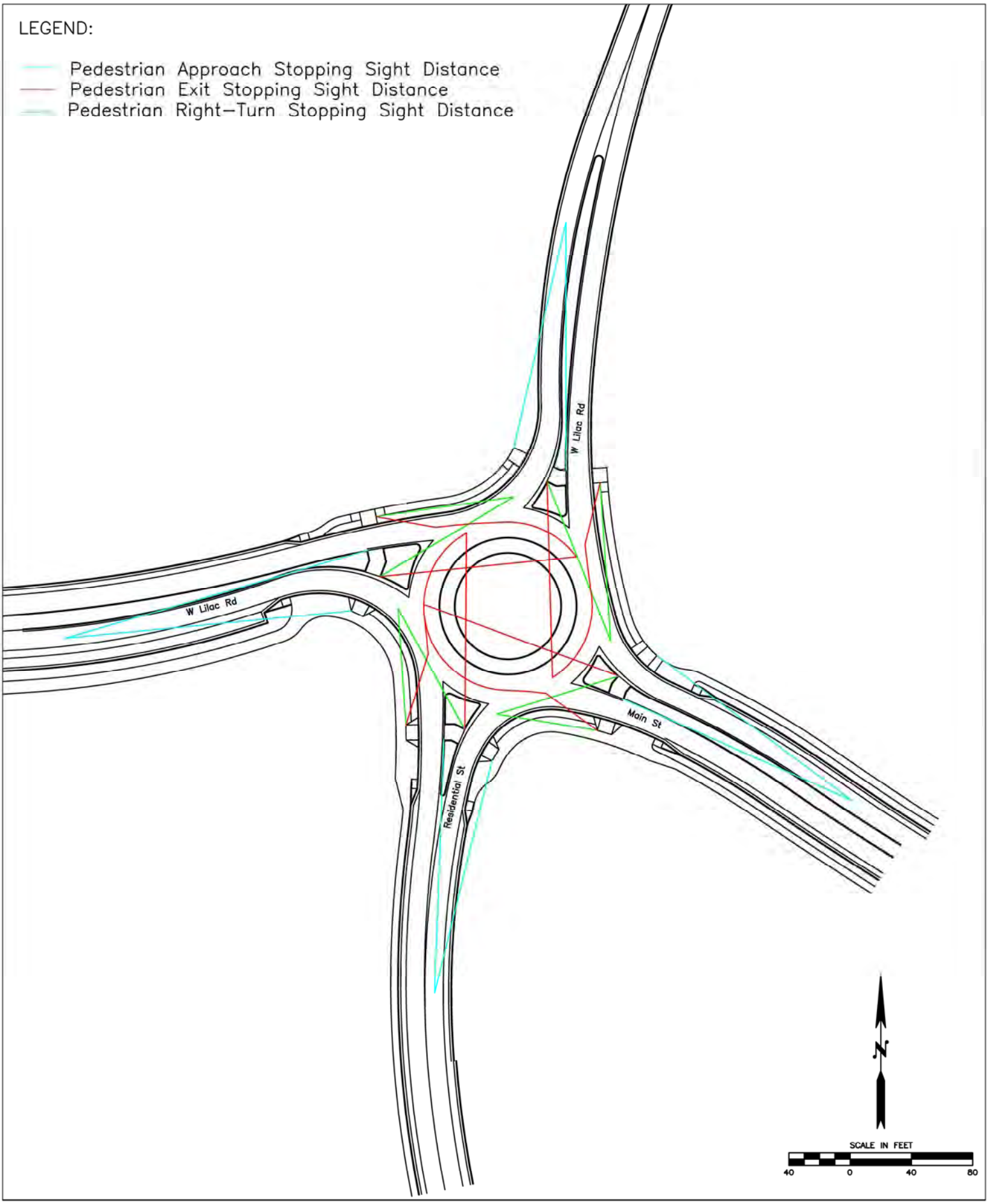
W Lilac Rd Roundabouts
October 2013

	Northbound		Southbound		Eastbound		Westbound	
	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)
R1	112	22	106	21	87	20	114	22
R2	88	18	94	19	140	22	78	18
R3*	-	27	-	27	-	28	-	28
R4	50	15	50	15	50	15	50	15
R5	74	18	92	20	81	19	125	23

* R3 speed = lesser of [speed-radius table value] or [R2+Acceleration*Distance to Crosswalk)
+2% superelevation assumed for R1, R3, and R5 movements
-2% superelevation assumed for R2 and R4 movements

Calculated R3 Speed from Acceleration and Distance to Crosswalk
FHWA Acceleration 6.9 ft/sec^2 NCHRP Report 572

	Beginning Speed R2 (MPH)	R2 Speed in FT/SEC	Distance from R2 to Crosswalk (ft)	Approx. Travel Time (sec)	Speed Increase (mph)	Exiting Speed (mph)
Northbound	18	26	48	1.8	9	27
Southbound	19	28	45	1.6	8	27
Eastbound	22	32	41	1.3	6	28
Westbound	18	26	54	2.1	10	28



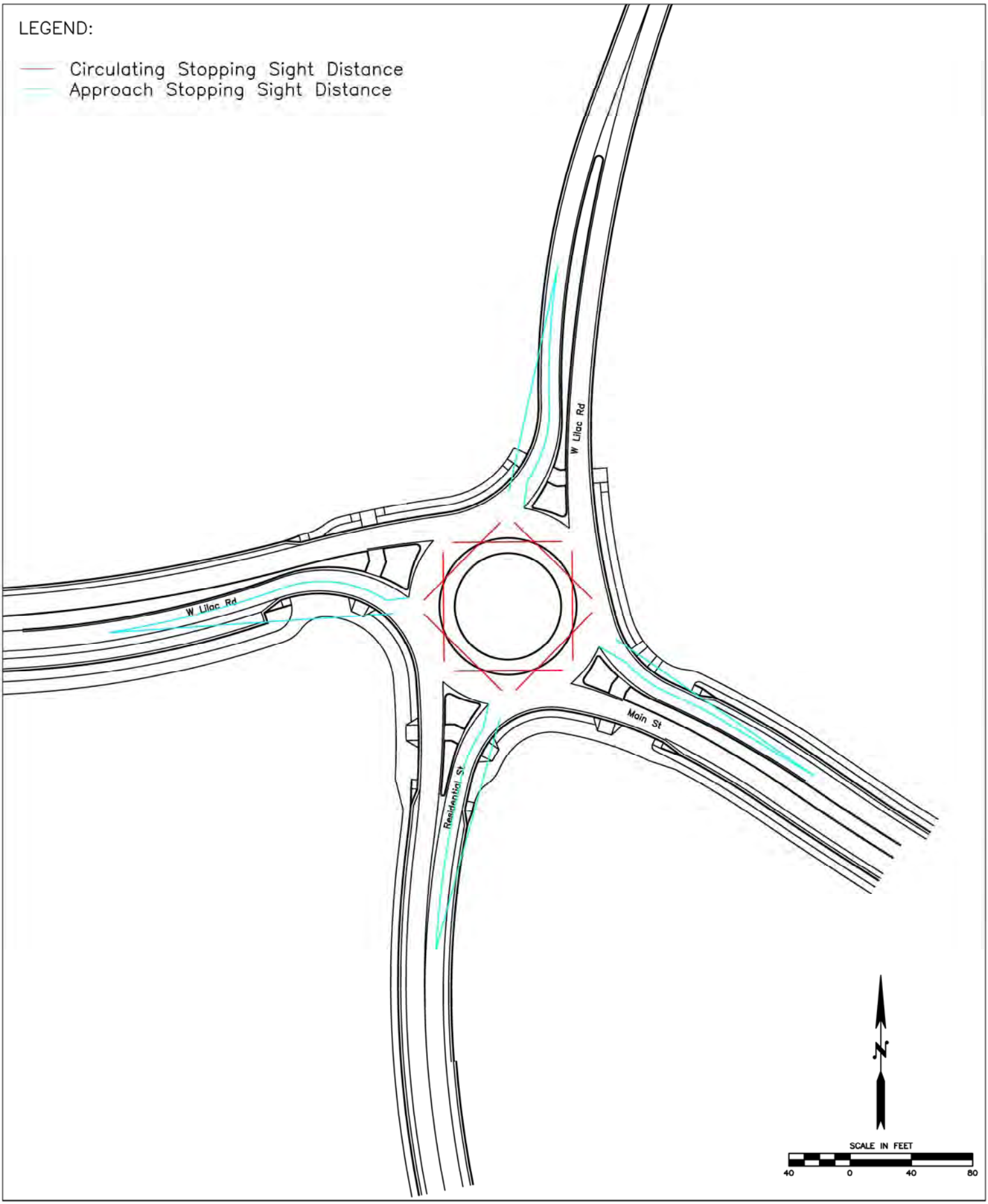
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - Pedestrian Stopping Sight Distance

Figure B-8

W Lilac Rd Roundabouts

October 2013



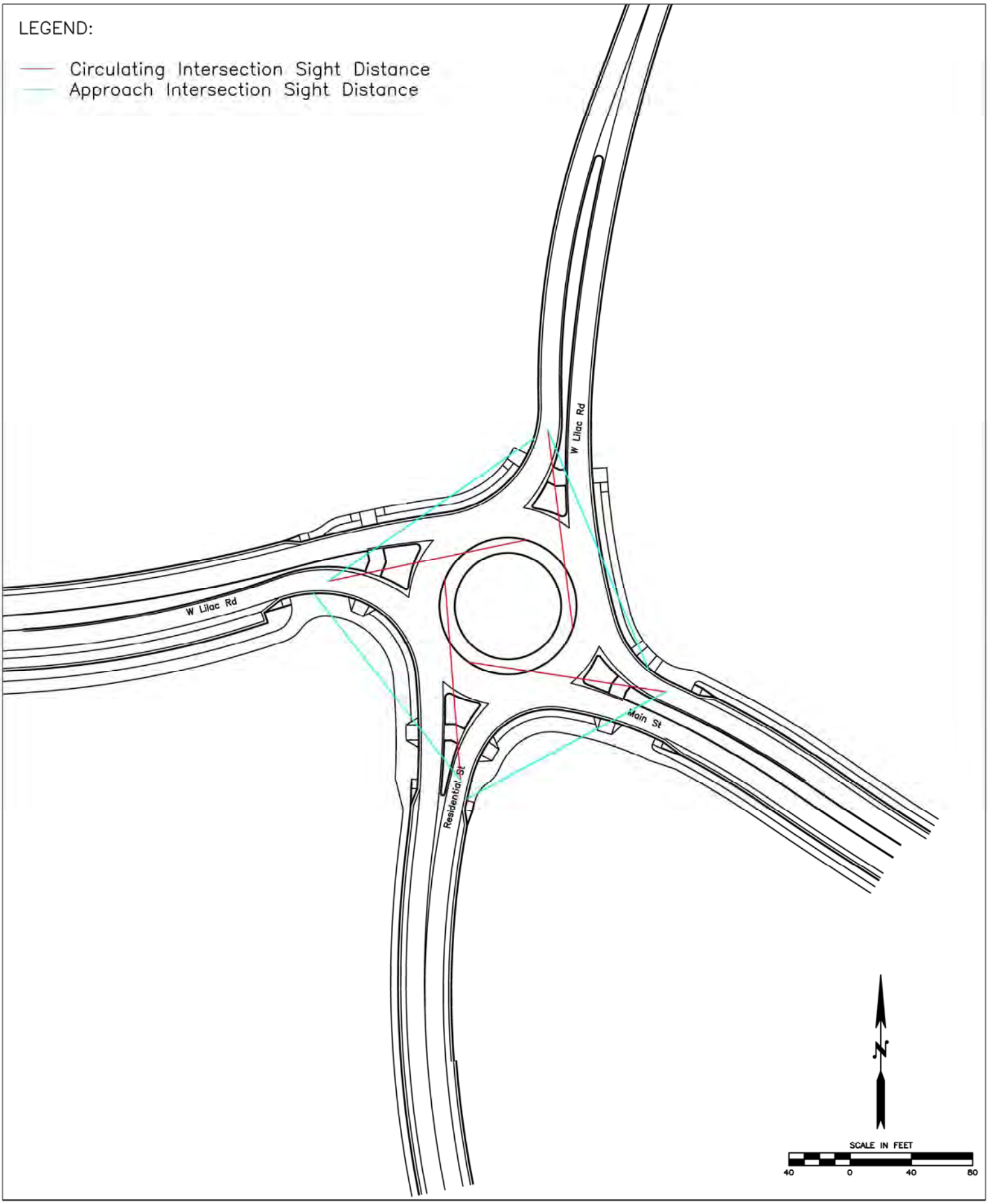
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - Traffic Stopping Sight Distance

Figure B-9

W Lilac Rd Roundabouts

October 2013



ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 - Intersection Sight Distance

Figure B-10

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 1 - Sight Distance Calculations

W Lilac Rd Roundabouts
October 2013

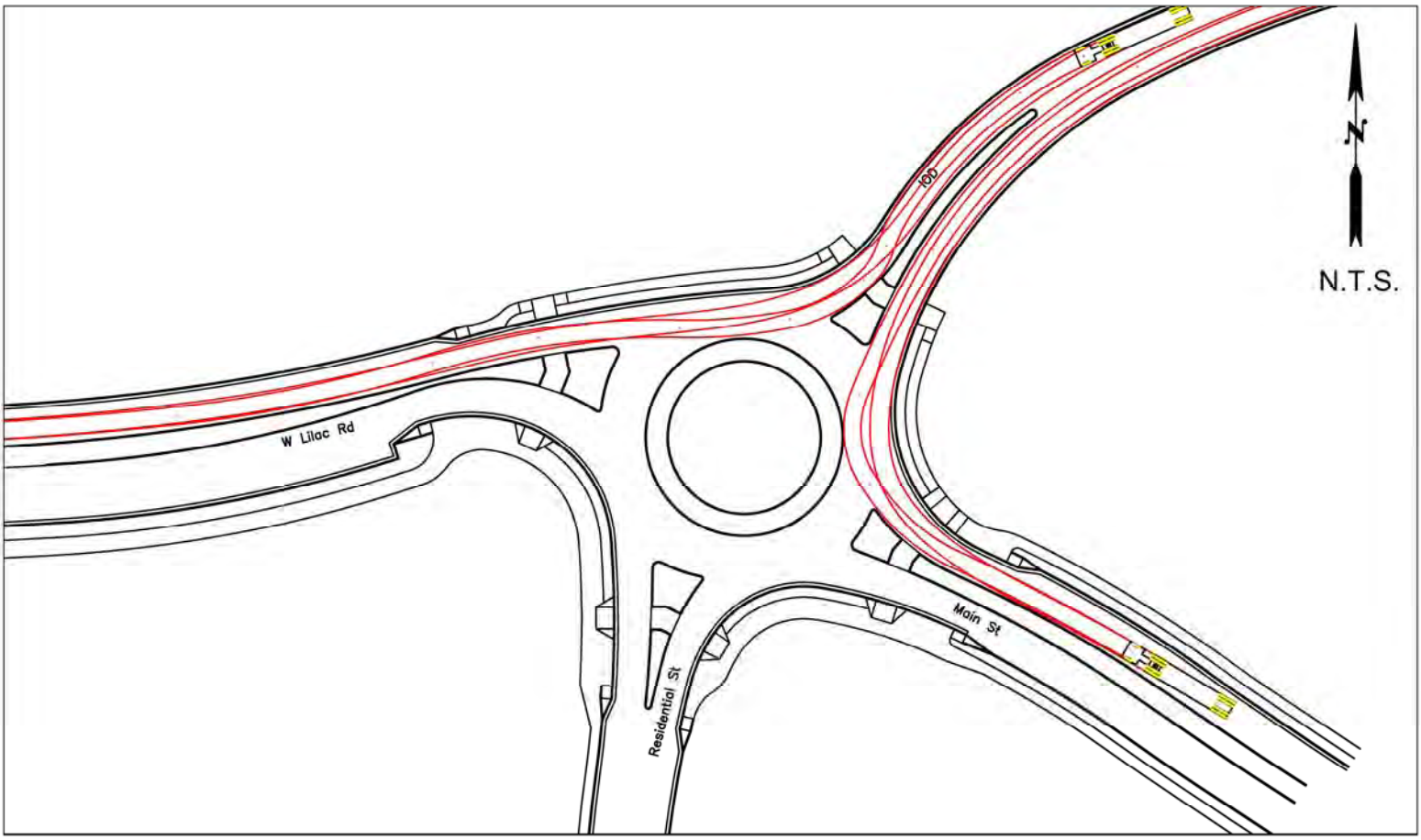
Stopping Sight Distance d= 1.468*2.5*V+1.087*V^2/11.2

	Posted Speed Limit (mph)	R1 Speed (mph)	Average Approach Speed (mph)	Approach Stopping Sight Distance (ft)	R2 Speed (mph)	R3 Speed (mph)	Average Exit Speed (mph)	Exit Stopping Sight Distance (ft)
Northbound	30	22	26	**161**	19	27	23	**136**
Southbound	30	21	26	**157**	19	27	23	**136**
Eastbound	40	20	30	**197**	22	28	25	**152**
Westbound	30	22	26	**161**	18	28	23	**136**

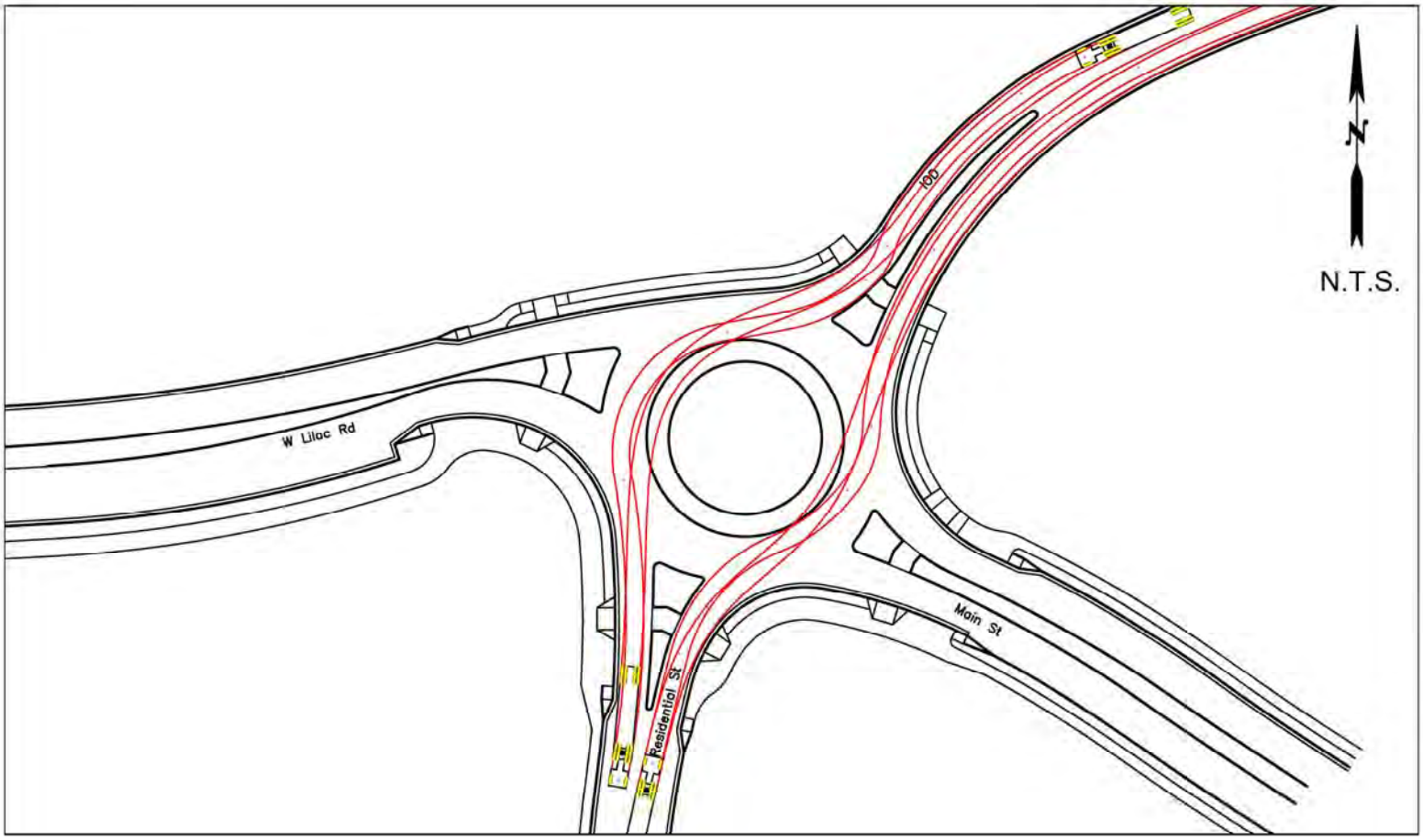
	Circulating Speed (mph)	Circulating Stopping Sight Distance (ft)
Circulating	15	**77**

Intersection Sight Distance S= 1.468*V*5.0

	Adjacent R1 Speed (mph)	Adjacent R2 Speed (mph)	Average Adjacent Entering Speed (mph)	Circulating Stream Speed (mph)	S1 - Entering Intersection Sight Distance (ft)	S2 - Circulating Intersection Sight Distance (ft)
Northbound	20	22	21	15	**154**	**110**
Southbound	22	18	20	15	**147**	**110**
Eastbound	21	19	20	15	**147**	**110**
Westbound	22	19	21	15	**150**	**110**



WB-50 Turning Movements



WB-50 Turning Movements

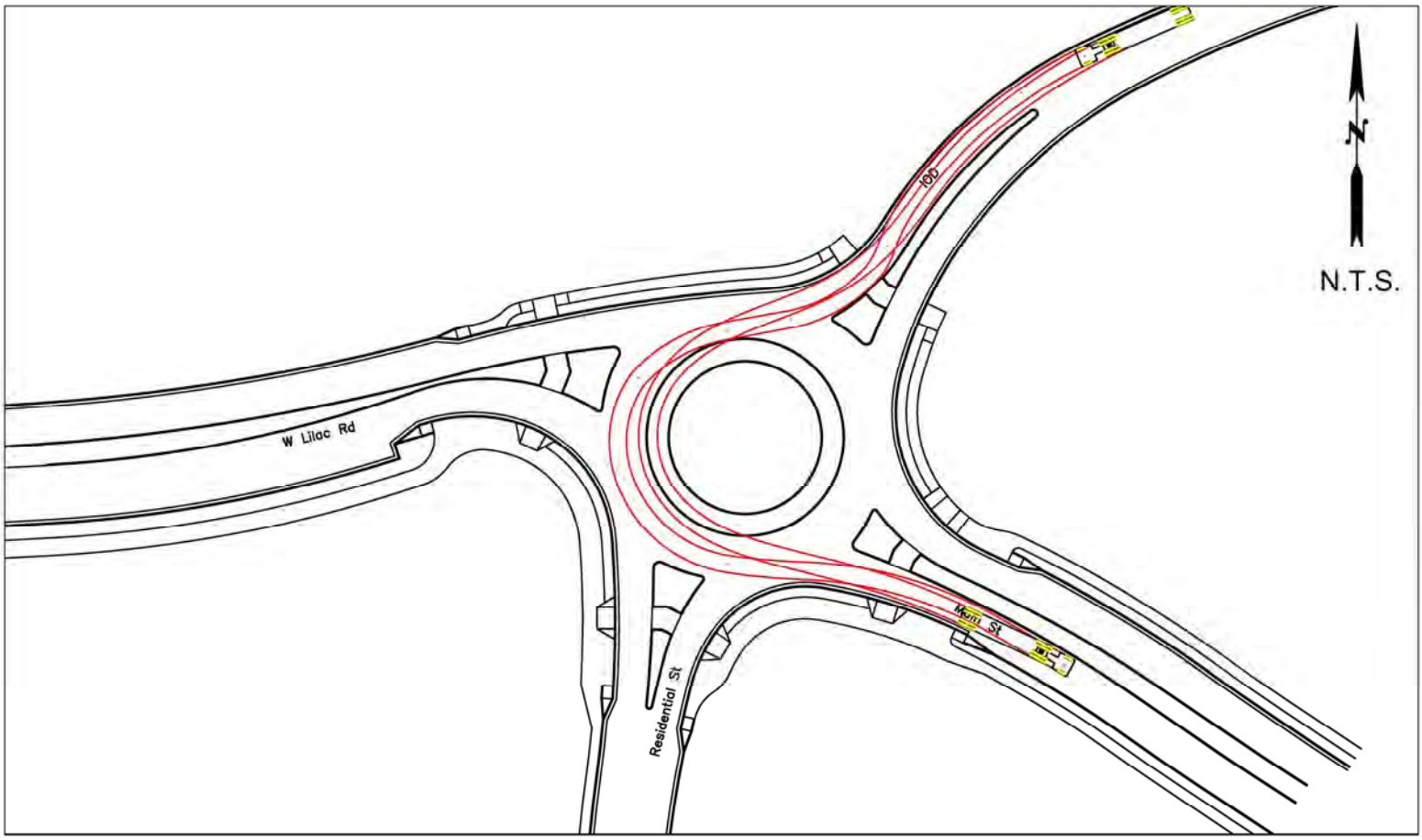
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - TRUCK TURNING

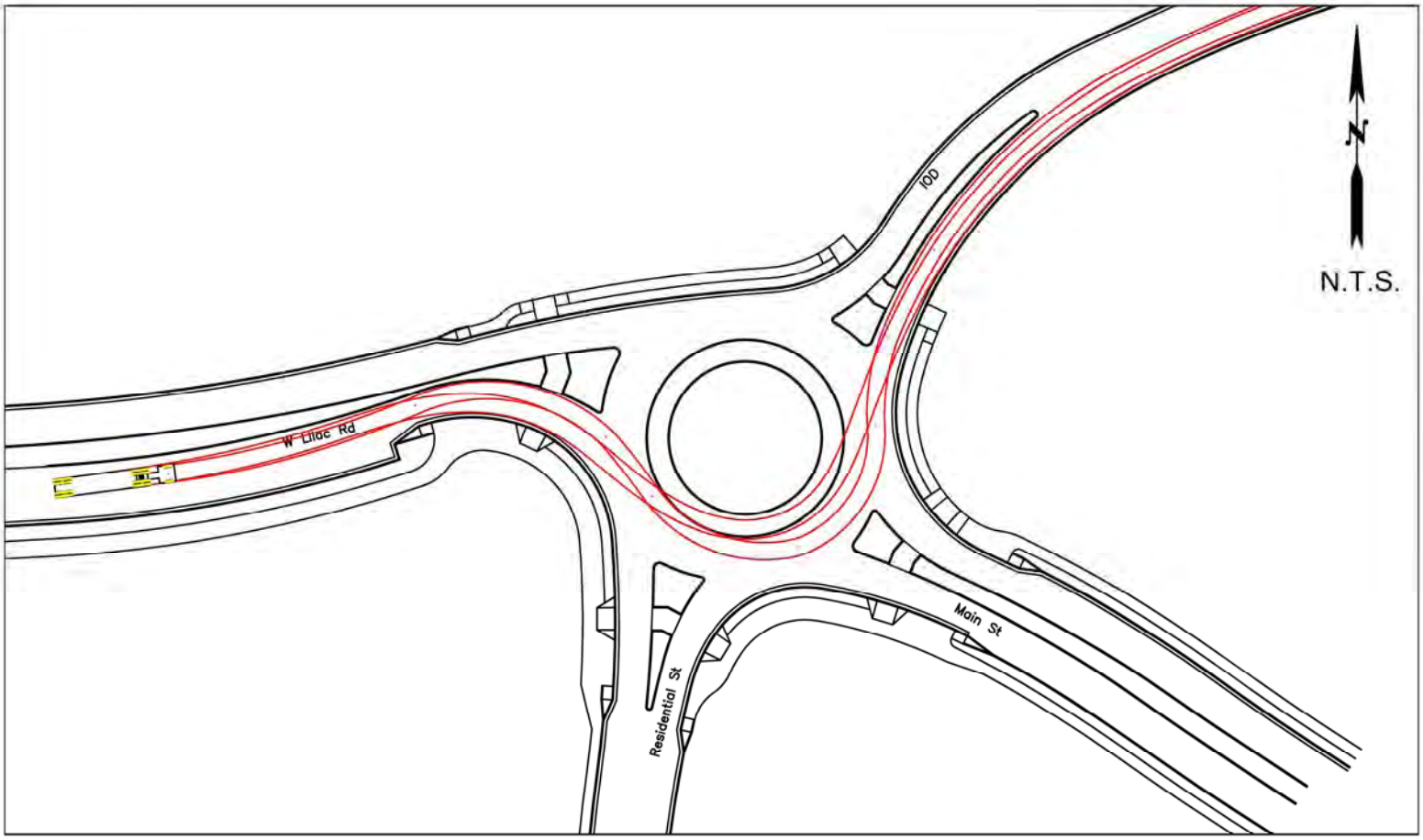
W Lilac Rd Roundabouts

Figure B-12

October 2013



WB-50 Turning Movements



WB-50 Turning Movements

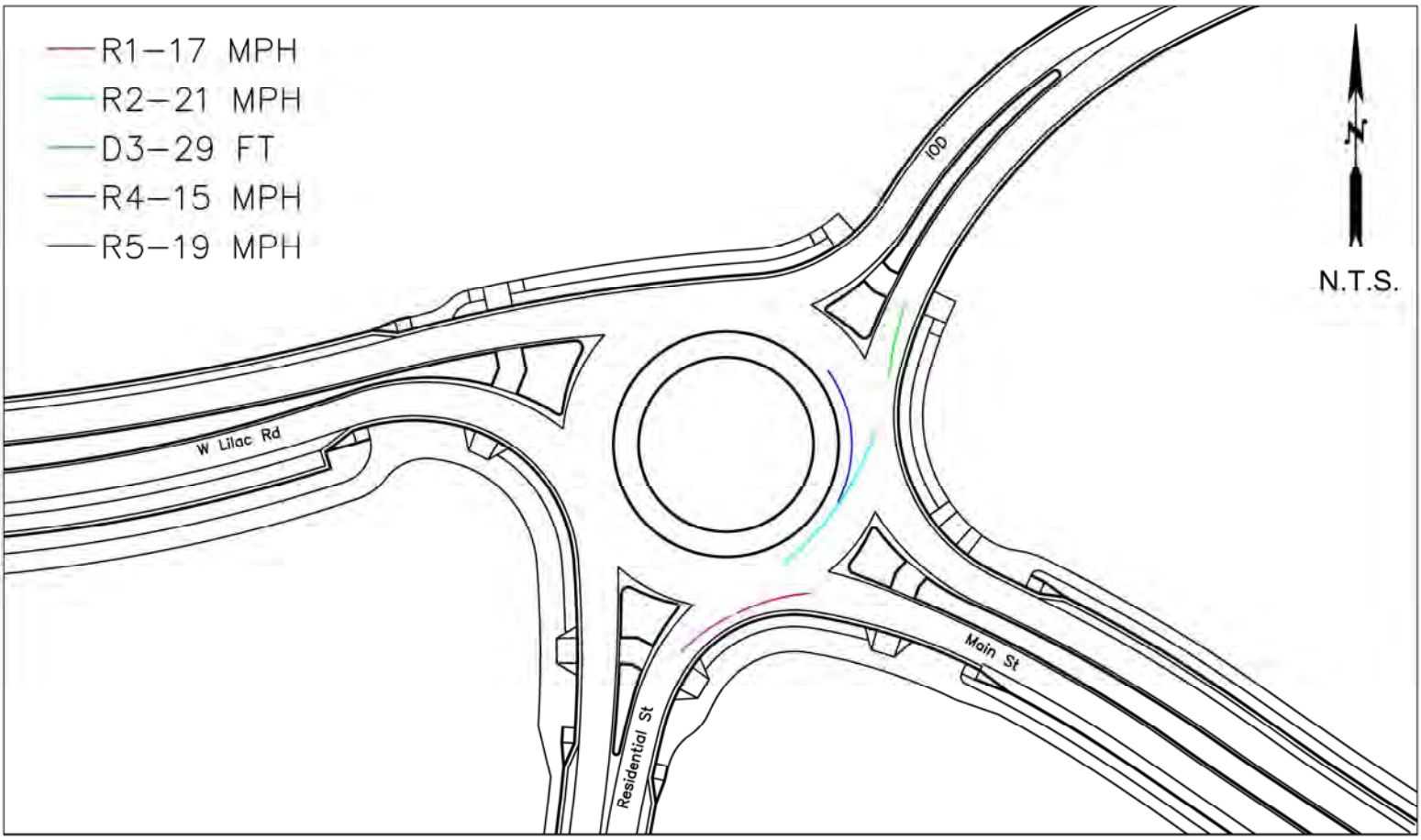
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - TRUCK TURNING

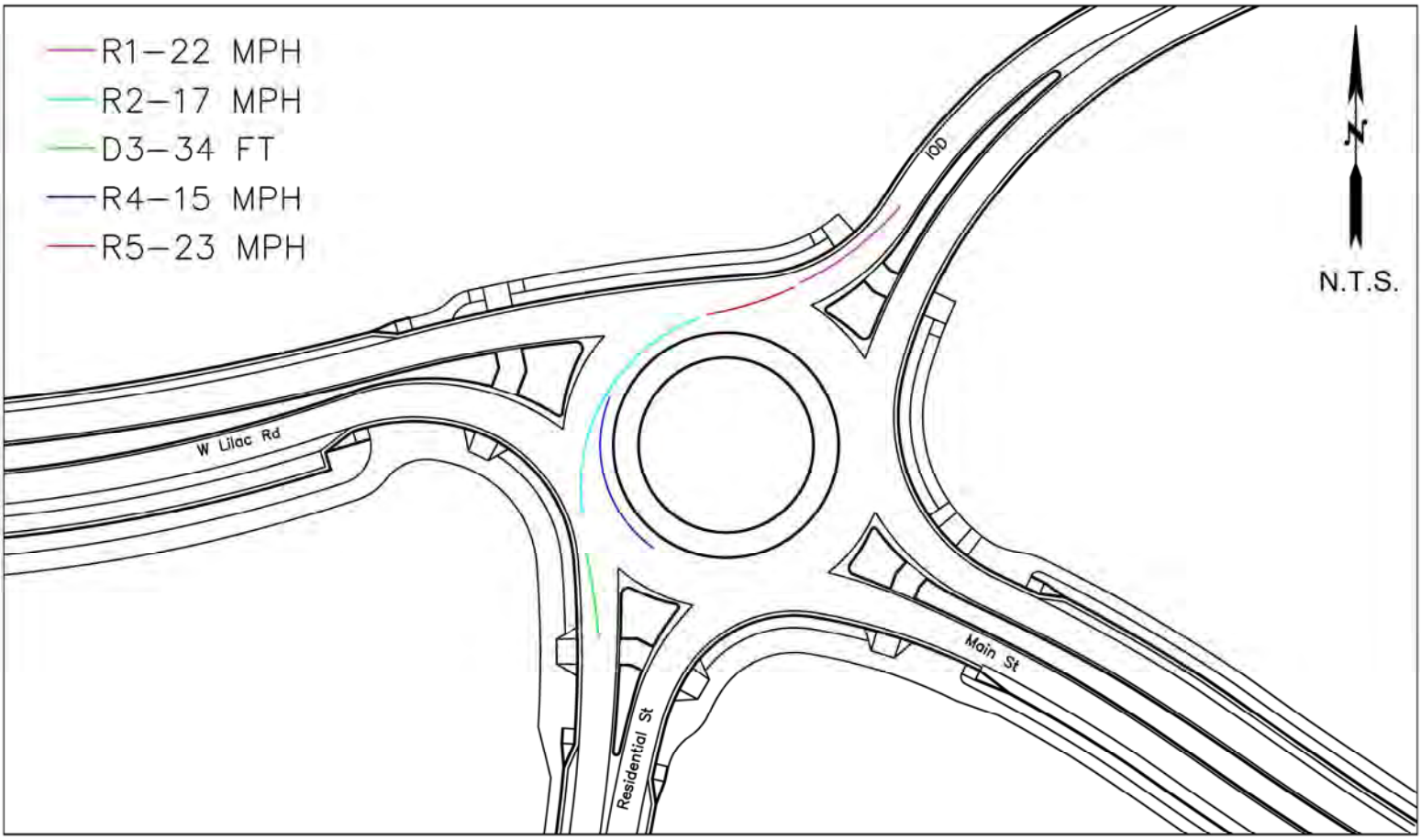
W Lilac Rd Roundabouts

Figure B-13

October 2013



Northbound



Southbound

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - SPEED CURVES

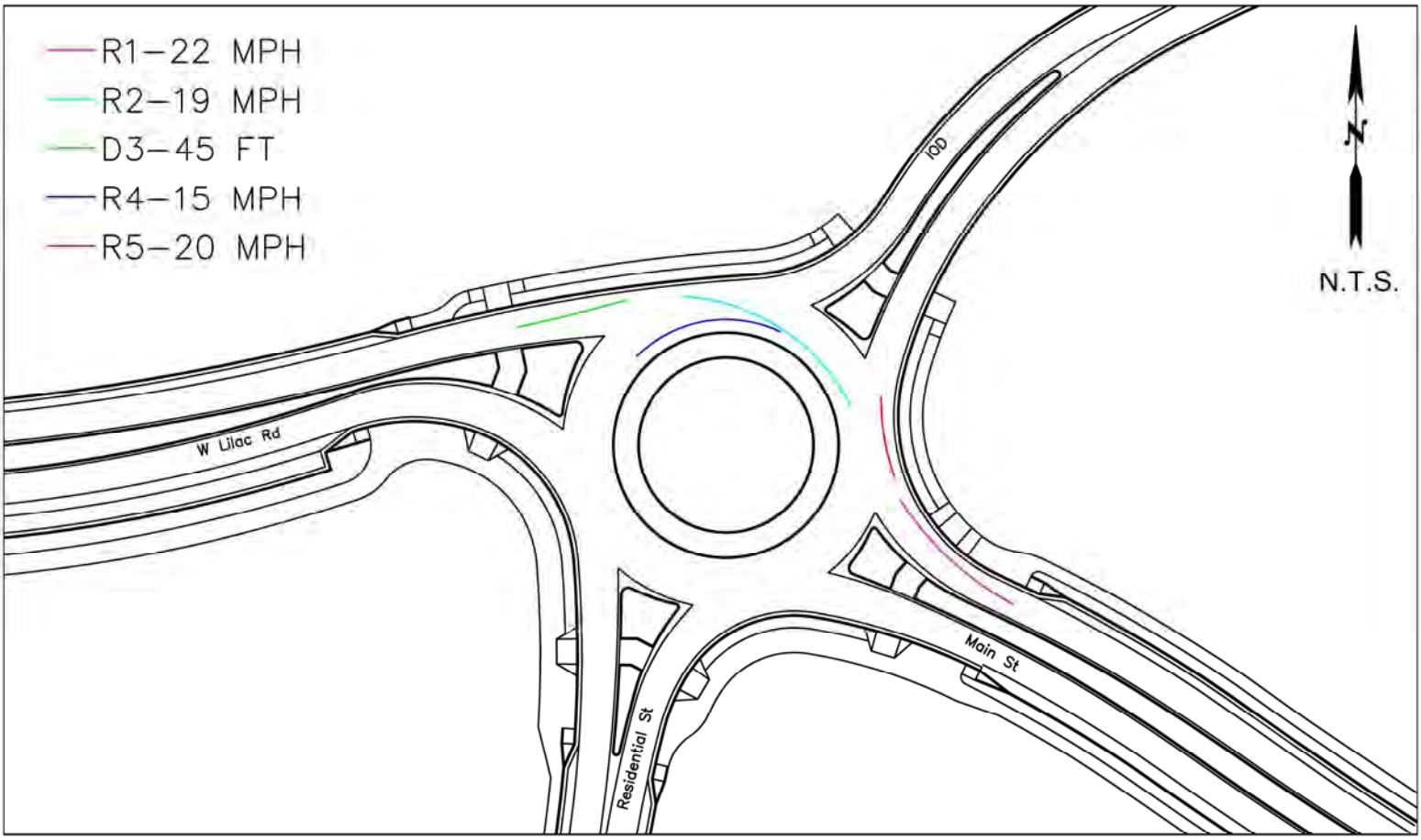
Figure B-14

W Lilac Rd Roundabouts

October 2013

See Figure B–6 for Eastbound Speed Curves

Eastbound



Westbound

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - SPEED CURVES

W Lilac Rd Roundabouts

Figure B-15

October 2013

Reid Middleton RB 1 (Alt A) - Speed Calculations

W Lilac Rd Roundabouts
October 2013

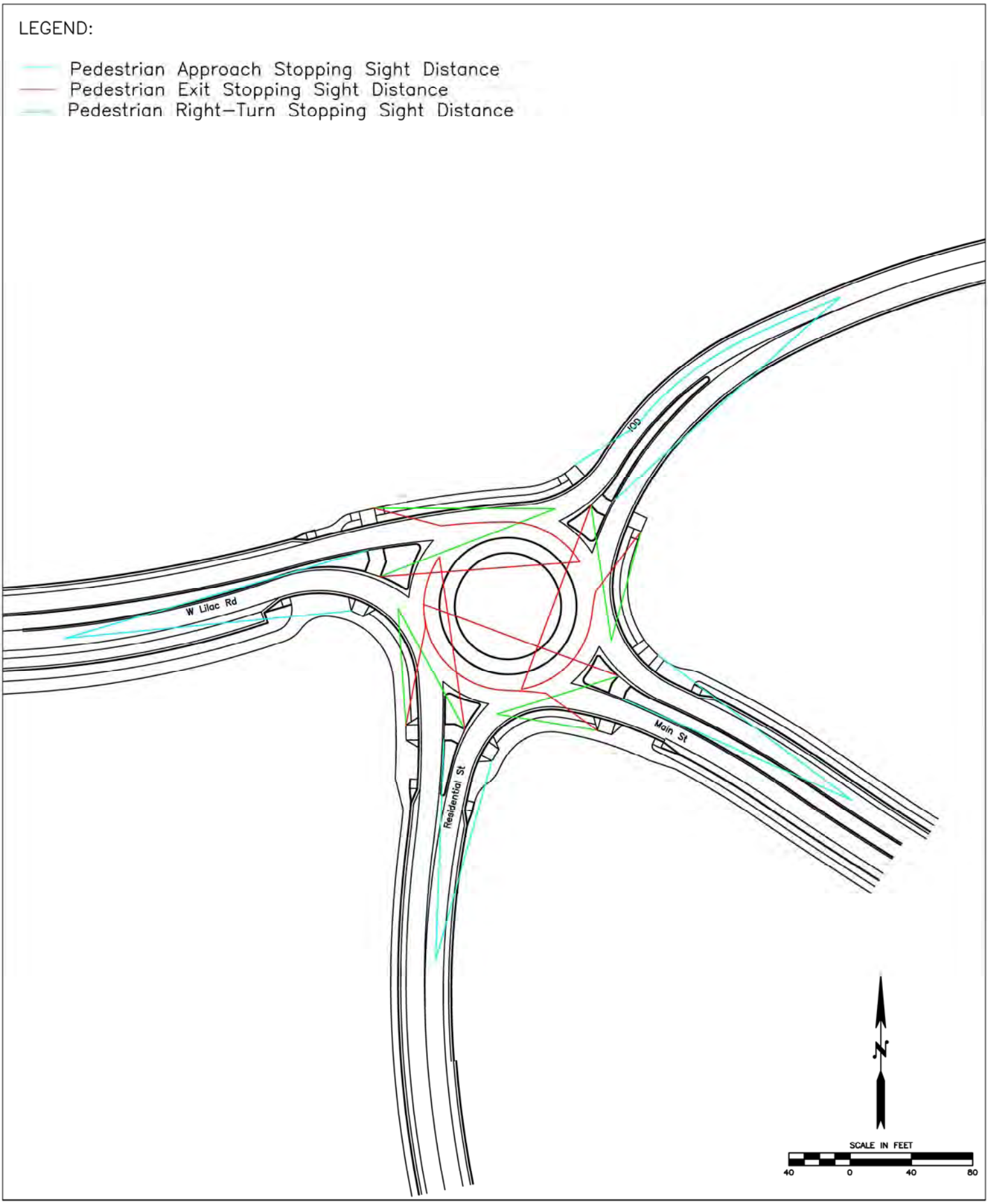
Copied from Roundabout 1

	Northbound		Southbound		Eastbound		Westbound	
	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)
R1	64	17	115	22	88	20	123	22
R2	116	21	71	17	140	22	80	19
R3*	-	25	-	23	-	28	-	28
R4	50	15	50	15	50	15	50	15
R5	75	19	127	23	81	19	90	20

* R3 speed = lesser of [speed-radius table value] or [R2+Acceleration*Distance to Crosswalk)
+2% superelevation assumed for R1, R3, and R5 movements
-2% superelevation assumed for R2 and R4 movements

Calculated R3 Speed from Acceleration and Distance to Crosswalk
FHWA Acceleration 6.9 ft/sec^2 NCHRP Report 572

	Beginning Speed R2 (MPH)	R2 Speed in FT/SEC	Distance from R2 to Crosswalk (ft)	Approx. Travel Time (sec)	Speed Increase (mph)	Exiting Speed (mph)
Northbound	21	31	29	0.9	4	25
Southbound	17	25	34	1.4	6	23
Eastbound	22	32	41	1.3	6	28
Westbound	19	28	45	1.6	8	27



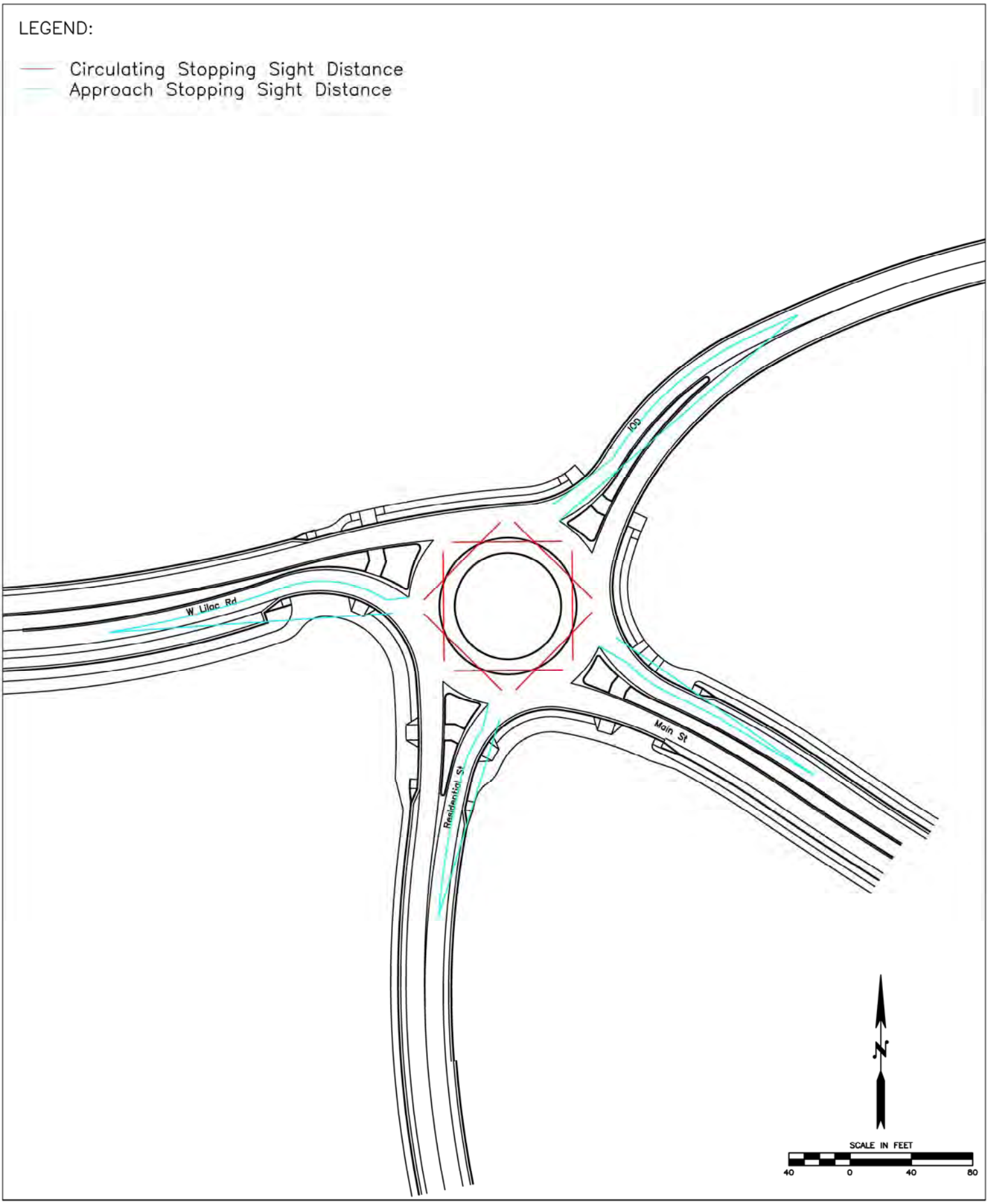
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - Pedestrian Stopping Sight Distance

Figure B-17

W Lilac Rd Roundabouts

October 2013



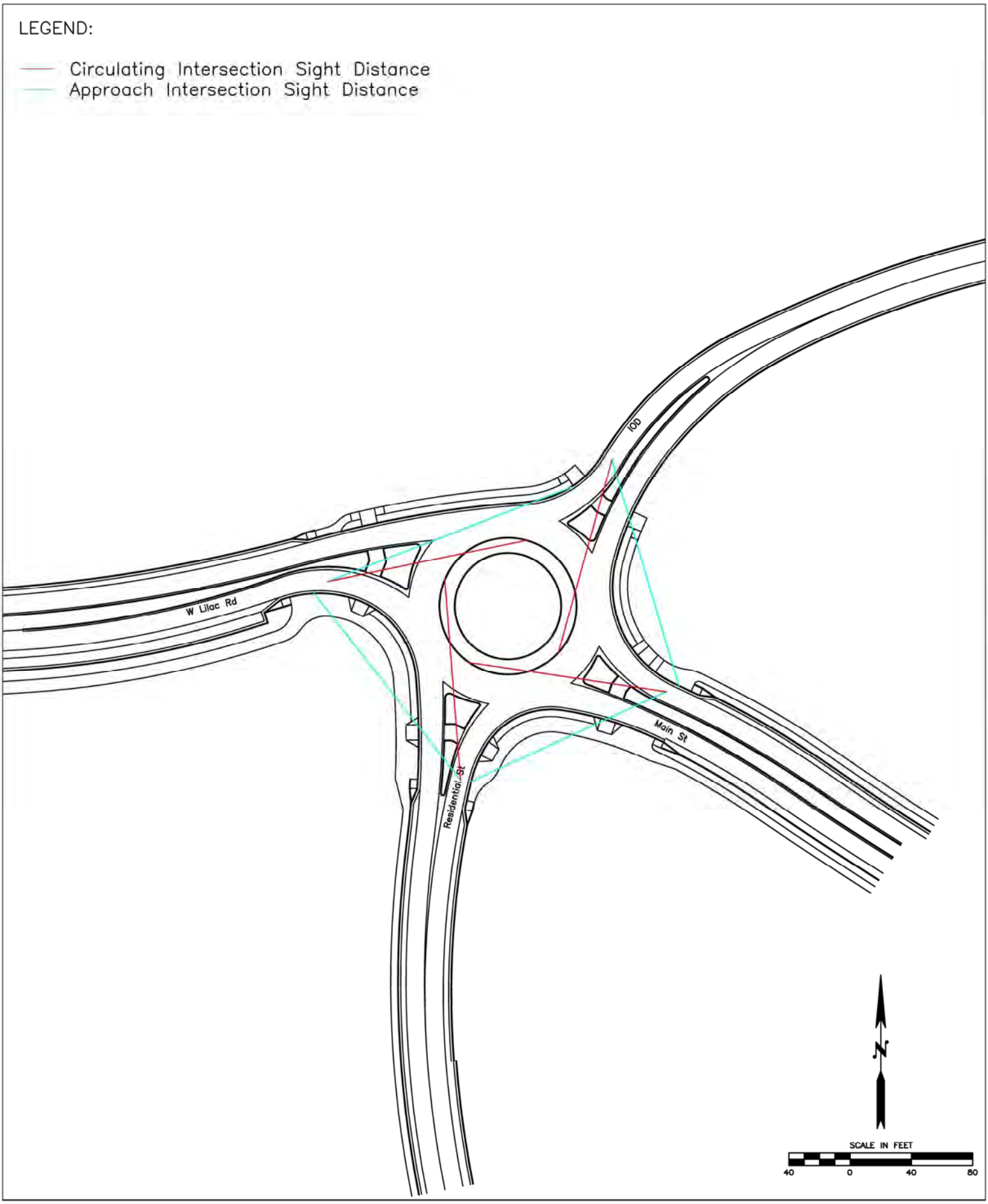
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - Traffic Stopping Sight Distance

Figure B-18

W Lilac Rd Roundabouts

October 2013



Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt A) - Intersection Sight Distance

Figure B-19

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 1 (Alt A) - Sight Distance Calculations

W Lilac Rd Roundabouts
October 2013

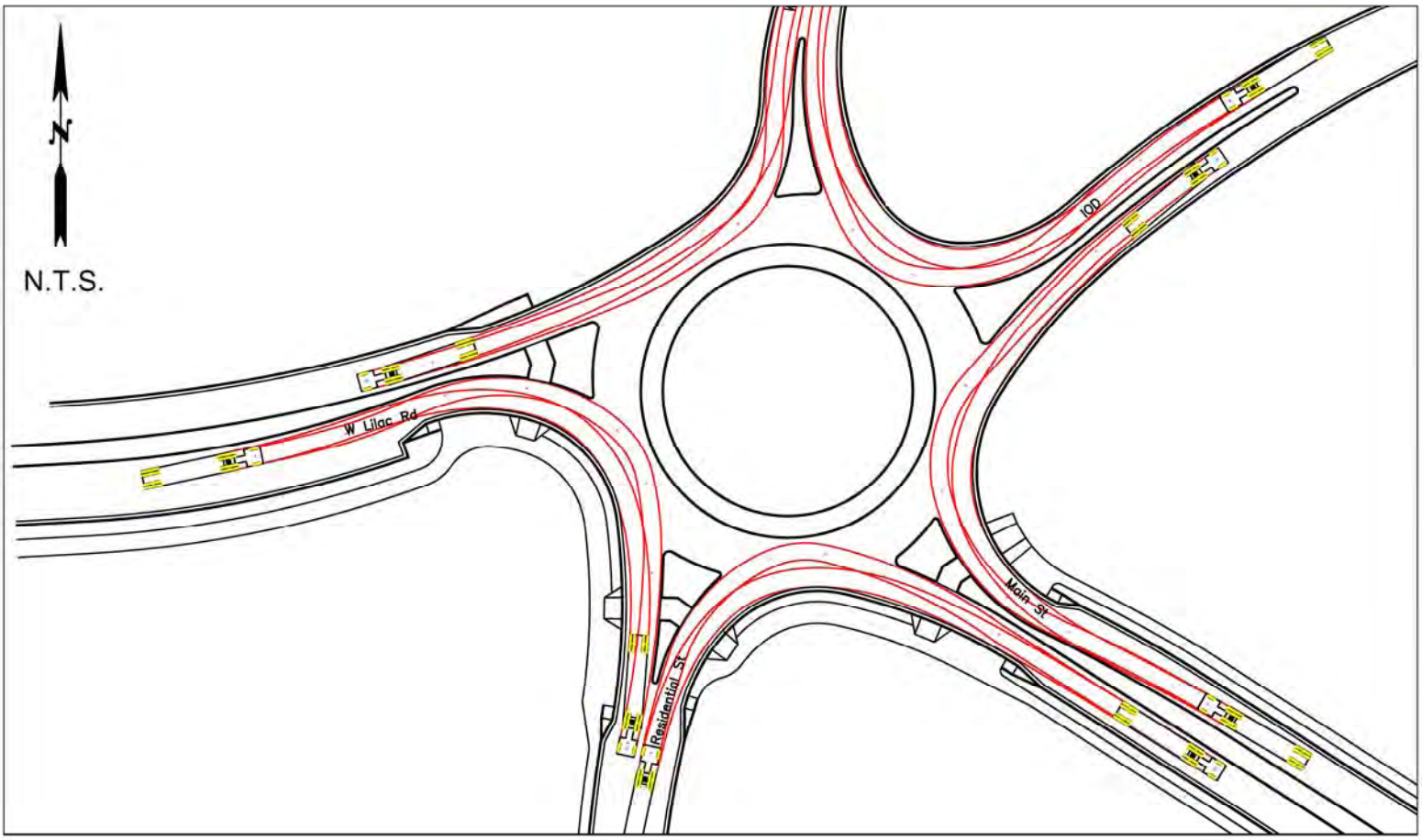
Stopping Sight Distance d= 1.468*2.5*V+1.087*V^2/11.2 **Copied from Roundabout 1**

	Posted Speed Limit (mph)	R1 Speed (mph)	Average Approach Speed (mph)	Approach Stopping Sight Distance (ft)	R2 Speed (mph)	R3 Speed (mph)	Average Exit Speed (mph)	Exit Stopping Sight Distance (ft)
Northbound	30	17	24	**140**	21	25	23	**136**
Southbound	40	22	31	**207**	17	23	20	**112**
Eastbound	40	20	30	**197**	22	28	25	**152**
Westbound	30	22	26	**161**	19	28	24	**140**

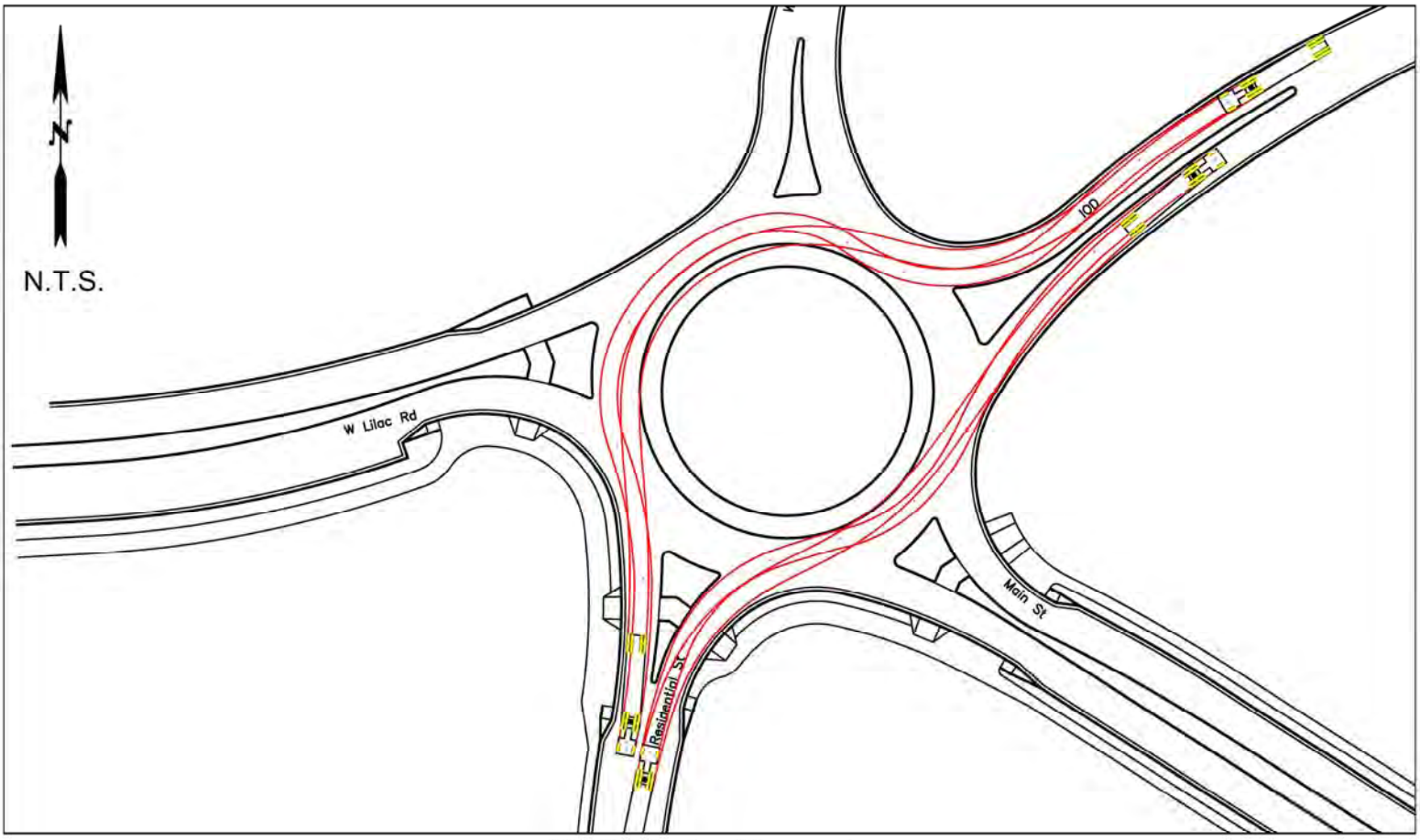
	Circulating Speed (mph)	Circulating Stopping Sight Distance (ft)
Circulating	15	**77**

Intersection Sight Distance S= 1.468*V*5.0

	Adjacent R1 Speed (mph)	Adjacent R2 Speed (mph)	Average Adjacent Entering Speed (mph)	Circulating Stream Speed (mph)	S1 - Entering Intersection Sight Distance (ft)	S2 - Circulating Intersection Sight Distance (ft)
Northbound	20	22	21	15	**154**	**110**
Southbound	22	19	21	15	**150**	**110**
Eastbound	22	17	20	15	**143**	**110**
Westbound	17	21	19	15	**139**	**110**



WB-50 Turning Movements



WB-50 Turning Movements

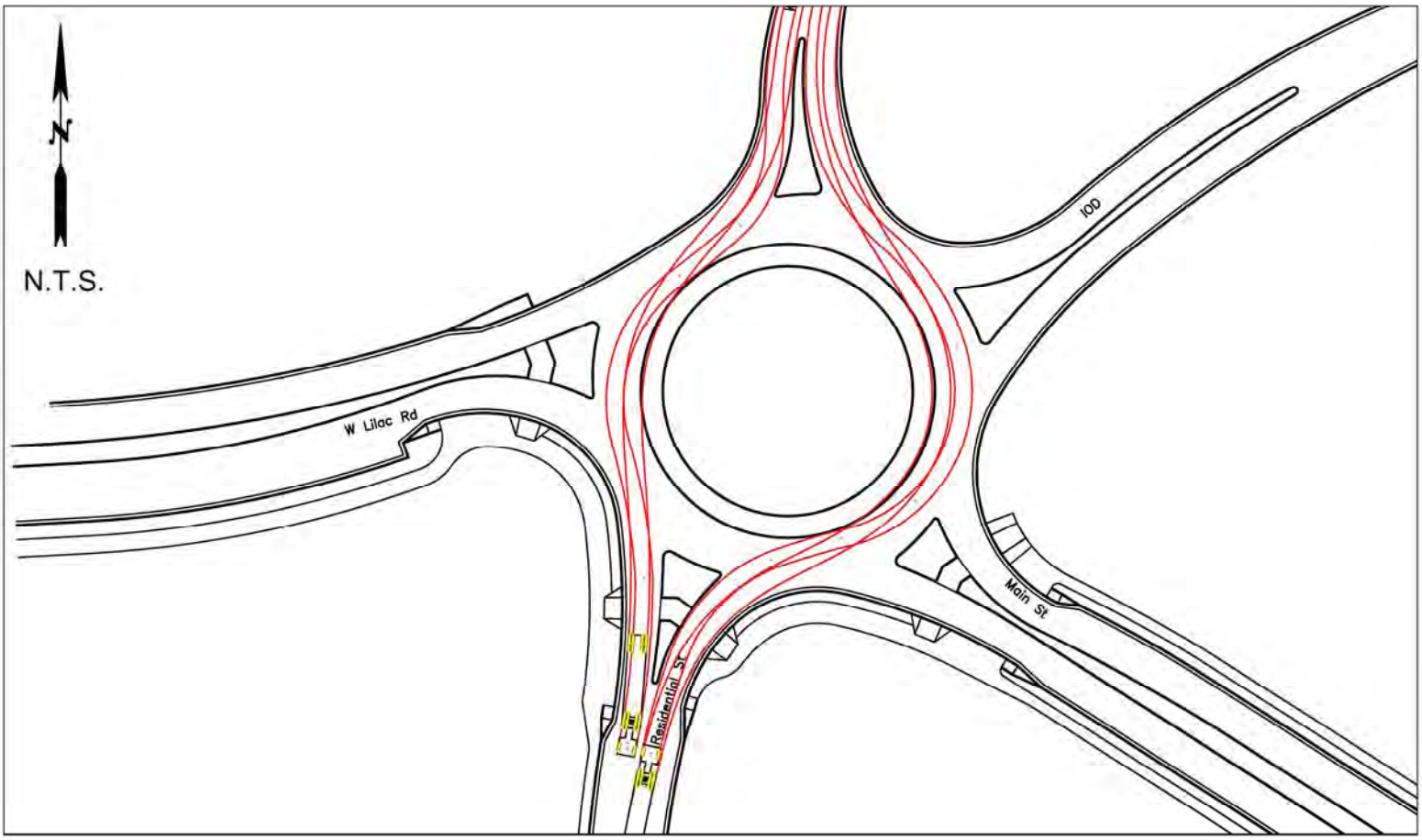
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - TRUCK TURNING

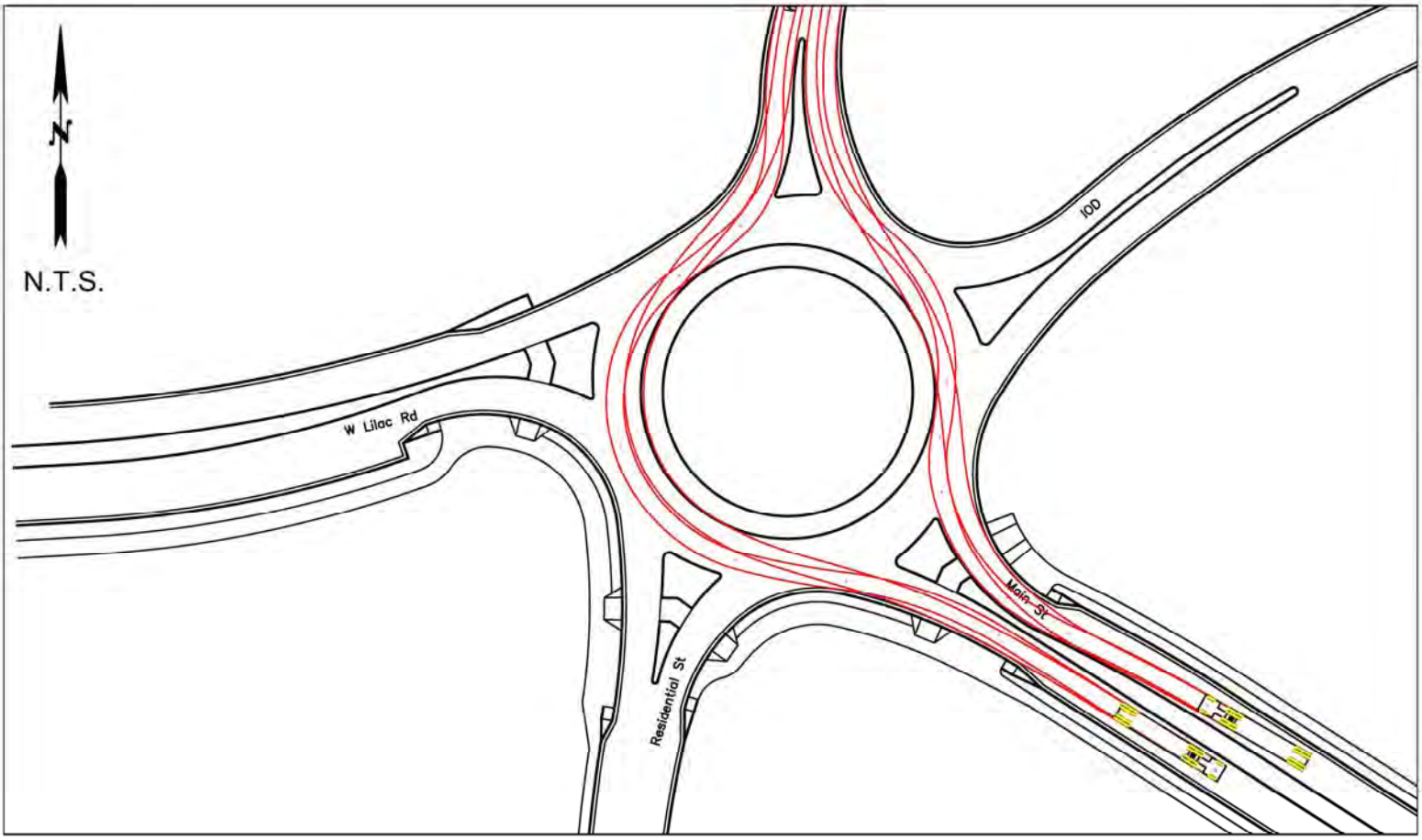
Figure B-21

W Lilac Rd Roundabouts

October 2013



WB-50 Turning Movements



WB-50 Turning Movements

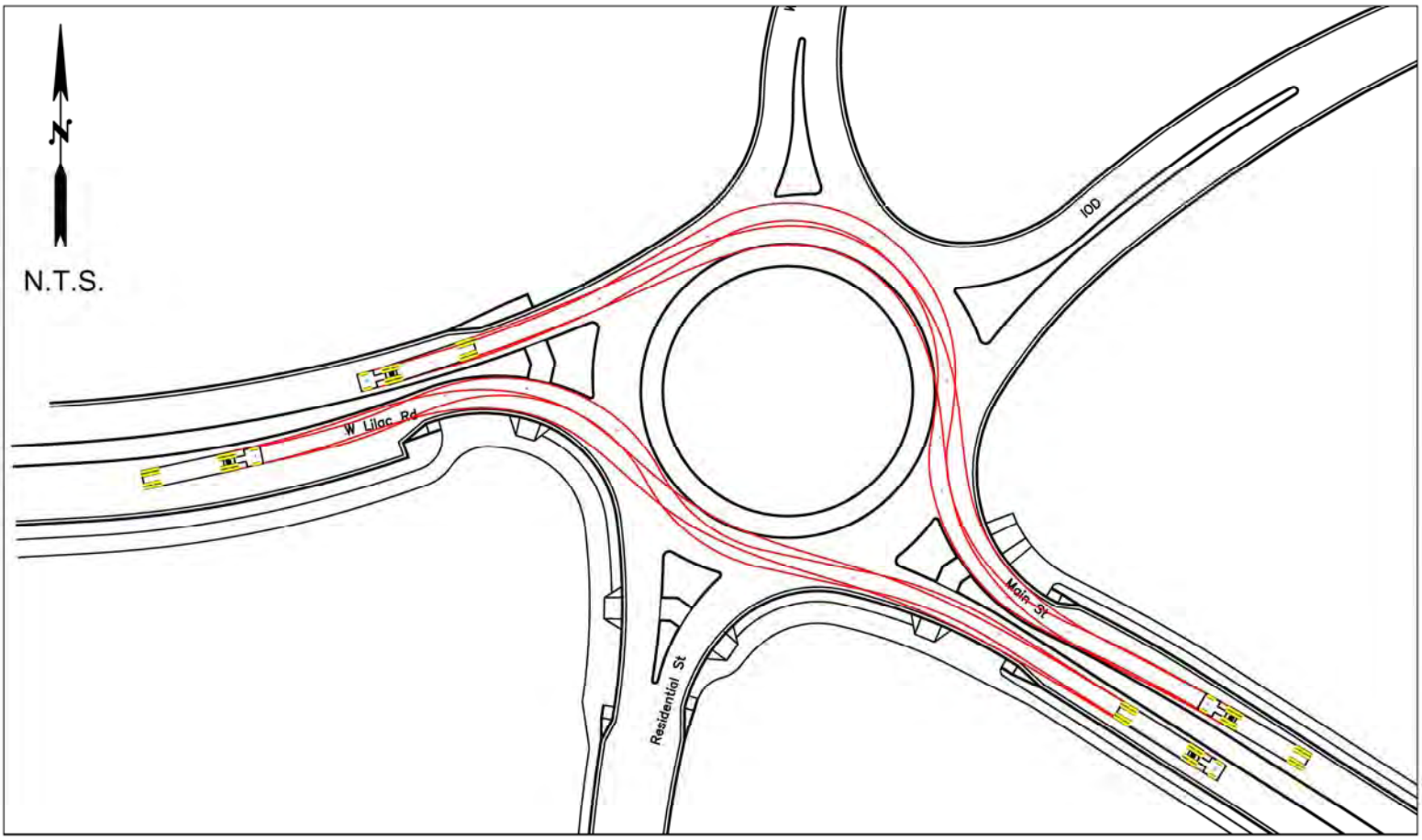
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - TRUCK TURNING

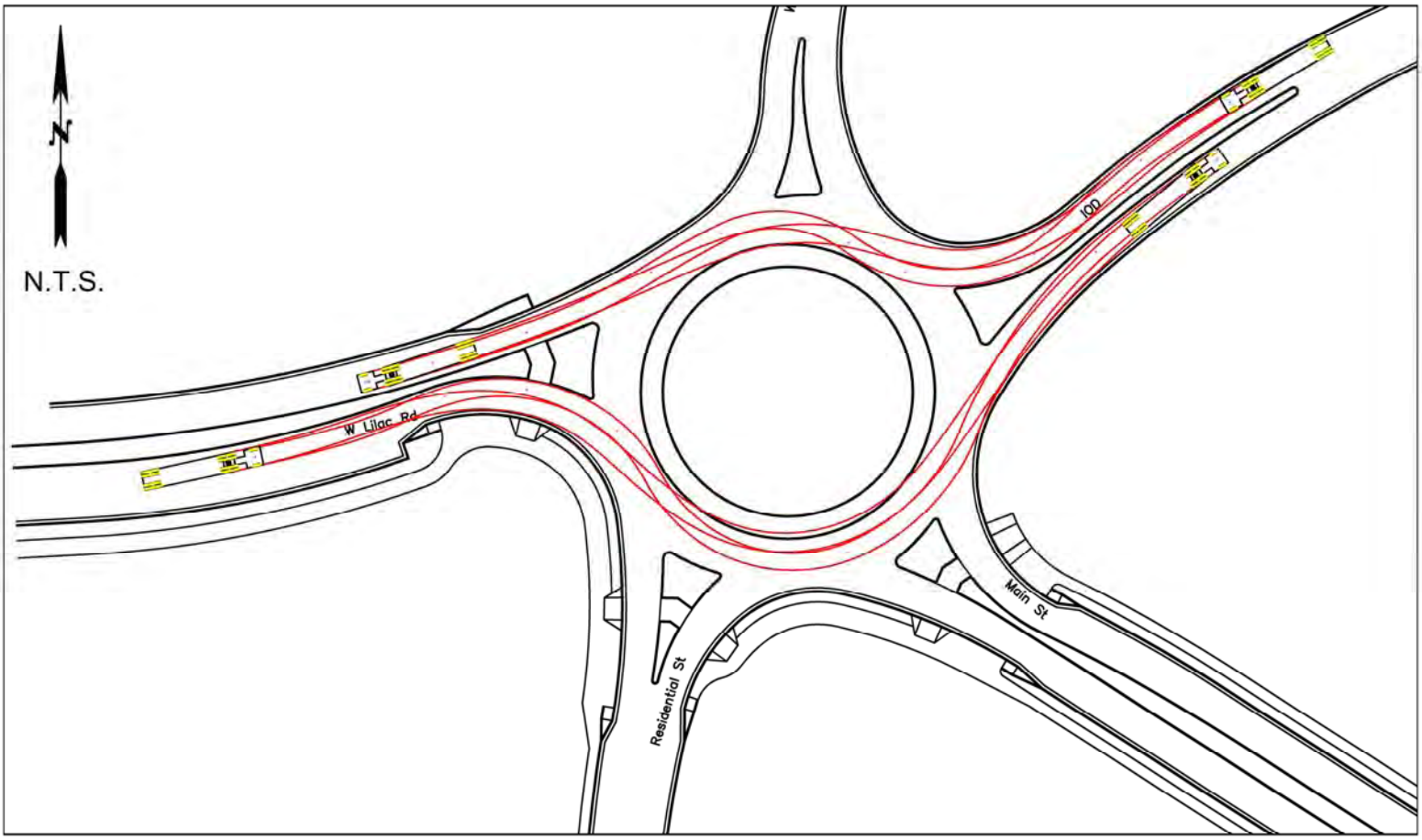
Figure B-22

W Lilac Rd Roundabouts

October 2013



WB-50 Turning Movements



WB-50 Turning Movements

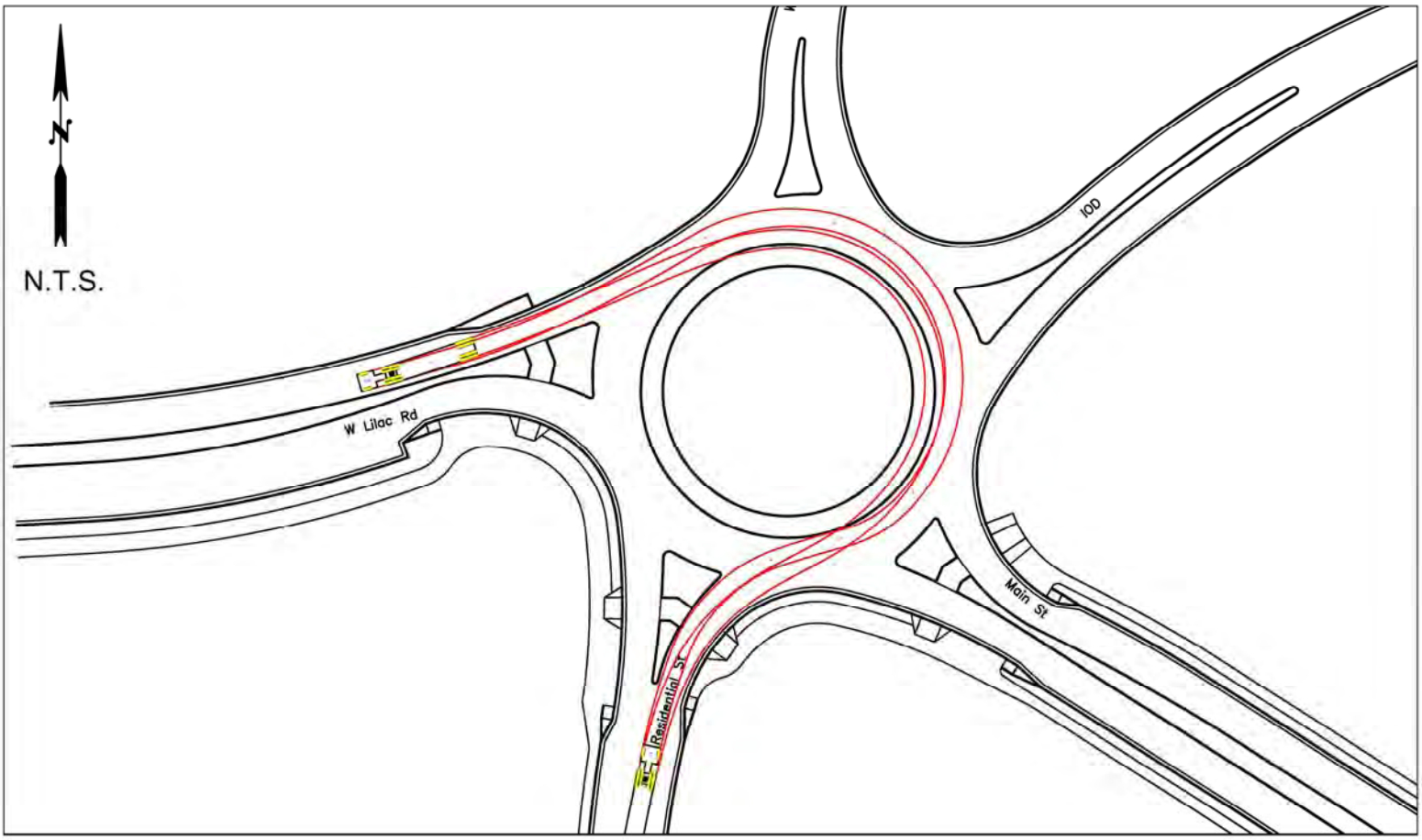
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - TRUCK TURNING

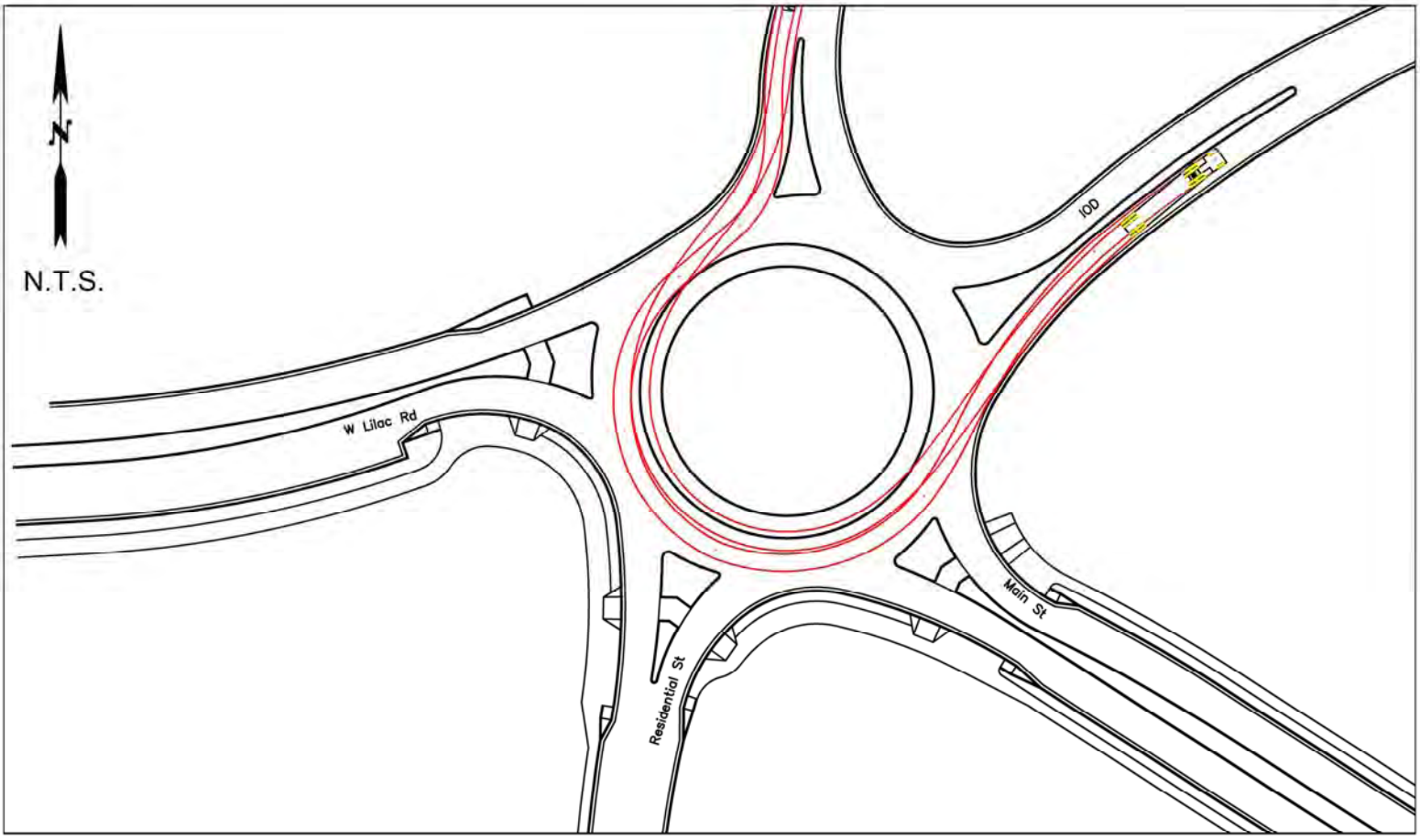
W Lilac Rd Roundabouts

Figure B-23

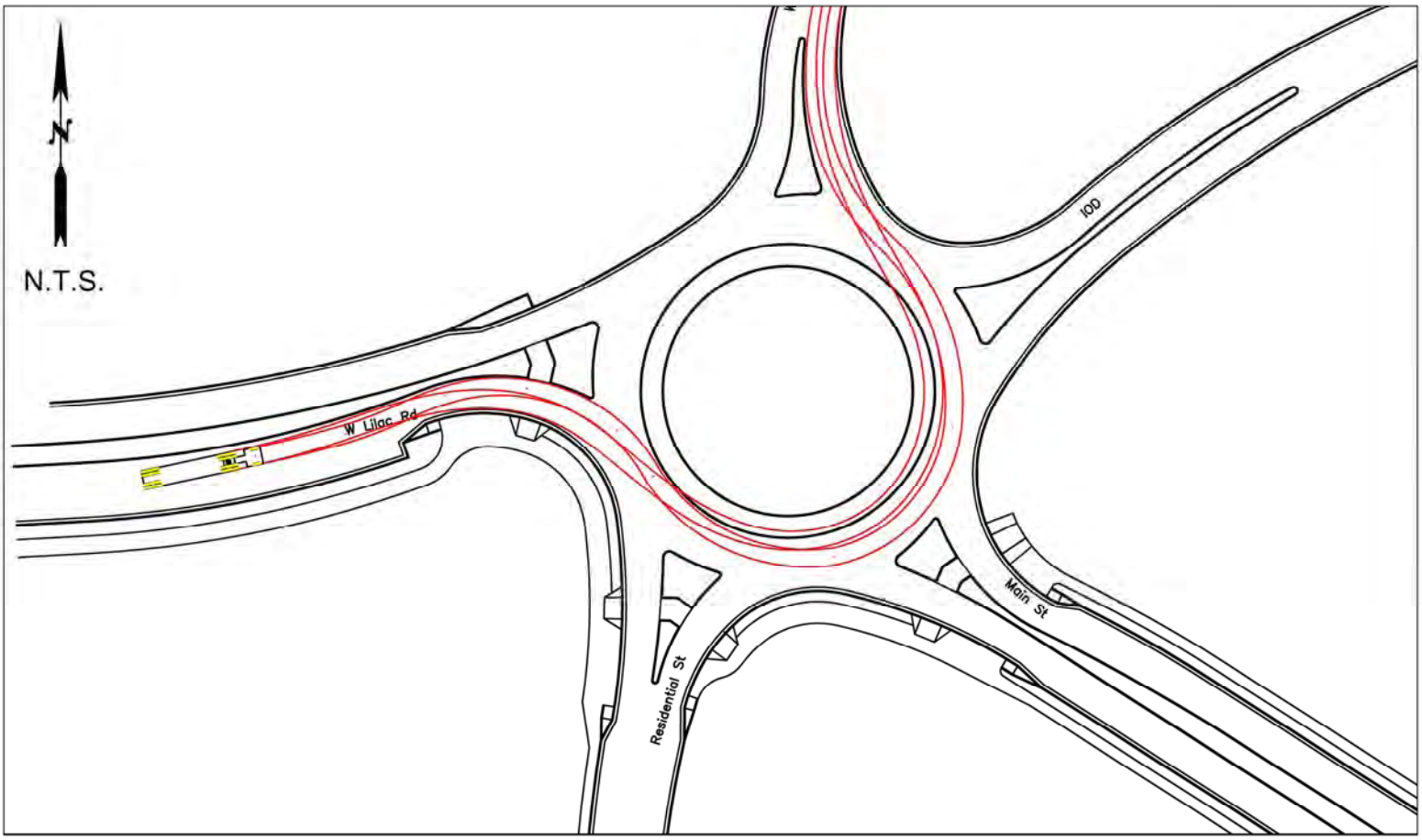
October 2013



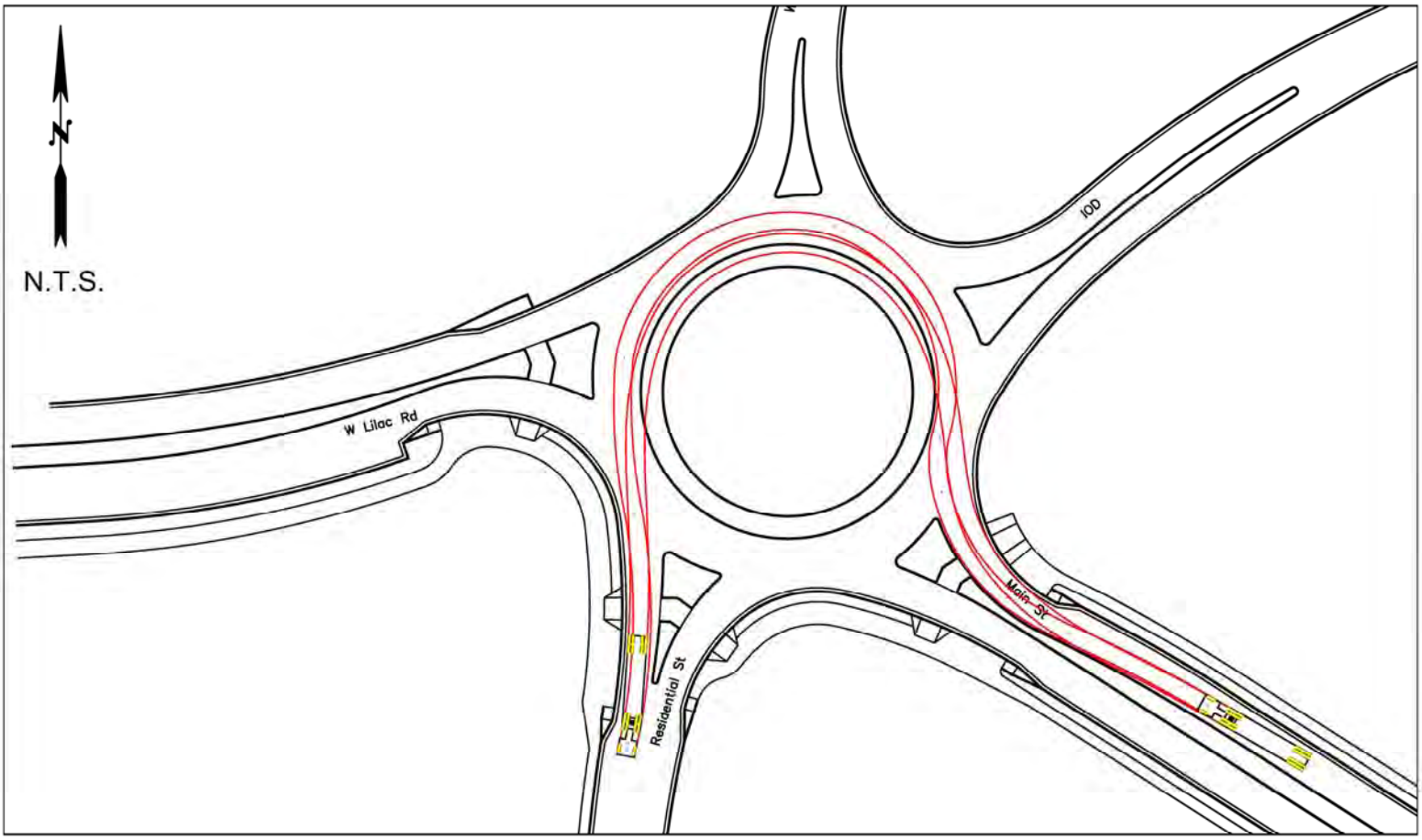
WB-50 Turning Movements



WB-50 Turning Movements



WB-50 Turning Movements



WB-50 Turning Movements

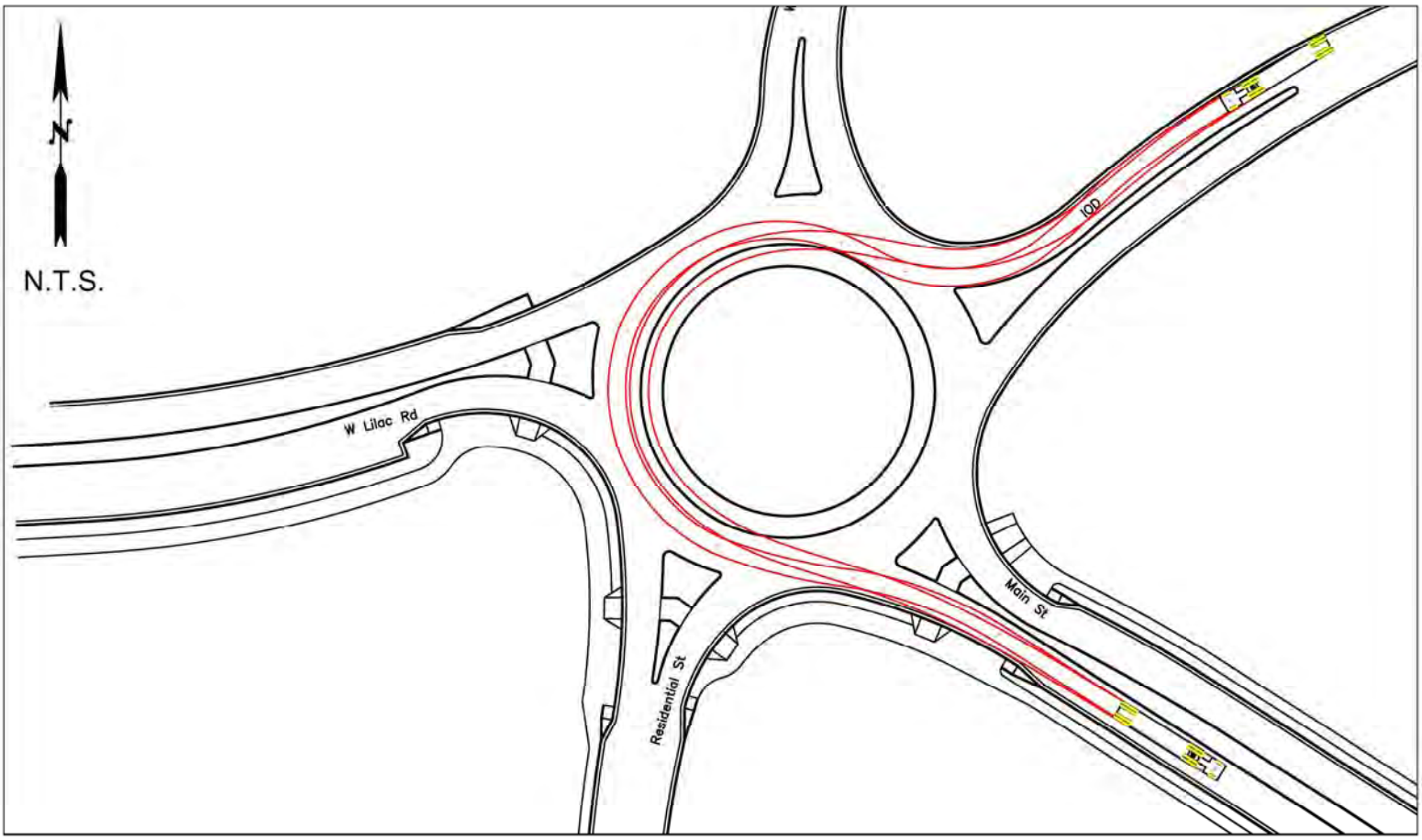
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - TRUCK TURNING

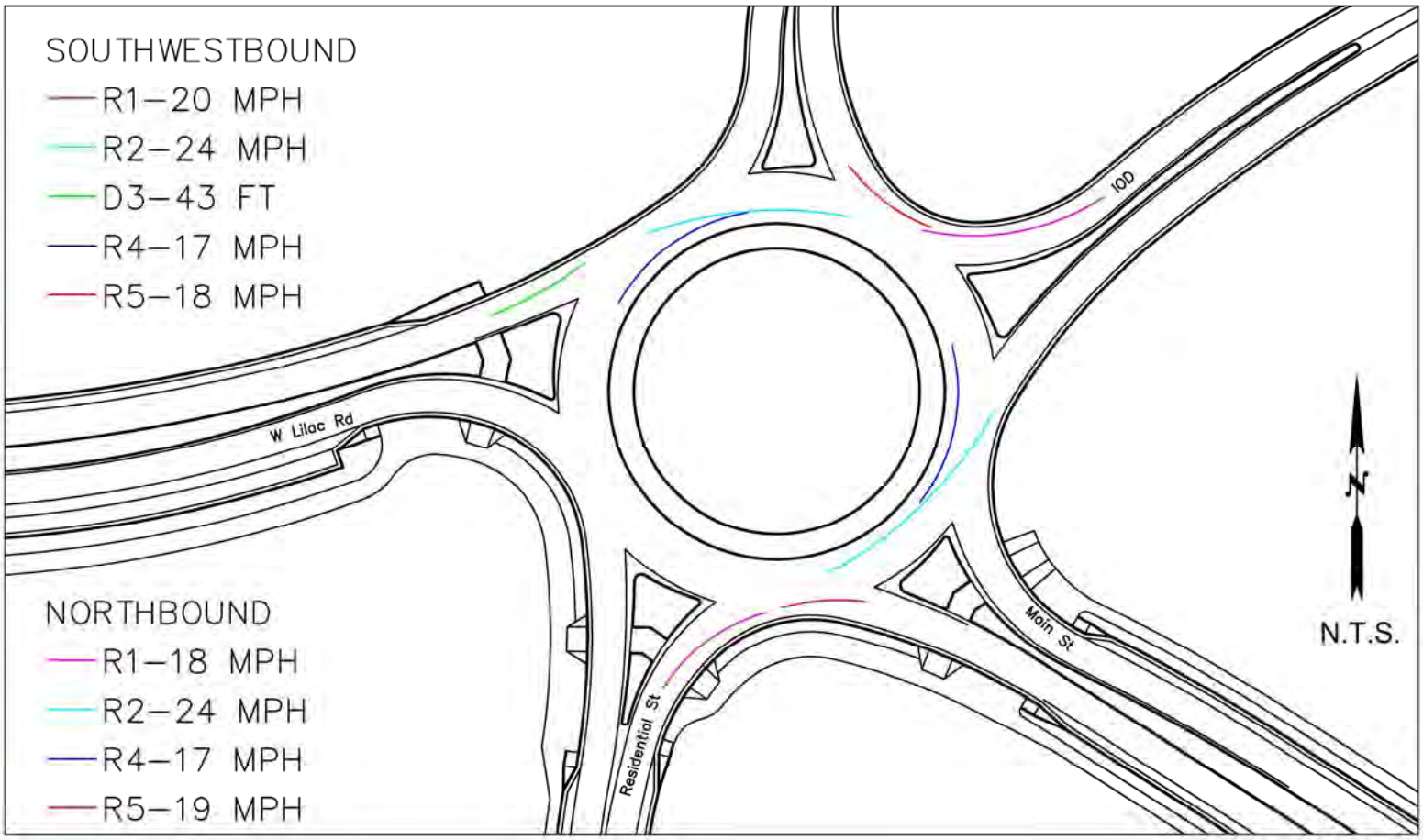
Figure B-25

W Lilac Rd Roundabouts

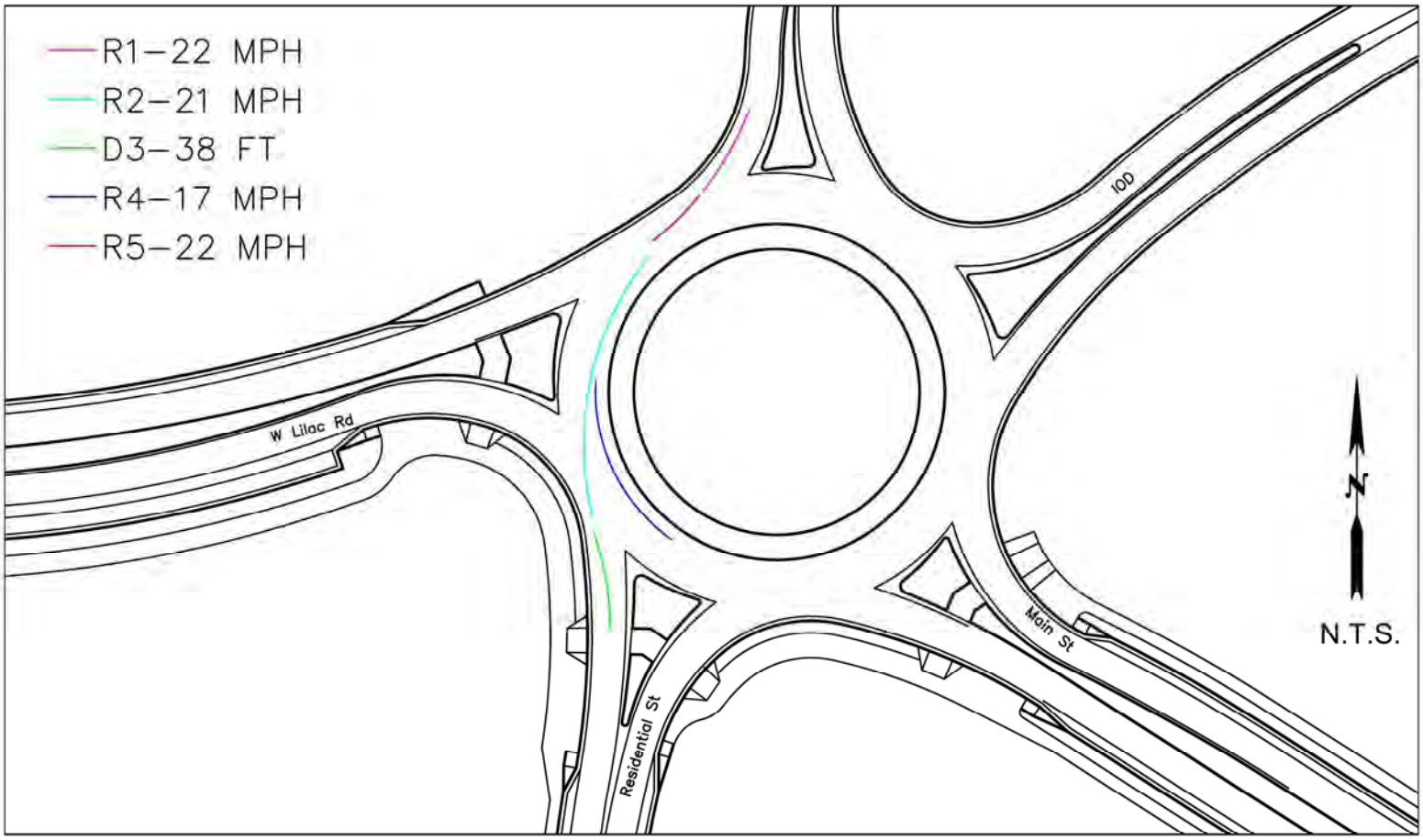
October 2013



WB-50 Turning Movements



Northbound and Southwestbound



Southbound

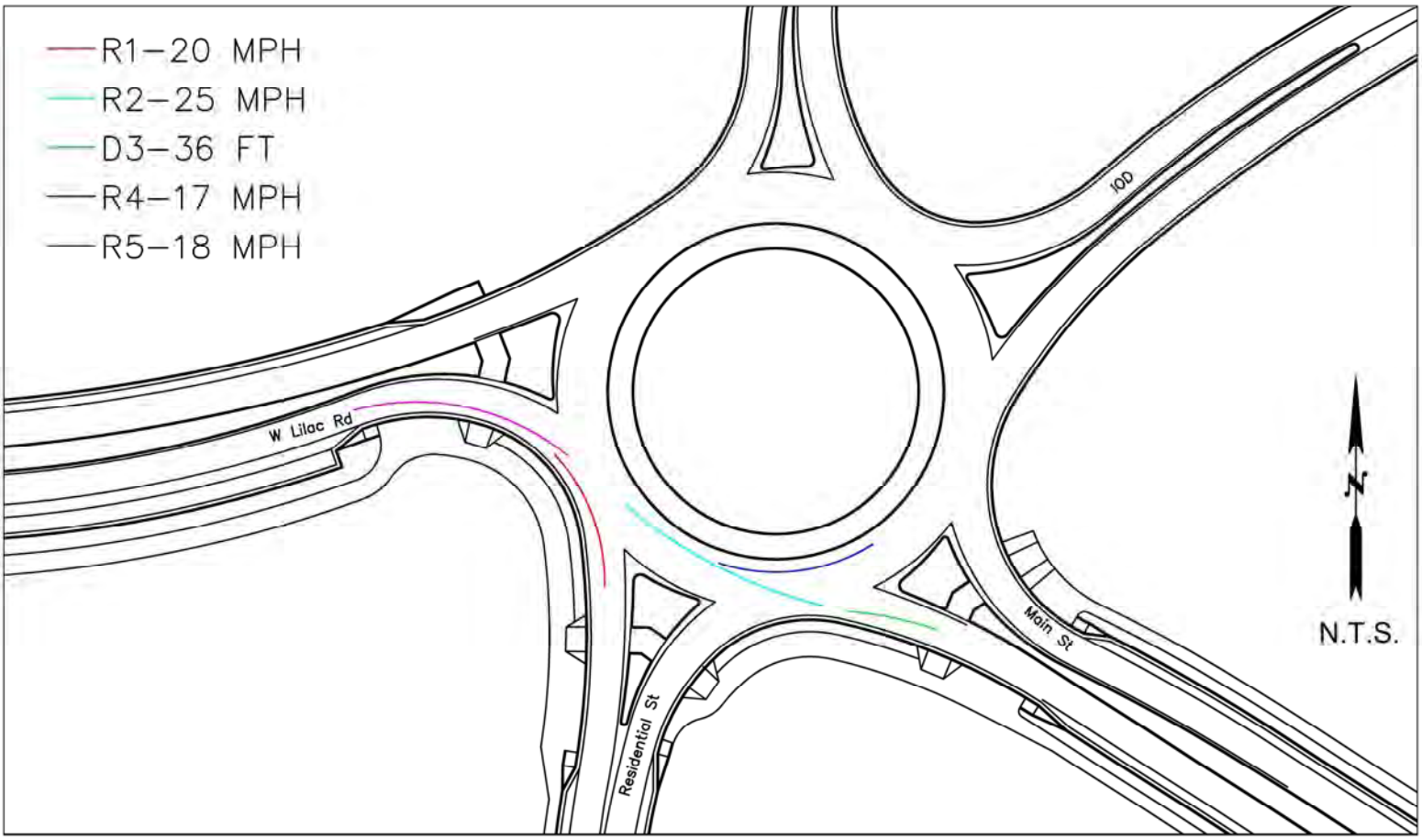
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - SPEED CURVES

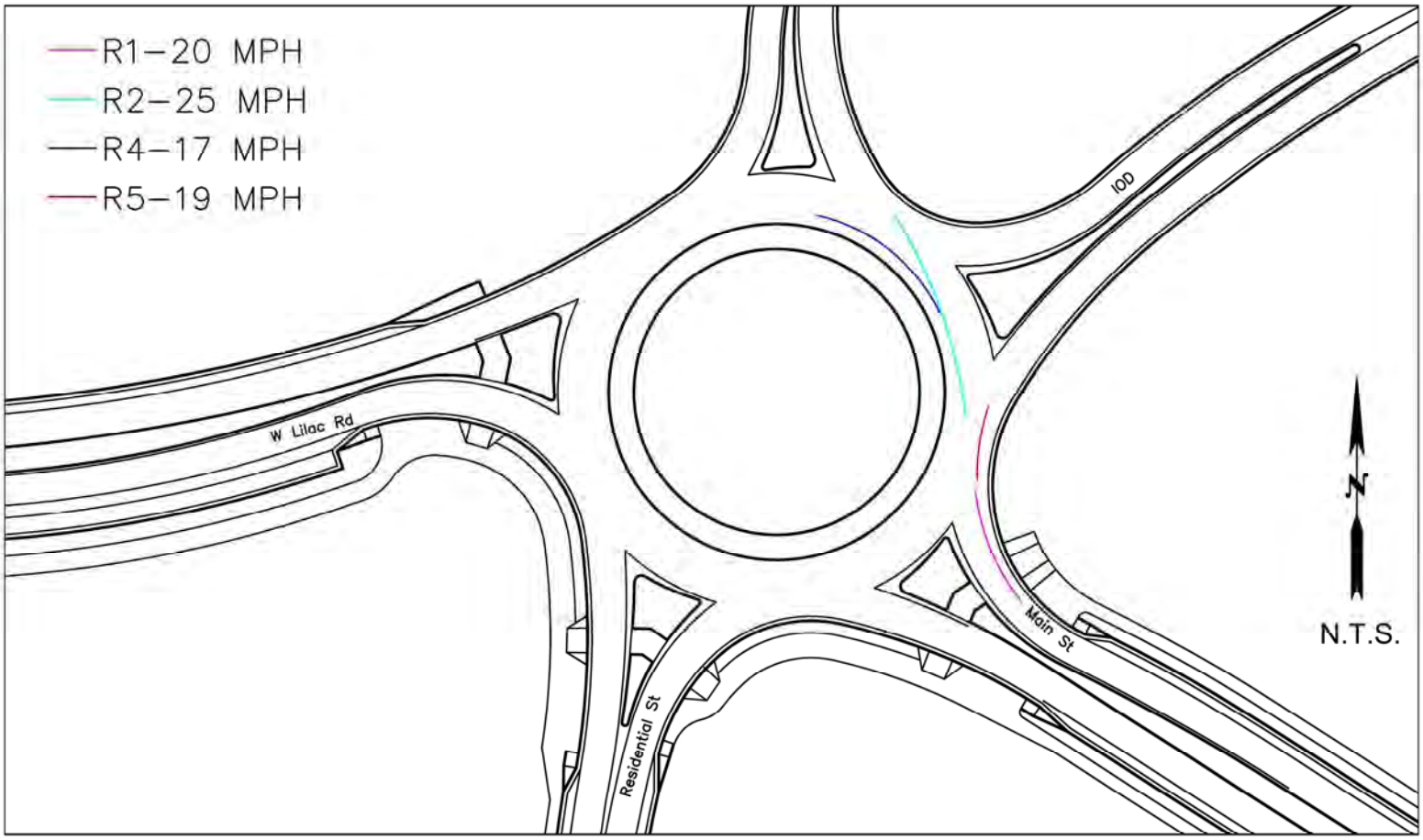
Figure B-27

W Lilac Rd Roundabouts

October 2013



Eastbound



Westbound

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - SPEED CURVES

Figure B-28

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 1 (Alt B) - Speed Calculations

W Lilac Rd Roundabouts

October 2013

	Northbound		Southbound		Eastbound		Westbound		Southwestbound	
	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)
R1	71	18	120	22	96	20	89	20	96	20
R2	166	24	120	21	189	25	195	25	153	24
R3*	N/A	-	-	27	-	30	N/A	-	-	30
R4	72	17	72	17	72	17	72	17	72	17
R5	83	19	121	22	74	18	83	19	72	18

* R3 speed = lesser of [speed-radius table value] or [R2+Acceleration*Distance to Crosswalk)

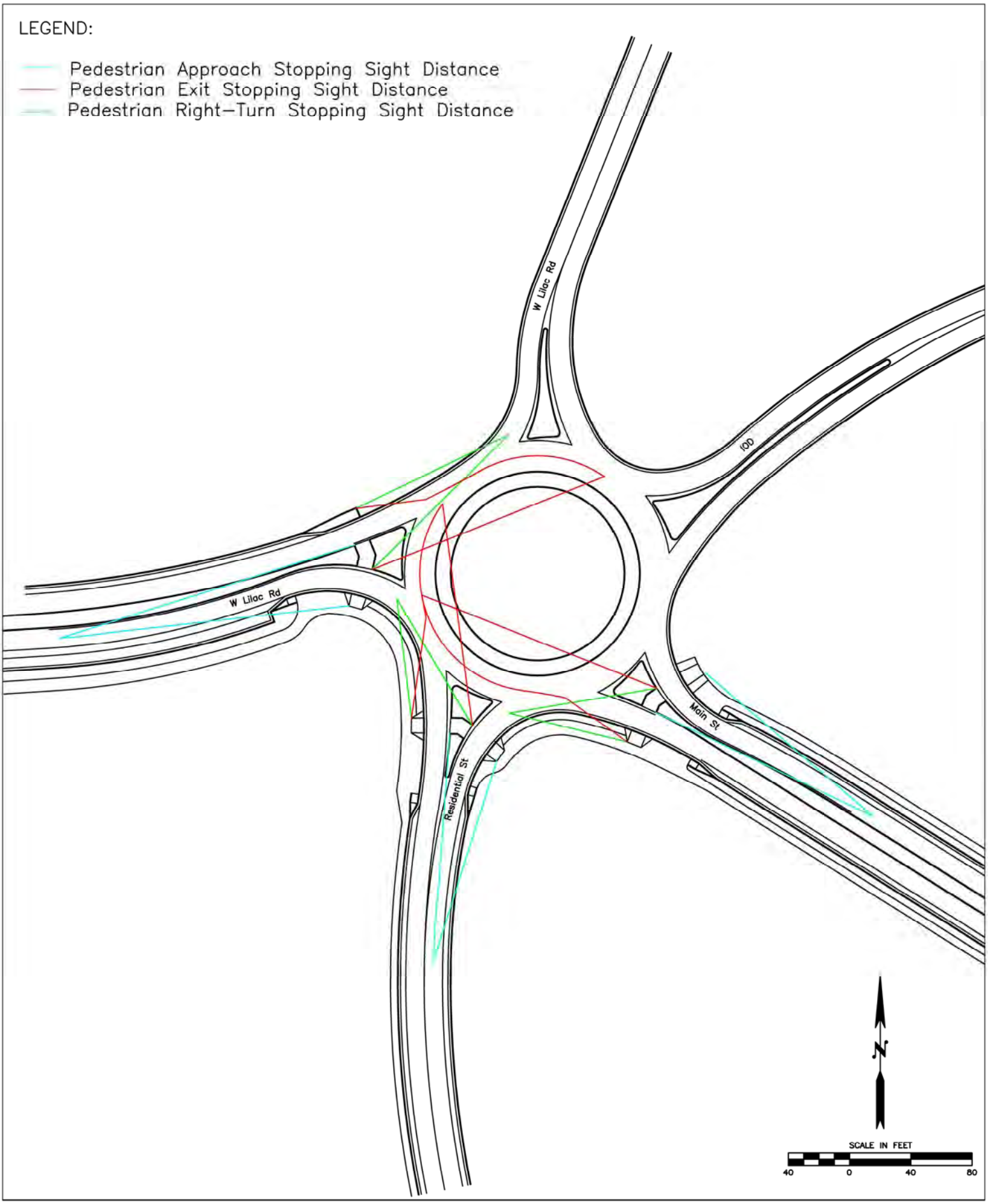
+2% superelevation assumed for R1, R3, and R5 movements

-2% superelevation assumed for R2 and R4 movements

Calculated R3 Speed from Acceleration and Distance to Crosswalk

FHWA Acceleration 6.9 ft/sec^2 NCHRP Report 572

	Beginning Speed R2 (MPH)	R2 Speed in FT/SEC	Distance from R2 to Crosswalk (ft)	Approx. Travel Time (sec)	Speed Increase (mph)	Exiting Speed (mph)
Northbound	24	35	N/A	-	-	-
Southbound	21	31	38	1.2	6	27
Eastbound	25	37	36	1.0	5	30
Westbound	25	37	N/A	-	-	-
Southwestbound	24	35	43	1.2	6	30



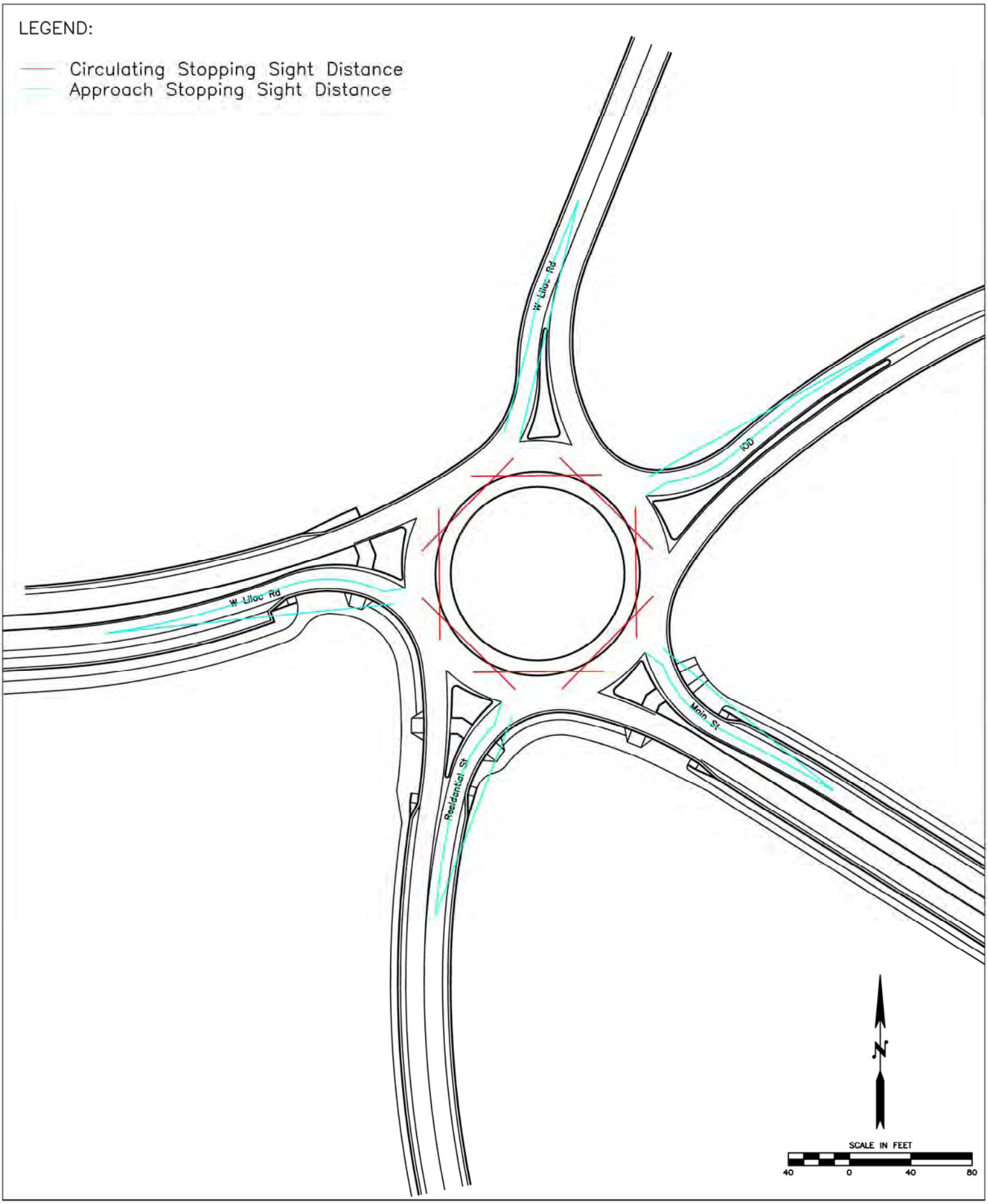
ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - Pedestrian Stopping Sight Distance

Figure B-30

W Lilac Rd Roundabouts

October 2013



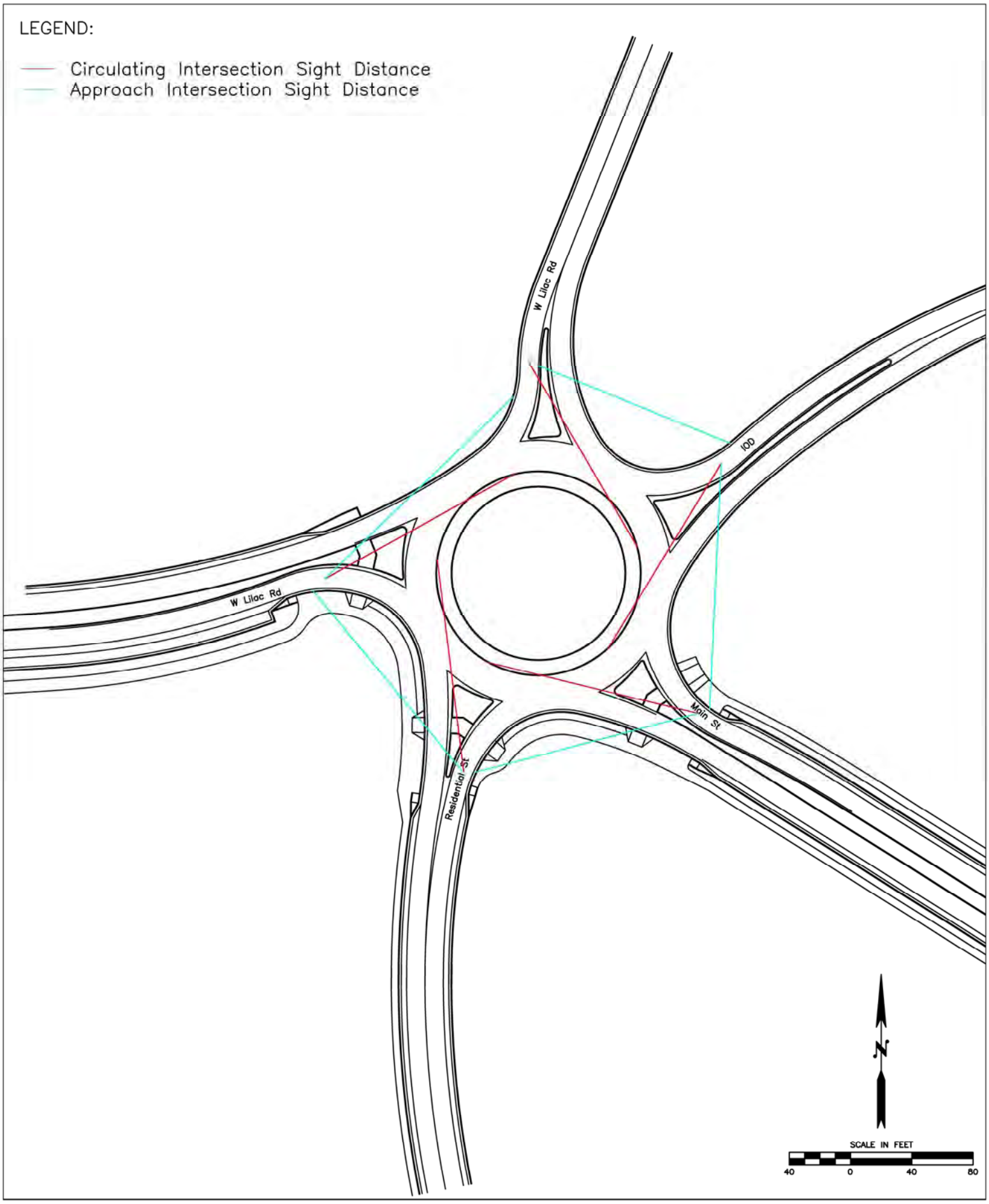
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - Traffic Stopping Sight Distance

Figure B-31

W Lilac Rd Roundabouts

October 2013



Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 (Alt B) - Intersection Sight Distance

Figure B-32

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 1 (Alt B) - Sight Distance Calculations

W Lilac Rd Roundabouts
October 2013

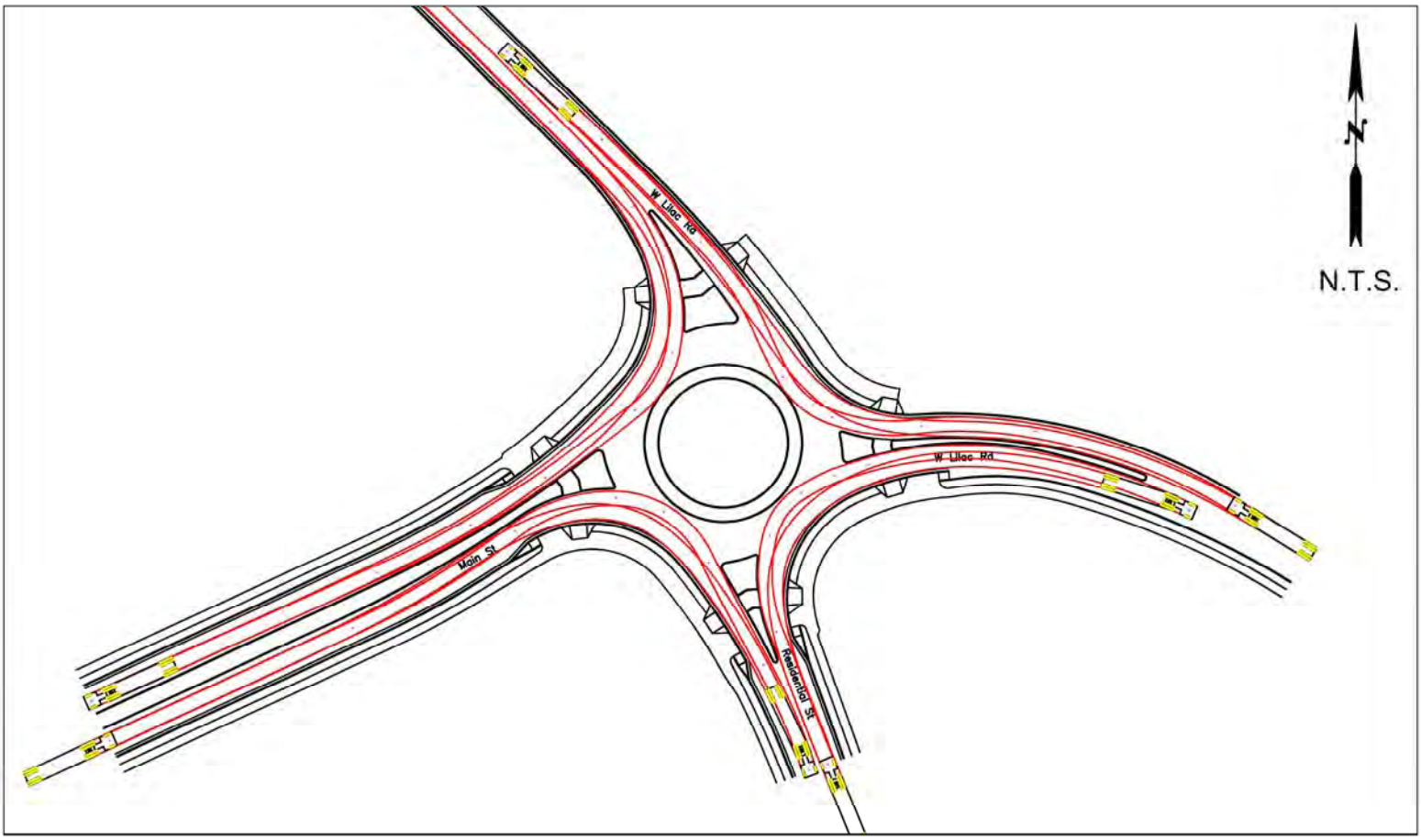
Stopping Sight Distance d= 1.468*2.5*V+1.087*V^2/11.2

	Posted Speed Limit (mph)	R1 Speed (mph)	Average Approach Speed (mph)	Approach Stopping Sight Distance (ft)	R2 Speed (mph)	R3 Speed (mph)	Average Exit Speed (mph)	Exit Stopping Sight Distance (ft)
Northbound	30	18	24	**144**	24	N/A	N/A	**N/A**
Southbound	30	22	26	**161**	21	27	24	**144**
Eastbound	40	20	30	**197**	25	30	28	**174**
Westbound	30	20	25	**152**	25	N/A	N/A	**N/A**
Southwestbound	40	20	30	**197**	24	30	27	**170**

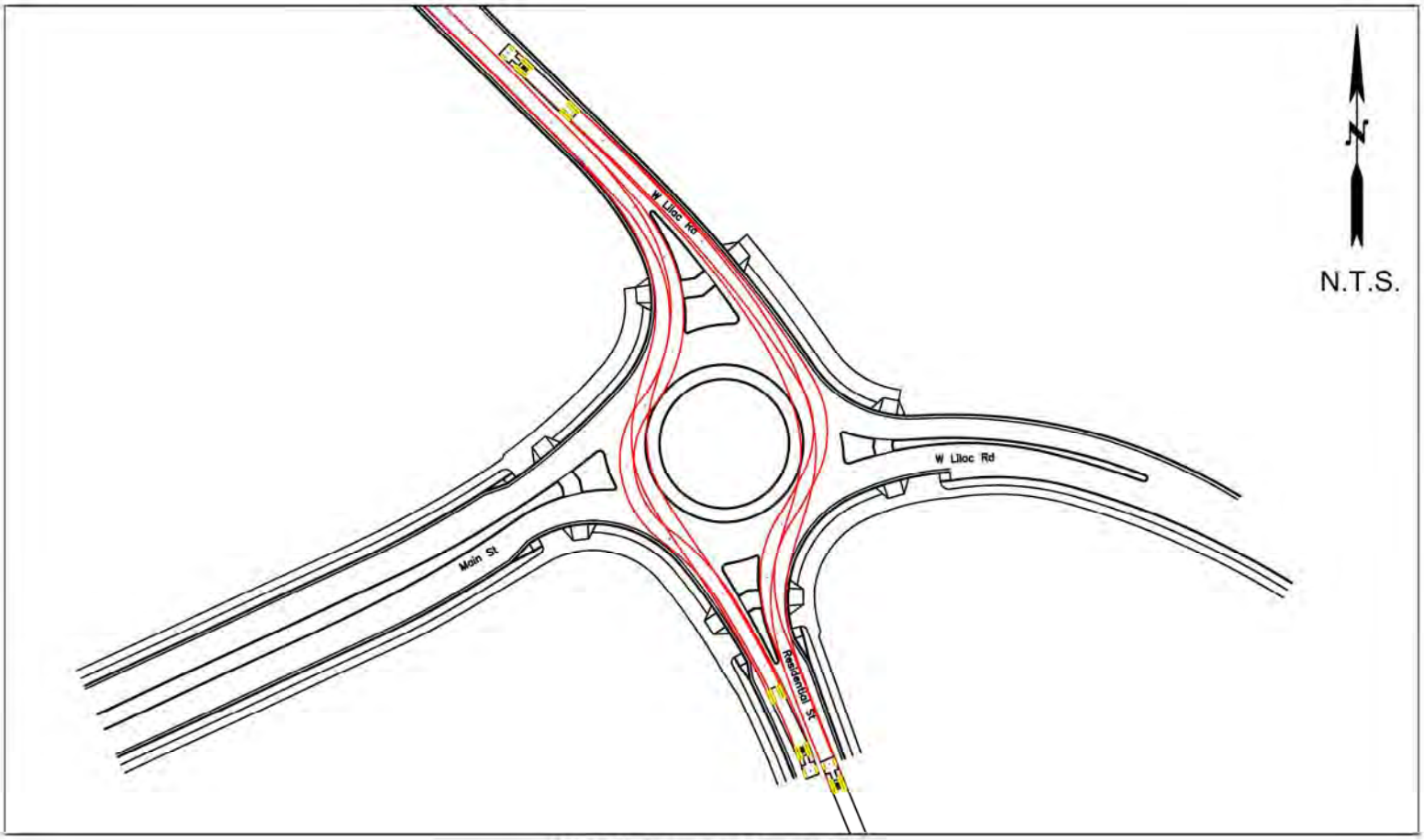
	Circulating Speed (mph)	Circulating Stopping Sight Distance (ft)
Circulating	17	**90**

Intersection Sight Distance S= 1.468*V*5.0

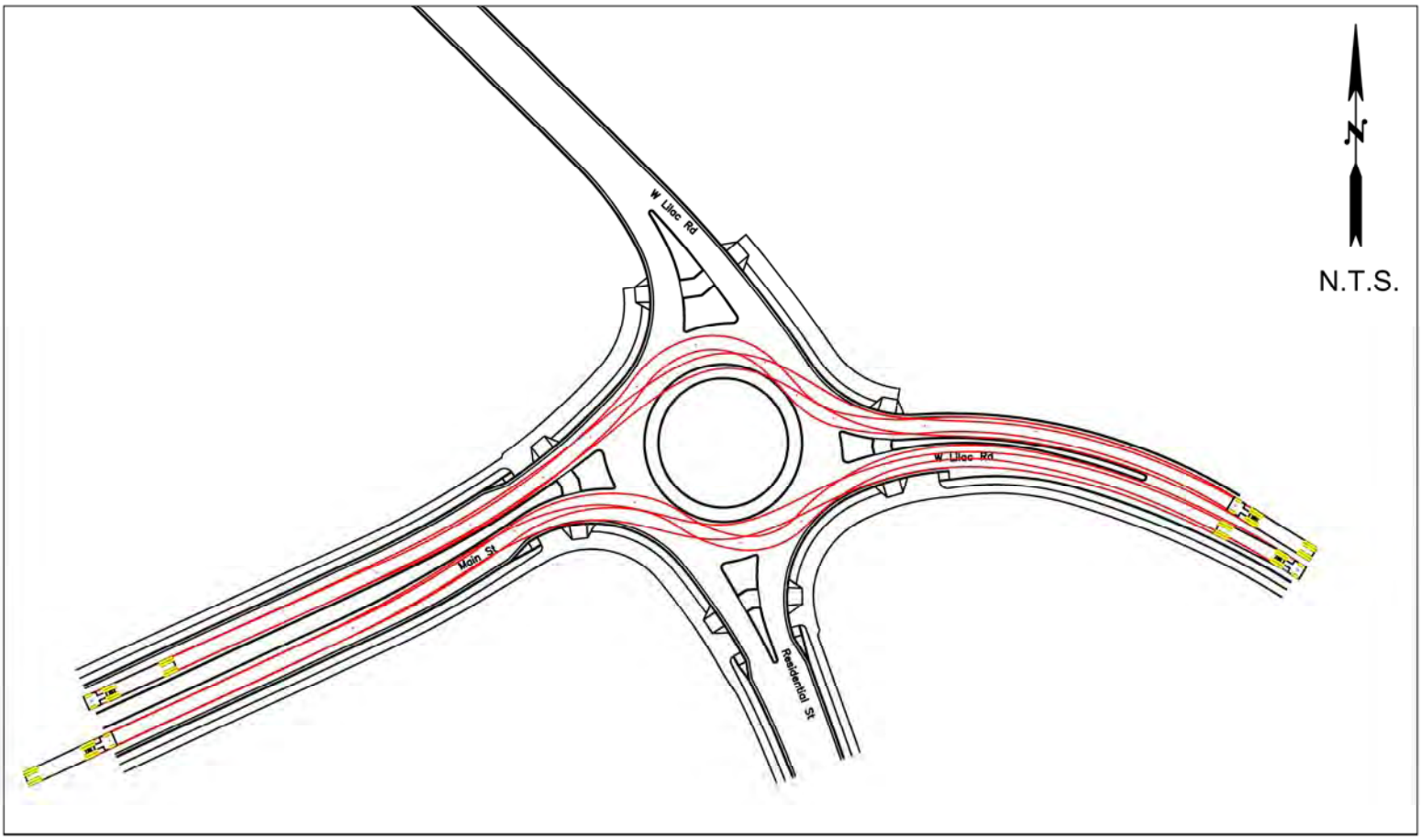
	Adjacent R1 Speed (mph)	Adjacent R2 Speed (mph)	Average Adjacent Entering Speed (mph)	Circulating Stream Speed (mph)	S1 - Entering Intersection Sight Distance (ft)	S2 - Circulating Intersection Sight Distance (ft)
Northbound	20	25	23	17	**165**	**125**
Southbound	20	24	22	17	**161**	**125**
Eastbound	22	21	22	17	**158**	**125**
Westbound	18	24	21	17	**154**	**125**
Southwestbound	20	25	23	17	**165**	**125**



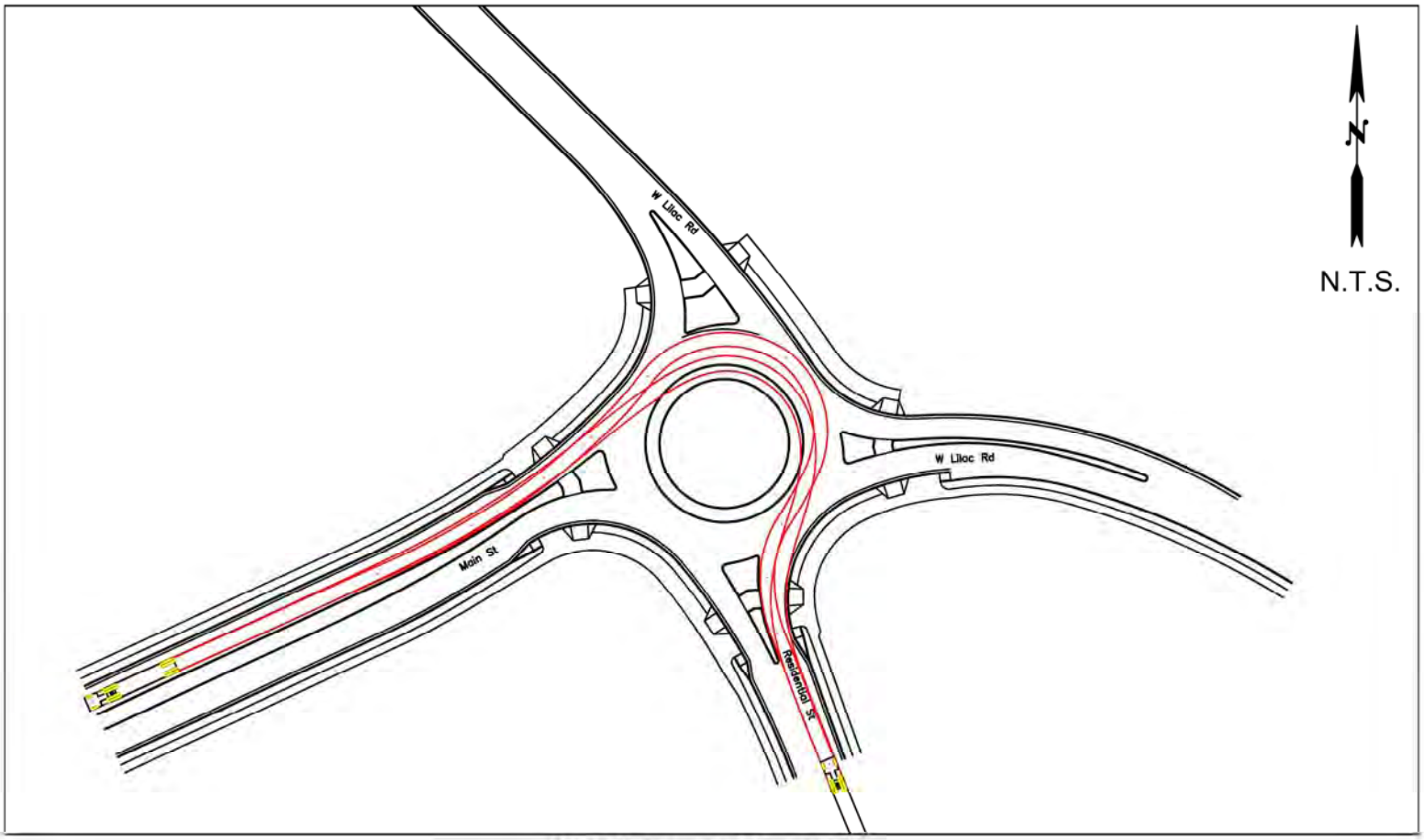
WB-50 Turning Movements



WB-50 Turning Movements

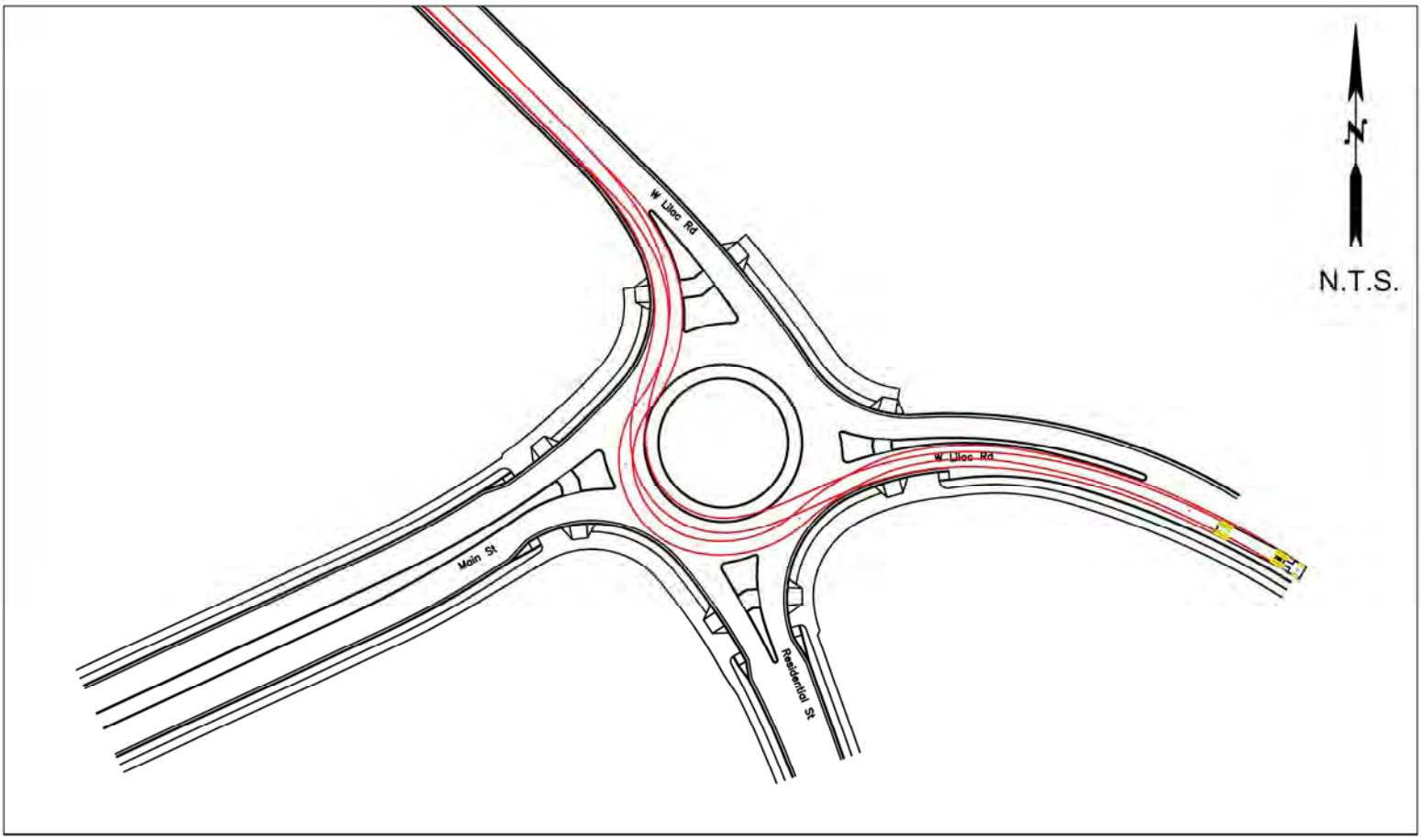


WB-50 Turning Movements

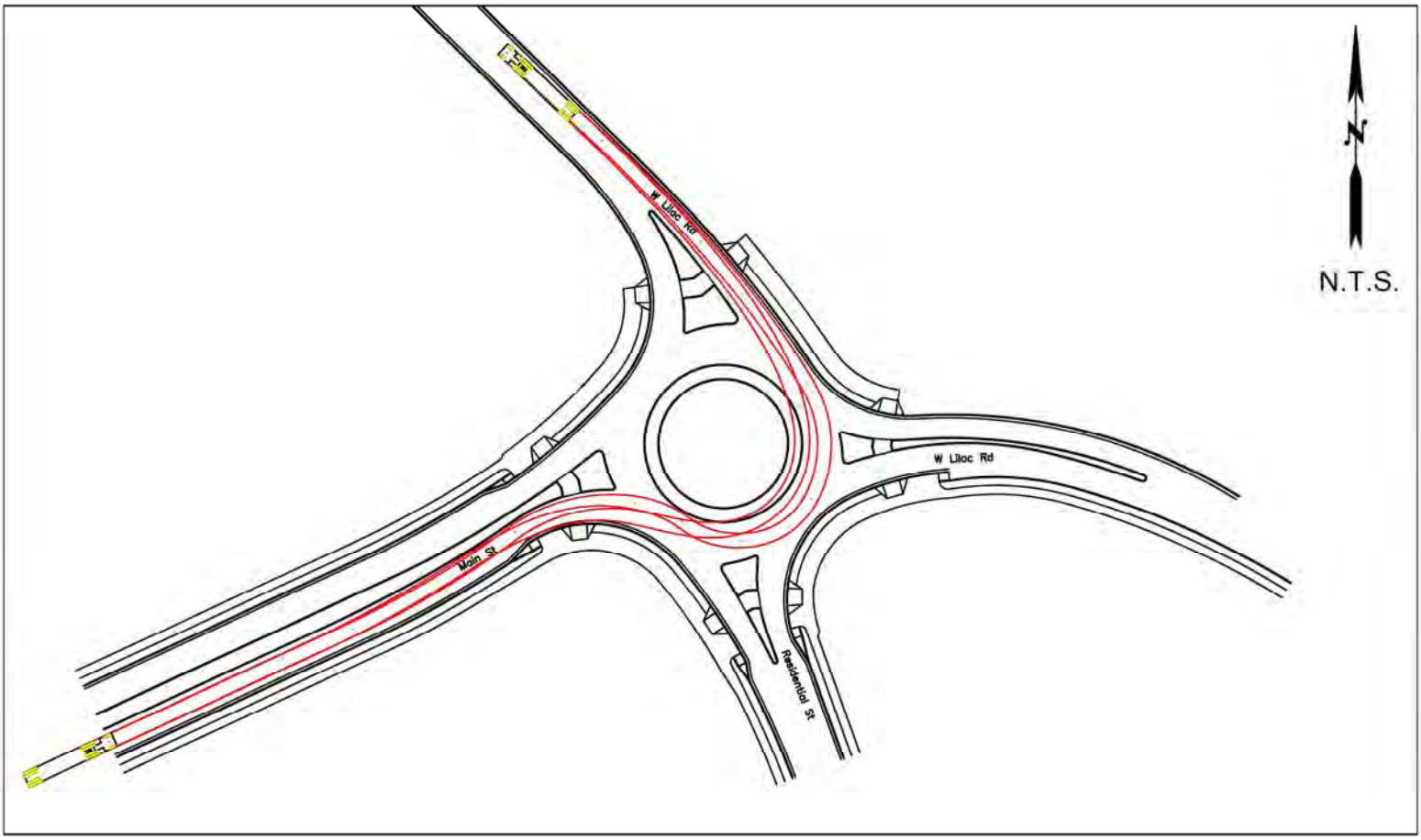


WB-50 Turning Movements

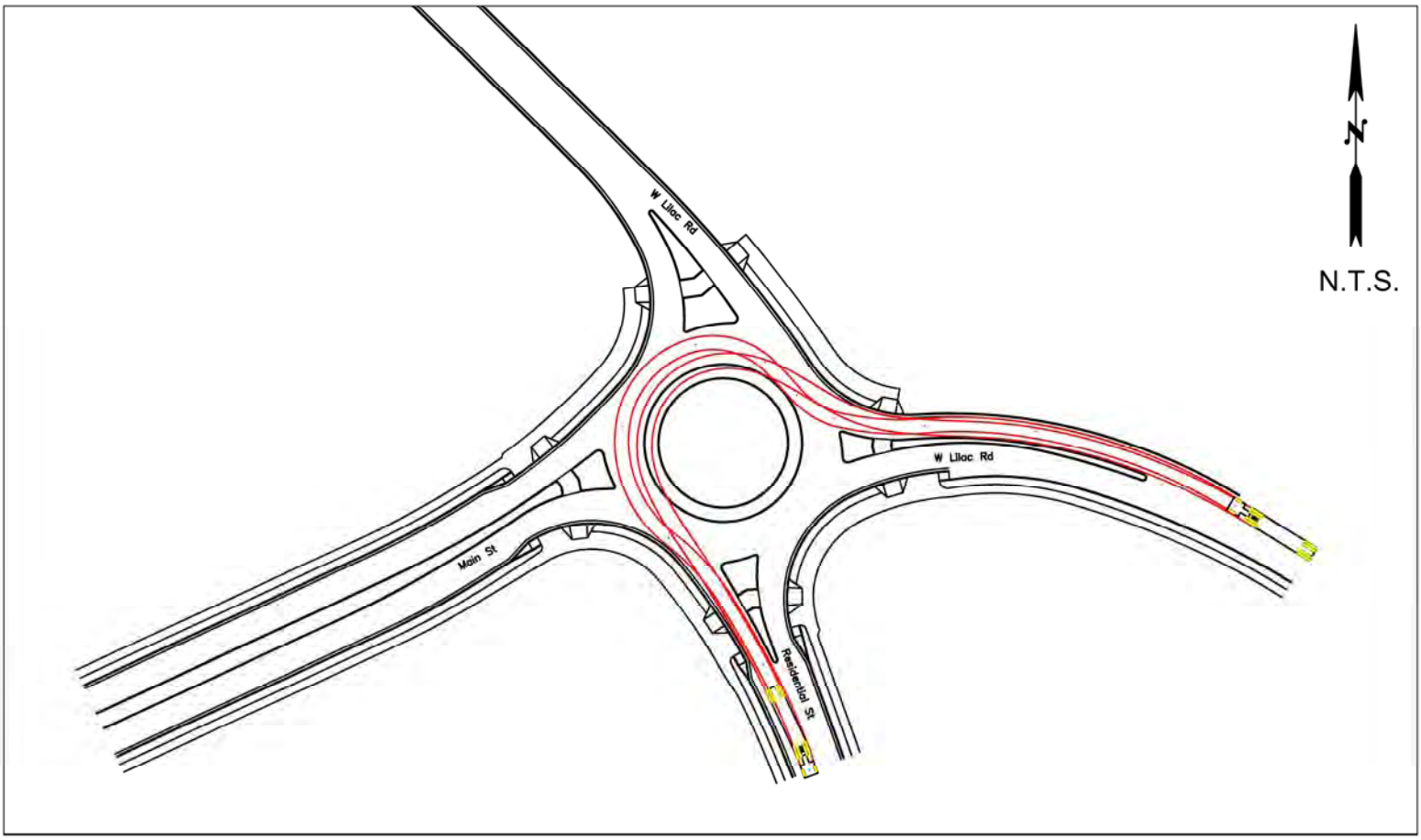
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



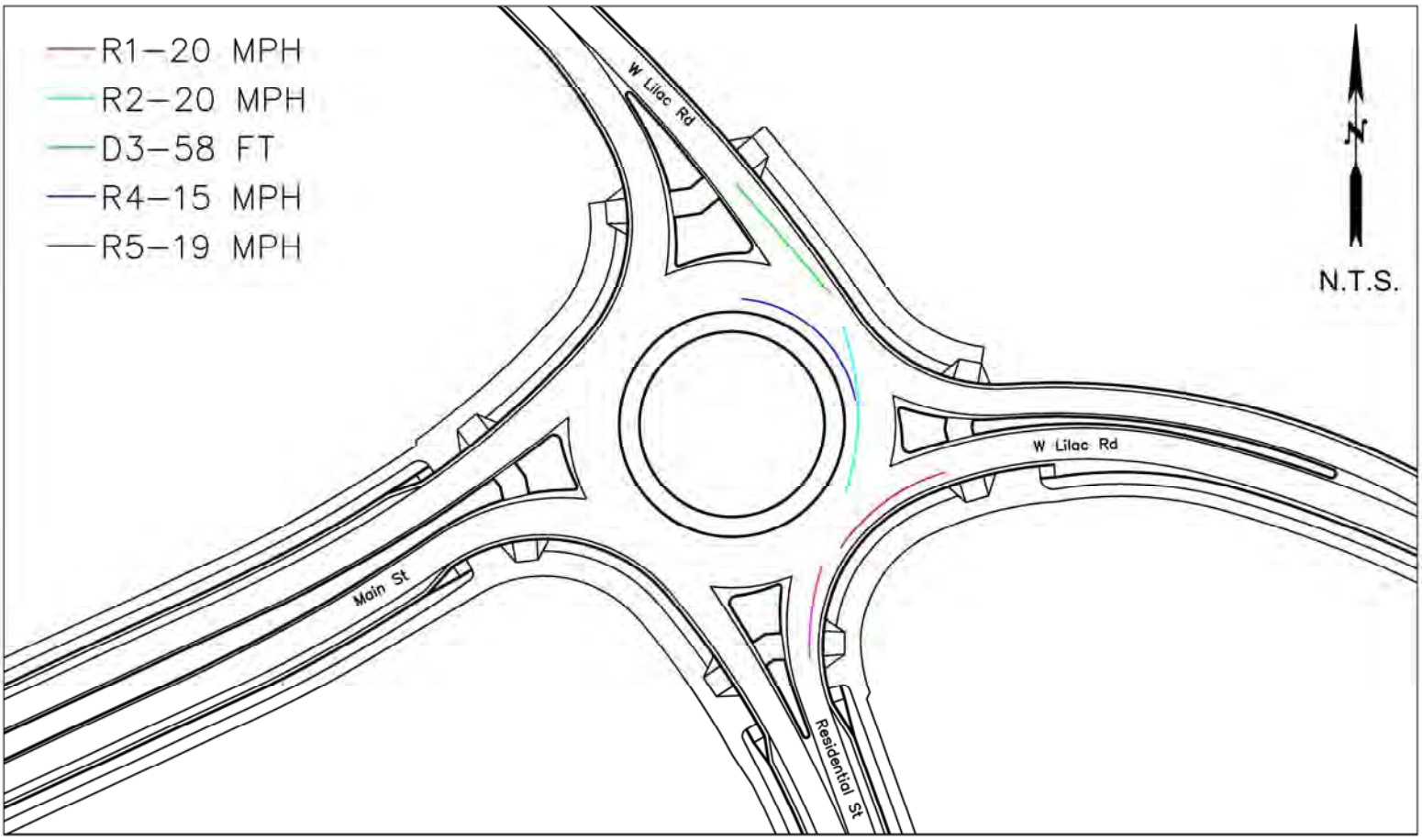
WB-50 Turning Movements



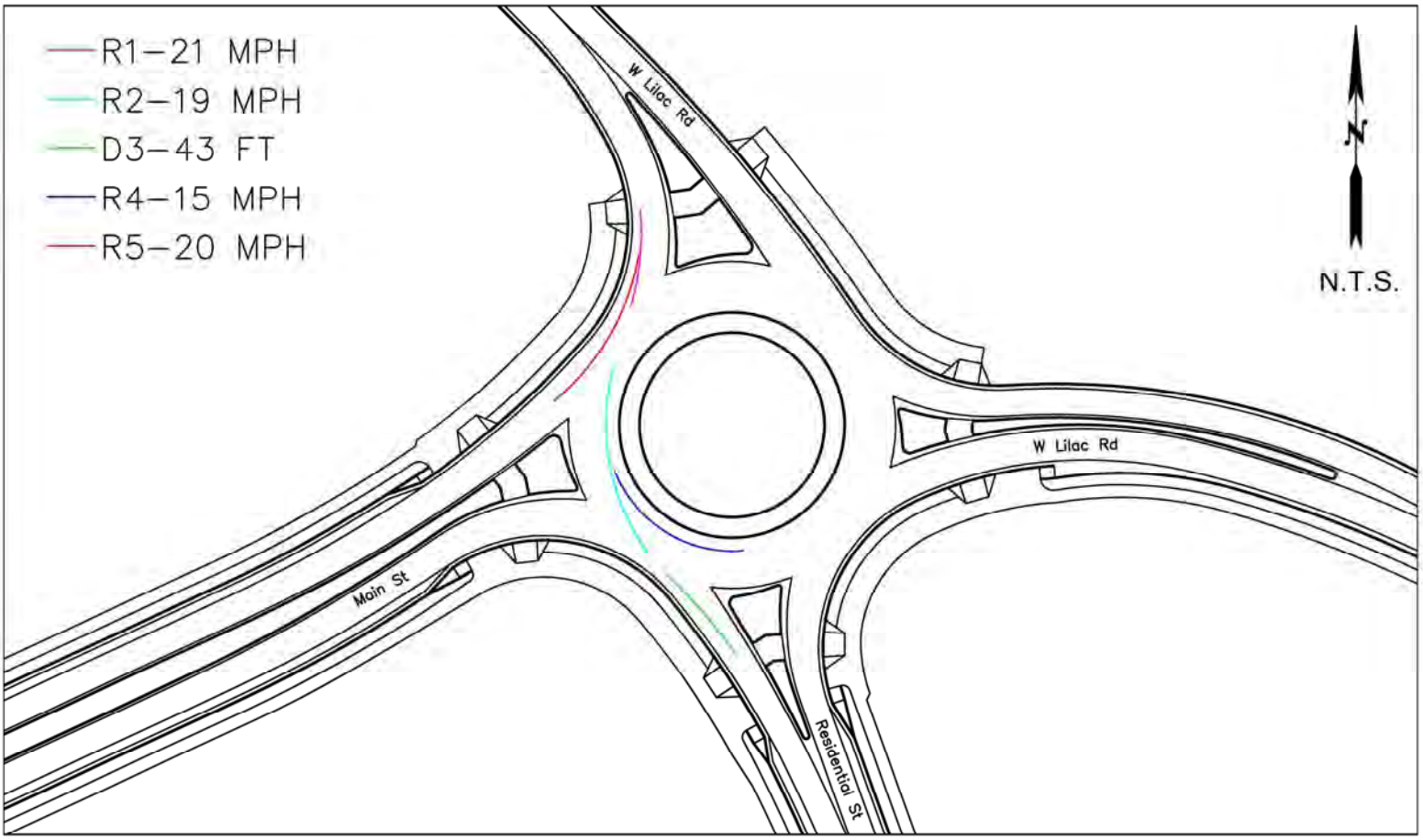
WB-50 Turning Movements



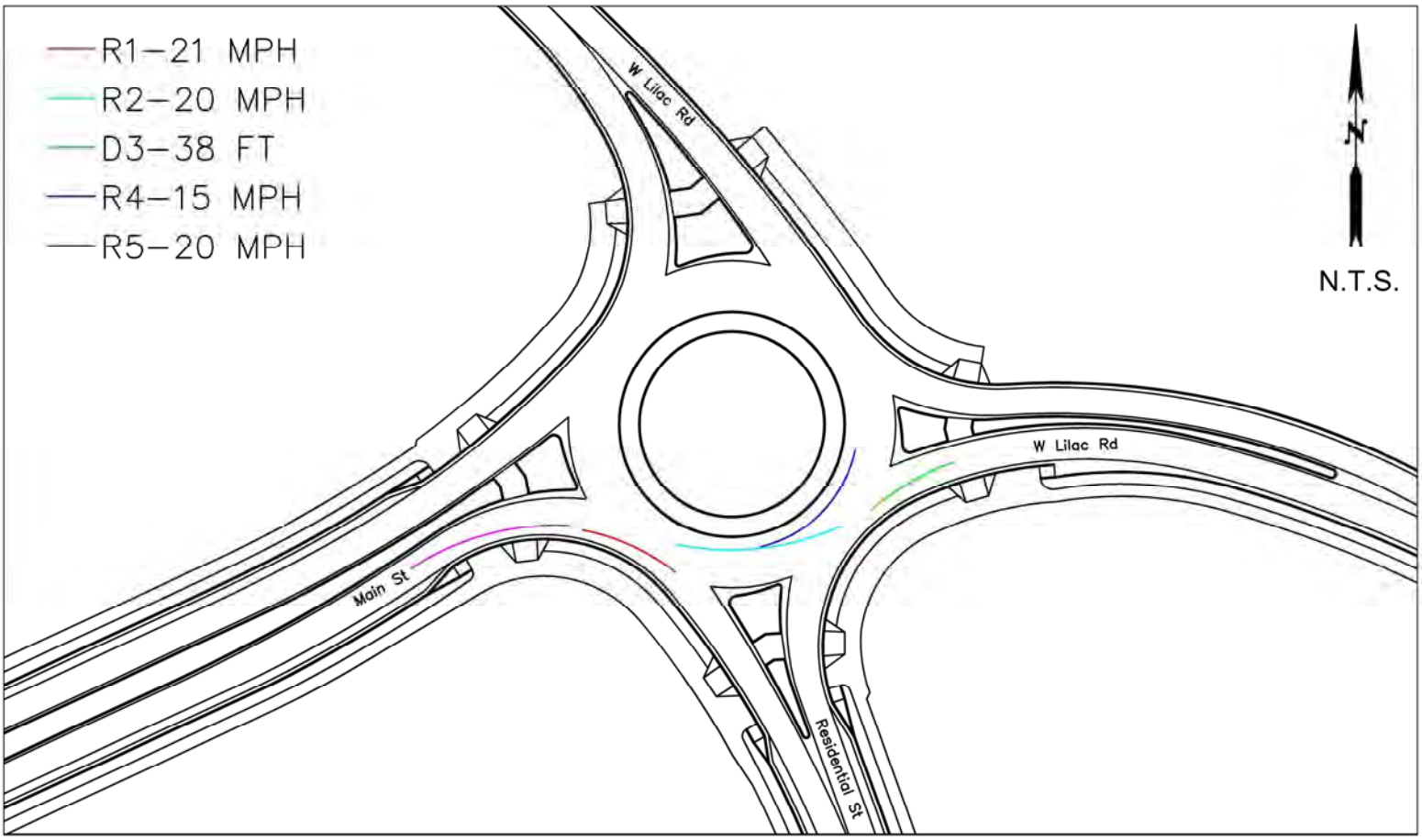
WB-50 Turning Movements



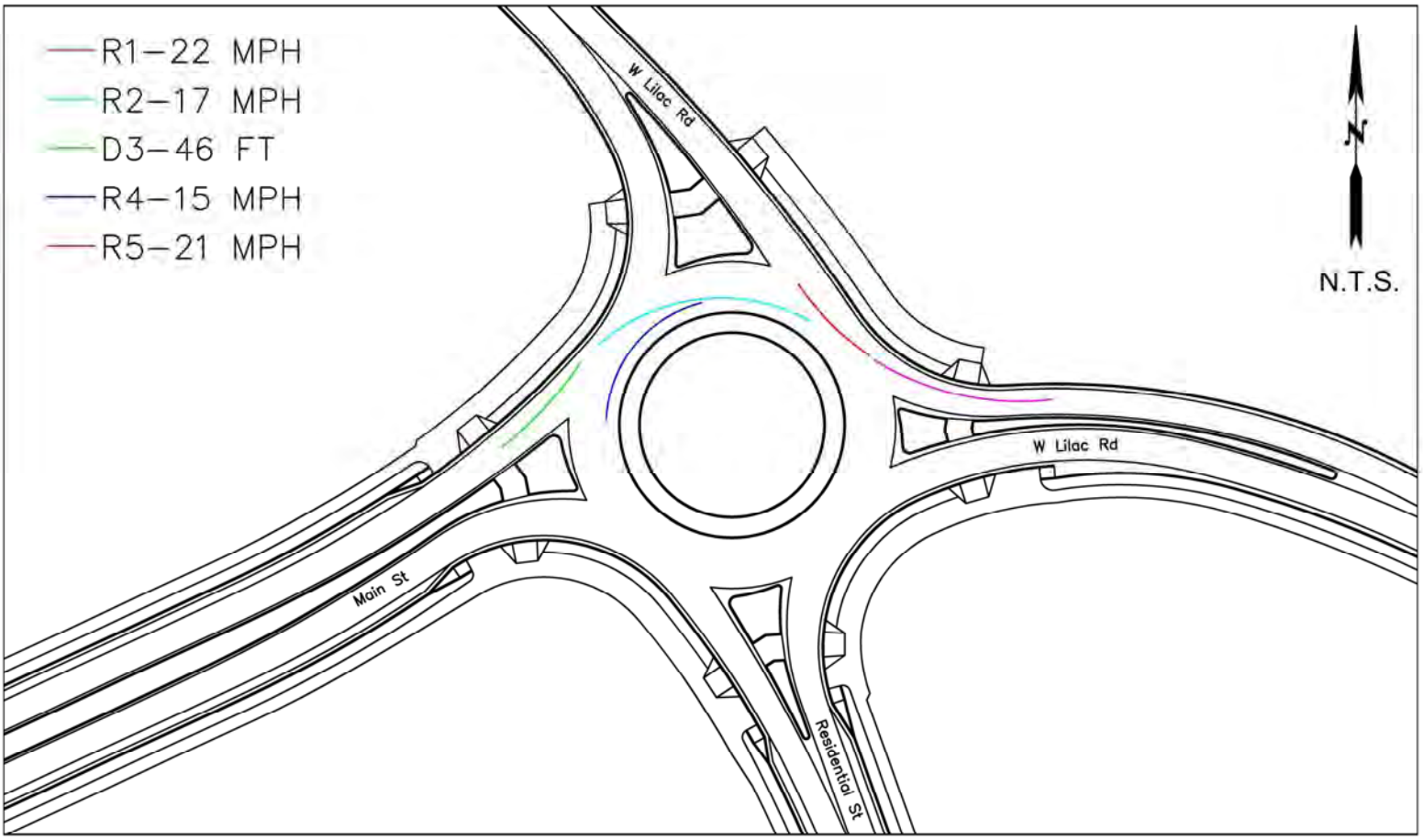
Northbound



Southbound



Eastbound



Westbound

Reid Middleton RB 2 - Speed Calculations

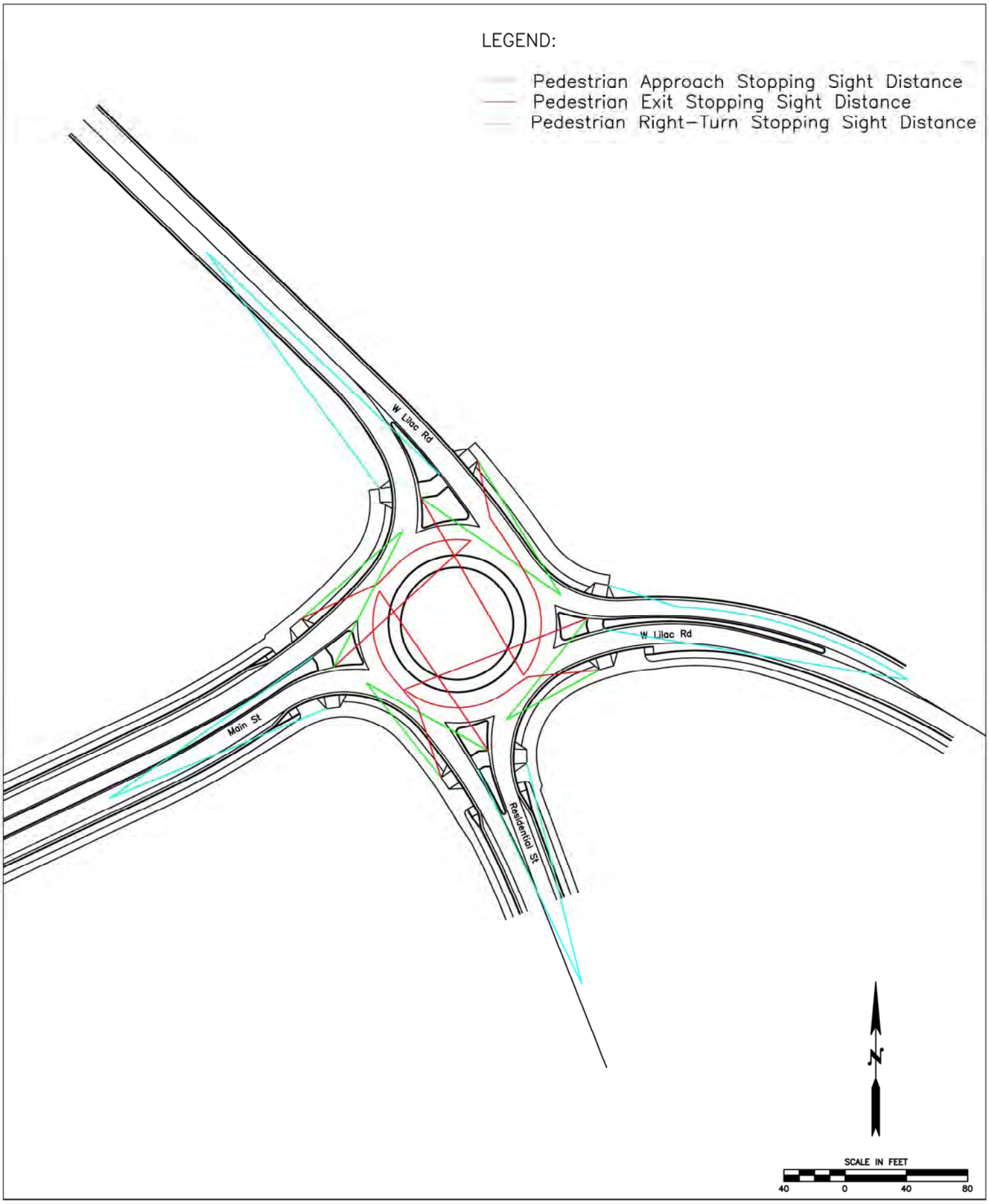
W Lilac Rd Roundabouts
October 2013

	Northbound		Southbound		Eastbound		Westbound	
	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)	Radius (ft)	Speed (mph)
R1	98	20	104	21	102	21	111	22
R2	101	20	88	19	105	20	73	17
R3*	-	29	-	26	-	26	-	26
R4	50	15	50	15	50	15	50	15
R5	78	19	94	20	86	20	106	21

* R3 speed = lesser of [speed-radius table value] or [R2+Acceleration*Distance to Crosswalk)
+2% superelevation assumed for R1, R3, and R5 movements
-2% superelevation assumed for R2 and R4 movements

Calculated R3 Speed from Acceleration and Distance to Crosswalk
FHWA Acceleration 6.9 ft/sec^2 NCHRP Report 572

	Beginning Speed R2 (MPH)	R2 Speed in FT/SEC	Distance from R2 to Crosswalk (ft)	Approx. Travel Time (sec)	Speed Increase (mph)	Exiting Speed (mph)
Northbound	20	29	58	2.0	9	29
Southbound	19	28	43	1.6	7	26
Eastbound	20	29	38	1.3	6	26
Westbound	17	25	46	1.9	9	26



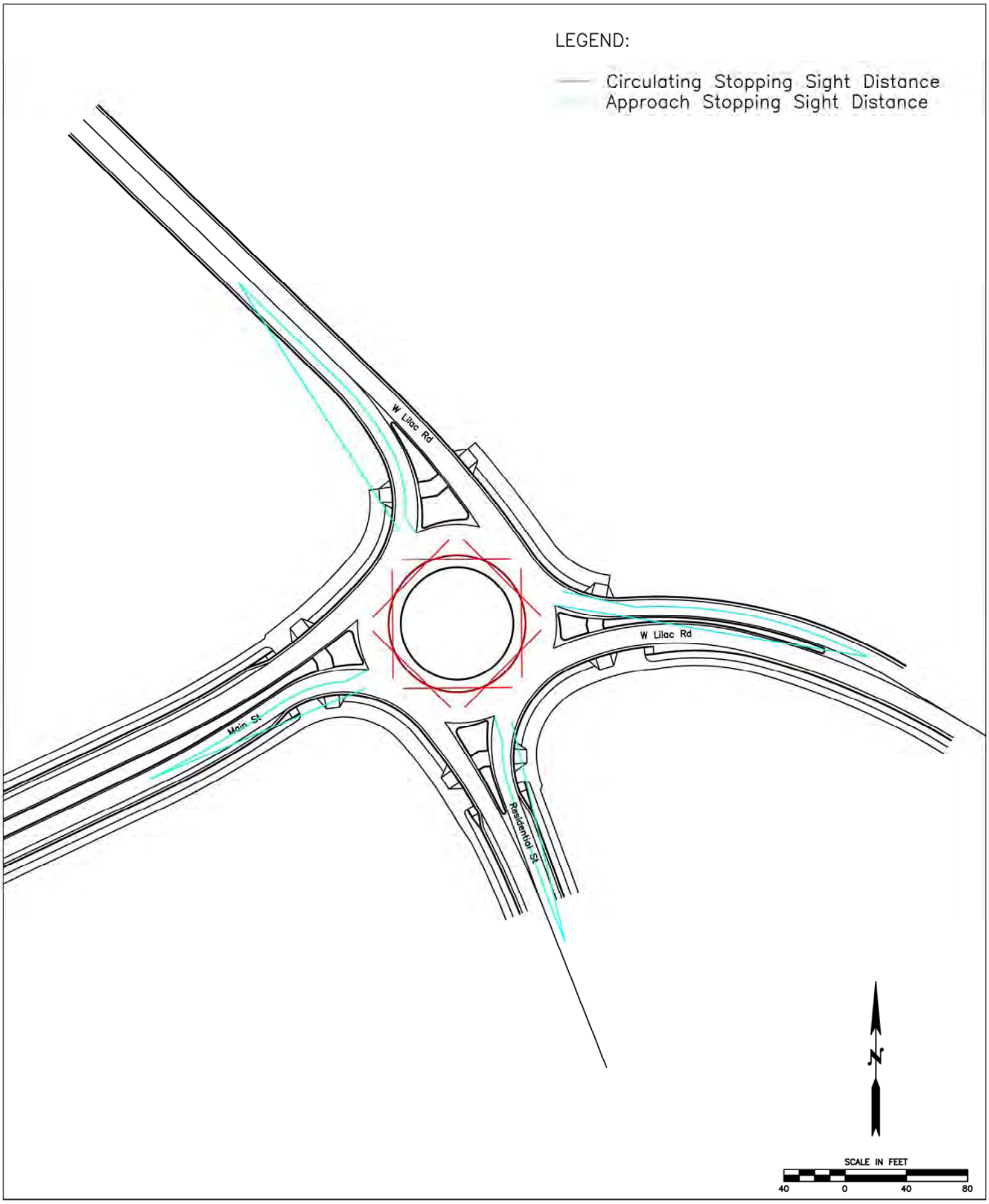
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 2 - Pedestrian Stopping Sight Distance

Figure B-41

W Lilac Rd Roundabouts

October 2013



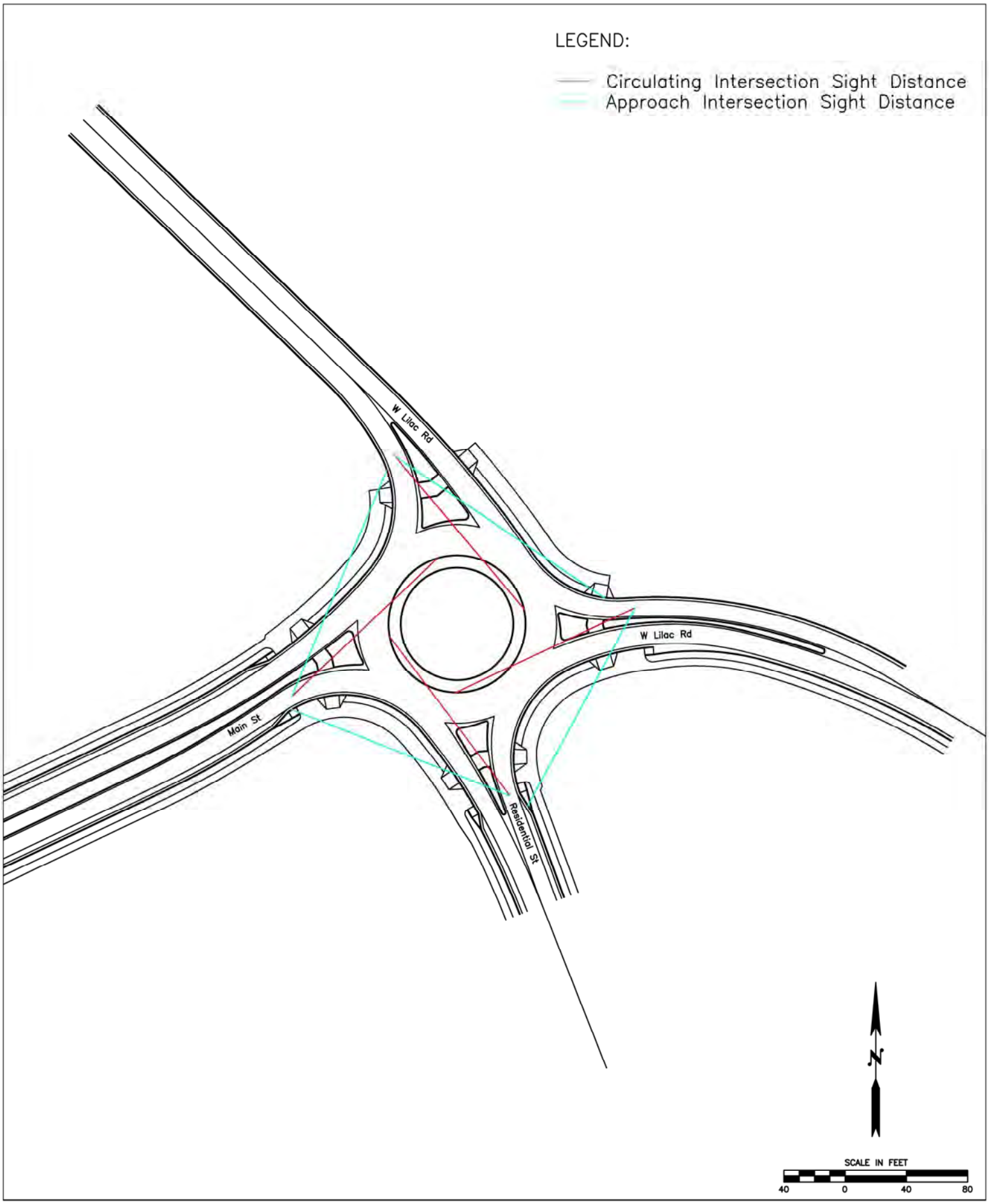
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 2 - Traffic Stopping Sight Distance

Figure B-42

W Lilac Rd Roundabouts

October 2013



Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 2 - Intersection Sight Distance

Figure B-43

W Lilac Rd Roundabouts

October 2013

Reid Middleton RB 2 - Sight Distance Calculations

W Lilac Rd Roundabouts
October 2013

Stopping Sight Distance d= 1.468*2.5*V+1.087*V^2/11.2

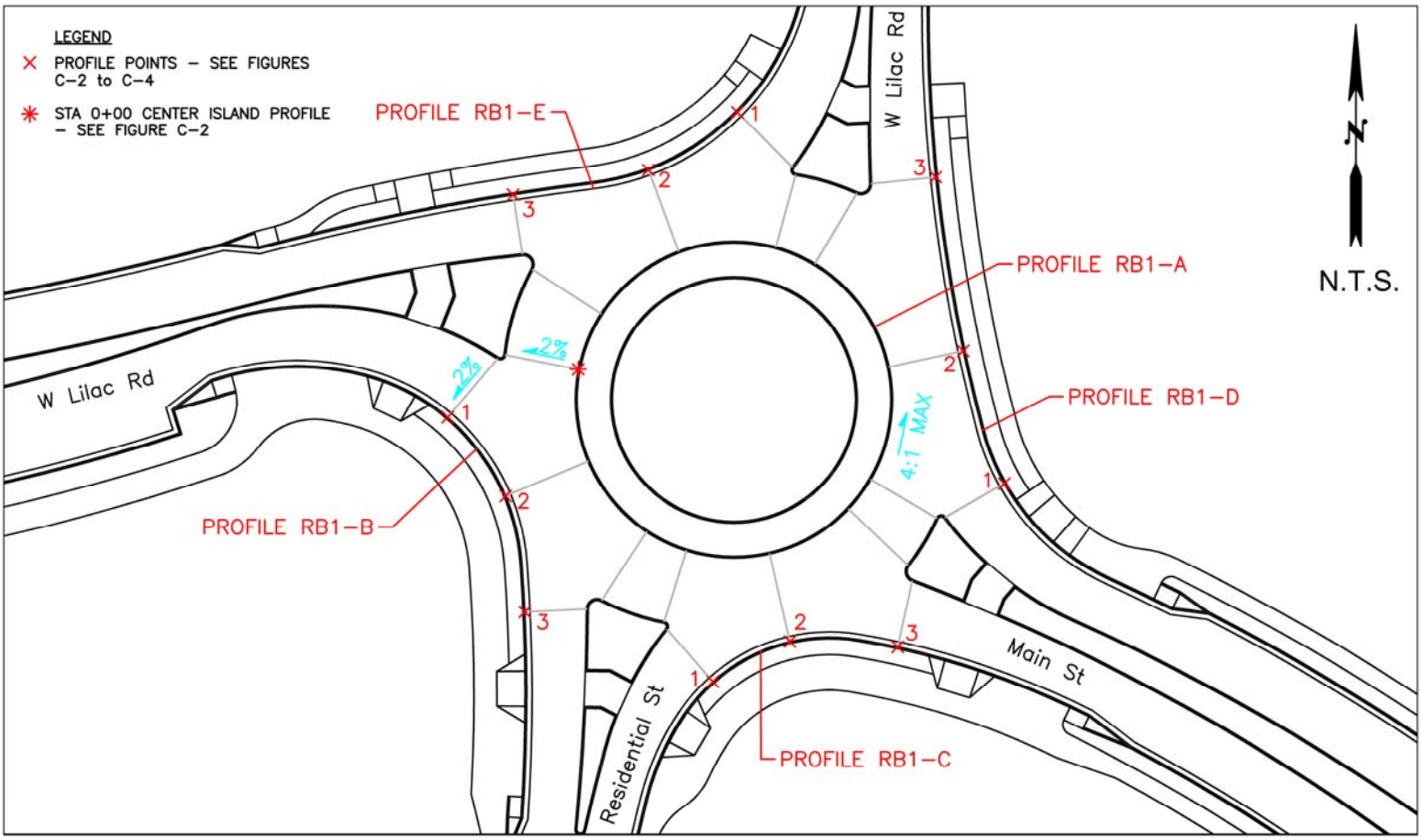
	Posted Speed Limit (mph)	R1 Speed (mph)	Average Approach Speed (mph)	Approach Stopping Sight Distance (ft)	R2 Speed (mph)	R3 Speed (mph)	Average Exit Speed (mph)	Exit Stopping Sight Distance (ft)
Northbound	30	20	25	**152**	20	29	25	**148**
Southbound	40	21	31	**202**	19	26	23	**132**
Eastbound	30	21	26	**157**	20	26	23	**136**
Westbound	40	22	31	**207**	17	26	22	**124**

	Circulating Speed (mph)	Circulating Stopping Sight Distance (ft)
Circulating	15	**77**

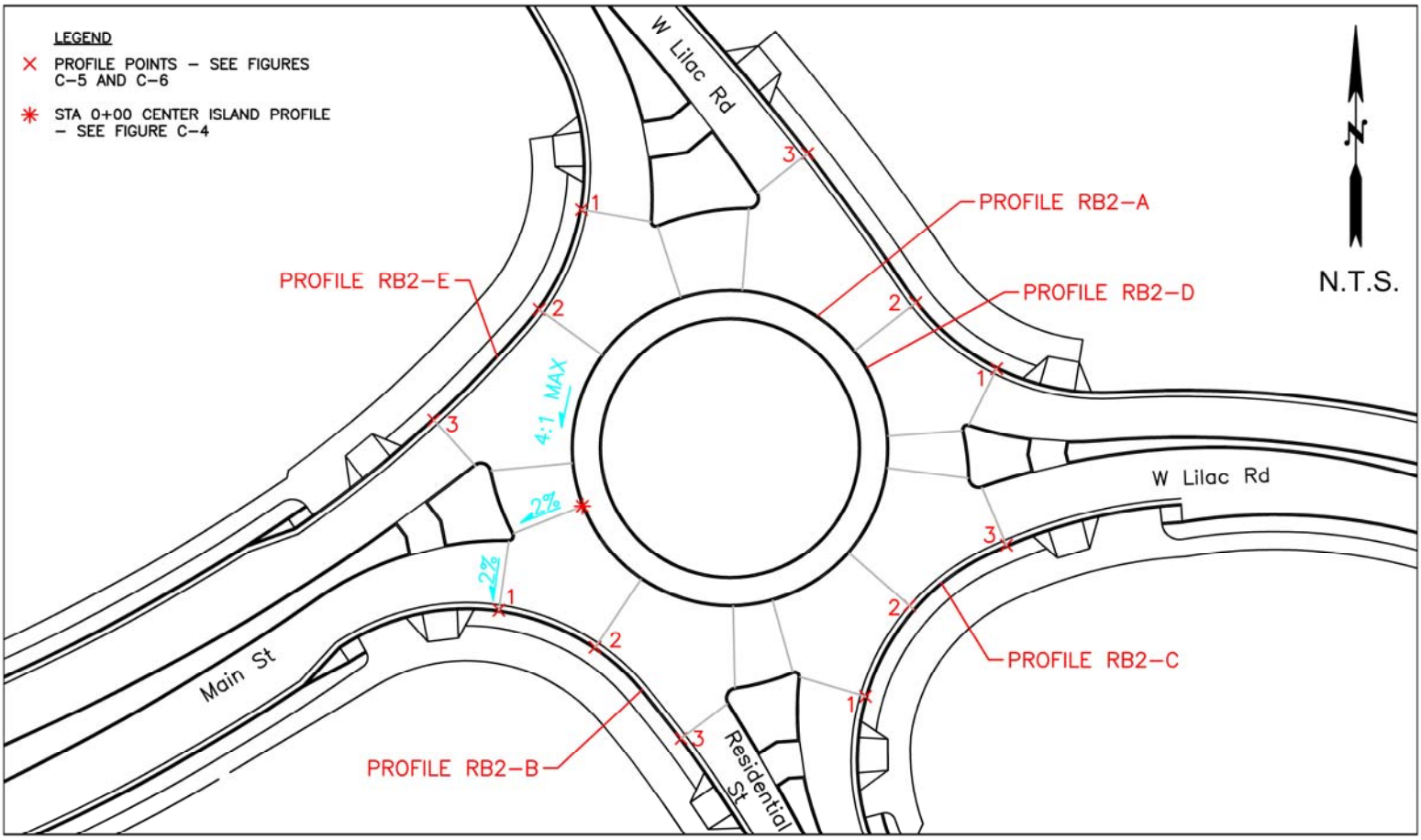
Intersection Sight Distance S= 1.468*V*5.0

	Adjacent R1 Speed (mph)	Adjacent R2 Speed (mph)	Average Adjacent Entering Speed (mph)	Circulating Stream Speed (mph)	S1 - Entering Intersection Sight Distance (ft)	S2 - Circulating Intersection Sight Distance (ft)
Northbound	21	20	21	15	**150**	**110**
Southbound	22	17	20	15	**143**	**110**
Eastbound	21	19	20	15	**147**	**110**
Westbound	20	20	20	15	**147**	**110**

APPENDIX C
(GRADING EXHIBITS)



Roundabout 1



Roundabout 2

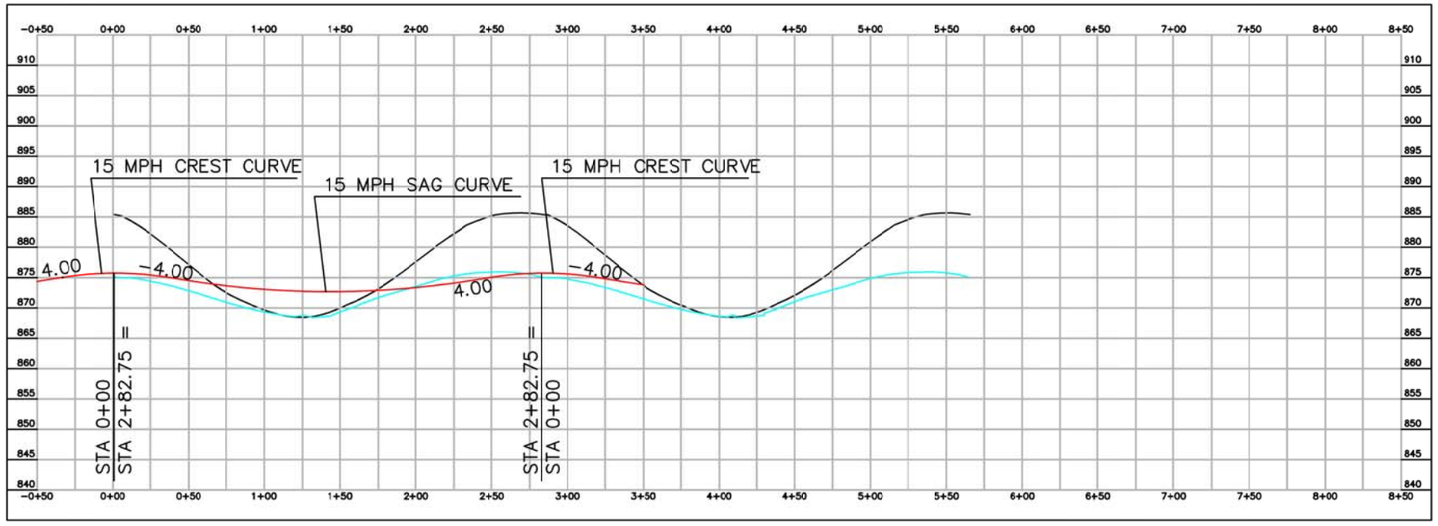
Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

Reid Middleton RB 1 & 2 - GRADING EXHIBITS

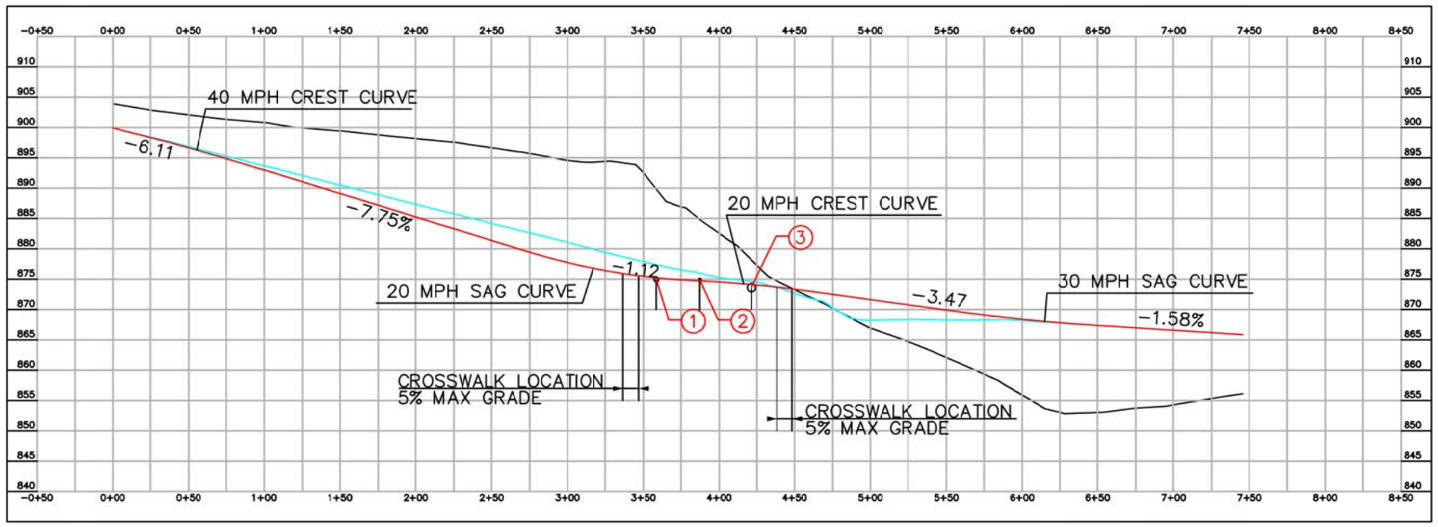
W Lilac Rd Roundabouts

Figure C-1

October 2013



RB1-A



RB1-B

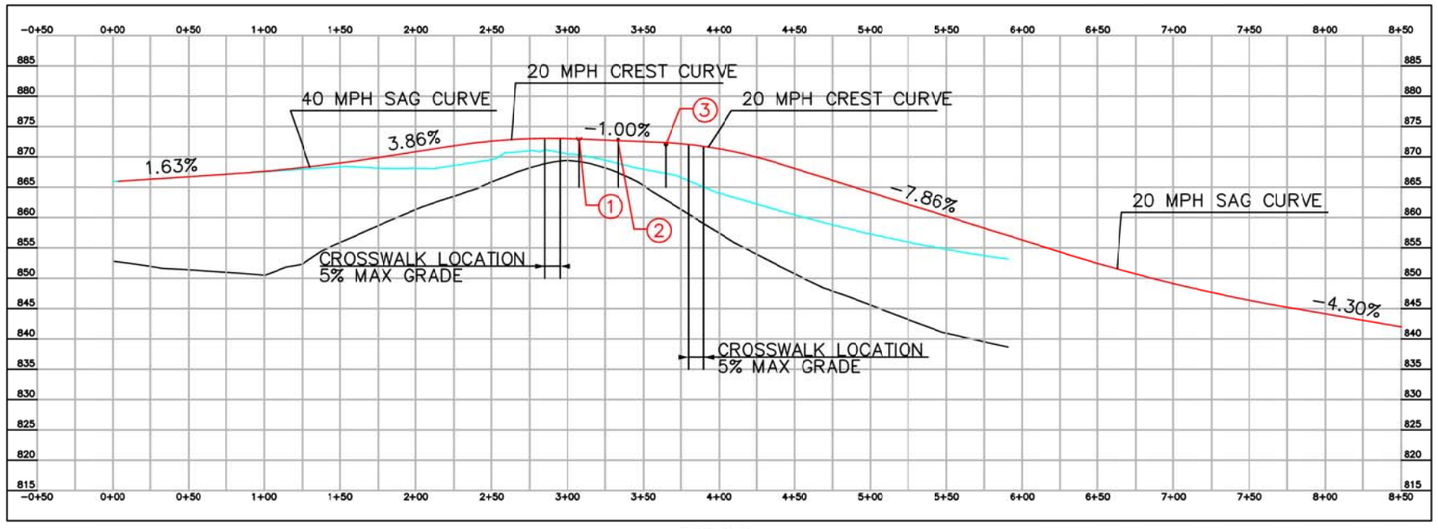
LEGEND

- Existing Ground
- Initial Finished Ground
- Roundabout Profile
- Ⓧ Profile Points - See Figure C-1

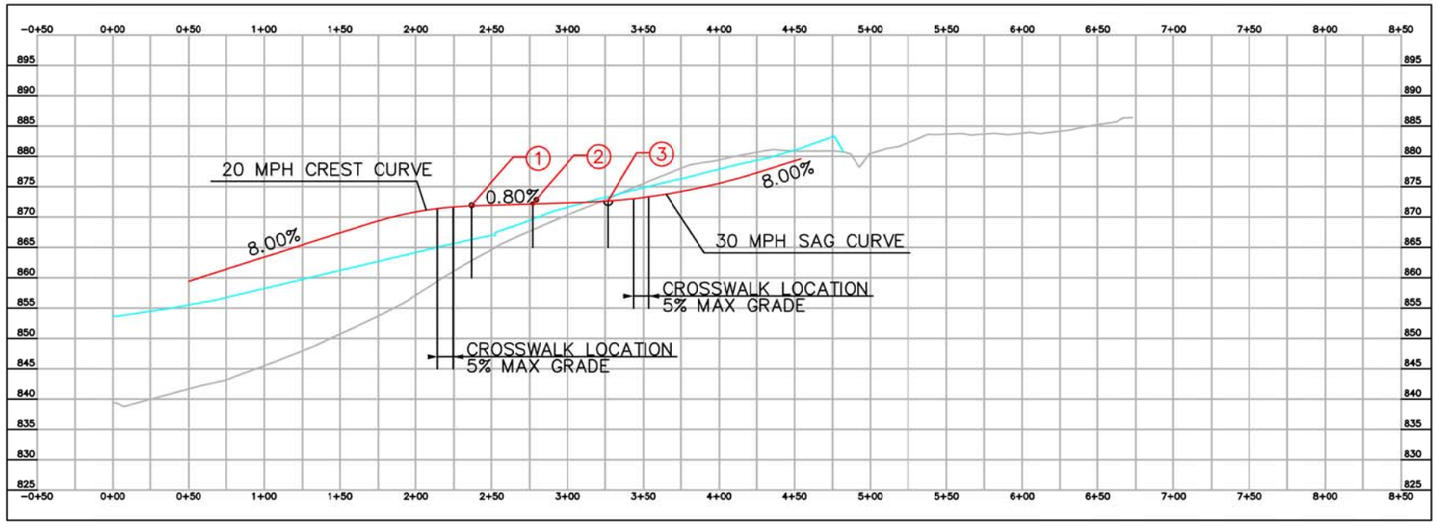
HORIZONTAL SCALE IN FEET
50 0 50 100

VERTICAL SCALE IN FEET
12.5 0 12.5 25

ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



RB1-C



RB1-D

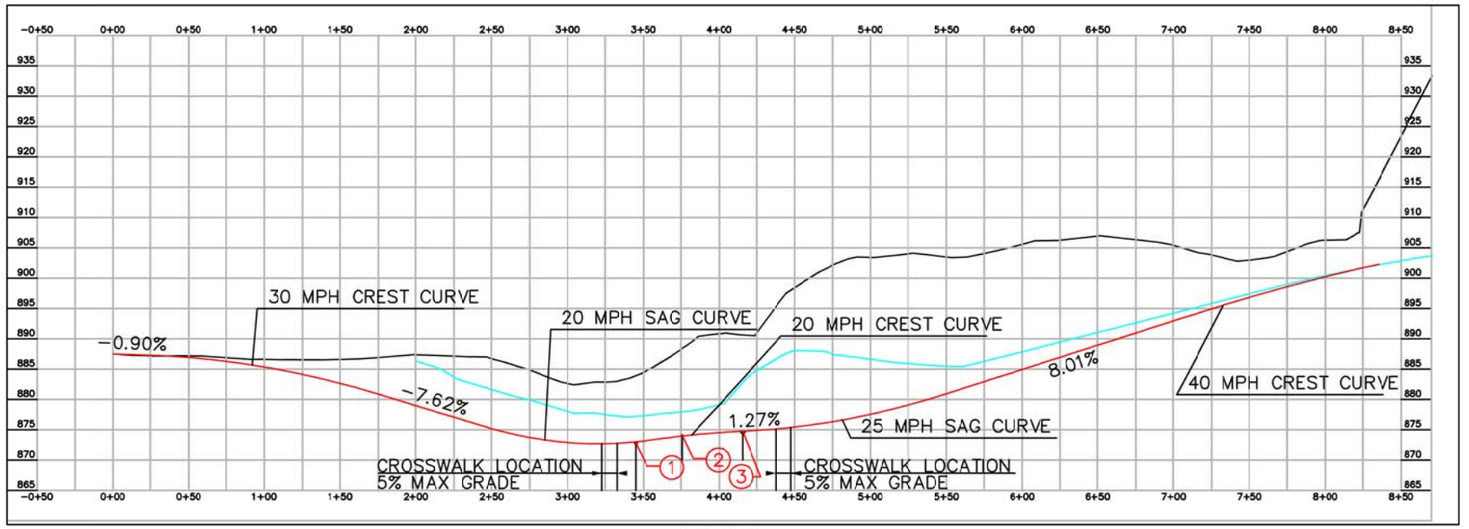
LEGEND

- Existing Ground
- Initial Finished Ground
- Roundabout Profile
- Profile Points - See Figure C-1

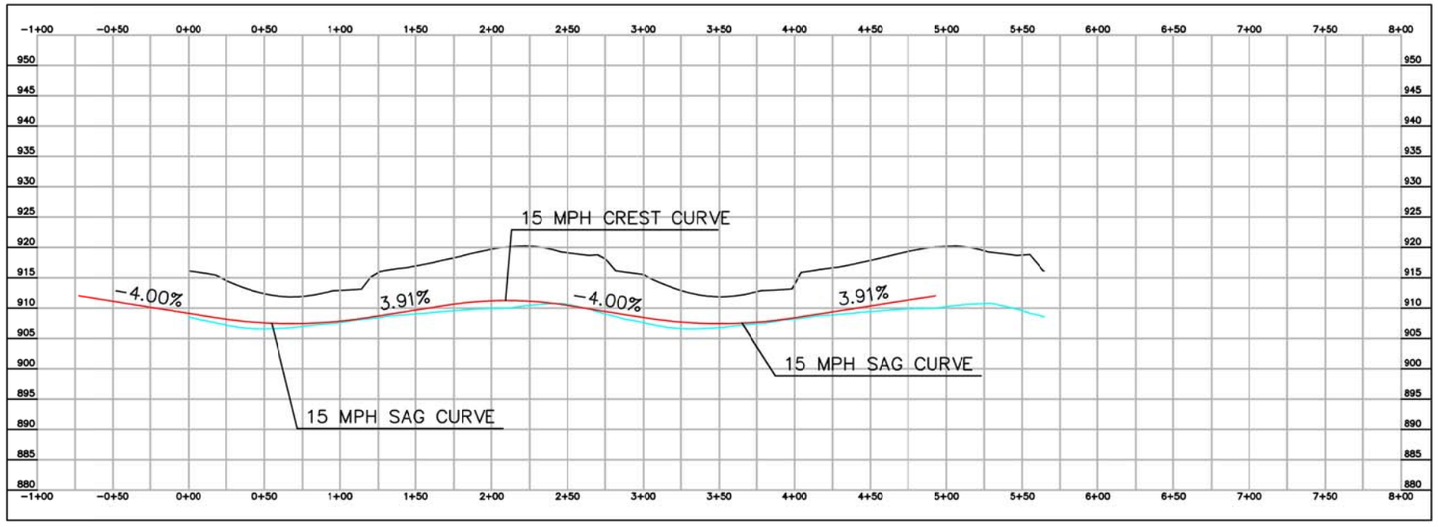
HORIZONTAL SCALE IN FEET
50 0 50 100

VERTICAL SCALE IN FEET
12.5 0 12.5 25

ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



RB1-E



RB2-A

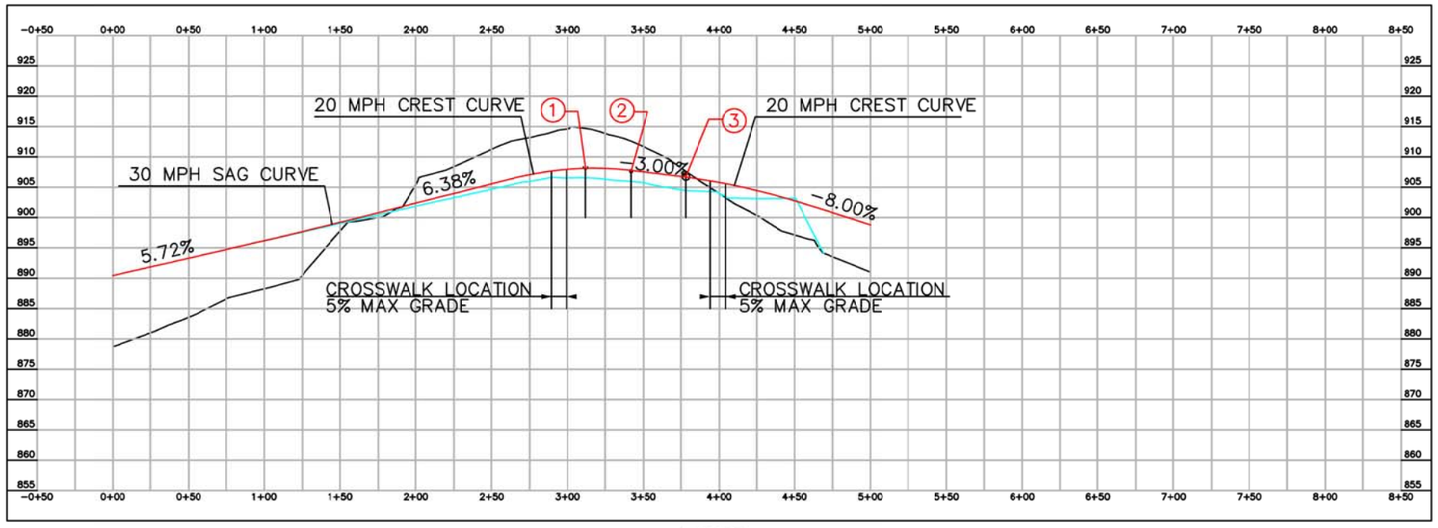
LEGEND

- Existing Ground
- Initial Finished Ground
- Roundabout Profile
- Profile Points - See Figure C-1

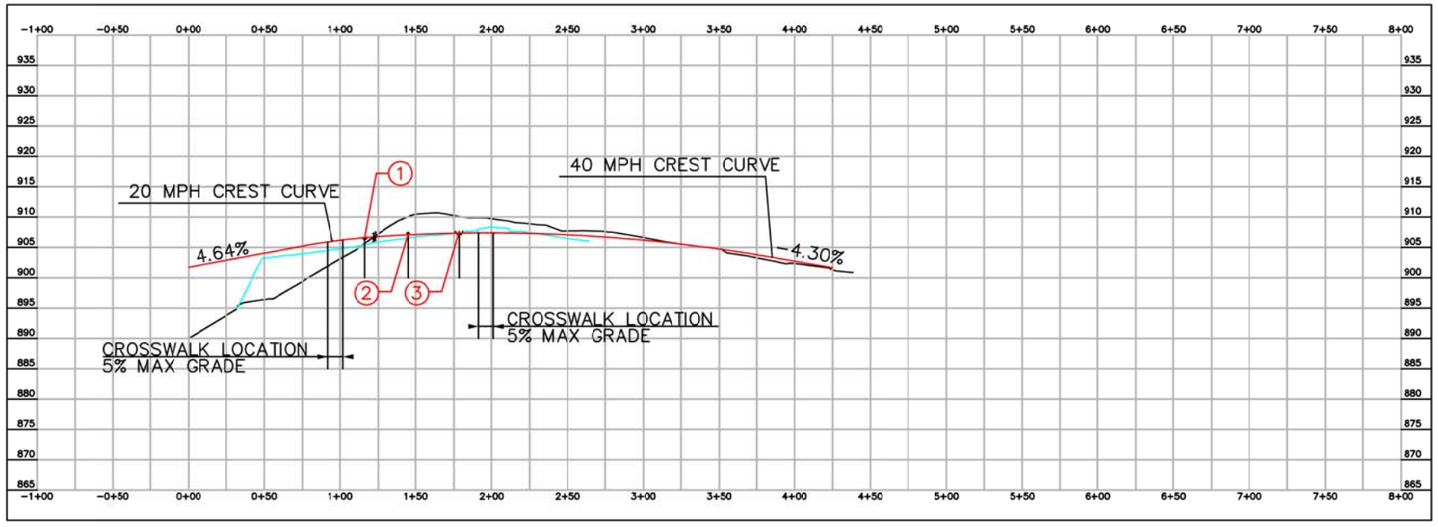
HORIZONTAL SCALE IN FEET
50 0 50 100

VERTICAL SCALE IN FEET
12.5 0 12.5 25

ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



RB2-B



RB2-C

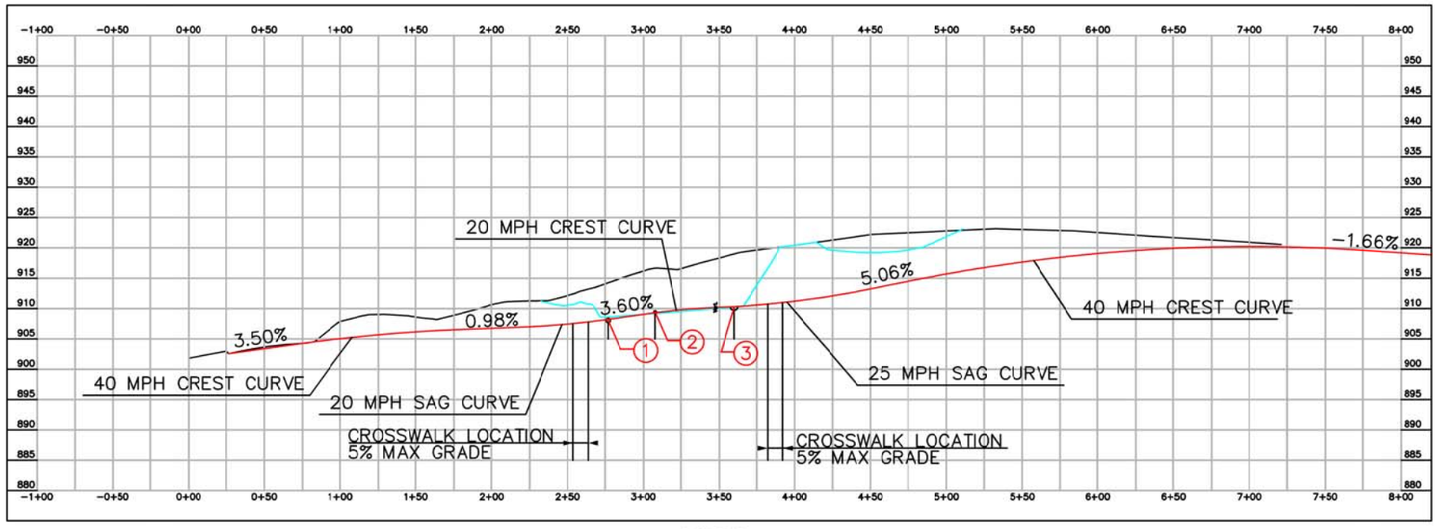
LEGEND

- Existing Ground
- Initial Finished Ground
- Roundabout Profile
- Profile Points - See Figure C-1

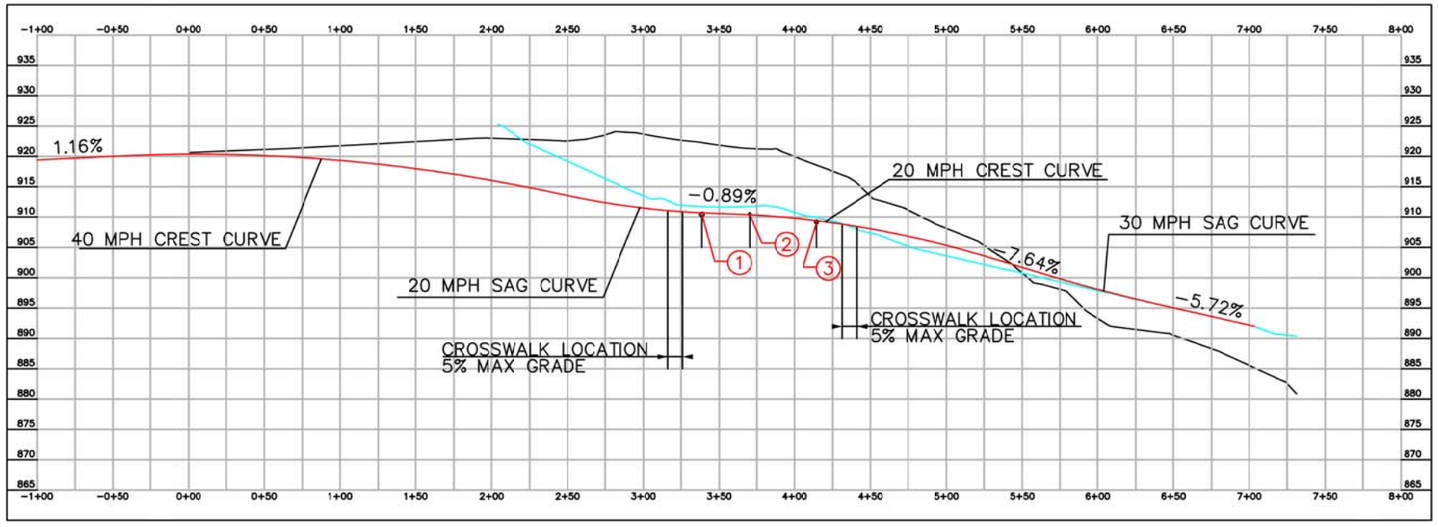
HORIZONTAL SCALE IN FEET
50 0 50 100

VERTICAL SCALE IN FEET
12.5 0 12.5 25

ReidMiddleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800



RB2-D



RB2-E

LEGEND

- Existing Ground
- Initial Finished Ground
- Roundabout Profile
- Ⓧ Profile Points - See Figure C-1

HORIZONTAL SCALE IN FEET
50 0 50 100

VERTICAL SCALE IN FEET
12.5 0 12.5 25

Reid Middleton
728 134th Street SW Suite 200
Everett, Washington 98204
Ph: 425 741-3800

APPENDIX D
(ACHD FASTEST PATH PROCEDURE)

Appendix A
ACHD Fastest Path Procedure

Fastest Path Definition

The fastest path is the path of least travel time made by a passenger vehicle traversing through the roundabout in the absence of other traffic and ignoring all lane markings. A true fastest path is comprised of a series of consecutive spiral curves that are tangent to each other. The speeds of the fastest path are limited by the smallest radius of each spiral, superelevation, and a vehicle's ability to accelerate.

Procedure Objectives

All measured fastest paths and their corresponding speeds are estimates based on engineering practices and judgment. The purpose of the ACHD Fastest Path Procedure is to remove as much guesswork and variability from fastest path measurements as possible and to achieve the following goals:

- Be objective;
- Be repeatable;
- Be consistent with the most current edition of the FHWA Roundabout Guide recommendations; and
- Reflect anticipated driver behavior and vehicle performance.

Procedure Applicability

The ACHD Fastest Path Procedure should be used to estimate the fastest paths of typical roundabouts with one and two entry lanes with either flat or tight exit geometry. In rare cases (e.g., a dog bone shaped roundabout) the Procedure is not anticipated to be applicable and an experienced roundabout designer hand sketch should be used. The ACHD Fastest Path Procedure is performed with a Computer Aided Drafting (CAD) software but should be supplemented with an experienced designer's hand sketch or other tested procedure to confirm the results and identify potential enhancements to the procedure.

*The resulting path from the ACHD Fastest Path Procedure is not intended to trace or resemble the actual fastest path because it is replacing spirals with arcs and tangents. Rather, the results are intended to provide arc radii that match the actual fastest path spiral radii at their tightest points.

Procedure Steps

First, determine whether the subject approach has one or two entry lanes and whether the corresponding exit has flat or tight exit geometry (Procedure A – Exit Type Test). Second, follow the applicable procedure (Procedure #1, #2, or #3) and measure the fastest path radii and/or acceleration distances for the subject approach. Next, determine the roadway's superelevation for each measurement (typically e = +0.02 for right-turns and e = -0.02 for left-turns at roundabouts). Last, calculate an estimated 85th-percentile speed for each movement with the applicable equations (see below).

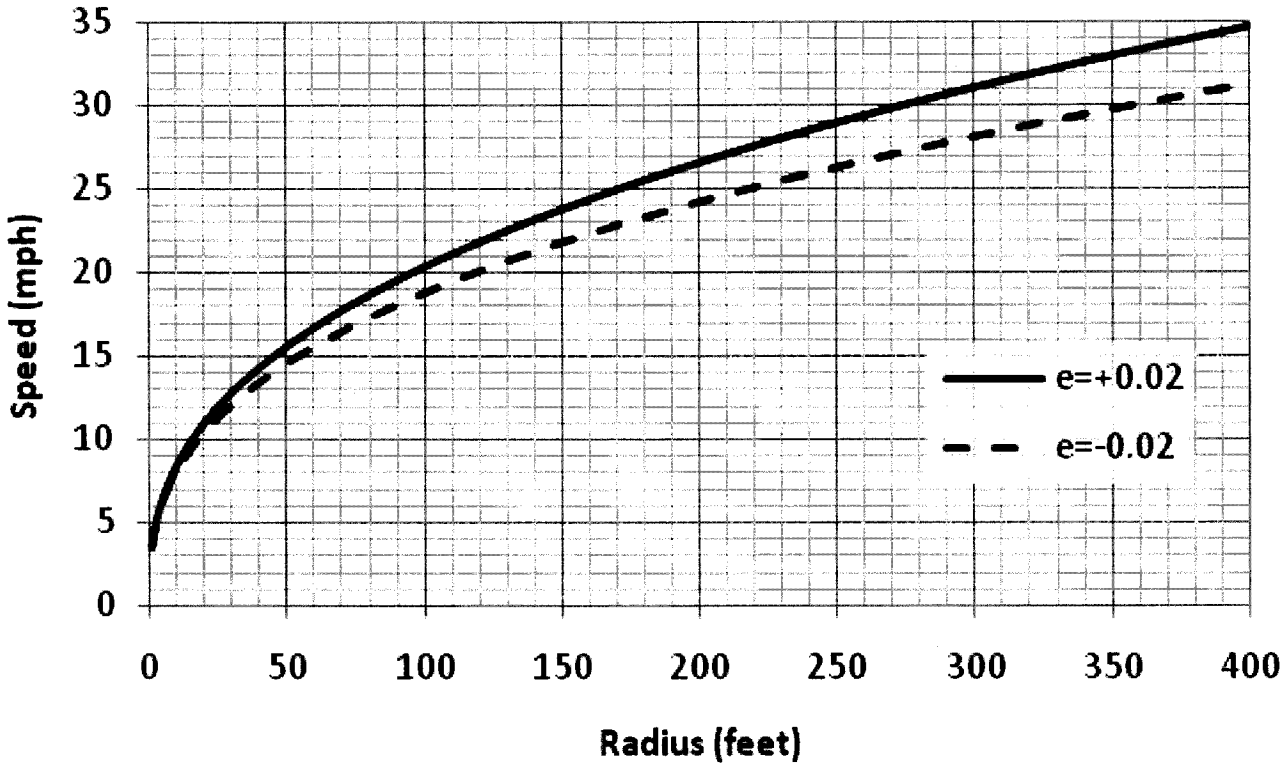
Speed Based on Defining Radius

Below are fitted equations that are used to estimate vehicle speed (V, mph) based on its path radius (R, feet) and superelevation (e). These equations should be used to estimate most or all of the fastest path speeds in a roundabout. Figure A1 plots the speed versus radius equations for supplementary reference.

$$V = 3.4415 \times R^{0.3961}, \text{for } e = +0.02$$

$$V = 3.4614 \times R^{0.3672}, \text{for } e = -0.02$$

Figure A1
Speed-Radius
Relationship



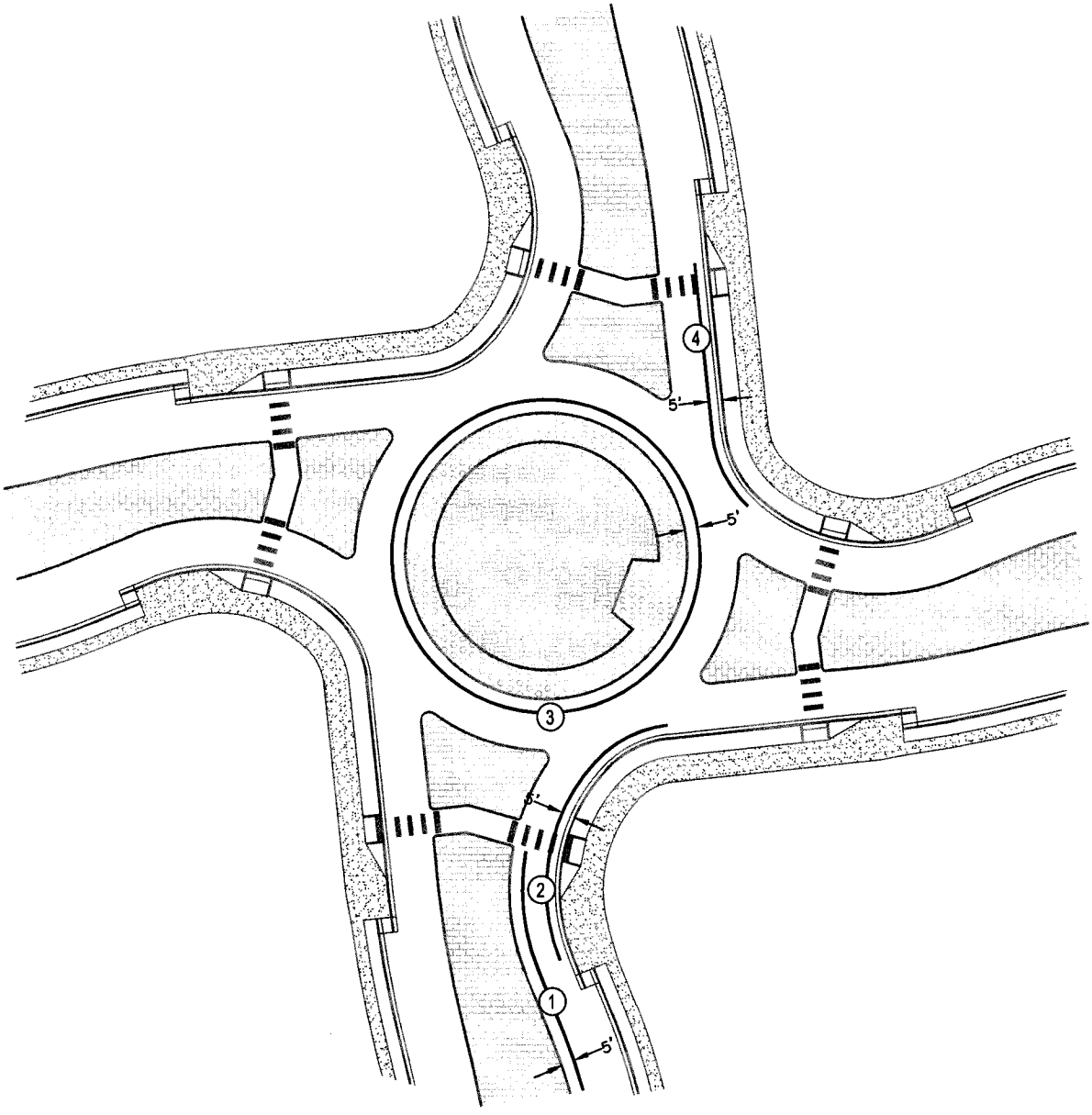
Speed Based on Acceleration Distance

The equation below is used to estimate vehicle speed (V_3, mph) based on the previous movement's speed (V_2, mph) and the distance (D, feet) between the midpoint of the V_2 path and the point of interest along the V_3 path. This equation is typically used to estimate the speed of exiting through movement vehicles in roundabouts with flat exits. Figure A2 plots the speed versus acceleration distance equation for supplementary reference.

$$V_3 = \frac{1}{1.47}\sqrt{(1.47 \times V_2)^2 + 13.8 \times D}$$

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Offset Construction Points
Steps 1 to 4

Step (1) – Offset The Inside Approach Curb By 5–Feet Toward The Outside.

Step (2) – Offset The Outside Entry Curb By 5–Feet Toward The Inside.

Step (3) – Offset The Center Island Curb (Outside Of Truck Apron If Present) By 5–Feet Toward The Outside.

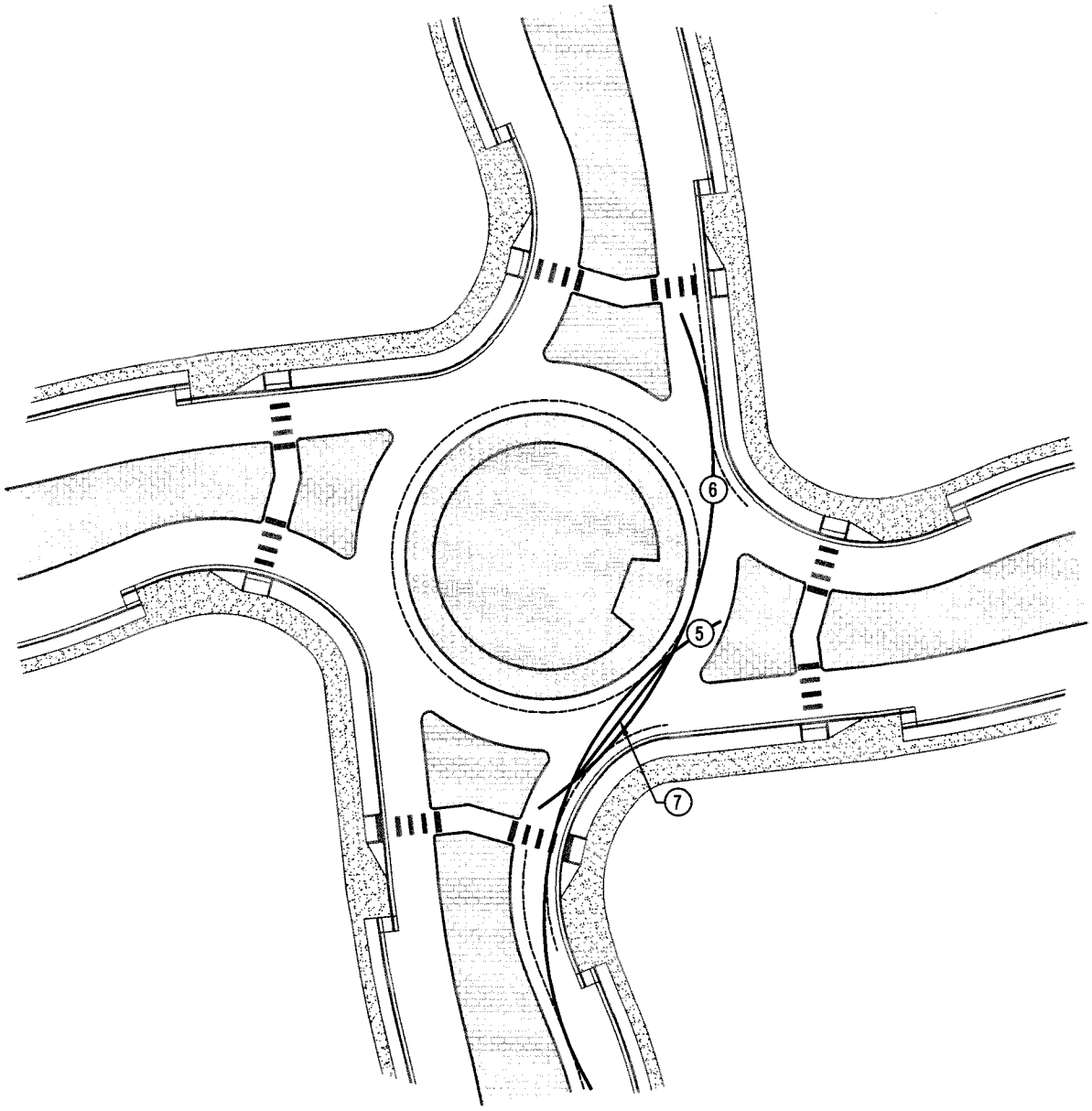
Step (4) – Offset The Outside Departure Curb By 5–Feet Toward The Inside.

Fastest Path Values

R4 = The Radius Of The Circle Drawn In Step (3)

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Tangent Construction Lines
Steps 5 to 7

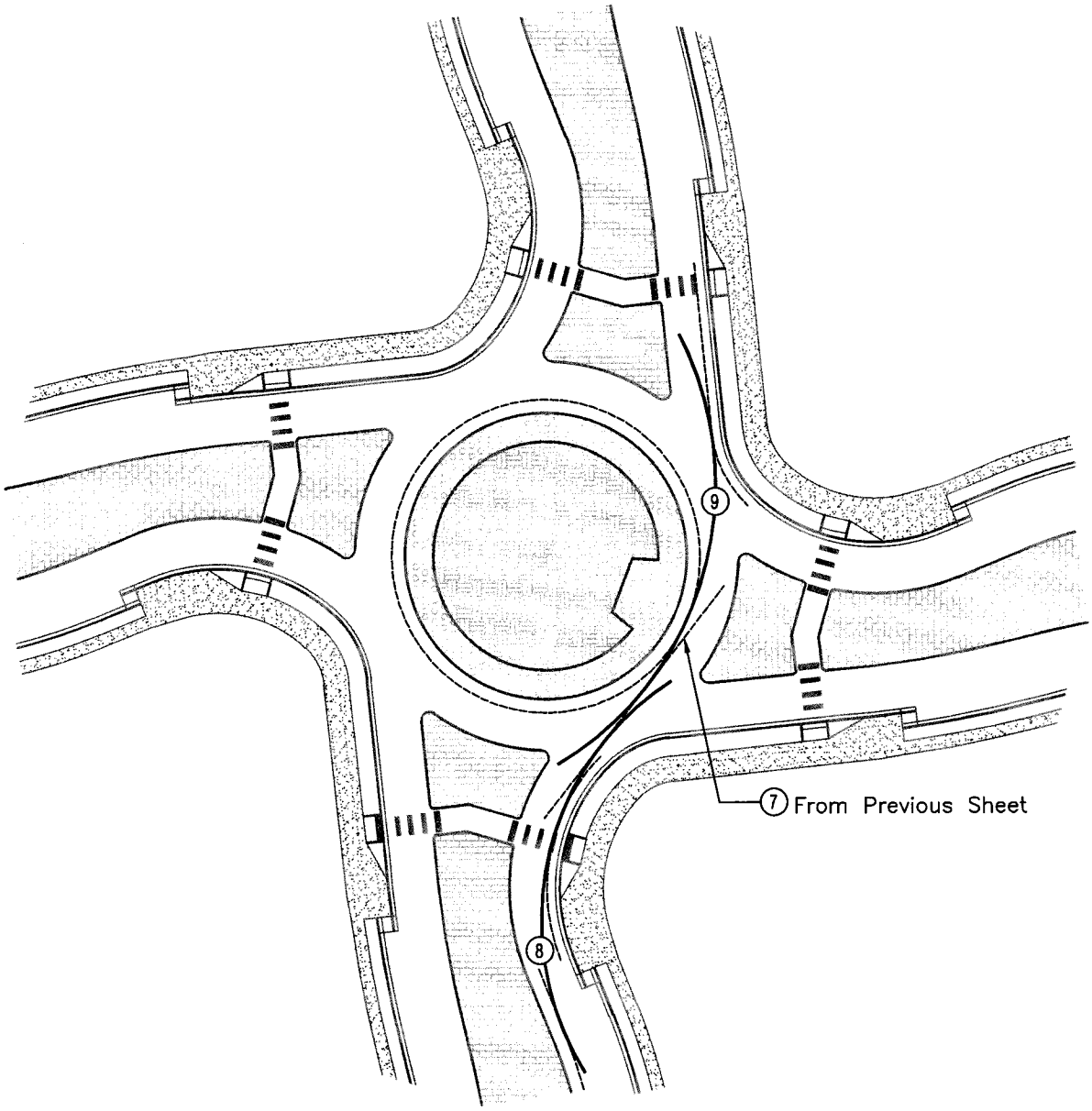
Step (5) – Draw A 3 Point Circle, Tangent To Inside Approach Offset, The Outside Entry Offset, And The Center Island Offset.

Step (6) – Draw A 3 Point Circle, Tangent To Outside Entry Offset, Center Island Offset, And Outside Exit Offset.

Step (7) – Draw A Straight Line Between The Two Points Where The Circles From Step (5) And Step (6) Cross Each Other.

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Tangent Construction Circles
Steps 8 to 9

Step (8) – Draw A 3 Point Circle, Tangent To Inside Approach Offset, The Outside Entry Offset, And The Straight Line Drawn In Step (7).

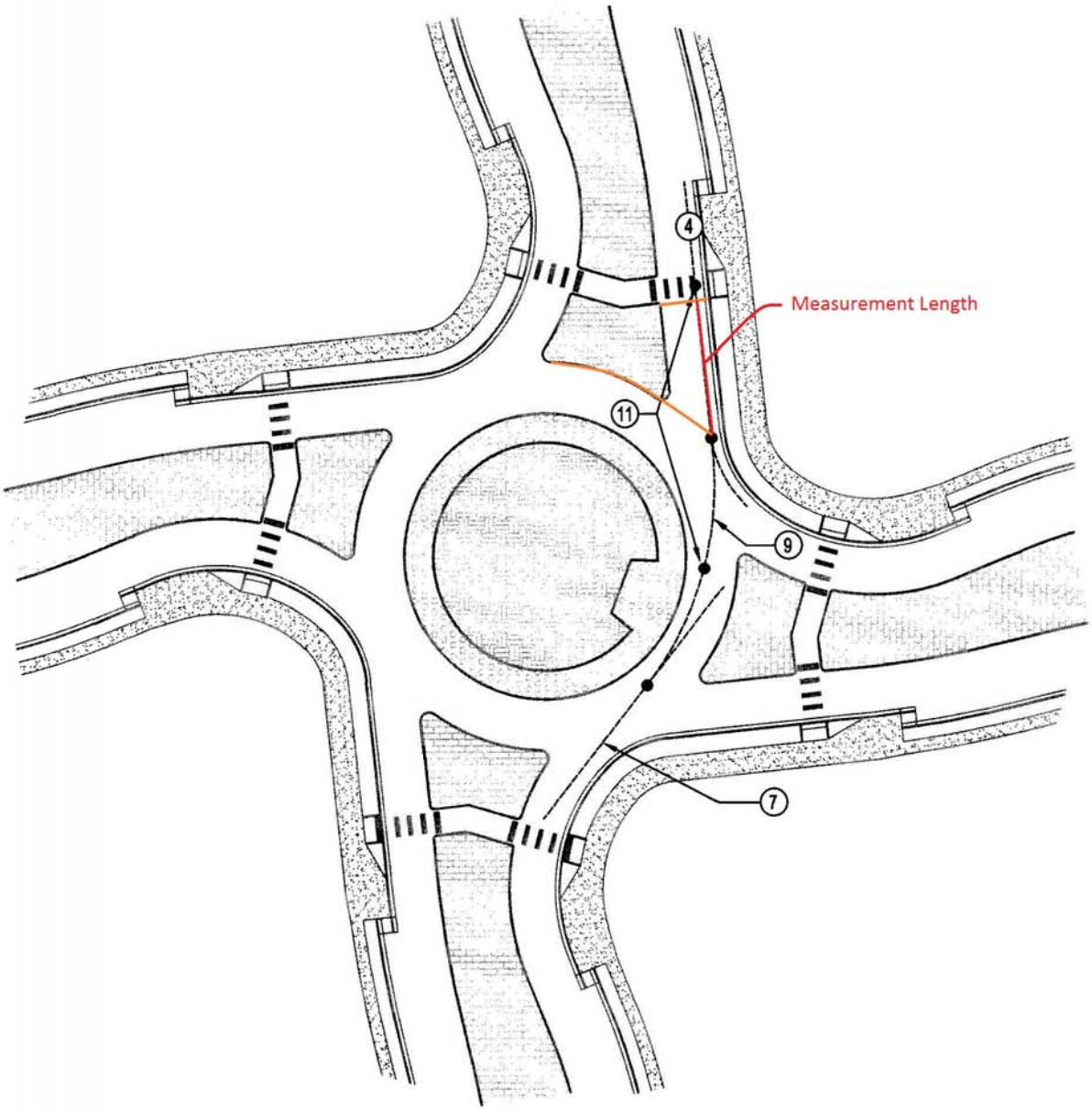
Step (9) – Draw A 3 Point Circle, Tangent To The Straight Line Drawn In Step (7), The Center Island Offset, And The Outside Departure Offset.

Fastest Path Values

R2 = The Radius Of The Circle Drawn In Step (9)

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Acceleration Distance
Steps 10 to 11

Step (10) – Trim The Circle Drawn In Step (9) With The Line Drawn In Step (7) And The Outside Departure Offset Drawn In Step (4).

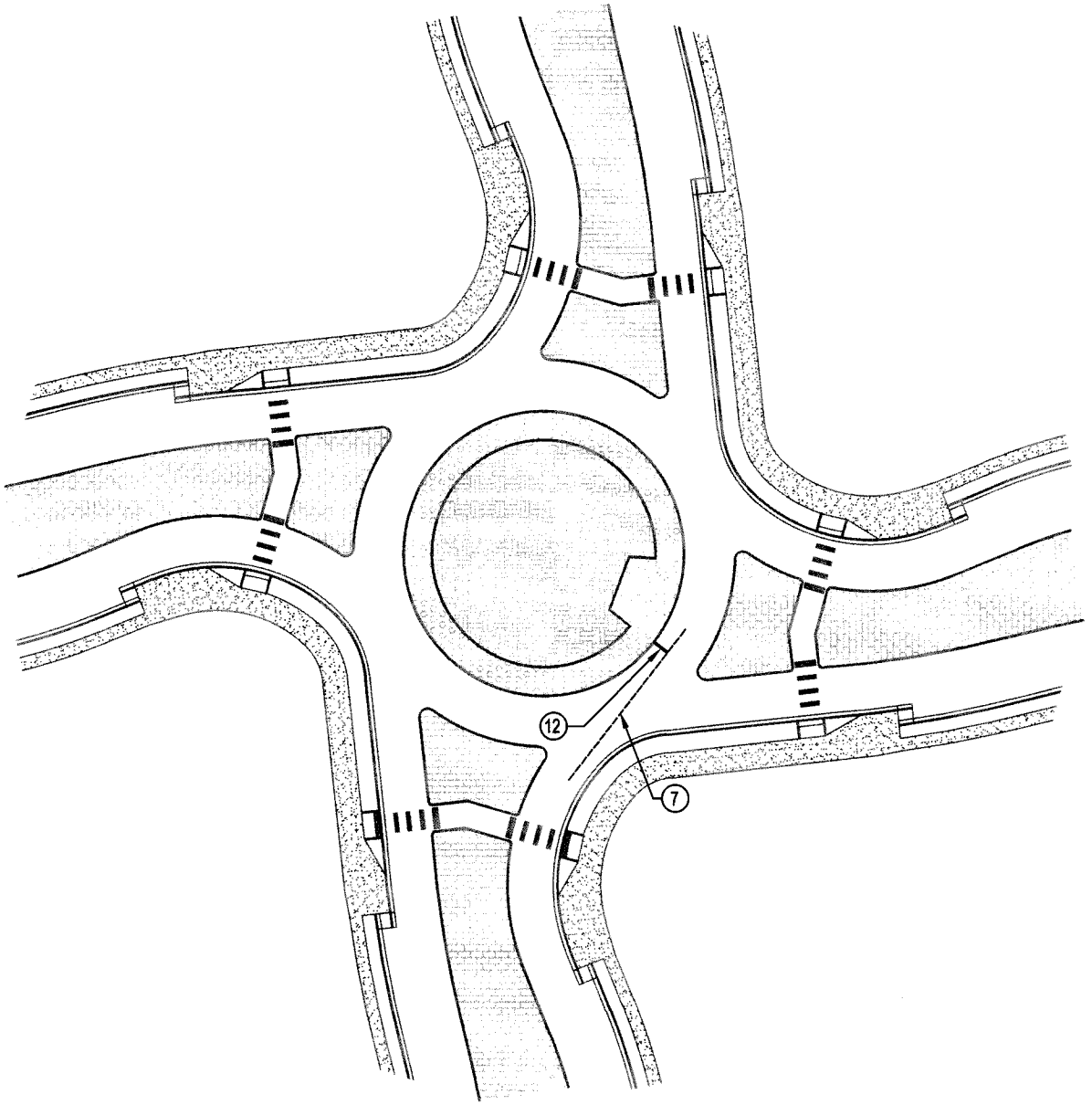
Step (11) – Measure The Distance Traveled Along The Combination Of The Arc Created In Step (10) And The Tangent Outside Departure Offset From ~~The Midpoint Of The Arc Crated In Step (10) To The Midpoint Of The Pedestrian Crosswalk.~~ See Above Figure for Measurement Length

Fastest Path Values

V3 = Calculate Based On Speed Of R2 And Acceleration Over Distance Measured In Step (11).

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



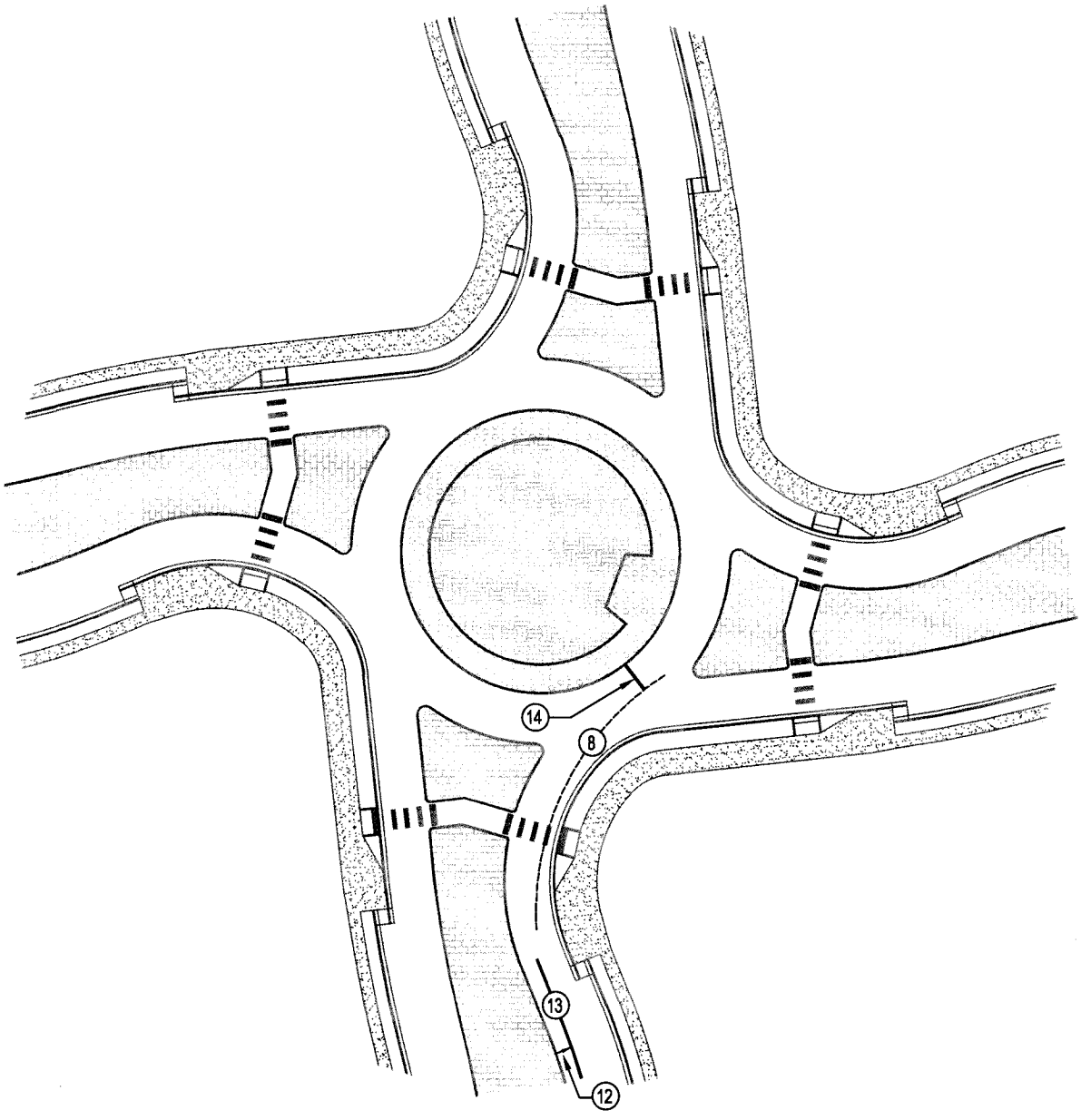
Fastest Path Layout

New Offset Measurement
Step 12

Step (12) – Draw A Straight Line From The Center Of The Roundabout, Perpendicular To The Straight Line Drawn In Step (7), And Measure The Distance Along This Line From The Center Island Curb (Outside Of The Truck Apron Curb If Present) To Line (7).

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

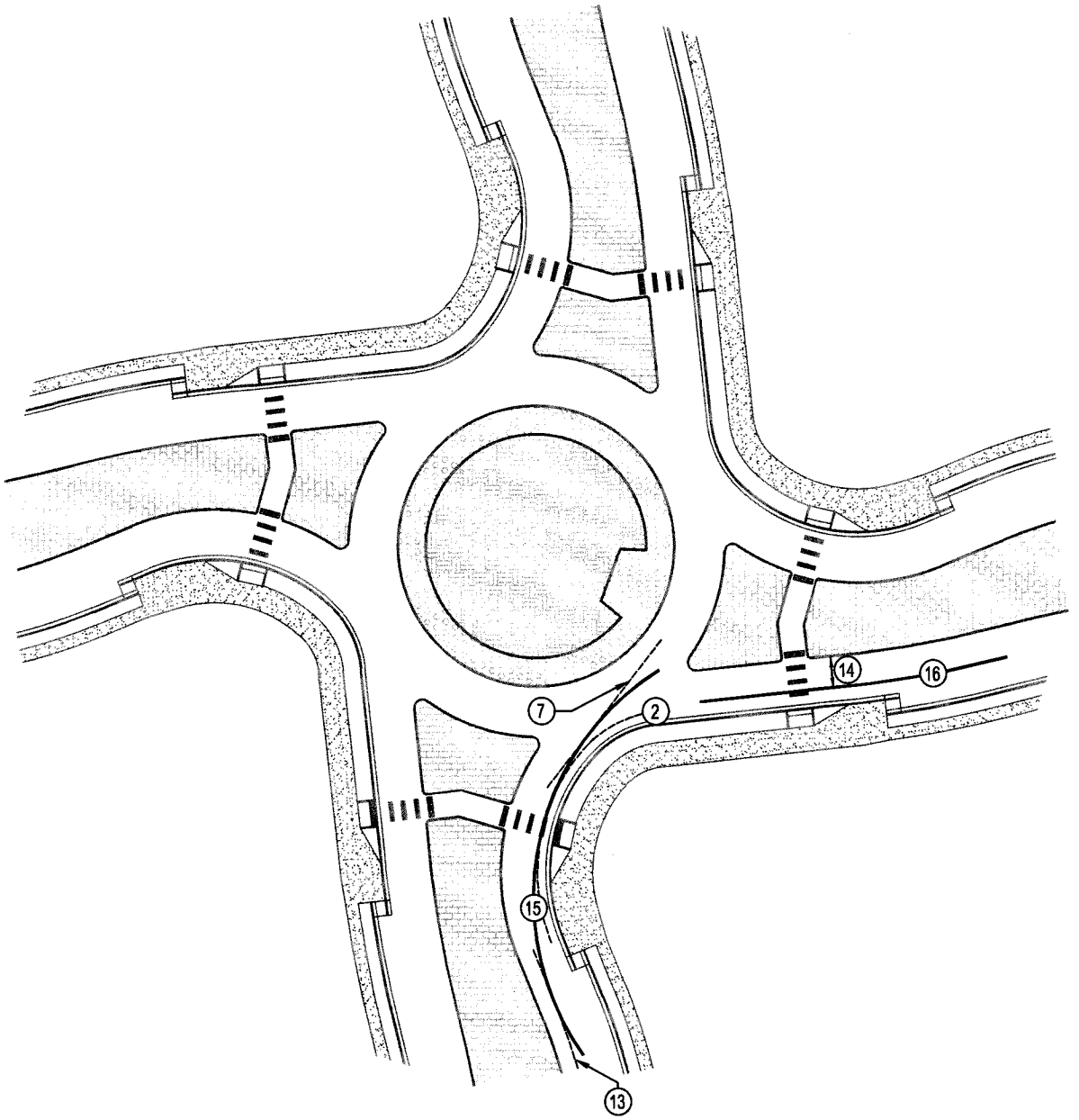
Construction Offset Lines
Steps 13 to 14

Step (13) – Offset The Inside Approach Curb By The Distance Measured In Step (12) Toward The Outside.

Step (14) – Draw A Straight Line From The Center Of The Roundabout, Perpendicular To The Circle Drawn In Step (8), And Measure The Distance Along This Line From The Center Island Curb (Outside Of The Truck Apron Curb If Present) To Circle (8).

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Measurement Circle
Steps 15 to 16

Step (15) – Draw A 3 Point Circle, Tangent To The Inside Approach Offset Drawn In Step (13), The Outside Entry Offset Drawn In Step (2), And The Straight Line Drawn In Step (7).

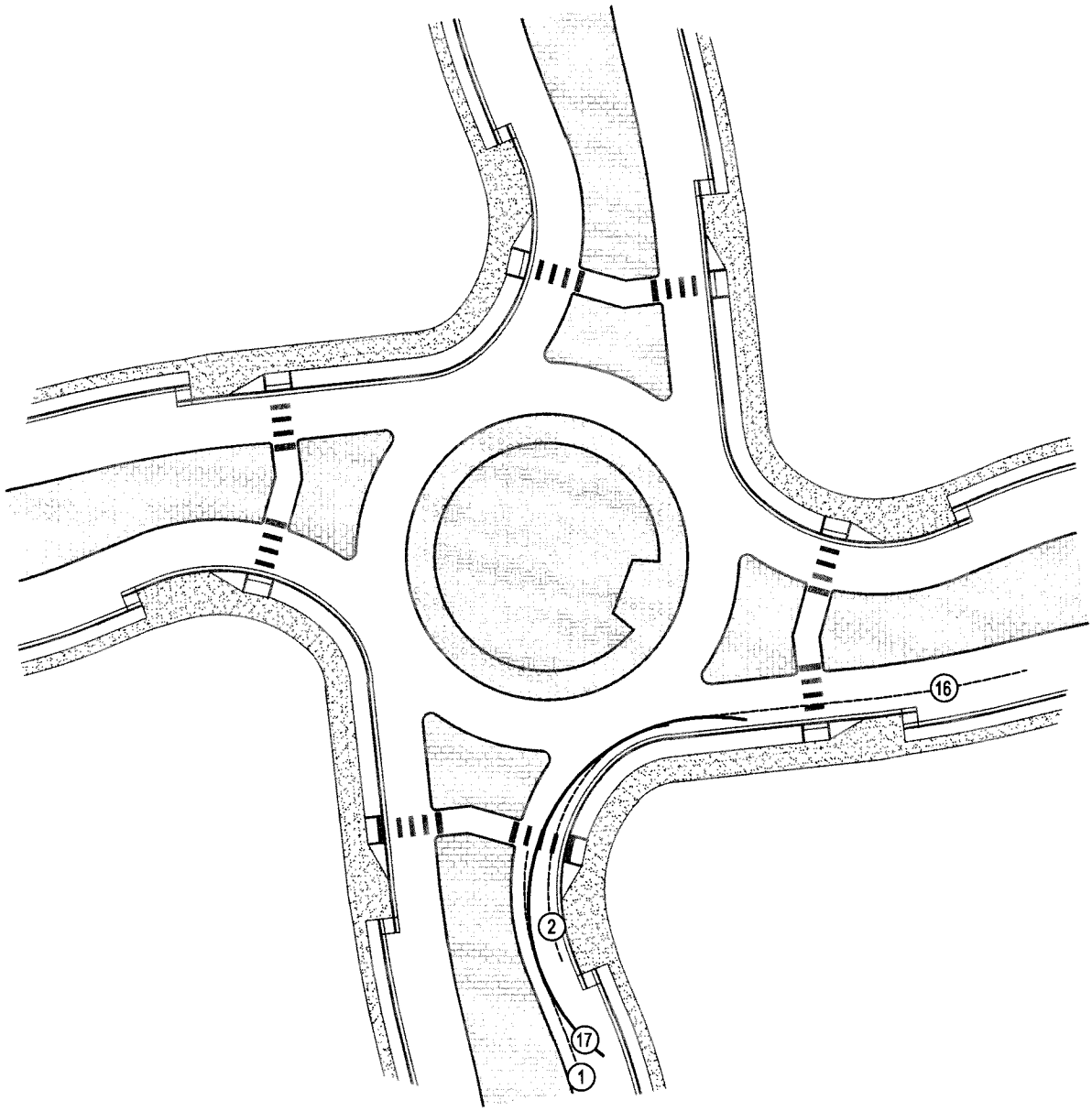
Step (16) – Offset The Inside Right–Turn Departure Curb By The Distance Measured in Step (14) Toward The Outside.

Fastest Path Values

R1 = The Radius Of The Circle Drawn In Step (15)

ACHD FASTEST PATH PROCEDURE

Procedure #1 – Single Entry Lane With Flat Exit
Revised: November 30, 2010



Fastest Path Layout

Right Turn Measurement Circle
Step 17

Step (17) – Draw A 3 Point Circle, Tangent To The Inside Approach Offset Drawn In Step (1), The Outside Entry Offset Drawn In Step (2), And The The Inside Right–Turn Departure Curb Offset Drawn In Step (16).

Fastest Path Values

R5 = The Radius Of The Circle Drawn In Step (17)

APPENDIX E
(BICYCLE FACILITIES)

ReidMiddleton

728 134th Street SW, Suite 200
Everett, WA 98204
Ph: 425/741-3800; Fax: 425/741-3900

Bicycle Design Treatments

Introduction

At roundabouts, the goal of the pedestrian and bicycle facilities are to safely accommodate multi-modal users including commuter bicyclists, recreational bicyclists and pedestrians. The recommendation found on Page 6-74 *of NCHRP 672 - Roundabouts: An Information Guide* shows the following:

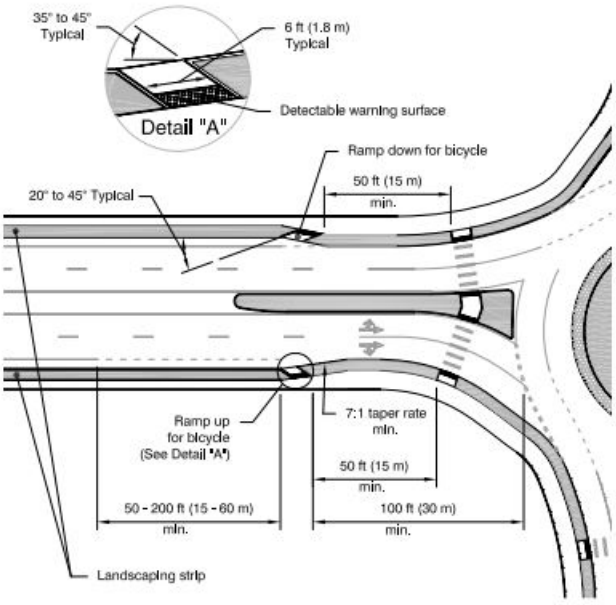


Figure 19: Possible Bicycle Design Treatments

Exhibit 6-67 from NCHRP 672

There are several concerns with this recommended practice that Reid Middleton has observed in the operation of roundabouts over the last 15 years. During that time, Reid Middleton has developed a design for bike ramps that alleviates some of the concerns while still encouraging the correct user behavior at roundabouts.

35° to 45° Angle

The recommendation found on Page 6-73 *of NCHRP 672 - Roundabouts: An Information Guide* states the following:

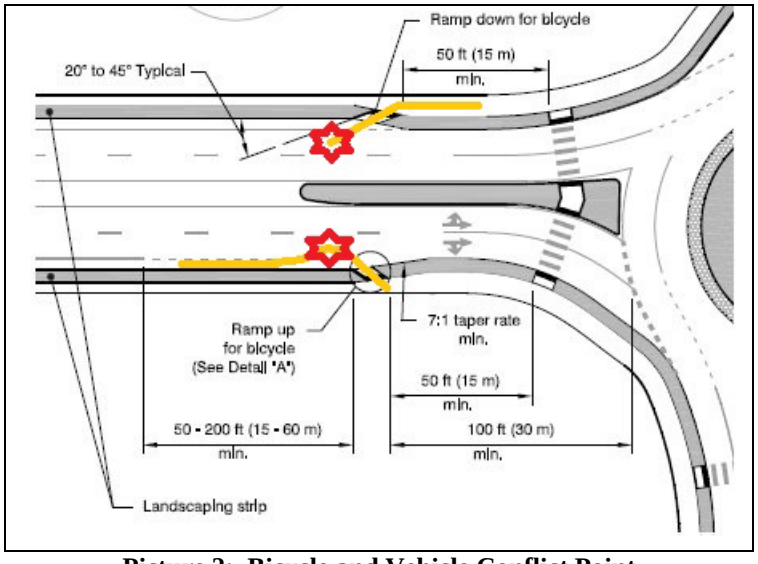
> *"Bike ramps should not be placed directly in line with the bike lane or otherwise placed in a manner that appears to cyclists that the bike ramp and the sidewalk is*

the recommended path of travel through the roundabout. This encourages more sidewalk use by bicyclists, which can have a negative effect on pedestrians at the roundabout and may be less safe for bicyclists as well."

In early roundabout projects, designers provided an angle for the bicycle ramp, see Picture 1, consistent with the approach stated above.

Picture 1: Angled Bike Ramp

After observing this and other roundabouts with similar designs, Reid Middleton no longer recommends this type of angled design. This configuration causes the cyclist to line themselves up with the ramp by swinging wide into the adjacent lane. It is even more pronounced and hazardous on the exit as bicyclists are directed into the travel lane rather than the bike lane, see Picture 2. The unexpected appearance of bicyclists in the travel lane is a key factor in bicycle fatalities at circular intersections.



Picture 2: Bicycle and Vehicle Conflict Point

In an effort to keep inexperienced bicyclists out of the travel lane as they negotiate the bike lane, this type of bike ramp was provided directly in line with the bike ramp as shown in Picture 3. This type of ramp caused minimal confusion for the commuter bicyclist, and kept the recreational bicyclist on an appropriate path. However, the right angles of the curbing collected debris which was difficult to remove with traditional street sweepers. In addition, recreational bicyclists could enter the multi-use trail without any encouragement to check their speed.

Picture 3: Ramp with Minimal Landscaping Buffer

In our designs, the bike ramps are still in line with the bike lane, but with an angled curb. This ensures recreational bicyclists remain on an appropriate path but with an appropriate speed. This bike ramp provides positive reinforcement for commuter bicyclists to claim the travel lane (in line with vehicles) at this location. In addition, the angled curb assists with sweeping and road maintenance. This type of ramp, shown in Picture 4, has been installed in numerous roundabouts with great success.

Picture 4: Angled Bike Ramp

Location of Bike Ramps

Commuter bicyclists would usually rather "claim the vehicle lane" and traverse through a roundabout in line with vehicles. Placement of the bicycle ramp is critical in creating a safe environment for which to do this. If the ramp is placed too far from the intersection, vehicle speeds will not be slow enough for bicyclists to safely merge in line with vehicle traffic. In this case, the bicyclist has the tendency to "hug the edge" which is not a safe way to traverse through the intersection on a bicycle. Placing the ramp closer to the intersection ensures vehicle and bicycle speeds are similar.

Taper Rate of Bicycle Lane

The desired bicycle behavior at roundabouts is to center the bicycle in the vehicle lane, directly in line with vehicles. The effect of providing a gradual taper rate as the bike lane ends, is that bicyclists do not move into the center of the travel way. With a gradual taper, bicyclists tend to stay near the right gutter causing safety concerns as they traverse through the roundabout.

Conclusion

Over the last 15 years, Reid Middleton has observed bicycle treatments at roundabouts and revised our own design practices to achieve desired user behavior. The principles outlined in *NCHRP 672* provide a good starting point for bicycle treatments, but need to be refined for improved safety at specific locations. In locations with a heavy commuter bicycle presence, commuter bicyclists have shown no tendency to favor the multiuse trail over "claiming" the vehicle lane. The concerns of having the bike ramp in line with the bike lane have been mitigated by the angled curb.